



Dear TestAS candidate,

You have decided to study in Germany. You are considering which path of study would be the right one for you and how you can make the best of your academic training by studying at a German university.

This process involves important decisions about your future: which subject would you like to study and which university should you choose?

With our brochure, we would like to provide you with advice to help you optimise this process. TestAS can help you and the German universities to make the right choice.

Aptitude tests like the Test for Academic Studies - TestAS - in combination with the marks attained in your university entrance examination allow a particularly precise prediction about your chances of success as a student. This is the reason why many German universities are already implementing TestAS as an objective, reliable and standardised aptitude test in their selection and admission of foreign students.

In those countries where Academic Evaluation Centres (APS) have already been installed - such as in The People's Republic of China or in Vietnam - TestAS is part of the APS procedure. Specially gifted students having a good command of German who can apply for the PASCH programme in many countries via the German Academic Exchange Service (DAAD), also take TestAS.

In this brochure you will find sample questions from the so-called Core Test, which every applicant has to complete, and further tasks from all Subject-Specific Modules of which one module has to be selected according to your chosen field of study.

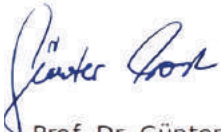
You will find a lot of helpful tips on how to proceed when solving the tasks. With good results you will increase your chances of getting an attractive offer from a university that suits your personal goals and interests.

The DAAD has consigned the ITB Consulting GmbH in Bonn with the development of TestAS and the Society for Academic Study Preparation and Test Development (Gesellschaft für Akademische Studienvorbereitung und Testentwicklung e. V., g.a.s.t.), the TestDaF-Institut, with the worldwide organisation of the test.

Many of you will already be familiar with g.a.s.t. from the Test of German as a Foreign Language (TestDaF) and the TestDaF-Institut. Among others, the portfolio of ITB comprises the Test for Medical Studies (TMS), the TM WISO and the Self-Application Test of the German National Academic Foundation. You may be assured that TestAS will determine your aptitude and competence in an objective, reliable and fair manner.

We do ask you to take the preparation for the test very seriously in order to give yourself the optimum chance of proving your real capabilities. On behalf of the TestAS team we hope you will obtain the university place you are aiming for and furthermore, we wish you success in your studies and hope you will be able to enjoy and profit greatly from studying in Germany.

We wish you great success!



Prof. Dr. Günter Trost
ITB Consulting GmbH



Dr. Hans-Joachim Althaus
g.a.s.t. / TestDaF-Institut

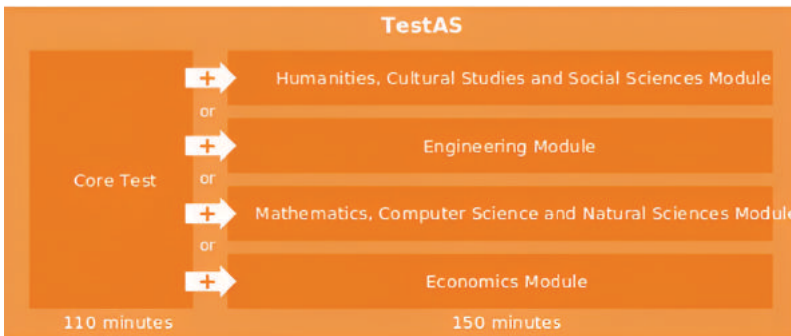


Why should I take TestAS?

TestAS is the most important aptitude test for foreign applicants wishing to study in Germany. TestAS analyses skills necessary for successful studies, e.g. logical thought processes, recognising structures or solving problems. German universities use the TestAS certificate in order to select and admit suitable students for their courses. TestAS increases your chances of obtaining a university place in Germany.

How is TestAS structured?

TestAS is offered both in English and German. When registering you select either the language you are better at or the one the university requires.



The **Core Test** assesses skills necessary for successful studies in all subjects.

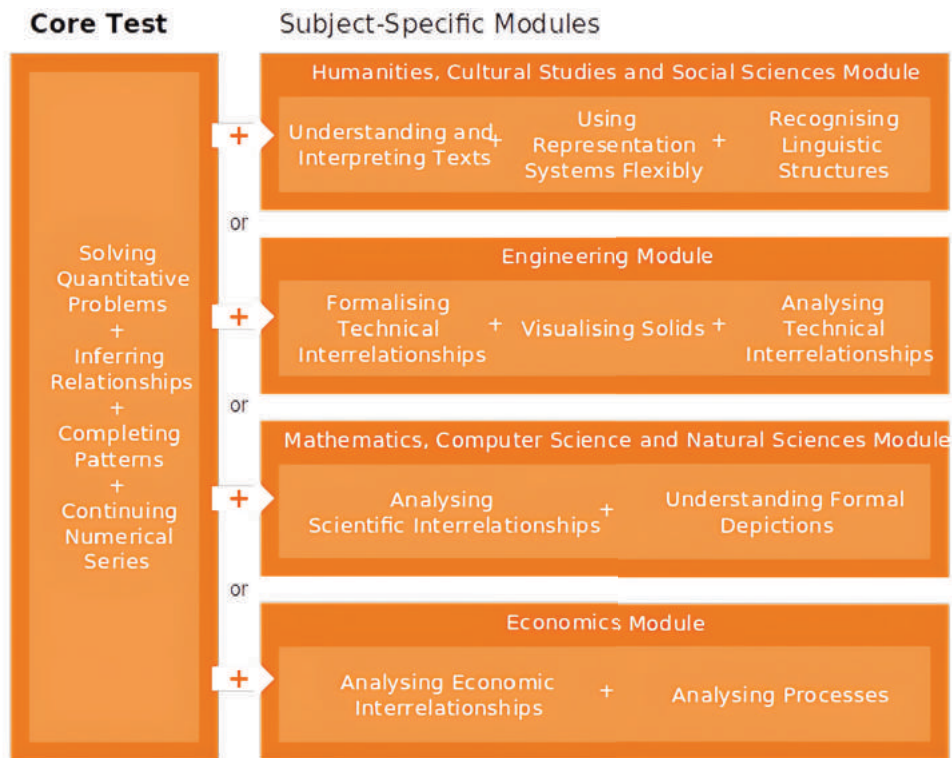
Subsequently you work through the Subject-Specific Module which analyses skills you will need in typical situations in your particular field of study.

The university you have decided to study at will determine which Subject-Specific Module you will be required to take according to your chosen course of studies.
 Below you will find some examples of which courses may well suit which Subject-Specific Module.

Humanities, Cultural Studies and Social Sciences	Engineering	Mathematics, Computer Science and Natural Sciences	Economics
German language and literature	Mechanical Engineering	Mathematics	Business Economics
Linguistics	Electrical Engineering	Chemistry	Political Economics
Sociology	Mechatronics	Physics	Management
Politics	Civil Engineering	Computer Science	Business Management
Philosophy	Automotive Engineering	Psychology	Education Management
Historical Science	Environmental Engineering	Pharmacology	Energy and Water Management
Law	Chemical Engineering	Medicine	

Which tasks will I have to solve?

In the Core Test, as well as in the Subject-Specific Module, you will be required to solve two to four different subtests. You will find these subtests in the table below. You will find more detailed information for each subtest (What is it about? How many tasks are there?) at the beginning of each subtest in this brochure.



In both the Core Test and the Subject-Specific Module you will be answering multiple-choice questions only.

Tips on how to proceed

Organise your working time well:

→ **Work quickly but take care.**

It is very important to read the tasks through carefully. If you read too quickly and hence not thoroughly enough, then you will miss important information.

→ **Work through the questions in the given order.**

The first tasks in any group tend to be easier than later ones. That is why we would suggest that you work through the booklet in the given order. But:

→ **If a particular question is too difficult for you, then come back to it later.**

It is better to use your time on tasks you find easier. On average, test takers solve about half of the tasks.

→ **If you are solving mathematical problems, try to find your own solution first.**

Then check if your answer is among those in the multiple-choice. If you look at the choices first, it may lead to confusion. If you are not able to find a solution, then try to exclude the answers which are most likely going to be false.

→ **If you have very little time left...**

You do not get minus points if the answer is wrong. Enter all solutions onto your answer sheet.



Sample questions

Engineering Module

The Engineering Module is divided in three different subtests. You have a total of 150 minutes to solve the tasks. In the table below you can see how many tasks there are in each subtest and how much time is allowed.

To prepare for this, there are six tasks to solve for each subtest on the following pages. The tasks at the beginning are easier than those at the end. At the beginning of each subtest there is a short explanation about the type of the tasks, together with instructions on how to solve the tasks.

You can find the solutions starting at page 53.

Subtest	Amount of tasks	Time allowed
Formalising Technical Interrelationships	22	60 minutes
Visualising Solids		
- Question type 1	13	30 minutes
- Question type 2	13	
Analysing Technical Interrelationships	22	60 minutes
Total working time		150 minutes

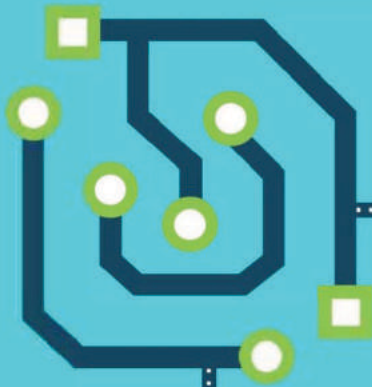
2. Preparation book for the

TestAS

engineering

Develop views - task type 1

2020



- ✓ Detailed explanation of task and the resolution strategy
- ✓ Helpful graphic representations for visual illustration
- ✓ Extensive collection of tasks with detailed solutions

ABOUT THE EXPERT MODULE ENGINEERING KNOWLEDGE SHAFT

1

The engineering subject module is relevant for those students who want to study engineering in the future. The university you are applying to decides which subject module you need for your application. In the case of the following subjects, the engineering module is typically required:

- Electrical engineering
- mechanical engineering
- automotive engineering
- Civil Engineering

If you are unsure which subject-specific test module is suitable for you, please contact the university to which you would like to apply directly.

The engineering module consists of three task groups:

1. Formalize technical issues (22 questions; 60 minutes)
2. Open up views, consisting of 2 types of tasks (26 questions; 30 minutes)
3. Analyzing technical contexts (22 questions; 60 minutes).

The 1st and 3rd part is mainly about questions of physics and mathematics and rarely about biology and chemistry. We will cover these parts in separate books. Basically, in our experience, it is very helpful to have basic knowledge of the most diverse subject areas of physics and mathematics. However, according to the manufacturers of TestAS, in-depth knowledge of physics and mathematics is not necessary.

Part 2 "Opening Views" consists of two task variants:

- Task type 1: Two-dimensional views of an object: 2D views of a 3D body are specified and another 2D view is sought. There are 13 questions in the exam. - In this book we focus on this type of task.
- Task type 2 (covered in a separate book): Three-dimensional views of a cube: A 3D view of a cube is given. The direction of the second 3D view is searched. There are also 13 questions in the exam.

TIME MANAGEMENT 1ST ESSENTIAL

You have a total of **30 minutes** for the **26 questions** in the "Opening Views" section, ie about **one minute per question** . You can switch back and forth between the two sections as you wish.

In both task types, the first questions are the easiest. Ie, questions 1-5 and 14-18 are easier than, for example, questions 9-13 and 22-26. It might be a good strategy to solve questions 1-7 and 14-20 first, and then answer the remaining questions.

Please make sure that there is a good distribution of time between the two task types. Many students will be in the 1st Task type so deep that you only have little time for the 2nd part, although the first questions are easy to solve.

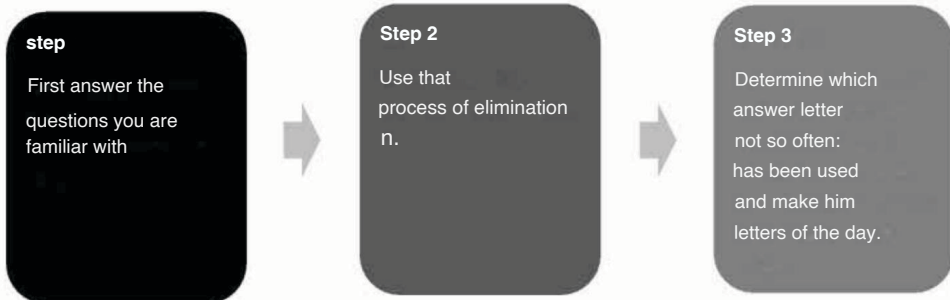
And if you get along better with the 2nd type of question, ie the dice questions, it can make sense to solve them first and then to devote yourself to the 2D questions.

Students report that they were often able to answer significantly less than half of the questions. And some make the mistake of delving too deeply into the 2D questions and thus not having time for the first (and easy) dice questions.

Each question answered correctly increases your points - we suspect the increase affects this part more than other parts of engineering because the average in this part is low. By practicing Stacking Up, you can be better than average and get a good grade.

WHAT'S THE BEST ADVICE?

We recommend the following approach to increase the probability of correct guessing.



STEP 1: First answer the questions you are familiar with.

On the first run, focus on these questions and skip those that require extensive thought or that you are unfamiliar with.

Circle the questions you skipped so you can find them easily.

STEP 2: Use the process of elimination where possible.

Once you've seen all the questions, go back to the skipped questions. This two-round strategy may make you more confident, as you realize that you can answer many questions correctly, despite skipping questions.

Now use the process of elimination to rule out possible answers that you think are wrong or wrong. If you see clearly wrong answers while working through the questions, cross out the answer letter so that it is clearly visible.

STEP 3: Determine which answer letter has not been used that often in this sub-test and make it the letter of the day.

See which answer letter from A to D you ticked the least often in the subtest. This will then become your letter of the day. (In years past, the TestAS had each of the four answer letters in each subtest with approximately the same frequency.) Use it for any answer you need to guess. This increases the likelihood of answering more questions correctly.

Skip step 2 if you run out of time so you have marked at least one answer choice for all questions.

THE 2D/3D QUESTION TYPES SINO WELL TRAINABLE

This task is very unusual for high school graduates. Your spatial imagination will be tested here. That means you have to imagine objects in two and three dimensions in order to answer the questions. This is a skill that you will deal with regularly during your studies. And the good news is - **this ability is highly trainable!**

Both types of tasks are similar in approach, but they also differ greatly from each other in some aspects. Therefore, please read the respective introduction, as well as the solution strategies and useful tips for both sections, and memorize them.

The ability to solve this type of problem **depends very much on practice**. The following section contains four practice tests. It is advisable to first work through an exam without assistance and then to consult the explanations afterwards. Then you can see which question types you should focus on the most.

HOW DO I PROVIDE THE ANSWERS ON THE ANSWER SHEET?

The core test and the field-specific test module are each given in a small exercise book. There is **a separate answer sheet for this**, on which the answers must be marked with a ballpoint pen. The answers in the exercise book are not checked.

You must use a blue or black ink pen to mark the answers.

Don't use a pencil. The selected answer must be marked with an X. In the example below, Answer B is highlighted.



If you want to change an already marked answer, color in the entire circle and place an X in the circle of your new answer. In the example below, answer D is highlighted.



In the unlikely event that you change your mind a third time, color in the entire circle and place an X in the circle of your new answer. In the example below, answer C is highlighted.



If you should change your mind again and decide for the first answer, although you have already changed it, you can write the correct letter (A, B, C, D) at the end of the answer line. In the example below, answer B is highlighted.



Since the answer sheets are scored by a computer and you cannot check the scores of the answer sheets after the test is over, we recommend that you do not make too many changes of this kind.

Please make sure you have entered all answers in the answer sheet before the time runs out. After the end of the sub-test, you must start working on the next group of tasks and are not allowed to scroll back. Only the markings on the answer sheet count towards the score.

If you're having trouble with a particular task, don't try to solve it compulsively. Better to go by the exclusion principle and try to guess. Incorrect answers and unmarked answers have the same effect on your endpoint score. There is no deduction of points for wrong answers.

PRACTICAL TIPS FOR THE TEST DAY

The test lasts over five hours. Please bring drinks and snacks with you to have enough energy for the entire test.

In addition, it is very important to get enough sleep the night before the test. This may sound self-explanatory, but it is necessary to keep you focused for five hours.

AVIEWS

DEVELOP,

TASK TYPE 1:

2D VIEWS

2

CONSTRUCTION

The questions in this section test your ability to visualize the sides of a three-dimensional body based on two-dimensional images.

Two views are given for each question. A third view of this body is sought. The given and sought views are the following:

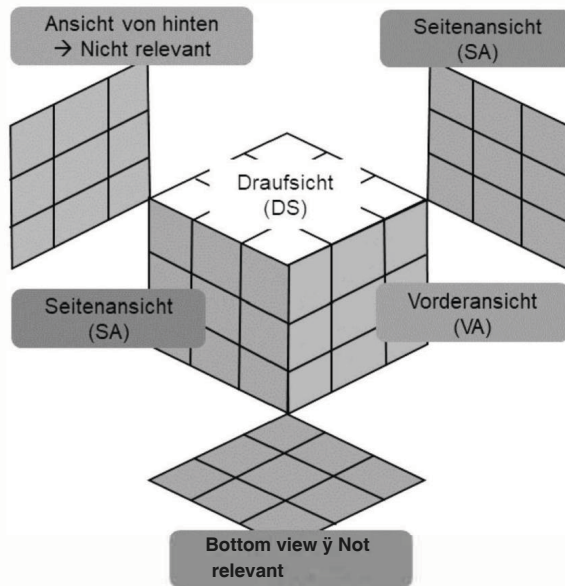
- the front view (VA), the
- side view (SA) from the right or left
- the top view (DS)

That is, in each question 2 of the above views are given and the 3rd is asked for. The view from behind or below is irrelevant for these questions.

In the test, you don't have to explicitly distinguish between the left and right view, as we did in the example.

To solve the questions you have to **use certain characteristics to find out** what the 3D body looks like and which of the four possible answers is the right one.

As in the rest of the TestAS, the level of difficulty for each task type increases with increasing task. If you get stuck with a task, mark it and continue with the next task. If you have time later, return to this task.



During your engineering degree you will use the ability to visualize objects in three dimensions. Some questions may seem difficult to answer at first, but practice makes perfect with this question. This type of task is easy to train.

Below we present a procedure for solving the tasks. In addition, we have added an image of the three-dimensional body and arrows to the answers for easy orientation. We hope these will help you master this type of task quickly.

Let's start with an example. The three-dimensional image of the object helps a lot for a better understanding of the questions. But please try to solve the questions first without looking at the answer. You may find it difficult to make progress with the first tasks, but with practice and with the help of the three-dimensional images, you will quickly get used to this type of question.

How can you visualize the three-dimensional object? Pay attention to the following points.

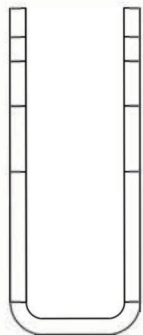
- What is the shape of the body? Are there round or elliptical components, or does the body have a cylindrical shape?
- Where are the elements of the body located? Front or back, right or left, top or bottom, or in the middle.
- Are there parts that stick out of the body? Or are there recesses or holes?
- Which parts are visible, which are completely or partially covered?
- What edges or corners are shown as a line from a different perspective?



EXAMPLE

side view (SA)

(VA)-



top view (DS)



(VA)

Wanted: front view (VA) of the body

(A)

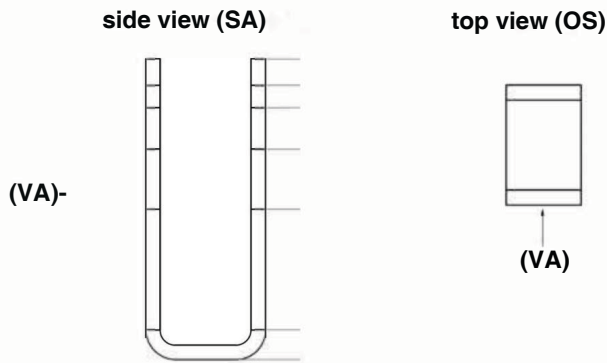
(b)

(c)

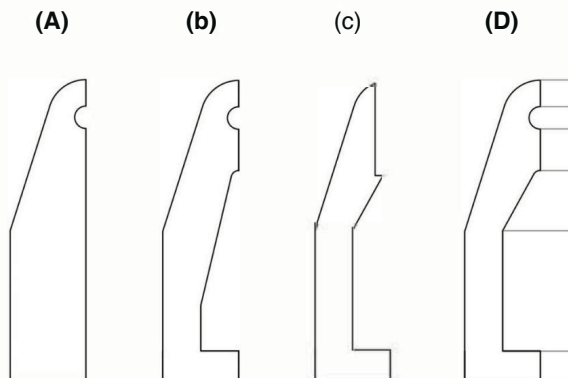
(D)



Answer:D



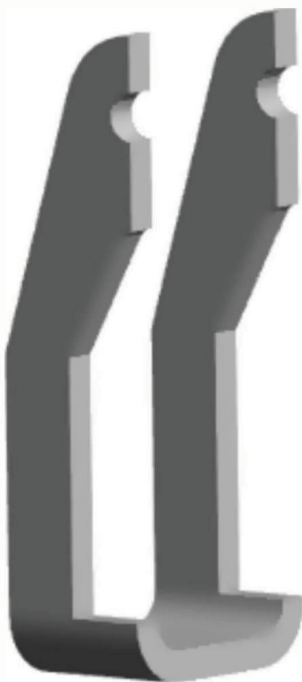
Wanted: front view (VA) of the body



(The steps below are explained in detail on the following pages.)

*Step 1: Determine the distinctive features: **spaces** on the left side of the VA.**Step 2: Mark the prominent features in the views.**Step 3: Right or Prong Side in SA? Right side.**Step 4: Exclude : Side view must be right side view. The **distances** between the horizontal lines must correspond to the **edges** from the front view you are looking for.*

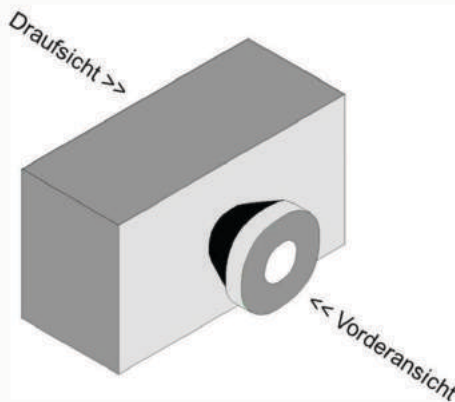
**30 view
of the body**



SA

WHAT DO THE DIFFERENT VIEWS LOOK LIKE?

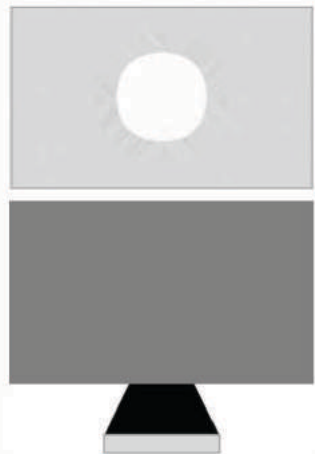
We start with a simple example. Suppose we consider the following object.



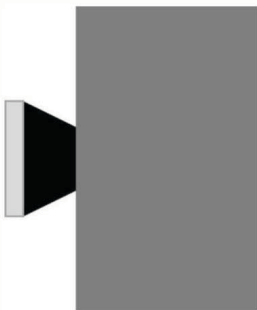
In the two-dimensional views, all visible edges of the object are displayed as a line.

The front view 0

The top view



The side view (right)



The side view (left)



The view from below (this view is **not** asked for!)



HINTS FOR THE 2D TASKS

1

Alle sichtbaren Kanten von dem Objekt werden als Linie dargestellt. Die Rundungen sind nicht erkennbar.

2

Wenn Du den Körper gedanklich nach links drehst, wirst Du seine rechte Seite sehen. Und umgekehrt.

3

Wenn die gesuchte Ansicht die Seitenansicht ist und diese nicht mit Pfeilen bei der Vorderansicht angezeigt wird, musst Du beide Seitenansichten bewerten.

Determine the depth of the body, which can be helpful for a quick elimination.
Based on the views, the height, width, and

feet
III

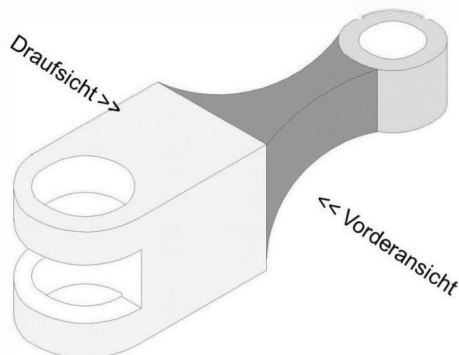
Right stays right in front view (VA) and top view (DS).

5

Oben bleibt oben in der Vorderansicht (VA) und Seitenansicht (SA).

7

Papierkanten/Stiftkanten helfen Dir, um die Position und Abstände von Merkmalen der Ansichten und Lösungsmöglichkeiten zu vergleichen.

RE NOTE 1: ROUNDINGS SINO NOT RECOGNIZABLE

The two-dimensional views look like this:

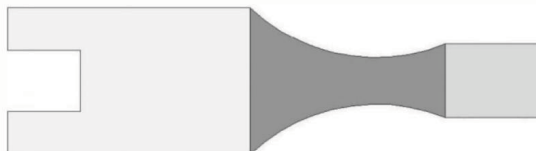
side view

FI (left) D



Top view

front view



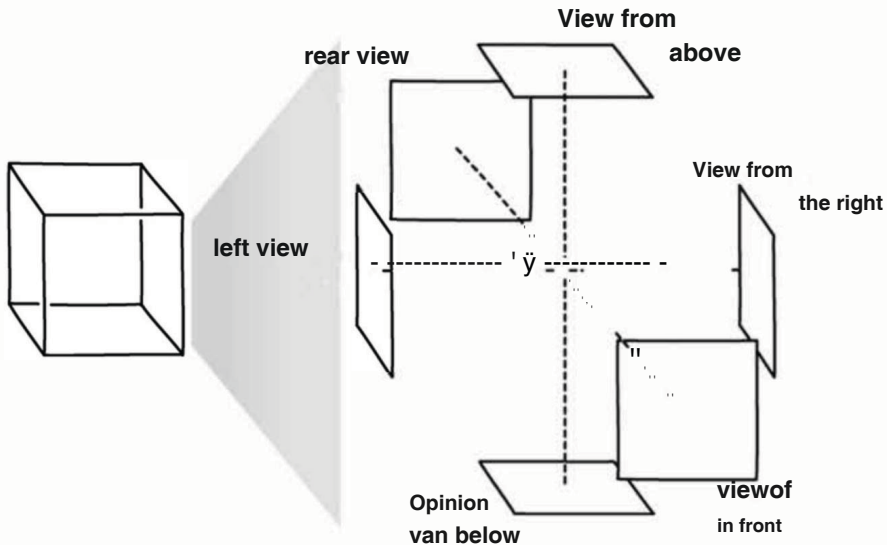
RE NOTE 2: RIGHT AND LEFT

Some students confuse the right and left sides. Please consider:

- If you made the view from **the left** , you have to mentally turn the body to **the right** .
- If you made the view from **the right** , you have to mentally turn the body to **the left** .

With this task type, you don't have to differentiate between the left and right view. It only asks for the distinction between top view, front view and side view. However, it is helpful to practice turning the body in your mind.

(In the case of task type 2, which we explain in another book, it is essential to be able to distinguish between the two side views.)



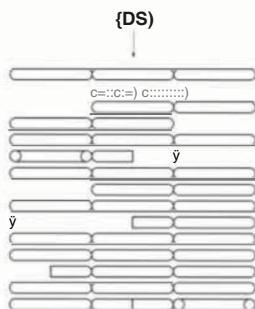
**RE NOTE 3: TEST BOTH SIDES IF DESIRED SIDE IS NOT ON
WILL BE SHOWN**

The example below asks for the page view. But there are no arrows identifying the side view direction. So we need to check which of the answers is either the right view or the left view. So you have to check the answers twice and this makes these questions quite time consuming.

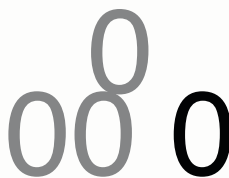


EXAMPLE

Front view (VA)



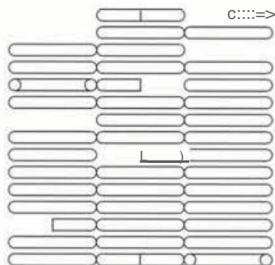
top view (DS)



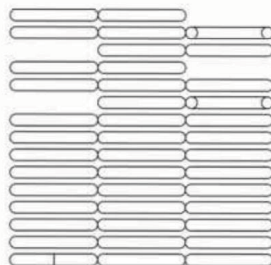
{VA}

Wanted a side view (SA) of the body

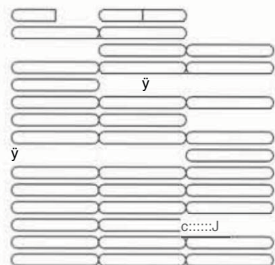
(A)



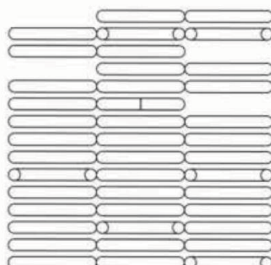
(b)



(c)



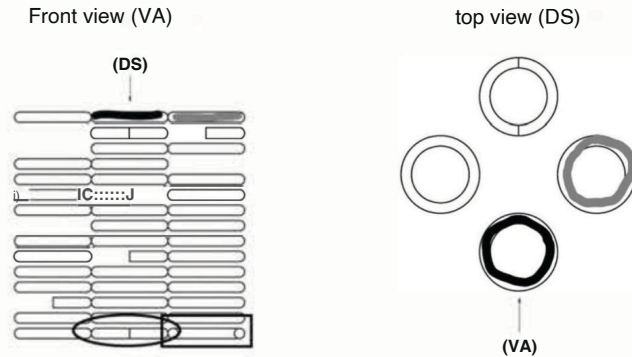
(D)



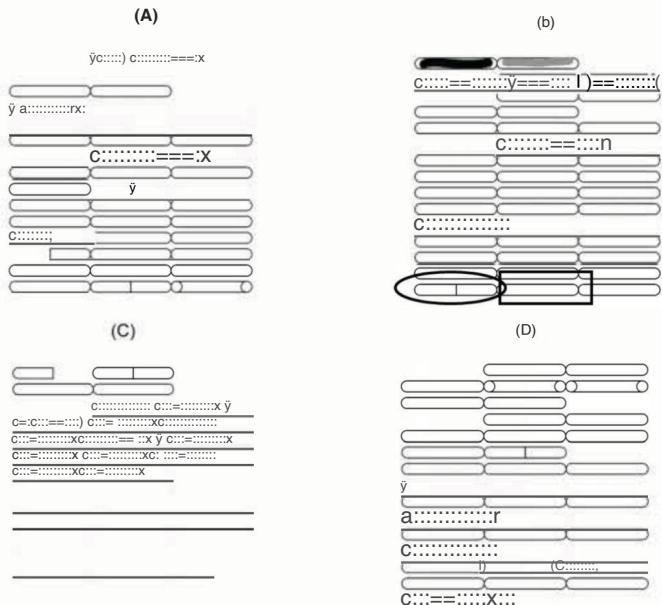
In this example we see that the two-dimensional views show the edges of the body as a line. How are the curves shown in the 2D view? Because there is no edge, they look more like a square.

To get to the solution, we first test the right side view.

Answer:D



Wanted a side view **(SA)** of the body



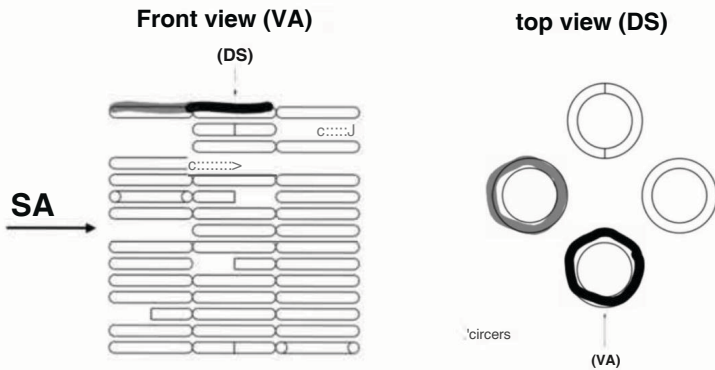
S 1: Determine the distinctive features: **top layer** of the rings (DS and VA), **bottom** layer of the rings.

S2: Mark the prominent features in the views.

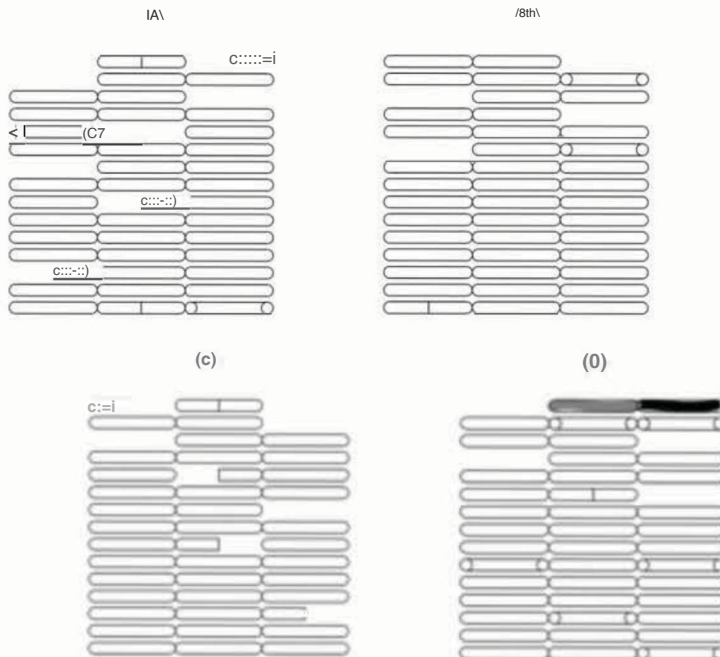
S3: Right or prong side in SA? We first test whether the requested page is on the right.

S4: Exclude: If we look at the top layer, answer B could possibly be correct. But there are discrepancies at the bottom layer of the rings. It is therefore the side view from the left.

Again we start with the top layer because we know from the top view that the 3 front rings are one whole ring.



Wanted a side view (SA) of the body



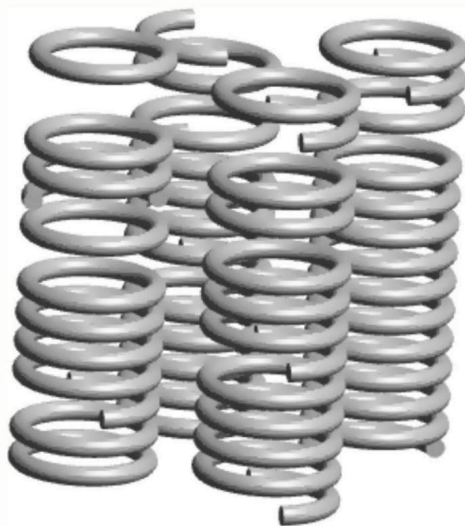
S1: Determine the prominent features: top layer of the rings (DS and VA).

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

S4: Excluding: Only answer D has the rings where we expect them to be.

3D view of
body



Of course you can now look for further evidence that D really is the left side view. But remember: **You have about 1 minute per question.**

We would recommend you not to spend too much time on one task. Even with the more difficult tasks, two possible answers can usually be ruled out quickly. There is no penalty for wrong answers and by excluding the two definitely wrong answers you have a 50 percent chance of choosing the right answer.

When you find yourself stuck, guess based on what you can eliminate. You can mark this question so you can look at it again later if you have time.

REGARDING NOTE 4: THE VIEWS SHOW THE HEIGHT, WIDTH, AND DETERMINE BODY DEPTH

Views share certain properties of the object:

- High front = High side = Height of object.
- Front width = Top view width = Object width.
- Side view wide = Top view high = Depth of object.

The example below illustrates these points.

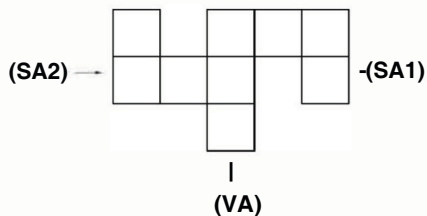
IMPORTANT!

We include (SA1) and (SA2) here to better illustrate the hint. In the exam, only one side view is usually shown or asked for per question.



EXAMPLE

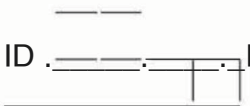
top view (DS)



side view (SA2)

EEb

Front view (VA)



side view (SA1)

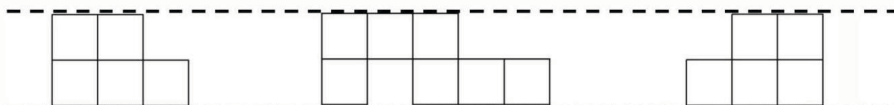
dE

You can see the **height of the body** in the front view as well as the side views.

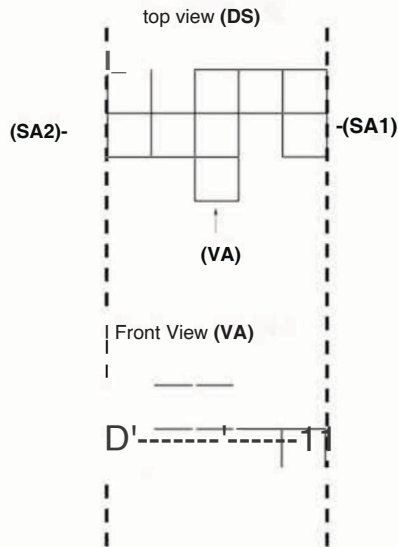
side view (SA2)

Front view (VA)

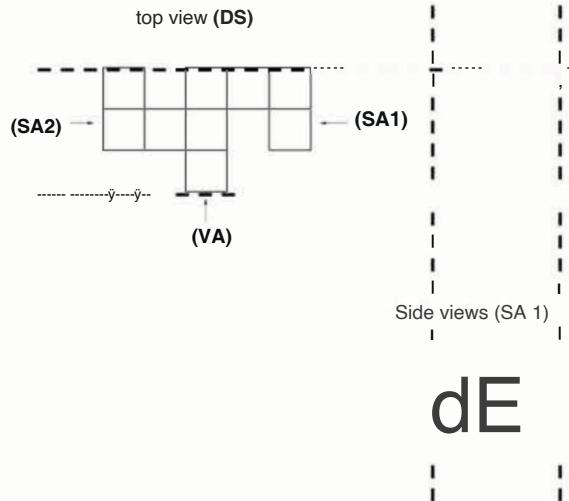
side view (SA1)



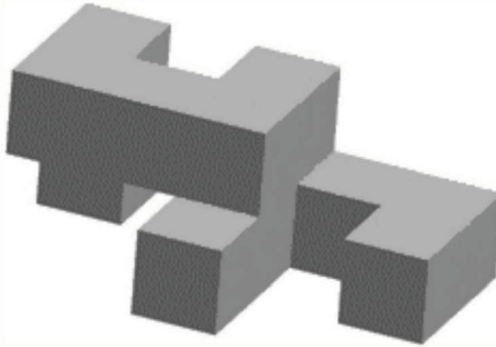
The **width of the body** can be seen from the width of the front view and top view.



The **depth of the body** can be inferred from the side and top views.



3D view of
body



RE NOTE 5: RIGHT STAYS RIGHT IN THE VA AND DS

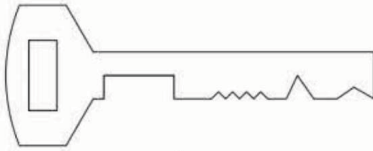
The features that are on the right side of the front view will also be on the right side of the top view.

The same applies to the left: the features that are in the left half of the front view will also be found on the left in the top view.

**EXAMPLE**

top view (DS)

side view (SA)

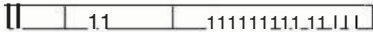


(VA)

Wanted: front view (VA) of the body

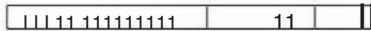
(A)

(b)



(c)

(D)



The items in the left half of the front view can be found in the left half of the top view. Thereby we can answer this question.

Answer: A

top view (DS)

side view (SA)

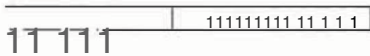


(VA)

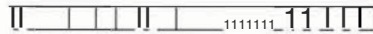


Wanted: front view (VA) of the body

(A)



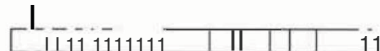
(b)



(c)



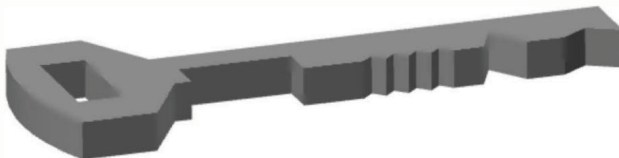
(D)

S 1: Determine the distinctive features: **distances** between the edges .

S2: Mark the prominent features in the views.

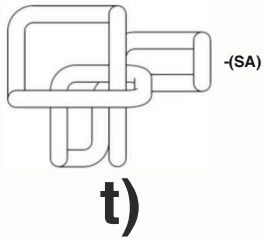
S3: Right or prong side in SA? Left.

S4: Exclude: The distances of the edges from the plan view must agree with the distances of the vertical lines from the searched front view.

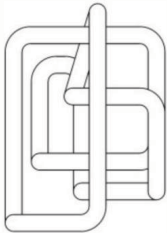
3D view of
Ki:irpers**RE NOTE 6: ABOVE REMAINS ABOVE IN VA AND SA**

The features that are in the top half of the front view will also be at the top of the side view.

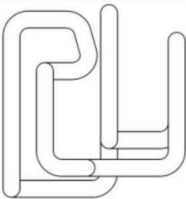
Ditto for below: the features that are in the lower half of the front view will also be found below in the side view.

**EXAMPLE****top view (DS)****side view (SA)****Wanted front view (VA) of the body**

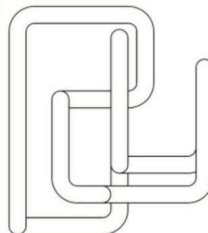
(A)



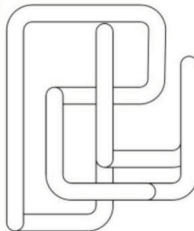
(c)

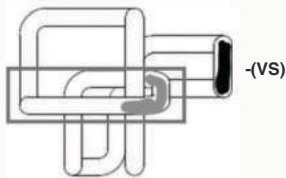


(b)

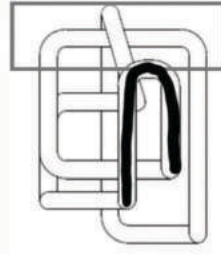


(D)

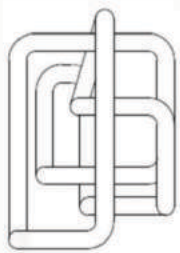
**Answer: B**

top view (DS)

YES)

side view (SA)**Wanted front view (VA) of the body**

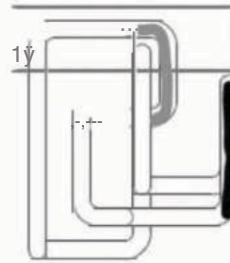
(A)



(c)



(b)



(D)



S 1: Determine the distinctive features: **the uppermost tube** and **the tube sticking out**.

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? To the right.

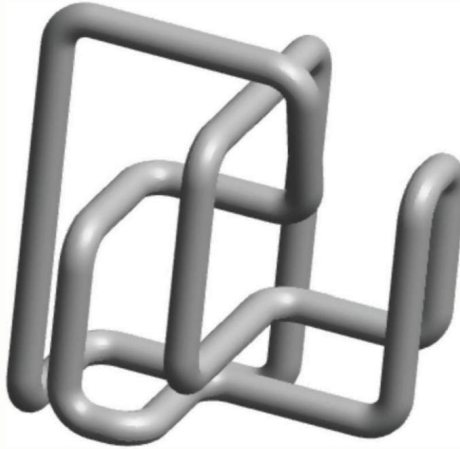
S4: Exclude:

If we look at the **boxed area**, we see that answer C is out of the question. At C, the height of the body is different and the top section is missing.

In the top and side views, we see that a **long and narrow part**, colored dark, should be to the right of the front view. This is not the case with answer A.

Then let's see what the differences are between B and D. The distance from the brighter tube to the vertical tube is a difference that we can use as a guide. With the answer D, the distance is too great. The correct answer is B.

3D view of
body



RE NOTE 7: PAPER EDGES / PENCIL EDGES WILL HELP YOU MEASURE

Spaces between lines and edges are often a good clue to the correct answer. They can help to quickly rule out one or two of the wrong answers directly, even if the rest of the body structure is difficult to assess. This could be especially helpful if you have little time left and have to guess.

It is not permitted to bring aids such as rulers or set squares into the exam. But you can use the edges of the blank note sheets you will receive from the note taking testing center to compare the heights and widths of the views. It's not about the exact measurement; ie it is unimportant how many cm a corpse is exactly high. But you want to check if the views have the same size properties. For this it is sufficient to use the edges of the notebook.

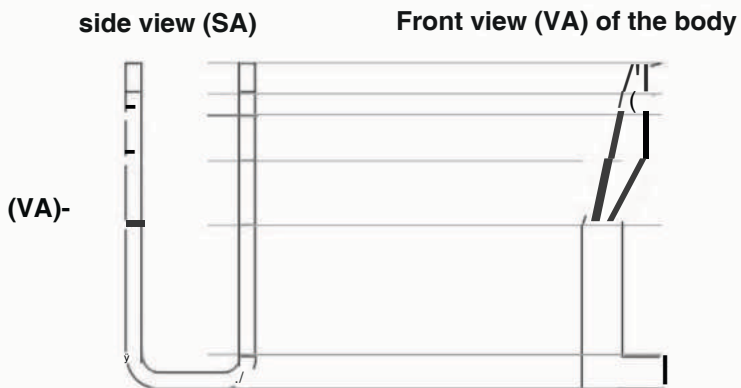
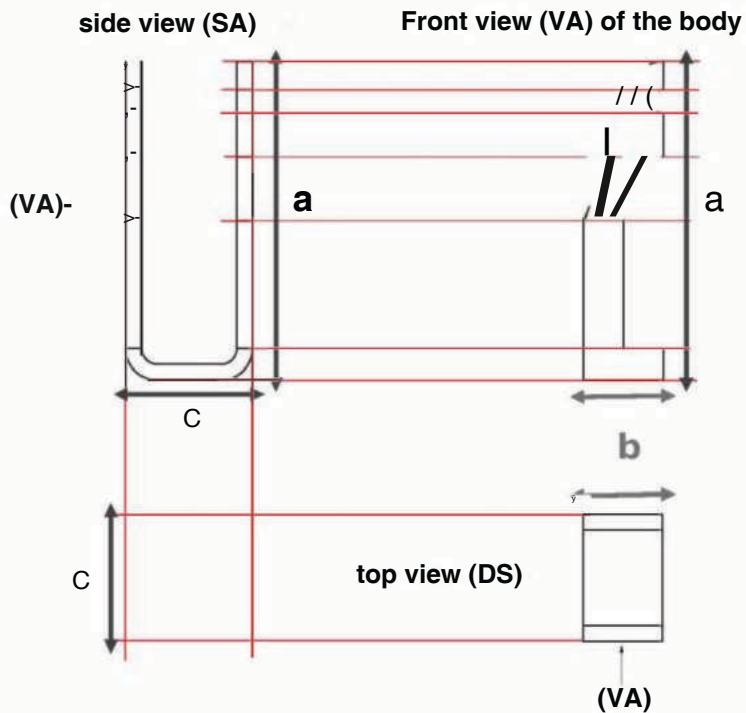
Below we show **example 1** with guidelines.

RE NOTE 7: PAPER EDGES / PENCIL EDGES WILL HELP YOU MEASURE

Spaces between lines and edges are often a good clue to the correct answer. They can help to quickly rule out one or two of the wrong answers directly, even if the rest of the body structure is difficult to assess. This could be especially helpful if you have little time left and have to guess.

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Below we show **example 1** with guidelines.



**30 view
of the body**

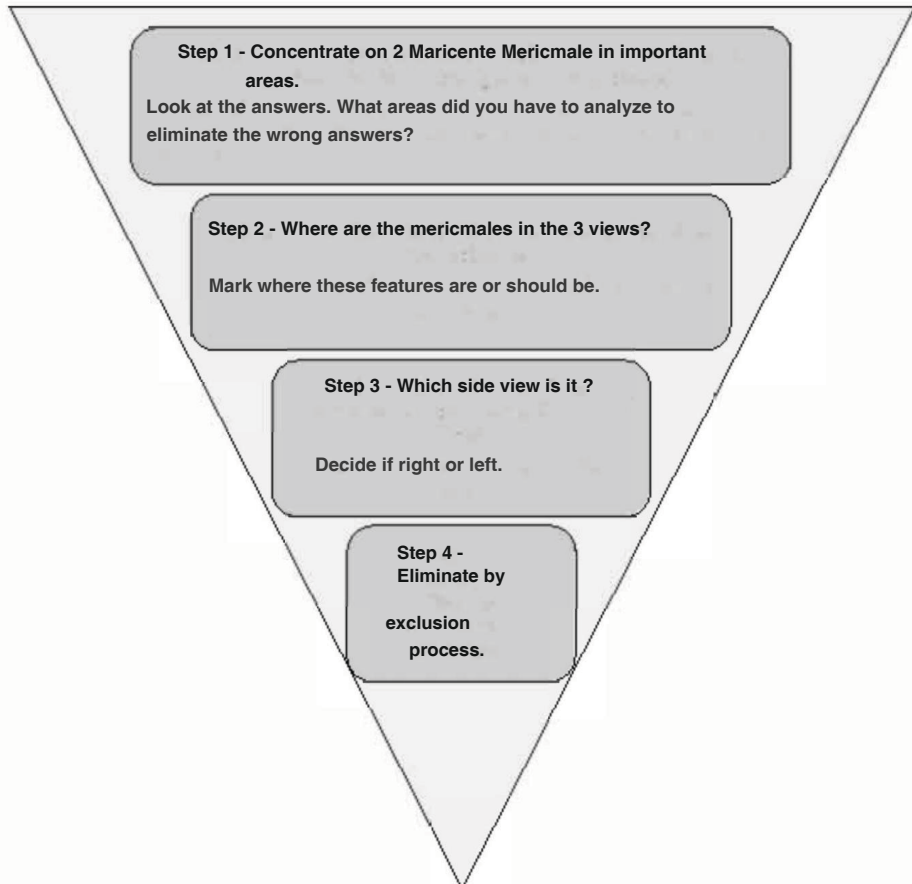


SA

OUR SUGGESTED PROCEDURE

Below we present our proposal for an approach based on the principle of exclusion. Of course, the procedure described below is to be regarded as subjective. If you can solve the task better with a different approach, then use your own approach to accomplish the task.

You should then practice these often with your preferred approach. You'll find these questions quickly go 16s short if you guess what to look out for.



STEP 1: Focus on the important areas. What are the distinctive features here?

Look at the answers and focus on the differences between the answers. What areas would you need to analyze to eliminate the wrong answers? In which parts of the picture are there the most differences?

By focusing on the answers, you can preview the important parts and save time by ignoring the unimportant parts. This occurs with the simpler tasks than with the more difficult ones.

Table 2-3 distinctive features in these areas.

Try to find one or two features that stand out. These can be lines, edges or shapes in the specified views that must or must not be found in the views searched for. For example, you could see an edge in a given view, which must be recognizable as a line in the answer you are looking for.

If you don't notice any distinctive features at first glance, compare the given views with each other and then with the possible answers. This often reveals the shape of the body and thus also features that were not initially obvious.

STEP 2: Mark the features in the 3 views.

Compare where the prominent features are, or should be, in the views. Mark on the drawings what you discovered and which answers you can rule out.

See exactly which views are given and which view is being searched for. Then focus on where the prominent features are in the 3 views. This allows you to get a rough idea of the 3D body.

Mark the distinctive features that you notice with a pencil in your exercise book. This is especially useful for the more difficult tasks. Sometimes, for more complex objects with multiple features, it can also be helpful to number the markings so that you can assign them better and visualize the position more easily.

Take simple and clear notes. If you are not sure which is the correct answer to a question, then clearly mark the answer options that you can definitely rule out. For example, you could cross out the answer options (A) and (C) with an X if you are sure that they are wrong. You could put a question mark next to an answer option that you are unsure about.

STEP 3: Which side view is it?

If the side view (SA) doesn't show up with an arrow, try to determine which side it must be in this step.

If you're not making progress, test both sides one at a time. For example, first assume that it is the view from the right and in the next step evaluate whether you can reduce the answers to one correct one. Then run the evaluation again, assuming it is the left view.

STEP 4: Eliminate by process of elimination.

Once you have identified salient features and made the comparison, it is often possible to quickly rule out 1-2 answers. After that, look at the remaining answers and focus on the areas where the answers differ until you identify the correct answer. So you're looking for more clues or additional distinctive features. If you get stuck, we would recommend you to guess.

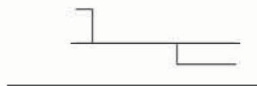
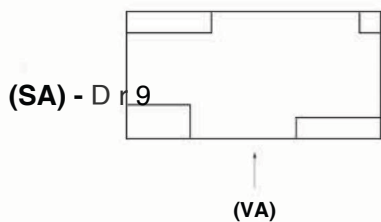
As you can see, we focus more on eliminating the wrong answers than trying to visualize the three-dimensional body and then choose the correct answer. The challenge in this type of task is the lack of time. You have about 1 minute per question. And many students need a lot more to work through the questions "bottom-up." In our experience, the quickest way to solve most problems is to rule out the wrong possible answers.



EXAMPLE

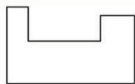
top view (DS)

Front view (VA)

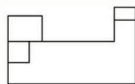


Wanted: the drawn side view (SA) of the body

(A)



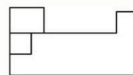
(b)



(c)

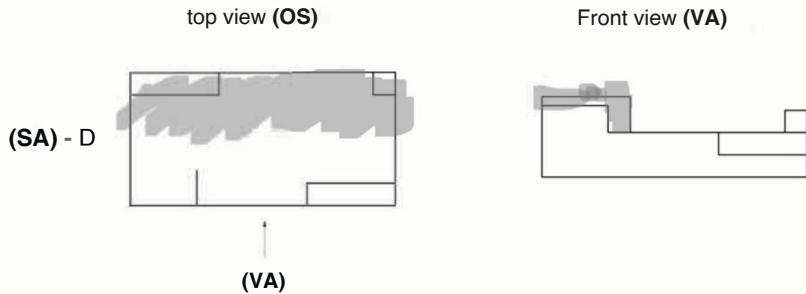


(D)

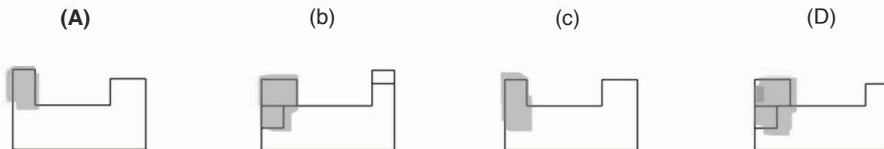


STEP 1 - focus on the important areas. What are the distinctive features here?

The left part of the SA is meaningful because this part differs between the answer options.



Wanted: the drawn side view (SA) of the body



The left pane of the left view corresponds to:

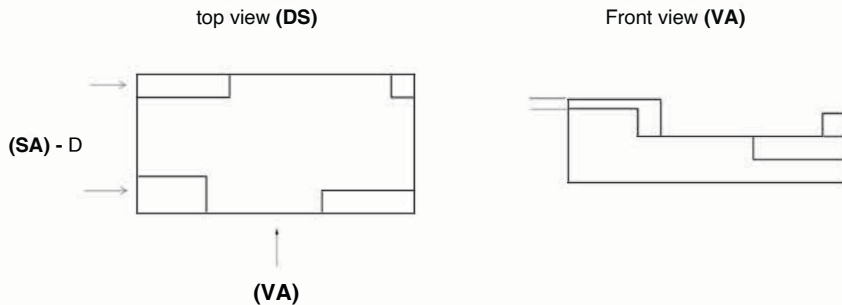
- The top half of the top view.
- The left rear area of the front view.

So let's focus on those areas first.

STEP 2 - Mark the features in the 3 views.

Comparing DS and VA, we can see that the **narrow rectangle** in the upper left corner of the DS is higher than the **wider rectangle** in the lower left corner and is the tallest part of the body. This is revealed by the horizontal lines of the VA, since these must be edges.

The narrow rectangle in the top left corner of the DS is the tallest body and is on the left side of the answer choices.

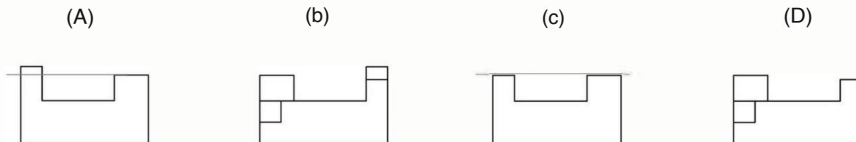
**STEP 3** - Which side view is it?

Links (specified in the question).

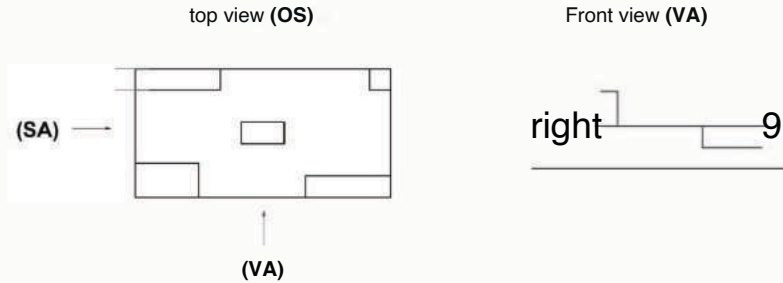
STEP 4 - Eliminate by elimination process.

For **answer B**, it can be seen that the **right part** of this answer choice is higher than **the left part**. This definitely rules out this answer. In **answer C**, the **left** and **right parts** are of the same height, so this answer can also be ruled out.

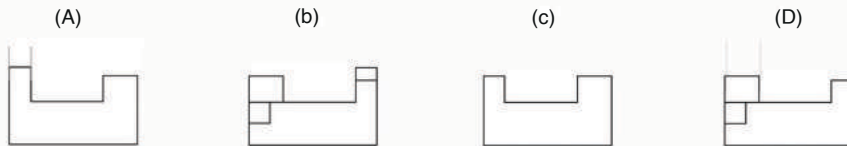
Wanted: the drawn side view **(SA)** of the body



Now we have to choose between answer A and D. Looking again at the DS and our distinctive feature (the narrow rectangle), we can see the **height of the rectangle** in the DS, which must correspond to the **width of the object** on the left in the SA we are looking for. For **answer D**, the object on the left is **too wide** and doesn't fit the **height of the rectangle**. In **answer A**, this **distance** is exactly the same. We have eliminated all wrong answers and all important features are reflected in answer A.



Wanted: the drawn side view (SA) of the body



3D view of
body



PRACTICE QUESTIONS TO2D VIEWS

3

You have a total of **30 minutes** in the TestAS exam for the **26 questions** in the section "Smash views". The following 4 tests consist of task type 1 with the 2D views, ie you only solve half of the questions. It's best to try You can solve these exams (13 questions each) in 15 minutes.

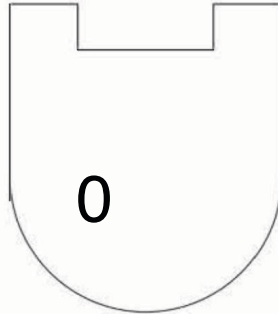
During the official exam, you can switch between the 2 task types and split the 30 minutes as you wish.

TASK BLOCK

EXAMINATION 1

1.1.

Front view (VA)



side view (SA)



Wanted: top view of the body (DS)

(A)



(b)



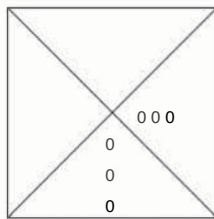
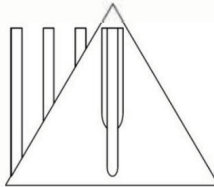
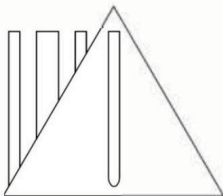
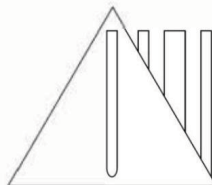
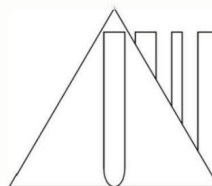
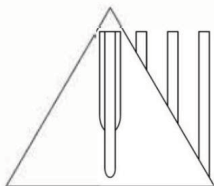
(c)



(D)



1.2.

top view (DS)**(VA)****side view (SA)****Wanted front view (VA) of the body****(A)****(c)****(b)****(D)**

1.3.

top view (DS)



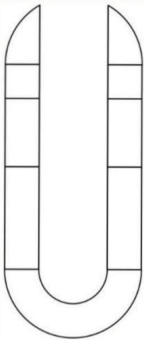
↑
(VA)

side view (SA)

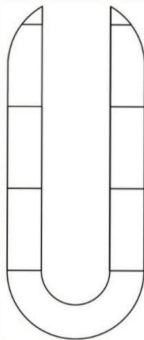


Wanted: front view (VA) of the body

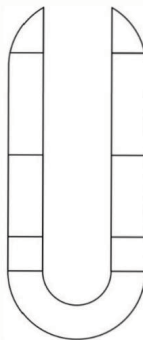
(A)



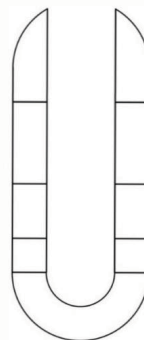
(b)



(c)

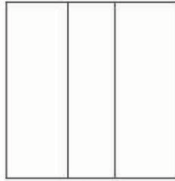


(D)



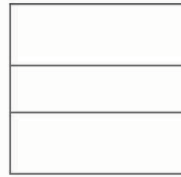
1.4.

top view (DS)



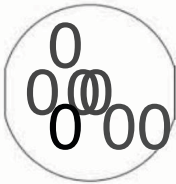
↑
(VA)

side view (SA)

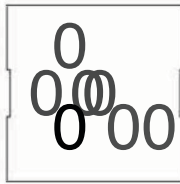


Wanted front view (VA) of the body

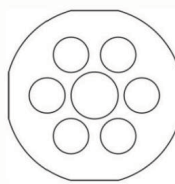
(A)



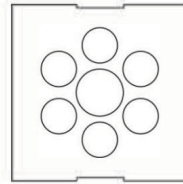
(b)



(c)



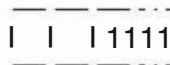
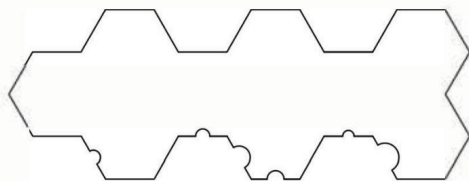
(D)



1.5.

top view (DS)

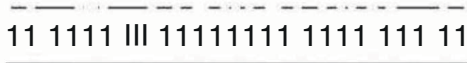
side view (SA)



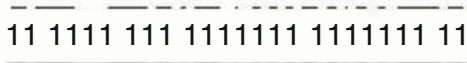
↑
(VA)

Wanted: front view (VA) of the body

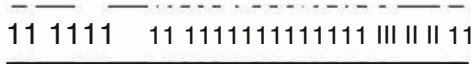
(A)



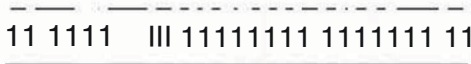
(b)



(C)

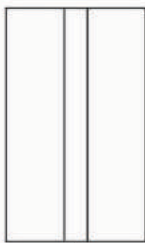


(D)



1.6.

top view (DS)



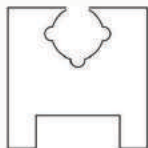
(VA)

side view (SA)

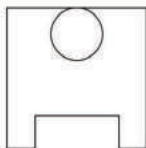


Wanted: front view (VA) of the body

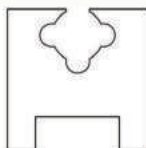
(A)



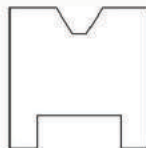
(b)



(c)



(D)



1.7.

top view (DS)**(VA)****side view (SA)****Wanted: front view (VA) of the body****(A)****(b)****(c)****(D)**

1.8.

top view (DS)



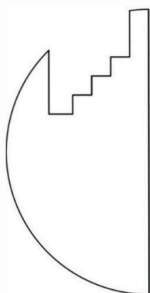
(VA)

side view (SA)

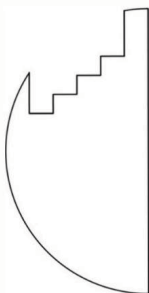


Wanted: front view (VA) of the body

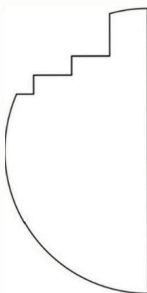
(A)



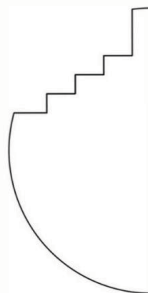
(b)



(c)

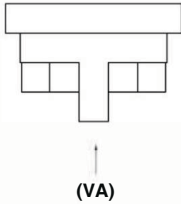


(D)

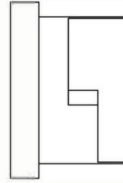


1.9.

top view (DS)



side view (SA)



Wanted front view (VA) of the body

(A)

(b)

(c)

(D)

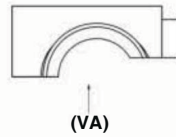


1.10.

side view (SA)

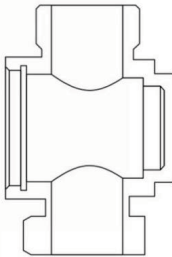


top view (DS)

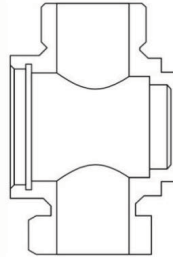


Wanted front view (VA) of the body

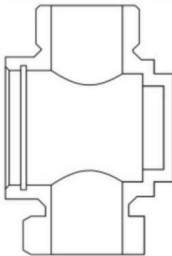
(A)



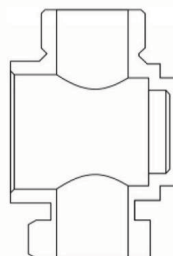
(b)



(c)



(D)

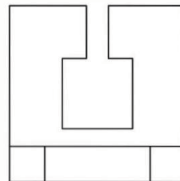
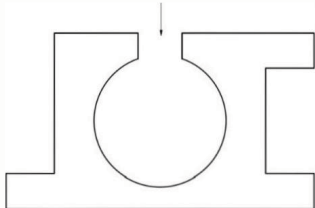


1.11.

Front view (VA)

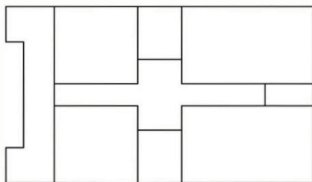
side view (SA)

(DS)

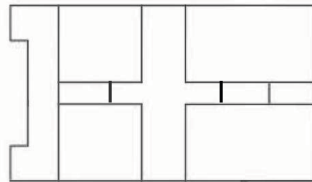


Wanted: top view (DS) of the body

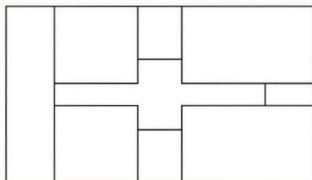
(A)



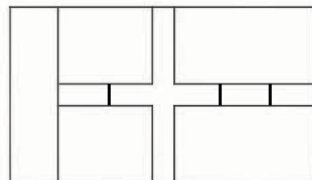
(b)



(c)

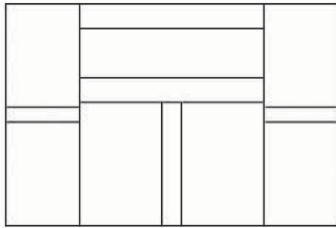


(D)

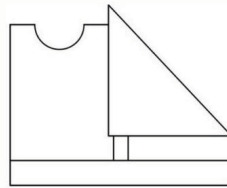


1.12.

top view (DS)



side view (SA)

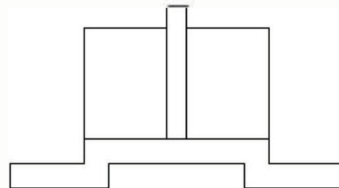


(VA)

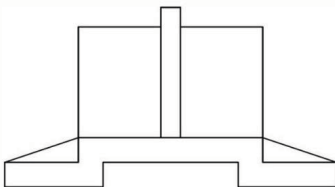
Wanted: front view (VA) of the body

(A)

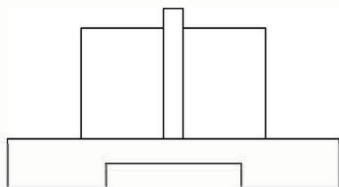
Jyl III (B)



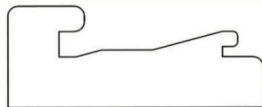
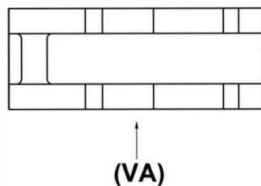
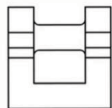
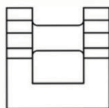
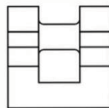
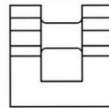
(C)



(D)



1.13.

Front view (VA)**top view (DS)****Wanted a side view (SA) of the body****(A)****(b)****(c)****(D)**

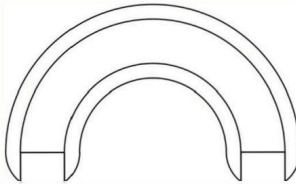
EXAMINATION2

2.1.

top view (DS)



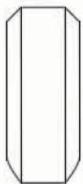
side view (SA)



(VA)

Wanted: front view (VA) of the body

(A)



(b)



(c)



(D)



2.2.

side view (SA)

Front view (VA)

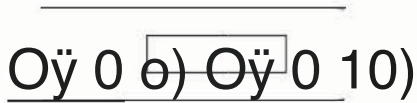


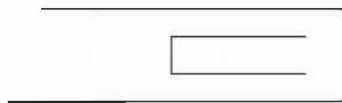


Wanted: top view (DS) of the body

(A)

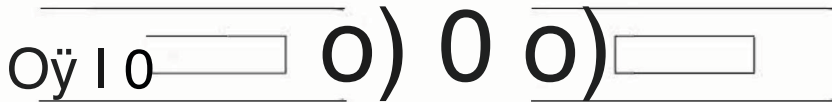
(b)





(c)

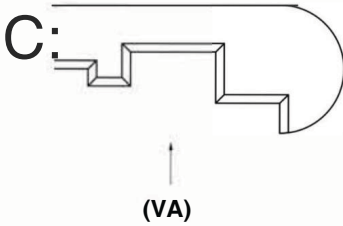
(D)



2.3.

top view (DS)

side view (SA)



Int1

Wanted: front view (VA) of the body

(A)



(b)



(c)



(D)



2.4.

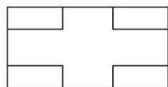
Front view (VA)

side view (SA)

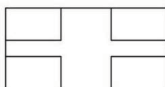
D

Wanted: top view (DS) of the body

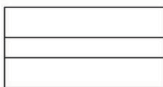
(A)



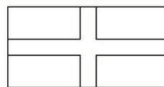
(b)



(c)

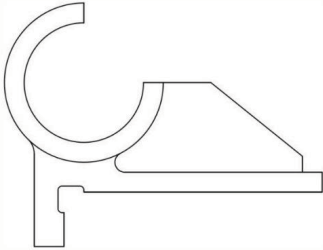


(D)

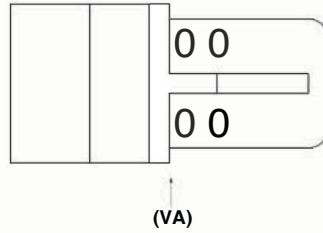


2.5.

Front view (VA)

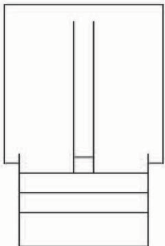


top view (DS)

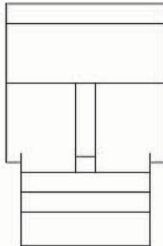


Wanted: a side view (SA) of the body

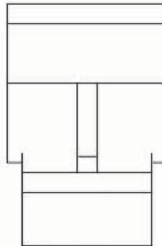
(A)



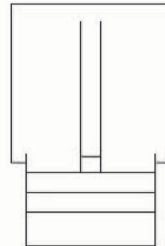
(b)



(c)



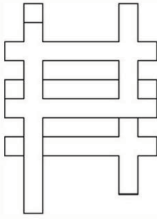
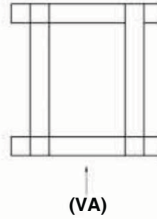
(D)



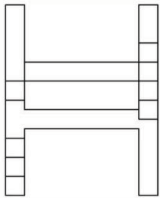
2.6.

Front view (VA)

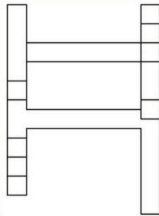
(SA)-

**top view (DS)****Wanted: the drawn side view (SA) of the body**

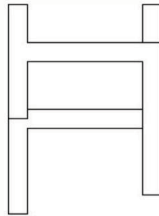
(A)



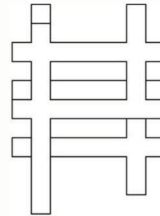
(b)



(c)



(D)



2.7.

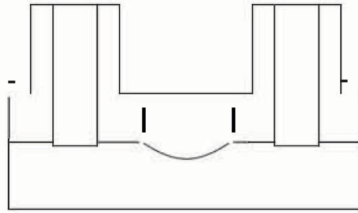
top view (DS)

Front view (VA)

y

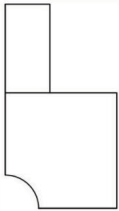
|
(VA)

-(SA)

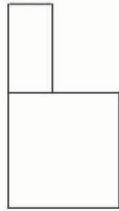


Wanted: the drawn side view (SA) of the body

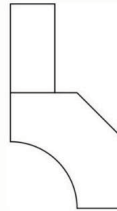
(A)



(b)



(c)



(D)



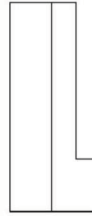
2.8.

top view (DS)

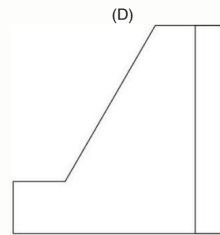
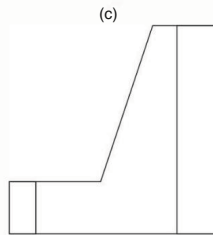
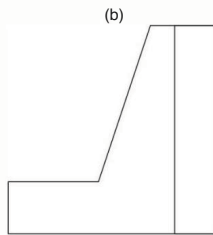
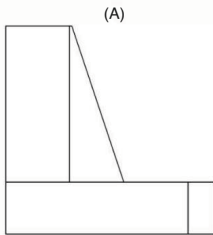


(VA)

side view (SA)

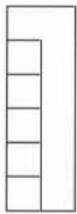


Wanted: front view (VA) of the body



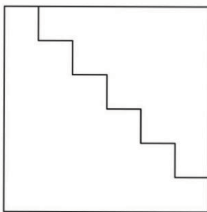
2.9.

top view (DS)



(VA)

side view (SA)



Wanted: front view (VA) of the body

(A)



(b)



(c)

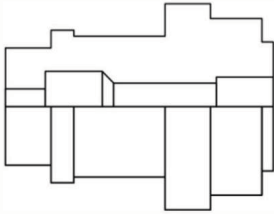


(D)



2.10.

Front view (VA)



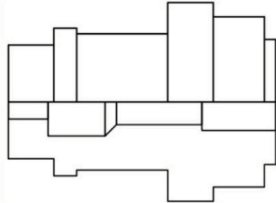
side view (SA)



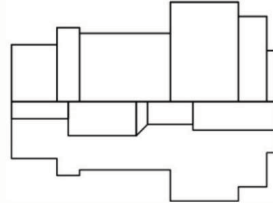
-(SA)

Wanted top view (DS) of the body

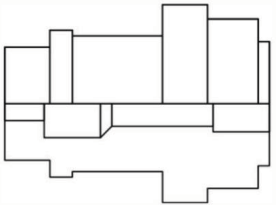
(A)



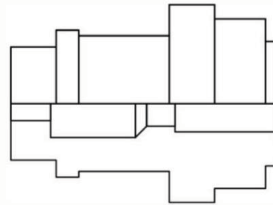
(b)



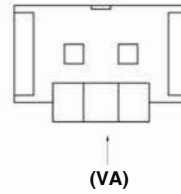
(c)



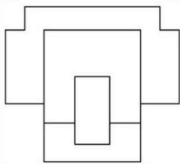
(D)



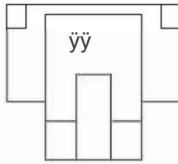
2.11.

side view (SA)**top view (DS)****Wanted front view (VA) of the body**

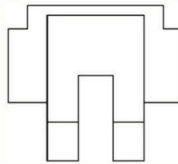
(A)



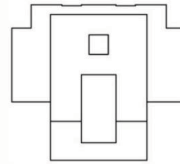
(8th)



(c)

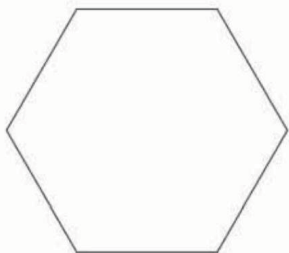


(0)



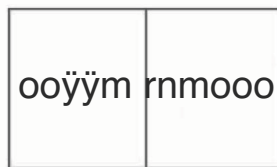
2.12.

top view (DS)



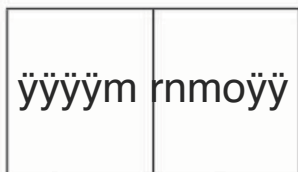
(VA)

side view (SA)

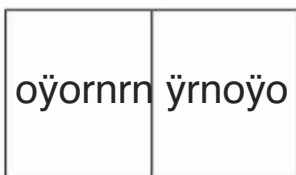


Wanted front view (VA) of the body

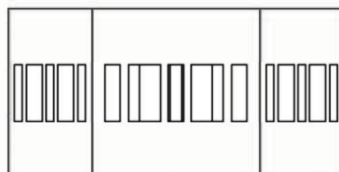
(A)



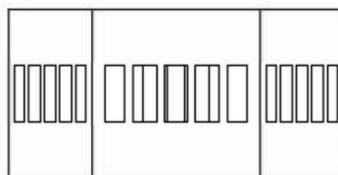
(c)



(b)



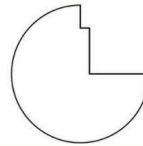
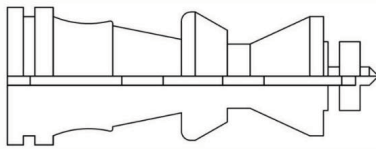
(D)



2.13.

top view (DS)

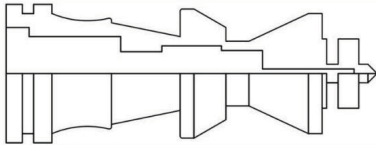
side view (SA)



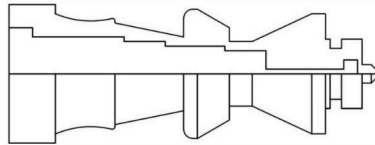
↑
(VA)

Wanted: front view (VA) of the body

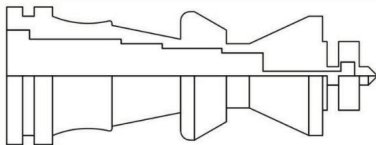
(A)



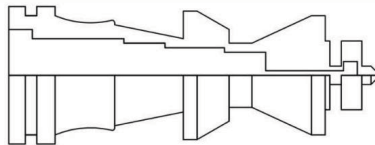
(b)



(c)



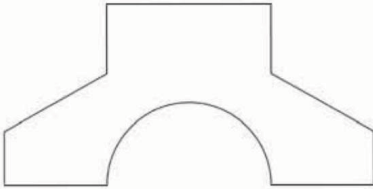
(D)



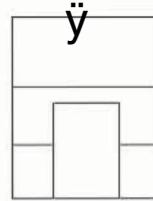
TEST3

3.1.

Front view (VA)



side view (SA)



Wanted: top view (DS) of the body

(A)



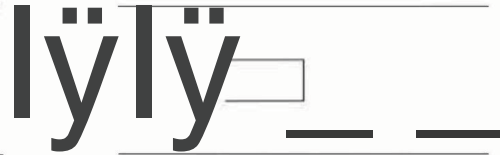
(b)



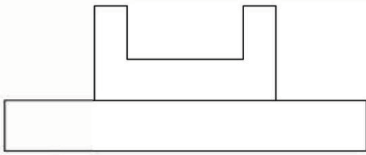
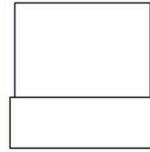
(c)



(D)



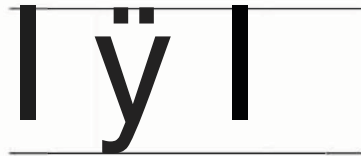
3.2.

Front view (VA)**side view (SA)****Wanted: top view (DS) of the body**

(A)



(b)



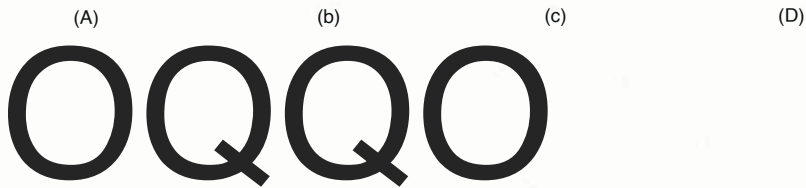
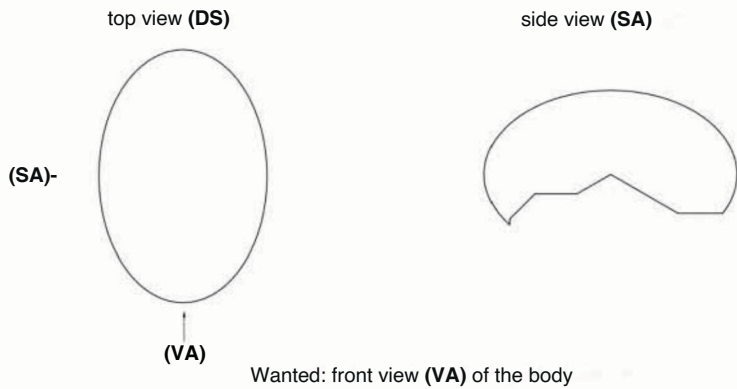
(c)



(D)

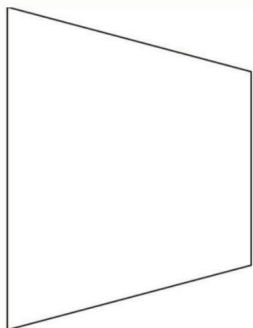


3.3.



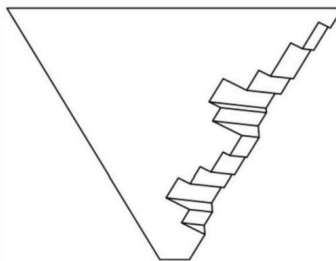
3.4.

top view (DS)



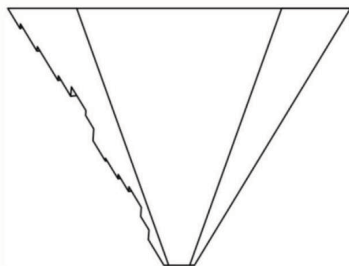
(VA)

side view (SA)



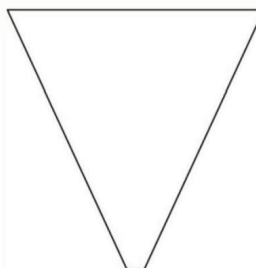
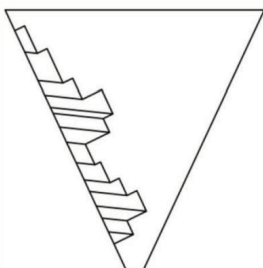
(A)

(b)

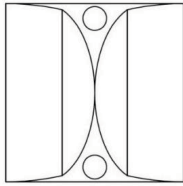


(c)

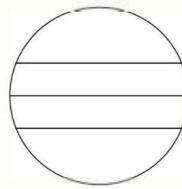
(D)



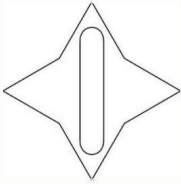
3.5.

top view (DS)

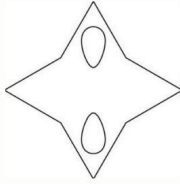
↑
(VA)

side view (SA)**Wanted: front view (VA) of the body**

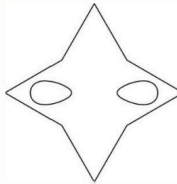
(A)



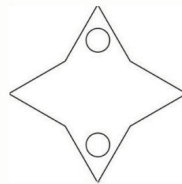
(b)



(c)



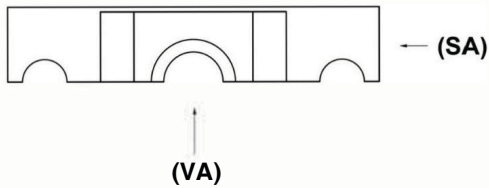
(D)



3.6.

top view (DS)

side view (SA)



Wanted: front view (VA) of the body

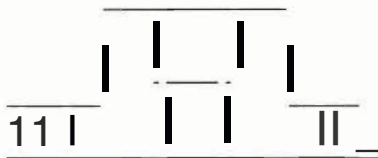
(A)



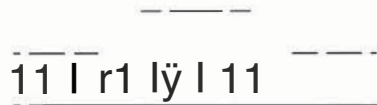
(b)



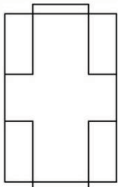
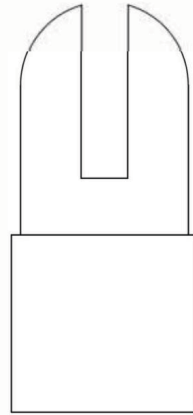
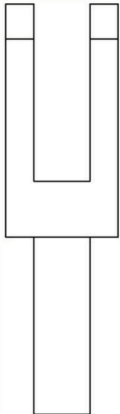
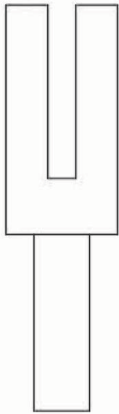
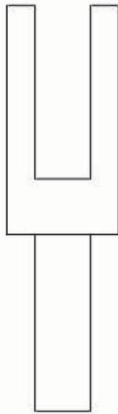
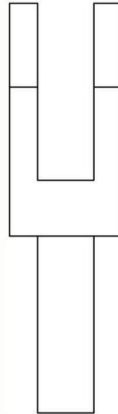
(c)



(D)

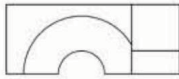


3.7.

top view (DS)**(VA)****side view (SA)****Wanted: front view (VA) of the body****(A)****(b)****(c)****(D)**

3.8.

top view (DS)



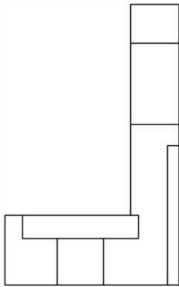
(VA)

side view (SA)

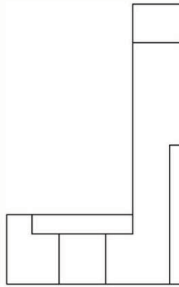


Wanted: front view (VA) of the body

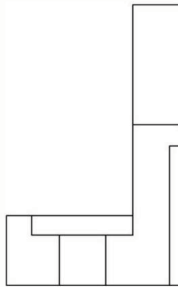
(A)



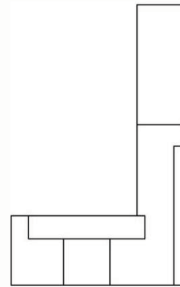
(b)



(c)

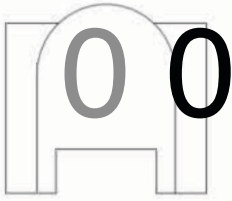


(D)

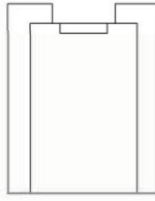


3.9.

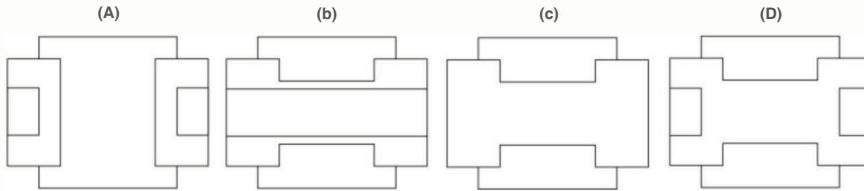
Front view (VA)



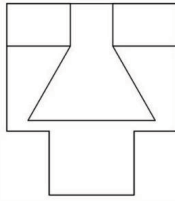
side view (SA)



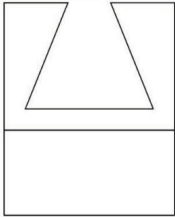
Wanted top view (DS) of the body



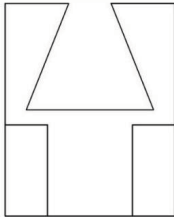
3.10.

top view (DS)**(VA)****side view (SA)****Wanted: front view (VA) of the body**

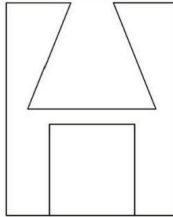
(A)



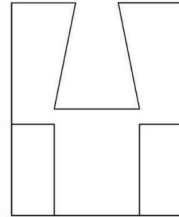
(b)



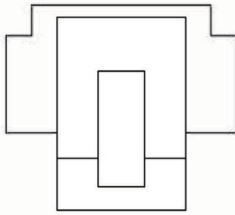
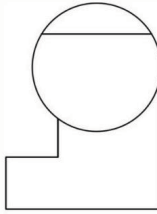
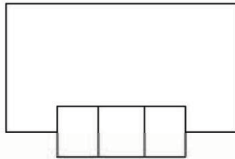
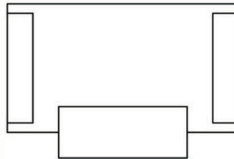
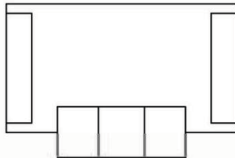
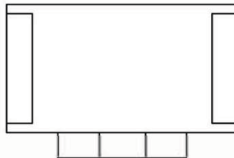
(c)



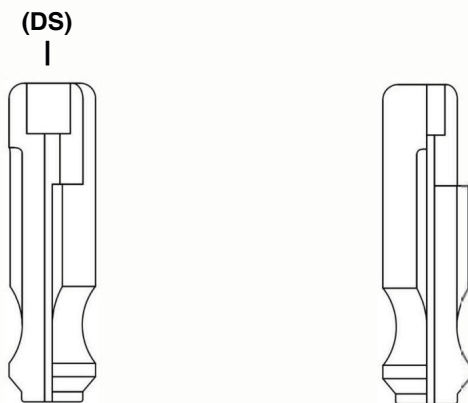
(D)



3.11.

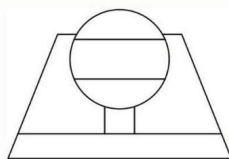
Front view (VA)**side view (SA)****Wanted: top view (OS) of the body****(A)****(b)****(c)****(D)**

3.12.

Front view (VA)**side view (SA)****Wanted: top view (DS) of the body****(A)****(b)****(c)****(D)**

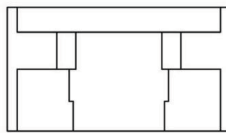
3.13.

Front view (VA)



y (SA)

top view (DS)



(VA)

Wanted: the drawn side view (SA) of the body

(A)

QI

(b)

ID

(c)

ID

(D)

ID

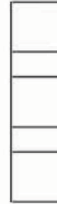
EXAMINATION4

4.1.

top view (DS)

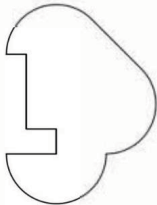

(VA)

side view (SA)

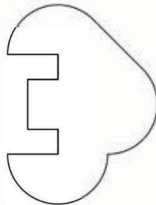


Wanted: front view (VA) of the body

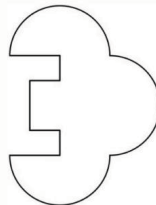
(A)



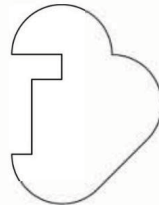
(b)



(c)



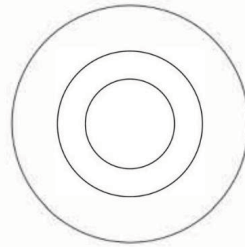
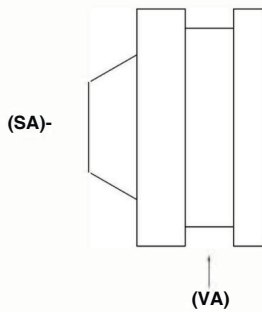
(D)



4.2.

top view (DS)

side view (SA)



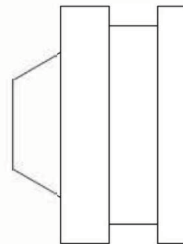
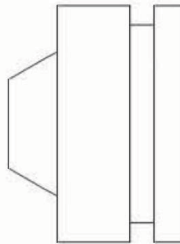
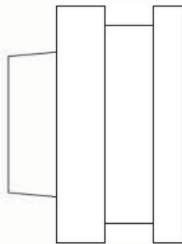
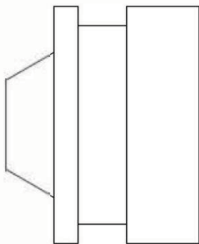
Wanted: front view (VA) of the body

(A)

(b)

(c)

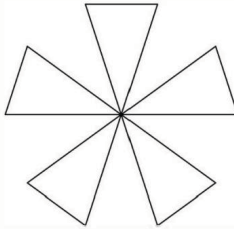
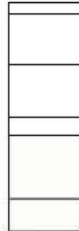
(D)



4.3.

top view (DS)

↑
(VA)

side view (SA)**Wanted: front view (VA) of the body****(A)****(b)****(c)****(D)**

4.4.

top view (DS)

111 °0 111

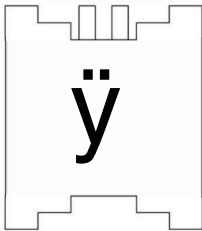
(VA)

side view (SA)

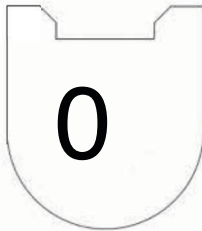


Wanted: front view (VA) of the body

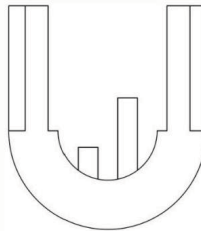
(A)



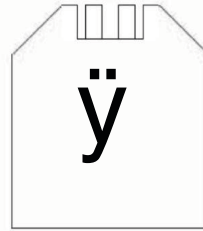
(b)



(c)



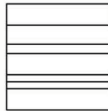
(D)



4.5.

top view (DS)

side view (SA)

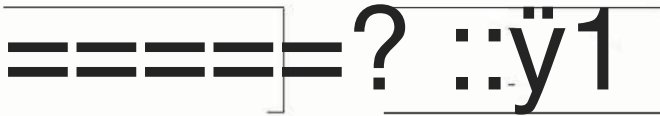


↑
(VA)

Wanted: front view (VA) of the body

(A)

(b)



(c)

(D)



4.6.

Front view (VA)

top view (DS)

Wanted: a side view (SA) of the body

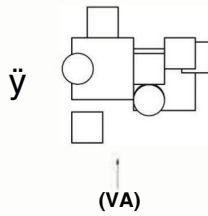
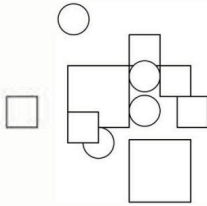
(A)

(b)

(c)

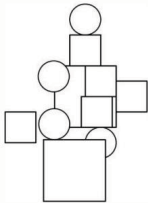
(D)

top view (OS)

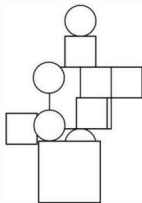


Wanted: a side view (SA) of the body

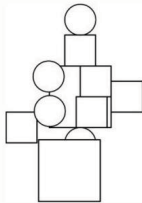
(A)



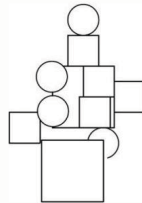
(b)



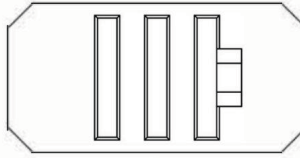
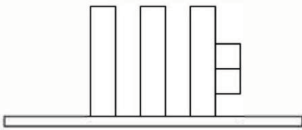
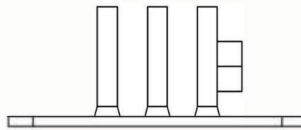
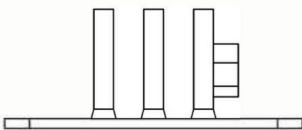
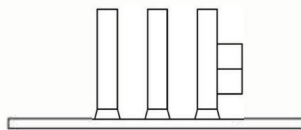
(c)



(D)

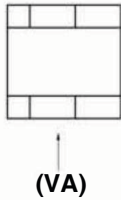


4.8.

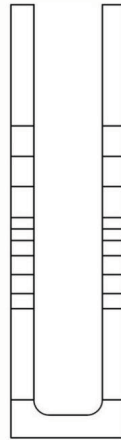
side view (SA)**top view (DS)****(DS)****(VA)-ifil****(VA)****Wanted: front view (VA) of the body****(A)****(b)****(c)****(D)**

4.9.

top view (DS)



side view (SA)

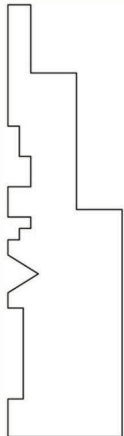


Wanted: front view (VA) of the body

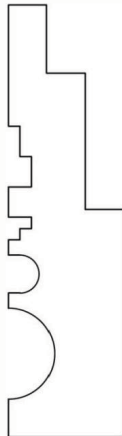
(A)



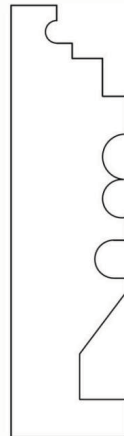
(b)



(c)

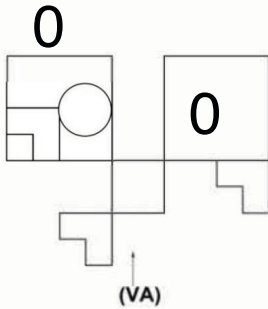


(D)

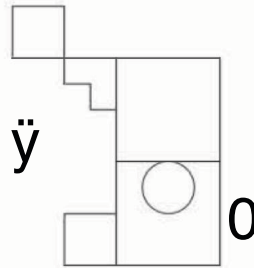


4.10.

top view (DS)

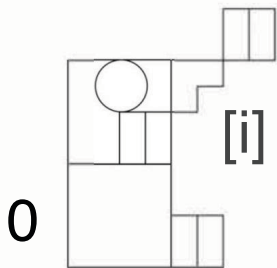


side view (SA)

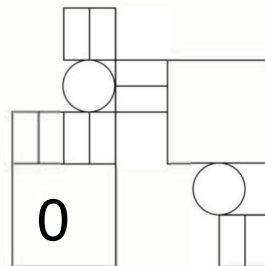


Wanted front view (VA) of the body

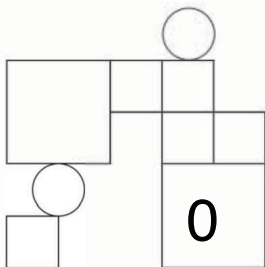
(A)



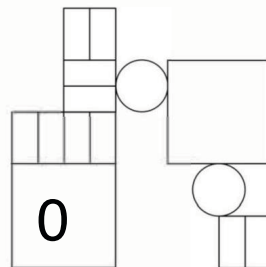
(b)



(c)



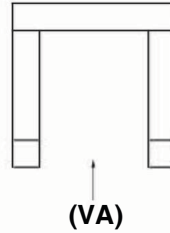
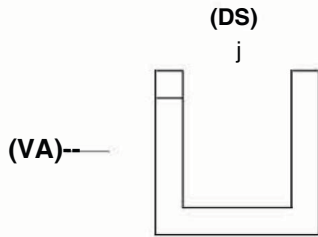
(D)



4.11.

side view (SA)

top view (DS)



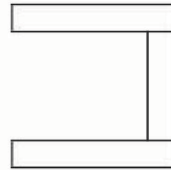
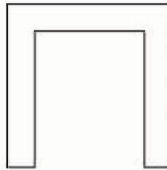
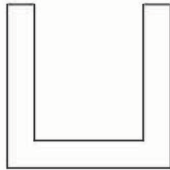
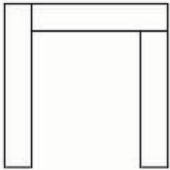
Wanted: front view (VA) of the body

(A)

(b)

(c)

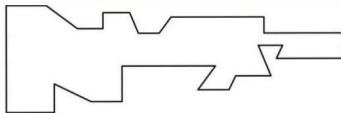
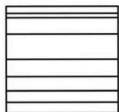
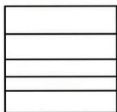
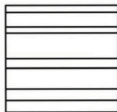
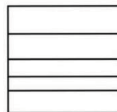
(D)



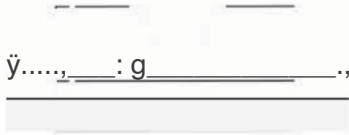
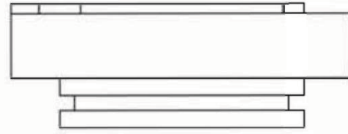
4.12.

top view (DS)

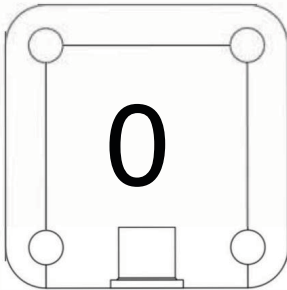
↑
(VA)

side view (SA)**Wanted: front view (VA) of the body****(A)****(b)****(C)****(D)**

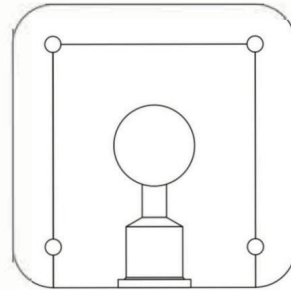
4.13.

Front view (VA)**side view (SA)****Wanted top view (DS) of the body**

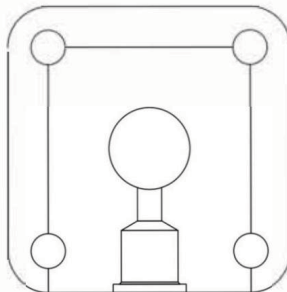
(A)



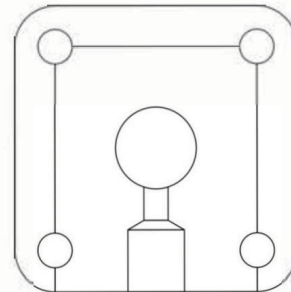
(b)



(c)



(D)



SOLUTION KEY

Prüfung 1			Prüfung 2	
Aufgabe	Antwort		Aufgabe	Antwort
1.1.	A		2.1.	A
1.2.	B		2.2.	A
1.3.	A		2.3.	B
1.4.	C		2.4.	A
1.5.	D		2.5.	B
1.6.	C		2.6.	B
1.7.	A		2.7.	D
1.8.	D		2.8.	B
1.9.	D		2.9.	C
1.10.	B		2.10.	C
1.11.	B		2.11.	D
1.12.	C		2.12.	D
1.13.	A		2.13.	C



Prüfung 3			Prüfung 4	
Aufgabe	Antwort		Task	Answer
3.1.	B		4.1.	C
3.2.	A		4.2.	D
3.3.	D		4.3.	A
3.4.	C		4.4.	B
3.5.	B		4.5.	D
3.6.	B		4.6.	D
3.7.	C		4.7.	C
3.8.	D		4.8.	B
3.9.	D		4.9.	B
3.10.	B		4.10.	B
3.11.	C		4.11.	A
3.12.	A		4.12.	A
3.13.	C		4.13.	C

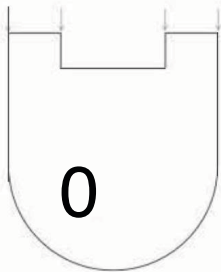


DETAILED SOLUTIONS

EXAMINATION 1

1.1.

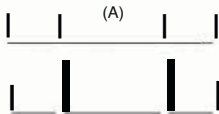
Front view (VA)



side view (SA)



Wanted: Plan view of the body (OS)



(b)



(c)



(D)



Answer: A

S1: Determine the distinctive features: middle lines on the DS, uppermost area of VA.

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

*S4: Exclude: We're looking for the top view, so let's look at the top part of the front view first and see if there are any distinctive features. We see **four edges** that should appear as **vertical lines** in the top view. Samit drops answer **D**.*

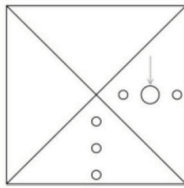
*We must now choose between **A**, **B** and **C** decide. This is not difficult if we look at the **distances** between the **four edges** from the front view. Comparing answer **C** with the top view, we can see that the **distances** between the lines **are much too short** and do not match the **distances** in the front view. They are too indifferent to answer **B**, so it can also be ruled out.*

*We have excluded all answers to **A**. Here you can see **four vertical lines**, which also exactly match the **distances** of the **four edges** from the front view.*

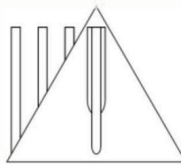
3D view of
body



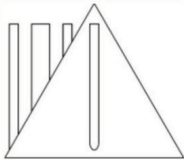
1.2.

top view (DS)

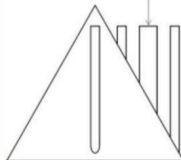
(VA)

side view (SA)**Wanted front view (VA) of the body**

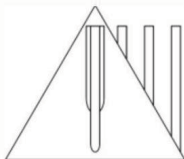
(A)



(b)



(C)



(D)



Answer: B

*S1: Determine the prominent features: **large circle** (DS).*

S2: Mark the prominent features in the views.

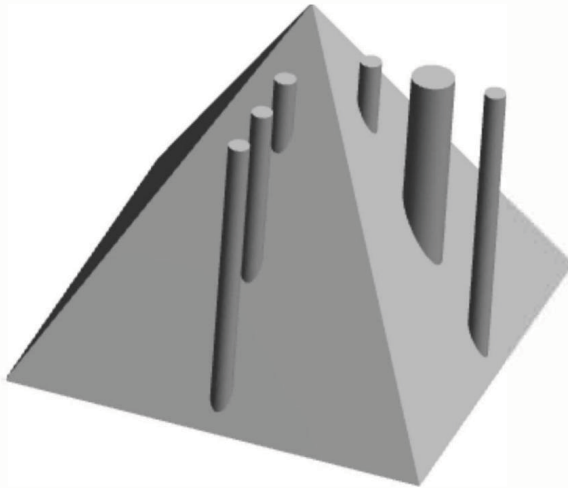
S3: Right or prong side in SA? Right.

*S4: Exclude: Immediately it should catch the eye that there are **six** circles in plan view, one of which is **larger** than the others. This feature alone can lead us to the solution. On the possible answers and also in the side view, we can see that the points from the top view are actually columns.*

*The SA is the view from the right; so there must definitely be some of the dots on the **right side of the triangle** in the front view. This jills answer A away because there are top view dots on the **left** .*

*We know that one column to the right of the triangle must be **larger** than the other two, namely the **middle one** . Since this is only the case for answer **B** , we exclude the rest of the answers. For answer **B**, the **middle column** to the right of the triangle is larger and the column in the middle of the triangle shows no change*

3D view of
body



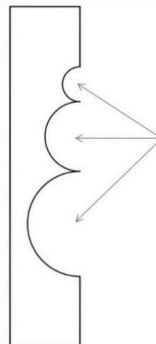
1.3.

top view (OS)



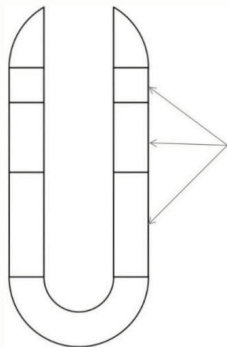
(VA)

side view (SA)

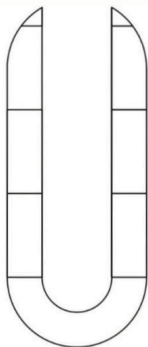


Wanted: front view (VA) of the body

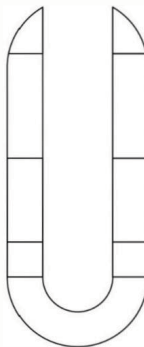
(A)



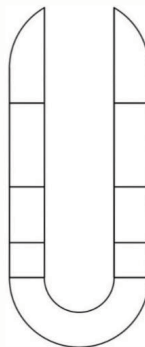
(b)



(c)



(D)



Answer: A

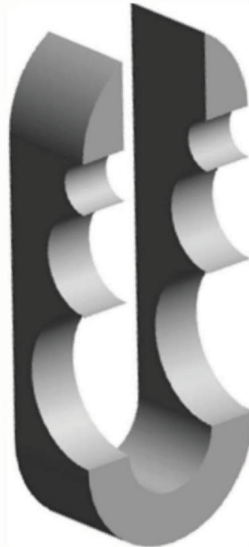
S 1: Determine the distinctive features: **Size of the semicircles** in the SA (the plan view does not help us with this task).

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

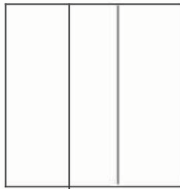
S4: Excluding: With the SA, it is striking that all three **semicircles** have different **sizes**. If we now try to imagine the front view, we can conclude that here, too, sections must become smaller towards the top. If you look at the possible answers with this in mind, you can see relatively quickly that this is only the case for answer A.

3D view of
body



1.4.

top view (DS)



1 1 1

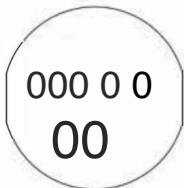
(VA)

side view (SA)

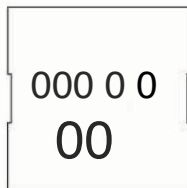


Wanted: front view (VA) of the body

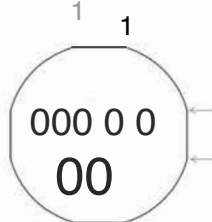
(A)



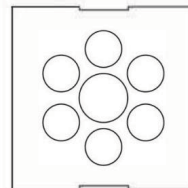
(b)



(c)



(D)



Answer: C

*S 1: Determine the distinctive features: **Two parallel lines** in the middle.*

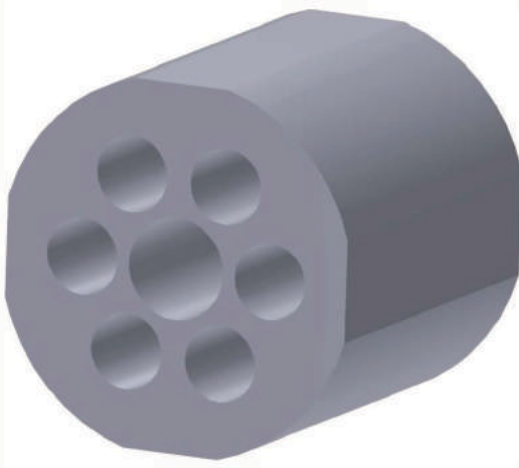
S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

*S4: Exclude: Due to our distinctive feature, we are aware that **two parallel edges** must be visible in the middle of the answer options at the top edge and on one side edge. Once we understand that, excluding the wrong answers is easy for us too.*

*Answer A only has two parallel edges left and right in the middle. Answer B too. Answer **C** has **parallel edges** in the middle on all sides, and answer **D** only at the top and bottom. All images except An answer C are missing edges either on the top and bottom **or** on the left and right sides.*

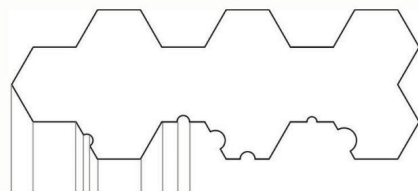
3D view of
body



1.5.

top view (DS)

side view (SA)



(VA)

III 1111

Wanted: front view (VA) of the body

(A)

11 1111 II 1111 1111111111 11

(b)

11 1111 111 11111111111111 11

(c)

11 1111 11111111111111 III II 11

(D)

II III 1111111111 11 111111 II

Answer: D

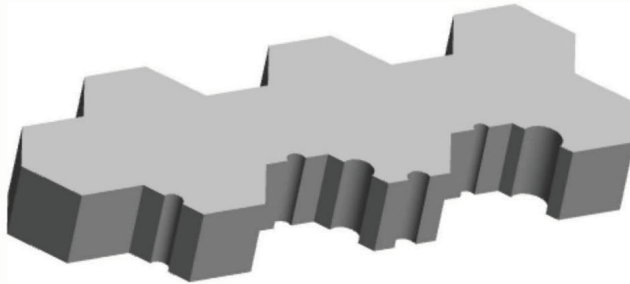
*S1: Determine the prominent features: central area in the VA, **distances between the edges**.*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

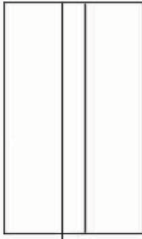
*S4: Exclude: The **distances of the edges** from the top view must correspond to the **distances between the vertical lines** of the correct answer.*

3D view of
body



1.6.

top view (DS)

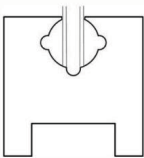
rn
(VA)

side view (SA)

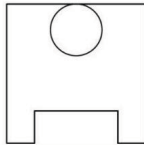


Wanted: front view (VA) of the body

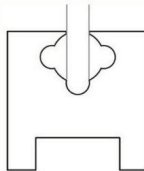
(A)



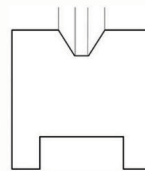
(b)



(c)



(D)



Answer: C

S1: Determine the distinctive features: Two **parallel vertical lines** in the middle (DS).

S2: Mark the prominent features in the views.

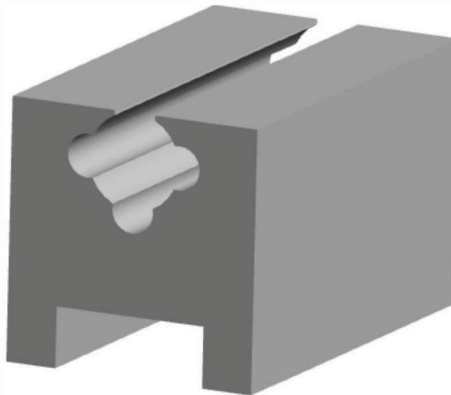
S3: Right or prong side in SA? Can be both.

S4: Exclusion: Answer **A** can be excluded because the **opening** at the top is **larger** than the small semicircular opening below. In this case, **four** parallel lines would appear in the plan view.

Answer **B** can be ruled out because there is **no opening** at the top of the image. If answer B is correct, look the top view the same as the side view.

Answer **D** can be ruled out, since due to the funnel shape, **four** parallel lines should also be visible in the top view.

All that remains for us is An two rt **C** ilbrig. In this picture you can see that the upper opening is the same size as the semicircular opening below, which means that in the plan view you would only see **two parallel lines**, which is the case.



3D view of
body

1.7.

top view (DS)**side view (SA)****Wanted: front view (VA) of the body****(A)****(b)****(c)****(D)**

Answer:A

S 1: Determine the distinctive features: **Two extremely narrow bars** (DS) .

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? (Right.) All possible answers could match the page view because we don't know which side the page view shows. So on to the comparison between the DS and the VA you're looking for.

S4: Exclude: We now have to look for the source of the **two extremely narrow bars** in order to arrive at the correct answer. Answer **C** cannot be correct because there is absolutely no evidence for the **two extremely narrow bars** .

Answer B cannot be correct either, because only two lines (right and left) should be visible when viewing this answer option from above. The top view would be a rectangle with no other features.

The same applies to answer **D**. There is absolutely no evidence of the **two extremely narrow bars** . Again, the top view would be a rectangle with no other features.

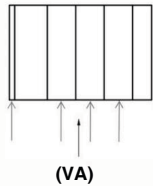
Only answer **A** remains . The **two extremely narrow bars** result from the fact that the upper point of the crescent is truncated and thus shorter than the lower point. Samit makes the bottom tip of the crescent the first line (from left to right) in the plan view, the bottom tip of the cropped portion makes the second line, and the top tip of the cropped area makes the third line.

3D view of
body



1.8.

top view (DS)

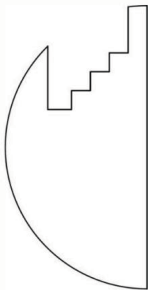


side view (SA)

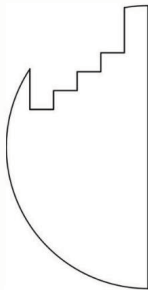


Wanted: front view (VA) of the body

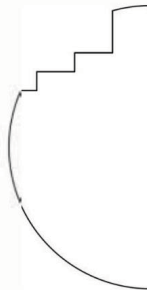
(A)



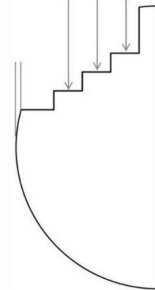
(b)



(c)



(D)

**Answer:D**

S1: Determine the distinctive features: 6 bars, of which **a narrow bar** on the far left, a wide bar, **three bars of equal size**, and a medium-sized bar on the far right (DS).

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Based on the four possible answers, we recognize that the view from the right must be involved.

S4: Exclude: When comparing, it is noticed that **A** and **B** are very similar and so is **C** and **D**. First of all, we can rule out an answer immediately with our **6-bar** feature, namely An answer **C**. Here it can be clearly seen that there are not enough edges and not **three** equal steps in the middle.

Remember : All lines in the given views represent edges in the answer options. In these images, the bulge on the far left must also represent an edge, i.e. a line in the top view.

We can rule out two more answers with our other feature **of narrow bars** on the far left. Namely, we see that the space between the top left peak and the bulge on the far left in images A and B is much too large and could never show such a **narrow bar** in plan view.

We've eliminated all other answers, leaving only answer D. There are 6 bars in total.

*The **three equally sized bars** from the top view fit into the picture, and only here is there a **tiny little space between the leftmost peak and the bulge**, since we've already ruled out answer C.*

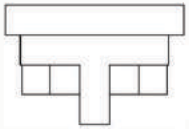
So only answer D can be correct.

3D view of
body



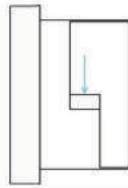
1.9.

top view (DS)



(VA)

side view (SA)



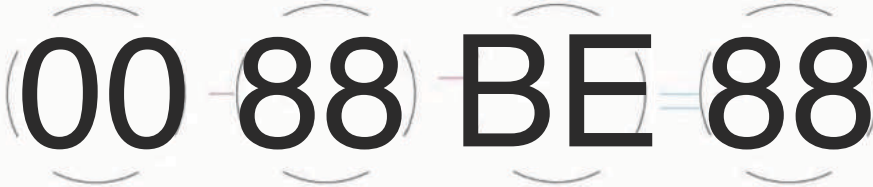
Wanted: front view (VA) of the body

(A)

(b)

(c)

(D)



Answer: D

S 1: Determine the distinctive features: **Small rectangle (SA)**.

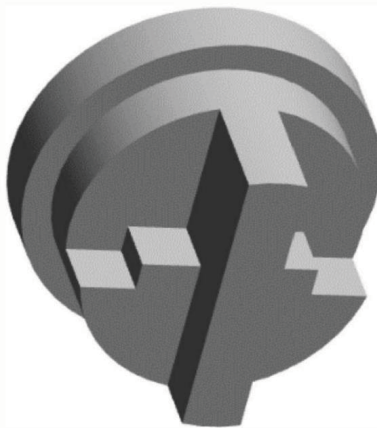
S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

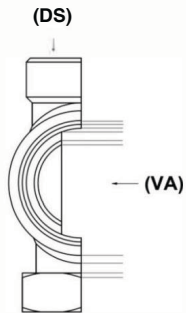
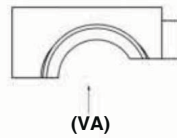
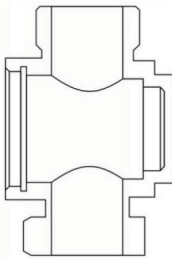
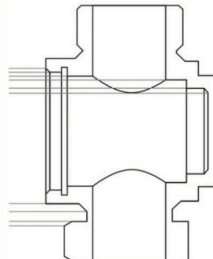
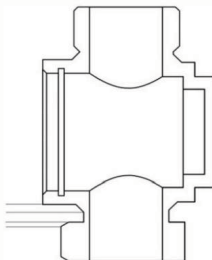
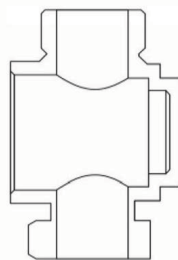
S4: Exclude: The **small rectangle** is the result of two superimposed edges, which must be visible in the SA in order for this rectangle to arise. In the case of the VA, it is noticeable that this **rectangle** is not possible for the answer options B and C. The **small staircase**, which must form the **rectangle** in the SA, leads **down to the middle** of the VA. Same would only see a line and no **rectangle** in the SA.

Now we have to choose between A and D. Once again we have to focus on the side view. The small **rectangle** is not in the middle in relation to the upper and lower edges, but lower. Since the **stairs** in answer D are lower than in answer A, we can conclude that answer D is the correct one.

3D view of
body



1.10.

side view (SA)**top view (DS)****Wanted front view (VA) of the body****(A)****(b)****(c)****(D)**

Answer: B

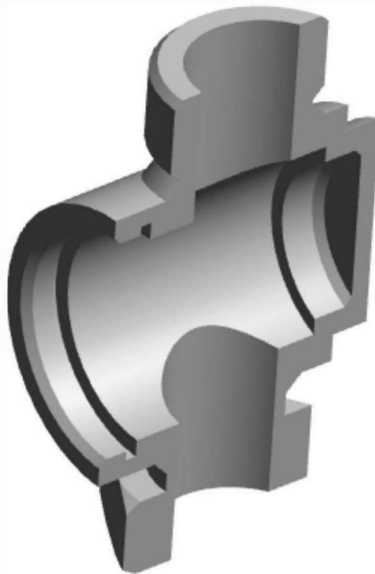
*S 1: Determine the distinctive features: **edges on foot fl** (SA), **upper edges** (SA).*

S2: Mark the prominent features in the views.

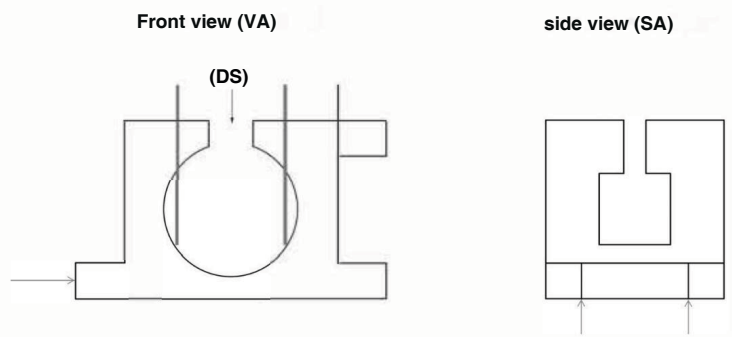
S3: Right or prong side in SA? Left.

*S4: Exclude: If one compares the **edges at the foot** of the body from the side view with the possible answers, it can be determined that these only match two of the possible answers (B and C). When comparing the **distances between the upper edges** from the side view with the possible answers, it becomes clear that these can only agree with one of the remaining answers.*

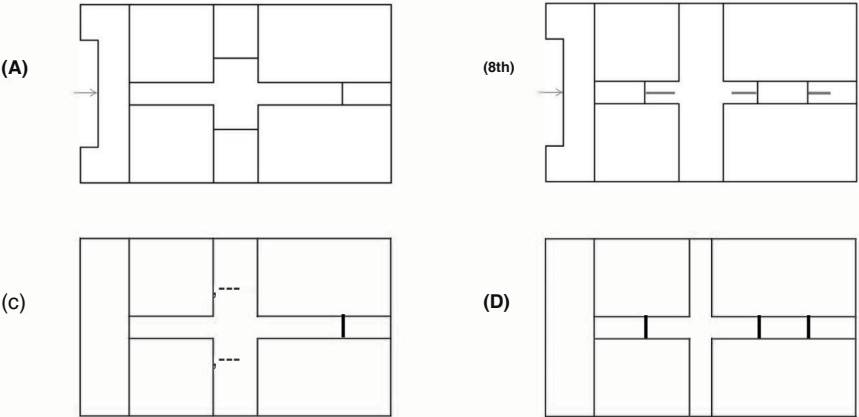
3D view of
body



1.11.



Wanted: top view (DS) of the body



Answer: B

S 1: Determine the prominent features: cavity in the middle (SA) .

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

*S4: Knockout: We can see something in the side view that isn't visible in the front view, and that is that the figure's foot must have a **cutout** . This can be seen in the two **middle vertical lines** of the foot (SA). If we now look for these **gaps** in the possible answers, which must be visible in the searched top view because the figure's foot protrudes, we notice that they *can only be found* in answer **A** and **B**. We can exclude **C** and **D**.*

*Deciding between **A** and **B** is not easy. The solution brings us the side view. Here we see a cavity in the middle **without any other objects**. If we now look at the other answers, we see that in answer **A** there is only one vertical line in the cavity. But there must be **three** , one for the **edge of the cavity** on the left, one for the **edge of the cavity** on the right, and one for the **right foot** of the object.*

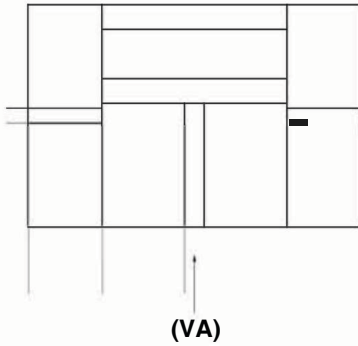
*We have eliminated all answers to **B** , which is the correct solution. Here the above mentioned **recess** can be seen and the **three** vertical lines correspond to the edges which can be seen as vertical lines in the plan view through the cavity that can be seen above in the side view.*

3D view of
body

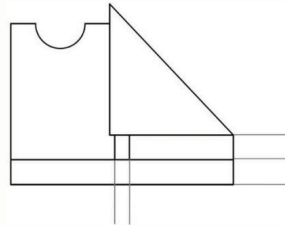


1.12.

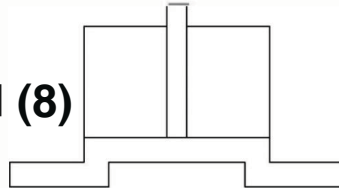
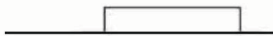
top view (DS)



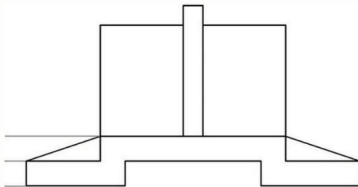
side view (SA)



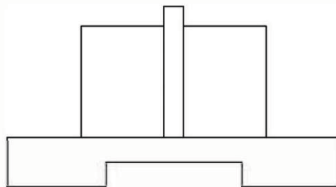
Wanted: front view (VA) of the body

(A) $\ddot{y}$ _____ • • | (8)

(C)



(D)



Answer: C

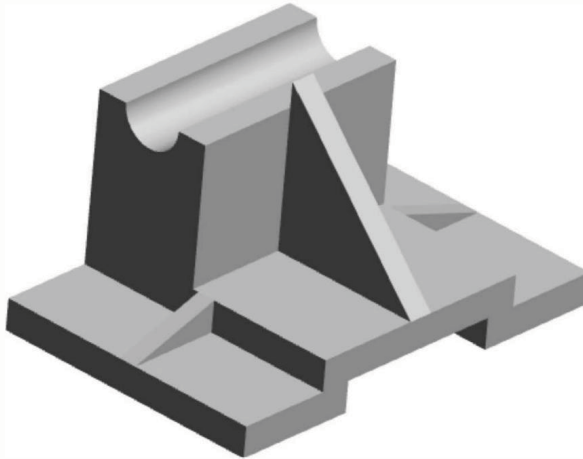
*S 1: Determine the distinctive features: **horizontal lines** (SA), **small rectangle** (SA).*

S2: Mark the prominent features in the views.

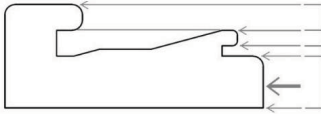
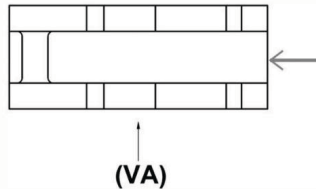
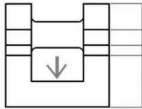
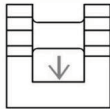
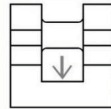
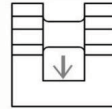
S3: Right or prong side in SA? Left.

*S4: Exclusion: The lower part of the side view shows three **horizontal lines**, which means that the corresponding parts of the figure stand out from each other. They must appear as vertical lines in the plan view. The **small rectangle** also stands out from the rest and since its **spacing** can be found in the top view, it must be an elevation.*

3D view of
body



1.13.

Front view (VA)**top view (DS)****Wanted: a side view (SA) of the body****(A)****(b)****(c)****(D)****Answer: A**

S1: Determine the distinctive features: shape of the front view, **number of edges** (VA).

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right. The left view would only allow two horizontal lines in the side view.

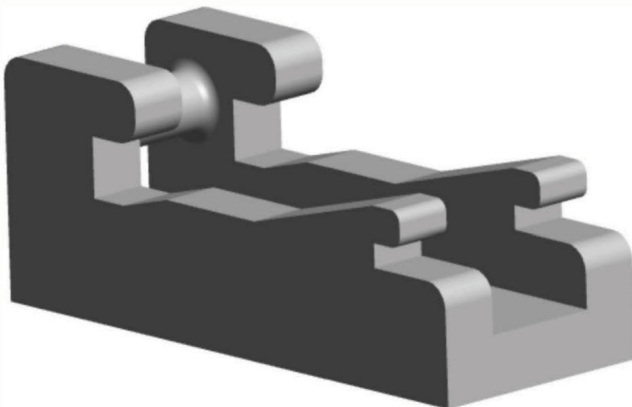
S4: Exclude: To narrow down the possible answers, we need to **count** the **edges** from the front view, which can be seen as **horizontal lines** from the side view. That's exactly **5** pieces (the second horizontal line in the middle of the side view you are looking for (**see bold arrows**) can be neglected, since the corresponding edge is not visible in the front view). We can rule out answer B and D because dart 6 horizontal lines can be counted.

When deciding between answers A and C, we have to consider the **level** of the respective increments from the front view. From the bottom edge to the next one above it, the **distance** is greater than between all other edges. If you look closely, you could already see that the **distance** between the lowest horizontal line and the one above it in answer C is too small.

Another indication that only A can be the correct solution is the **distance** between the second edge (from below) and the one above. This one is just very small. In answer C, the **spacing** is not really small and the lines above are spaced much too **regularly**. In the front view, we clearly see that this cannot be.

We have excluded all answers to A. Here the **distance** between the second and third horizontal line (from below) is very small and the other **distances** also match the front view.

3D view of
body



EXAMINATION2

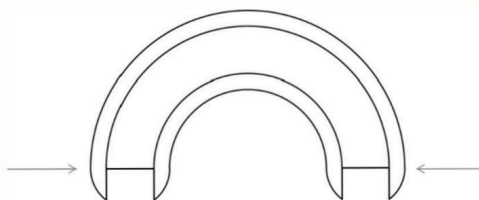
2.1.

top view (DS)



(VA)

side view (SA)

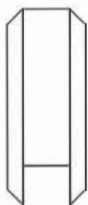


Wanted: front view (VA) of the body

(A)



(b)



(c)



(D)



Answer: A

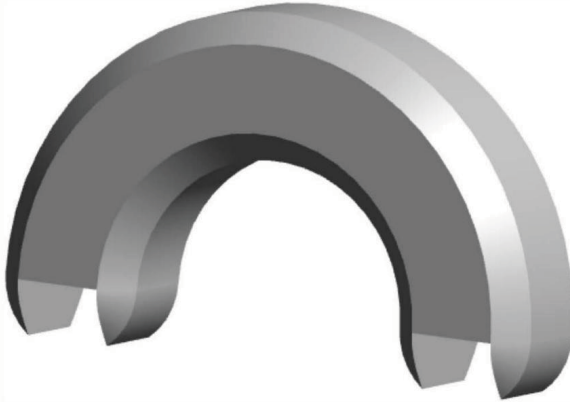
*S1: Determine the distinctive features: **Auflerer Bogen** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

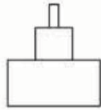
*S4: Close out: **Outer arc** has no openings.*

3D view of
body

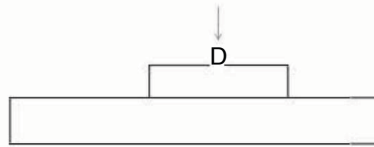


2.2.

side view (SA)

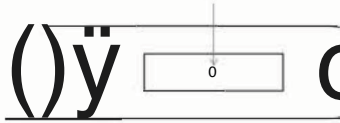


Front view (VA)



Wanted: top view (DS) of the body

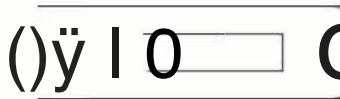
(A)



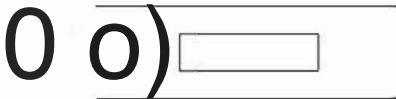
(b)



(c)



(D)



Answer:A

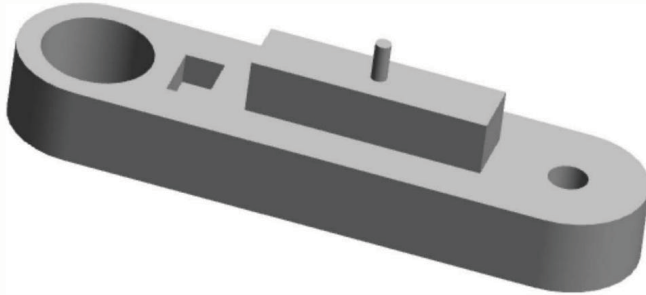
*S 1: Determine the distinctive features: **Small rectangle** (VA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

*S4: Exclude: The **small rectangle** from the front view is in the **middle** of the rectangle below. This must be seen in the correct answer.*

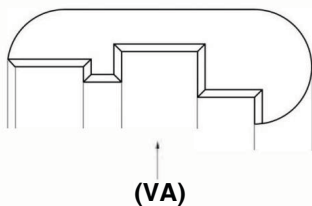
3D view of
body



2.3.

top view (DS)

side view (SA)



Wanted: front view (VA) of the body

(A)



(b)



(c)



(D)



Answer: B

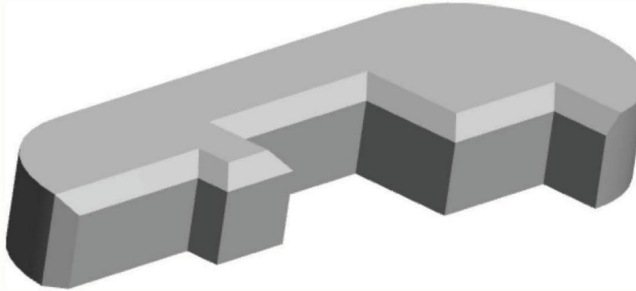
*S1: Determine the distinctive features: **distances** between the edges (DS).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

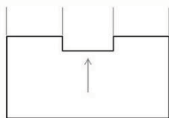
*S4: Exclude: **distances** must match.*

3D view of
body

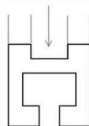


2.4.

Front view (VA)

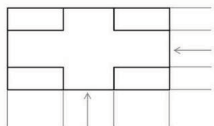


side view (SA)

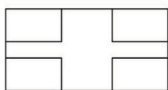


Wanted: top view (DS) of the body

(A)



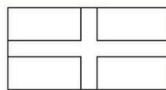
(b)



(c)



(D)



Answer: A

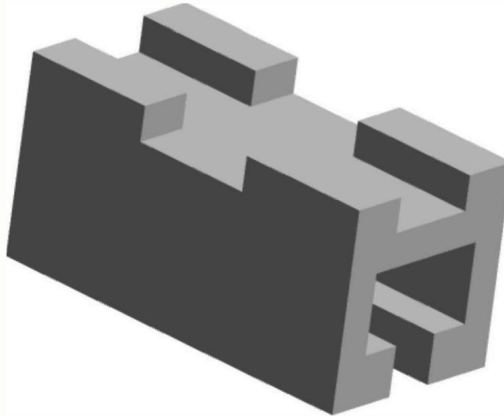
*S1: Determine the prominent features: **savings** and **edge distances** (VA and SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

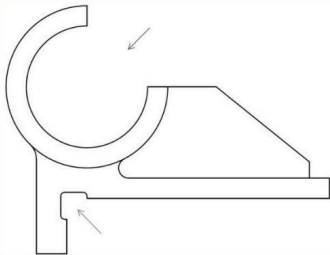
*S4: Exclude: **Savings** form a cross. **Edge distances** must match.*

3D view of
body

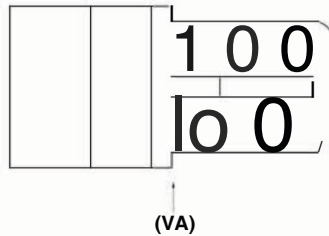


2.5.

Front view (VA)

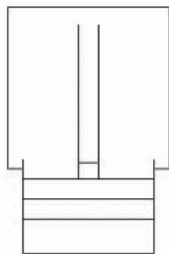


top view (OS)

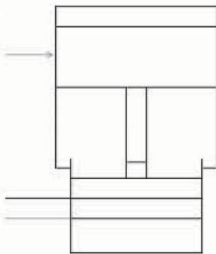


Wanted: a side view (SA) of the body

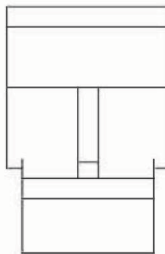
(A)



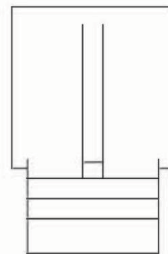
(b)



(c)



(D)



Answer: B

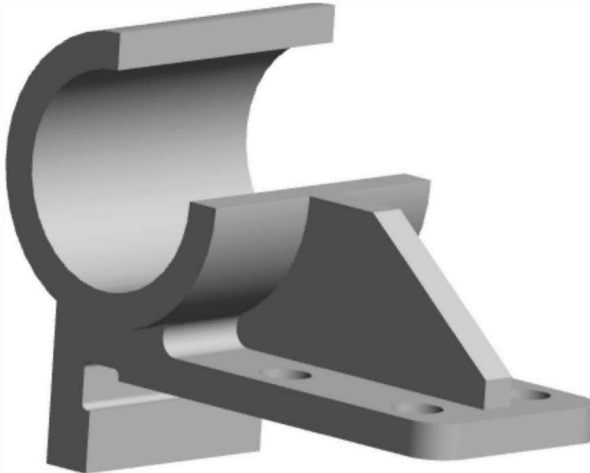
*S 1: Determine the distinctive features: **opening of the circle, small savings (VA).***

S2: Mark the prominent features in the views.

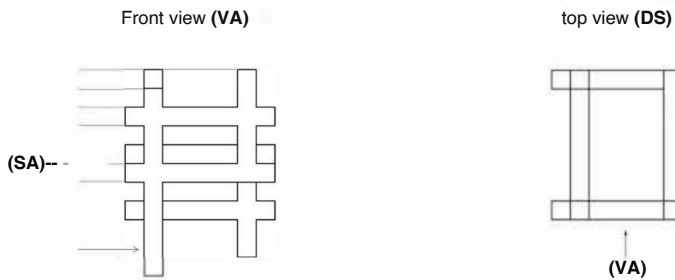
S3: Right or prong side in SA? Right.

S4: Exclude: Side view can only be right view. The horizontal lines of the possible answers must correspond to the edges from the front view.

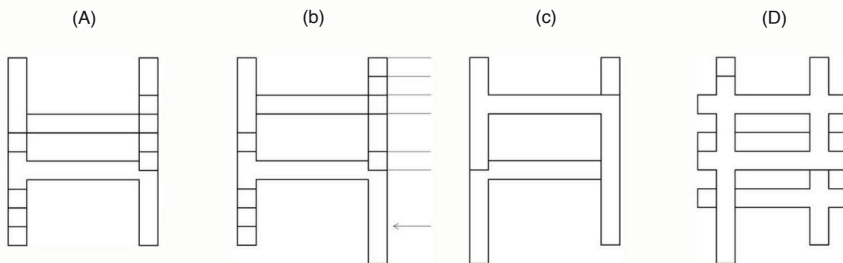
3D view of
body



2.6.



Wanted: the drawn side view (SA) of the body



Answer: B

*S1: Determine the distinctive features: **left lowest part** (VA), **numerous edges**.*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

*S4: Excluding: **Left bottom part** / longer than the parallel vertical counterpart. **Many edges** from the front view must show up as horizontal lines in the side view.*

3D view of
body



2.7.

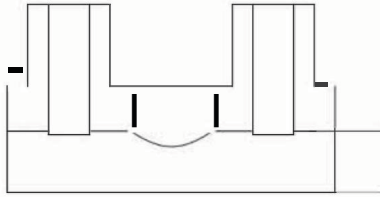
top view (DS)

Front view (VA)

y

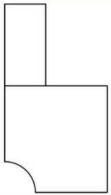
-(SA)

(VA)

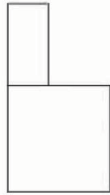


Wanted: the drawn side view (SA) of the body

(A)



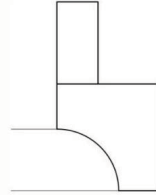
(b)



(c)



(D)



Answer:D

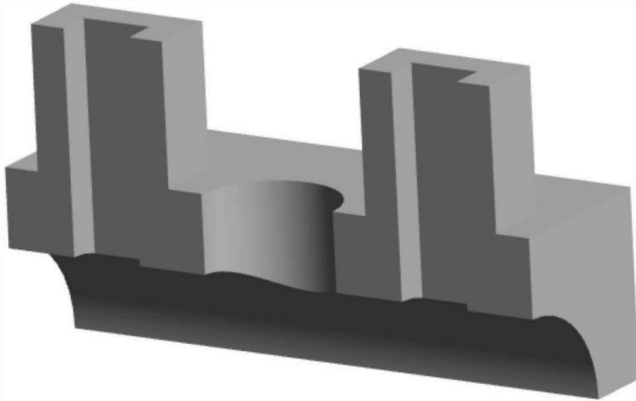
*S1: Determine the prominent features: **lower part** (VA), **upper part** (DS).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

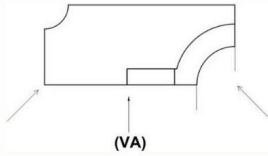
*S4: Exclude: The **horizontal lines of the lower part** of the front view show that in the side view we are looking for, there must be **two edges with the same height** on the left side. The **upper part of the plan view** reveals that there must be **no further edges** in the upper right part of the answer options*

3D view of
the body



2.8.

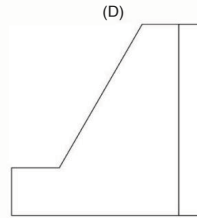
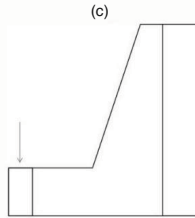
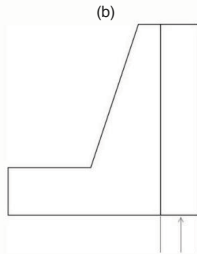
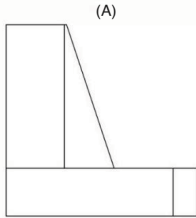
top view (DS)



side view (SA)



Wanted: front view (FA) of the body



Answer: B

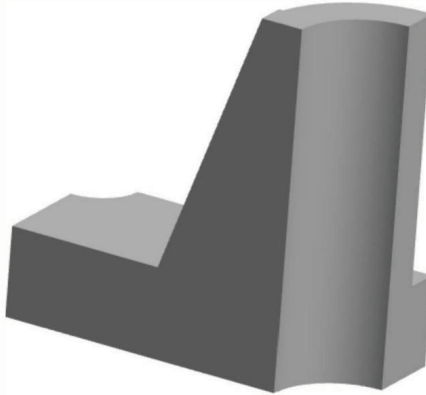
*S 1: Determine the distinctive features: **quarter circle** bottom right (VA), **distances** .*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

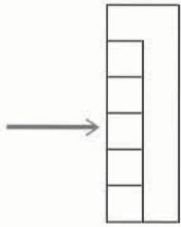
*S4: Exclude: The side view reveals that the right part of the possible answers must be high. **No edge** in the lower left corner of the plan view. The **distances between** the edges must match (e.g. **quarter of a circle** from the top view).*

3D view of
body



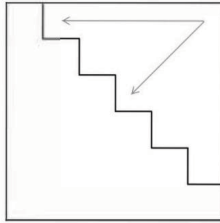
2.9.

top view (DS)



(VA)

side view (SA)



Wanted: front view (VA) of the body

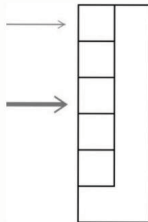
(A)



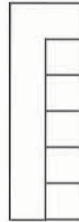
(b)



(c)



(D)



Answer: C

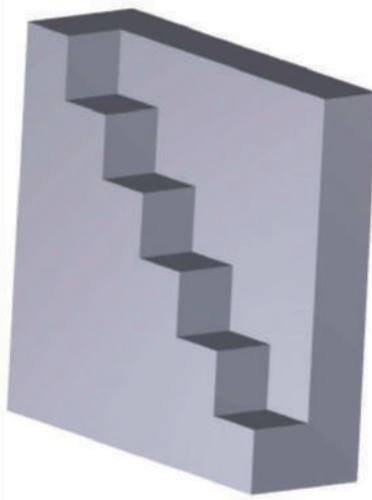
*S 1: Determine the distinctive features: **staircase (SA)**, **position of the small squares** .*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

*S4: Exclude: **Small squares** must be on the left of the correct answer. **Stairs** go all the way up.*

3D view of
body



2.10.

Front view (VA)

side view (SA)

$\ddot{y}$
 $cu=w$

$\ddot{y}(SA)$



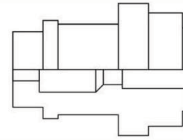
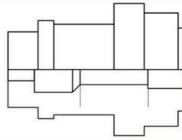
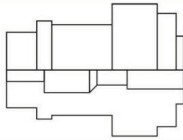
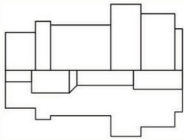
Wanted: top view (DS) of the body

(A)

(b)

(c)

(D)



Answer: C

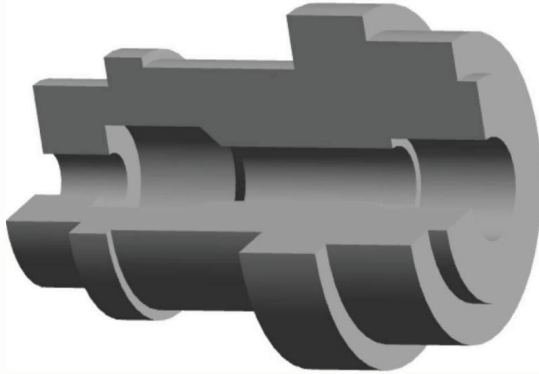
*S 1: Determine the distinctive features: **distances** .*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

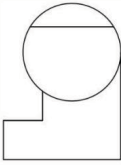
*S4: Exclude: **distances** must match.*

3D view of
body

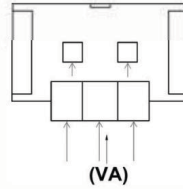


2.11.

side view (SA)

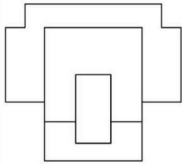


top view (DS)

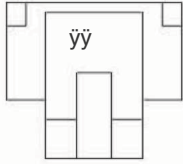


Wanted: front view (VA) of the body

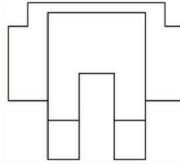
(A)



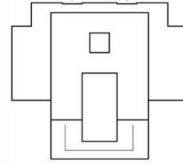
(b)



(c)



(D)



Answer:D

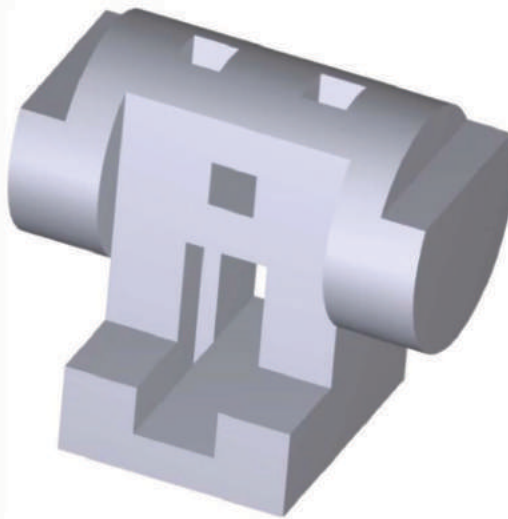
*S1: Determine the prominent features: **small squares** (DS), **three rectangles** (DS).*

*S2: Mark the prominent features in the views. When comparing the side view and the top view, it can be seen that the surface on which the **two small squares** lie does not have to be straight, but curved. The two **small squares** can therefore only be savings. Due to the curved surface, these must be able to be found in the correct answer.*

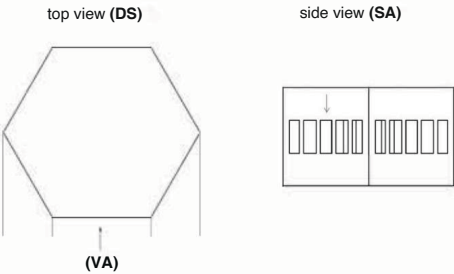
S3: Right or prong side in SA? Right.

*S4: Exclude: The **three rectangles** in the top view must form an arc as in answer D, since a comparison between the side view and the top view shows that the middle rectangle is a savings.*

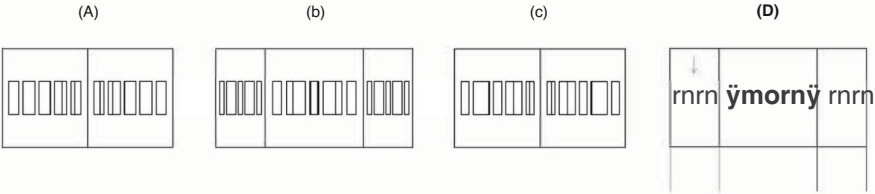
3D view of
body



2.12.



Wanted: front view (VA) of the body



Answer:D

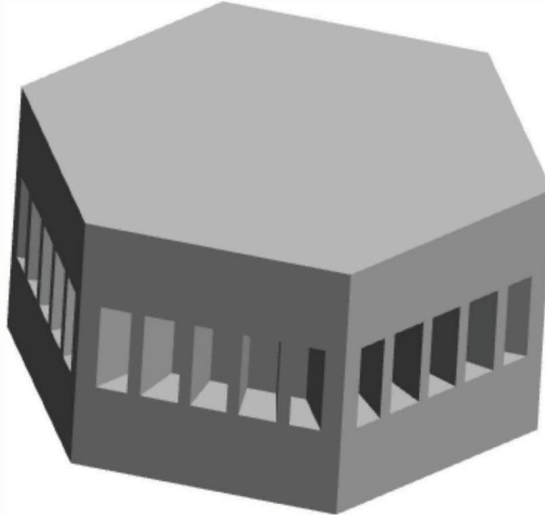
*SL: Determine the distinctive features: **4 edges** (DS), **rectangles** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

*S4: Exclusion: Since the side view is a mirror image, it makes no difference whether it is the left or right view. The **4 edges** of the top view show up as **4 vertical lines** in the front view (left, right and two in the middle). In the side view you can see that the **cutouts** (shown as **rectangles**) must be approximately the same width.*

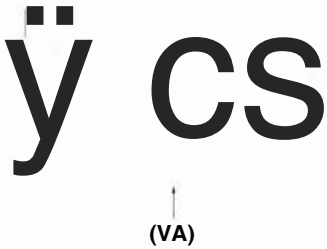
3D view of
body



2.13.

top view (DS)

side view (SA)



Wanted: front view (VA) of the body

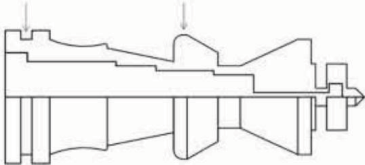
(A)



(b)



(c)



(D)



Answer: C

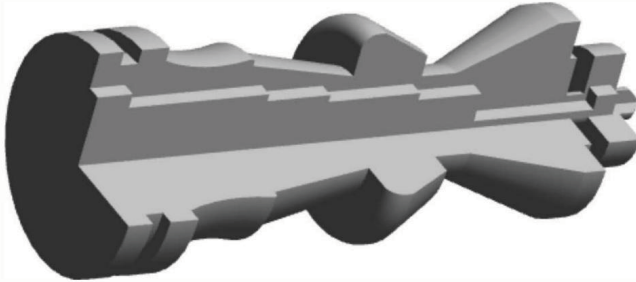
*S1: Determine the distinctive features: **notch** on the left, **rounded corner** in the middle (DS).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

*S4: Closing: There must be an **indentation** on the left side . In addition, the bump must have a **rounded corner** in the middle .*

3D view of
body



Answer: B

*S1: Identify the prominent features: **small square** (SA), **economy** (SA).*

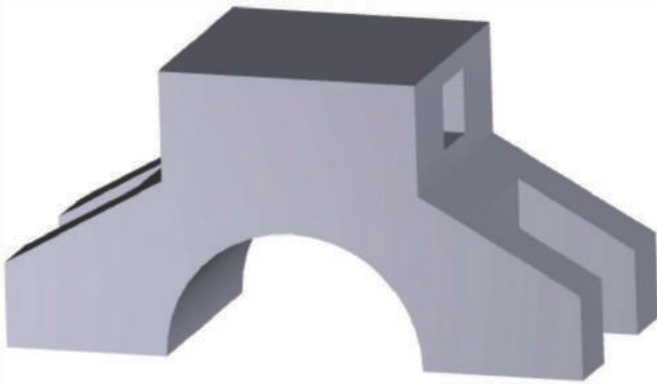
S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

*S4: Exclude: The **small square** from the side view must **not** be visible in the searched top view.*

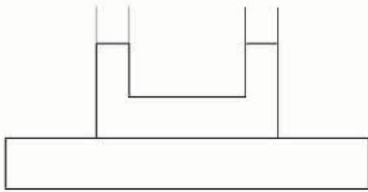
*The **savings** from the side view **must** be visible in the desired top view.*

3D view of
body



3.2.

Front view (VA)



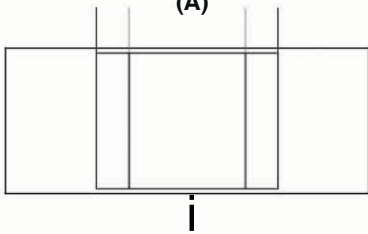
side view (SA)

G

Wanted: top view (DS) of the body

(A)

(b)



(c)

(D)



Answer:A

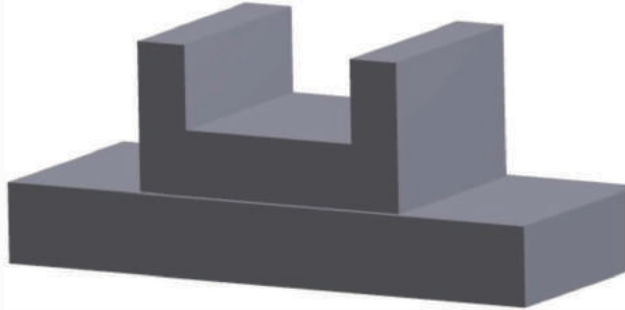
*S1: Determine the prominent features: **distances** (VA), **edges** (SA).*

S2: Mark the prominent features in the views.

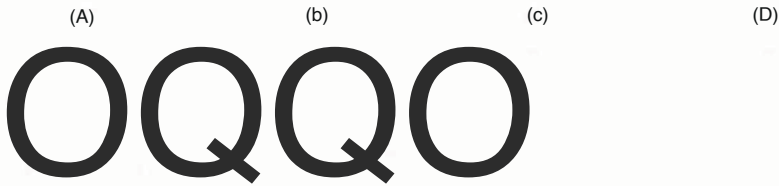
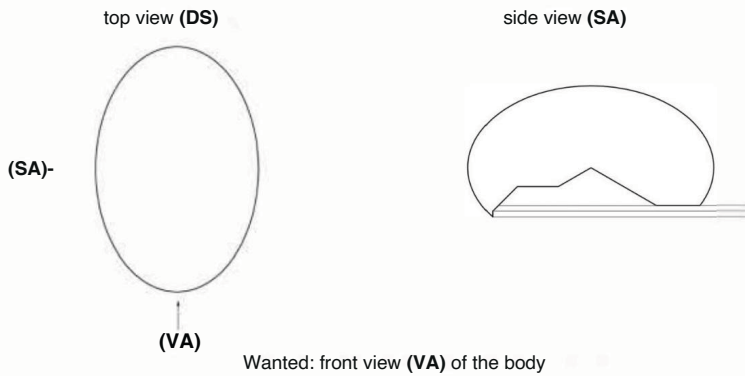
S3: Right or prong side in SA? Can be both.

*S4: Exclude: The **distances** (VA) must agree with the possible answers. The **edge** from the side view must be visible in the answer choices.*

3D view of
body



3.3.



Answer:D

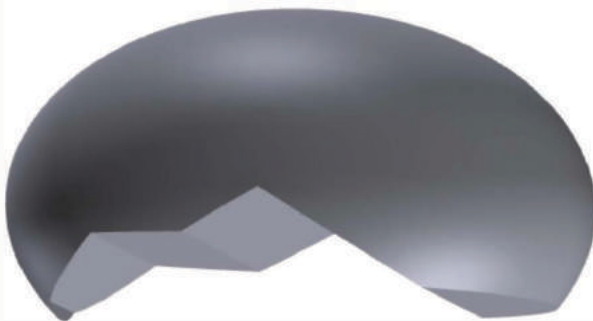
*S1: Determine the prominent features: **edges** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

*S4: Exclude: Side view must be left view. The **edges** in the side view must be recognizable as equally **spaced lines** in the correct answer .*

3D view of
body



Answer:D

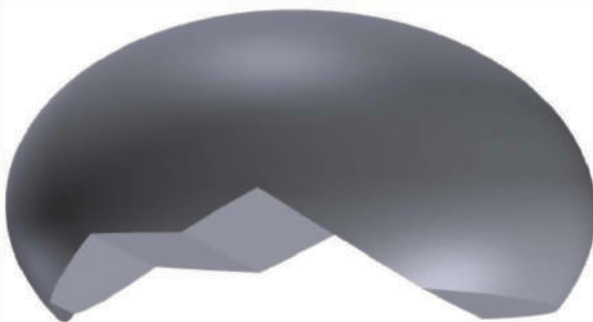
*S1: Determine the prominent features: **edges** (SA).*

S2: Mark the prominent features in the views.

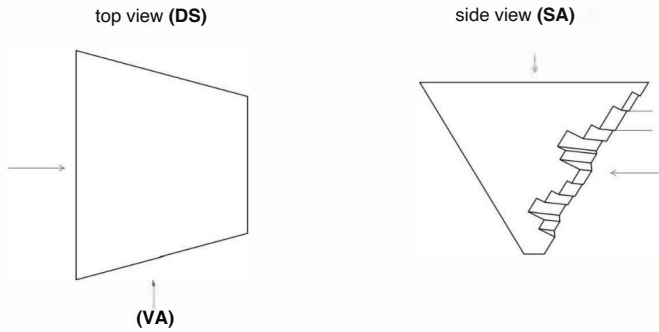
S3: Right or prong side in SA? Left.

*S4: Exclude: Side view must be left view. The **edges** in the side view must be recognizable as equally **spaced lines** in the correct answer .*

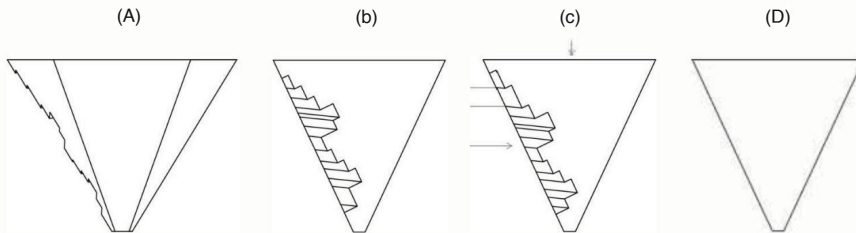
3D view of
body



3.4.



Wanted: front view (VA) of the body



Answer: C

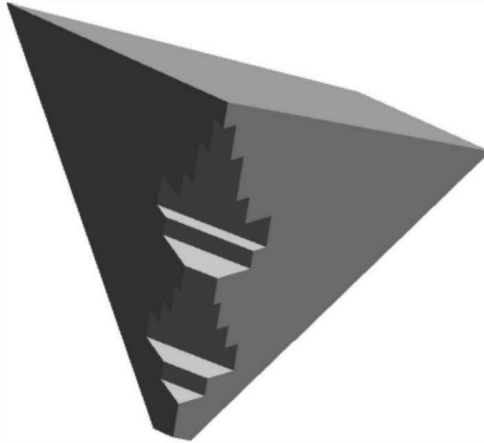
*S 1: Determine the distinctive features: **length of the outer lines** (DS and SA), **distances between the edges** (SA).*

S2: Mark the prominent features in the views.

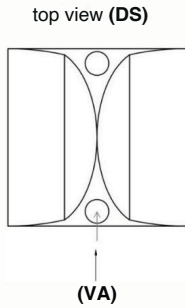
S3: Right or prong side in SA? Left.

*S4: Exclude: side view must be left view (**length of outer lines**); **Spacing** of the notches (SA) must correspond to possible answers.*

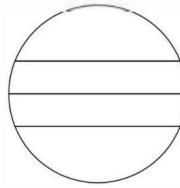
3D view of
body



3.5.

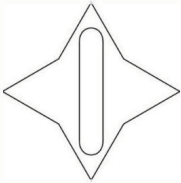


side view (SA)

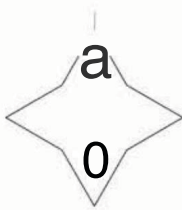


Wanted: front view (VA) of the body

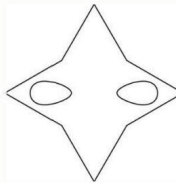
(A)



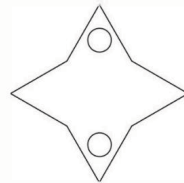
(b)



(c)



(D)



Answer: B

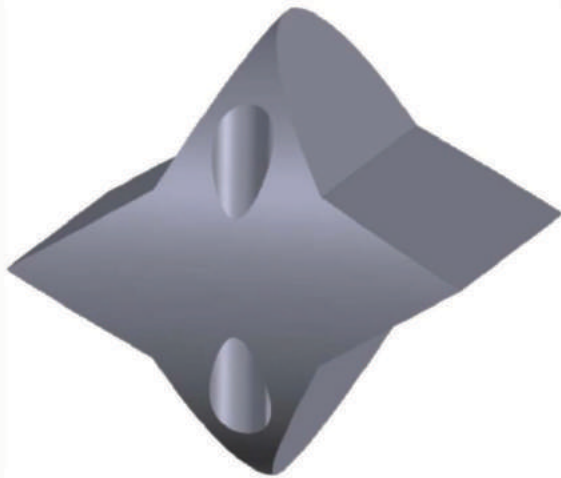
*S1: Determine the salient features: **Closed circle** (DS).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

*S4: Exclude: The lower **closed circle** (DS) must have a **teardrop shape** in the front view sought, since the figure is curved. (A perfect circle can be seen in top view. It may not appear the same in front view.)*

3D view of
body



3.6.

top view (DS)



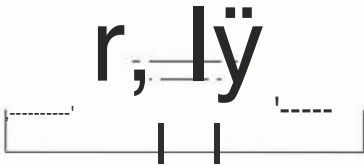
ŷ lŷl IN ŷ(SA)
(VA)

side view (SA)

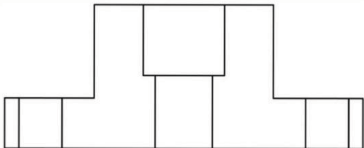


Wanted: front view (VA) of the body

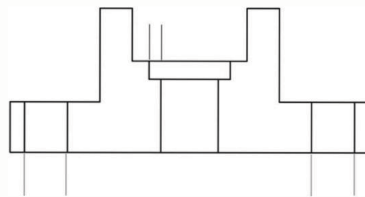
(A)



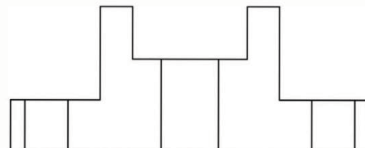
(c)



(b)



(D)



Answer: B

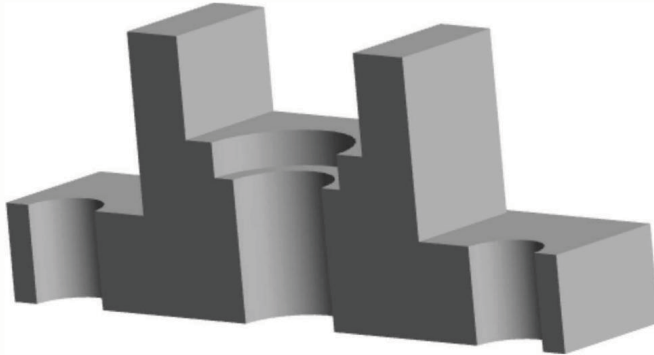
*S1: Determine the distinctive features: **Outer semicircles (DS)**, **middle semicircles (DS)**.*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

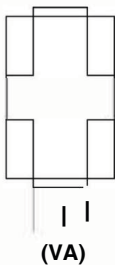
*S4: Exclude: The two **outermost semicircles** in the top view form edges that must appear as **vertical lines** in the front view. The **semicircles in the middle** must **stand out from each other** in the desired front view*

3D view of
body



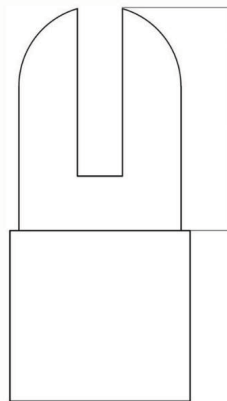
3.7.

top view (DS)



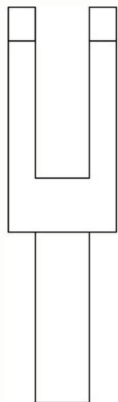
(VA)

side view (SA)

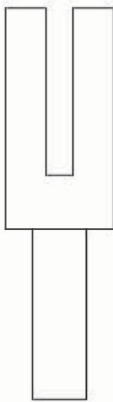


Wanted: front view (VA) of the body

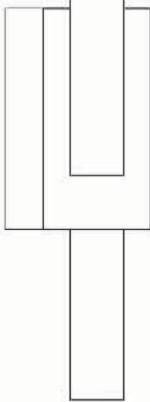
(A)



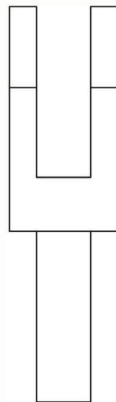
(b)



(c)



(D)



Answer: C

*S 1: Determine the distinctive features: **width of the savings (DS)**, **shape of the side view**.*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

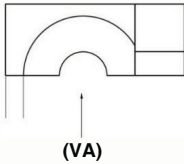
*S4: Exclude: The **space** in the middle of the answer choices must have the **same width** as the **bottom part of the top view**. The **form of the side view** reveals that there must be no horizontal lines in the "fork" of possible answers*

3D view of
body

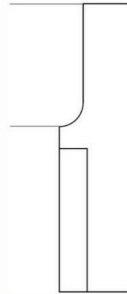


3.8.

top view (DS)

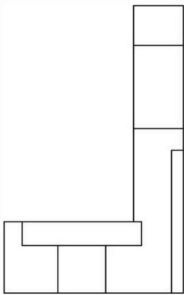


side view (SA)

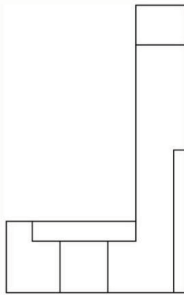


Wanted: front view (VA) of the body

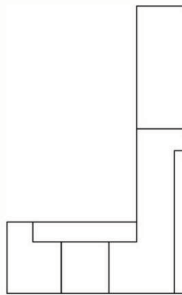
(A)



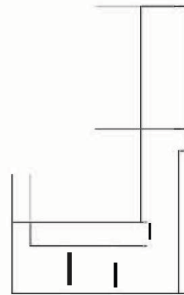
(b)



(c)



(D)



Answer: D

*S1: Determine the prominent features: **distance** (DS), **edges** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

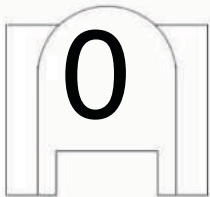
*S4: Exclude: The **distance** of the lower left part of the top view must agree with the possible answers. The **edge distance** from the side view must form horizontal lines with the same **distance** in the searched front view .*

3D view of
body

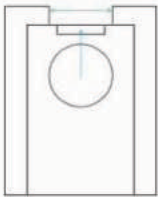


3.9.

Front view (VA)

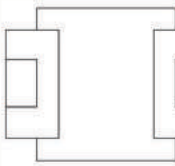


side view (SA)

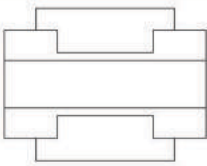


Wanted: top view (DS) of the body

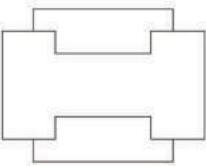
(A)



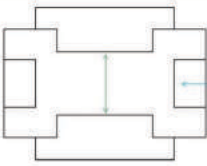
(b)



(c)



(D)



Answer:D

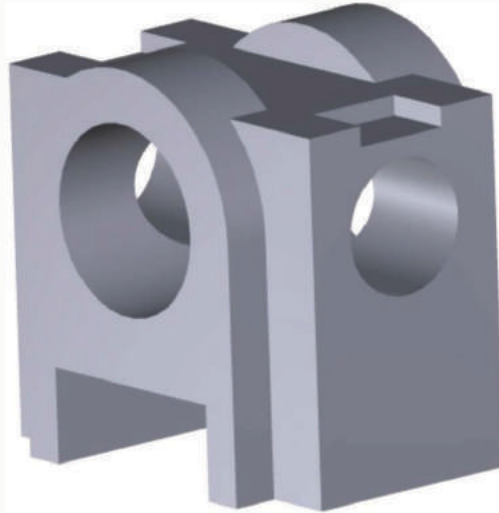
*S 1: Determine the distinctive features: **small savings** (SA), **large savings** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

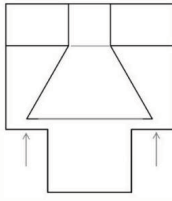
*S4: Exclude: The **small saving** above the large circle reveals that this must also be visible in the plan view. The breadth of the **large saving** (DS) suggests that a portion of the **appropriate height** must be discernible in the correct answer.*

3D view of
body



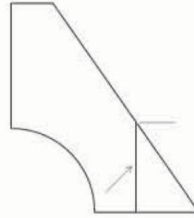
3.10.

top view (OS)



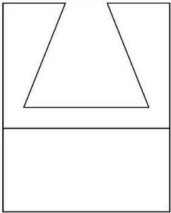
(VA)

side view (SA)

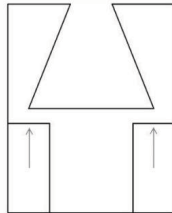


Wanted: front view (VA) of the body

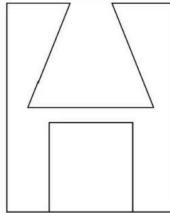
(A)



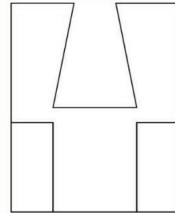
(b)



(c)



(D)



Answer: B

*S1: Identify the salient features: **width of the savings** (DS), **triangle** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

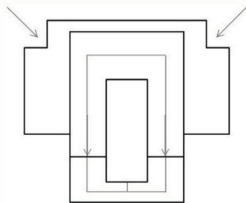
*S4: Exclude: The **width of the savings** in the top and bottom area from the top view must be the same in the answer options. The **triangle** tells (in combination with the top view) that the correct answer must have two short **horizontal lines**.*

3D view of
body

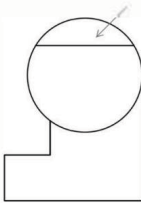


3.11.

Front view (VA)

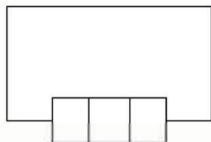


side view (SA)

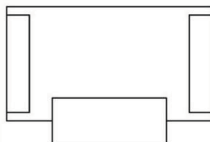


Wanted: top view (DS) of the body

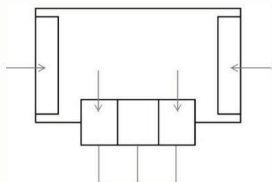
(A)



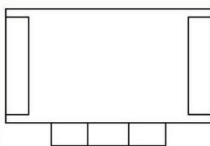
(b)



(c)



(D)



Answer: C

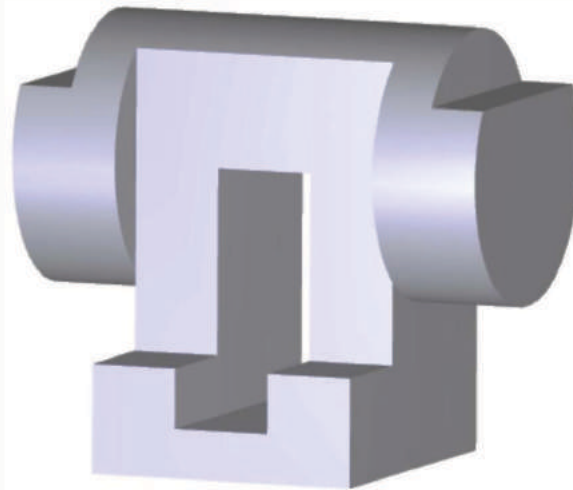
*S1: Determine the distinctive features: **large arch** (VA), shape of the side view, **steps** (VA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

*S4: Exclude: Comparing the front and side views, one can see that the **large arch** is lower than the small arch below. That is why three small **rectangles** appear at the lower end in the top view due to the **small arc**. The **large arc** lies behind the circle from the side view, so the rectangles cannot be as small as in answer D. The **steps** from the front view form the **long rectangles** of the possible answers.*

3D view of
body

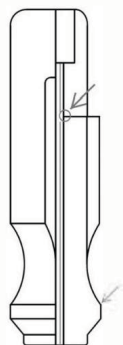
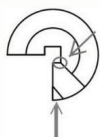


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3.12.

Front view (VA)**side view (SA)****Wanted: top view (DS) of the body****(A)****(b)****(c)****(D)**

Answer:A

*SL: Determine the distinctive features: **truncated edge** (middle of VA), **horizontal line** (right side of SA - middle).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

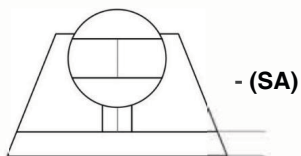
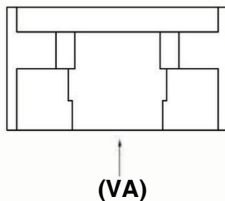
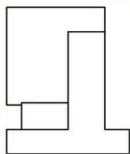
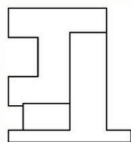
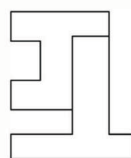
*S4: Exclude: Side view is from the left (recognizable by one of the lower edges - **see small arrows**).*

*The **truncated edge** (VA) must appear in the correct answer. The **horizontal line** on the right side of the side view shows that the center part of the top view must be a square (if there is a circle, a **second pincer vertical line would appear**).*

3D view of
body



3.13.

Front view (VA)**top view (DS)****Wanted: the drawn side view (SA) of the body****(A)****(b)****(c)****(D)**

Answer: C

*S1: Determine the distinctive features: **body in the circle** (VA), **body under the circle** (VA), foot (VA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Rights (specified in the question).

*S4: Exclusion: The **body in the circle** indicates that it must stand out from the circle (it must be lower or in front of it). Also, the **body under the circle** must be a savings or protrude. The **height of the foot** (VA) must match the **height of the foot** of the correct answer.*

3D view of
body



EXAMINATION4

4.1.

top view (DS)



(VA)

side view (SA)

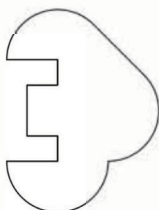


Wanted: front view (VA) of the body

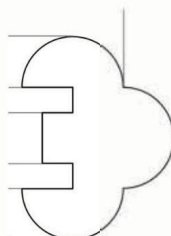
(A)



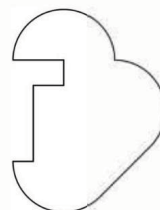
(b)



(c)



(D)



Answer: C

*S1: Determine the distinctive features: **vertical line** (DS), **distances** (SA).*

S2: Mark the prominent features in the views.

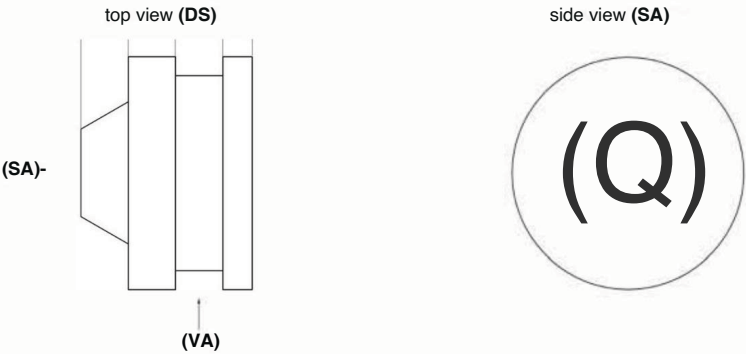
S3: Right or prong side in SA? Left.

*S4: Exclude: The **vertical line** from the top view indicates that there must be an **edge** in the upper part of the correct answer. The **distances between** the horizontal lines of the side view must be recognizable as **edges** on one side of the correct answer.*

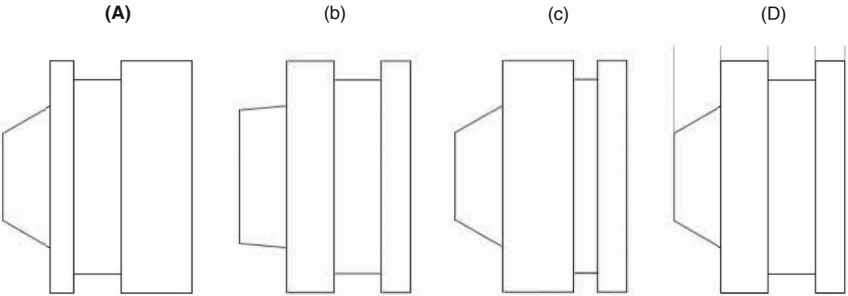
3D view of
body



4.2.



Wanted: front view (VA) of the body



Answer:D

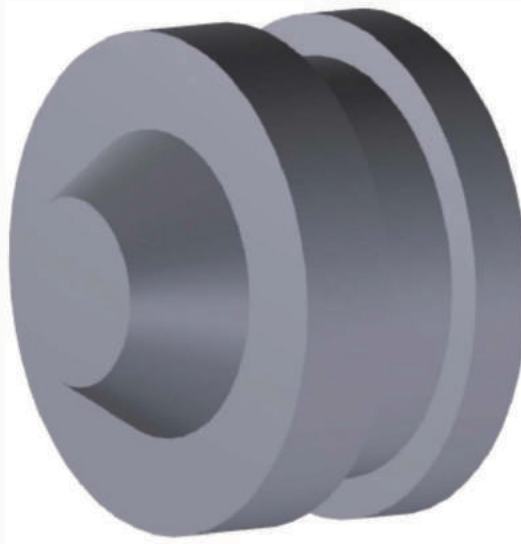
*S 1: Determine the distinctive features: **distances** between edges (DS), shape (SA).*

S2: Mark the prominent features in the views.

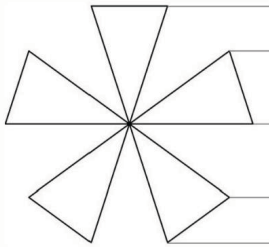
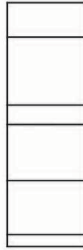
S3: Right or prong side in SA? Left.

*S4: Exclude: Viewed from the side, the body is completely round. For this reason, the front view you are looking for must be exactly the same as the top view, which can also be seen from the distances between the **edges** .*

3D view of
body



4.3.

top view (DS)**(VA)****side view (SA)****Wanted: front view (VA) of the body****(A)****(b)****(c)****(D)**

Answer:A

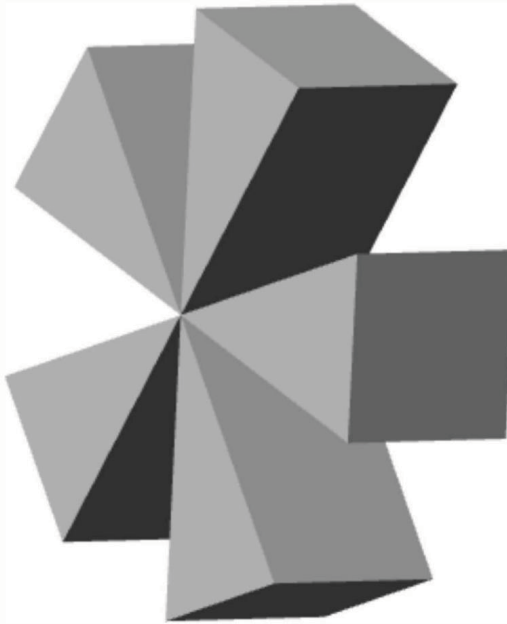
*S1: Determine the prominent features: **distances** between the edges (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

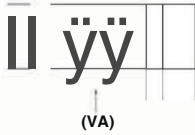
*S4: Exclude: The **distances** between the edges from the side view must be equal to the **distances** of the horizontal lines of the correct answer. The solution can also be found by counting the edges (5 edges in the side view = 5 horizontal lines in the possible answers).*

3D view of
body



4.4.

top view (OS)

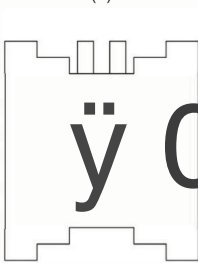


side view (SA)

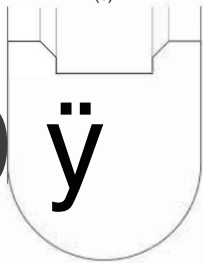


Wanted: front view (VA) of the body

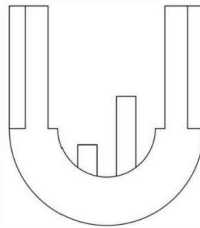
(A)



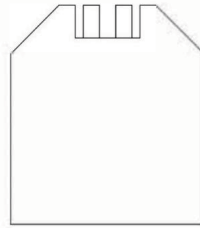
(b)



(c)



(D)



Answer: B

*S1: Determine the prominent features: **distances** (DS).*

S2: Mark the prominent features in the views.

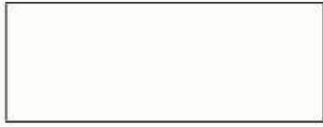
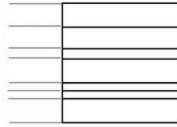
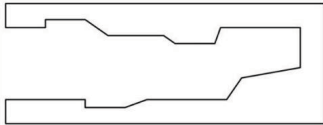
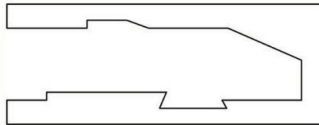
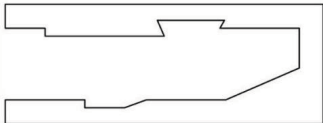
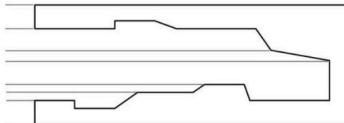
S3: Right or prong side in SA? Can be both.

*S4: Exclude: The **distances** between the **vertical lines** of the plan view must coincide with the **edges** of the correct answer. The two squares in the top view do not necessarily have to be recognizable, as these can also be savings.*

3D view of
body



4.5.

top view (DS)**side view (SA)**
(VA)**Wanted: front view (VA) of the body****(A)****(b)****(c)****(D)**

Answer: D

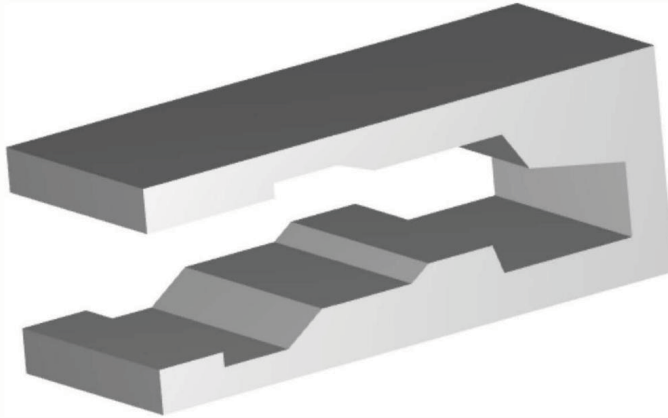
*S 1: Determine the distinctive features: **distances** between the horizontal lines (SA).*

S2: Mark the prominent features in the views.

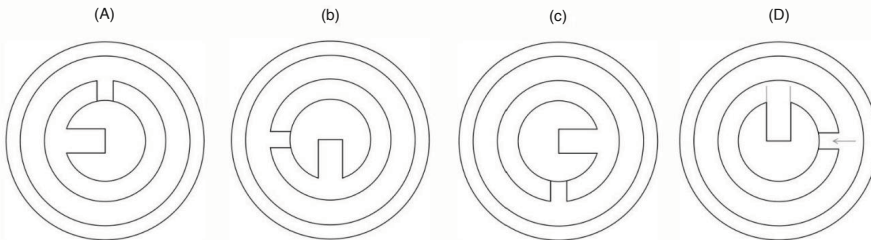
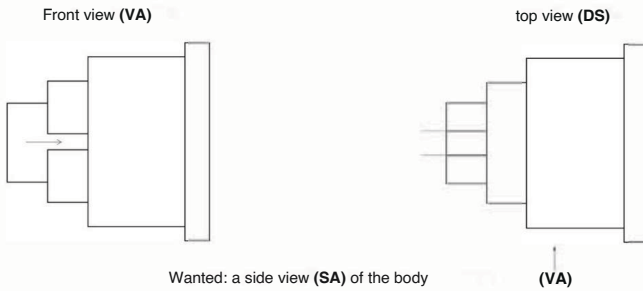
S3: Right or prong side in SA? Left.

*S4: Exclude: Side view can only be left view. The **spacing** of the horizontal lines from the side view must match the **spacing of the edges** in the correct answer.*

3D view of
body



4.6.



Answer:D

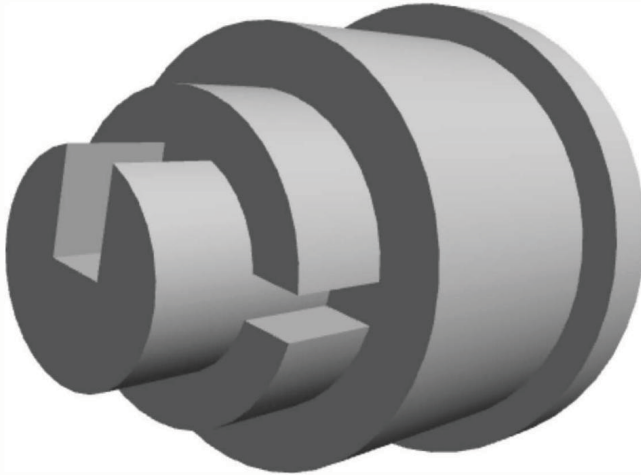
*S1: Determine the distinctive features: **savings** (VA), **horizontal lines** (DS).*

S2: Mark the prominent features in the views.

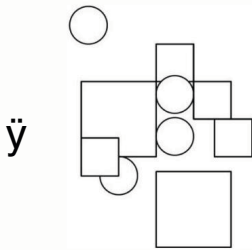
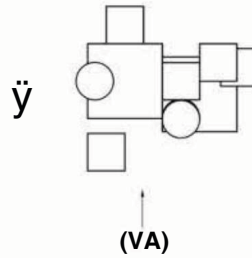
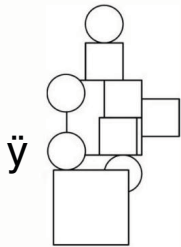
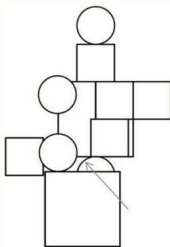
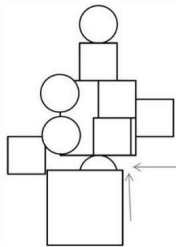
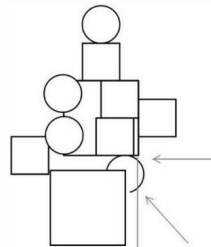
S3: Right or prong side in SA? Left.

*S4: Exclude: Searched view must be left view (no characteristics for right view). The **saving** of the front view must be on the right in the searched answer. The two **horizontal lines** of the leftmost part of the top view must be visible in the answer you are looking for.*

3D view of
body



4.7.

Front view (VA)**top view (DS)****Wanted: a side view (SA) of the body****(A)****(b)****(c)****(D)**

Answer: C

*S1: Determine the prominent features: **spheres** (DS and SA).*

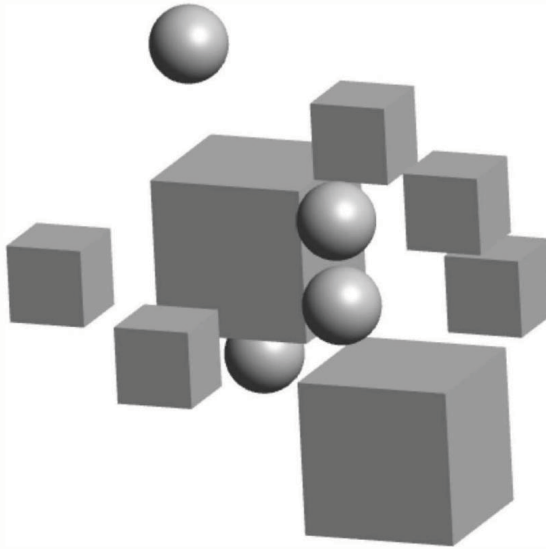
S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

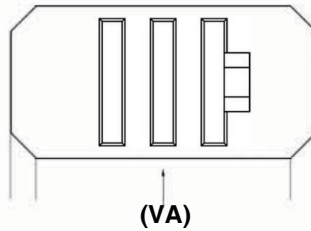
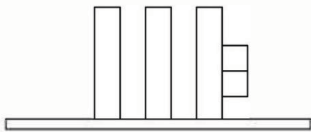
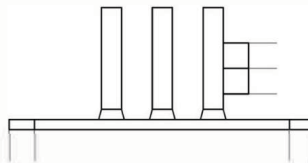
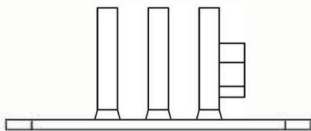
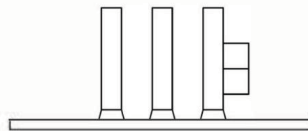
S4: Exclude: The heights of the spheres in the side and front views should be the same. This is only the case with C and D.

In order to be able to decide between C and D, let's look at what makes these images different. The difference is the placement of the bottom ball. Since this sphere is not visible in the top view, it must be **completely behind the rectangle**. This is not the case for answer D.

3D view of
body



4.8.

side view (SA)**top view (DS)****(DS)****(VA)-, Qs}****(VA)****Wanted: front view (VA) of the body****(A)****(b)****(c)****(D)**

Answer: B

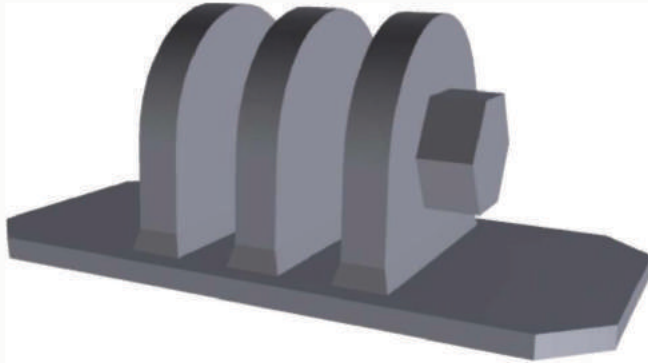
*S 1: Determine the distinctive features: **edges of the hexagon (SA)**, **base of the figure (DS)**.*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

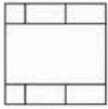
*S4: Exclude: The **edges of the side view hexagon** must appear as **horizontal lines** in the correct answer (it protrudes in the top view). Since **edges** can be seen at the foot of the figure in the side view, these must appear as **vertical lines** in the correct answer.*

3D view of
body



4.9.

top view (DS)



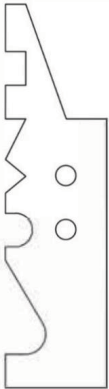
(VA)

side view (SA)

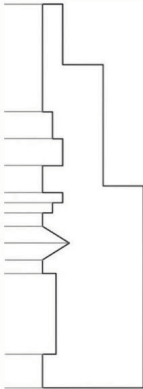


Wanted: front view (VA) of the body

(A)



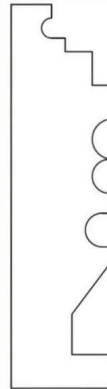
(b)



(c)



(D)



Answer: B

*S1: Determine the prominent features: **distances** (SA).*

S2: Mark the prominent features in the views.

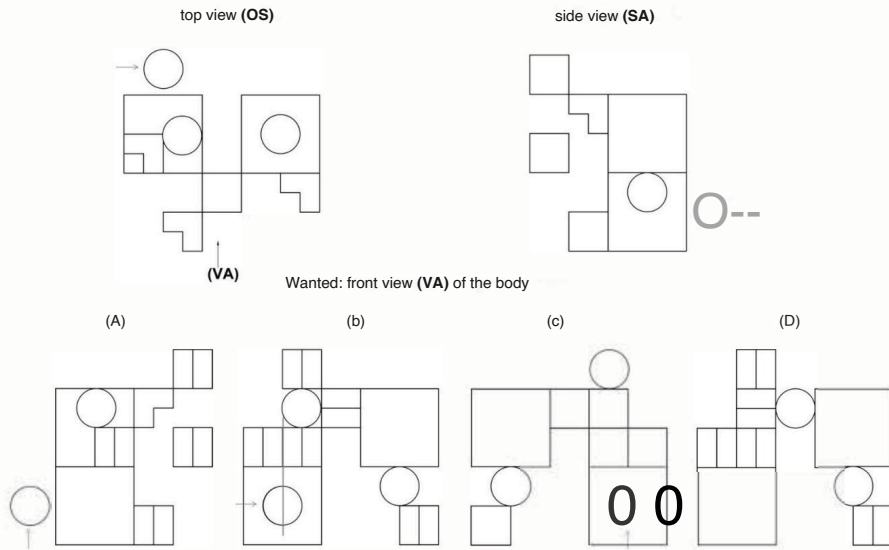
S3: Right or prong side in SA? Left.

*S4: Exclude: The default side view must be the left view because there are not enough edges on the right side of all possible answers. The **distances** between the **horizontal lines** of the side view must match the **distances of the edges** from the possible answers.*

3D view of
body



4.10.

**Answer: B**

SL: Determine the distinctive features: **ball at the lower back corner** (VA), horizontal positions of the two right balls (VA).

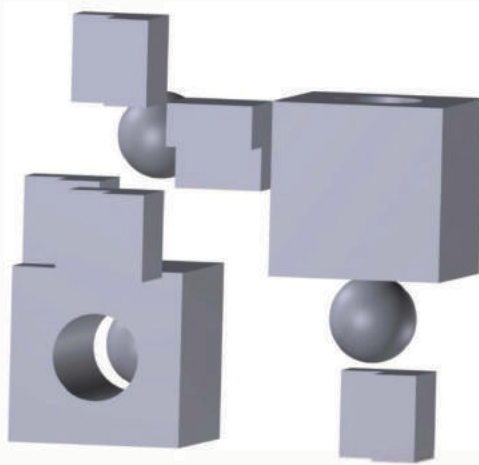
S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

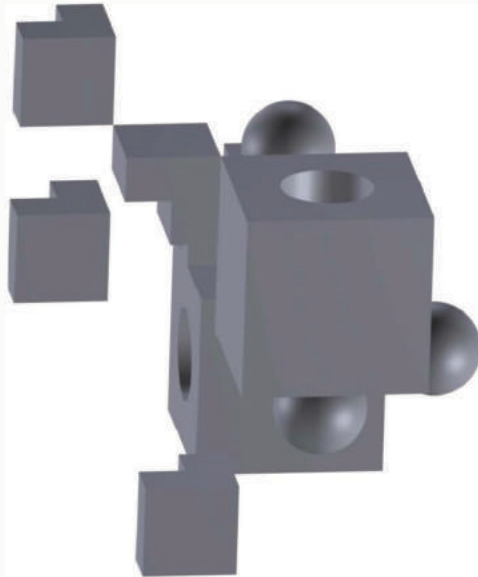
S4: Exclusion: If the answer is correct, the **sphere** that is distanced from the rest of the objects in the DS and SA must be **at the bottom left of the VA**. This only applies to answers A, B and D.

An two rt A can be ruled out because the sphere is to the side of the rectangles. The horizontal position of the right eek and the ball should be overlapping.

The main difference between B and D is the location of the middle ball. So let's focus on that. In the DS, we see that the **spheres overlap horizontally**. This is only the case for answer B.



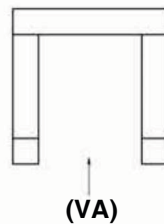
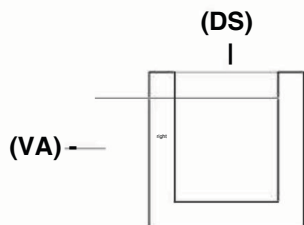
3D views of the body



4.11.

side view (SA)

top view (DS)



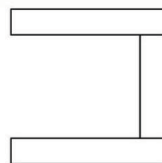
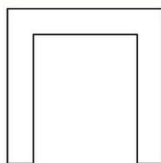
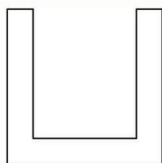
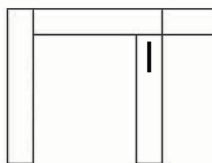
Wanted: front view (VA) of the body

(A)

(b)

(c)

(D)



Answer: A

*S 1: Determine the distinctive features: **Short horizontal line** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Right.

*S4: Excluding: The **short horizontal line** in the side view shows that there must be a higher bar behind the front bar on the right, otherwise the line would not exist. In the front view you are looking for, there must also be a horizontal line, at the same height.*

3D view of
body



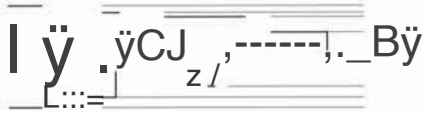
4.12.

top view (DS)



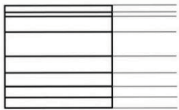
↑
(VA)

side view (SA)

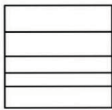


Wanted: front view (VA) of the body

(A)



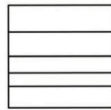
(b)



(C)



(D)



Answer:A

*S1: Determine the prominent features: **distances between the edges** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Left.

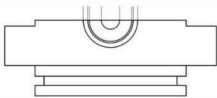
*S4: Exclude: side view must be left view (recognisable by comparing top and side view). The **distances between the edges** of the side view must equal the **distances between the horizontal lines** of the searched front view.*

3D view of
body

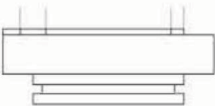


4.13.

Front view (VA)

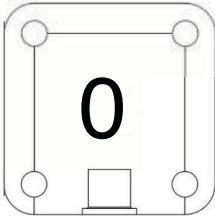


side view (SA)

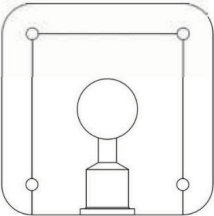


Wanted: top view (DS) of the body

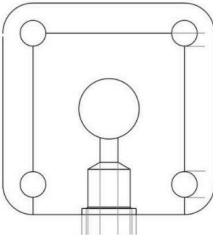
(A)



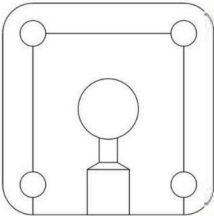
(b)



(c)



(D)



Answer: C

*S1: Determine the distinctive features: **distances** between semicircles (VA), **distances** (SA).*

S2: Mark the prominent features in the views.

S3: Right or prong side in SA? Can be both.

*S4: Exclude: The **distances** between the semicircles must equal the **distances** of the edges in the correct answer. The **distances** between the vertical lines of the top part of the side view must match the **edges of the circles** of the correct answer.*

3D view of
body



AAPPENDIX:

AANSWER SHËET

4

test 1				
	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8th				
9				
10				
11				
12				
13				

1111

test2				
	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				

1111

exam 3				
	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				

1111

test4				
	A	B	C	D
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11				
12				
13				

1111

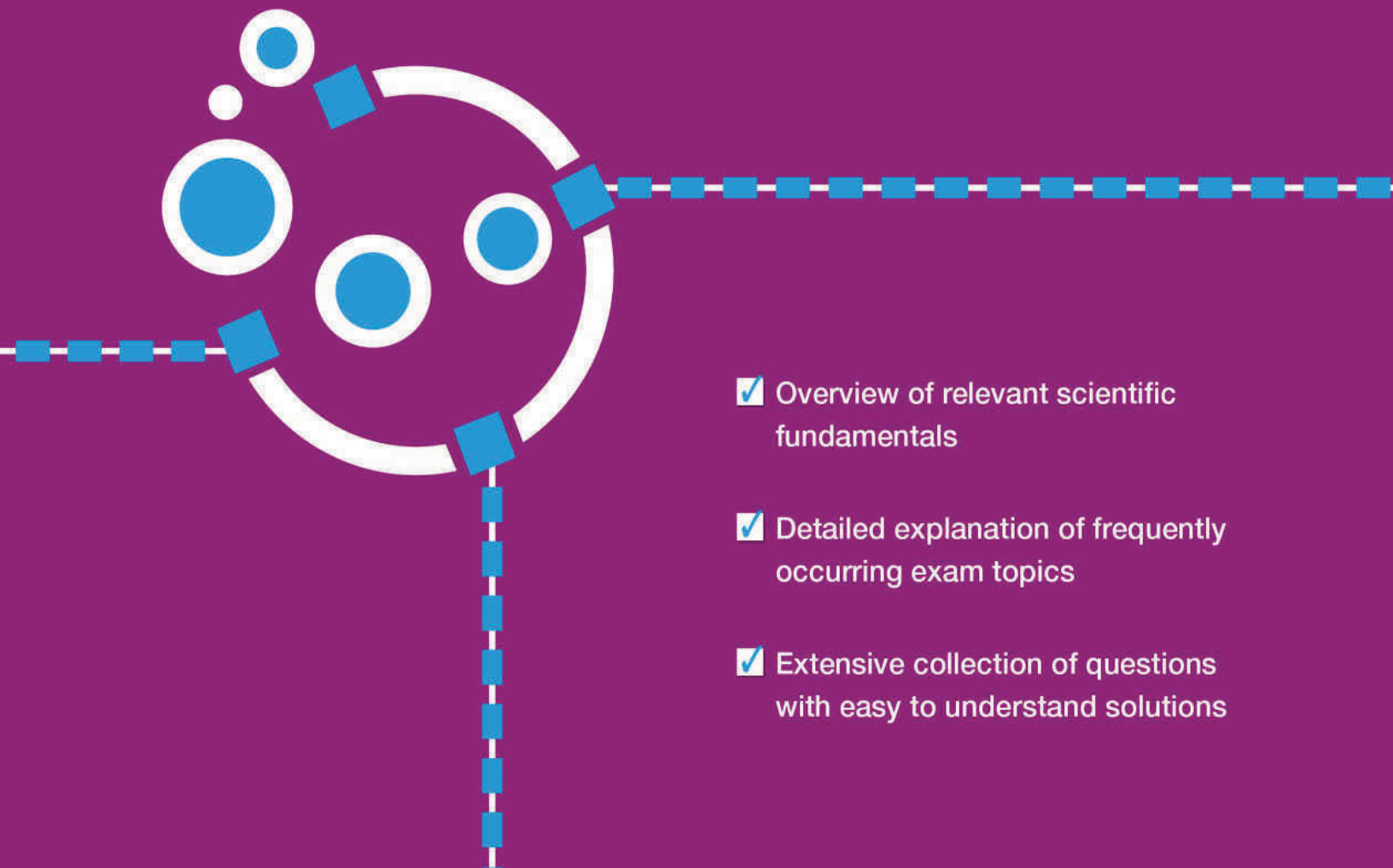
1. Preparation Book for the

TestAS

*Mathematics, Computer Science
and Natural Sciences*

Analyzing Scientific Interrelationships

2020



- ✓ Overview of relevant scientific fundamentals
- ✓ Detailed explanation of frequently occurring exam topics
- ✓ Extensive collection of questions with easy to understand solutions

ABOUT THE “MATHEMATICS, COMPUTER SCIENCE AND NATURAL SCIENCES” MODULE

1

The “Mathematics, Computer Science and Natural Sciences” module is relevant for students hoping to study subjects of natural science. Universities will specify which subject models are required for application to each of their programs. The module “Mathematics, Computer Science and Natural Sciences” is important for students perusing a degree in one of the following faculties:

- Medicine / Dentistry / Veterinary Medicine
- Psychology
- Pharmacology
- Mathematics
- Computer Science
- Biology
- Chemistry / Biochemistry
- Physics

If you are unsure which subject-specific test module is suitable for you, we encourage you to contact the university to which you would like to apply.

The subject module “Mathematics, Computer Science and Natural Sciences” consists of two subsections:

- 1. Analyzing Scientific Interrelationships (22 questions; 60 minutes)
- 2. Understanding Formal Depictions (22 questions; 85 minutes)

This book focuses on the preparation for the first subsection, “Analyzing Scientific Interrelationships” (we offer a separate book specific to the second subsection, “Understanding Formal Depictions”). In our experience, this section calls upon a basic knowledge in a wide-variety of subject areas. According to the authors of Test-AS, in-depth knowledge of high-school level science is not necessary. But knowing the topics will increase your speed and accuracy.

HOW SHOULD I PREPARE FOR THE TEST?

The entire TestAS exam consists of two parts: The first part is the Core Test (110 minutes), which every participant needs to take. The second part of the exam is a subject-specific module (145-150 minutes), dependent on the field of study that you have chosen.

The test covers a wide range of topics. We suggest that you first assess which sections are the most difficult for you (e.g., by going over the sample questions provided by the test authors or a practice test). Then start with these sections first. For example, if you are already good at chemistry and biology and feel insecure about physics, start with physics first.

If you are short on preparation time, at least skim through the questions in this book, focusing on the ones whose answer you do not know.

Additionally, below please find some more tips on preparation and the exam day.

General tips:

1. Familiarize yourself with the different types of questions and answers several weeks before the test day.

- The subtests “Analyzing Scientific Interrelationships” and “Understanding Formal Depictions” take some getting used to. In addition, the answer sheet and correction format on the answer sheet is different from common multiple choice exams.

2. Solve all questions in this book without a calculator or dictionary.

- As you will not have access to aids during the exam, it is best to prepare for the exam with the same conditions as the day you will take the exam.

3. Answer our practice questions under real test conditions (without distractions) and pay attention to the time constraints.

- The test is long and many students report difficulty concentrating towards the end. In order to build your stamina and train your concentration skills, you should practice by repeatedly simulating the conditions of the exam. We strongly recommend you practice with a timer; during this period, remove any distractions while solving our practice questions. These tips should help you identify common careless mistakes and limit them on test day.

4. You should begin preparing for the exam several weeks in advance.

- You will be able to successfully monitor your own progress and readiness if you complete the exercises conscientiously and without outside or inadmissible help.

Tips for a successful preparation:

1. Find out your areas of weakness and focus on these.

- Knowledge of the basic natural sciences phenomena, especially chemistry and physics, is necessary to solve some of the questions in this subtest. In-depth knowledge is not required. Given the wide breadth of topics covered in the TestAS, focus on your weaknesses first rather than perfecting what you already know well (even if this makes studying less fun). Detailed factual knowledge (such as memorizing formulas) is not necessary. You never liked the motion-time graphs? It is better to start learning them rather than spending valuable study time refreshing your knowledge of photosynthesis.

2. Review (only) the main concepts out of the full range of natural science topics.

- The test questions cover the full breadth of natural sciences: you'll find a lot of biology, chemistry and physics, but also less common subjects such as geology and astronomy. Such specialized questions are explained in detail in the exam, but with a language that is time consuming and difficult to decipher. A preliminary understanding of the main natural science topics will help you answer questions correctly and rapidly, even if your English is not perfect. Use our list of common topics as a starting point.

3. Get familiar with the different types of diagrams and tables.

- Almost every question in the exam will have an accompanying visual (e.g., table, diagram, drawing.) You need to know how to interpret the x and y axes and understand the legends and units of different charts. What does the area underneath the lines mean? What is indicated by a U-shaped, concave line? How are inversely proportional lines depicted? Additionally, you need to be able to read tables and understand and convert units. We have provided many examples for you to practice.

4. Strong language skills are key to your success.

- A lot of the questions are wordy and include heavy terminology, replicating the material which you will encounter in your university studies. Take the exam in the language (German or English) in which you feel most comfortable.

Tips for the day of the exam:

1.

- **Some seemingly highly technical questions are actually just math questions.** Some questions use a long text involving complex-sounding terminology, but answering it might only require that you simplify the given equation or interpret a graph. Look at the graph and use the available answer choices to guide you. Sometimes by plugging the answer choices into the graph you can derive the correct answer quickly.

2.

- **If you are stuck on a question, eliminate the obviously wrong answers using your common sense, and then guess.** There is no penalty for mistakes.

3.

- **Answer the easy questions quickly and proceed!** The questions are given to you in increasing order of difficulty. Some students become suspicious when seeing the no-brainer questions at the beginning and re-solve these. You have roughly 3 minutes per question. This may sound like a lot, but most questions are lengthy. Moreover, 1-2 exercises toward the end of the exam will stretch your mind: The necessary diagrams will be either missing or too vague, resulting in you having to draw them yourself. Save time for these tough questions.

4.

- **If you have had limited exposure to one of the topics of natural science, consider answering such questions at the end.** A sensible test strategy could be to first focus on familiar topics and to address less-familiar topics later. Let's assume that you have a B2 level of English and that your high school science classes were not in English. Moreover, you never took physics and you do not have much time to study physics before the exam. In this case, you will likely need quite some time to read the lengthy questions and visuals even on the topics familiar to you. You may consider doing the biology and chemistry questions first.

5.

- **Pay attention to the units.** Sometimes an actual value is given and a percentage change may be asked. Or a different unit may have been asked (question text describes the time in hours but answers need to be in minutes. Or the carbon dioxide rate is given, but the actual amount (which can be read in the graph) is asked.

6.

- **Beware of optical illusions.** Some charts start from a negative value or a much higher value. Always pay attention to what the x and y axis stand for and which range they show.

7.

- **Don't boil the ocean.** If a question asks for a “may be” or “may not be” solution, you are not looking for a conclusive answer. One plausible scenario is sufficient for it to be counted as a yes or no.

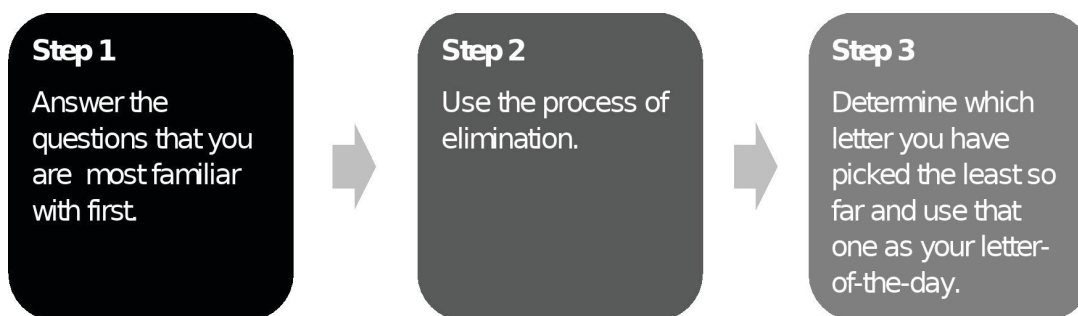
8.

- **Bring ample water and food with you.** Exam day is long and in many test centers, participants are not allowed to leave the test center until testing has concluded.

HOW TO GUESS?

Answer all questions – if you get stuck on one, guess after eliminating the obviously wrong answer choices. There is no penalty for incorrect answers.

We recommend the following approach to increase your likelihood of answering all questions and guessing effectively.



STEP 1: Answer the questions that you are familiar with first.

On the first pass, focus on those questions and skip questions that seem to require more thinking or that you need to read two or three times before you understand.

Circle questions that you skip so that you may easily identify them later on.

STEP 2: Use the process of elimination wherever possible.

Once you have gone through all the questions, go back to the ones that you skipped earlier. This two-round strategy might boost your self-confidence as you will see that – despite the skipped questions – you can still solve many questions correctly.

Use the process of elimination to rule out answer options that you know or believe are wrong. Mark these ruled-out answers clearly on the question sheet by crossing them out.

STEP 3: Determine which letter you picked the least so far and use that one as your letter-of-the-day.

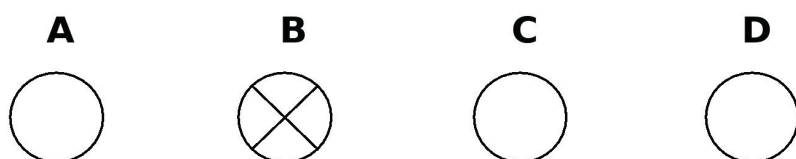
Determine which of the letters (A to D) you have selected the least on your answer sheet so far in that section. This will then be your letter-of-the-day (in past years each of the four answer letters were more or less equally often correct). Use that letter each time you guess (unless you have already eliminated this option). This will increase the likelihood of answering more questions correctly.

Skip step 2 if you are running out of time so that you have at least marked one answer for every question on the answer sheet.

HOW DO I ENTER MY ANSWERS ON THE ANSWER SHEET?

The questions of the core test and the subject-specific test modules are presented in a small exercise book. There is a **separate answer sheet** on which the answers must be marked with a ballpoint pen. Answers marked within the exercise book are not checked.

You must use a ballpoint pen with blue or black ink to select the answers. Do not use pencil. The selected answer must be marked with an X. In the example below, answer choice B has been selected.



In case you need to change an answer that you already marked, fill in the entire wrong circle and put an X in your new answer choice. In the example below, D is marked.



In the unlikely event that you would like to change your answer again, fill in the wrong circles and cross the correct answer. In the example below, C is marked.



If you change your mind again and you would like to re-enter an answer which you have already crossed out, you need to fill in the

wrong circles and manually write the correct letter (A, B, C, D) at the end of the answer row. In the example below, B is marked.



Take note that the answer sheets are evaluated by a computer, not a human, once the exam is finished. Because of this, we recommend that you try to avoid making multiple changes to your answer sheet.

Make sure that you have entered all answers in the answer sheet before the time runs out. After the end of the subtest, you will begin working on the next section and cannot return to the previous section. Remember that only the markings on the answer sheet, not the exercise book, will be counted in your exam score.

If you have difficulty with a specific question, do not spend too much time dwelling on it. Instead, use the process of elimination and try to guess. You are not penalized for wrong answers, so it is better to guess than to leave a question blank.

USEFUL TIPS FOR THE EXAM DAY

The test will take more than five hours. Make sure to bring adequate food and drinks to have enough energy for the duration of the test.

It is very important to get sufficient sleep the night before the exam. This may sound obvious, but it is certainly necessary as you will have to remain focused for several hours.

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ANALYZING SCIENTIFIC INTERRELATIONSHIPS	
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2

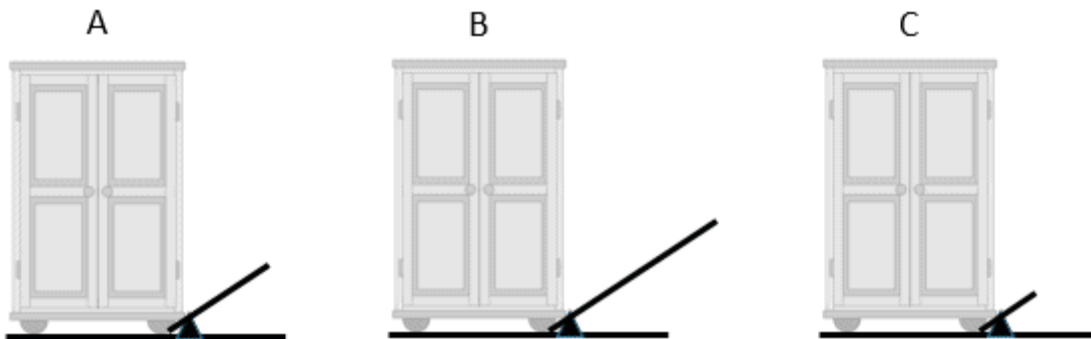
INTRODUCTION

The questions in the first subtest “Analyzing Scientific Interrelationships” are based on texts and illustrations dealing with topics in the natural sciences. This test measures your ability to draw sensible conclusions from the provided textual and visual information. The topics can be from the full breadth of natural sciences; however, most questions will target information commonly taught in high school sciences classes.

Let's look at three examples to illustrate the basic idea of the test:



EXAMPLE



Which lever would require the biggest force to elevate the cupboard?

- (A) Lever A
- (B) Lever B
- (C) Lever C
- (D) Same force is required for all levers.

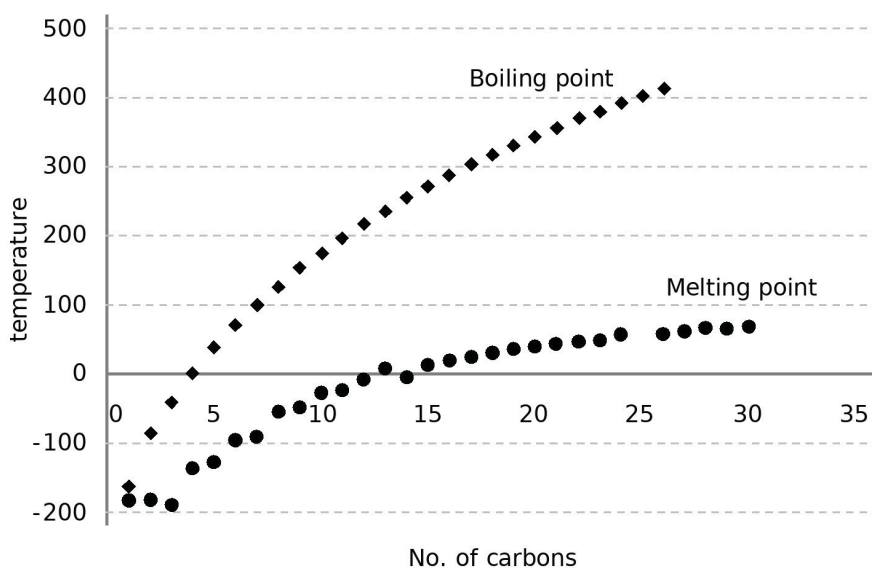
Answer: C

The longer the lever, the less force needed to elevate the cupboard. In other words, using the shortest lever will require the most force.



EXAMPLE

Alkanes are organic compounds consisting entirely of single-bonded carbon and hydrogen atoms and lacking any other functional groups. The boiling point and melting point of these compounds varies according to their size. Alkanes are highly combustible and are valuable as clean fuels. The graph below shows how boiling point and melting point vary with the number of carbon atoms in alkanes:



Pentadecane ($C_{15}H_{32}$) at $30^{\circ}C$ exists as...

- (A) Liquid
- (B) Solid
- (C) Gas
- (D) Cannot be determined.

Answer: A

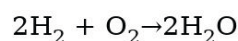
From the graph, it can be seen that for an alkane with 15 carbon atoms, the melting point is around $0^{\circ}C$ and the boiling point is

around 300 °C. Hence, the compound will be in a liquid state.



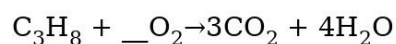
EXAMPLE

The changes that take place during chemical reactions are represented by chemical equations. For example:



This equation describes the reaction of hydrogen with oxygen to produce water. A balanced equation obeys the law of conservation of mass and, therefore, must have the same number of each kind of atom on both sides.

The combustion reaction (creating fire or heat) of propane (C_3H_8) and oxygen gives CO_2 and water.



This equation is only partially balanced. Fill in the missing coefficient next to O_2 .

- (A) 2
- (B) 3
- (C) 4
- (D) 5

Answer: D

To answer this question, you first must determine the number of oxygen atoms on the right side of the equation. The exact same number must then also be on the left side. Since oxygen appears as a molecule (O_2) on the left-hand side (two atoms), the value of the coefficient has to be divided by two:

$$3 \times \text{O}_2 + 4 \times \text{O} = 10 \text{ O - atoms} \Rightarrow 5 \times \text{O}_2$$

As these examples show, the test does not measure whether you have memorized complex formulae, the names of scientific laws, or the details of natural phenomena. Instead, it tests whether you have developed the ability to think through (i.e., whether you have the intuition for) the main concepts that are taught in different natural science classes.

THIS TEST IS ABOUT

- Understanding primary concepts in biology, chemistry, physics and geosciences (e.g., Kepler's law of areas) and how to apply these concepts to scientific problems (e.g., how does the volume of a metal change as it is being heated up?).
- Your ability to read the provided visuals (e.g., radioactive decay curve) and interpret them. (i.e., you do not need to already know about the radioactive decay curve, but knowing it would help).
- Your knowledge of a few of the most important scientific formulae (e.g., the acceleration formula applied on data from motion and time graphs).
- Your ability to understand a long description (with complex terminology) of a natural science phenomenon and your ability to apply this knowledge to answer the question (e.g., determining the stiffness of a spring after a detailed explanation of the Hooke's law).

THIS TEST IS NOT ABOUT

- Having detailed knowledge of natural sciences subjects (e.g., knowing the difference between mitosis and meiosis I, or the factors influencing the photosynthetic rate).
- Your ability to apply complex formulae without instructions (e.g., the solute potential of a solution).
- Memorizing terminology (e.g., torque).

According to the creators of TestAS, on the exam any relevant background information needed to answer questions will be provided to you. This is certainly true for many of the questions, but from our perspective you need to have an intuition for and should already have gained some preliminary knowledge about the topics on the exam. For example, how does the velocity change for a stone that has been thrown diagonally a net distance of 12 meters? To be able to answer such questions, you need to know the principles underlying gravitation and velocity.

Moreover, knowledge of the main formulae and natural phenomena will help you answer the questions more quickly. Students we interviewed generally agreed: if they already knew a topic, reading the lengthy text and complex visuals was quick and easy, and they were able to pick the right answer with confidence. For topics that they had not studied (e.g., astronomy, geology), they reported struggling and having to guess at the end. Studying these natural science topics beforehand certainly helps.

HOW CAN YOU PREPARE FOR THIS SUBTEST?

The subtest covers a very broad range of topics, including questions about specific science phenomena. However, the more common, general topics are of greater importance to understand. It is important to assess what you know, and first tackle your areas of weaknesses before moving on to the areas with which you feel most comfortable. For instance, if you have taken mostly natural sciences classes in high school, you might start with the subject with which you have the least amount of confidence, let's say physics. In this case, you might already have a good base in chemistry and biology, enabling you to comfortably answer related questions.

In view of this, you need to focus your preparation, identifying your weak spots and studying accordingly:

- Did you take biology, chemistry, physics and geosciences in high school? The test has questions from all four subjects. If you feel weak in any of these, we recommend that you read an upper high-school level course book. While reading, focus on the main concepts (usually summarized in the chapter overviews at the end of each section.) Additionally, look at all the visuals (diagrams, tables, pictures) and become familiar with these. There is no need to study the details of the topics.
- While solving the questions in this book, with which topics do you struggle the most? Make a list of these topics and study these using high school textbooks. Again, focus especially on the visuals. (In the exam, almost all questions have a visual. In some cases, the visual may be redundant, but in most cases, understanding the visual is necessary to answer the question.)
- With which of the main concepts below are you not familiar? If you feel weak on a topic, it could be worth refreshing your knowledge on this.

THE MAIN CONCEPTS

As already mentioned, the exam can address all topics from high school biology, chemistry and physics. It therefore may be beneficial to go through high school textbooks on these subjects and to build up a basic knowledge (if you have the time to do so).

Below we list common topics. This list does not cover all topics taught in high school courses, but lists only the topics that have often been addressed by TestAS in recent years.

If you have very little time, it is advisable to skip straight to doing the practice questions and not spend time on theoretical review. However, if you start early enough, work through our main concepts and augment this by looking at high school textbooks

! We marked topics that were particularly common in the past with an exclamation mark. Even if the topics are partially explained within the question prompt, it is of great advantage (allowing for better use of the limited test time) to go into the exam with a solid understanding of these topics.

PHYSICS

Mechanics

- Kinematics
- Newton's laws and forces
 - Newton's laws
 - Gravitation
 - Free fall

- Normal force
- Spring Scale
- Pendulum

Thermodynamics

- Important quantities and units
- Heat and Energy
- States of Matter
 - Abnormal properties of water—ice
- Gases
 - Ideal and real gases
- Hydrometer

Astronomy

- Kepler's laws
- Using the sun to determine direction

The difference between physical and chemical change.

BIOLOGY

- Mendel's law of inheritance
- Blood types
- Photosynthesis

CHEMISTRY

- Alkane

PHYSICS

MECHANICS

KINEMATICS

Kinematics describe in a mathematical way how bodies move in space. Sometimes called geometry of motion, you will find that most kinematics problems are presented in terms of the position, time, velocity and/or acceleration of a moving object. In the following section, we'll explain some additional important concepts which you will need to understand to do calculations and to interpret graphs.

Past tests have included several questions (especially diagrams) on the subject of kinematics. As such, we provide ample opportunity to practice and prepare for these questions. In the task set, you will find sample tasks with solutions.



Distance – time graph:

Distance-time graphs are the most common graph used to test subject of kinematics; you need to know how to interpret these graphs. What does the area under the curve mean? What is negative speed? How does constant acceleration affect speed? How do you calculate the distance from the starting point and the total distance covered using these graphs?

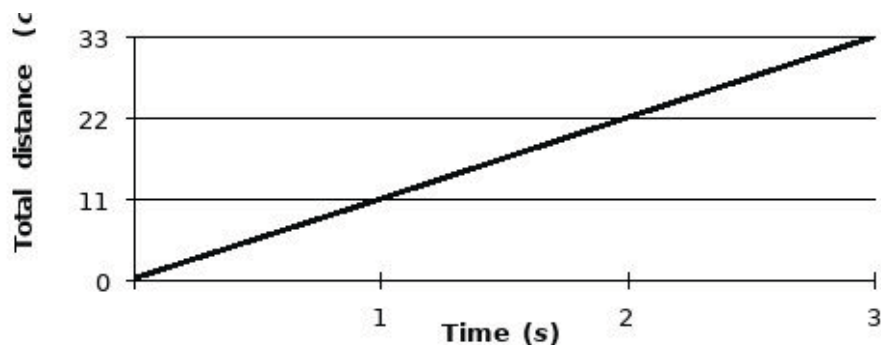


EXERCISES

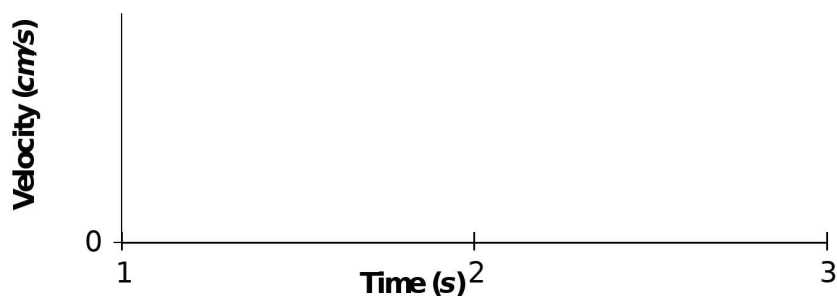
a) This example looks at an object that moves in slow motion.

Interval distance (cm)	Total distance (cm)	Total time (s)	Average interval (cm/s)
11	11	1	11
11	22	2	11
11	33	3	11

This graph shows that the object moves the same distance in equal time intervals i.e. constant velocity (constant slope).



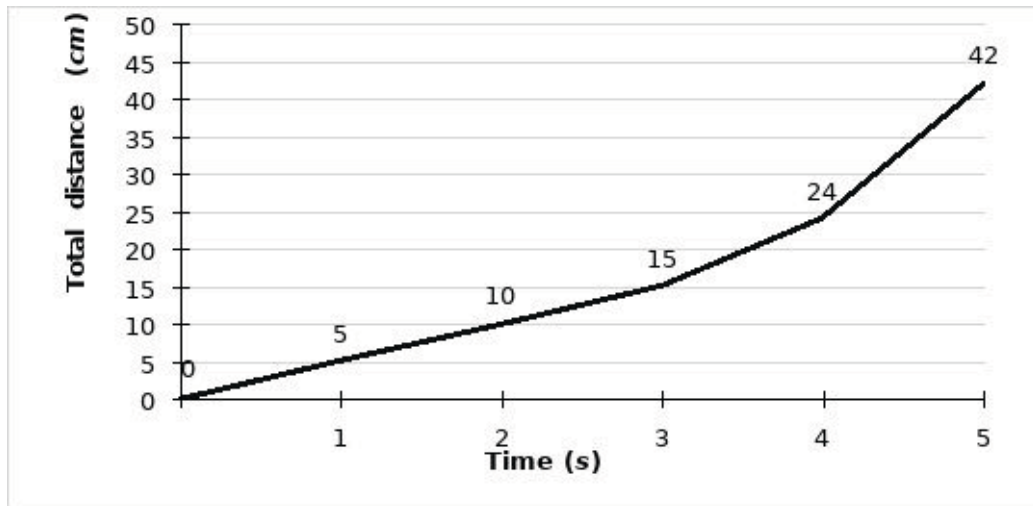
Please draw a graph showing that the object moves at the same rate (velocity) at all times and calculate the acceleration.



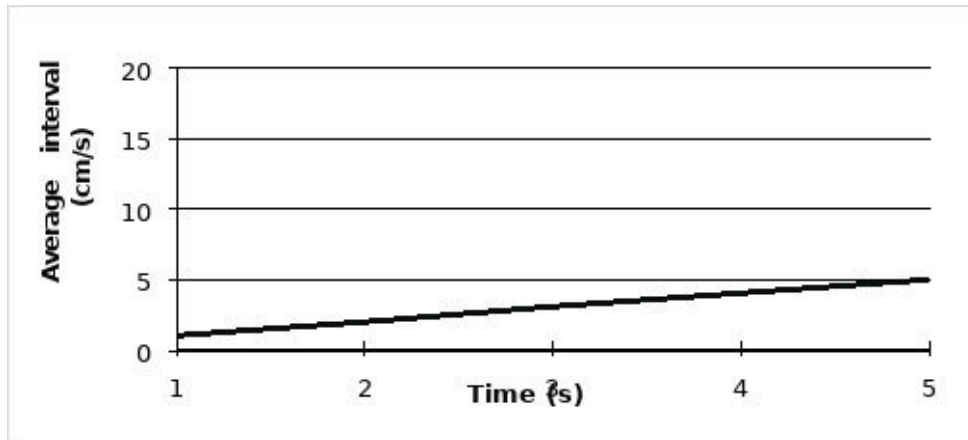
b) This example examines an object that is speeding up.

Interval distance (cm)	Total distance (cm)	Total time (s)	Average time interval (cm/s)
5	5	1	5
5	10	2	5
5	15	3	5
9	24	4	9
18	42	5	18

The table above and the following graph show an object that moves at a constant speed for the first 3 seconds. After that, the velocity increases (steeper slope) and more distance is covered per second.



Draw a graph that represents the speed of the object described above.

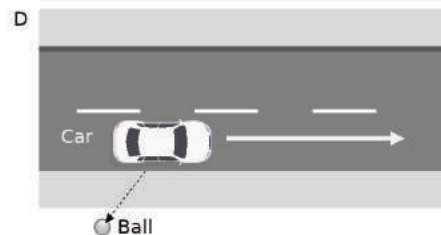
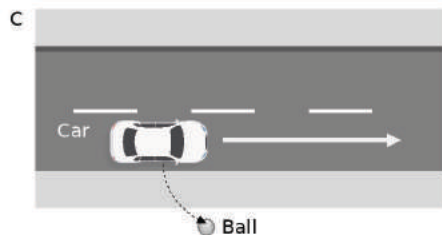
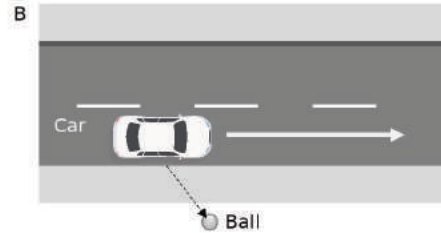
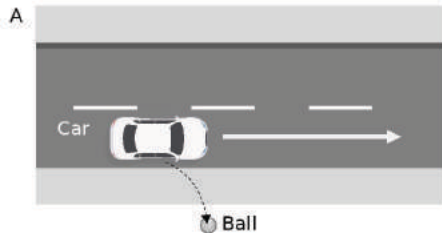


c) A ball is rolling down from a roof. Which of the following is true, if we assume that $F_G = m \cdot g$ for gravitation?

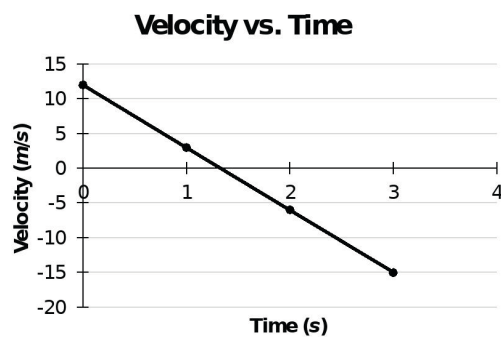
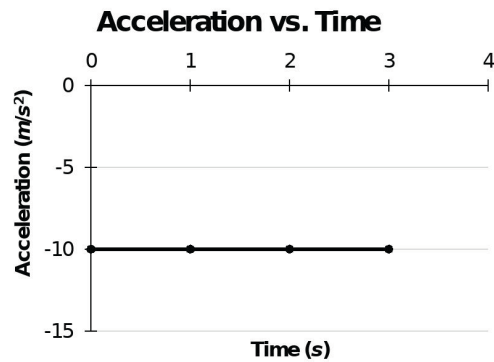
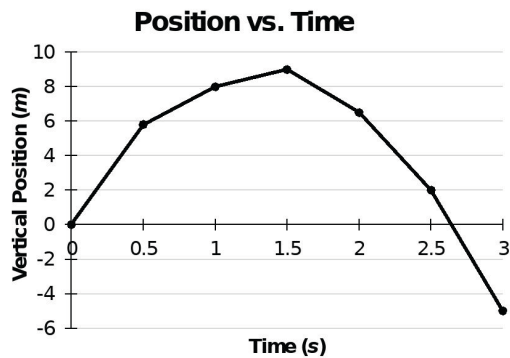
- I. The heavier the ball, the greater is its acceleration.
- II. If there is no air resistance, the speed of the ball would increase until it hits the ground.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

d) A ball is thrown out of the passenger window of a car which is moving to the right. If the ball is thrown perpendicular to the direction of travel of the car, which of the following illustrations best describes the path of the ball? To simplify matters, air resistance can be neglected.



e) Use the graphs below to answer the following questions:



e1) The object is:

- (A) falling.
- (B) being thrown up in the air.
- (C) first thrown in the air and then falling.
- (D) falling and hits the ground; bounces and goes to its initial falling position.

e2) According to the graphs, what is the acceleration experienced by the object?

(A) -10 ms^{-2}

(B) -10 ms^{-2}

(C) -15 ms^{-2}

(D) 8 ms^{-2}

e3) At second 3, please describe:

(A) The position of the object

(B) The velocity of the object

(C) The acceleration of the object

e4) What distance does the object travel?

(A) 16 m

(B) 20 m

(C) 21 m

(D) 23 m

e5) True or false?

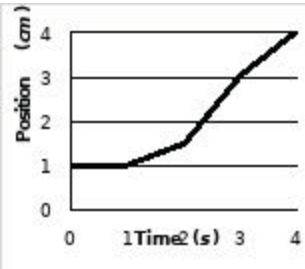
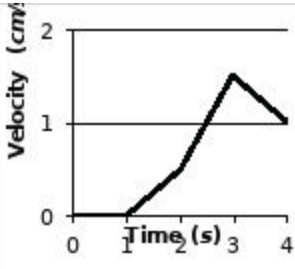
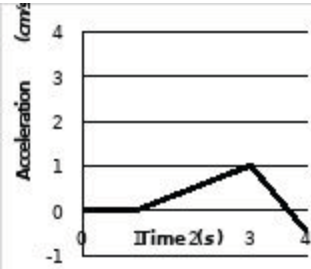
(A) The velocity of the object is constant.

(B) The acceleration of the object is constant.

(C) The object continually increases in velocity and never stops.

(D) The object lands 5 m below the initial starting position.

f) Use the graphs below to answer the following questions.

	Position-time graph	Velocity-time graph	Acceleration-time graph
			
1)	Where is the object in 0.5 s?	How fast is the object moving at 1 s?	What is the acceleration of the object at 2 s?
2)	Where is the object in 2 s?	How fast is the object moving at 3 s?	What is the acceleration of the object at 4 s?
3)	Where is the object in 3 s?	What is the value and meaning of the area beneath the graph between 0 s and 2 s?	What describes the slope of the graph?
4)	What is the value and meaning of the slope from 0 s to 1 s?	What is the value and meaning of the area beneath the graph between 2 s and 4 s?	What is the area under the graph between 1 and 2 seconds; what physical value describes the area below the graph?
5)	What is the value and meaning of the slope from 1 s to 2 s?	What is the value and meaning of the slope between 0 s and 1 s?	What is the area under the graph between 1 and 3 seconds and what physical shape describes the area below the graph?

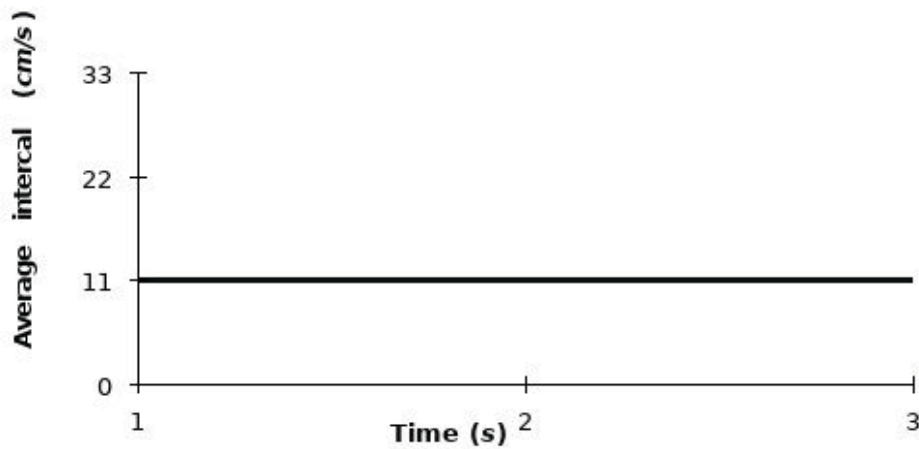
	Position-time graph	Velocity-time graph	Acceleration-time graph
6)	What is the value and meaning of the slope from 2 s to 4 s?	What is the value and meaning of the slope between 2 s and 4 s?	

Please enter your answers on the next page.

	Position-time graph	Velocity-time graph	Acceleration-time graph
	Position-time graph: The y-axis is Position (cm) from 0 to 4. The x-axis is Time (s) from 0 to 4. The graph starts at (0,1), is horizontal until t=1, then increases linearly to (4,4).	Velocity-time graph: The y-axis is Velocity (cm/s) from 0 to 2. The x-axis is Time (s) from 0 to 4. The graph is at 0 until t=1, then increases linearly to (3,1.5), and finally decreases linearly to (4,1).	Acceleration-time graph: The y-axis is Acceleration (cm/s²) from -1 to 4. The x-axis is Time (s) from 0 to 4. The graph is at 0 until t=1, then increases linearly to (3,1), and finally decreases linearly to (4,-1).
1)			
2)			
3)			
4)			
5)			
6)			

SOLUTIONS

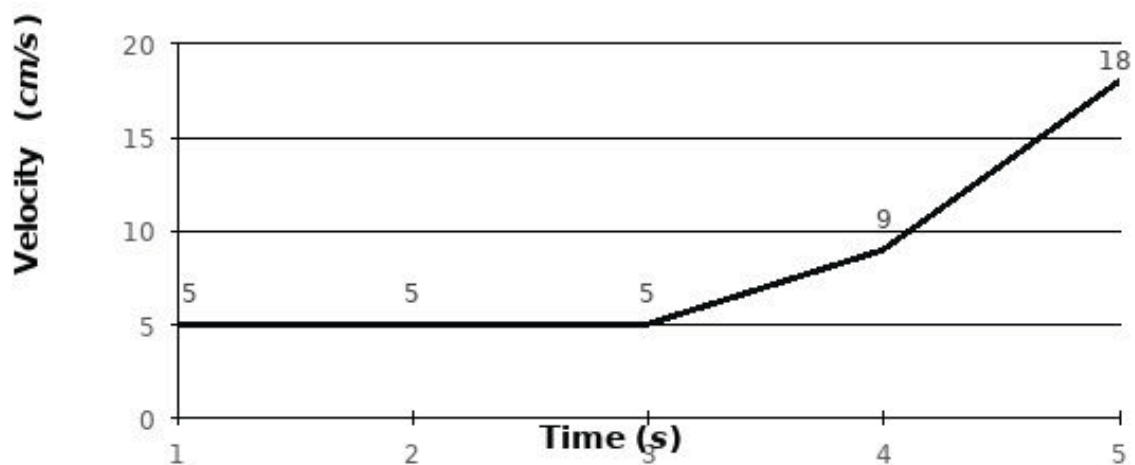
a)



The slope of the graph, which indicates speed as a function of time, indicates that the acceleration:

$$a = \frac{\Delta v}{\Delta t} = \frac{11 \text{ cm/s} - 11 \text{ cm/s}}{3\text{s} - 0\text{s}} = 0 \text{ cm/s} = \text{no acceleration}$$

b)



The slope of the graph is:

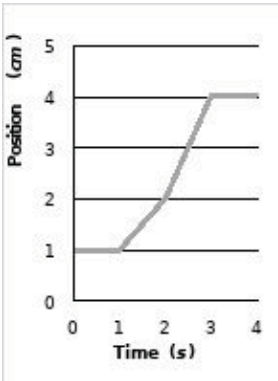
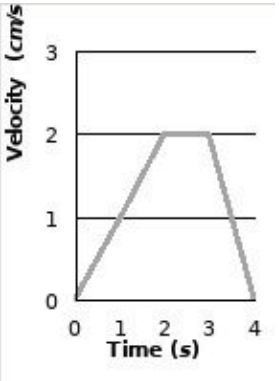
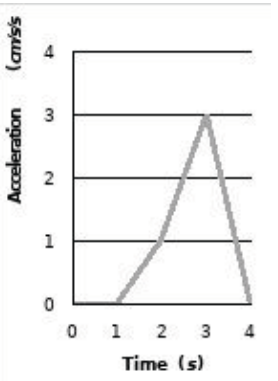
$$a = \frac{\Delta v}{\Delta t} = \frac{5 - 5}{3 - 0} = 0 \text{ in the first 3 seconds}$$

$$= \frac{9 - 5}{4 - 3} = 4 \text{ cm/s from 3 s to 4 s}$$

$$= \frac{18 - 9}{5 - 4} = 9 \text{ cm/s from 4 s to 5 s}$$

The acceleration increased from 0 cm/s^2 to 4 cm/s^2 , and then to 9 cm/s^2 .

In summary, we can infer the following information from the different graphs:

Types of graphs	Position-time graph	Velocity-time graph	Acceleration-time graph
			
Direct Reading	Object's position at a given time	Object's velocity at a given time	Object's acceleration at a given time
Slope	Velocity of the object within a given time interval	Acceleration (change in velocity) of the object within a given time interval	Change in acceleration of the object within a given time interval

Types of graphs	Position-time graph	Velocity-time graph	Acceleration-time graph
Area beneath the graph	—	Displacement (change in position) of object within a given time interval	Change in velocity within a given time interval

c) Answer: B

Statement I: The acceleration of the ball is not dependent on its mass. Acceleration on earth is always appr. $g = 9.81 \text{ m/s}^2$. This statement is not correct.

Statement II: Without air resistance the ball would continue to accelerate until it hits the ground. The statement is correct.

d) Answer: B

The velocity of the ball is will be the sum of the velocity of the car and the velocity of the ball. This is how B represents the correct path of motion.

e)

e1) Answer: C

e2) Answer: A

e3)

(A) The object lands 5 m below its original starting position.

(B) The velocity of the object is -15 m/s , indicating that the object has a speed of 15 m/s in the negative direction.

(C) The acceleration of the object is -10 ms^{-2} .

e4) Answer: C

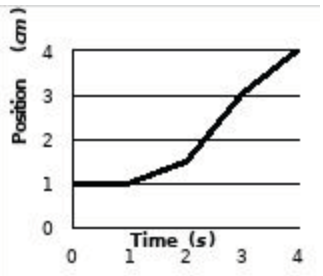
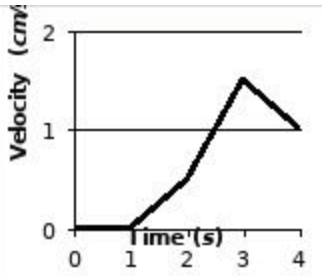
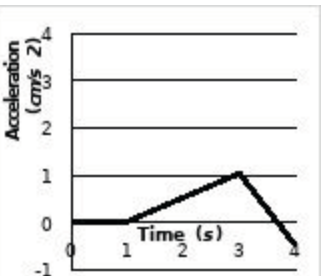
e5)

(A) False

(B) True

(C) False

(D) True

	Position-time graph	Velocity-time graph	Acceleration-time graph
f)			
1)	0 cm from the starting point.	0 cm/s	From the graph, we see the acceleration is -0.5 cm/s^2
2)	0.5 cm from the starting point.	1.5 cm/s	Again, the acceleration-time graph shows the acceleration at 4 s is 0.5 cm/s^2
3)	2 cm from the starting point.	The area under the velocity-time graph is the displacement. It can be calculated: $A = \frac{0.5 \frac{\text{cm}}{\text{s}} \times 1 \text{ s}}{2}$ $= 0.25 \text{ cm}$	The slope indicates the change in acceleration depending on the time.
4)	The slope of the position-time graph is the velocity. It can be calculated: $v = \frac{1 \text{ cm} - 1 \text{ cm}}{1 \text{ s}}$ $= 0 \text{ m/s}$	The slope is the change in velocity, i.e. it indicates the acceleration. It can be calculated: $a = \frac{0.5 \frac{\text{cm}}{\text{s}}}{1 \text{ s}} = 0.5 \text{ cm/s}^2$	The area under the graph (the integral of the acceleration) is the change in velocity. It can be calculated: $A = v = \frac{0.5 \text{ cm/s}^2 \times 1 \text{ s}}{2}$ $= 0.25 \frac{\text{cm}}{\text{s}}$

	Position-time graph	Velocity-time graph	Acceleration-time graph
5)	The slope is the velocity. $v = \frac{0,5\text{cm}}{1\text{s}} = 0,5 \text{ cm/s}$	The slope is the acceleration: $a = 0$	The area under the curve is how much the velocity has changed: $A = v = \frac{1 \frac{\text{cm}}{\text{s}^2} \times 2 \text{ s}}{2} = 1,0 \frac{\text{cm}}{\text{s}}$
6)	The slope is the velocity: $v = \frac{2,5 \text{ cm}}{2\text{s}}$ $= 1,25 \text{ cm/s}$	The slope is the acceleration: $a = \frac{0,5 \frac{\text{cm}}{\text{s}}}{2\text{s}}$ $= 0.25 \text{ cm/s}^2$	

NEWTON'S LAWS AND FORCES

- 1. Newton's Law – Inertia:** An object remains at rest or in a uniform, linear movement as long as the sum of the forces acting on it is zero.

An object at rest therefore remains at rest if no external forces act on it. An object moving at a constant speed continues to move at a constant speed if no external forces act on it. In everyday life, frictional forces often act as external forces that slow down an object that is in motion.

- 2. Newton's law –** If a force F acts on a body of mass m , it experiences an acceleration a in the direction of the force.

F = Force on the object
 m = Mass of the object
 a = Acceleration
 $F = m \times a$

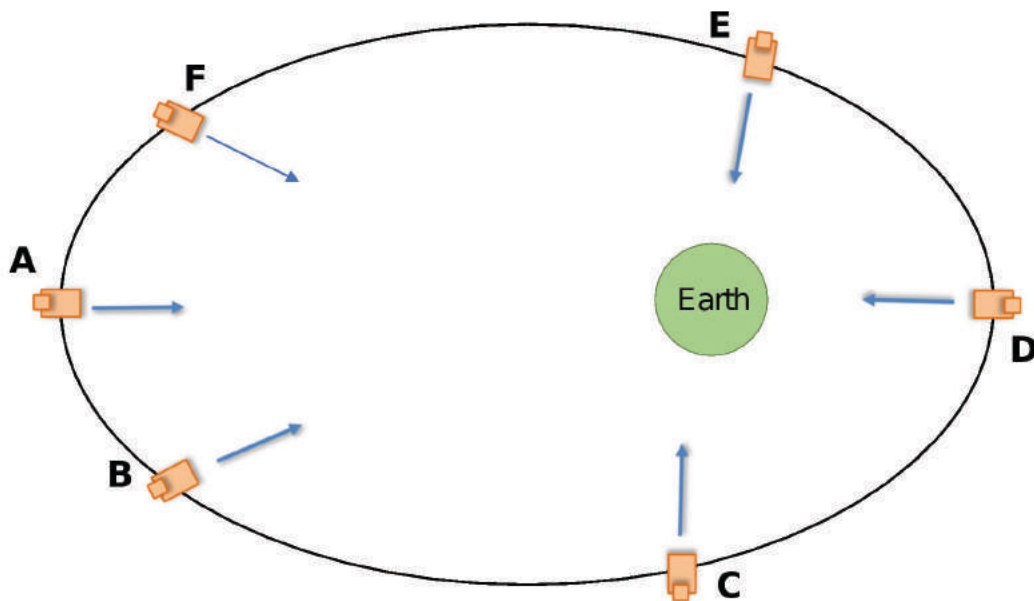
3. Newton's Law – Every action has an equal and opposite reaction: If two objects interact, an equal and opposite force acts on each object. The forces are the same magnitude and act in the opposite direction ($\vec{F}_{AB} = -\vec{F}_{BA}$). A classic example is tug of war. Another example is centripetal force: If an object moves in a uniform circular path, a force pointing inwards to the center of the circle must act on the object. This is called centripetal force (see appendix below).



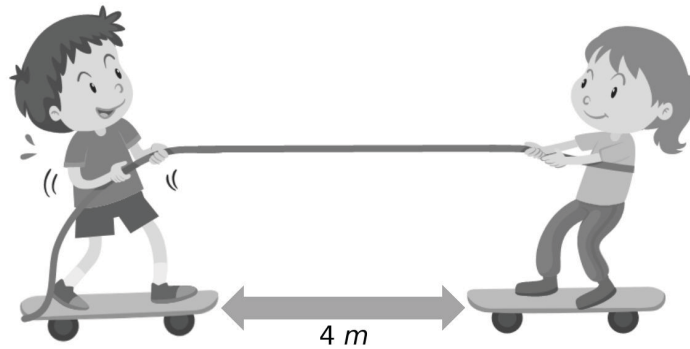
GOOD TO KNOW

1. Newton's Law – What keeps satellites in orbit?

Satellites continue to orbit the earth because the force of gravity always is perpendicular the movement of the satellite. The arrows in the following illustration illustrate the gravitational force acting on the satellite. Because the satellites vary in their distances from the Earth, the magnitude of the gravitational force differs at the individual positions. Gravitational force here is considered a centripetal force because it acts towards the center of movement and forces the satellite to move in a circular path. Also, since satellites are in space, air resistance does not slow them down. If the velocity of the satellite is high enough, it will continue move. This is Newton's first law: An object experiencing an equilibrium of forces (sum of all forces = 0) will maintain its speed and direction of movement (velocity). In reality, the orbits are never circular, but always elliptical.



3. Newton's Law – Tug of war

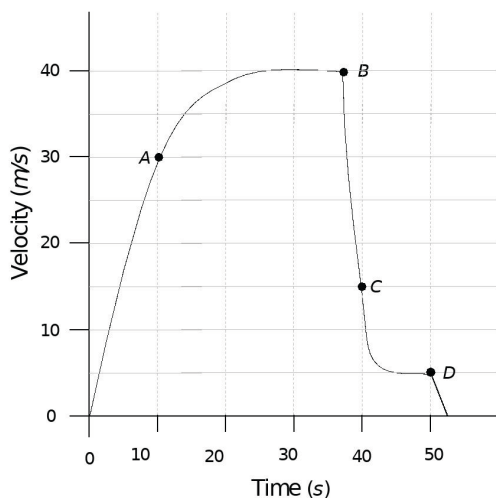


Newton's third law describes the principle of interaction between objects. If two objects interact, a force of the same magnitude and opposite direction acts on both objects. The principle of counteraction is summarized by the formula “ $\text{actio} = \text{reactio}$ ”.



EXERCISES

- a) The speed-time graph below describes a person jumping out of a plane and parachuting to the ground.



- a1) At which point does the person open his parachute?

- (A) A
- (B) B
- (C) C
- (D) D

- a2) At which point is the person free falling without the parachute deployed?

- (A) A
- (B) B
- (C) C
- (D) D

a3) At which point is the person free falling with the parachute fully deployed?

(A) A

(B) B

(C) C

(D) D

a4) What is the terminal velocity after the parachute is deployed?

(A) 5 ms^{-1}

(B) 10 ms^{-1}

(C) 20 ms^{-1}

(D) 40 ms^{-1}

a5) How long does it take the person to deploy the parachute after jumping out of the plane?

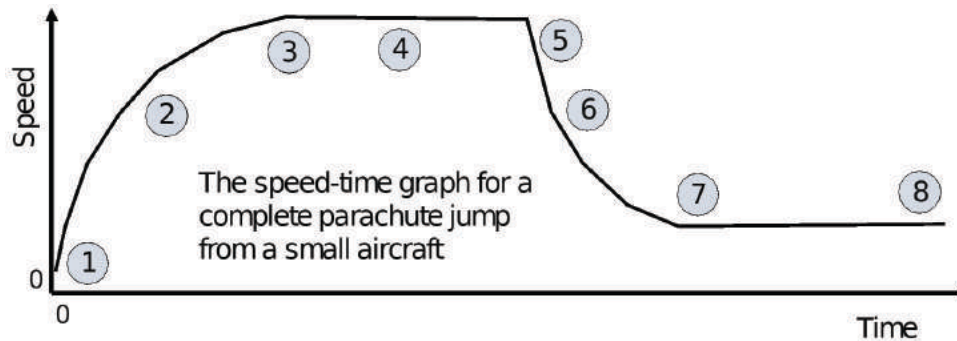
(A) 15 s

(B) 35 s

(C) 40 s

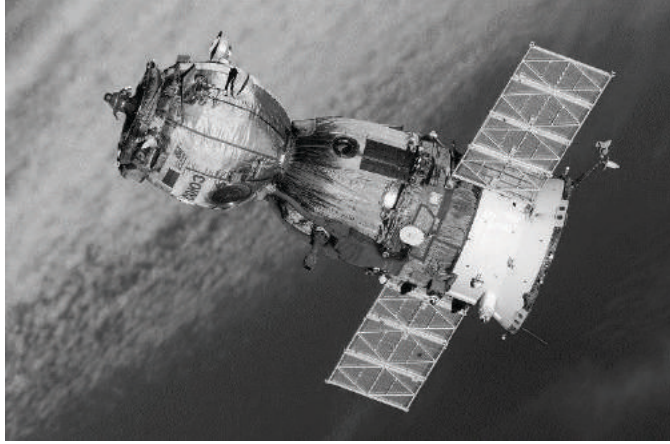
(D) 55 s

- b) Describe the labelled points on the following speed-time graph of a complete parachute jump from a small aircraft.



Point in time	Description (e.g., what forces act on the falling person? What is the velocity compared to other times? How big is the force of air resistance compared to weight?)
1	
2	
3	
4	
5	
6	
7	
8	

- c) The “Soyuz” weather satellite was launched into space by a rocket in 2018. It helps obtain precise data for the weather forecast. Which of the following applies?



- I. If gravity were to suddenly stop, the satellite would crash into the earth.
 - II. If the satellite were sped up or slowed down, it would launch off into space or fall into the earth.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

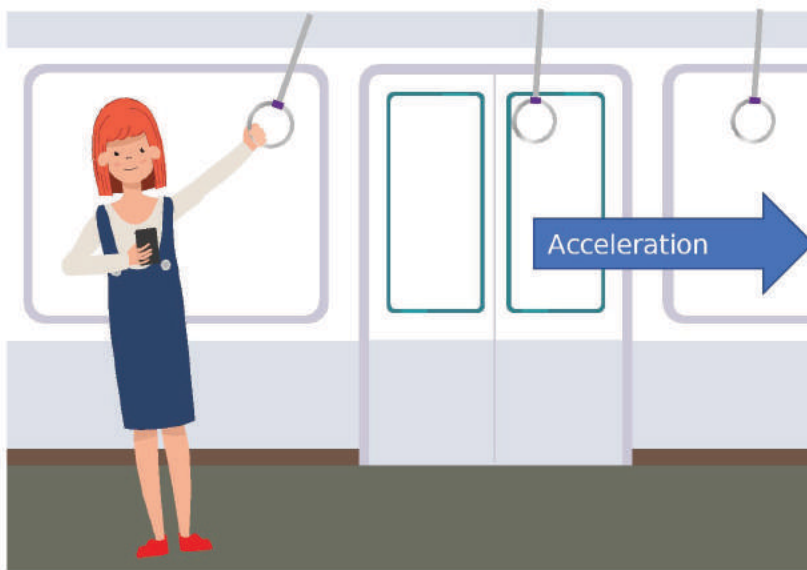
- d) Larry and Lisa play a game of tug-of-war. Larry weighs 90 *kg* and Lisa weighs 45 *kg*. (Assume that the mass of the rope is negligible and that it is perfectly horizontal.) Which of the following statements is or are correct?

- I Larry exerts a greater force on the rope than Lisa.
 - II. Larry and Lisa exert the same force on the rope.
- (A) Only statement I is correct.
(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

- e) Inertia is the tendency of matter to continue to move uniformly or to remain at rest unless an external force acts on it. A bus drives west on the street, and suddenly it brakes hard. In which directions do the bus and passengers move when the bus breaks?



(A) Passengers: West – Bus: West

(B) Passengers: East – Bus: South

(C) Passengers: West – Bus: East

(D) Passengers: South – Bus: West

SOLUTIONS

a)

a1) Answer: B

a2) Answer: A

a3) Answer: C

a4) Answer: A

a5) Answer: C

b)

b1)The person starts to fall. The main force acting on the object is gravity (the force of air drag is still relatively small at this point). The person accelerates.

b2)As the person's speed increases, the force of air drag increases, so their overall acceleration decreases. The speed is still increasing, just more slowly than before.

b3)Eventually, the air drag equals the weight and the person reaches their terminal velocity.

b4)The person is travelling at a constant velocity.

b5)The person opens their parachute. The parachute has a large surface area, so the air drag increases and their speed decreases rapidly.

b6)As their speed decreases, the force of air drag decreases, so the speed decreases less rapidly.

b7)The air drag and weight are once again balanced, so the parachutist reaches a new terminal velocity.

b8)The person travels at this constant velocity.

c) Answer: B

If gravity were to suddenly stop, according to Newton's first law, the satellite would continue to move in the same direction it was traveling. Since the velocity of the satellite is always tangent to its orbit, it would continue to move along this straight-line path. Statement I is therefore incorrect.

A satellite stays in orbit because the downward motion of gravity is balanced by the straight-line horizontal trajectory (i.e., which is tangent to the circle) of the satellite. But the satellite never actually falls into the earth because, in the absence of air resistance, its horizontal speed is maintained. Were it somehow slowed down, the satellite would fall into the earth, and vice versa. Statement II is therefore correct.

d) Answer: B

According to Newton's third law, Larry and Lisa exert the same force on the rope. Statement I is incorrect because, although Larry is (possibly) stronger than Lisa and is heavier than Lisa, he cannot exert a greater force on her. Larry might win, however, because he is able to push harder on the ground than Lisa can. In other words, his larger mass would be balanced by a larger normal force, creating more friction.

e) Answer: A

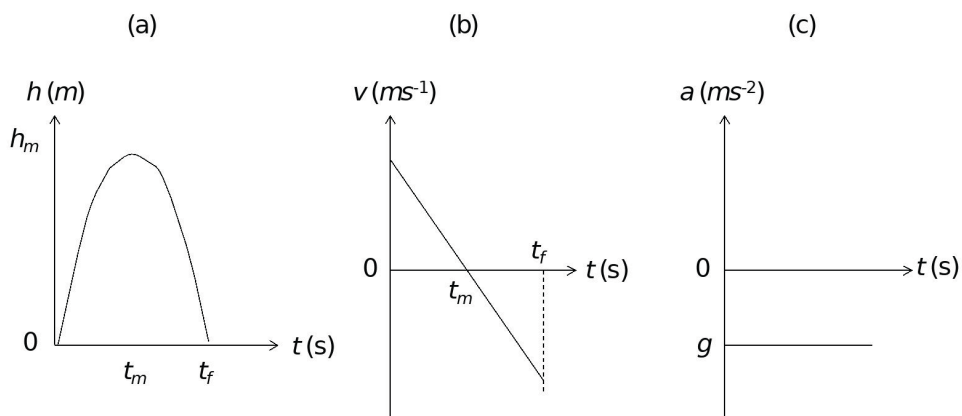
Before braking, the bus and passengers are moving in exactly the same direction. After braking, the passengers will behave according to the law of inertia, continuing to move forward.

GRAVITY

Gravity is the force of attraction between two objects, dependent on their masses. The gravitational acceleration of a free-falling object on the surface of the earth is always -9.8 m/s^2 .

The force of gravity on Earth is always acting downwards because the Earth is so much more massive than we are.

The following graphic and table show the kinematics of a perpendicular throw, where an object is thrown from $h = 0$ up in the air to a maximum altitude h_m . Due to gravity, the direction of the movement changes at h_m (at the time t_m), and the object falls back to the earth. When this happens, the direction of the velocity changes, too. During the whole process, the gravitational acceleration g affects the movement of the object.



Time interval	Distance-time graph (a)	Velocity-time graph (b)	Acceleration-time graph (c)
$0 - t_m$	Object is being thrown from the original position ($h = 0$) to a height ($h = h_m$).	Object is being thrown upwards with a starting velocity $v(t_0)$. When the object reaches the maximum height ($h = h_m$), $v = 0$.	At all times, the object experiences acceleration due to gravity, g , which has a value of -9.8 ms^{-2} .
$t_m - t_f$	Object is falling from a height ($h = h_m$) to its original starting position ($h = 0$).	The object is falling with an initial velocity ($v = 0$) and increases in velocity until its final velocity $v(t_f)$ right before it reaches the ground. Note that the velocity is negative, indicating that the object has changed direction.	Its value is negative as acceleration due to gravity always acts towards the ground.

Air drag

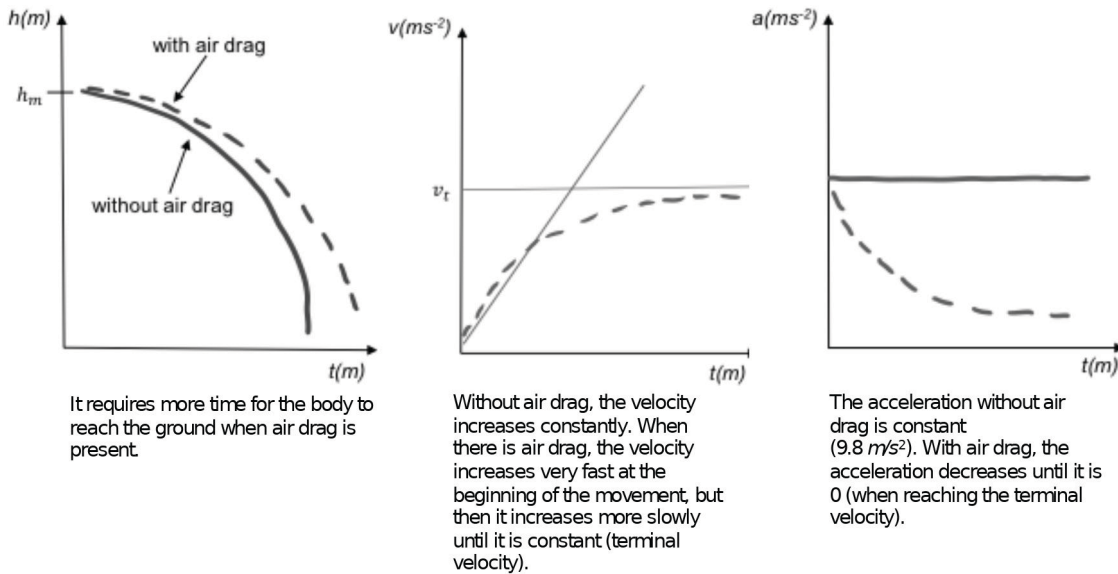
The two main factors that affect the air drag on an object are 1) the speed of the object and 2) the surface area of the object. The greater the speed and surface area of the object, the greater the air drag experienced by that object.

The force due to drag acts opposite to the object's direction of movement. For example, if the object is falling, the force due to air drag would be upwards, and vice versa.

Terminal Velocity

While an object is falling, the force due to gravity and the force due to air drag can become equal, given sufficient distance between the ground and the start of the fall. This will cause the object to stop accelerating and fall at a constant velocity called the terminal velocity. The acceleration acting on the object is not constant, but decreases continuously during the course of movement until reaching 0, when the final and constant velocity is reached.

The following graphs show the effects of air drag on the free fall (starting at the height h_m) of a body):



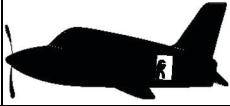
After having reviewed the ideas of gravity, air drag and terminal velocity, we'd like to show you a set of example questions to test your knowledge and understanding on your own.

Of course, in the official TestAS, your knowledge of the topic "kinematics" is only checked with a few questions, not a complete test. Nevertheless, completing the following exercises will expose and prepare you for these questions.

! FREE FALL

On past tests, questions about free fall were regularly asked. Below you will find a brief overview of these questions and several examples.

The table below describes the parachute jump of a person weighing approx. 61 kg.

					
Active Forces	Immediately after the jump, only weight affects the jump.	During free fall, the air resistance counteracts the weight.	The air resistance finally balances the weight. The max speed is reached, and the parachutist falls at a constant speed.	When the parachute is opened, the air resistance increases and the fall is slowed down.	As soon as both forces are in balance, the final speed is reached.
Force F	 600 N	 600 N Increase to 600 N	 600 N 600 N	 600 N Increase to 900 N	 600 N Decrease to 600 N
Acceleration a	$9.8 \frac{\text{m}}{\text{s}^2}$	From $9.8 \frac{\text{m}}{\text{s}^2}$	$0 \frac{\text{m}}{\text{s}^2}$	$-37 \frac{\text{m}}{\text{s}^2}$	From $-37 \frac{\text{m}}{\text{s}^2}$ to

		$\frac{\text{m}}{\text{s}^2}$			$\frac{\text{m}}{\text{s}^2}$
		to 0			0
Velocity v	$\frac{\text{m}}{\text{s}}$	From 0	$\frac{\text{m}}{\text{s}}$	$\frac{\text{m}}{\text{s}}$	$\frac{\text{m}}{\text{s}}$
	0	$\frac{\text{m}}{\text{s}}$ to 50	50	30	10
		$\frac{\text{m}}{\text{s}}$			

**EXAMPLE**

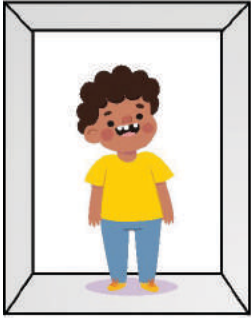
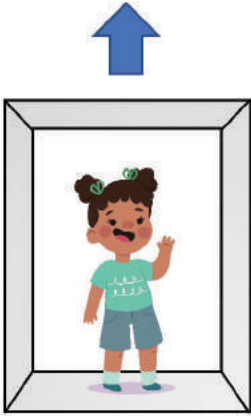
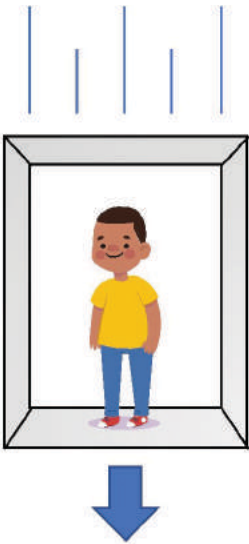
A skydiver, 33 years old and weighing 61 kg, completes a test jump for NASA, which wants to collect data about the free fall. Which of the following is true?

- I The skydiver experiences a greater upward force at the post-parachute top speed (10 m/s) than at the original top speed (50 m/s).
 - II. The downward force she experiences is constant throughout the jump.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Statements I and II are correct.
(D) None of the statements are correct.

Answer: B

Since the parachutist's body weight does not change throughout the fall, the downward force she experiences is a constant $61 \text{ kg} \times 9.8 \text{ m/s}^2 = 600 \text{ N}$. At the top speed, when the acceleration is zero, the upward force must be also 600 N. This applies to a top speed of 10 m/s and 50 m/s.

NORMAL FORCE

			
Stationary elevator Apparent weight = Normal weight Acceleration: 0 m/s^2	Elevator going up Apparent weight > Normal weight Acceleration: 50 m/s^2	Elevator going down Apparent weight < Normal weight Acceleration: 5 m/s^2	Elevator falling down Apparent weight = 0 Acceleration: 9.8 m/s^2

The apparent weight of an object is the actual weight of an object plus the influence of another accelerating force besides gravity. For example, a woman standing on the earth has a certain mass that, under the influence of gravity, corresponds to an actual weight that can be measured with a scale. Normally, the weight of that woman is balanced by an opposite supporting force called the normal force. However, if that same woman were to weigh herself while riding up or down on an elevator, her apparent weight would change.



EXERCISES

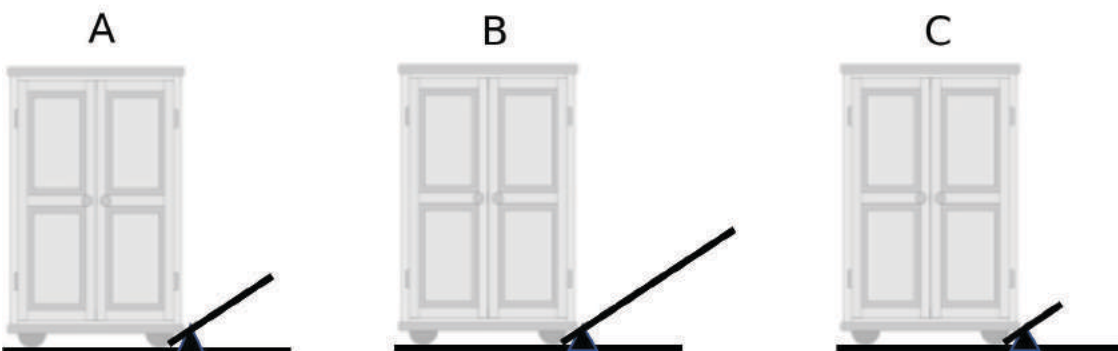
- a) A woman who works on the 3rd floor of a building takes the elevator to the 10th floor to attend a meeting.

Which of the following statements is or are correct?

- I. If the elevator goes up, both her apparent weight and actual weight would increase.
- II. If the elevator goes up, only her apparent weight would increase. Her actual weight would remain the same.

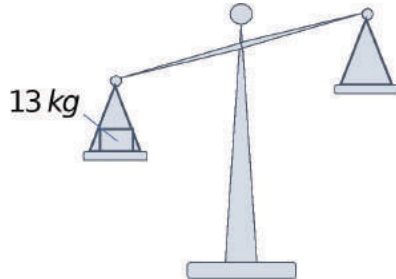
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

- b) Which lever would require the greatest force to elevate the cupboard?



- (A) Lever A
- (B) Lever B
- (C) Lever C
- (D) Same force is required for all levers.

- c) There is a weight of 13 kg in one weighing pan. The arms of the scale are the same length. How should weights be placed on the other side of the scale to achieve balance? The following weights are available: 0.5 kg , 2 kg , 5 kg .



- (A) $2 \times 0.5\text{ kg} + 3 \times 2\text{ kg} + 1 \times 5\text{ kg}$
(B) $6 \times 2\text{ kg} + 1 \times 5\text{ kg}$
(C) $2 \times 0.5\text{ kg} + 1 \times 2\text{ kg} + 2 \times 5\text{ kg}$
(D) $2 \times 2\text{ kg} + 2 \times 5\text{ kg}$

SOLUTIONS

a) Answer: B

Her actual weight is a product of her mass and the influence of gravity. Since the gravitational force is largely determined by the mass of the earth, it would not be affected by the movement of the elevator. So, if the elevator goes up, her actual weight would remain the same. On the other hand, her apparent weight would increase because the scale measures the force that is supporting her (i.e., the normal force), which, in a rising elevator, also includes the elevator's upward acceleration.

b) Answer: C

The longer the lever, the less force necessary to elevate the cupboard. In other words, using the shortest lever will require the most force.

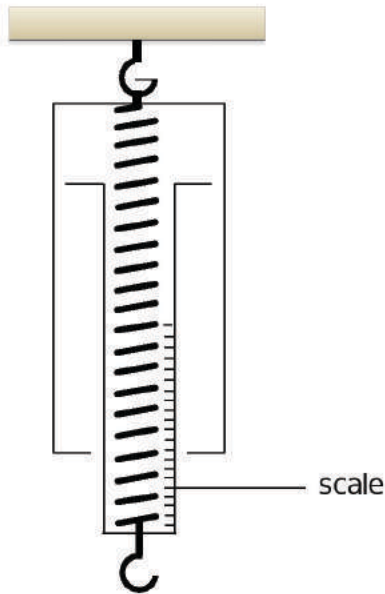
c) Answer: C

In order to balance the scales, the total sum of the weights on the right side must also be 13 kg. The correct solution is therefore (C).

$$2 \times 0.5 \text{ kg} + 1 \times 2 \text{ kg} + 2 \times 5 \text{ kg} = 13 \text{ kg}$$

SPRING SCALE

A spring scale is a type of weighing scale consisting of a (metal) spring, a printed scale and weights. The greater the force exerted by the weight on the spring scale, the further the spring extends. Like other weighing scales, the spring scale is not required to measure the absolute weight of an object, but rather the weight force in Newtons that the object exerts.



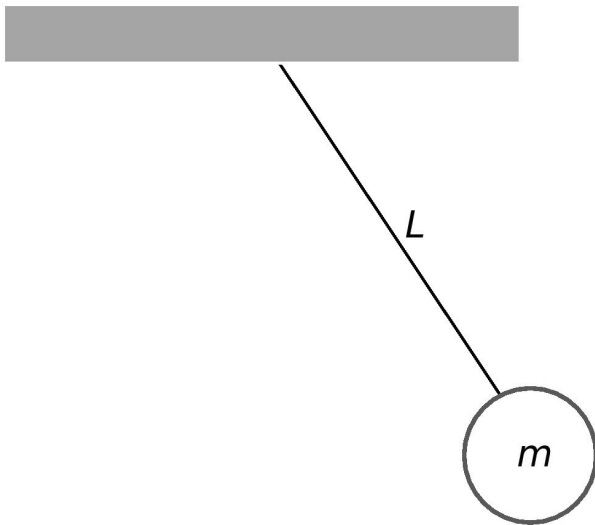
When reading the result, always look out for the unit on the printed scale. Different printed scales can be in different units, which means that even when the length of two scales is the same, the two devices may be indicating different values.

In our experience, there are only a few questions about spring scales per test, but some past test participants have reported difficulties with this topic (some former participants did not use spring scales at school). As such, we provide the opportunity to practice intensively with following exercises. You will find the solutions with detailed explanations below.

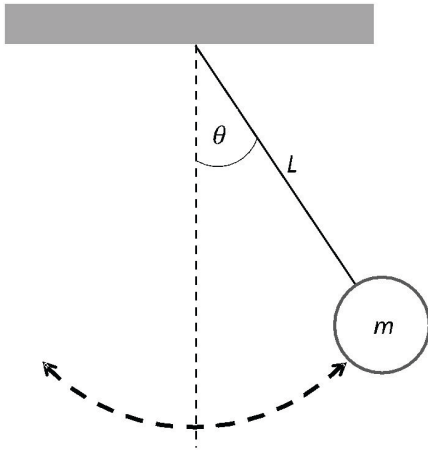
SIMPLE PENDELULUM

Usually no calculations are required, but rather inferring the difference between different scenarios. For example, does a pendulum with a short thread oscillate faster than a pendulum with a long thread (under otherwise identical conditions)?

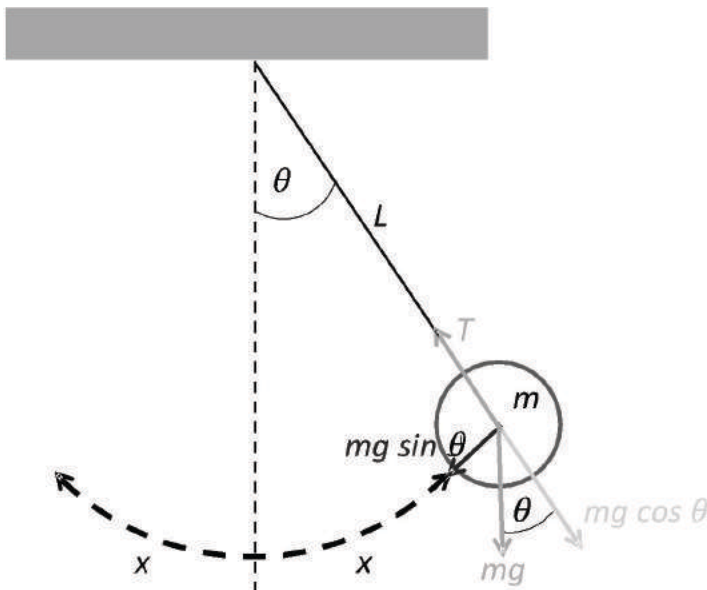
A simple pendulum consists of a small mass m otherwise known as bob which is hung on a light and non-elastic string (thread) of length L attached to a fixed and rigid support as in the figure below.



When the bob is as in the position shown in the figure, the pendulum is not in equilibrium. Gravity acts on the bob, pushing it to the lowest position possible and moving the pendulum towards a stable vertical position. But the string prevents the pendulum from falling down, instead pulling it back towards center. That's why it swings and would continue to swing in ideal conditions. Therefore, it is appropriate to study the time it takes the pendulum to complete one full swing from one position and back (the period) in order to obtain useful information about the characteristics of this periodical motion.



Let's denote by θ the initial angle formed by the string and the vertical position. There are two forces acting on the bob: the gravitational force $G = m \times g$ and the tension force T of the string. Since these two forces do not have opposite directions, they don't cancel each other. Thus, a non-zero resultant force will appear in the swinging direction as in the figure below:



This non-zero resultant force

$$F = - mg \sin \theta$$

is known as restoring force. It is responsible for the swinging process.

The angle θ is taken very small for two reasons:

1. Because the effect of air resistance becomes negligible and the situation becomes very similar to harmonic motion. (As we know, harmonic motion is periodical as well.)
2. Because for small angles $\sin \theta \approx \theta$ (in radians).

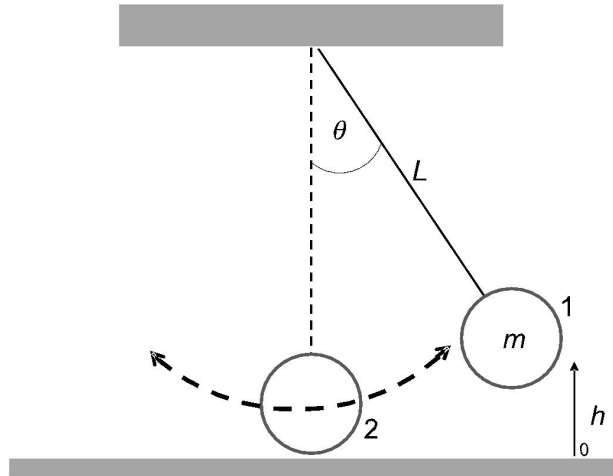
The equation of the period of spring oscillation is

$$T = 2\pi\sqrt{\frac{L}{g}}$$

From this equation we draw the following conclusions:

1. A pendulum with a shorter string (L is small) has a smaller period of oscillation (a smaller numerator decreases the value of fraction). This means the bob in these conditions swings faster than if the pendulum had a longer string.
2. If the pendulum had a higher starting point, the initial angle θ would be greater. Consequently, the displacement x would be greater as well. Also, the restoring force would be greater. However, in absence of air resistance, this would not affect the period of pendulum as it does not depend on the angle θ or displacement x .
3. If the bob had a greater weight (or mass), this would not affect the period of pendulum as period is independent from mass.
4. In the above explanation, we have considered the case when the bob is released without any initial speed. If it is pushed at a certain speed, the restoring force increases as it responds to an additional force besides the gravity. Thus, the bob makes a greater arc (the angle θ increases). However, this doesn't affect the period of pendulum.

5. To know the highest speed and position of the bob, we use the law of energy conservation. Thus, if considering the bob at position 1 at rest, its kinetic energy is zero.



On the other hand, the kinetic energy is at maximum at the lowest point (position 2 or the vertical position). In this position, gravitational potential energy is zero and all mechanical energy is converted into kinetic energy.

For the velocity, we can write:

$$v = \sqrt{2gL(1 - \cos \theta)}$$

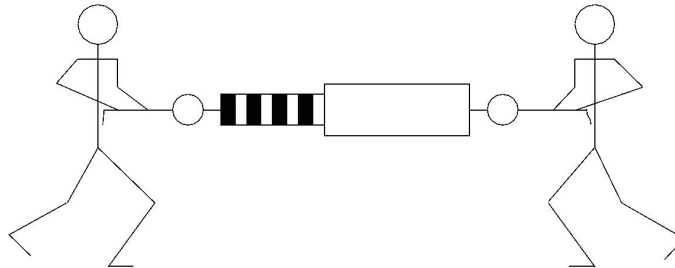
After calculating v for known values of L and θ , we can find also h giving:

$$h = L (1 - \cos \theta)$$



EXERCISES

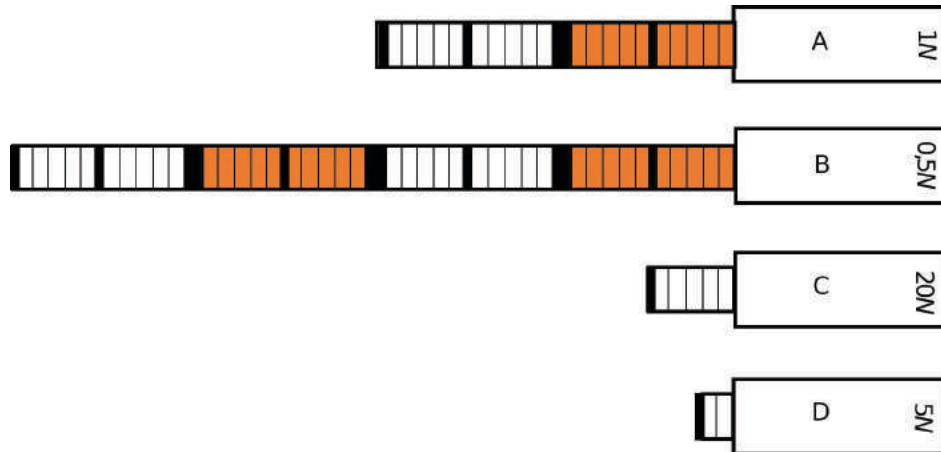
- a) Two friends pull on a spring scale at the same time. The scale indicates a force of 800 N .



Which of the two statements is or are correct?

- I. The person on the left must exert twice as much force as the one on the right.
 - II. The person on the left must exert 800 N of force.
- (A) Only Statement I is correct.
(B) Only Statement II is correct.
(C) Statements I and II are correct.
(D) Neither of the two statements is correct.

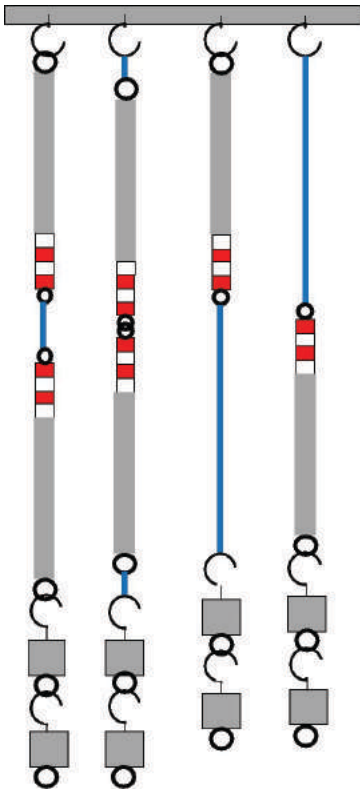
- b) Each spring scale has a printed scale with 5 sections. The sections alternate grey and white in color. The number shown on the scale is the largest weight that scale can measure.



Which of the two statements is or are correct?

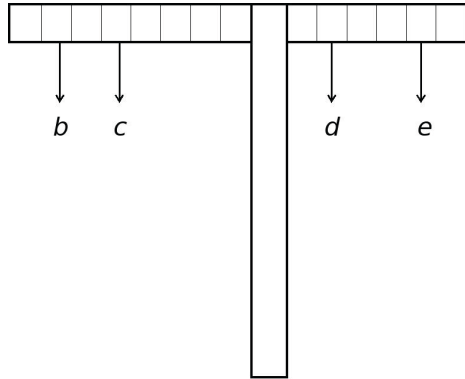
- I. Balance scale C is indicating a weight force of 2 newtons.
 - II. Balance scales A, B and D are all indicating the same measurement value.
- (A) Only Statement I is correct.
- (B) Only Statement II is correct.
- (C) Statements I and II are correct.
- (D) Neither of the two statements is correct.

c) Four different spring scales are shown in the diagram below. Which of the two statements is or are correct?

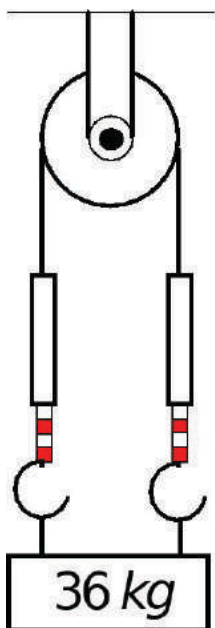


- I. The two spring scales on the left each consist of two connected scales. Each of these scales indicate half of the total weight force exerted by the two grey objects at the bottom.
 - II. The strings do not alter the amount of weight force being exerted on the spring scales.
- (A) Only Statement I is correct.
- (B) Only Statement II is correct.
- (C) Statements I and II are correct.
- (D) Neither of the two statements is correct.

d) Four weights are attached to a scale. What is true?



- I. If only weights *c* and *d* were attached to the scale, weight *d* must be heavier than *c* in order for the scale to be balanced.
 - II. If all four weights weigh the same and are attached to the scale, the left-hand side of the scale will move upwards.
- (A) Only Statement I is correct.
- (B) Only Statement II is correct.
- (C) Statements I and II are correct.
- (D) Neither of the two statements is correct.



e) A weight of 36 *kg* hangs on a spring scale. Calculate using 1 *kg* = 10 *N*. Which of the two statements is or are correct?

- I. Each single-color section on the printed scale represents 40 *N*.
- II. If you double the weight, the lengths of both springs (and therefore the visible portions of the printed scales) would also double.

- (A) Only Statement I is correct.
(B) Only Statement II is correct.
(C) Statements I and II are correct.
(D) Neither of the two statements is correct.

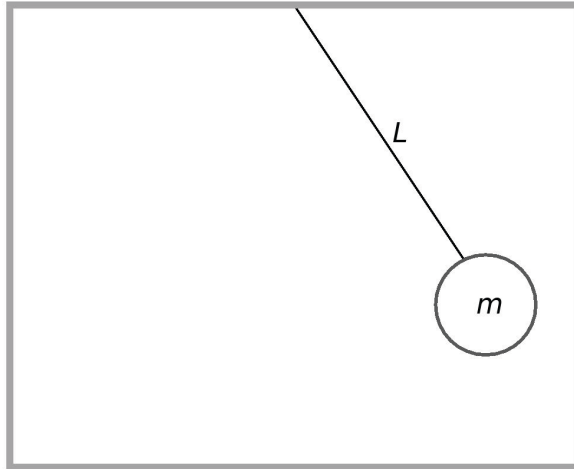
f) Which statement(s) below is (are) correct?

- I. In absence of gravity, the period of pendulum decreases but it doesn't become zero.
- II. No matter how heavy the bob is; the pendulum will swing equally for a fixed angle if the angle is small.

III. In absence of air the period of pendulum depends only by thread's length.

- (A) Only I
- (B) I and III
- (C) Only II
- (D) II and III

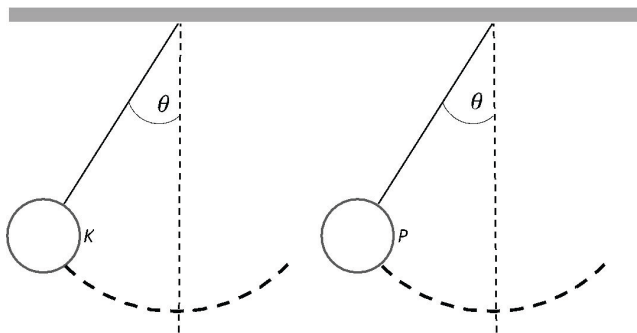
- g) A pendulum of length L and mass m swings (assume harmonic motion) inside a cabin which is free to move in all direction as in the figure.



Which of the following causes an increase in the period of pendulum?

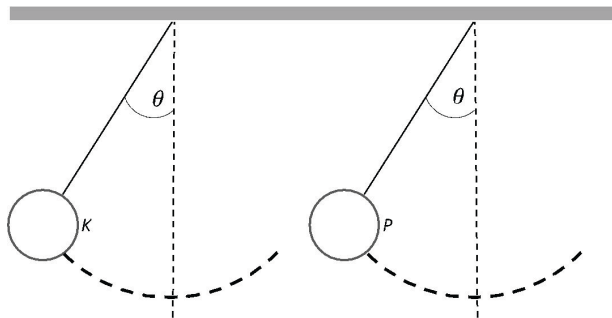
- (A) Decreasing L
- (B) Increasing m
- (C) Pushing the bob down
- (D) Moving the bob to the right at a constant speed

- h) The period of the pendulums K and P in the figure are 8 s and 12 s, respectively.

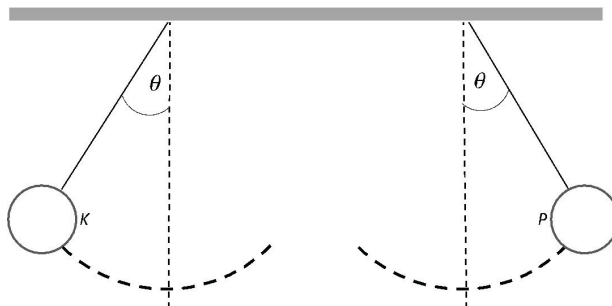


If they are released from the rest at the positions shown in the figure, what will their position be after 6 s?

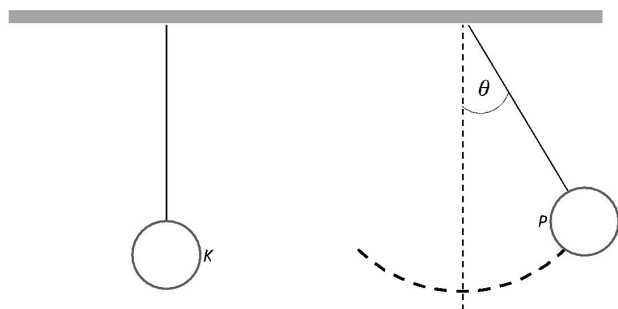
(A)



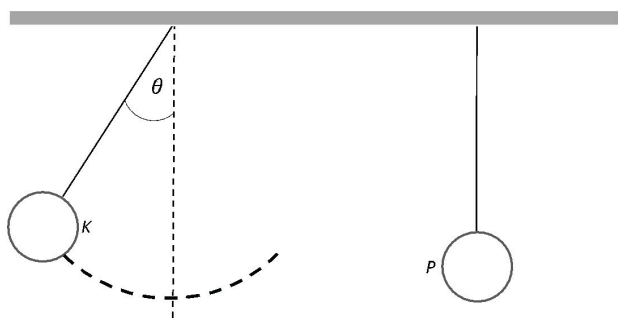
(B)



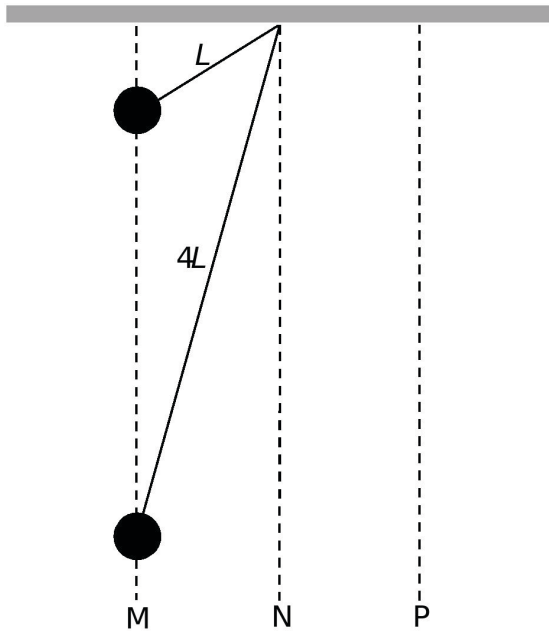
(C)



(D)



- i) The pendulums with lengths L and $4L$ respectively are released to move freely between three vertical lines as shown in the figure.



At which position will the bobs again have the same horizontal position? (The pendulums do not touch each other.)

- (A) At N (B) Between N and P
(C) At P (D) At M

SOLUTIONS

a) Answer: B

Statement I is not correct; in this case, both people must exert the same force.

Statement II is correct; both people must exert 800 N of force.

b) Answer: A

Statement I is correct. The problem states that there are 5 grey and 5 white sections on each spring scale. On balance scale C, since only one white section is revealed, we calculate: $1/10 \times 20 \text{ N} = 2 \text{ N}$.

Statement II is not correct: While Scale A and Scale B indicate 0.4 N, Scale D indicates only 0.2 N.

Scale A: $4/10 \times 1 \text{ N} = 0.4 \text{ N}$.

Scale B: $8/10 \times 0.5 \text{ N} = 0.4 \text{ N}$.

Scale D: $2/15 \times 1/10 \times 5 \text{ N} = 0.2 \text{ N}$.

c) Answer: B

Statement I is not correct; both parts of the spring scale indicate the total weight force exerted by the grey objects below.

Statement II is correct.

d) Answer: A

In order to balance two or more weights on a pivot, we need to remember the following general formula:

Force₁ × distance₁ from pivot = force₂ × distance₂ from pivot.

Since the force is inversely proportional to the distance from the axis, and in this case the distance d_c of the weight c from the axis is greater than the distance d_d of the weight d from the axis, according to the above formula the weight d must be greater than the weight c. Statement I is correct .

If there are multiple weights on each side of the pivot, the formula becomes

$F_1d_1 + F_2d_2 = F_3d_3 + F_4d_4$, etc. In statement II, we can simplify the equation based on the same weight of all 4 weights so that it then reads

$$F_1d_b + F_1d_c = F_1d_d + F_1d_e.$$

$$F_1(d_b + d_c) = F_1(d_d + d_e) \qquad d_b + d_c = d_d + d_e.$$

The units are not shown in the figure, but you can still count how far individual weights are from the axis, because each of the rectangles seem to be the same size: $d_b = 7$, $d_c = 5$, $d_d = 2$, $d_e = 5$.

If we put these numbers into the formula it becomes clear that the balance is not in balance: $7 + 5 > 2 + 5$. The right side of the balance moves up. Statement II is incorrect.

e) Answer: B

Statement I is not correct, it is $45 \text{ N} \times 8 = 360 \text{ N}$.

Statement II is correct.

f) Answer: C

From the equation of the period of the pendulum, we see that the factors affecting period are length and gravity.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Thus, in absence of gravity, the denominator of the above fraction would become zero and therefore, the fraction value becomes infinity. This means the period does not exist. Hence, the statement I is wrong.

Statement II is correct. From the same equation we conclude that for small angles, the only factors affecting the period of pendulum are thread's length and gravity, not mass of the bob. Therefore, no matter how heavy the bob is, it will swing equally (for small angles).

Statement III is wrong as the absence of air does not exclude the presence of gravity. For example, the moon has its own gravity although it has no air. Therefore, even in absence of air, the period of the pendulum is only affected by the string's length and gravity.

g) Answer: C

From the equation of a simple pendulum, we see that decreasing L would not increase the period of pendulum. Thus, (A) is wrong.

(B) is wrong as well because period of pendulum does not depend on the bob's mass. Look at again the above equation.

(C) is correct as pushing (i.e. accelerating) the bob downwards reduces the effect of gravity. Remember that gravitational force $G = m(g - a_v)$ where a_v is the vertical acceleration. Thus, the effect of gravity decreases compared to cases when no vertical acceleration occurs. Also, when the bob starts to accelerate,

the angle θ increases and it is not so small anymore. Thus, we can no longer ignore the effect of a large angle on a pendulum's period.

(D) is wrong as moving the bob in any direction at a constant speed does not affect the state of motion because no acceleration is taking place. Thus, the period of pendulums remains unchanged.

h) Answer: C

Since the period of pendulum K is 8 s, it will make $6/8 = 0.75$ of a complete swing in 6 s. Thus, it will be at a vertical position at this instant. Remember that a quarter of swing is when the bob first passes through a vertical position after being released. Then it makes a half swing, reaching the opposite side, then at three quarters of a swing it again passes through the vertical position. Finally, it completes a swing (a full period) when comes again to its original position.

Since the period of pendulum P is 12 s, it makes half a swing in 6 s. Thus, it is at the opposite side to the initial position at this instant. Since it was initially on the left, now it is on the right of the figure. Hence, the answer is (C).

i) Answer: D

From the equation of simple pendulum, we see that the period of the long pendulum is twice the period of the short one because:

$$T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow T_1 = 2\pi\sqrt{\frac{4L}{g}} = 2 \times 2\pi\sqrt{\frac{L}{g}} = 2 \times T_s$$

Thus, the long pendulum makes one complete swing in the time the short pendulum makes two complete swings. At this instant, they are again at the same horizontal position (one below the other). Therefore, the answer is (D). In no other position is this condition is met.

THERMODYNAMICS

IMPORTANT QUANTITIES AND UNITS IN THERMODYNAMICS

! **Pressure:** The pressure indicates how large the force is on an area:

$$p = \frac{F}{A}$$

Units:

Pascal Pa (SI)

Bar bar ($1 \text{ bar} = 1 \times 10^5 \text{ Pa}$)

! **Temperature:** All entities (solids, gases, liquids) consist of innumerable particles (atoms, molecules) that are not rigid in a fixed place, but move within the entity. Temperature can be thought of as a measure of the state of motion of the particles of an entity: the faster the particles move, the higher their kinetic energy and the higher the temperature of that entity. The slower the particles move, the lower the temperature. As a result, there is a limit to the lowest temperature that an object can theoretically reach. This is the absolute temperature (0 K or -273.15 °C), at which there is no more particle movement.

Units:

Kelvin K (SI)

Degrees Celsius °C ($1 \text{ °C} = 1 \text{ K} - 273.15$)

Degrees Fahrenheit F (

$$1 \text{ F} = \frac{5}{9}(1 \text{ K} - 459.67),$$

Heat: The energy that is transferred between thermodynamic systems through a temperature difference is called heat.

! Density: Density is the quotient of mass and volume:
 $\rho = \frac{m}{V}$. It is temperature dependent.

Amount: When a mole of any substance is present, there are 6.022×10^{23} particles of this substance. This number is called Avogadro constant N_A .

The following equation applies: $n = \frac{m}{M}$

Here n is the amount of particles in mol, m is the mass of the substance in kg and M is the molar mass of the particle in kg mol^{-1} .

HEAT AND ENERGY

In addition to the principle of energy conservation (total energy remains constant within an isolated system), the following principles of thermodynamics describe the most important properties of heat and energy in a system:

0. Principle:

If a system A is in thermal equilibrium with system B, and B is in thermal equilibrium with system C, then A and C are also in thermal equilibrium. Thermal equilibrium denotes a state in which both systems have the same temperature.

1. Principle:

Change of thermal energy of a system is associated with the addition or release of heat and/or the performance of work.

2. Principle:

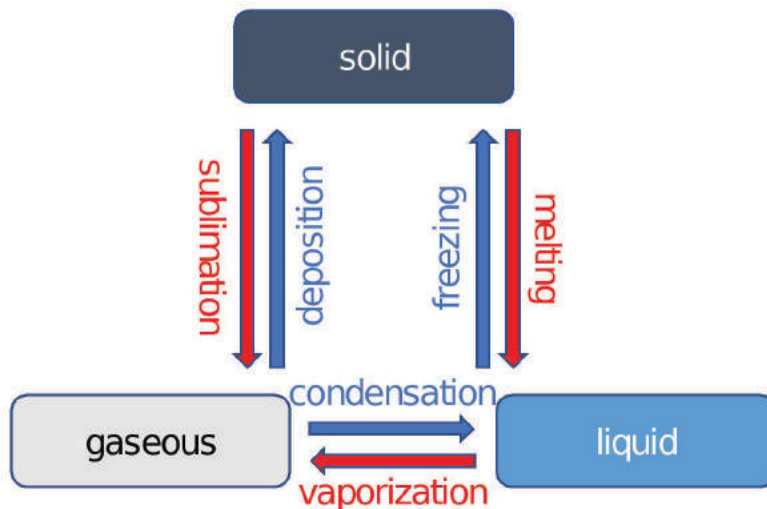
Heat can never pass from a system of lower temperature to a system of higher temperature by itself. Rather, heat can only be transferred from the higher temperature system to a lower temperature system.

3. Principle:

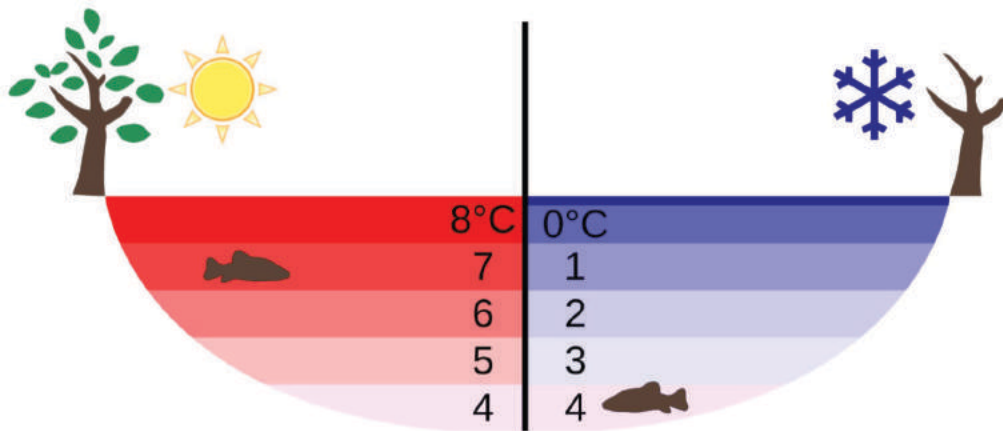
There is an absolute temperature zero, which can never actually be reached.

STATES OF MATTER

A single substance (e.g. water) can take three different “forms”: solid, liquid and gaseous. These forms are called aggregate states and are dependent on the pressure that acts on the substance and its temperature. These two factors influence the speed at which particles within the substance move. Classification of aggregate states by particle movement is called the particle model.



! Abnormal properties of water – ice



Source: Klaus-Dieter Keller, *Anomalie des Wassers*, 13.09.2012,
https://commons.wikimedia.org/wiki/File:Anomalous_expansion_of_water_Summer_Winter.svg, Accessed 11.11.2019

Normally, the volume of a substance decreases as the substance gets colder. Water is unusual because it does not follow this trend: its volume is smallest at a temperature of 4 °C, and water in the solid form (ice) has greater volume than in the liquid form (this is why ice floats on water). This is called the *anomaly of water*.

GASES

Ideal and real gases

The term “ideal gas” is a simplified model of real gases based on the following assumptions:

- All intermolecular attractive forces between the gases are ignored
- All gas particles interact with each other or with the walls of their container only via elastic collisions, i.e., without loss of energy.

Formulas for ideal gases

While the behavior of real gases can be very difficult to calculate, the following simple formulas apply under the assumptions mentioned above for ideal gases:

- **The ideal gas equation:** $pV = nRT$ or $pV = Nk_B T$

Here p is the pressure, V the volume and T (in K) the temperature of the gas. Depending on which version of the equation you use, you need the amount of substance in mols n and the *universal gas constant* $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$, or the amount of particles N and the *Boltzmann constant* $k_B = 1.380 \times 10^{-23} \text{ J K}^{-1}$.

Boyle's Law: $p_1 V_1 = p_2 V_2$ for $T = \text{const.}$
 $T_2 V_1 = T_1 V_2$ for
 $p = \text{const.}$

In word form: the lower the pressure of a gas, the greater its volume and vice versa, provided the temperature is constant. At constant pressure, the smaller the temperature, the smaller the volume and vice versa.

Flowing gases and liquids

Venturi effect:

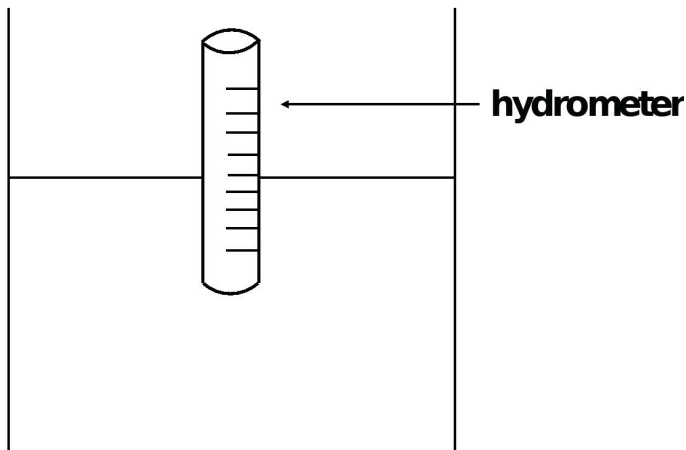
The Venturi effect is the fact that the narrower the cross-section gasses or liquids flow through, the faster they flow: $A_1 v_1 = A_2 v_2$

Bernoulli's Law:

Bernoulli's law establishes a connection between the velocity of a gas or a liquid and its pressure. Two types of pressures are relevant; static pressure P of the surrounding medium and the dynamic pressure $\frac{1}{2}\rho v^2$ of the flowing gas or liquid.

$$\frac{1}{2}\rho v^2 + p = \text{const.}$$

! HYDROMETER



The hydrometer is a measuring device used to determine the density of liquids. It measures according to the Archimedean principle, which states that when an object is immersed in liquid, the weight of the displaced liquid corresponds to the weight of the immersed body. The hydrometer consists of a glass body with a scale. You can read the scale from top to bottom.

It follows that an object of the same weight will immerse further in a liquid of lower density.



EXERCISES

a) Which of the following statements cannot be valid as evidence for the anomaly of water?

- (A) Ice floats on water.
- (B) The temperature of the bottom of the deep ocean remains at a constant 4 °C.
- (C) At -18 °C, a bottle of water bursts in the freezer.
- (D) In very high-altitude areas, e.g. in high mountain ranges, water boils at less than 100 °C.

b) Which of the following plant attributes would not be expected to enhance the collection of dew?

- (A) A shallow root system
- (B) Trough-shaped leaves
- (C) Dark leaf surfaces that radiate heat efficiently
- (D) Leaf mass that does not cast much shade near the base of the plant

c) A submarine is a boat that was built for underwater cruising. The term submarine is mostly used for military boats, while civilian submarines are usually called diving boats. What is true?

I. Submarines rise in water by filling their ballast tanks with water.

II. A sinking submarine can be said to be neutrally buoyant.

(A) Only statement I is correct.

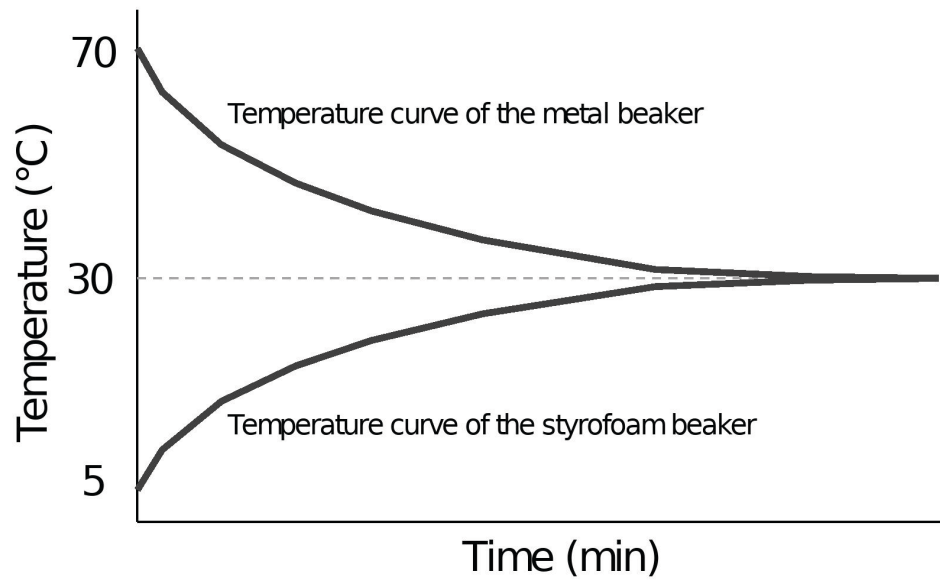
(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

d) In the following experiment, a small metal cup with hot water was placed in a larger Styrofoam cup with cold water. The temperature of the hot water was originally 70 °C and the temperature of the cold water in the outer cup was

5 °C. Both cups were equipped with thermometers, which measured the water temperature of both cups over a certain period. The figure reflects the results:

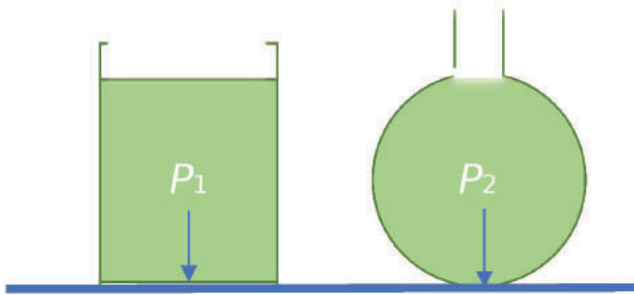


Which of the following statements is or are correct according to figure?

- I. The cold water is heated to a lower temperature than the temperature to which the warm water cools.
- II. If the cold water does not continue to heat up and the hot water does not continue to cool beyond what is depicted in the figure, the waters' temperatures will eventually equalize.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

e) Two vessels are filled with water at the same height. The pressure on the floors is P_1 and P_2 . How do P_1 and P_2 change when the temperature is lowered?



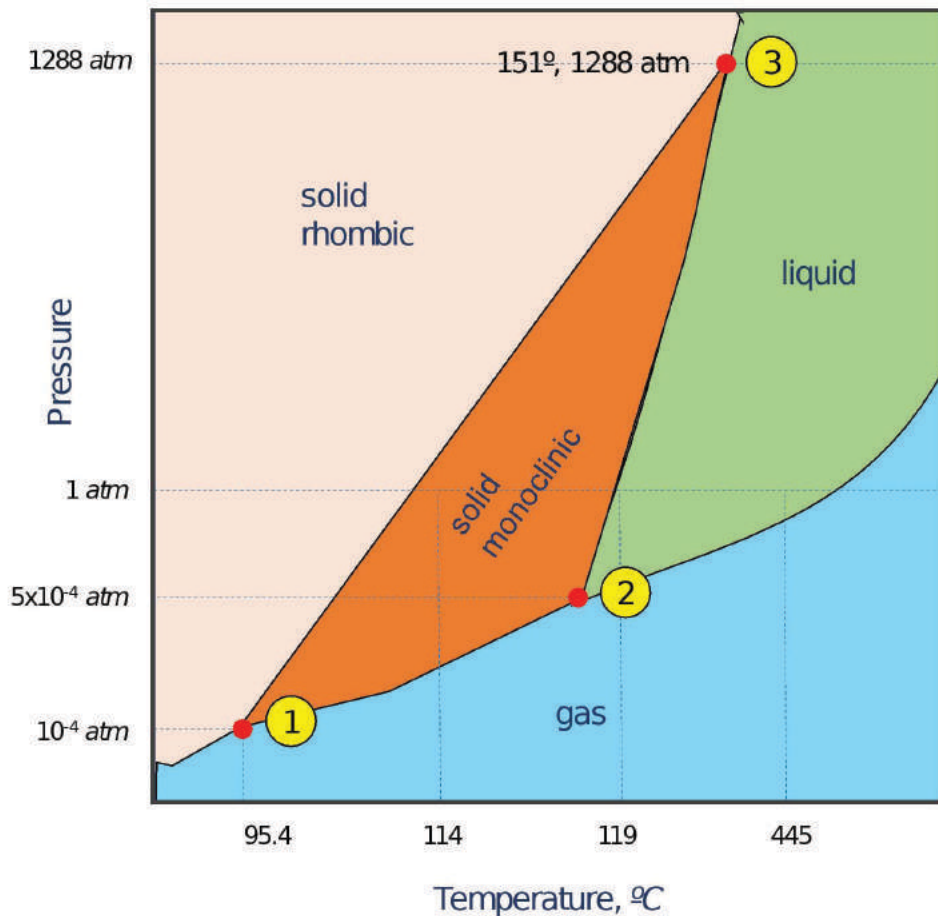
- (A) P_1 and P_2 decrease.
- (B) P_1 and P_2 remain unchanged.
- (C) P_1 remains unchanged, P_2 increases.
- (D) P_1 increases, P_2 decreases.

- f) The following picture shows two candles under a glass container. No new oxygen can flow into the vessel from outside. What behavior of the candles can be expected? What is true?



- (A) The big candle goes out first.
- (B) The little candle goes out first.
- (C) After a short time, both candles go out at the same time.
- (D) Both candles go out immediately.

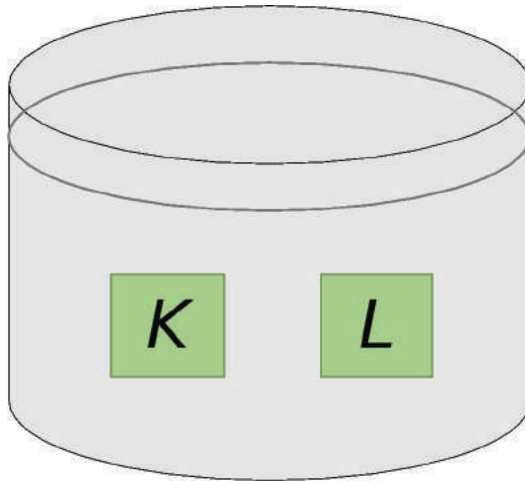
g) A phase diagram demonstrates the phase of a certain substance at a given pressure and temperature. Below is the phase diagram for carbon dioxide. Which temperature could be used at 1 atm to achieve a solid, monoclinic state?



Source: Stephen Lower, <https://socratic.org/questions/how-would-you-explain-the-phase-diagram-of-sulphur>, Accessed 11.09.2019

- (A) 113 °C
- (B) 120 °C
- (C) 117 °C
- (D) 445 °C

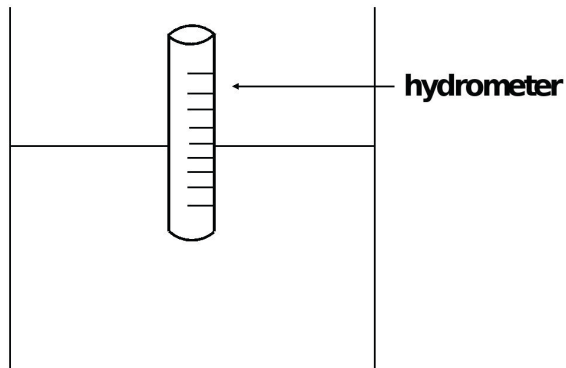
- h) The illustration below shows two substances, K and L , in water. The coefficients of expansion of K , L and water are a_K , a_L and a_W respectively. As temperature rises, K sinks further within the container and L rises. What is the relationship between the coefficients of expansion?



- (A) $a_K > a_L > a_W$
- (B) $a_K = a_L = a_W$
- (C) $a_K > a_W > a_L$
- (D) $a_L > a_W > a_K$

- i) A hydrometer measures the density of liquids. An object is immersed so that the weight of the displaced liquid corresponds to the weight of the object in the liquid.

Which of the following statements is or are correct?



- I. The density is read from top to bottom.
 - II. The higher the density of the liquid, the more the hydrometer is immersed in the liquid.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

SOLUTIONS

a) Answer: D

While A, B, and C are related to the anomaly of water, the decrease in the boiling point is due to decreased pressure at higher altitudes.

b) Answer: D

Answers A, B, and C enhance the collection of dew. A shallow root system quickly absorbs light moisture from dew, which would otherwise rapidly be evaporated during summer. Trough-shaped leaves hold and funnel moisture to plant roots. Dark leaf surfaces that radiate heat efficiently promote the cooling needed to cause moisture condensation. D, however, would not enhance dew collection because morning sunlight would quickly evaporate dew. Daytime shadows, therefore, would be expected to reduce the evaporation rate from soil near the plant roots.

Source: Luna B. Leopold, Dew as a source of plant moisture, Pacific Science Vol. V, July 1952, pages 159-261, Accessed 11.09.2019

c) Answer: D

For an object to float, or rise within water, its average density must be less than the surrounding water. Large submarines do this by pumping their ballast tanks with air (which is less dense than water), not water. Neutrality would imply that the buoyancy of the submarine and the surrounding water are equal. But here, the submarine is sinking. It is said to be negatively buoyant.

d) Answer: B

Statement I is wrong and Statement II is correct. The illustration shows that the temperature curves meet at the same point. In other words, the cold water heats up and the hot water cools down until both have reached the same temperature. So, B is the correct answer.

e) Answer: B

The formula for pressure is: $P = \rho \times g \times h$. As you can see, temperature does not show up. This means that pressure is independent of temperature and P_1 and P_2 do not change.

f) Answer: A

The candles burn oxygen and create heat, carbon dioxide and water. Hot carbon dioxide gas collects at the top of the glass container and begins to push the oxygen-rich air downwards. The big candle goes out first because it is suffocated by the rising carbon dioxide gas.

g) Answer: C

Phase diagrams are easy to understand if you draw a horizontal line over the diagram. This corresponds to an increase in temperature at constant pressure. Since this diagram the line, which corresponds to 1 atm pressure, intersects with the temperature lines, it can be determined that at 1 atm, the temperature must be above 114 °C and below 119 °C for the substance to be in the solid, monolithic phase. Thus, the correct answer is 117 °C.

h) Answer: D

L rises within the water, so density must decrease and volume must increase. As the volume has increased to a greater extent than water (causing L to float in the water), a_L is larger than a_W .

K sinks within the water; its density increases and the volume decreases. Since the volume has increased to a lesser extent

than water (causing K to sink in the water) a_K is smaller than a_W .

i) Answer: A

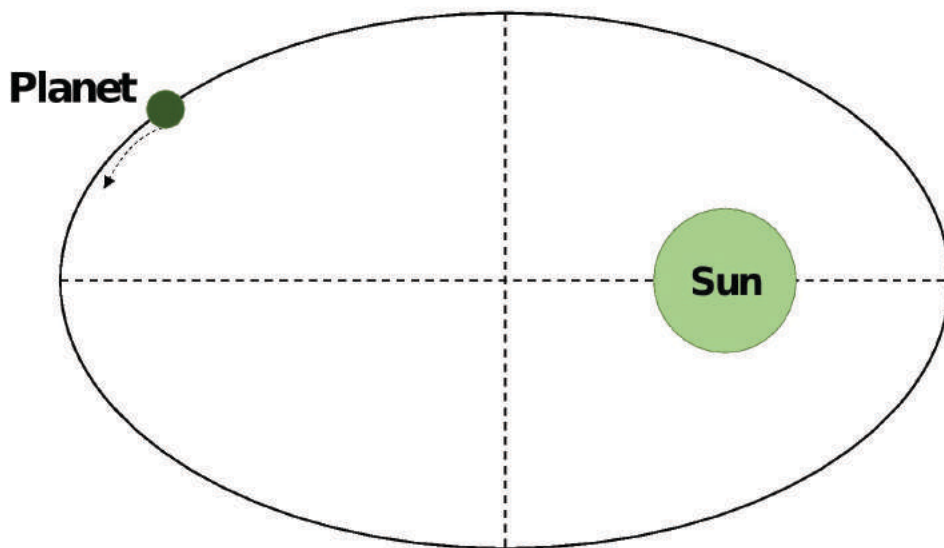
You read density from top to bottom on a hydrometer. If the liquid has a low density, the hydrometer immerses deeper in the liquid and a lower value is read. If the density is higher, the hydrometer is not immersed as deeply and a larger value is read.

ASTRONOMY

KEPLER'S LAW

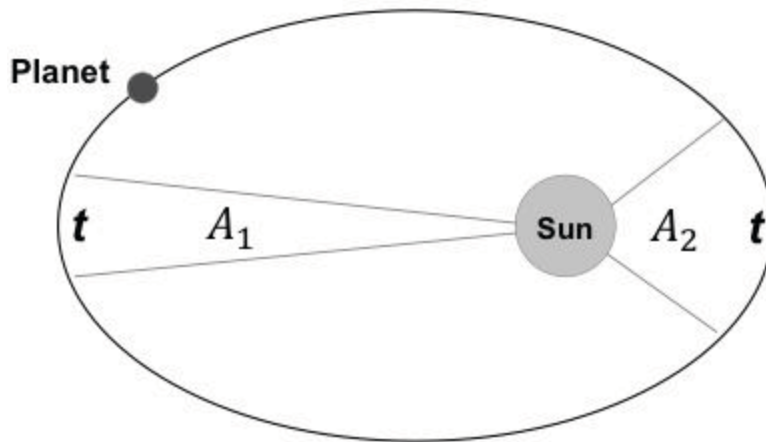
Johannes Kepler, who lived from 1571 to 1630, discovered the laws according to which planets move around the sun. They are called “Kepler’s laws” in his recognition. Regarding these laws, the TestAS exam does not ask for or expect memorization of formulas, but it is helpful to be familiar with the laws and understand the relationships between various variables.

1. **Kepler’s law of ellipses:** All planets move on elliptical orbits. In our solar system, the sun is the focal point of the orbit. And while planets orbit around the sun, their distance to the sun is constantly changing because they travel in an ellipse. The point in a planet’s orbit when it is closest to the sun is called perihelion; the point with the greatest distance to the sun is called aphelus.



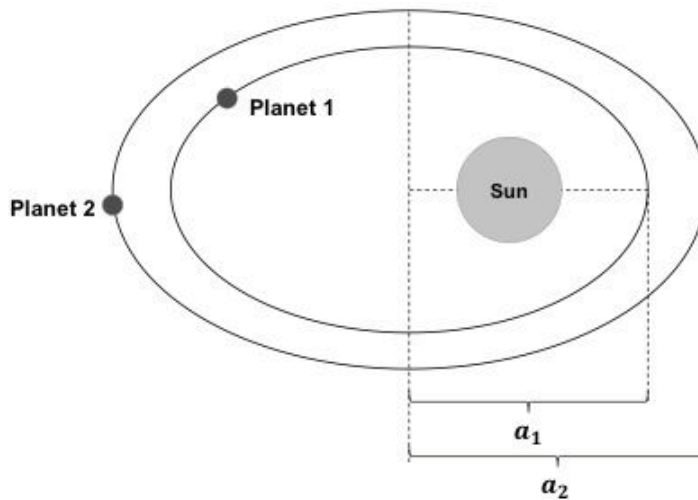
2. **Kepler's law of equal areas:** If a line is drawn from the sun to a planet, the area swept out by the planet's movement will always be the same over an equal amount of time, regardless of where in orbit a planet is. This means that the planet moves at different speeds throughout the orbit, moving fastest when closest to the sun.

A = swept out area t = time $\frac{A_1}{t} = \frac{A_2}{t}$



3. **Kepler's law of harmonies:** This law compares the motion of different planets with the following ratio: the square of a planet's period (time it takes to do one full rotation) to the cube of the planet's average distance from the sun (major semi axis). This ratio is the same for all planets. This means that planets further from the sun take longer to orbit the sun than planets closer to the sun.

T = period a = major semi axis $\frac{T_1^2}{T_2^2} = \frac{a_1^3}{a_2^3}$



Newton's universal law of gravitation: The force with which two bodies attract each other due to their mass. This force is greater ...

- ... the larger the mass m of the object.
- ... the smaller their distance from each other.

The direction of these forces runs along the line between the centers of gravity of the two objects, and the two forces point in opposite directions (due to the law of interaction). Newton's reasoning is based on observations of the planetary movement by Johannes Kepler.



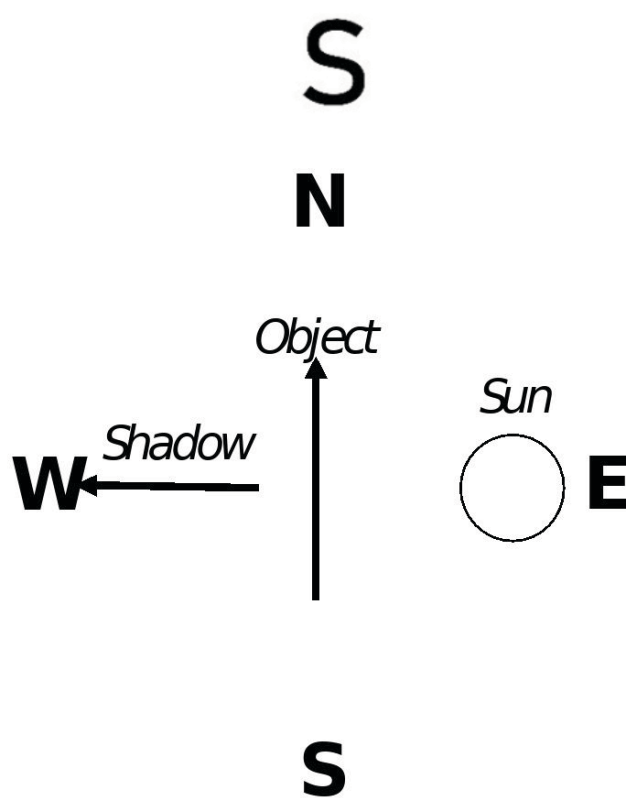
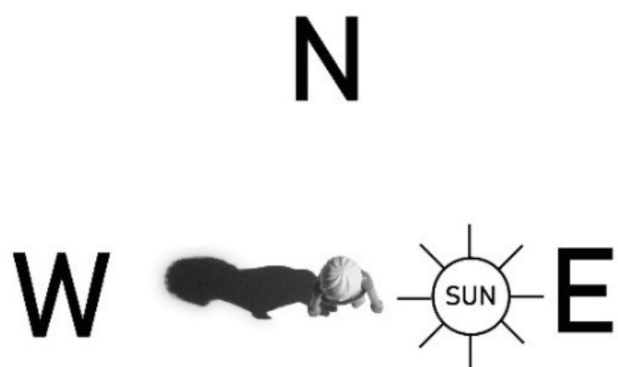
GOOD TO KNOW

USING THE SUN TO DETERMINE DIRECTION

Shadows cast by the sun can be used to determine the general direction in which a person is facing or travelling. This could be one of the four main directions (north, south, east or west) or one of the four cardinal directions (north-east, south-east, south-west, north-west). To use the sun's shadow to determine direction, first we must understand a few things about the earth's position in relation to the sun.

In the northern hemisphere, the sun rises in the east and sets in the west. When the sun is at its highest point (i.e., at 12 noon), it is in the south. Objects directly beneath it do not cast any shadows. At any other time, the sun creates shadows that shift in a clockwise motion throughout the day. This is due to the earth spinning on its axis. If a person stands facing east at sunrise, their shadow will be cast west. At sunset, shadows are always pointing east. If a person stands facing north at sunrise, their shadow will be cast to their left (towards the west), whereas at sunset, their shadow will be cast to their right (towards the east).

One further note: in the southern hemisphere (that is, southern parts of Africa, most of South America and Australia), the motion and direction of shadows is reversed. However, you can assume that all questions asked during the exam will pertain to the northern hemisphere.

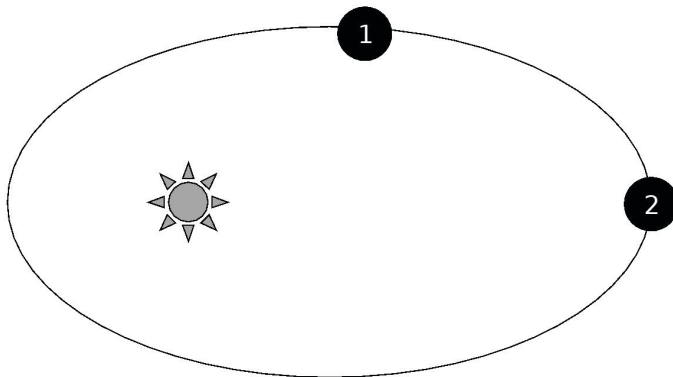


**Object/ Person faces North*



EXERCISES

- a) The following diagram shows a planet at two different points of orbit. Which of the following statements is or are correct?



- I. The planet is traveling faster at point 1 than point 2.
- II. The gravitational force attracting the planet to the sun is stronger at point 1 than point 2.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

- b) Marc is biking as the sun is just rising. His shadow falls to his left side. Which direction is he biking to?

- (A) North
- (B) West
- (C) South
- (D) East

c) Early in the morning, a cyclist rides towards the mountains. Since the sun is shining, the mountains cast a long shadow. The cyclist rides in the mountain's shadow. In which direction does the cyclist ride?

- (A) North
- (B) West
- (C) East
- (D) South

d) One morning Lisa and Paul were talking to each other face to face at a crossing. If Paul's shadow was exactly to the Lisa's left, which direction was Lisa facing?

- (A) East
- (B) West
- (C) North
- (D) South

e) One evening while going home, Karen met Laura at a road crossing. Laura's shadow was exactly to Karen's right. If they were face to face, which direction was Karen facing?

- (A) North
- (B) East
- (C) South
- (D) West

SOLUTIONS

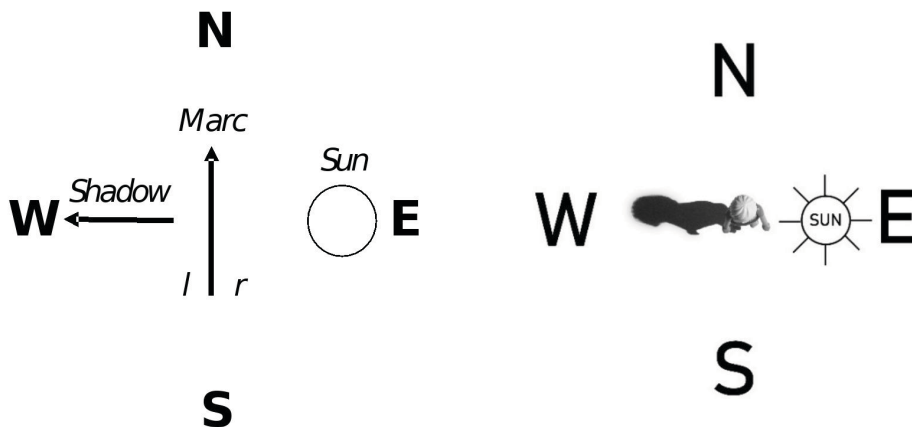
a) Answer: C

Statement I: According to Kepler's law of equal areas, a planet will sweep out an equal amount of area over an equal amount of time regardless of where it is in orbit. This means that the closer the planet is from the focal point of its orbit (the sun), the faster the planet travels. Therefore, the planet is traveling faster at point 1 than 2, and statement I is correct.

Statement II: The law of gravitation dictates that the closer two objects are, and the greater their masses, the stronger the attractive force between them will be. Masses remain constant, but the planet is closer to the sun at point 1 than point 2, so the attractive force of gravity is stronger at that point. Statement II is therefore also correct.

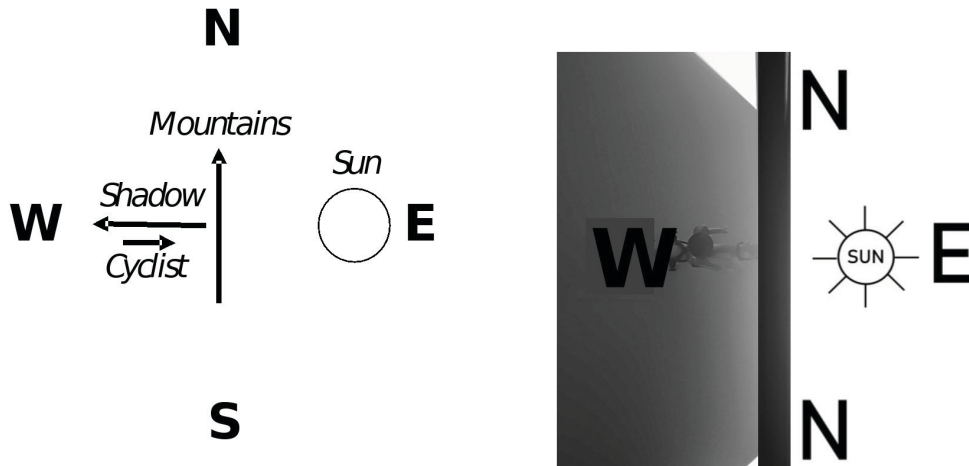
b) Answer: A

In the morning, the sun rises in the east. So, in the morning, the shadow falls towards the west. Therefore, he is biking towards the north.



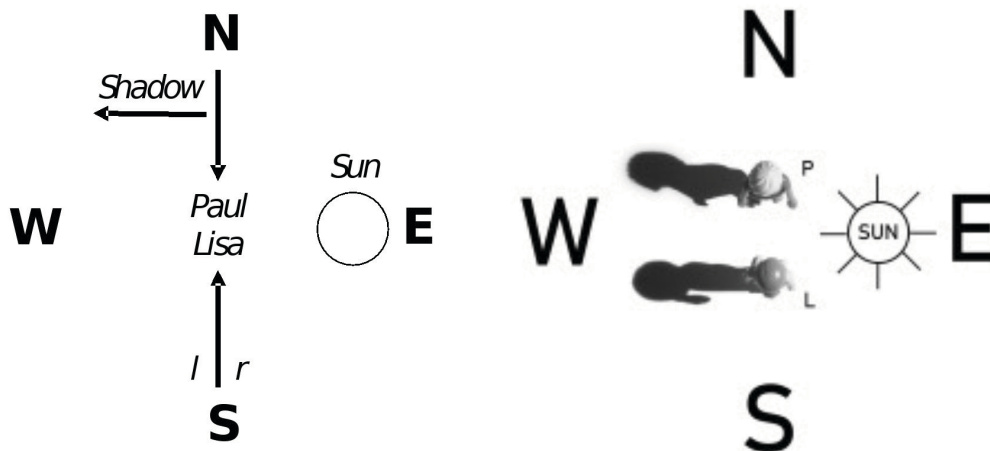
c) Answer: C

In the morning the sun rises in the east. So, the shadow falls towards the west. As the cyclist can see the shadow, he is riding towards the east. Seeing the shadow means he must be on the same side of the mountain as the shadow itself is.



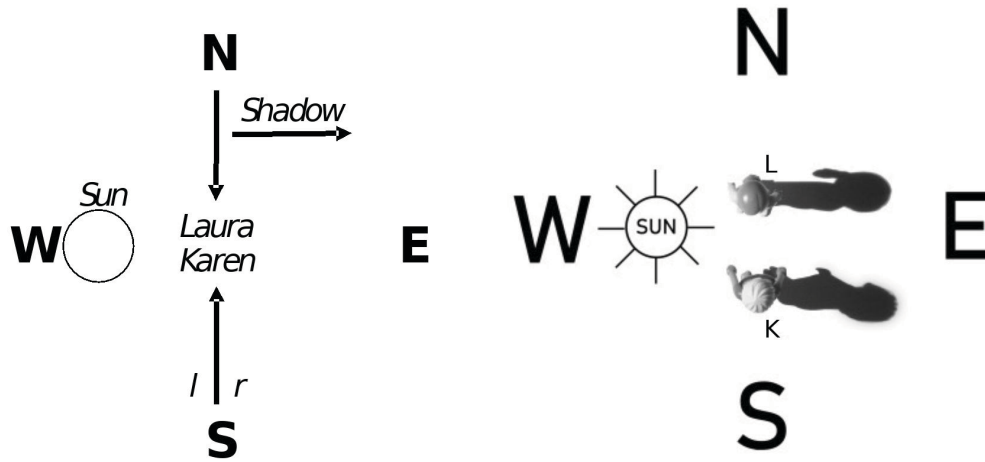
d) Answer: C

In the morning, the sun rises in the east. So, in the morning, shadows fall towards the west. Paul's shadow falls to Lisa's left. Hence Lisa is facing North.



e) Answer: A

In the evening, the sun sets in the west. So, in evening, shadows fall towards the east. Now Laura's shadow falls to Karen's right. Hence Karen is facing North.



THE DIFFERENCE BETWEEN PHYSICAL AND CHEMICAL CHANGES

Simply put, a physical change in a substance - though it often involves a change of (aggregate) state - doesn't change what the substance is. Consider a melting ice cube. The ice becomes liquid water, but its molecular formula, H_2O , remains the same. If we apply heat to the liquid, its state changes again, to gaseous water vapor, but its molecular formula still remains the same.

Consider also a piece of paper being cut up into smaller pieces: although there is a change in the paper's size and shape, it does not undergo any change on a molecular level. (In this example, there is no change of state, either.)

In contrast, in a chemical change, a new substance is formed and energy is either given off (an exothermic reaction) or absorbed (an endothermic reaction). Chemical changes occur when two or more molecules interact. Consider the example of burning a sugar cube, in which fire activates a chemical reaction between sugar and oxygen. The oxygen in the air reacts with the sugar and causes chemical bonds to break, with the result that the substance is no longer sugar. However, melting a sugar cube is a physical change, because even after the cube is melted, the substance is still sugar.

Physical changes are typically reversible, while chemical changes are generally very difficult or even impossible to reverse. Furthermore, physical changes are usually immediately apparent, whereas chemical changes typically occur on a much smaller scale and may not be immediately apparent to the observer.



EXERCISES

a) Which of the following is an example of a physical change?

- (A) A nail rusting
- (B) Acid rain wearing away a rock
- (C) Melting butter
- (D) Burning a piece of paper

b) Which of the following statements is true for chemical changes?

- (A) They are easy to reverse
- (B) They always involve a change of state
- (C) They always result in heat being given off
- (D) They always result in (a) new substance(s) being formed

c) Imagine you are freezing water to make ice cubes. Which of the following statements does NOT apply?

- (A) Water freezes at 0 degrees Celsius
- (B) Water molecules lose energy during the freezing process
- (C) Molecular bonds are broken and reformed during the freezing process
- (D) Water freezing represents a temporary change of state

d) Complete the statement: Physical changes

(A) are permanent.

(B) are exothermic.

(C) always involve a change of state.

(D) can be caused by exposing a substance to heat or cold.

SOLUTIONS

a) Answer: C

Answer C is the only one in which no change occurs at a molecular level. In A, oxygen in the air reacts with the metal to produce a new substance; in B, chemicals in the rain react with minerals in the rock; and in D, fire triggers a reaction between paper and air.

b) Answer: D

Chemical changes are difficult or impossible to reverse. They do not necessarily involve a change of state (e.g. roasting meat is a chemical change, but the meat remains solid throughout). Chemical changes can be either exothermic (give off energy) or endothermic (absorb energy). D is correct and is one of the defining characteristics of a chemical change.

c) Answer: C

We know A to be correct. B is correct because in order to freeze, water molecules must lose heat to their surroundings (exothermic reaction). D is correct because the freezing process is easy to reverse. C does not apply because freezing is not a chemical change: the frozen liquid retains the molecular formula H_2O .

d) Answer: D

A is false because physical changes are usually reversible. B is false because they can be exothermic (e.g. freezing water to get ice) or endothermic (e.g. melting ice to get water). C is false: they often involve a change of state, but not always. D is true, as we see in the example of melting and freezing.

BIOLOGY

MENDEL'S LAWS OF INHERITANCE

On past tests, several questions related to Mendel's laws of inheritance. Between 1856 and 1863, Gregor Mendel discovered some of the basic principles of inheritance through a series of breeding experiments which he conducted with pea plants. By observing the visible traits (phenotype) of pea plants, over many generations, Mendel derived a set of rules that helped explain how offspring could inherit traits from parents. By cross-breeding plants with different phenotypes and carefully recording the ratios of inherited traits, Mendel discovered that some genes were more dominant than others, leading to the discovery of recessive and dominant genes.

The two main conclusions that he derived from his observations include what is now called the Law of Segregation and the Law of Independent Assortment. A third law, the Law of Dominance, is also related to his research.

Law of segregation : Each parent contributes only one of two gene copies (alleles) during meiosis. It is the specific combination of either dominant or recessives alleles that determines which trait will be expressed in the offspring.

Law of independent assortment : The expression of an individual trait is independent of the expression of another. In other words, inheritance of alleles for separate traits is the result of completely random combination of parental chromosomes.

Law of dominance : The law of dominance states that one of the alleles will be dominant and the other will be recessive, unless both are recessive.

Based on these observations, whenever dominant and recessive allele are combined, it is the dominant allele that will be

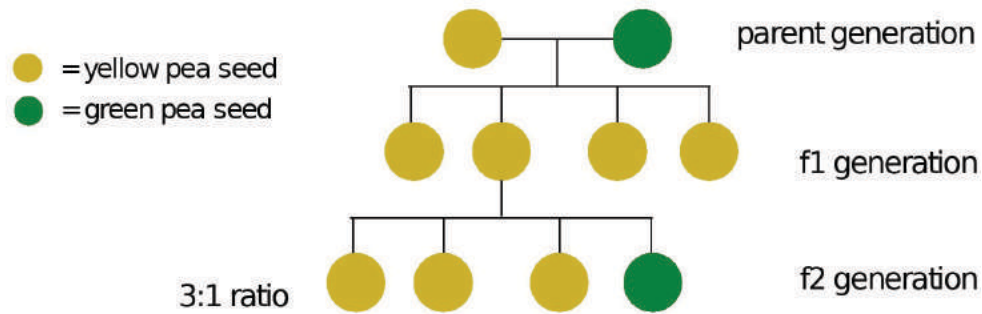
expressed. When an individual has one dominant and one recessive allele, this is referred to as being heterozygous. When an individual has two of the same allele, whether dominant or recessive, this is referred to as homozygous.

*Source: https://en.wikibooks.org/wiki/High_School_Biology/Mendel%27s_Investigations;
https://en.wikibooks.org/wiki/High_School_Biology/Mendelian_Inheritance; Accessed
25.01.2020*



EXERCISES

- a) In the diagram below, what accounts for the green pea seed in the f₂ generation?



- (A) On average, 1 out of 4 offspring of heterozygous parents will be homozygous recessive.
- (B) The yellow allele is dominant over the green one.
- (C) The green allele is dominant over the yellow one.
- (D) The f₁ generation parents are homozygous yellow.
- b) In a certain plant, purple flowers are dominant to red flowers. If the cross of two purple-flowered plants produces some purple-flowered and some red-flowered plants, what is the genotype of the parent plants?

- (A) PP x Pp
- (B) Pp x Pp
- (C) pp x PP
- (D) pp x pp

SOLUTIONS

a) Answer: A

Since the recessive allele is green, only plants that are homozygous green for this trait will have a green phenotype. The homozygous yellow and the heterozygous ones will all be yellow.

b) Answer: B

Answer C indicates that only one parent is purple, so C can't be the answer.

Answer D indicates that neither parent is purple, so D can't be the answer.

*For any offspring to be recessive, each parent **MUST** have at least one recessive allele (in this case, p); therefore, B has to be the answer.*

! BLOOD TYPES

Questions about blood types can also appear on TestAS exams. Learning a few central concepts related to blood types will help you to complete these questions easily and quickly.

First and foremost, you must have a basic understanding of the different blood types, and the inheritance as well as donation abilities of each. There are 4 different blood types (A, B, AB, and O), and in each category one can either be positive or negative, based on its Rh factor (Rhesus factor). The Rh factor is a type of protein on the surface of red blood cells. Key facts to remember:

- O type blood is recessive and therefore one's parents must both pass on a recessive gene in order to have a type O child.
- A and B types express a special dominance relationship, called codominance, which means that type A and B parents can have an AB child.
- O blood type is the “universal donor”, meaning all other blood types can accept it.
- AB blood type is the “universal acceptor”, since individuals with this blood type can accept blood from any other type.



EXERCISES

a) The universal blood donors for the ABO system are type:

- (A) A
- (B) B
- (C) O
- (D) AB

b) If one of your parents is blood type A and the other is type B, which of the following blood types would you likely be?

- (A) A
- (B) B
- (C) O
- (D) All of the above.

c) A mother of blood group O has a child of blood group O. The father could be of the blood type:

- I. A
- II. B
- III. O
- IV. AB

Choose the best answer:

- (A) I or II
- (B) I, II or III
- (C) IV only
- (D) I, II or IV

SOLUTIONS

a) Answer: C

Since type O blood normally lacks both A and B antigens, it will not be recognized as an alien type of blood in anyone. As a result, anyone can usually be transfused with O blood type without concern about rejection of this blood group.

b) Answer: D

Since you could inherit A or O alleles from one parent and B or O alleles from the other, you could be any of the ABO blood types.

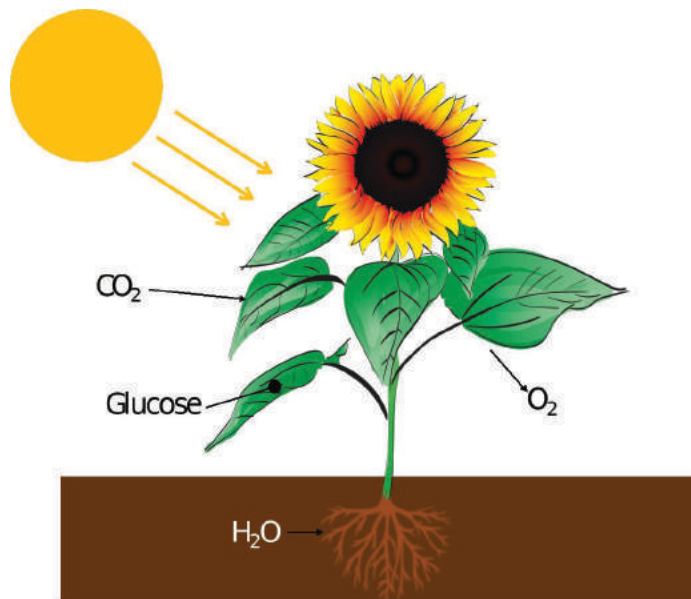
c) Answer: B

See chart below for explanation.

		Father's blood type				Child's blood type must be
		A	B	AB	O	
Mother's blood type	A	A or O	A, B, AB or O	A, B, or AB	A or O	
	B	A, B, AB or O	B or O	A, B, or AB	B or O	
	AB	A, B, or AB	A, B, or AB	A, B, or AB	A or B	
	O	A or O	B or O	A or B	O	

		Child's blood type				Father's blood type must be
		A	B	AB	O	
Mother's blood type	A	A, B, AB or O	B or AB	B or AB	A, B or O	
	B	A or AB	A, B, AB or O	A or AB	A, B or O	
	AB	A, B, AB or O	A, B, AB or O	A, B, or AB	Not possible	
	O	A or AB	B or AB		A, B, or O	

PHOTOSYNTHESIS



Photosynthesis is the process by which plants (as well as algae and certain bacteria) use the energy of sunlight and convert it into chemical energy.

Reactants:

- Water (absorbed through the roots of the plants)
- Carbon dioxide (absorbed through the leaves)

Products:

- Glucose (the plant needs it to build organic substances)
- Oxygen (is released to the environment via the leaves)

Required:

- Chlorophyll (in Chloroplasts)
- Light energy (radiation energy of the sun)

Location of photosynthesis:

- In the chloroplasts of the leaves

Procedure:

- Carbon dioxide and water are absorbed into the chloroplasts
- Inside the chloroplasts, glucose and oxygen are formed as products
- It is an endothermic process, since the energy amount of the raw materials is smaller than the amount of energy in the products, i.e., overall, energy is needed for this reaction to occur
- Light energy (absorbed by chlorophyll) is converted into chemical energy (glucose)
- In summary: Photosynthesis consumes the carbon dioxide of all breathing organisms and introduces the oxygen back into the atmosphere

Light independent photosynthesis:

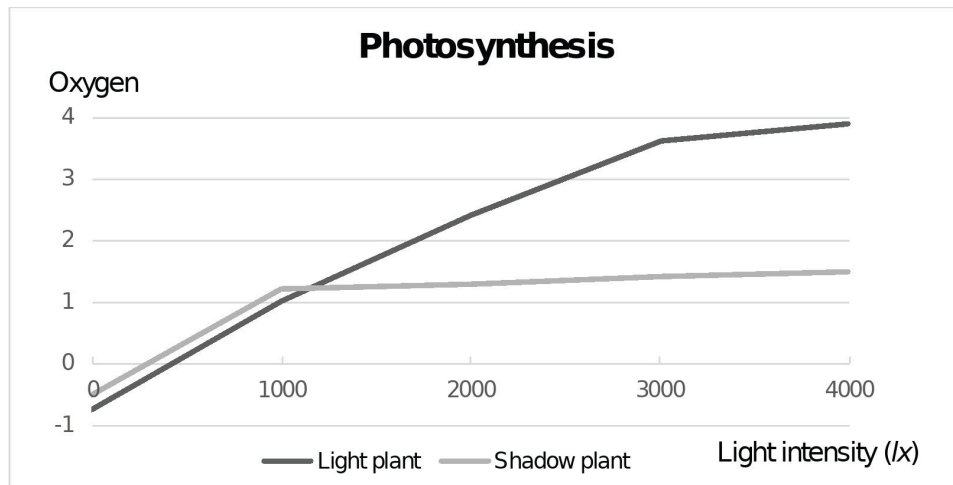
- Light-independent reactions (dark reactions, Calvin cycle): reactions using light as a product produce energy which drives light-independent or “dark” reactions



EXERCISE

There are two types of plants that complete photosynthesis: shadow plants and light plants. The shadow plants are adapted to living in little sunlight and produce oxygen even with these small amounts of available light. In fact, these plants quickly reach their light saturation point, at which point additional sunlight does not contribute to greater oxygen production.

The relationship between light intensity and oxygen production of two plants is shown in the figure below.



Which of the following statements is or are correct?

- I. Light plants reach the light saturation point earlier than shade plants.
 - II. If there is no light at all ($= 0 \text{ lux}$), both plants consume the same amount of oxygen.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.

(D) Neither of the two statements is correct.

Answer: D

Light plants are adapted to copious amounts of sunlight and therefore their light saturation point (when additional light no longer contributes to oxygen production) is higher than that of shadow plants which grow in places with less sunlight.

The figure shows oxygen production, not consumption. Both plants must consume oxygen photosynthesize and survive. The amount required by each plant depends on the surface size of the plant. It is therefore impossible to say whether both plants would use the same amount of oxygen to breathe.

ALKANE

N-ALKANE

[illegible]

NOMENCLATURE

General naming according to the IUPAC system:

1. The carbon atoms of the longest continuous carbon chain are numbered in such a way that the tertiary (attached to three further carbon atoms) or quaternary (attached to four further carbon atoms) carbon atoms each receive the lowest possible number (i.e. the carbon atoms from which side chains originate get the lowest possible number). According to this longest chain, the molecule gets its parent name (last part).
2. The names of the branching alkyl groups (side chains) (replace “-an” with “-yl”) are also determined by their length and are put in front of the parent name of the alkane, sorted in alphabetical order.

Additional rule a) If more than one alkyl group with the same name branches off the main chain, these alkyl group names are preceded by their number in Greek notation (2 = di, 3 = tri, 4 = tetra, 5 = penta, ...) as a numerical word. (These numerical words are not taken into account when sorting alphabetically.)

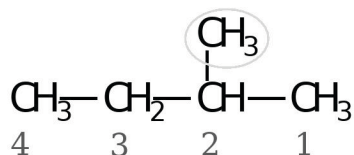
3. These alkyl group names are preceded by the numbers, separated by hyphens, of the carbon atoms on which they branch off.

Additional rule b) If there are several branching alkyl groups with the same name, the numbers are listed with increasing values separated by commas. If two identical alkyl groups branch off on a quaternary carbon atom, the number of the carbon atom is noted twice.

NAMING BASED ON EXAMPLES



EXAMPLE

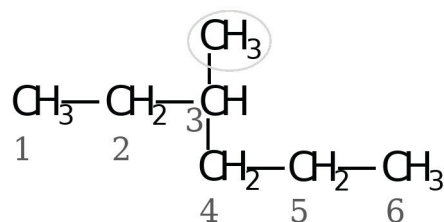


2-Methyl-butane

1. Longest chain: 4 C-Atoms, therefore parent name **Butane**
2. Alkyl groups: 1 C-Atom, Name **Methyl**
3. Branches off at C atom number **2**



EXAMPLE

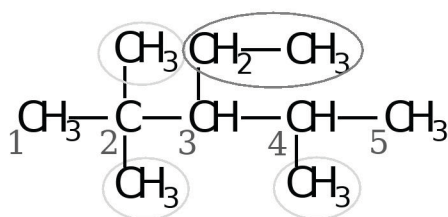


3-Methyl-hexane

1. Longest chain: 6 C-Atoms, therefore parent name **Hexane**
2. Alkyl groups: 1 C-Atom, Name **Methyl**
3. Branches off at C-Atom number **3**



EXAMPLE



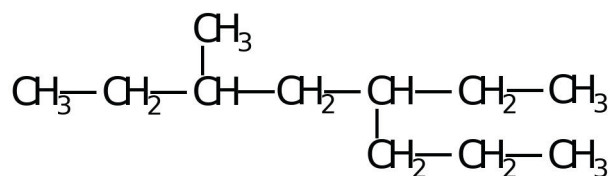
3-Ethyl-2,2,4-trimethyl-pentane

1. Longest chain (with the most side chains): 5 C-Atoms, therefore parent name **Pentane**
2. Alkyl groups: 2 C-Atoms, Name **Ethyl**; 3 (**tri**) times: 1 C-Atom, Name **Methyl**
3. Branches off at C-Atom number **3**; branches off at C-Atom number **2, 2** and **4**.



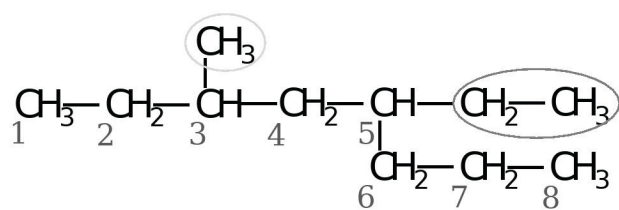
EXERCISES

1. What is the name of the following alkane?

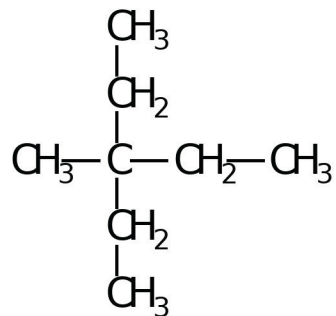


Answer:

5-Ethyl-3-methyloctane

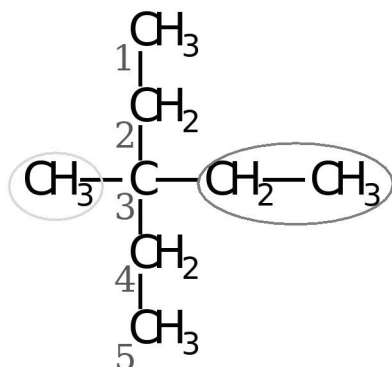


2. What is the name of the following alkane?



Answer:

3-Ethyl-3-methylpentane





GOOD TO KNOW

READING FROM THE MIRROR

A new question type appeared on recent tests— one requiring you to read a text in a mirror and sort out what it is saying. This type of question uses a visual puzzle to test one’s problem solving and reasoning. Below you’ll find tips to make solving these questions easier and quicker.

TIPS

This type of question usually appears in the same set up: an individual is looking into a mirror and seeing text written on the door or wall behind them. The question then asks you to solve for this text. This text could be a single word or it could be a sequence of numbers and letters. One nice thing about this question is that there is little unknown – the mirror always provides the same type of reflection; one only needs to use some visual deciphering to find the answer that is correct.

Visualizing the “Flip”

The easiest way to describe the “flip” of the letters and/or numbers is to visualize yourself picking up the left side of a piece of paper with a word printed on it (pick up the side with the beginning of the word), and flipping it over so the left end is now the right end, and you are looking at the back of the paper. The physical motion of this action helps to understand where the letters will wind up – it may help to practice with real slips of paper and simple sequences.

Quickly eliminate potential answers

This is a question type where it can be easy to eliminate obviously wrong answers. For example, if there is a sequence that begins and ends with a letter, and one of the answers shows a sequence starting or ending in a number, it can immediately be ruled out. Even if the entire sequence is letters, by checking the first and last

letters and cross-referencing these with the answers, it can be easy to eliminate options with a third/different letter present.

The following table shows the numbers (0 – 9) and the letters of the alphabet in mirror writing:

MIRROR WRITING									
Digits		Alphabet (capital)				Alphabet (miniscule)			
0	0	A	A	N	И	a	ɐ	n	ɱ
1	1	B	B	O	O	b	d	o	o
2	2	C	C	P	Ɔ	c	ɔ	p	q
3	3	D	D	Q	Q	d	b	q	p
4	4	E	E	R	Я	e	ə	r	ɿ
5	5	F	F	S	Ƨ	f	ɟ	s	z
6	6	G	G	T	T	g	g	t	ɟ
7	7	H	H	U	U	h	ɥ	u	u
8	8	I	I	V	V	i	i	v	v
9	9	J	L	W	W	j	ɿ	w	w
		K	K	X	X	k	ɥ	x	x
		L	J	Y	Y	l	l	y	ɥ
		M	M	Z	Σ	m	m	z	Σ



EXERCISES

1. Peter looks into a mirror and notices a text written on the wall behind him. He sees the following text:

EMERGENCY EXIT

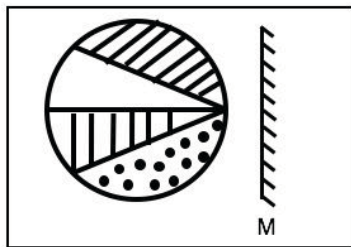
What phrase is Peter seeing?

- (A) EMERGING EXIT
 - (B) EMERGENCY TAXI
 - (C) EXISTENTIAL TEXT
 - (D) EMERGENCY EXIT
2. The following sequence of letters and numbers is reflected in a mirror. What does it look like when one is looking into the mirror?

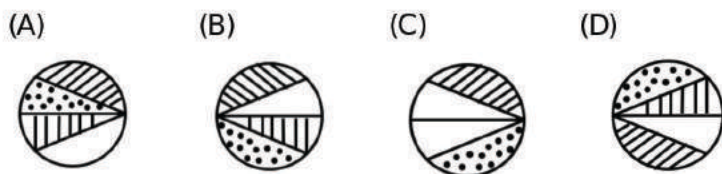
75MSY319BK

- (A) Ǝ19Ǝ2Ǝ8Y2M
- (B) Ǝ2W2Ǝ319BK
- (C) Ǝ2W2Ǝ3Ǝ3KB
- (D) Ǝ2Ǝ2W319BK

3. Take a look at the following image:



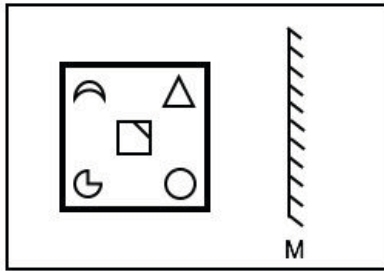
Which of the given pictures shows the correct reflection, if the mirror is placed as indicated above?



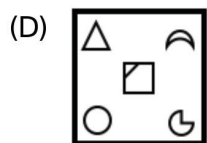
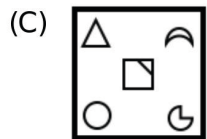
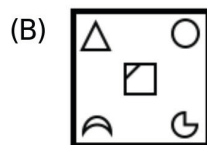
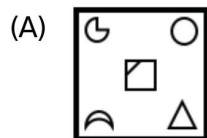
Source:

<https://www.doorsteptutor.com/Exams/NTSE/Stage-I-State-Level/MAT/Questions/Topic-Non-Verbal-Intelligence-1/Subtopic-Mirror-Image-4/Part-1.html>, Accessed 13.02.2020

4. Take a look at the following image:



Which of the given pictures shows the correct reflection, if the mirror is placed as indicated above?



Source:

<https://www.doorsteptutor.com/Exams/NTSE/Stage-I-State-Level/MAT/Questions/Topic-Non-Verbal-Intelligence-1/Subtopic-Mirror-Image-4/Part-1.html>, Accessed 13.02.2020

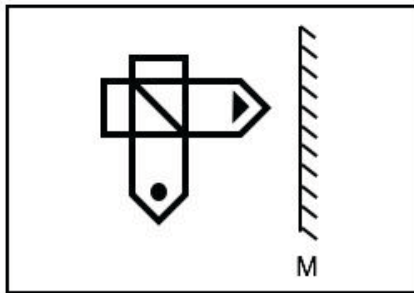
5. Anne sees the following digit-letter sequence in a mirror:

2A8N96MEO

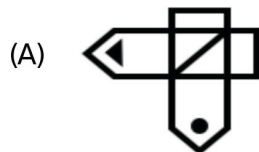
Which of the following is reflected?

- (A) SA8N96MEO
- (B) SAN069MEO
- (C) SA8M96MOE
- (D) SA89N6MEO

6. Take a look at the following image:



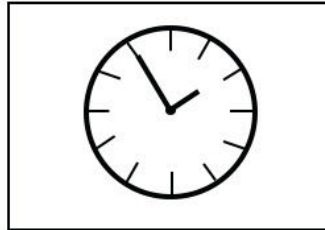
Which of the given pictures shows the correct reflection, if the mirror is placed as indicated above?



Source:

<https://www.doorsteptutor.com/Exams/NTSE/Stage-I-State-Level/MAT/Questions/Topic-Non-Verbal-Intelligence-1/Subtopic-Mirror-Image-4/Part-2.html>, Accessed 13.02.2020

7. Paul sees the reflection of a clock in the window. It shows 1.55, but what time is it really?



- (A) 10.10 o'clock
- (B) 10.05 o'clock
- (C) 09.55 o'clock
- (D) 10.55 o'clock

Source: <http://www.thecompetitionworld.com/2014/04/mirror-images.html>, Accessed 13.02.2020

8. The band name “The White Stripes” is written on a poster behind Tobias. What does it look like when Tobias looks at it in a mirror in front of him?

- (A) The Witre Stripes
- (B) The Witre Stripes
- (C) Teh Witre Stripes
- (D) The Witre Stripes

Answers:

1-D, 2-B, 3-B, 4-D, 5-A, 6-A, 7-B, 8-D

TYPES OF VISUALS ENCOUNTERED IN THE EXAM

Our ability to notice patterns from visual information is a powerful tool for understanding and interpreting data. By depicting information graphically, using tables and diagrams, it is often much easier to observe trends and to make comparisons between data that might otherwise be difficult to understand through the use of words or numbers alone.

The following types of illustrations are often found within the exam. All of the diagrams are displayed using linear scales unless otherwise stated.

TABLE

A table is a summarized overview of various data. The table consists of a horizontal “row” and a vertical “column”. The boxes in which data are found, as seen in the following example, are called “cells”. Data within a table almost always have a relationship to one another and are displayed in this form for a clear overview and for comparison purposes.



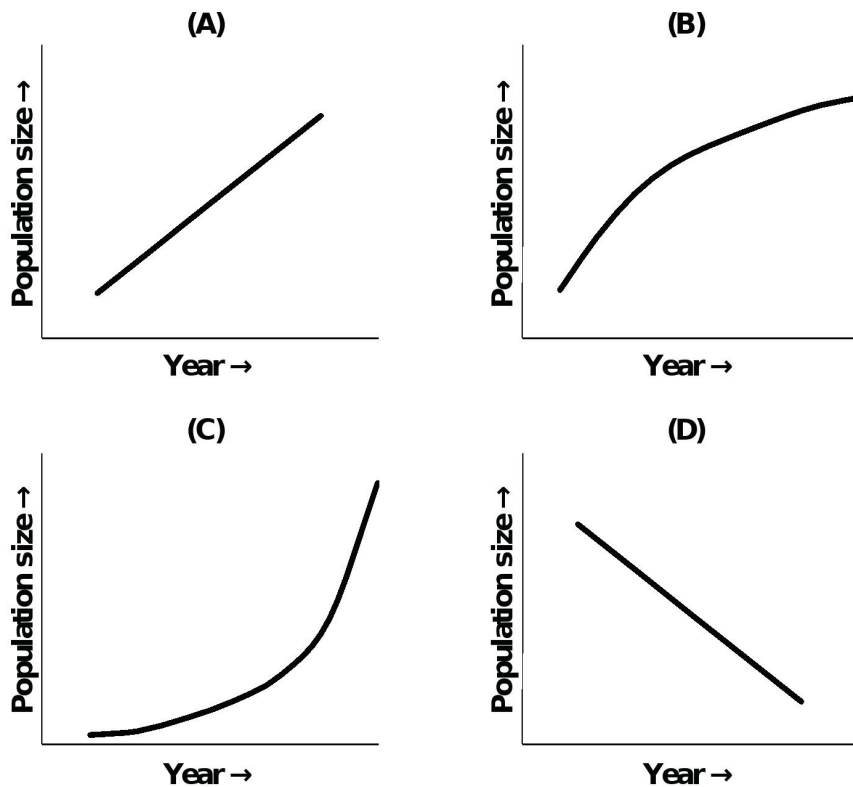
EXERCISES

1. Below is a table of data obtained for a rabbit population over a period of several years.

Year	Number of rabbits
1	4
2	17

3	62
4	245

Which of the following graphs best represents the data on rabbit population size?



Answer: C

The population size of the rabbits increases by a larger amount each year (e.g., year 1 to 2 = 13, year 2 to 3 = 45), which is best represented by C.

2. In different organisms, the amino acid sequences of proteins with the same functions are similar but not identical. The level of similarity between sequences is one indication of how closely organisms are related to one another. The following data table shows the number of different amino acids in the beta hemoglobin chain of various organisms compared to that of humans.

Organism	Number of different amino acids
Human	0
Mouse	27
Frog	68
Monkey	11
Fish	125
Chicken	35
Gibbon	2

Which of the following statements is or are correct?

- I. Birds are more closely related to amphibians than to mice.
 - II. Gibbons are closer to humans than monkeys.
- (A) Only statement I is correct.
 - (B) Only statement II is correct.
 - (C) Both statements are correct.
 - (D) Neither of the two statements is correct.

Answer: B

Comparing the structure of hemoglobin, the amino acid sequence of chickens is more closely related to that of mice than of frogs. Statement I is incorrect. The amino acid sequence of gibbons is more closely related to human's than to monkeys'. Hence statement II is correct.

SIMPLE LINE CHART

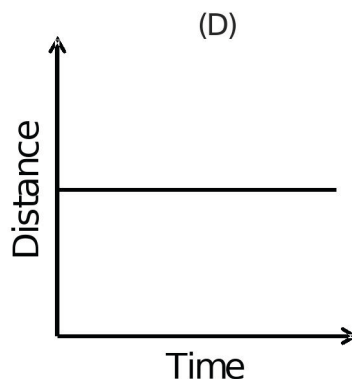
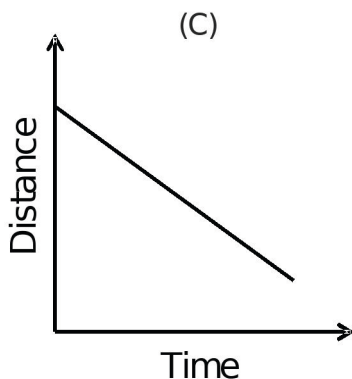
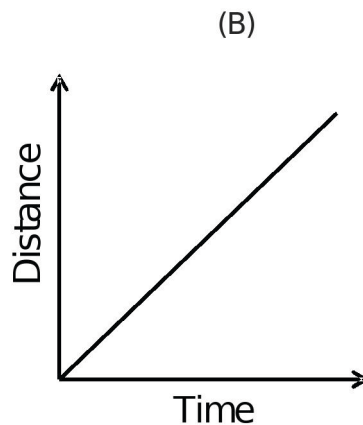
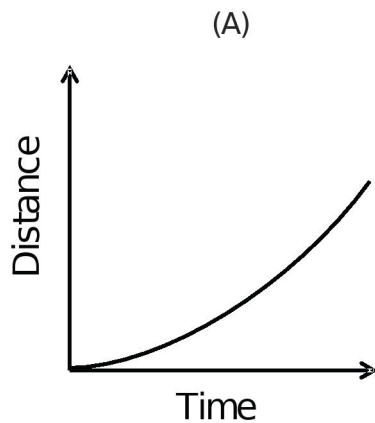
A line chart shows a tendency, a process or a trend (e.g. as a function of time). It is often used to observe development processes within a timeframe.

We strongly advise you to be very familiar with the distance (or velocity, acceleration or displacement) and time graphs. You need to be able to look at one of these types of charts and know how to calculate the distance traveled from the starting point as well as knowing what the slope and the area mean.



EXERCISES

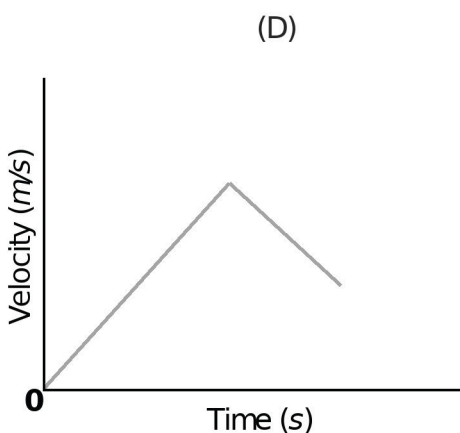
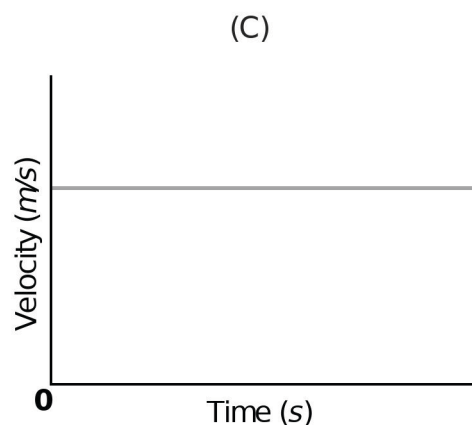
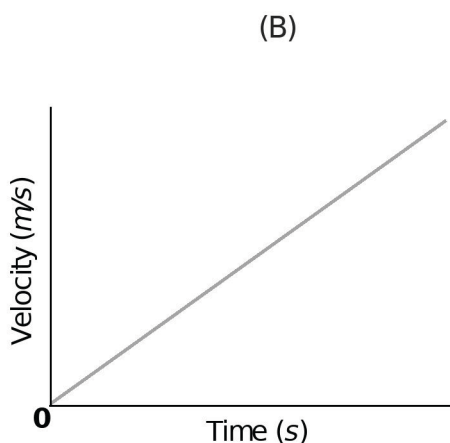
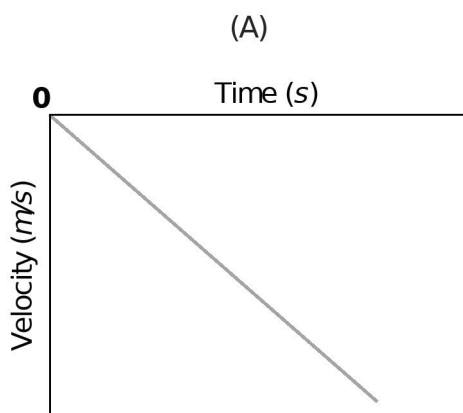
1. An object moves away from a motion detector with a constant speed. Which graph best represents the motion of the object?



Answer: B

The graphs that represent a constant speed are graph B and D. The distance increases at a constant rate. Graph D shows an object moving towards a motion detector (negative slope, distance is decreasing). Graph B is the correct answer, as the distance from the detector increases at a constant rate.

2. A ball falls down from the 50th floor of a skyscraper. Which one of these graphs shows the speed of the ball correctly?



Answer: A

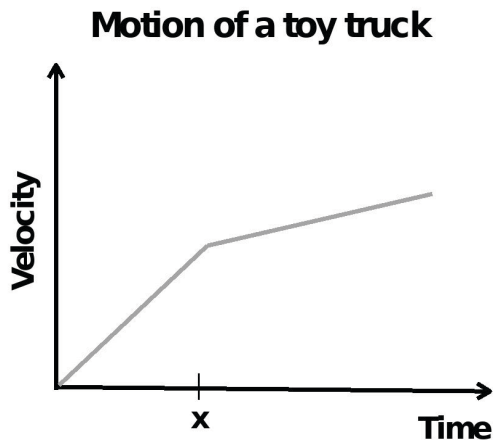
A free-falling object is undergoing an acceleration ($g = 9.8 \text{ m/s/s}$, downward), so we are looking a graph showing a constant acceleration. In the velocity/time graphs, this is depicted with a straight, diagonal line.

Given the freefall, the object starts with a zero velocity and moves in the negative direction. An object moving in the negative direction and speeding up has a negative acceleration.

The graph in answer A may not be correct to the digit, but we do not need to worry about this. This type of chart, as opposed to the options shown in B through D, shows the correct answer.

As seen with the above example, some questions will require you to identify which diagram best matches the information with which you are being presented. The diagram that you choose may only be directionally correct (i.e., correct compared to the other options which are clearly wrong), but not precisely correct. You are simply to choose the best available diagram based on the provided information.

3. A student applies a constant force to a toy car. Below is a graph showing the movement of the car:



Which of the following could best explain the change in velocity at time X?

- I. The truck went from moving in a straight path to moving in a curved path.
 - II. The truck began travelling up a slightly sloped surface.
- (A) Only statement I is correct.
 - (B) Only statement II is correct.
 - (C) Both statements are correct.
 - (D) Neither of the two statements is correct.

Answer: B

When the toy is moving in a straight to circular path, the velocity need not decrease as a constant force is still being applied. Thus, statement I is incorrect. When the toy is on a slightly sloped surface, the velocity would decrease because the toy would be moving against gravity. Thus, statement II is correct.

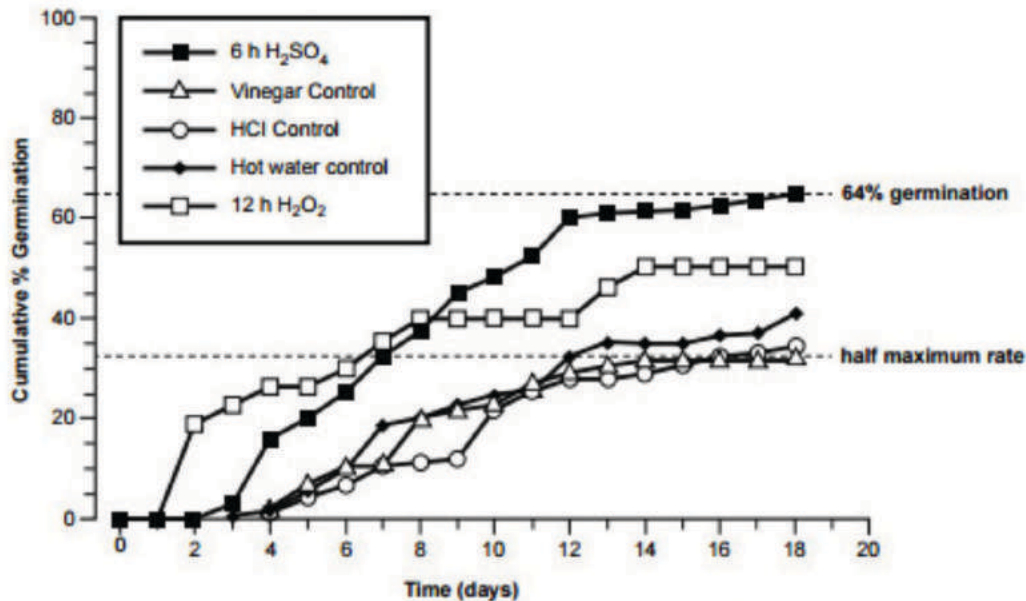
COMPLEX LINE CHART



EXAMPLE

Germination is a critical stage in the life cycle of plants. A number of methods are used to increase germination percentage and to shorten germination time. Treatment with hot water, acids like vinegar, HCl and H_2SO_4 are some of the common methods used.

In the diagram below you can see the percent germination of gourd seeds after being exposed to various treatments. (Note: Cumulative germination of gourd seeds following various peregrination treatments. N = 100 seeds per trial.)



Which of the following can be inferred from this data?

- (A) Gourd seeds that are exposed to the hot water control would grow better if they were also exposed to 6 h H_2SO_4
- (B) 64% is the highest germination rate possible for gourd seeds.
- (C) Strong acids, like H_2SO_4 , have a greater effect on germination of gourd seeds in the long run than do weak acids,

like vinegar.

- (D) Tomato seeds would have similar responses to the same treatments.

Answer: C

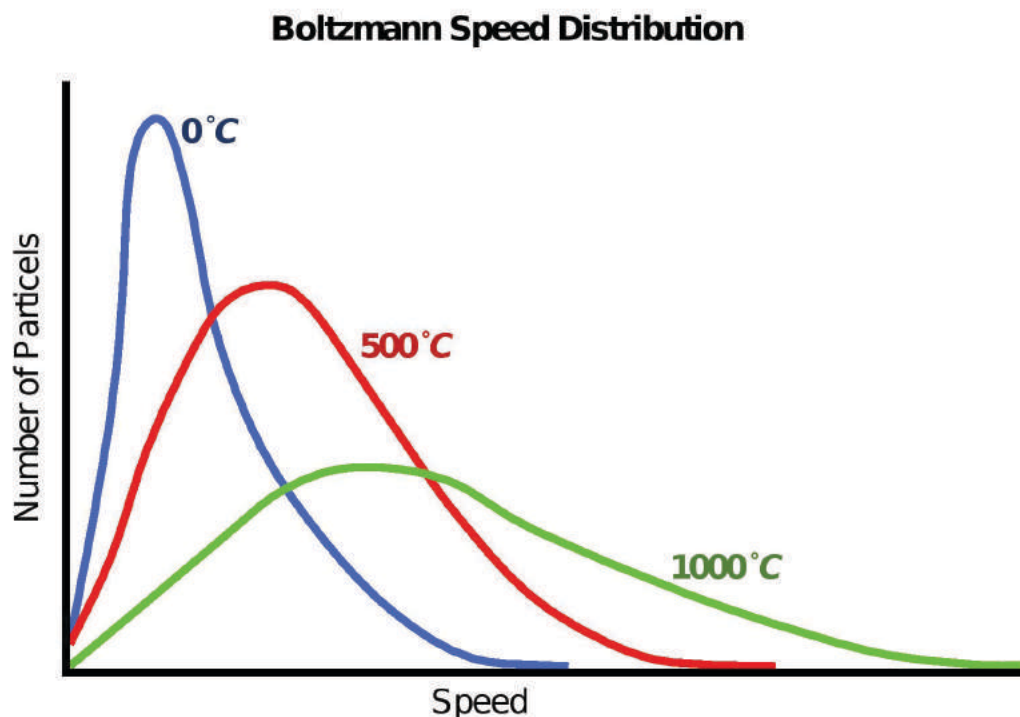
According to the data, gourd seeds exposed to 6 h H_2SO_4 had the highest germination rate. H_2SO_4 is considered a strong acid, while vinegar is considered a weak acid. It can be inferred from the graph that strong acids could have a greater effect on germination than weak acids. Choice (A) is incorrect because there is no information on the graph about exposing gourd seeds to both hot water and H_2SO_4 at once. Choice (B) is incorrect because the graph only provides information for gourd seeds given specific treatments; we have no way of knowing if other treatments exist which would be more effective. Choice (D) is incorrect because tomato is a different plant species; the effects of these treatments could be different on tomato seeds than gourd seeds.



EXAMPLE

An ideal gas is defined as one in which all collisions between atoms or molecules are perfectly elastic and in which there are no intermolecular attractive forces. In an ideal gas, not all gas particles move at the same speed; the speed has a certain statistical distribution depending on the gas and other criteria such as the temperature. This is often referred to as the Maxwell-Boltzmann speed distribution and is represented graphically by the diagram below.

According to this diagram, which of the following statements is or are correct?



- I. The speed at which the majority of the particles move at 1000 °C is greater than the speed at which the majority of the particles move at 0 °C.
- II. The more particles there are in a gas, the higher the average velocity of the particles.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

Answer: A

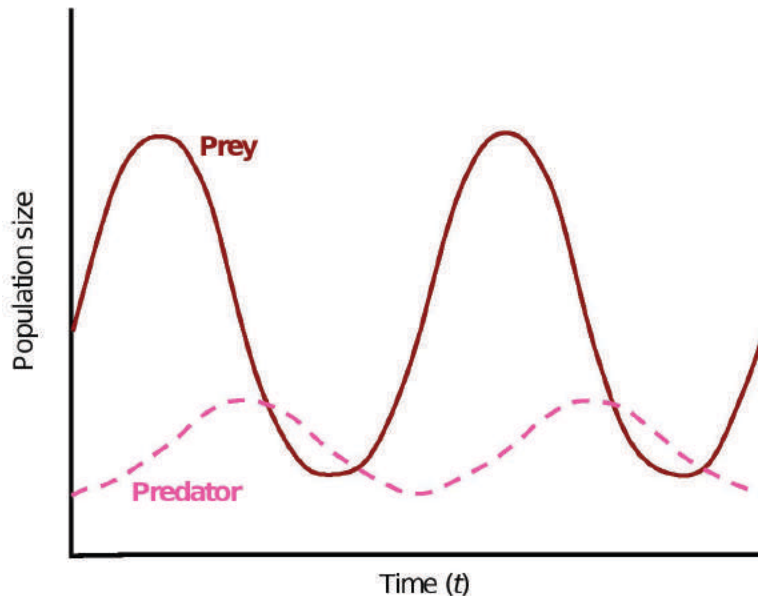
Statement I is correct. As the diagram shows, the majority of the particles at 1000 °C have a higher speed than the majority of the particles at 0 °C.

Statement II is incorrect. The number of particles in a gas gives no information about the average velocity of the particles.



EXAMPLE

The predator-prey relationship depends on several factors such as weather, birth rate, and catch rate.



- I. An increase in the prey population is often followed by an increase in the predator population.
 - II. The predator population eliminates the prey population.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

Answer : A

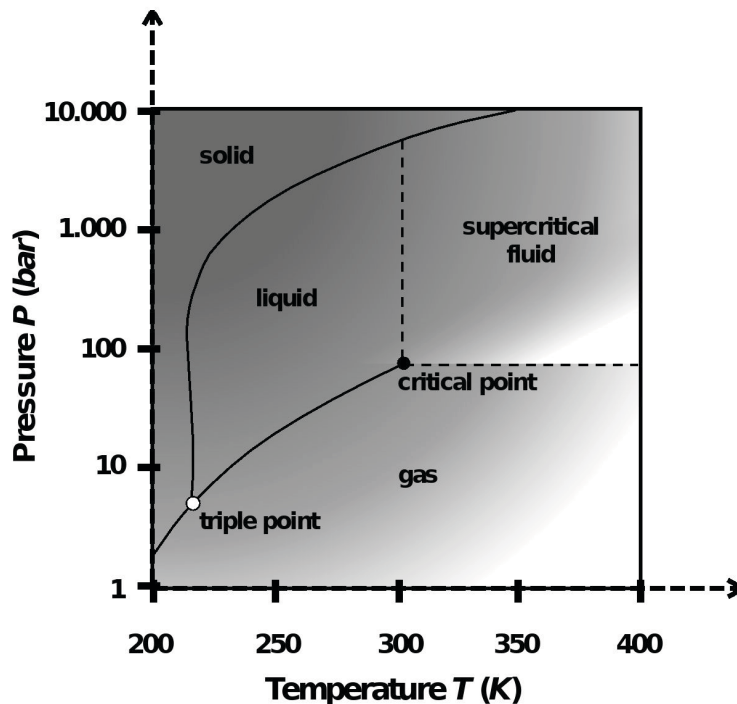
As the graph shows, an increase in the prey population is often followed by an increase in the predator population. However, predators very rarely eliminate the prey population because nature maintains the delicate balance between the two populations.

AREA CHART



EXAMPLE

A phase diagram provides information about the phases of a certain substance at a given pressure and temperature. Below is the phase diagram for carbon dioxide:



Source: Ben Finney and Mark Jacobs, Phase diagram of CO₂,

https://commons.wikimedia.org/wiki/File:Carbon_dioxide_pressure-temperature_phase_diagram.svg, Accessed

12.11.2019

At 290 K and 29 bar, in which phase does carbon dioxide exist?

- (A) Solid
- (B) Gas
- (C) Liquid
- (D) Solid, gas, liquid

Answer: B

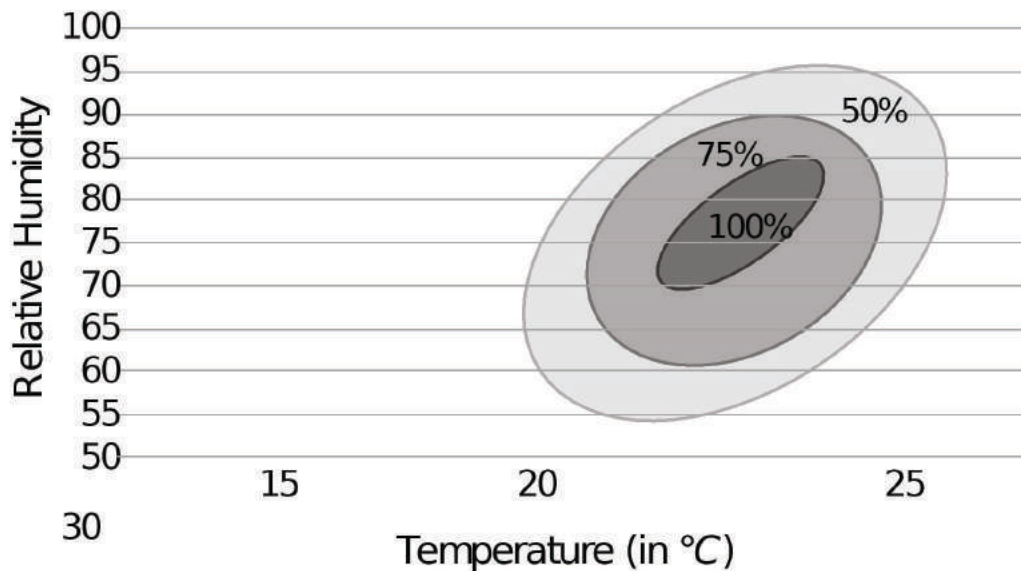
Find 290 K on the x-axis, then move vertically to a position corresponding to 29 bar on the y-axis. Carbon dioxide will exist as a gas.

Note: In this diagram, the y axis division is not scalar (as it is in most diagrams), but rather logarithmic. This means that the markings do not divide the axis into parts of the same size, but rather sizes of increasing magnitude (comparisons: 1 to 10, then 10 to 100, then 100 to 1000 and 1000 to 10 000).



EXAMPLE

Under optimal conditions, caterpillars develop into butterflies. Humidity and temperature play an important role in this process. If the conditions are unfavorable, only some caterpillars will transform into larvae and, later on, into butterflies. The graph depicts the relationship roughly.



Which of the following statements is or are correct?

- I. The number of caterpillars developing into a butterfly may be the same in 65% and 90% humidity levels.
 - II. It may be that at temperatures of 15°C and 25°C, the same number of caterpillars develop into butterflies.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

Answer: C

Statement I: When you check the percentage of caterpillars transforming into butterflies at a temperature close to 25°C and at humidity levels of 65% and 90%, you can see that both are at 75%. This is due to the three concentric elliptical shapes of the diagram. Statement I is correct.

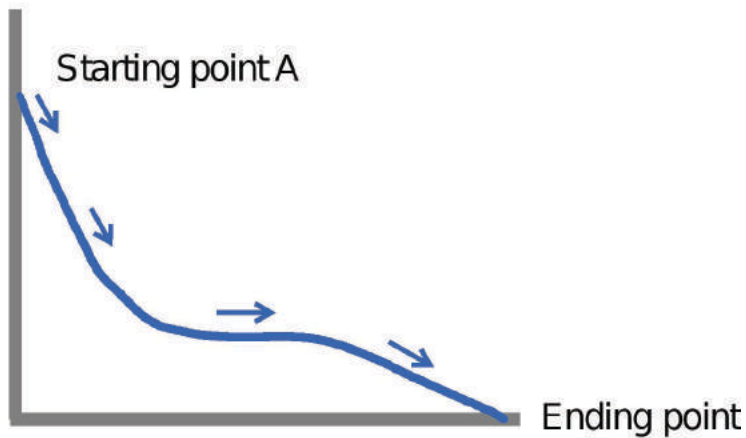
At humidity levels below 55% and approx. above 98%, caterpillars can't transform into butterflies (0%). In this case, the number of caterpillars developing into butterflies would be zero. Therefore, statement II is correct.

TICKER TAPE



EXAMPLE

A cart is released from point A as shown in the diagrammatic representation below.



Which of the ticker tape points given below would possibly represent the pattern of movement?

A



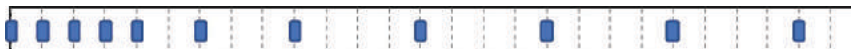
B



C



D



Answer: A

The distance between dots on a ticker tape represents the object's position change during that time interval.

- *A large distance between dots indicates that the object was moving fast during that time interval.*
- *A small distance between dots means the object was moving slowly during that time interval.*
- *Fast movement:*



- *Slower movement:*



Additionally, you can make conclusions about the acceleration of the object.

- *A changing distance between dots indicates a changing velocity and thus an acceleration.*



- *The larger the increase in the distance between the dots, the higher the acceleration.*



- *A constant distance between dots represents a constant velocity and therefore no acceleration.*



From the diagram, we can see that the slope of the line is initially very steep, then it levels off for a bit, then it increases again. The pattern, both for its acceleration and the distance between the dots, should be large increase ☐ no increase ☐ small increase. In other words, large acceleration ☐ no acceleration ☐ small acceleration.

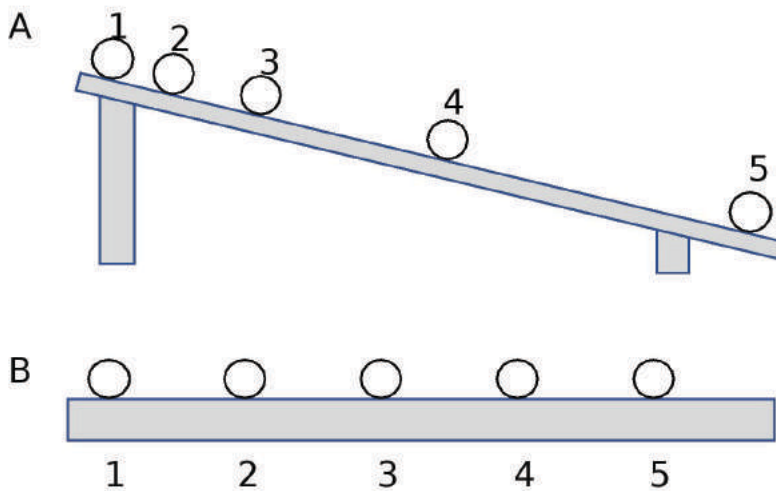
Looking at the answers, we can eliminate B and D because both show that the distance between the first few dots is constant. We know that this cannot be correct because the cart should be accelerating, and, therefore, the distance between the dots should be increasing.

The difference between A and C is more difficult to discern, since both show the correct overall pattern of increase $\square$ no increase $\square$ increase. By measuring the distance between dots for both A and C, we see that A is correct, because the pattern is large increase $\square$ no increase/small increase, whereas in C, the pattern is small increase $\square$ no increase $\square$ large increase.



EXAMPLE

Ball A is released from rest and rolls down an incline, while ball B rolls horizontally at constant speed. In the picture, the positions of balls A and B are marked at each second and the corresponding time stamps are shown near the positions. (Please assume no friction.)



Which of the following statements is or are correct?

- I. Ball A will have equal speeds at frames 2 and 4.
- II. At frames 2 and 4, both balls have the same acceleration.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

Answer: D

In the case of the ball A, the speed is continuously increasing (and hence the increasing size of distances in the ticker tape) because there is acceleration.

In the case of the ball B, the velocity is constant and the acceleration is zero.

Statement I is not correct because ball A is accelerating.

Statement II is not correct because ball A always has a higher acceleration than ball B.

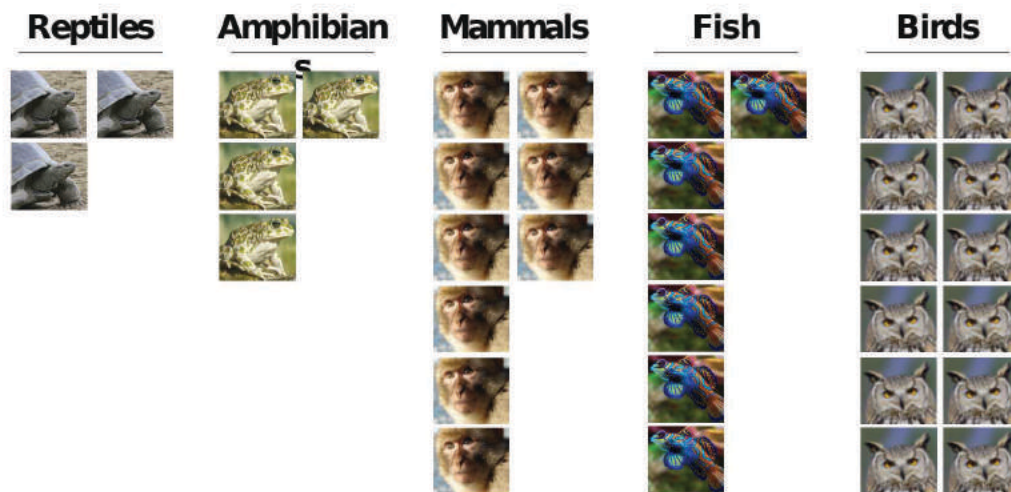
PICTOGRAM

Pictograms show comparisons using symbols. Here is an example:



EXAMPLE

The pictogram expresses the number of vertebrate species found in the country of XYZ. Each symbol represents 10,000 animals of this type.



Source: Wikipedia: Featured pictures: Animals,
https://en.wikipedia.org/wiki/Wikipedia:Featured_pictures#Animals, Accessed
20.01.2020

Aldabra giant tortoise, by Muhammad Mahdi Karim; Balearic green toad, by Richard Bartz; Barbary macaque, by Christopher Buttigieg; Mandarinfish, by Lviatour; Eurasian eagle-owl, by Kadellar.

The following table shows the growth rate of the number of the above depicted animal types.

	Reptiles	Amphibians	Mammals	Fish	Birds
Growth rate per year	+ 10%	- 20% due to illnesses	+ 5%	+ 10%	- 10%

Which of the following statements is or are correct?

- I. Within 3 years' time, more reptiles will exist in this country than amphibians.
- II. In five years, if all amphibians die out due to the current illnesses and the current growth rate per year for birds does not change, then the bird population will only be 50%.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

Answer: A

Statement I: Already after one year's time, the number of amphibians is only 32,000 and the reptiles will populate to 33,000. Thus, statement I is correct.

Statement II: Here, it is tempting to assume that because all the amphibians will die out after 5 years' time, the bird population will drop below 50%. But with some calculations, we see this is not true. Assuming there is 100% in the initial year, the bird population after 5 years' time is calculated as follows:

$$\text{1st year: } 100\% - (100\% \times 10\%) = 90\%$$

$$\text{2nd year: } 90\% - (90\% \times 10\%) = 81\%$$

$$\text{3rd year: } 81\% - (81\% \times 10\%) = 72.9\% \text{ etc.}$$

Therefore, the bird population is above 50% after 5 years' time. Thus, statement II is false.

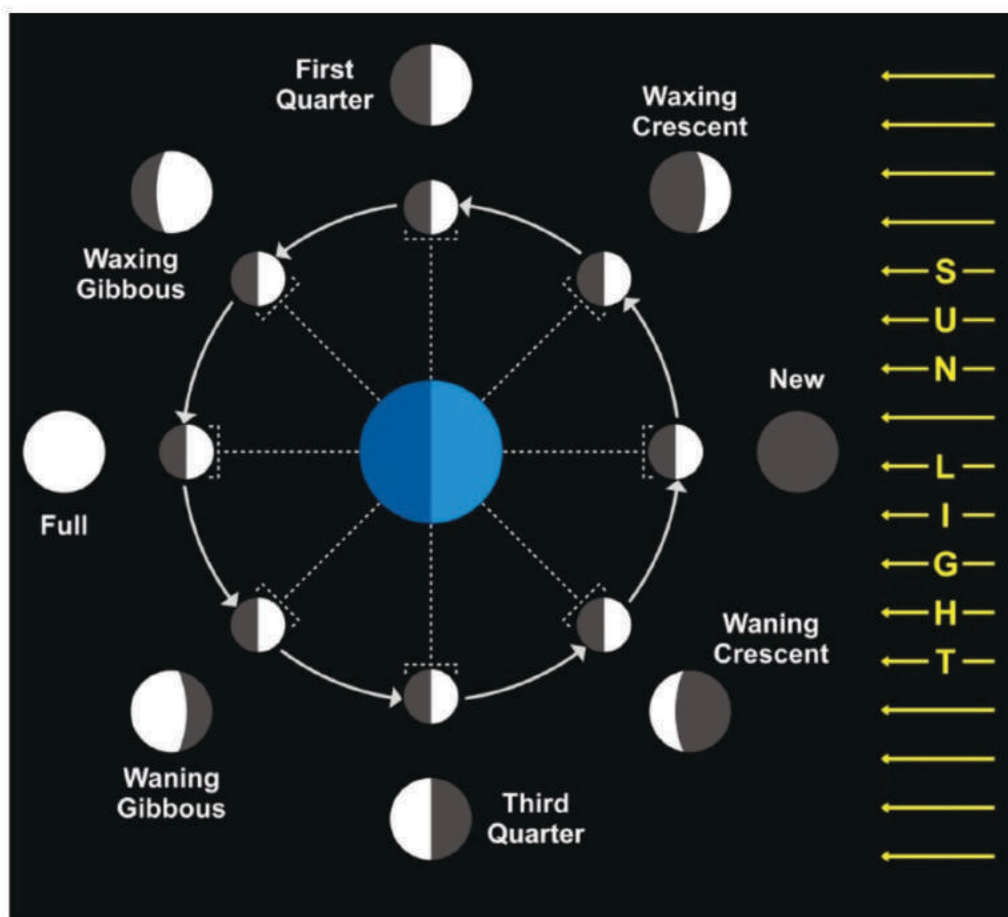
VISUAL EXPLANATION OF THE QUESTION

Some questions have figures/diagrams which you must interpret to answer the question.



EXAMPLE

As the moon revolves around the Earth, phases can be observed because of the way sunlight reflects off the moon. The figure below shows the different phases of the moon.



Source: udaix, Shutterstock, Accessed 05.07.2019

At which phase of the moon can there be a lunar eclipse?

(A) Full moon

(B) New moon

(C) There is no relationship between the phases and the time of eclipses.

(D) Last quarter

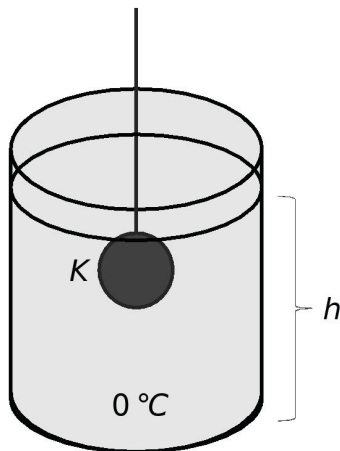
Answer: A

The phenomenon of lunar eclipses occurs when the moon is directly in the “shadow” of the earth and consequently appears much darker than usual. This is only possible when the moon is directly “behind” the earth (as seen from the sun), which is only the case when we see a full moon.



EXAMPLE

In the figure below, the mass K is balanced and the tension of the rope is not zero. Which of the following variables will increase when the temperature rises from $0\text{ }^{\circ}\text{C}$ to $+4\text{ }^{\circ}\text{C}$?



- (A) h
- (B) The tension in the rope
- (C) The density of the water
- (D) All variables will increase

Answer: C

The density of the water is highest at $+4\text{ }^{\circ}\text{C}$. Accordingly, density will increase. On the other hand, the volume of water is lowest at $+4\text{ }^{\circ}\text{C}$. Therefore, h decreases. The tension of the rope is the force of the weight of K minus the force of buoyancy from water acting on K ($G - F(K)$). G stays the same, but we know the water becomes denser, meaning the force of buoyancy increases: $F(K) = V \times d \times g$. d increases, g is a constant, and the volume of the water displaced remains equal to the volume of ball K $\square F(K)$

increases. As $F(K)$ increases, $G - F(K)$ decreases, and the tension in the rope decreases.

IMPORTANT VISUAL – REDUNDANT TEXT

If a question seems very complex or uses a lot of terminology, have a look at the visual first. You may not need to understand the question text to answer the question.

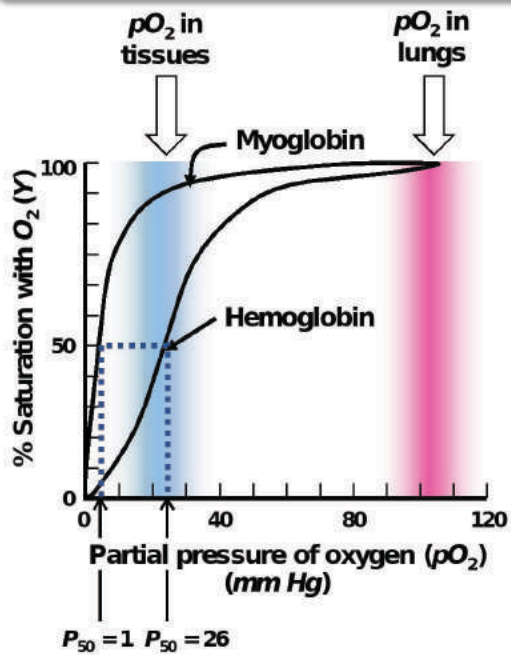
TestAS has been constructed in a way that it does not require much pre-knowledge. If something seems too complex, the chances are that the confusing text is just disguising a simple math question.



EXAMPLE

In medicine, oxygenation is when oxygen molecules enter the tissues of the body. Blood is oxygenated in the lungs, where oxygen molecules travel from the inhaled air and into the blood. Oxygen molecules may bind to hemoglobin, a protein found in red blood cells, or myoglobin, a protein found in muscle tissue.

The oxygen dissociation curve for Hb is steepest at the oxygen concentrations that occur in the tissues. This permits oxygen delivery to respond to small changes in pO_2 .



In myoglobin, what is the partial pressure of oxygen (pO₂) at 50% saturation with O₂ (in mm Hg)?

- (A) 1
- (B) 0.5
- (C) 0.75
- (D) 2

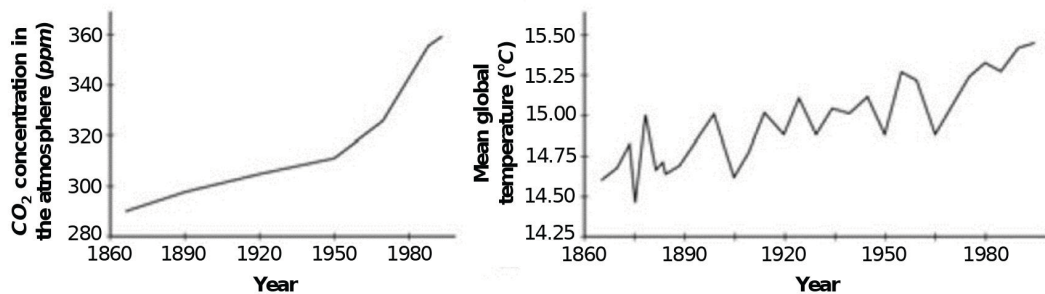
Answer: A

The legend below the graph indicates that the value of P_{50} is 1.



EXAMPLE

Carbon dioxide (CO_2) is a heat-trapping (greenhouse) gas which is released through human activities such as deforestation and burning fossil fuels, as well as natural processes such as respiration and volcanic eruptions. There is a close correspondence between average global temperature and CO_2 concentration. CO_2 is one of the most prominent causes of the greenhouse effect.



The graphs above show that the relationship between atmospheric CO_2 and mean global temperature is:

- (A) A positive correlation.
- (B) An inverse relationship.
- (C) A cause and effect relationship.
- (D) Evidence of an impending ice age.

Answer: A

The graphs show a positive correlation between atmospheric CO_2 and mean global temperature. As the amount of CO_2 in the atmosphere increases, there is a corresponding increase in mean global temperature. A is correct. B is wrong because the two graphs are both moving in the same direction. For it to be an inverse relationship, one would have to go up while the other went

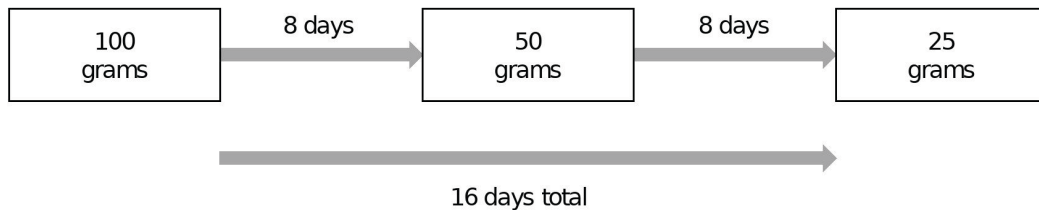
down. It is not necessarily a cause and effect relationship, though it very well may be. The trouble is that causality cannot be established from the graphs alone, as many other factors are involved in the greenhouse effect. Thus, A should be preferred over C. D is incorrect because the temperature increases, which cannot be evidence for an impending ice age.

VISUAL DUPLICATING THE TEXT



EXAMPLE

Radioactive decay is the loss of elementary particles from an unstable nucleus, ultimately changing the unstable element into another, more stable element. Half-life is the time it takes for half of the substance to decay. The rate of decay remains constant throughout the decay process. The figure below shows the transformation of an object due to half-life decay that weighs 100 grams and has a half-life of 8 days:



What is the weight of the object after 32 days?

- (A) 3.125 grams
- (B) 12.5 grams
- (C) 0.78125 grams
- (D) 6.25 grams

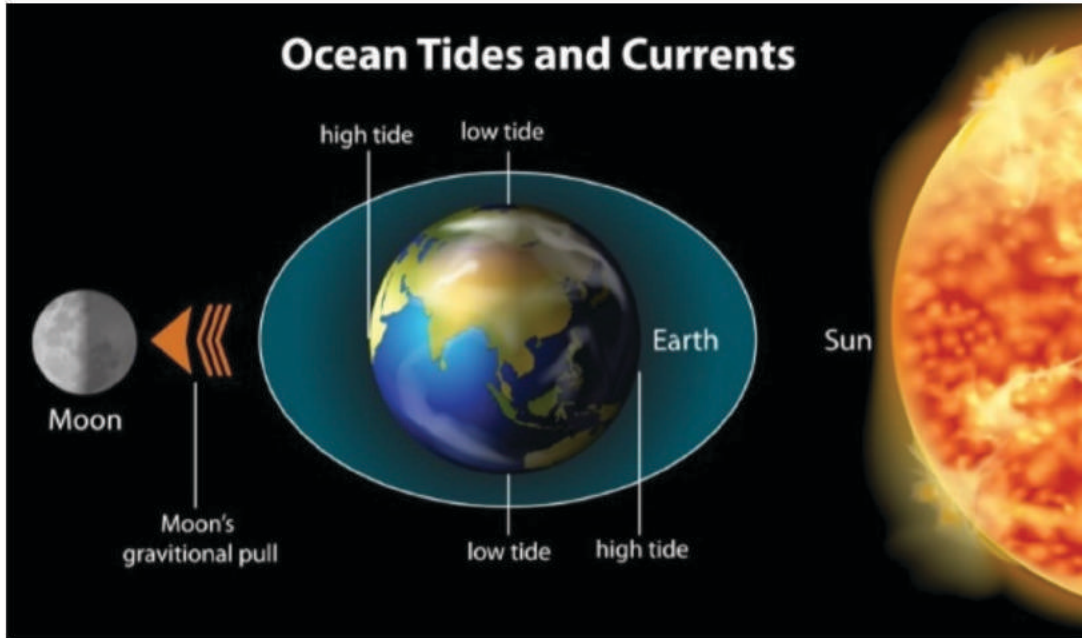
Answer: D

*In 24 days, the decay would be half of 25 grams, or 12.5 grams.
In 32 days, it would be half of 12.5, or 6.25 grams.*

“REDUNDANT” VISUALS



EXAMPLE



Source: BlueRingMedia, Shutterstock, Accessed 07.07.2019

The law of gravity, one of the fundamental laws of physics, states that all bodies with mass exert a force of attraction on other bodies; the larger the mass, the stronger the attraction. Which of the following statements is or are correct?

- I. The Earth attracts the moon; however, the Moon does not attract Earth because its mass is considerably smaller than the mass of Earth.
 - II. A spaceship which finds itself halfway between the Earth and the Moon will be attracted by both with the exact same strength.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.

(D) Neither of the two statements is correct.

Answer: D

Statement I: Both celestial bodies attract each other, meaning the Moon also affects the Earth. The statement is not correct.

Statement II: Even though the spaceship is attracted by both celestial bodies, the force of attraction exerted by the Earth is considerably stronger due to its higher mass. The statement is not correct.

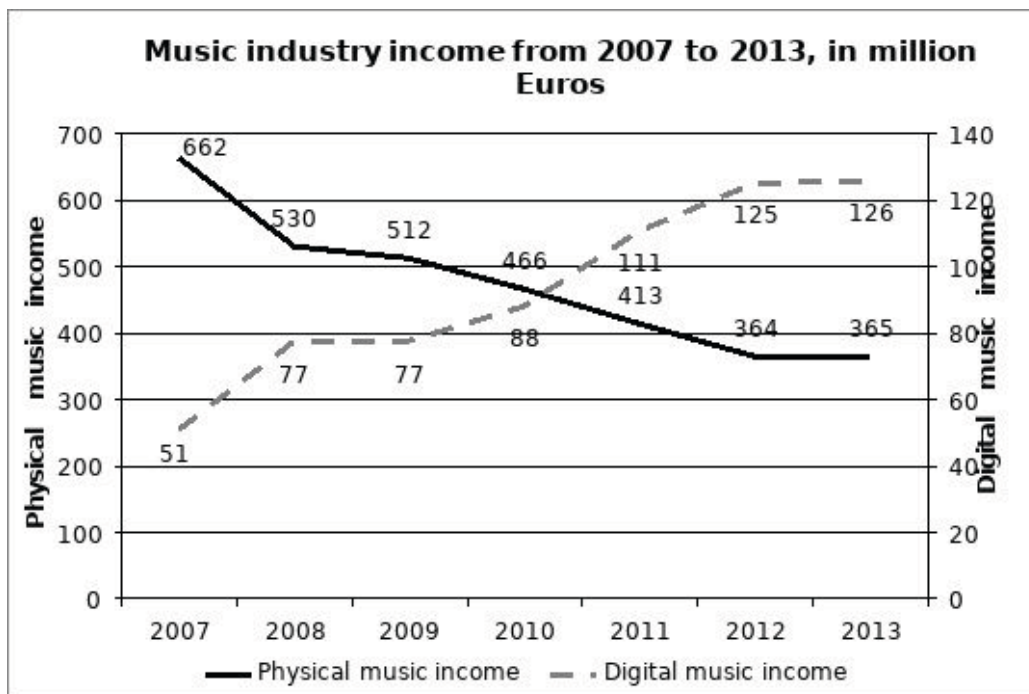
WHAT MAKES UP A DIAGRAM?

Using the following example, we will show you how a diagram is structured and what components make up the illustration as a whole. When first looking at the diagram below, you will see many numbers and lines which might seem confusing. But, within this chapter, we will explain to you how to quickly recognize and decode the components of each diagram. Once you get the hang of reading such diagrams, you will have more confidence to answer the corresponding questions in the exam. You can test your ability to read and decipher diagrams with the following example:



EXAMPLE

The line chart shows the income of the music industry within the country of XYZ over the last seven years. The income display is in millions of Euros.



Source: The Statistics Portal, Accessed 19.04.2020

Which of the following statements can be deduced from this information?

- I. The percentage change of the physical music income was larger in 2008 and smaller in 2013 (both in comparison to the respective previous years).
- II. The physical music income change was purely negative from 2007 to 2013.

- (A) Only statement I can be deduced.
- (B) Only statement II can be deduced.
- (C) Both statements can be deduced.
- (D) Neither of the two statements can be deduced.

Answer: A

Statement I: In 2008, the physical music industry had the largest reduction in income, with a reduction of almost 20% when compared to 2007. The income change in 2013 was the smallest. Thus, statement I can be deduced.

Statement II: In all of the years from 2007 to 2012, the income for physical music decreased; from 2012 to 2013, it increased slightly. Thus, statement II cannot be deduced.

THE TITLE

The title briefly explains the content of the diagram. It helps the reader determine the topic of the diagram and the information that it is presenting. Titles can be creative or simple. They should clearly explain what the diagram is about. The title of this diagram indicates that the content of the graph surrounds income of the music industry between 2007 and 2013.

THE LEGEND

The legend explains what the markings within the diagram mean. It does not matter if they are lines, numbers or shaded areas. Just like the legend of a map, a legend helps readers understand what the individual pieces of information mean in a greater context.

The legend here indicates that the solid line expresses the income of the physical music industry (audio media, CDs, etc.) and that the dotted line is the income of the digital music industry.

THE DATA

The most important part of the diagram is, of course, the information or data which it contains. Within this example, two sets of data are presented, namely the physical and the digital music income. Thanks to the numerical values presented above the lines (data labels), we can read specific values from the chart.

THE GRIDLINES

If we do not have any data labels or a data table within the diagram, we can use the gridlines to precisely or roughly determine the height of the columns or the length of the bars. The

gridlines within this example show a spacing of 100 units, which, from the title, we know to represent 100 million Euros.

THE Y-AXIS

Within a line chart, the y-axis runs vertically (from top to bottom). Typically, you will find numbers or entries pertaining to facts which are measured on the y-axis. The y-axis normally begins with 0 and can be divided into any number of sections.

Within this example, the left y-axis expresses the physical music income (in million €).

THE X-AXIS

Within a line chart, the x-axis runs horizontally (from left to right). Typically, you will find quantity entries, for example: various time entries, year numbers, or facts which can be compared to one another.

In this example diagram, the x-axis expresses time in years from 2007 to 2013.

THE SECOND Y-AXIS

Some diagrams do not just have the standard left y-axis, but also a second y-axis which you will always find on the right-hand side if one exists. This is the case in the example above. The second y-axis is used when two factors which have different values are to be compared with one another. Within the above example, the pertinent factors are the physical and digital music incomes. Since the digital income is much lower than the physical income, the values for the digital income are marked on a second y-axis with a different scaling. This allows for easier observation of the relationship between both lines and their changes over time, despite the large difference in their overall magnitudes.

THE SOURCE

The source explains where the information within the diagram comes from. Indicating the source is important for copyright reasons and is done out of respect for the person who collected the data.

In this example, the source informs us that the information in this diagram originates from the “The Statistics Portal”.

FREQUENTLY RECURRING PITFALLS

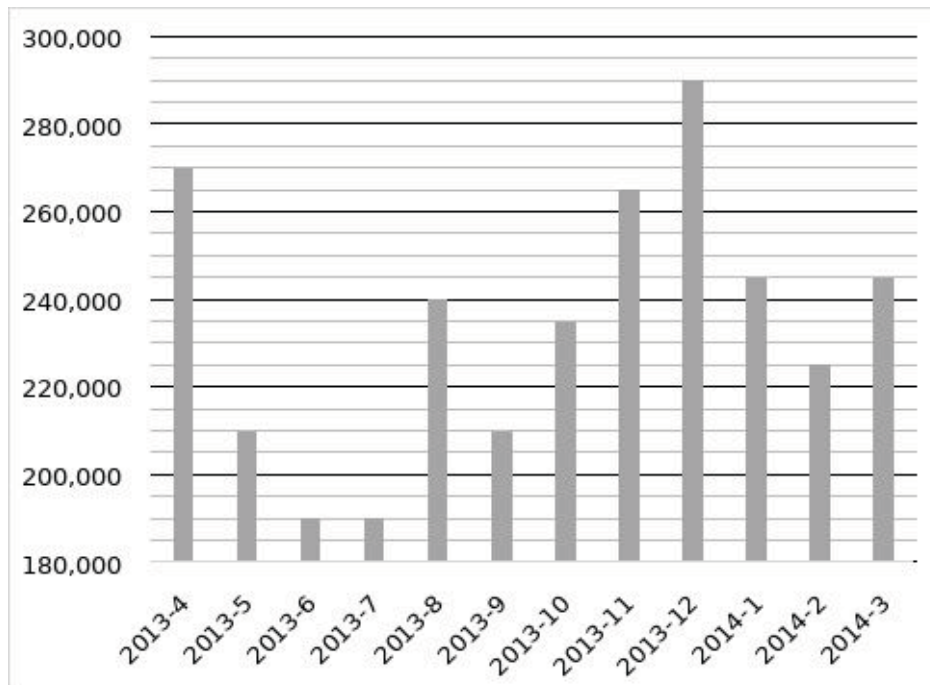
Focus especially on recurring pitfalls. One is in interpreting scale. Differences in numbers and size may be disproportionately illustrated through subtle changes in unit or scaling of the axes. For example, specific time periods with a positive development of numbers can be inflated to make the change appear larger than it really is. Below you find examples of such confusing illustrations.

THE START OF THE AXIS SCALE IS NOT ZERO.

In some column or bar charts, the axis scale does not start with zero. In these cases, you should view the difference between the column heights rather critically. The difference can be much smaller than the chart suggests at first glance.



EXAMPLE



Source: Ferry Bopender, <http://www.electricmonk.nl/log/wp-content/uploads/2014/07/3.png>, Accessed 30.01.2019

How high is the percentage change from 2013-5 to 2013-8? At first glance, it appears that the amount has doubled, indicating an increase of 100%. However, this would be a common pitfall. Before answering this question, you have to take a closer look at the y-axis: It starts with 180,000!

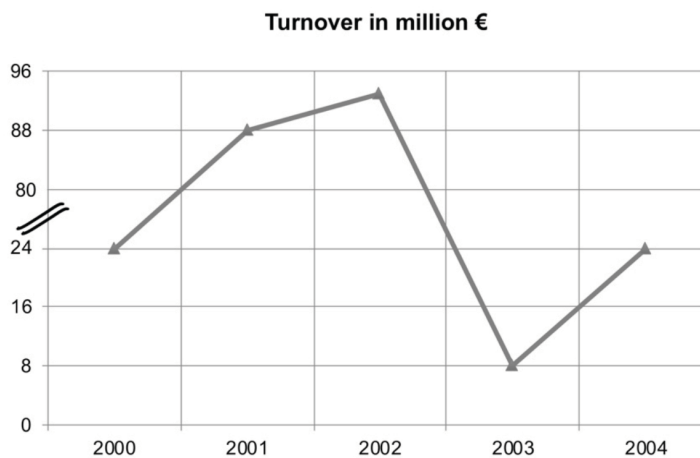
The percentage increase is thus $(240,000 - 210,000) \div 210,000 = 14.3\%$. So, although at first glance the change appeared to be an increase of 100%, it was really only an increase of roughly 14%.

THE Y-AXIS CAN MAKE JUMPS.

When analyzing a chart, it is important to look at the primary (and, if available, the secondary) y-axis. It is irrelevant how the increase is visualized in the diagram, only the numbers are important. Sometimes there are diagrams in which the spacing between 0 to 50 looks exactly like that of 50 to 500. It does not matter how large an increase within a chart appears; it is only important how the exact numbers change, which can be seen on the y-axis.



EXAMPLE



At first glance, it appears to be that the turnover difference between 2000-2001 and 2003-2004 is exactly the same in size. The name of the y-axis, however, shows the exact values and thus the actual change.

Turnover growth between 2000 and 2001: $88 - 24 = 62$ million €

Turnover growth between 2003 and 2004: $24 - 8 = 16$ million €

Always pay attention to the numbers on the axes instead of just relying on the optical effect of a chart. This is especially true when you have to calculate percentage changes. In the exam, you will probably come across a couple of questions like this.

The interruption of an axis by two diagonal lines or a jagged line always means a gathering of values. This means that the changes skip so many values that a better overview can be created by omitting them.

THERE ARE TWO Y-AXES.

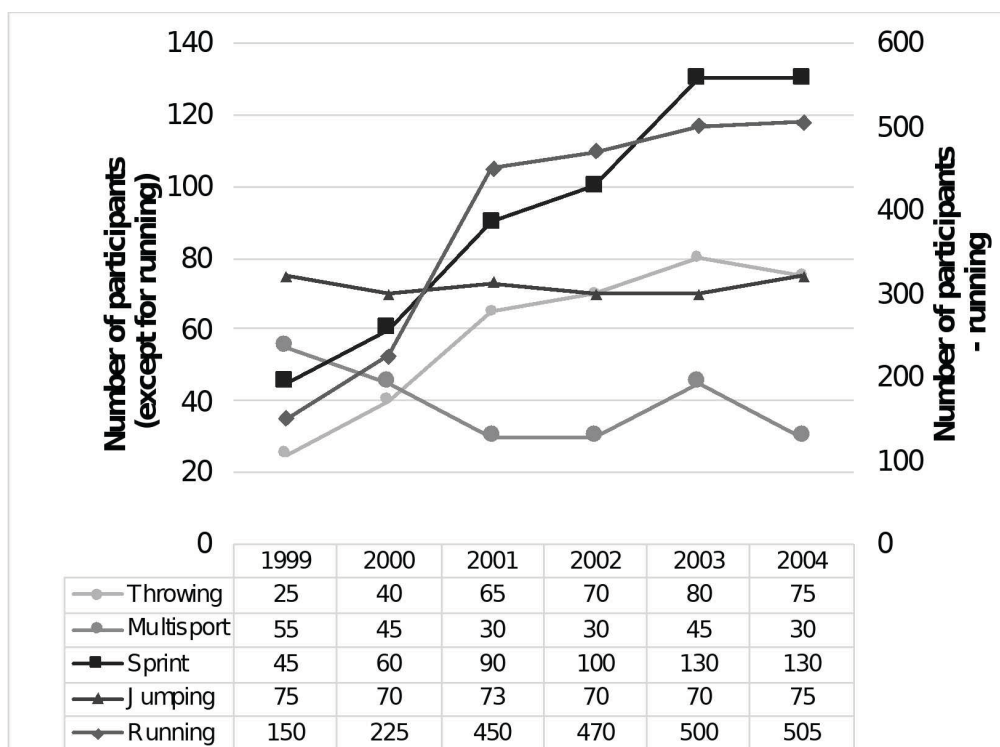
If numerous data series are displayed, then two different y-axis scales (one to the right and another to the left) may be used. If you see a y-axis on the right-hand side, then you should pay close attention to which scale a line or row of columns belongs to. Such a diagram can optically suggest a development for the displayed data series which is not really there because the scale is different. Be extra careful when evaluating the data before you make a statement concerning the tendency of development.



EXAMPLE

The chart below shows the number of participants for an annual track and field event in Australia. Each participant of the track and field event can only take part in one event per year.

Number of participants per sports event



Which of the following statements can be deduced from this information?

- I. Between 1999 and 2004, the largest growth in the number of participants was in the sprint event.
- II. Throwing was the only event in which less than 10% of the total number of track and field participants took place for the each of the years listed in the chart.

- (A) Only statement I can be deduced.
- (B) Only statement II can be deduced.
- (C) Both statements can be deduced.
- (D) Neither of the two statements can be deduced.

Answer: B

Statement I: Optically, it looks as if sprint has the strongest growth curve. However, the growth in the number of running participants is much higher – from 2000 on, runners made up more than 50% of all participants. This statement cannot be deduced.

Statement II: Over the course of the years, throwing had less than 10% of the total participants. Statement II can be deduced.

USEFUL TERMINOLOGY (not a prerequisite)

In this section we provide you with a list of the terminology of recurring topics in the TestAS. **You do not need to memorize these. If present on the test, each term will be explained in detail.** This being said, being familiar with the terms marked in bold would probably facilitate and accelerate your working through the test. Additionally, if you studied science courses in a language other than English, it may help to know the translations of these frequently encountered terms.

This section is the least important one among our study suggestions. You would be well advised to focus on this only after all else. Understanding frequently encountered topics, natural phenomena, and interpretation of scientific graphs is significantly more important to your preparation.

PHYSICAL SCIENCES

Physical Sciences concern the properties of energy and matter. Science in this group includes Chemistry, Physics, and Astronomy.

The **periodic table** is a tabular arrangement of the chemical elements, organized by atomic number (number of protons in the nucleus), electron configuration, and recurring chemical properties.

A **balanced equation** obeys the law of conservation of mass and, therefore, must have the same number of each kind of atom on both sides.

An **organic compound** is any chemical compound containing carbon. It may be gaseous, liquid, or solid.

A **solution** is a homogeneous mixture composed of only one phase. In such a mixture, a solute is a substance which is dissolved in another substance, known as a solvent. A **solute** can be a solid, liquid, or gas. **Solubility** describes how readily and completely a solute dissolves in a solid, liquid, or gaseous solvent to form a solution. The solubility of a substance fundamentally depends on the physical and chemical properties of the solute and solvent as well as the temperature, pressure and pH of the solution.

The three major components of any atom include the following: (1) **protons** – inside the nucleus with a positive (+) charge, (2) **neutrons** – inside the nucleus with no charge and (3) **electrons** – orbit the nucleus with negative (-) charge.

The **observed frequency** or pitch of a sound increases when the distance between the source of the sound and observer decrease. The greater the relative speed, the more the wavelength is foreshortened and the higher the frequency (pitch). This effect is called the Doppler effect.

The **visible light spectrum** consists of a range of frequencies, each of which corresponds to a specific color. ROYGBIV stands for red, orange, yellow, green, blue, indigo and violet. When visible light strikes an object and a specific frequency is absorbed, that frequency of light will never make it to our eyes. We only see the light which is instead reflected off the object.

Light moves in a straight line and according to the **law of reflection**. The ray of light approaching the mirror is known as the **incident ray**. The ray of light that leaves the mirror is known as the **reflected ray**. At the **point of incidence**, where the ray strikes the mirror, a line can be drawn perpendicular to the surface of the mirror. This line is known as a **normal line**.

BIOSCIENCES (LIFE SCIENCES)

Biosciences concern the nature of living things. Science in this group includes Human Biology, Botany, Zoology, Microbiology, and Exobiology.

An **endotherm** (homeotherm) is an organism that generates heat to maintain its body temperature, typically above the temperature of its surroundings. A **poikilotherm** (ectotherm) is an organism, such as a fish or reptile, having a body temperature that varies with the temperature of its surroundings. **Generalist** animals are those adapted to a wide range of environmental circumstances and food sources, while **specialist** animals are really good at one narrow thing they do.

Cell division involves the distribution of identical genetic material, DNA, to two daughter cells. **Mitosis** is the cell division resulting in two daughter nuclei which have identical genetic material to each other and to the mother cell. **Meiosis** is a special type of cell division that occurs in sexually reproducing organisms. Meiosis reduces the chromosome number by half, enabling sexual recombination to occur. Meiosis of diploid cells produces haploid daughter cells, which may function as gametes.

Proteins are large biological molecules consisting of one or more long chains of amino acid residues. Two **amino acids** join together with the elimination of water to produce a dipeptide. The link between the two amino acids is known as a peptide link. These **peptide bonds** can be broken by enzymes, which are usually specific to the type of amino acids that they work on .

Mitochondria are known as the powerhouses of the cell. They are organelles that act like a digestive system that takes in nutrients, breaks them down, and creates energy rich molecules for the cell. The biochemical processes of the cell are known as cellular respiration.

Neurons (cells of the nervous system) send information down axons, and away from the cell body, by creating an **action potential**. An action potential is a short-lasting event in which the

electrical membrane potential of a cell rapidly rises and falls, following a consistent trajectory.

A **zygote** is a eukaryotic cell formed by a fertilization event between two **gametes**. The zygote's genome is a combination of the DNA in each gamete and contains all of the genetic information necessary to form a new organism. In multicellular organisms, the zygote is the earliest developmental stage and represents a unique organism. In single-celled organisms, the zygote can divide asexually by mitosis to produce identical offspring.

The primary function of **hemoglobin** (Hb) is to transport oxygen. Since oxygen is not very soluble in water (the major constituent of blood) alone, an oxygen transport protein is utilized. Hemoglobin (Hb) is the oxygen transport protein used in the blood of vertebrates.

Insulin and **glucagon** work synergistically to keep blood glucose concentrations normal. When blood glucose concentrations are high, the body releases insulin, resulting in the uptake of glucose by body cells. However, the uptake of glucose in the liver, kidney and brain cells occurs by simple diffusion and does not require insulin.

A **prokaryote** is a single-celled organism that lacks a membrane-bound nucleus (karyon), mitochondria, or any other membrane-bound organelles. A **eukaryote** is an organism with complex cells or a single cell with a complex structure. In eukaryotes, the genetic material (DNA) is organized into chromosomes stored in the cell nucleus. Animals, plants, algae and fungi are all eukaryotes.

Cell membranes are **selectively permeable**. Some solutes cross the membrane freely, some cross with assistance, and others do not cross at all. A few lipophilic substances move freely across the cell membrane by passive diffusion. Cells behave differently in different types of solutions, which may be **hypertonic**, **hypotonic**

or **isotonic**. A hypertonic solution is one with a higher concentration of solutes outside the cell than inside the cell. A hypotonic solution has a lower concentration of solutes outside the cell than inside the cell. An isotonic solution is one in which its effective osmole concentration is the same as the solute concentration of the cell.

Enzymes are catalysts for biochemical reactions. They speed up reactions by providing an alternative reaction pathway of lower activation energy. Enzymes have an **active site**. This is part of the molecule that has just the right shape and functional groups to bind to one of the reacting molecules. The reacting molecule that binds to the enzyme is called the **substrate**. Enzymatic activity is affected by factors like temperature, pH, and concentration of enzyme and substrate.

In humans, the sex of an individual is determined by a pair of **sex chromosomes**. Females have two of the same kind of sex chromosome (XX) and are called the homogametic sex. Males have two distinct sex chromosomes (XY) and are called the heterogametic sex.

A **vaccine** is a product that produces immunity from a disease and can be administered through needle injections, by mouth, or by aerosol. A vaccination is the injection of a killed or weakened organism that produces immunity in the body against that organism. An **immunization** is the process by which a person or animal becomes protected from a disease. Vaccines cause immunization, and there are also some diseases that cause immunization after an individual recovers from the disease.

Photosynthesis is a process used by plants and other organisms to convert light energy, normally from the Sun, into chemical energy that can be later released to fuel the organism's activities. **Photorespiration** is a process in plant metabolism which attempts to reduce the consequences of a wasteful oxygenation reaction by an enzyme .

Evolution is change in heritable traits of biological populations over successive generations .

GEOSCIENCES (EARTH SCIENCES)

Earth Sciences concern the Earth and its composition and structure. Subjects in this discipline include Ecology, Geology, Geography, Oceanography, Meteorology, and Paleontology.

The **biogeochemical cycle** or cycling of substances is a pathway by which a chemical substance moves through both biotic (biosphere) and abiotic (lithosphere, atmosphere, and hydrosphere) compartments of Earth.

A **food chain** is a linear sequence of links in a food web starting from "producer" species (e.g., grass or trees) and ending at apex predator species (e.g., grizzly bears or killer whales), detritivores (e.g., earthworms or woodlice), or decomposer species (e.g., fungi or bacteria). A food chain also shows how the organisms are related with each other by the food they eat. Each level of a food chain represents a different trophic level.

An **energy pyramid** is a graphical model of energy flow within a community. The different levels represent different groups of organisms that might compose a food chain.

Biological interactions are effects that organisms of a community have on one another. **Competition** is a mutually detrimental interaction between individuals, populations or species. The term **symbiosis** is used only for cases where both organisms benefit from a relationship. Competition can be defined as an interaction between organisms or species in which the fitness of one is lowered by the presence of another. **Tolerance** is the ability of an organism to endure unfavorable environmental conditions.

Territory is the sociographical area that an animal of a particular species consistently defends against conspecifics. Animals that

defend territories in this way are referred to as territorial. A **survivorship curve** is a graph showing the number or proportion of individuals surviving to each age for a given species or group.

The **Earth's axis** is tilted from perpendicular to the plane of the ecliptic by 23.45° . This tilting is what gives us the four seasons of the year: spring, summer, autumn (fall) and winter. Since the axis is tilted, different parts of the globe are oriented towards the Sun at different times of the year.

The **greenhouse effect** is a process by which thermal radiation from a planetary surface is absorbed by atmospheric greenhouse gases and reradiated in all directions.

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PRACTICE QUESTIONS

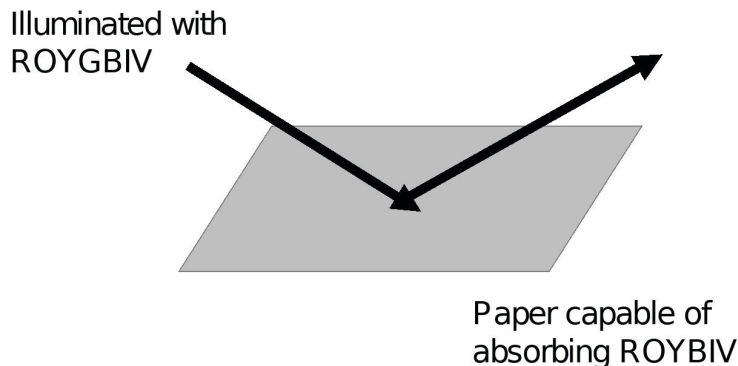
3

On the TestAS exam, you will have **60 minutes** to answer the **22 questions** of the subtest “Analyzing scientific issues”.

EXAM 1

1.1.

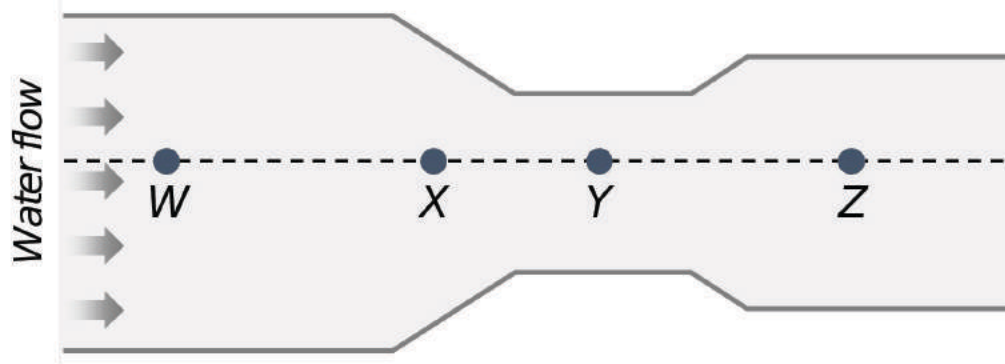
The visible light spectrum consists of the very small region of the electromagnetic spectrum that is visible to the human eye. The wavelengths of this region determine the colors that we can see: red, orange, yellow, green, blue, indigo and violet (abbreviated ROYGBIV). When visible light strikes an object and a specific wavelength is absorbed, that wavelength of light never makes it to our eyes. Our eyes will only see the remaining wavelengths of light that are reflected. When an object reflects all colors, the object appears white. According to this graph, which of the following statements is or are correct?



- I. The paper will appear to an observer to be violet in color.
 - II. If the paper is incapable of absorbing any color, then it will appear to be white.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

1.2.

The diagram below shows a cross-section of a water pipe. The diameter of the pipe changes along the length of this section.

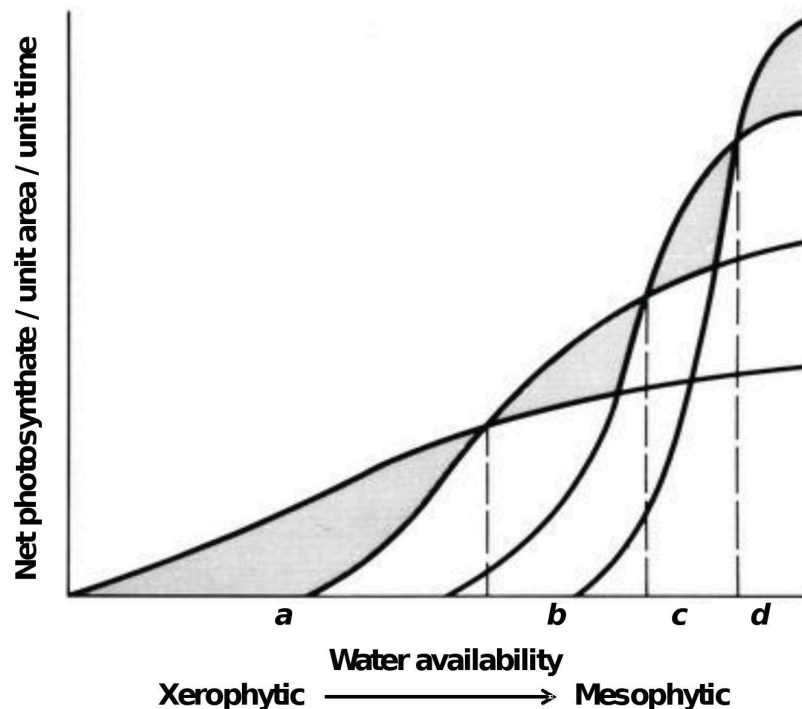


At which two points in the pipe does the water travel at approximately the same speed?

- (A) Points W and Y
- (B) Points W and Z
- (C) Points X and Y
- (D) Points X and Z

1.3.

Plants are classified on the basis of their structure in relation to water availability. Types of leaves range from the mesophytic (plants that live where the supply of water is adequate) leaf to the evergreen xerophytic (plants that live where water is scarce) leaf. Mesophytic leaves photosynthesize rapidly when compared to xerophytic leaves. This graph represents the probable relationship between the efficiency of photosynthesis and water availability among different types of leaves. Shaded areas indicate the superiority of various leaf types under different conditions of soil moisture availability.



Which of the following statements is or are correct?

- I. Under intermediate conditions of water availability, the most xerophytic leaf performs best.
 - II. The most mesophytic leaf does best when soil is wet.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

1.4.

A band is placed tightly around the earth and forms a ring with the radius $r = 6400 \text{ km}$. The band is lengthened, increasing the circumference of the ring U by 1 m . What is the distance between the surface of the earth and the ring with the circumference increased by 1 m ?

(A) $\frac{1}{2} \text{ m}$

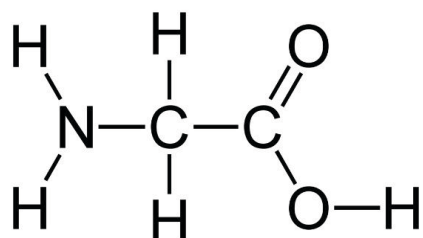
(B) 1 m

(C) $\frac{1 \text{ m}}{\pi}$

(D) $\frac{1 \text{ m}}{2 \times \pi}$

1.5.

The amino acid glycine is composed of the elements carbon, hydrogen, oxygen and nitrogen. The structural formula is as follows:



Now the molecule is represented in numbers. Each element is assigned the number of atoms that occur:

H	N	C	O
5	1	2	2

= 5-1-2-2

Now another molecule is considered which consists of the same elements, but in a different composition. Its elements are assigned numbers in the same order as above.

The following applies regarding the new molecule:

The number of C is 1 greater than that of O.

The number of H is twice that of C.

The number of N is 1 less than that of O

Which numbers can be assigned to the new molecule?

- (A) 6-2-3-4
- (B) 10-5-4-6
- (C) 8-2-4-3
- (D) 6-3-3-2

1.6.

The vertical columns of the periodic table are called groups. The elements in each group have the same number of electrons in their outer-most orbital. Chemical properties of the elements are based on the number of electrons in the outer-most orbital.

[illegible]

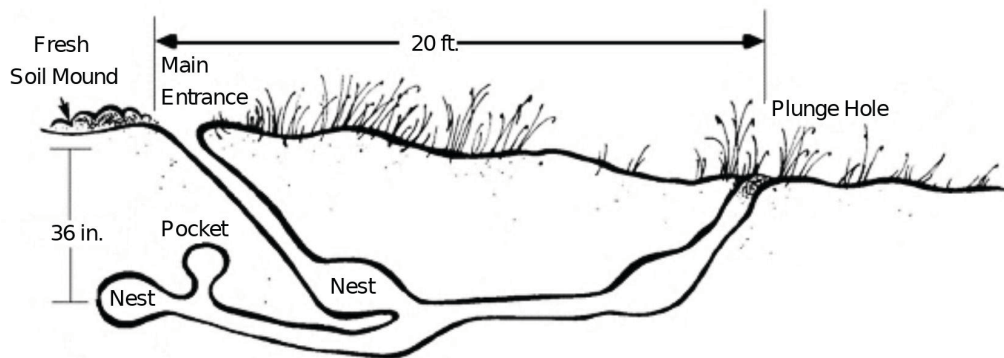
Chemical properties of Iodine (I) would be similar to that of:

- (A) Chlorine (Cl)
(B) Tellurium (Te)
(C) Manganese (Mn)
(D) Xenon (Xe)

1.7.

All organisms require resources to grow, reproduce, and survive. Competition is a negative interaction among organisms where they compete for the same limited resources like food, water, and territory.

The following diagram illustrates a typical woodchuck burrow. Note: “36 in.” stands for 36 inches, which is equal to approximately 91 cm.



Source: Entomology Department at Purdue University, Diagram of a typical woodchuck burrow, <http://www3.ag.purdue.edu/entm/wildlifehotline/pages/woodchucks.aspx>, Accessed 12.11.2019

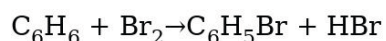
Which of the following scenarios would result in an increase in competition between the members of a woodchuck population in a large field?

- I. An increase in the woodchuck reproduction rate
- II. Spread of disease among the woodchucks
- III. Spread of disease among woodchuck predator species
- IV. Spread of disease in the food source of woodchucks

- (A) I and III
- (B) I, III and IV
- (C) All four statements are correct
- (D) None of the statements are correct

1.8.

The rate of a reaction is affected by a number of factors. According to Le Châtelier's principle, if a system in equilibrium experiences a change in temperature, pressure, or concentration of products or reactants, the system will tend to shift in the opposite direction so as to counteract the effect of the disturbance. Consider the following reaction:

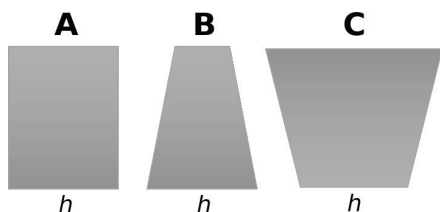


Which of the following changes will cause an increase in the products of the above reaction?

- (A) Increasing the concentration of Br_2
- (B) Decreasing the concentration of C_6H_6
- (C) Increasing the concentration of HBr
- (D) Decreasing the temperature

1.9.

Three containers with base of area h are filled with the same volume of water. Which container applies the greatest total force on the floor?

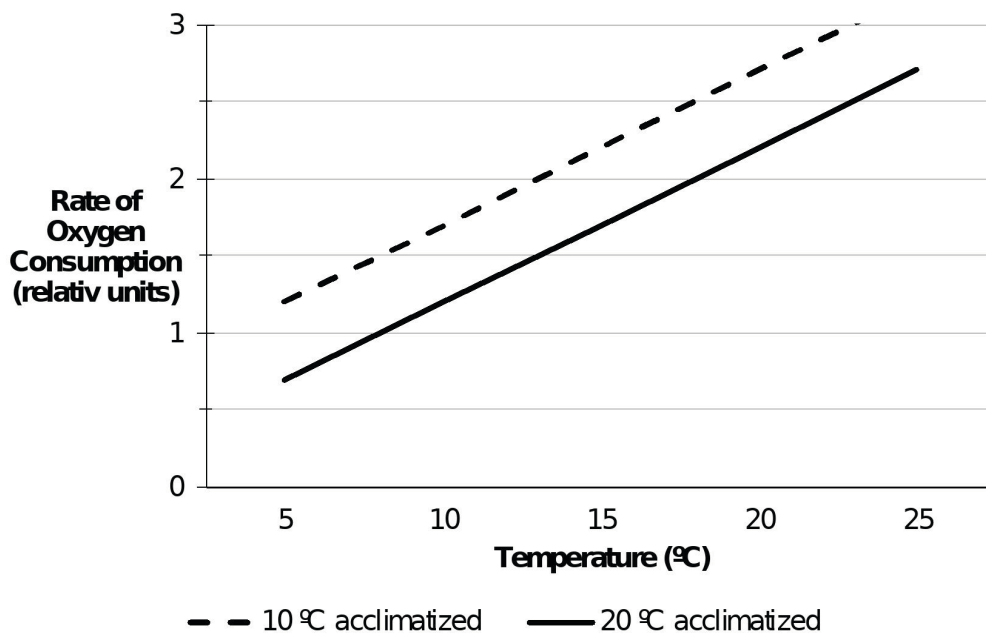


- (A) A
- (B) B
- (C) C

(D) The amount of force applied by each is the same.

1.10.

Oxygen consumption is the amount of oxygen taken up and utilized for various metabolic activities in the body. When body temperature increases, the metabolism of cardiac and respiratory muscles also increases. The oxygen consumption of marine crabs acclimated to either 10 °C or 20 °C was measured at environmental temperatures of 5 °C to 25 °C to produce the following graph:



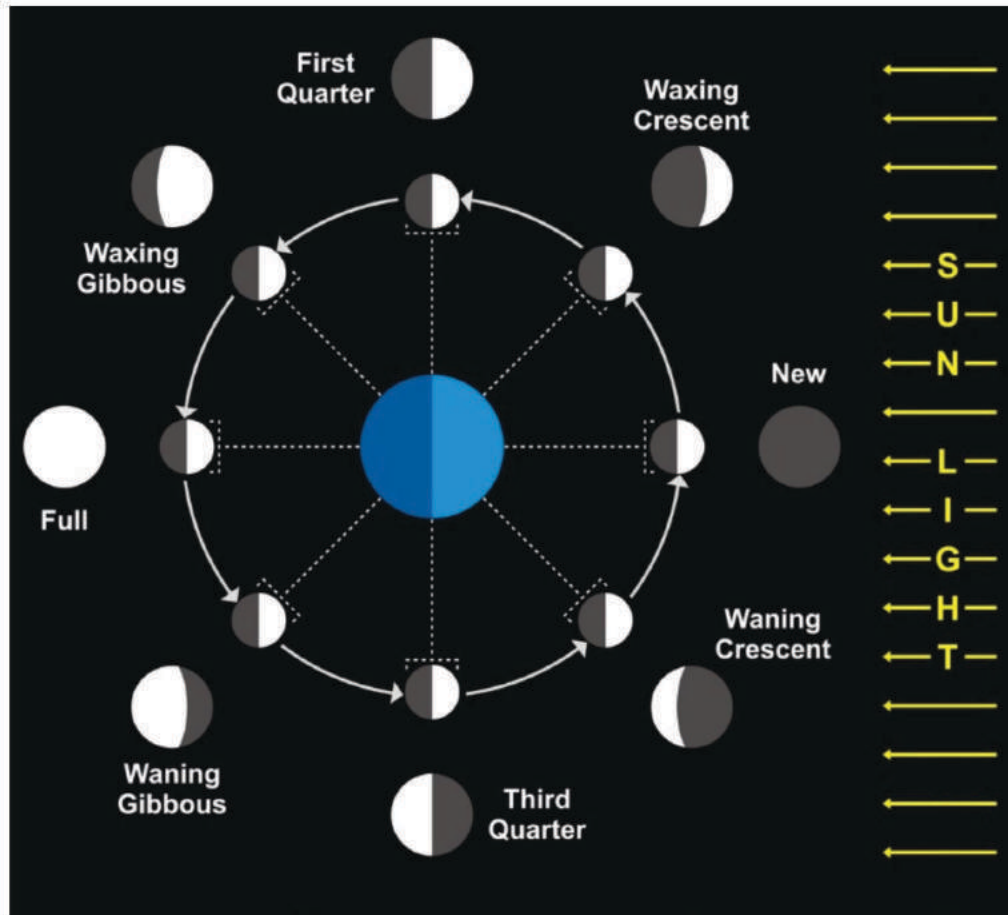
Which of the following can correctly be concluded from the information in the graph?

- (A) Acclimation temperature does not affect the rate of oxygen consumption.
- (B) Crabs have higher rates of oxygen consumption when measured at 10 °C than when measured at 20 °C.
- (C) Oxygen consumption is higher in the 10 °C acclimated crabs than in the 20 °C acclimated crabs at each environmental temperature.

(D) By looking at the acclimation temperature, one can calculate the oxygen consumption.

1.11.

Lunar phases are created by changing the angles (relative positions) of the earth, the moon and the sun as the moon orbits the earth. As seen from the earth, the moon goes through a series of phases due to changes in which of the following?

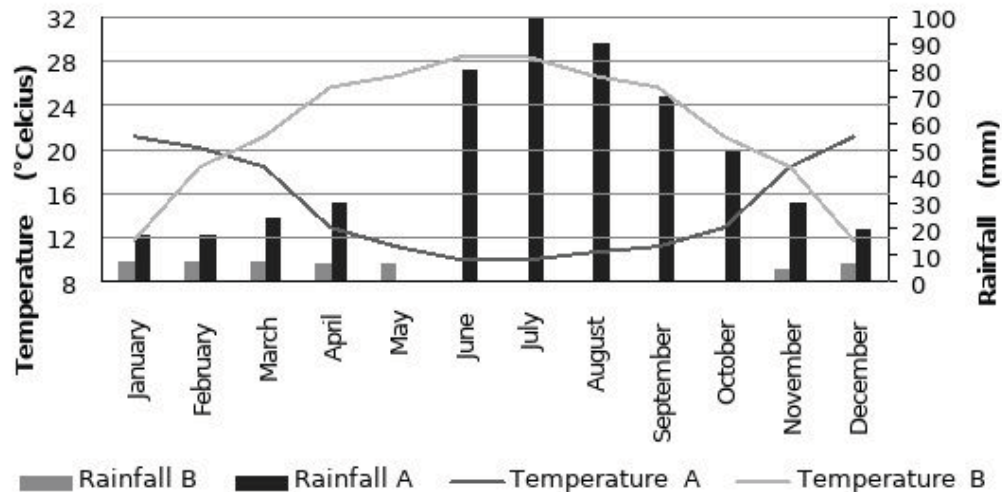


Source: udaix, Shutterstock, Accessed 05.07.2019

- (A) The amount of the Moon's surface that is in the Earth's shadow.
- (B) The tilt of the Moon on its axis.
- (C) The part of the moon that faces the Earth as the Moon rotates on its axis.
- (D) The amount of the illuminated side of the Moon that can be seen from the Earth.

1.12.

The climate of two different regions is described in terms of the average monthly temperatures (in °C) and the average monthly amount of rainfall (in mm). The lines on the graph represent the temperature, while the bars represent the amount of rain in two regions A and B.

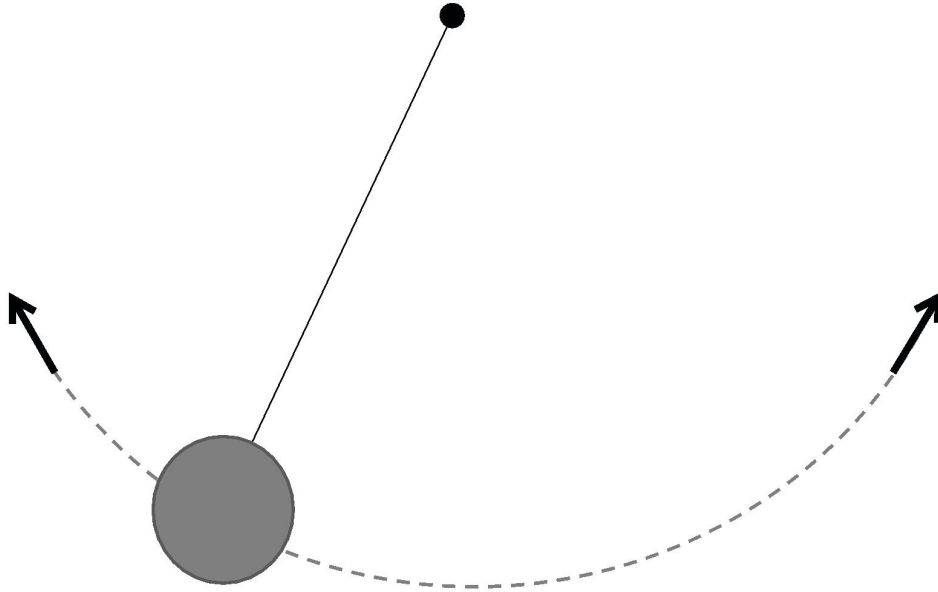


Which of the two statements is or are correct?

- I. The climate of region B could resemble that of a desert.
 - II. Rainfall and temperature are inversely related in region A.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

1.13.

A simple pendulum is pulled to the left-hand side as displayed in the graphic below.



Which of the two statements is or are correct?

- I. Without any friction, the pendulum will reach the exact same height on the opposite side.
 - II. Without any friction, the pendulum will never stop swinging.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

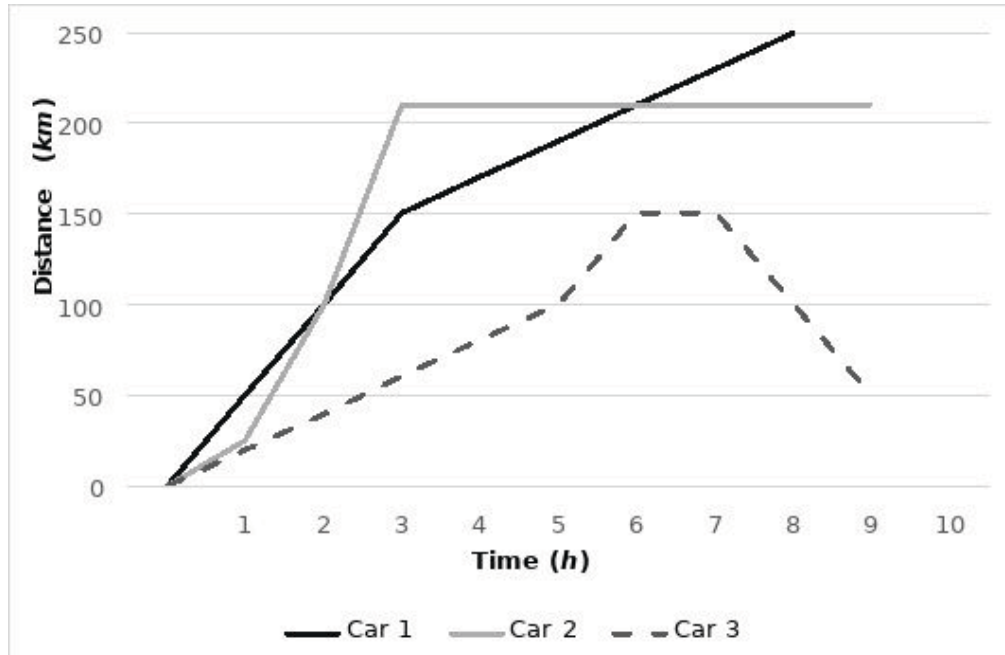
1.14.

Caleb is thirsty, but the well he must visit is situated at the top of a hill. Caleb knows that there are two sides to that hill, but one side is much steeper than the other. Which of the following statements is or are correct?

- I. Caleb will expend less energy by walking up the steep side of the hill because he will get there faster.
 - II. Caleb will expend less energy going up the steep side of the hill slowly than he will be going up the steep side of the hill quickly.
- (A) Only statement I is correct.
 - (B) Only statement II is correct.
 - (C) Both statements are correct.
 - (D) Neither of the two statements is correct.

1.15.

Three cars drive different routes. The graphic shows how far they move from the starting point over time.



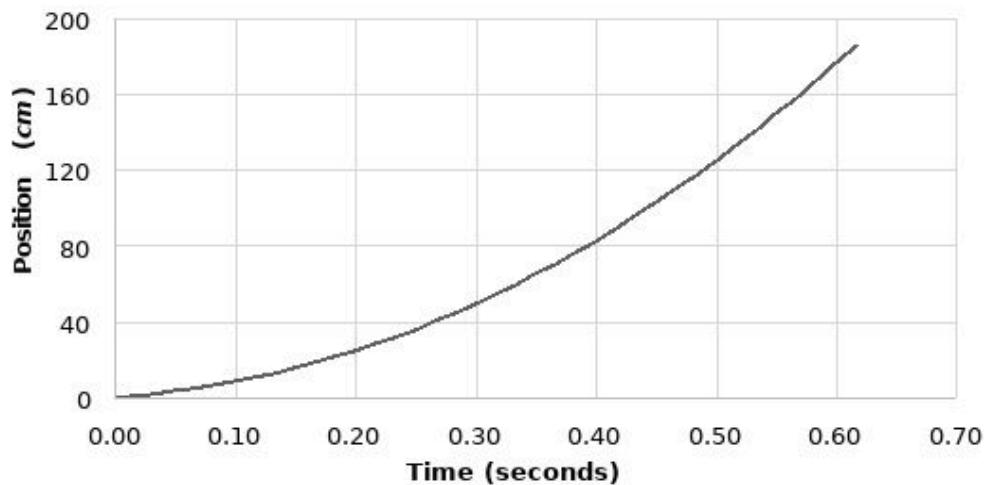
Which of the two statements is or are correct?

- I. In comparison to the other cars, car 1 is always the furthest from the starting point.
 - II. After 5 hours, car 2 drives back towards the starting point.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

1.16.

A skydiver jumps out of a plane. For a short time before the parachute opens, the skydiver is free falling.

The following diagram expresses the position of the skydiver during the free fall.

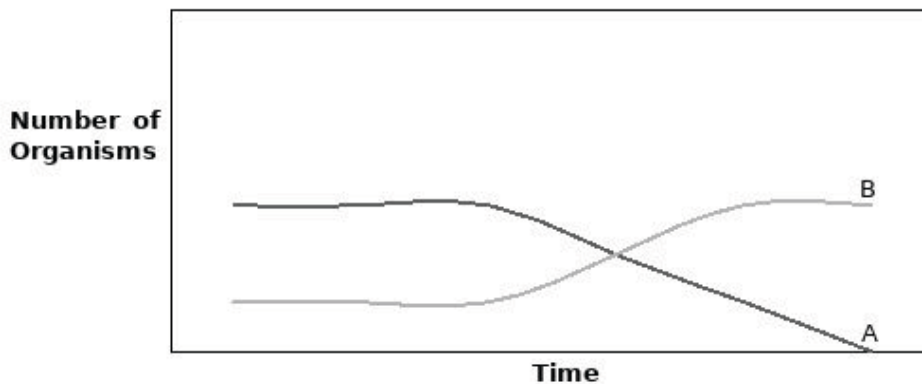


Which of the following statements is or are correct?

- I. The distance which the skydiver falls within the first 0.1 s is shorter than the distance the skydiver falls from 0.2 s to 0.3 s.
 - II. During the free fall (we assume $F_G = m \times g$) the skydiver's speed and acceleration both steadily increase.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

1.17.

Competition is a negative interaction between organisms for the same limited resource like food, territory or mating. Competing populations either coexist or cause one to go extinct. The best competitor among the two will survive and the other will be excluded (or go extinct). Alternatively, one of the competitors will evolve a trait or characteristic that is different from the competitor.

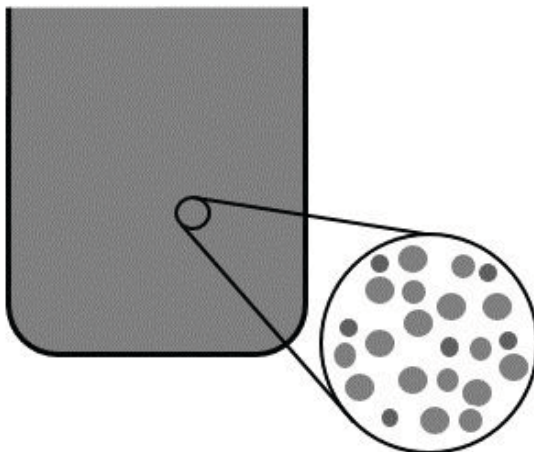


The graph above shows the changes in the populations of two herbivores in a grassy field. A possible reason for these changes may be that:

- (A) all of the plant populations in this habitat decreased.
- (B) population B competed more successfully for food than did population A.
- (C) population A produced more offspring than population B.
- (D) population A consumed the members of population B.

1.18.

In a solution, the intermolecular attractions between solute and solvent are stronger than attractions within the solute or the solvent. If the attractive forces among solid particles (solute) are less than the attractive forces between the solid and liquid (solvent), the solid will:



- (A) probably form a new precipitate as its crystal lattice is broken and reformed.
- (B) be unaffected because the attractive forces within the crystal lattice are too strong for the dissolution to occur.
- (C) begin the process of melting to form a liquid.
- (D) dissolve as particles are pulled away from the crystal lattice by the liquid molecules.

1.19.

An ideal gas is a theoretical gas composed of many randomly moving point particles that do not interact except when they collide elastically.

Model of an ideal gas

No.	Corollary
1	Molecules have insignificant volume (point particles).
2	Molecules are very far apart from each other.
3	Molecules are not attracted to each other.
4	Molecules are in continuous, completely random motion in all directions with varying speeds.
5	Molecules bounce off walls and each other perfectly elastically.

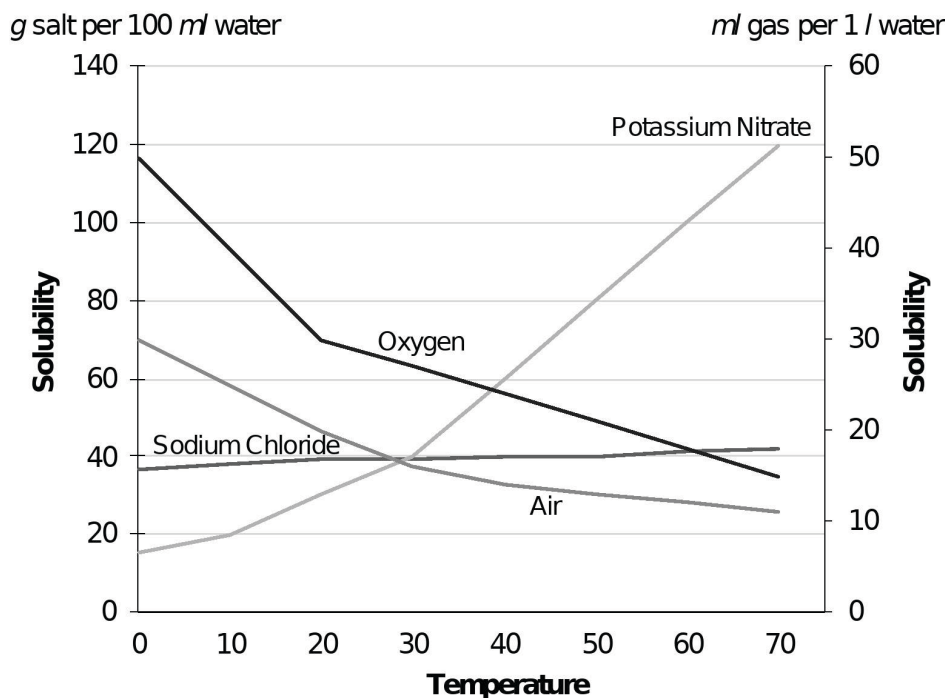
The model of ideal gases shown above is useful because it:

- I. accurately approximates the properties of most gas molecules.
- II. gives hints about the predictable behavior of other phases of matter.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

1.20.

The diagram shows the relationship between the solubility of substances in water and temperature. Potassium nitrate and sodium chloride are salts (shown as grams of salt per 100 milliliters of water). Oxygen and air are gases (shown as milliliters of gas per liter of water).

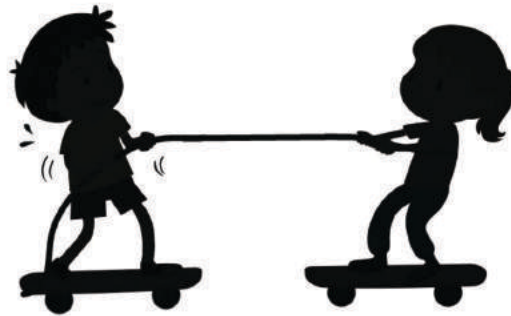


Which of the following two statements is or are correct?

- I. The solubility of sodium chloride does not increase as temperature increases.
 - II. As temperature increases, air is more soluble than oxygen in water.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

1.21.

Two skaters with both feet off the ground are facing each other and pulling against one another on a rope. Both skaters weigh the same.



Which of the following two statements is or are correct?

- I. The weaker of the two is pulled by the stronger one such that the weaker is eventually pulled all the way to the other end, while the stronger one remains in the same position.
 - II. If one of them weighed 10 *kg* more than the other, then the lighter skater would be pulled toward the heavier skater.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

1.22.

Rutherford's scattering experiment is a classic experiment showing the scattering of charged particles known as alpha particles that were directed at a thin foil of gold. Some of the alpha particles were deflected by a large angle with respect to the original direction of motion of the particle, while the rest passed straight through the foil without any deflection. The large deflection was due to a direct encounter with the nucleus of the gold atoms which has most of the mass and all of the positive electric charge.

Below is a table of observations and the proportion of alpha particles passing straight through:

Results of Firing Alpha Particles at Gold Foil

Observation:	Proportion:
Alpha particles went straight through gold foil.	> 98%
Alpha particles went through gold foil but were deflected at large angles.	= 2%
Alpha particles bounced off gold foil.	= 0.01%

What information do the experimental results above reveal about the nucleus of the gold atom?

- (A) The nucleus contains less than half the mass of the atom.
- (B) The nucleus is small and is the densest part of the atom.
- (C) The nucleus contains small positive and negative particles.
- (D) The nucleus is large and occupies most of the atom's space.

EXAM 2

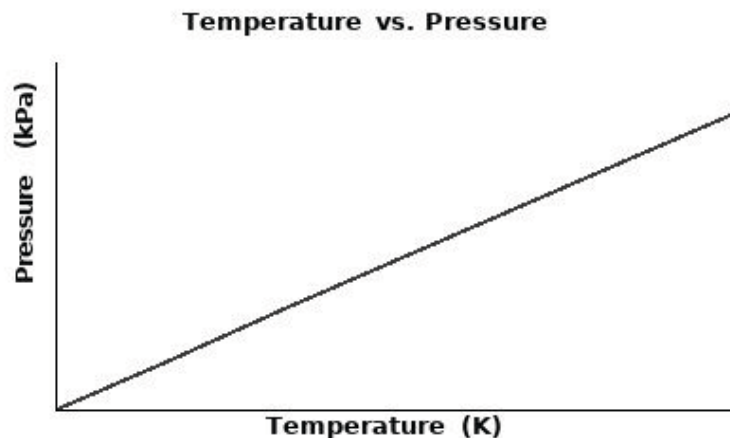
2.1.

Which of the following is an example of a chemical change?

- (A) Respiration
- (B) Condensation
- (C) Evaporation
- (D) Cutting up a piece of cooked meat

2.2.

Gay-Lussac's law is an ideal gas law which states that at a constant volume, the pressure of an ideal gas is directly proportional to its absolute temperature.



When a cold tire is inflated to a certain pressure and is then made warmer due to friction with the road, the pressure increases. This happens because the ...

- (A) air molecules hit the walls of the tire less frequently.
- (B) rubber in the tire reacts with oxygen in the atmosphere.
- (C) air molecules diffuse rapidly through the walls of the tire.
- (D) air molecules speed up and collide with the tire walls more often.

2.3.

One evening before sunset Julia and Thomas were talking to each other face to face. If Thomas's shadow was exactly to Julia's left, which direction was Thomas facing?

- (A) North
- (B) South
- (C) East
- (D) The data is inadequate.

2.4.

Peptide X consists of a chain of 10 amino acids. Each amino acid is designated by three letters (for example, "Trp"). Enzyme Ch splits the peptide into smaller pieces by cutting the bond between two adjacent amino acids. If the sequence of amino acids is known, it is then possible to work out the location of cut.

Peptide X = Leu-Gly-Trp-Tyr-Leu-Ala-Arg-Gly-Lys-Arg

The following four parts were obtained after splitting by enzyme Ch:

Leu – Gly

Trp – Tyr

Leu – Ala – Arg – Gly

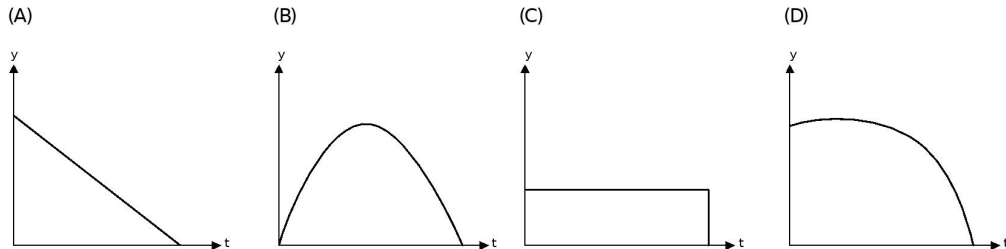
Lys – Arg

Behind which two amino acids does enzyme Ch cut?

- (A) Arg and Gly
- (B) Arg and Leu
- (C) Tyr and Arg
- (D) Tyr and Gly

2.5.

A boy throws a ball straight up in the air and then catches it again. Which of the graphs below best represents the ball's position with respect to time?



2.6.

A piece of iron is hung on a spring scale. Which of the two statements is or are correct?

- I. If the balance scale shows a reading of 100 N on Earth, it would show more than 1000 N on the Moon.
- II. When measured on Earth, a piece of moon rock with a mass of 900 g on the moon will have a mass of more than 1 kg .

- (A) Only Statement I is correct.
(B) Only Statement II is correct.
(C) Statements I and II are correct.
(D) Neither of the two statements is correct.

2.7.

Carbon dioxide is a by-product of respiration and several other chemical reactions in the body. It is produced when cells break down nutrients for energy. Since the accumulation of this gas is harmful to the body, it must be excreted. This occurs in humans through exhalation: CO₂ is soluble in water and is transported to the lungs in a dissolved form in the blood. From the lungs, it is released into the air during exhalation.

A distinction is made between the following body systems in an organism:

Endocrine

- relating to secreting internally into the blood or lymph

Circulatory

- relating to the circulation of blood throughout the body

Respiratory

- relating to or affecting respiration or the organs used in the action or process of inhaling and exhaling

Digestive

- having the function of digesting food

Reproductive

- relating to, characteristic of, or taking part in reproduction

Excretory

- relating to the process of discharging waste matter from the blood, tissues, or organs, or excreting matter such as urine or sweat

Which of the following pair of systems participate in the removal of carbon dioxide from the body?

- (A) Endocrine and Circulatory
- (B) Circulatory and Respiratory
- (C) Respiratory and Digestive
- (D) Reproductive and Excretory

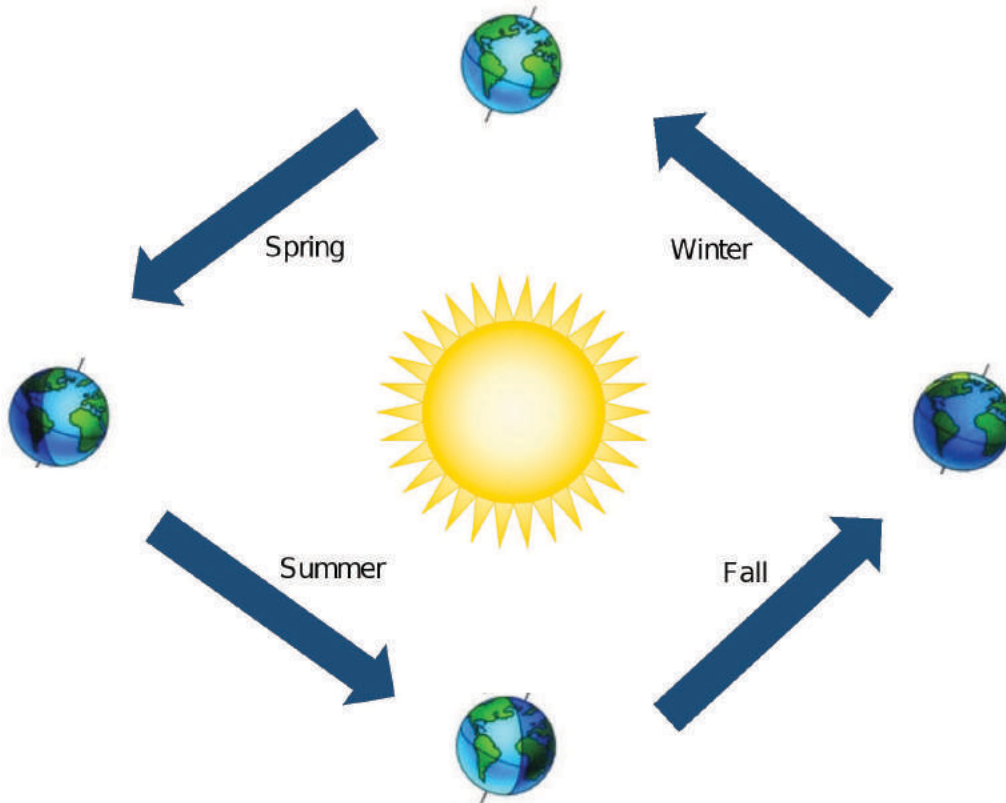
2.8.

A ball is rolling down from a roof. Which of the following two statements is or are correct ?

- I. The heavier the ball, the higher is its acceleration.
 - II. If there is no air resistance, the speed of the ball would increase until it hits the ground.
- (A) Only statement I is correct.
 - (B) Only statement II is correct.
 - (C) Both statements are correct.
 - (D) Neither of the two statements is correct.

2.9.

Below is a figure demonstrating why seasons are experienced on Earth.

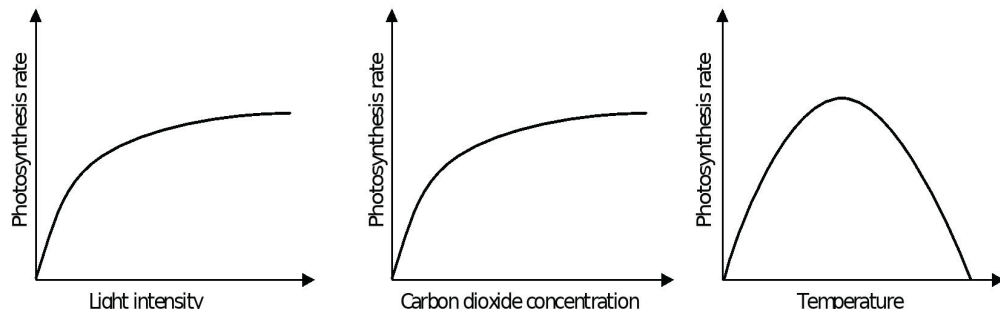


Which of the following is responsible for changes in the earth's seasons?

- I. The seasons on Earth appear to be dependent on the tilt of the earth.
 - II. The seasons on Earth appear to be dependent on the overall distance of the earth from the Sun.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

2.10.

Three factors can limit the speed of photosynthesis: light intensity, carbon dioxide concentration, and temperature.

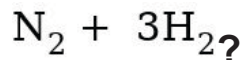


Based on the conditions above, which of the statements below is correct?

- (A) Increasing the light intensity will not further increase the rate of photosynthesis when the light intensity is already high.
- (B) Increasing the CO₂ concentration will not further increase the rate of photosynthesis when the CO₂ concentration is already high.
- (C) Increasing temperature will further increase the rate of photosynthesis when the temperature is already high.
- (D) There is a certain optimum temperature at which the rate of photosynthesis is highest.

2.11.

What is the result of the following chemical reaction:



- (A) 2NH₃
- (B) 3N₂H₃
- (C) 3NH₂

(D) $2\text{N}_2\text{H}_2$

2.12.

A balloon is placed in a vacuum and a vacuum pump is attached.



*Source: Balloon in a vacuum,
<https://www.leybold-shop.de/physik.html>, Accessed 11.09.2019*

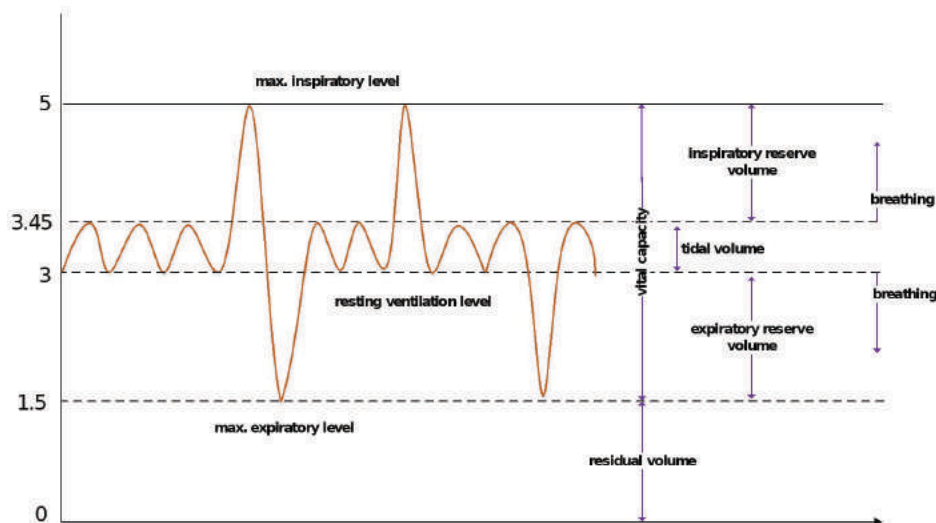
Which of the following two statements is or are correct?

- I. If the pump is turned on, the balloon will become smaller and smaller.
 - II. If the balloon is filled with very hot air, tied with a knot and submerged in a container of ice-cold water, it would suddenly become bigger.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

2.13.

Spirometry (the measuring of breath) is the most common lung-function test. It measures the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled. The image below is a graph of respiratory volumes and capacities. The following terms describe the various lung (respiratory) volumes:

- The **tidal volume (TV)** is the amount of air inspired during normal, relaxed breathing.
- The **inspiratory reserve volume (IRV)** is the additional air that can be forcibly inhaled after the inspiration of a normal tidal volume.
- The **expiratory reserve volume (ERV)** is the additional air that can be forcibly exhaled after the expiration of a normal tidal volume.
- The **residual volume (RV)** is the volume of air still remaining in the lungs after the expiratory reserve volume is exhaled.



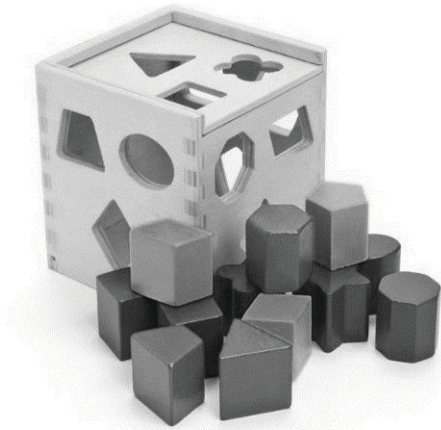
Which of the following statements is or are correct?

- I. The inspiratory reserve volume is greater than the volume of air inspired during normal breathing.
- II. The expiratory reserve volume is exhaled during normal, relaxed breathing.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

2.14.

A shape sorting cube is a toy that consists of a wooden box with holes, and each hole is in the shape of a square, circle, star, etc. In this particular toy, the circular hole is supposed to be 10 cm in diameter and the ball to be inserted is supposed to be 7 cm in diameter. However, this toy consists of a material which shrank homogeneously by 10 percent in all dimensions since it was manufactured.

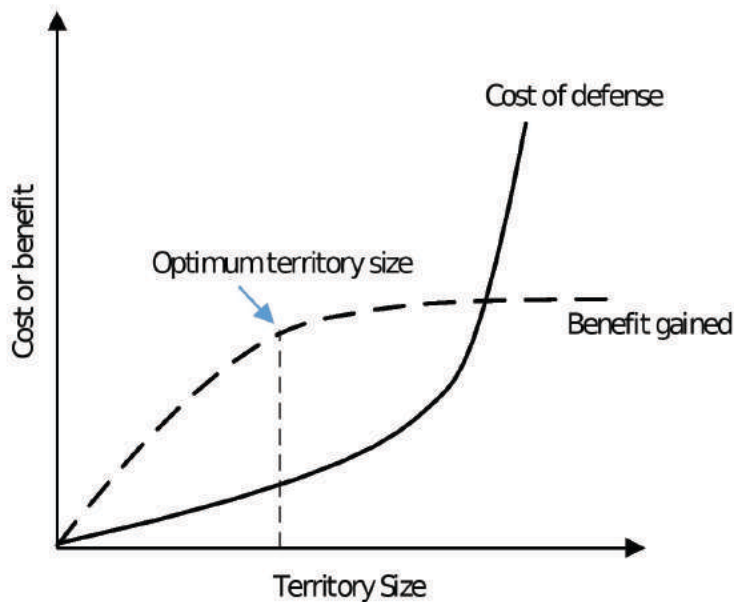


Which of the two statements is or are correct?

- I. Now the ball will not pass through the hole.
 - II. The circumference of the other holes has decreased by 10 percent.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

2.15.

Territories of animals are defended and used exclusively by an individual, pair, family, or small inbred group of individuals. The graph below shows the relationship between territory size and the benefit gained/cost of defense.

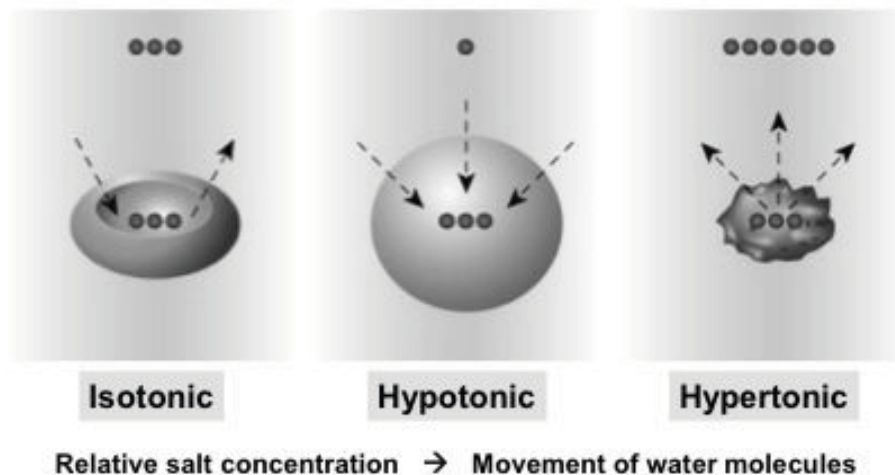


According to this graph, which of the following statements is or are correct?

- I. Benefit gained and cost of defense a territory both are directly related to the territory size.
 - II. As territory size increases, benefit gained increases and cost of defense decreases.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

2.16.

Solute concentration in a solution influences the movement of solvent molecules to and from a cell. The solution outside of the cell can be described as hypertonic (higher solute concentration), isotonic (equal solute concentration) or hypotonic (lower solute concentration). The movement of solvent molecules helps equalize solute concentrations on either side of the cell wall. Consider what might happen if red blood cells (erythrocytes) are placed in a solution of water (see image below):



Source: Blamb, Shutterstock, Accessed 11.07.2019

Why do the erythrocytes swell and burst when placed in water?

- (A) Since the water concentration is higher outside the cell, water moves inward by passive diffusion.
- (B) Since the hemoglobin concentration is higher inside the cell, hemoglobin moves outward by exocytosis.
- (C) Since potassium ions are more concentrated inside the cell, the potassium ions move outward by osmosis.
- (D) Erythrocytes pump water inward by active transport to balance osmotic gradients.

2.17.

Enzymes play a very important role in most biological reactions in the human body. Enzymes are globular proteins, larger in size compared to their substrates. After the enzymes bind to the substrate, the enzyme converts the substrate into smaller products. In other words, a substrate is a compound that binds to an enzyme and is converted to a product. When a substrate such as maltose is present in an excess amount, elevating the concentration of the corresponding enzyme will increase the reaction rate.

For instance, maltose, or malt sugar, is broken down into glucose molecules by the enzyme maltase. In this case, glucose is the final product.

The reaction rate for a given chemical reaction is the measure of the change in concentration of the reactants or the change in concentration of the products per unit time. In the glucose example, which of the following would instantaneously diminish the reaction rate?

- (A) Adding maltase**
- (B) Adding glucose**
- (C) Simultaneously adding maltose and maltase at the same quantity**
- (D) None of the above**

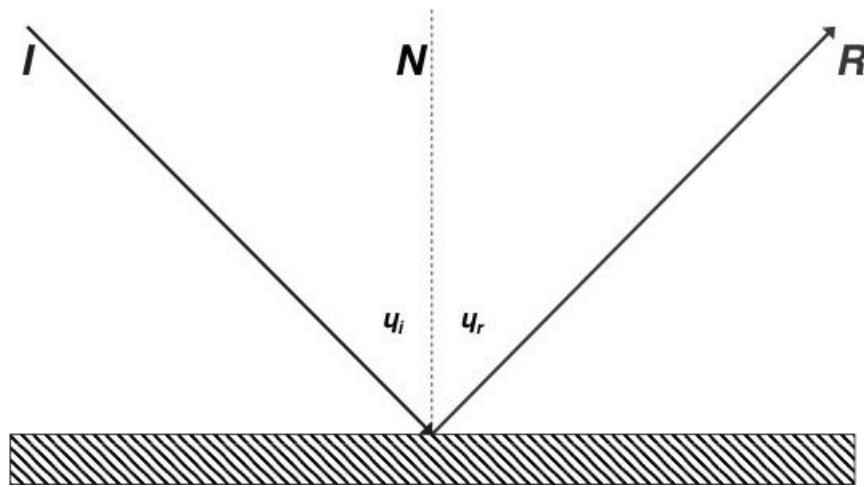
2.18.

In chemistry, bases are substances which are slippery to touch in aqueous solution, taste bitter, change the color of indicators (e.g., turns red litmus paper blue), react with acids to form salts by releasing hydroxide ions, and promote certain chemical reactions (base catalysis).

Potassium hydroxide (KOH) is a strong base because it:

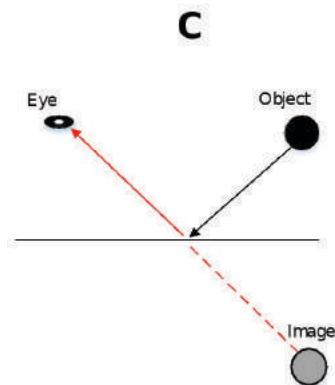
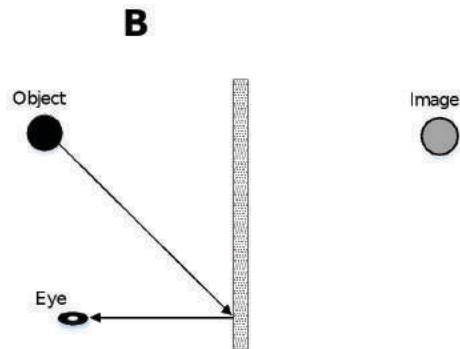
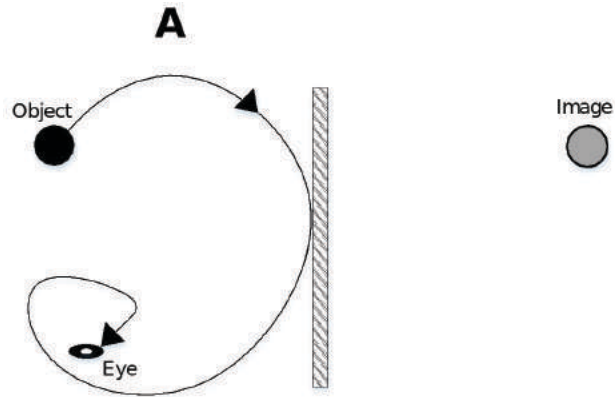
- (A) easily releases hydroxide ions.
- (B) does not dissolve in water.
- (C) reacts to form salt crystals in water.
- (D) does not conduct an electric current.

2.19.



Light moves in a straight line. According to the law of reflection, the ray of light approaching the mirror is the incident ray (labelled *I* in the diagram), and the ray of light leaving the mirror is the reflected ray (labelled *R* in the diagram). At the point of incidence, where the ray strikes the mirror, a line can be drawn perpendicular to the surface of the mirror. This line is known as the normal line (labelled *N* in the diagram). The normal line divides the angle between the incident ray and the reflected ray into two equal angles. The angle between the incident ray and the normal line is known as the angle of incidence (θ_i). The angle between the reflected ray and the normal line is known as the angle of reflection (θ_r). The angle of incidence and the angle of reflection are always the same.

According to the following diagrams, which of the following statements is or are correct?



- I. Both diagrams A and C follow the law of reflection.
 - II. The observer in diagram B cannot see the image in the mirror.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

2.20.

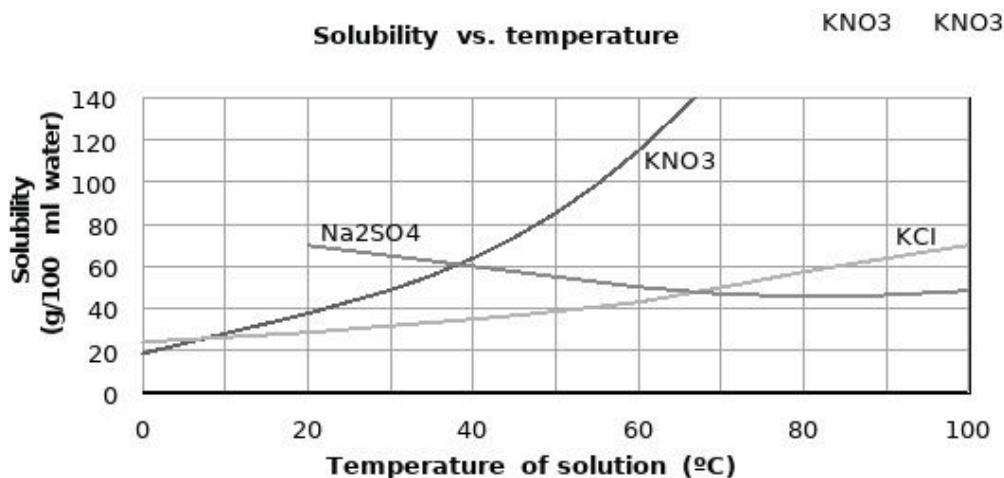
In a certain habitat there are green bugs and red bugs. The birds prefer the taste of red bugs and hence the red bugs are more often preyed upon. This process in which nature selects green bugs to survive and evolve is called natural selection. Those individual organisms who happen to be best suited to an environment survive and reproduce most successfully, producing both a greater number of offspring as well as similarly better-adapted offspring.

Which of the following would have the least effect on natural selection in a subspecies of giraffes that is geographically isolated from other subspecies of giraffes?

- (A) Available niches**
- (B) Existing predators**
- (C) Chromosome number**
- (D) Available food resources**

2.21.

The diagram shows the relationship between the solubility of substances in water at various temperatures. Potassium nitrate (KNO_3), potassium chloride (KCl) and sodium sulphate (Na_2SO_4) are salts (shown as grams of salt per 100 milliliters of water).



Which of the following two statements is or are correct?

- I. 100g of KNO_3 does not fully dissolve in 100 ml of water at 60 °C.
 - II. The solubility of KNO_3 increases more than that of KCl as temperature increases.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

2.22.

The efficacy of a drug was tested on two groups of diseased guinea pigs, A and B, with 10 guinea pigs each. The drug was randomly given to one group while the other group was administered a placebo. (A placebo is a substance without a therapeutic effect, usually given to deceive or placate the recipient). It remains unknown which group received the placebo, and which group the drug.



Source: PHOTO FUN, Shutterstock, Accessed 26.11.2019

The guinea pigs were placed under observation:

- In group A, all the pigs were normal.
- In group B, three guinea pigs were found dead, and they had rashes all over their skin.

Which of the following conclusions is or are correct?

- I. This drug can cause a fatal rash and should be prohibited.
 - II. Group A must have taken the placebo.
- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

EXAM 3

3.1.

Polymers are giant organic molecules that are assembled from many smaller molecules called monomers. They have many repeating monomer units that form in long chains. A polymer is analogous to a necklace made from many small beads (monomers).

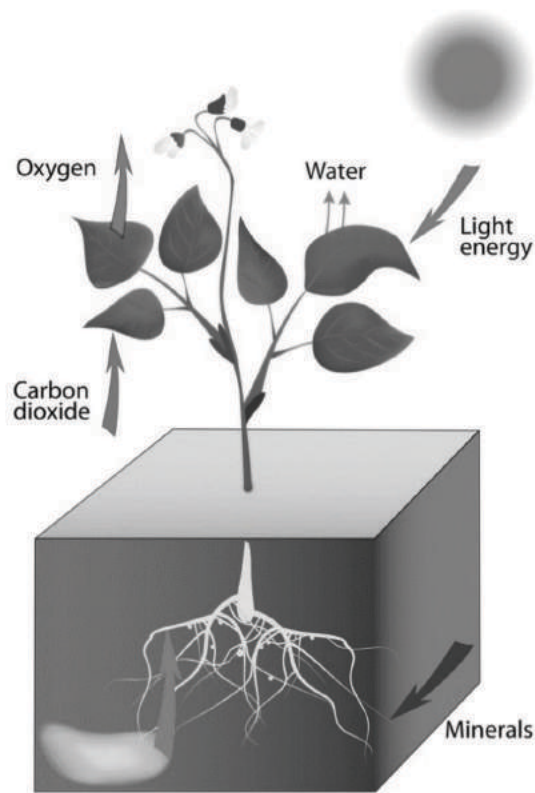
The polymer polyvinyl chloride (PVC) has the following chemical formula: $\text{CH}_2\text{CH}(\text{Cl})\text{CH}_2\text{CH}(\text{Cl})\text{CH}_2\text{CH}(\text{Cl})$.

Its repeating subunit is:

- (A) $\text{CH}(\text{Cl})$
- (B) $\text{CH}(\text{Cl})\text{CHCH}_2$
- (C) CH_2CH
- (D) $\text{CH}_2\text{CH}(\text{Cl})$

3.2.

Photosynthesis happens in two phases. In the first phase, the cellular protein pigment called chlorophyll is excited by light that propels the chlorophyll molecules into high-energy states. This energy is used to make ATP and also for splitting of water. In the second phase, the hydrogen released from the photolysis of water is used to reduce CO_2 with the help of ATP to form glucose.



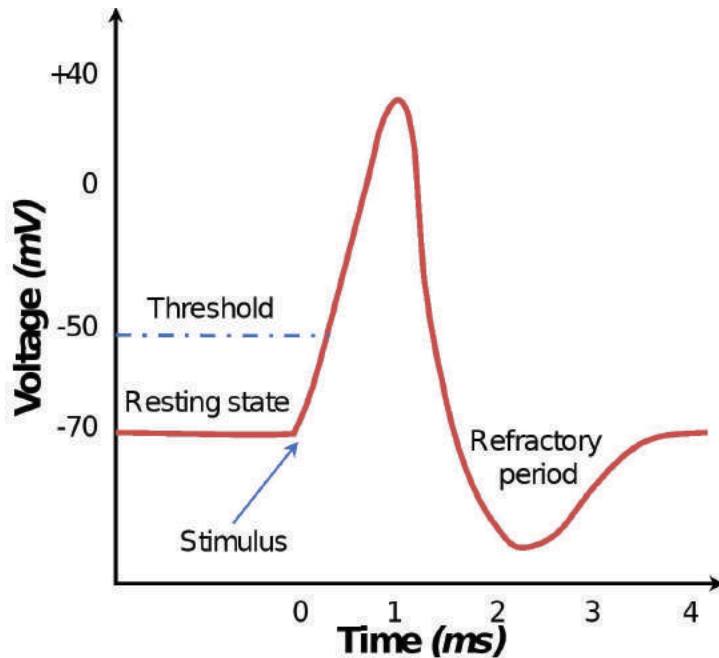
Source: Designua, Shutterstock

The first stage of photosynthesis in a chloroplast is:

- (A) light-dependent
- (B) water-dependent
- (C) glucose-driven
- (D) ATP-driven

3.3.

When cells in the nervous system transmit a stimulus to another cell, the electrical impulse must exceed a certain stimulus threshold, as shown in the following graphic:



Which statement(s) is or are correct?

- I. If the stimulus changes the voltage by 10 *mV*, the stimulus will not be transmitted.
 - II. The difference between the highest and the lowest voltage experienced by a cell in the nervous system is more than 100 *mV* overall.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

3.4.

The peptide Z consists of twelve amino acids. Each amino acid is designated by three letters (for example, "Arg"). The sequence of the amino acids is shown from left to right. This peptide has "Pro" and "Phe" peptides following each other in the chain.

With the enzyme Ch, the peptide Z is split behind the amino acids Arg and His. The parts obtained are:

Met - Trp

Asn - Ser - Arg

Met - Ala - Gly - Arg

Pro - Phe - His

With the enzyme Tr, the peptide Z is split behind the amino acids Pro and Gly. The following three parts come about as a result:

Arg - Asn - Ser - Arg - Pro

Met - Ala - Gly

Phe - His - Met - Trp

What is the structure of peptide Z?

- (A) Met-Gly-Asn-Ala-Arg-Ser-Arg-Pro-Phe-Trp-Met-His
- (B) Met-Ala-Gly-Arg-Pro-Phe-His-Asn-Ser-Arg-Met-Trp
- (C) Met-Ala-Gly-Arg-Asn-Ser-Arg-Pro-Phe-His-Met-Trp
- (D) Ser-Arg-Gly-Met-Pro-Phe-Trp-Met-His-Trp-Ser-His

3.5.

The skin has several accessory structures (adnexa), like hair, nails and exocrine glands that aid in external defense. Acting as a physical barrier, the adnexa and the skin provide protection against the invasion of the body by foreign particles. Sweat and skin secretions contain a mixture of molecules that kill or limit the growth of many types of microbes. This control of microbes is an example of:

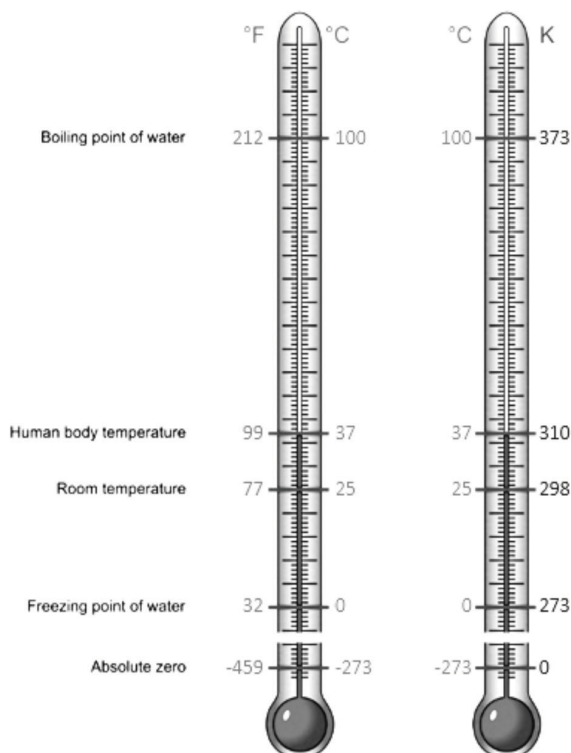
- (A) a nonspecific defense against infection.
- (B) an enzyme-catalyzed biochemical reaction.
- (C) a feedback loop to maintain homeostasis.
- (D) a specific immune response to infection by microbes.

3.6.

Found in eukaryotes, mitochondria is the organelle responsible for the production of energy in cells. It is found in cells in which the biochemical processes of respiration and energy production occur in proportion to the amount of energy needed. Which of the following tissues contains the largest number of mitochondria?

- (A) Nervous
- (B) Skin
- (C) Connective
- (D) Muscle

3.7.



Source: ALXR, Shutterstock, Accessed 23.10.2019

The freezing point or melting point of water is the temperature at which water changes phase, from a liquid to a solid or a solid to a liquid, respectively. Ordinarily, the freezing point of water is 0°C , which is equal to 273 K (Kelvin) or 32°F .

The boiling point of liquid nitrogen is 77 K . It is observed that ice forms at the opening of a container of liquid nitrogen.

The best explanation for this observation is that:

- (A) water at zero degrees Celsius is colder than liquid nitrogen and freezes.
- (B) the nitrogen boils and then cools to form a solid at the opening of the container.
- (C) the water vapor in the air over the opening of the liquid nitrogen freezes.

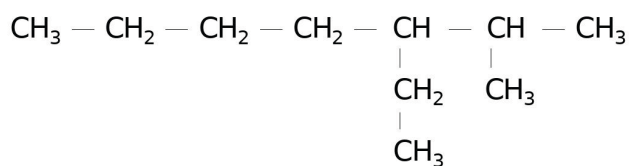
(D) water trapped in the liquid nitrogen escapes and freezes.

3.8.

The structural formulas of the most important alkanes are shown below.

Number of C-atoms	Name of the alkane	Molecular formula of the alkane	Structural formula of the alkane
1	Methane	CH ₄	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$
2	Ethane	C ₂ H ₆	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$
3	Propane	C ₃ H ₈	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array}$
4	Butane	C ₄ H ₁₀	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$
5	Pentane	C ₅ H ₁₂	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$
6	Hexane	C ₆ H ₁₄	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$
7	Heptane	C ₇ H ₁₆	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$
8	Octane	C ₈ H ₁₈	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$

What is the name of the following alkane?

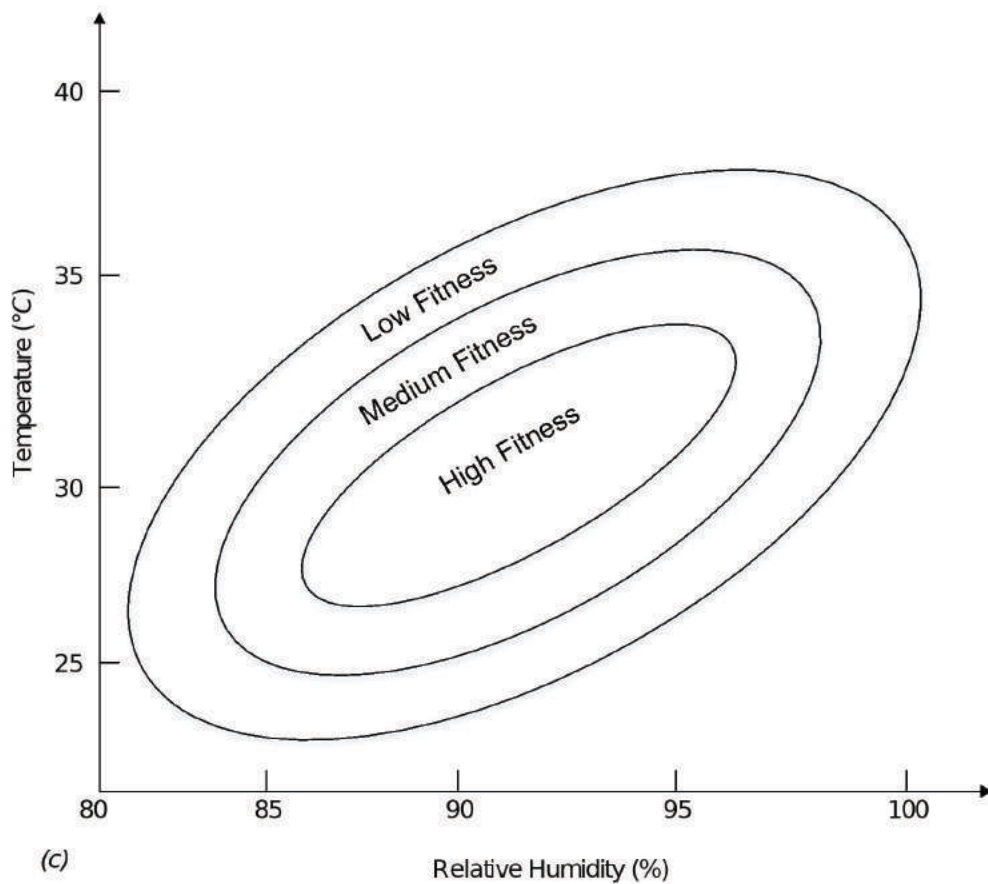


- (A) 5,6-Propylhexane (B) 3-Ethyl-2-methylheptane
 (C) 3-Ethyl-octane (D) 5-Propyl-6-ethylheptane

3.9.

The performance or tolerance of an organism is often sensitive to environmental variables. For example, the fitness of an organism varies in different humidity and temperature conditions.

This graph shows variation in fitness with respect to two different variables simultaneously.

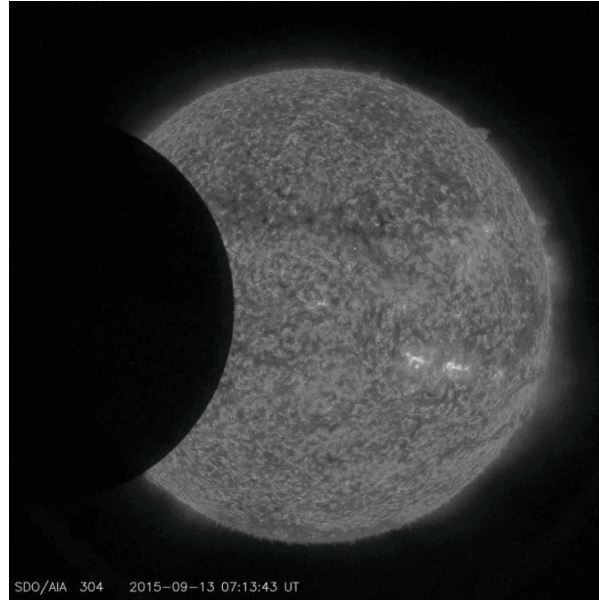


Which of the following statements is or are correct?

- I. The organism's fitness reaches its maximum at maximum temperature and humidity.
- II. The range of humidity tolerated is less at extreme temperature than it is at intermediate ones.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

3.10.



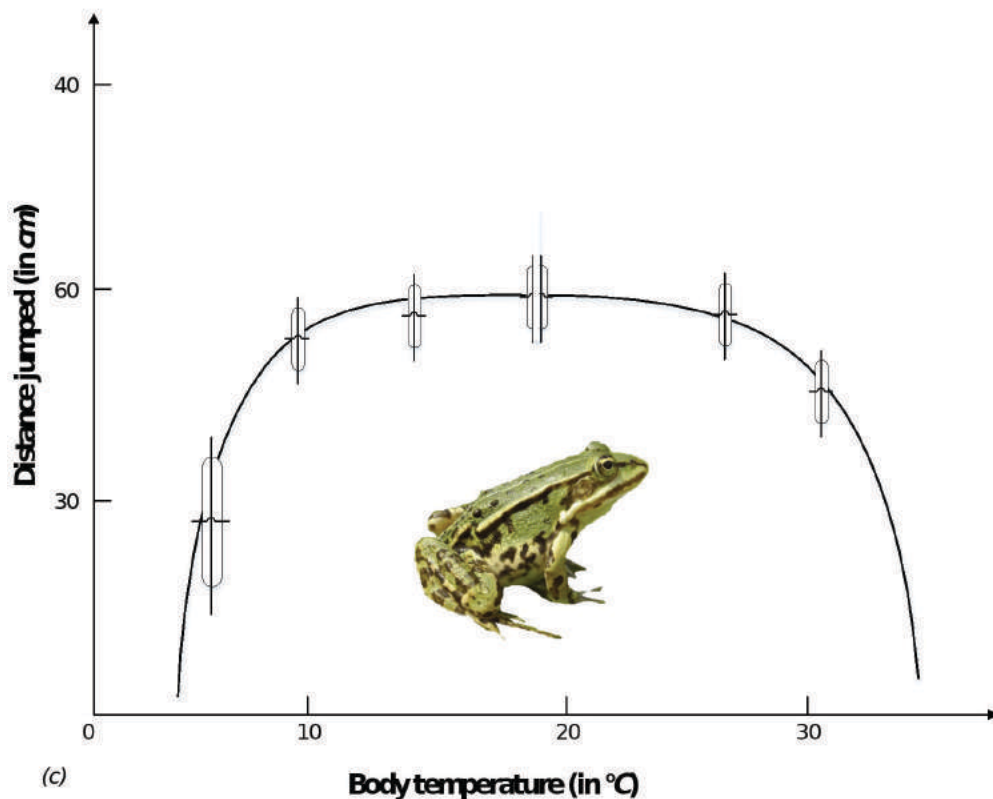
Source: NASA, *Moon photobombs the sun*, 17.9.2015,
<http://solarsystem.nasa.gov/galleries/moon-photobombs-the-sun>, Accessed 14.12.2019

Light travels in one second appr. $3,00 \times 10^8$ m. The distance between the Earth and the Sun is roughly 150,000,000 km. How much time would it take for the sun light to reach the Earth?

- (A) Under 7 minutes
- (B) Between 7 and 8 minutes
- (C) Between 8 and 9 minutes
- (D) More than 9 minutes

3.11.

On a normal day for a desert frog, the environment is too cold early in the morning, whereas later in the day it becomes too hot. The frog compensates for this somewhat by spending most of the early morning in sunny places, whereas later in the day most of its activities take place in the shade. Each frog has an optimal range of temperature, within the upper and lower limits of tolerance. When measures of performance are plotted against temperature, the curve obtained is given below:



Source: Huey, R. B. and Stevenson, R. D: Distance jumped by *Rana clamitans*,
In: Amer. Zool. 19: page 360, 1979, Accessed 13.04.2020

Which of the following statements is or are correct?

- I. The frog's best performance (furthest jump) occurs when the temperature is between 15 °C and 20 °C; therefore, 15 °C to 20 °C is its optimal range of temperature.

II. The frog's performance is lowest at extreme temperatures.

- (A) Only statement I is correct.
- (B) Only statement II is correct.
- (C) Both statements are correct.
- (D) Neither of the two statements is correct.

3.12.

The ability of a substance (solute) to dissolve in another substance (solvent) like water is known as solubility. Which among the following substances can act either as a solute or solvent when mixed with 100 grams of water at 20 °C?

SOLUBILITY OF SUBSTANCES IN WATER AT 20 °C

Substance	Formula/State	Solubility (g / 100 g H ₂ O)
Magnesium chloride	MgCl ₂ / solid	54.6
Ammonia	NH ₃ / gas	34.0
Ethanol	CH ₃ CH ₂ OH / liquid	infinite
Benzoic acid	C ₆ H ₅ COOH / solid	0.29

- (A) NH₃
- (B) C₆H₅COOH
- (C) MgCl₂
- (D) CH₃CH₂OH

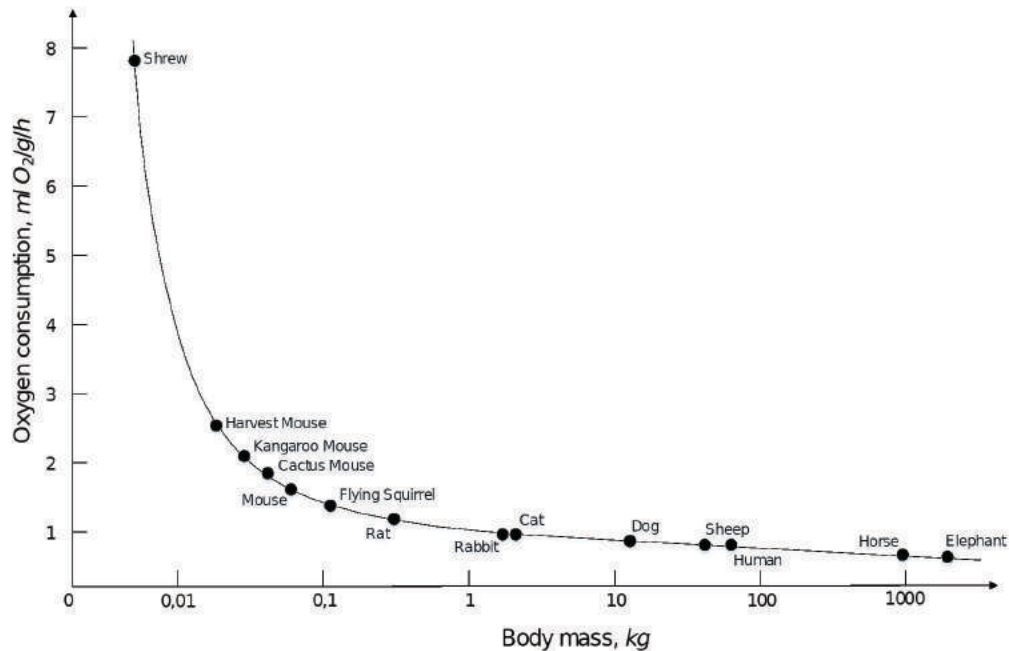
3.13.

In humans, females have two of the same kind of sex chromosome (XX), while males have two distinct sex chromosomes (XY). Female gametes, called ovum, contain the same type of chromosome, X. Sperm or male gametes may contain either an X or Y chromosome. Half of the sperm will contain X, while the other half will contain Y. The gender of the child will depend on the type of chromosome in the sperm. If a sperm cell containing an X chromosome fertilizes an egg, the zygote will be XX (female). If the sperm cell contains a Y chromosome, the resulting zygote will be XY (male). Based on only the sex chromosomes in typical human egg and sperm cells at fertilization, the probability of producing a female is:

- (A) 25%**
- (B) 50%**
- (C) 75%**
- (D) 90%**

3.14.

The total amount of energy needed by an animal for maintenance per unit time increases with increasing body mass. The rates of oxygen consumption per unit of body mass against body mass are shown for a wide variety of mammals on the semi logarithmic plot below.



Based on the graph, which of the following statements is or are correct?

- I. The oxygen consumption of a rabbit is approximately 1 *ml/g/hr*.
 - II. Large animals have greater energy requirements per unit of body mass than smaller animals.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

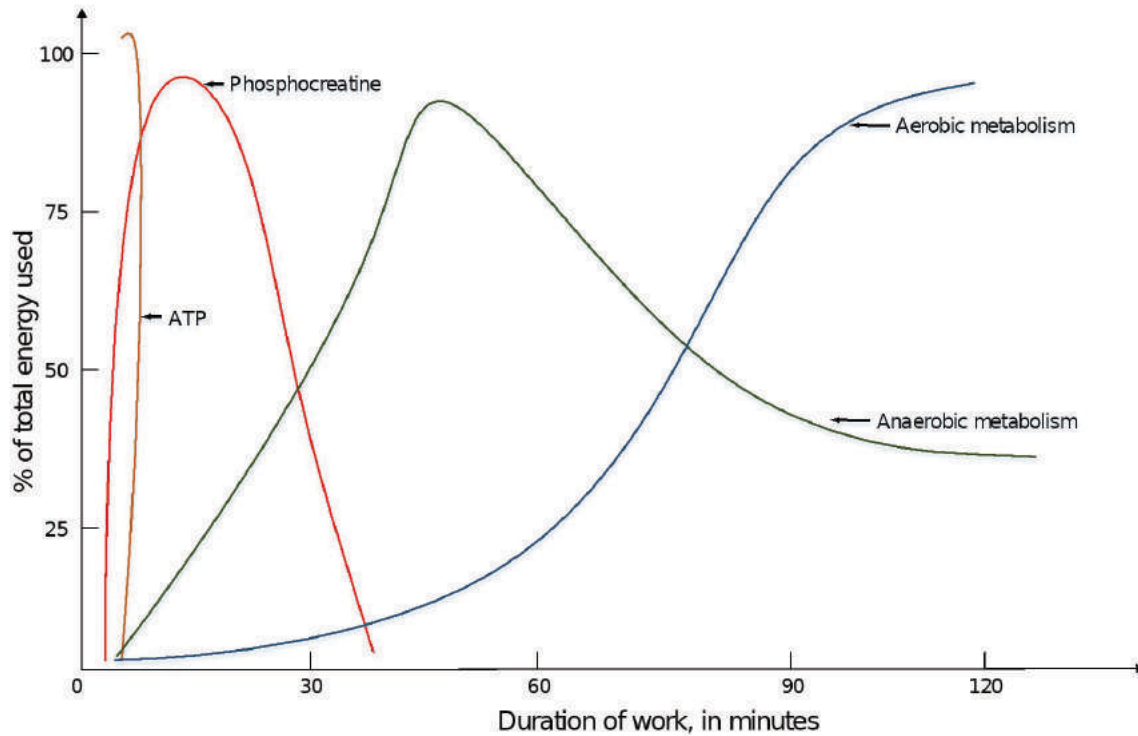
3.15.

Hardening of eggs and curdling of milk at high temperatures occurs by denaturation of proteins. Denaturation is the change in shape of a protein through some form of external stress (for example, applying heat, acid or alkali) in such a way that it will no longer be able to carry out its cellular function. Heat denatures protein by:

- (A) mutating DNA.
- (B) turning protein into carbohydrates.
- (C) changing protein structure.
- (D) stopping protein formation.

3.16.

A continuous supply of energy is needed for muscles to function. Below is a graph representing certain sources of energy and how they are used in working muscles.

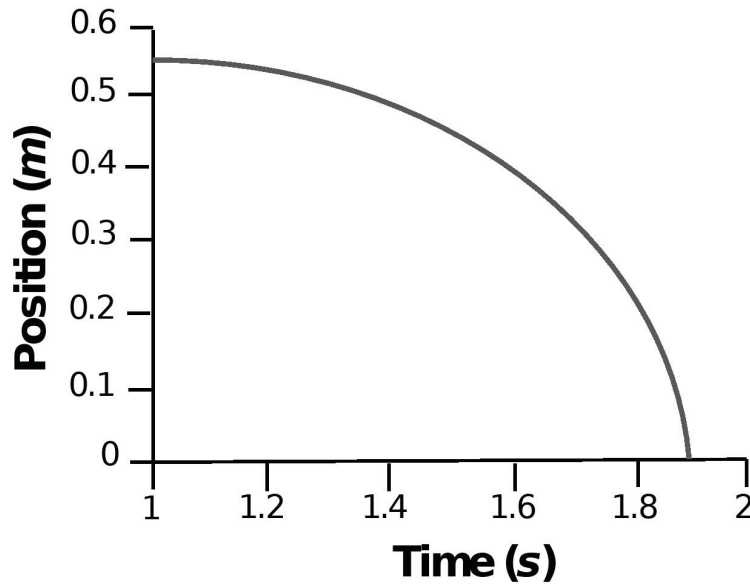


Which of the four sources provides the most energy after working for 45 minutes?

- (A) ATP
- (B) Phosphocreatine
- (C) Anaerobic Metabolism
- (D) Aerobic Metabolism

3.17.

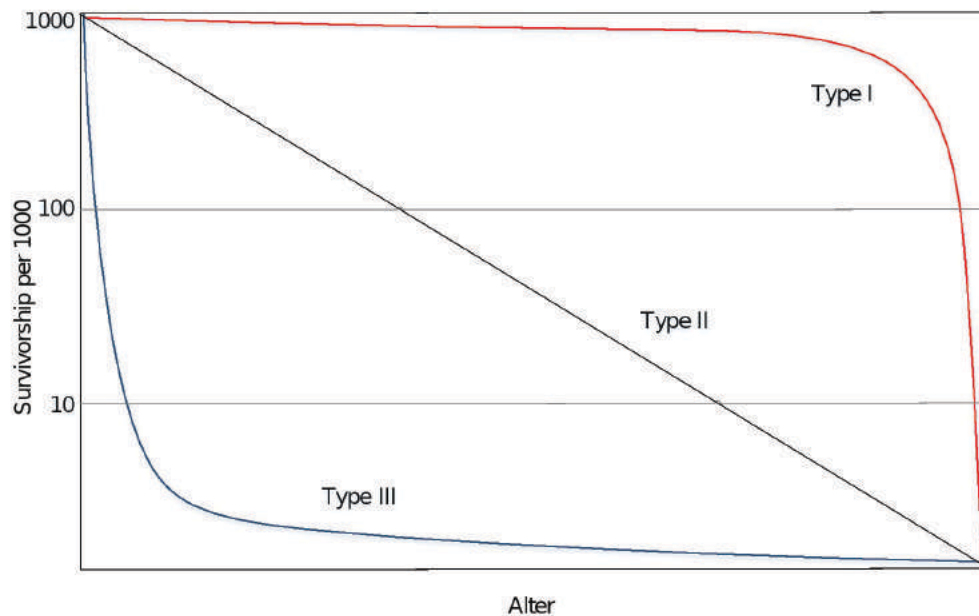
The graph below is a plot of position versus time for a moving object during a particular time interval:



Which of the following statements is or are correct?

- I. The speed of the object is constant.
 - II. The acceleration of the object is positive.
- (A) Only statement I is correct.
(B) Only statement II is correct.
(C) Both statements are correct.
(D) Neither of the two statements is correct.

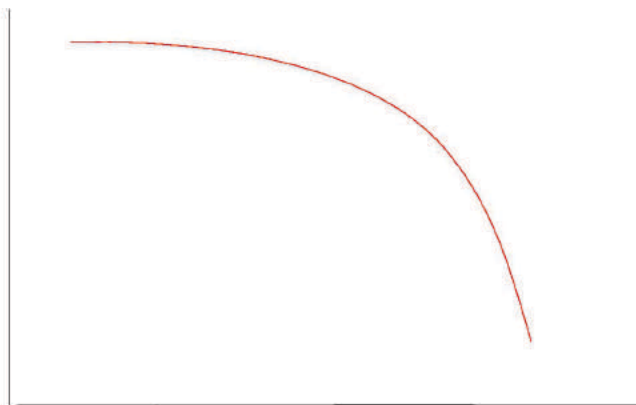
3.18.



The graphic above shows survivorship curves for different populations.

The Type II curve represents a population in which the probability of dying is independent of the age of the individual. The type III curve represents a population in which only a few individuals reach adulthood and in which the probability of dying increases with age.

Which of the following statements correctly describes the curve below?



- I. This curve represents a population in which there is high infant and juvenile mortality.
 - II. A curve like this can describe the survival rate of most human populations.
- (A) Only statement I is correct.
 - (B) Only statement II is correct.
 - (C) Both statements are correct.
 - (D) Neither of the two statements is correct.

3.19.



Source: claffra, Shutterstock, Accessed 14.07.2019

Termites and the bacteria in their gut have a very interesting relationship. Bacteria find food and shelter in the gut of the termite, and they benefit the termite by helping digest its food. This relationship, in which each individual benefits from the activity of the other, is called mutualism. Mutualistic interactions among two species in an ecosystem can be represented as?

- (A) -/-
- (B) -/0
- (C) +/0
- (D) +/+

3.20.

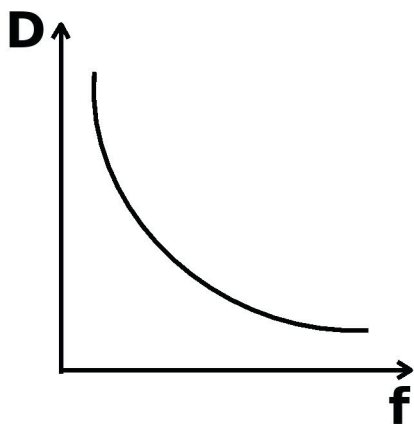
There is a metal mass on the heating pad. As the heating pad is increasing in temperature, which of the following statements is or are correct?

- I. The density of the metal decreases and its volume increases.
 - II. The mass of the metal increases.
- (A) Only statement I is correct.
 - (B) Only statement II is correct.
 - (C) Both statements are correct.
 - (D) Neither of the two statements is correct.

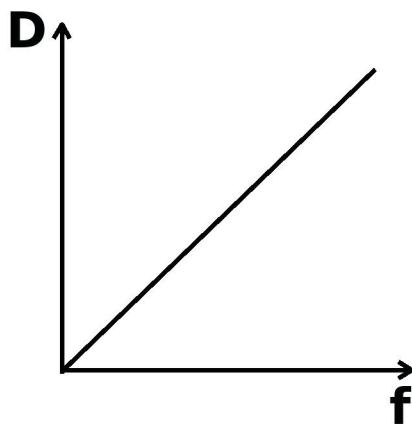
3.21.

The refractive power of a lens is expressed by the formula $D = 1 / f$, where f is the focal length of the lens. Which of the following graphs best describes the formula?

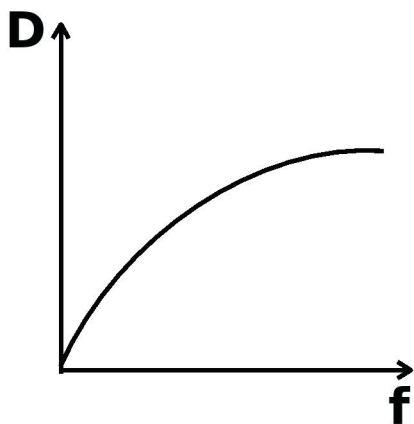
(A)



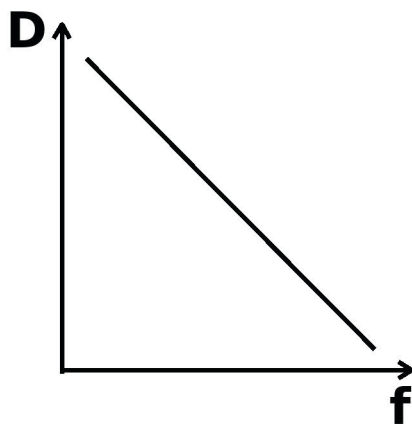
(B)



(C)

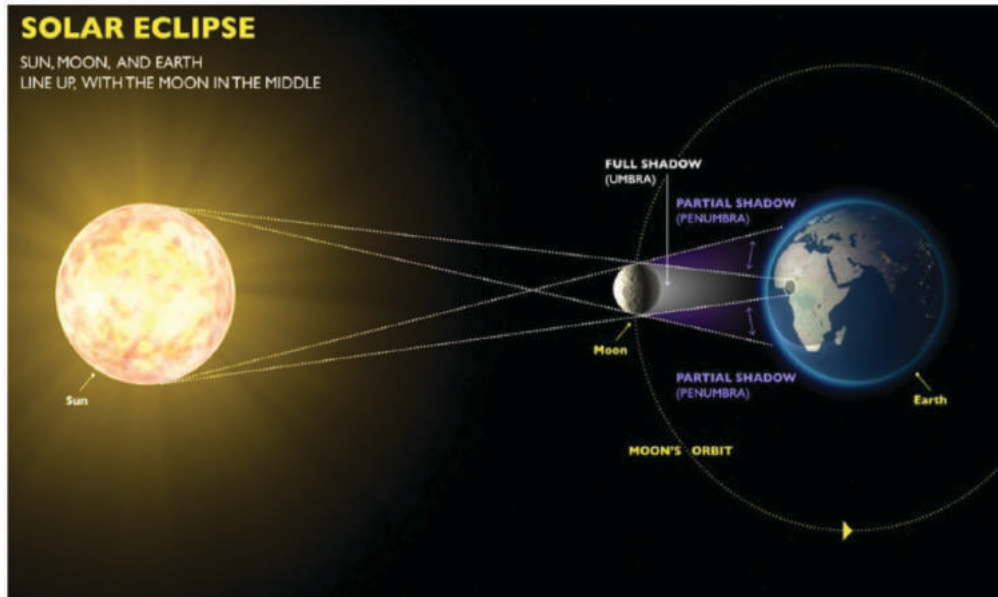


(D)



3.22.

An astronaut on the earth observes a solar eclipse.



Source: Naeblys, Shutterstock, Accessed 23.07.2019

At the same time, the moon experiences:

- (A) a solar eclipse.
- (B) an earth eclipse.
- (C) a lunar eclipse.
- (D) none of the above.

ANSWER KEYS

Exam 1			Exam 2			Exam 3	
Question	Answer		Question	Answer		Question	Answer
1.1.	B		2.1.	A		3.1.	D
1.2.	D		2.2.	D		3.2.	A
1.3.	B		2.3.	A		3.3.	C
1.4.	D		2.4.	D		3.4.	C
1.5.	C		2.5.	B		3.5.	A
1.6.	A		2.6.	D		3.6.	D
1.7.	B		2.7.	B		3.7.	C
1.8.	A		2.8.	B		3.8.	B
1.9.	D		2.9.	A		3.9.	B
1.10.	C		2.10.	D		3.10.	C
1.11.	D		2.11.	B		3.11.	C
1.12.	C		2.12.	D		3.12.	D
1.13.	C		2.13.	A		3.13.	B
1.14.	D		2.14.	B		3.14.	A
1.15.	D		2.15.	A		3.15.	C
1.16.	A		2.16.	A		3.16.	C
1.17.	B		2.17.	D		3.17.	D
1.18.	D		2.18.	A		3.18.	B
1.19.	A		2.19.	B		3.19.	D
1.20.	D		2.20.	C		3.20.	A
1.21.	B		2.21.	B		3.21.	A
1.22.	B		2.22.	D		3.22.	D

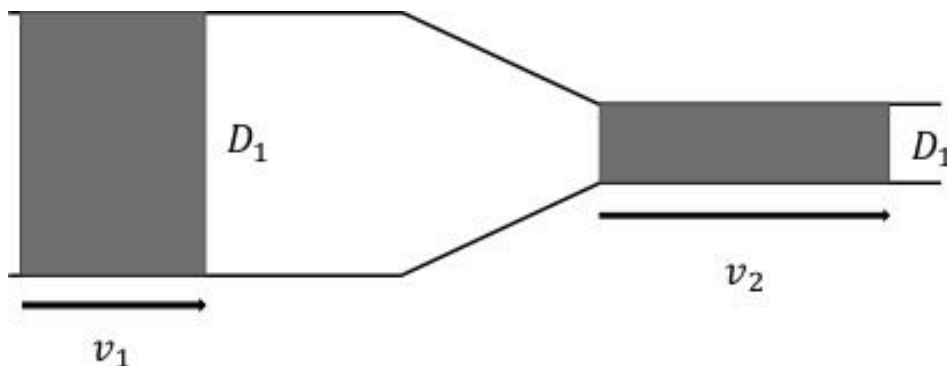
DETAILED ANSWERS

EXAM 1

1.1. Answer: B

Statement I is incorrect because the paper absorbs rather than reflects the violet wavelengths, along with red, orange, yellow, blue, and indigo (altogether, ROYBIV). Because only reflected wavelengths can be seen by an observer, the paper will appear to be green. On the other hand, statement II is correct because if none of the wavelengths are absorbed, the combined wavelengths of the original, visible light source will appear to be white. Therefore, B is the correct answer; only statement II is correct.

1.2. Answer: D



The shaded rectangles must always have the same area, so the following must apply:

$$v_1 \times D_1 = v_2 \times D_2$$

It follows that the larger a cross section D , the lower the speed, and vice versa.

The relationship between the flow rate of the liquid and the pipe diameter must be understood. Suppose a “liquid package” with volume V flows through this tube. A large cross-section of the volume flows through the wide areas, but when the pipe is narrower, significantly less of the “package” can fit through at ones. This means that, in order for the package (in all of its volume) to travel the same amount of distance over the same period of time, it must flow significantly faster through narrow areas than wide areas.

A large cross-sectional area means a low flow rate, and vice versa. For this question, you are asked to identify two points with a similar flow rate; you therefore look for two points that roughly have the same pipe diameter/cross sectional area: points X and Z. D is the correct solution.

Note: The quantitative relationship between the dimensions of the pipe and the flow rate is given by the following equation:

$$v = 0.408 \frac{V}{D^2}$$

D stands for the pipe diameter and V for the amount of liquid that flows through the pipe. v is the flow rate, or velocity, of the liquid.

1.3. Answer: B

Statement I is incorrect because xerophytic leaves cannot photosynthesize as rapidly when water is abundant, but they can extract water from relatively dry soil. The most xerophytic leaf performs best under conditions of low water availability (zone a), whereas the most mesophytic leaf does best when soils are wet (zone d).

Statement II is correct because mesophytic leaves photosynthesize and transpire at a rapid rate and hence require high water availability. Therefore, the correct answer is B.

1.4. Answer: D

The formula for the circumference of the Earth:

$$U_{\text{Earth}} = 2 \times \pi \times r_{\text{Earth}}$$

The band is exactly 1 meter longer than the circumference of the Earth:

$$U_{\text{Band}} = U_{\text{Earth}} + 1\text{m}$$

$$U_{\text{Band}} = 2 \times \pi \times r_{\text{Band}} = 2 \times \pi \times (r_{\text{Earth}} + x)$$

$$U_{\text{Earth}} + 1\text{m} = 2 \times \pi \times (r_{\text{Earth}} + x)$$

$$2 \times \pi \times r_{\text{Earth}} + 1\text{m} = 2 \times \pi \times r_{\text{Earth}} + 2 \times \pi \times x$$

$$1\text{m} = 2 \times \pi \times x \quad x = \frac{1\text{m}}{2 \times \pi}$$

In the step from the third to the fourth line, the information about r_{Earth} is omitted. The result is therefore independent of the size of the Earth. No matter how big the Earth is: if you extend the band by 1 m, it then sticks out by 15.9 cm.

1.5. Answer: C

We know that there is one more C than there is O. C must therefore be the correct answer.

1.6. Answer: A

The chemical properties of an element depend on the number of electrons in the outer orbital of the atom. Thus, iodine and chlorine, being in the same vertical group of the periodic table, have the same number of electrons in their outer orbitals and therefore similar chemical properties.

1.7. Answer: B

The correct answer is B. All three scenarios result in either an increase in woodchucks or a decrease in available food. (Sc. 1: More woodchucks □ higher competition. Sc. 3: Less predator species □ more woodchucks □ higher competition. Sc.4: Less food □ higher competition)

1.8. Answer: A

The correct answer is A. In this case, the concentration of the reactant increased, resulting in the formation of more product and increasing the reaction rate. All other options (B: lower concentration of the reactant C_6H_6 ; C: Higher concentration of the product HBr ; D: Lower temperature) will have the opposite effect.

1.9. Answer: D

The total force is the product of pressure and area. As each container holds the same volume of water, it can be assumed that each container has the same amount of weight. Since the bottom of each container covers the same area, the total force applied by each container is the same.

1.10. Answer: C

The graph shows that oxygen consumption is higher among 10 °C acclimated crabs than 20 °C acclimated crabs at all temperatures. Therefore, C is correct, while A and B are not. For D, in order to be considered correct, the rate of oxygen consumption of the 20 °C acclimated crabs at 20 °C would have to equal the rate of oxygen consumption of the 10 °C acclimated crabs at 10 °C (which it does not). Acclimation is one determinant of the oxygen consumption rate, but with only the given data, we cannot calculate how much oxygen is consumed by every crab, so D is not correct.

1.11. Answer: D

Exactly one-half of the moon is always illuminated by the sun. The part of the moon in the line of sight is what determines the particular phase of the moon.

1.12. Answer: C

Considering region B, the black bars and the black line reveal that the temperature remains high throughout the year and there is very little rainfall. These conditions resemble that of a desert. Thus, statement I is correct.

The graph also shows that the temperature of region A decreases when rainfall in the region increases. Thus, statement II is correct.

1.13. Answer: C

Statement I is correct. Because of the law of conservation of energy, the pendulum does not lose energy within a system of non-friction and can, therefore, reach the exact same height.

Statement II is also correct. Because no energy is lost, the pendulum continues to swing forever.

1.14. Answer: D

Statement I is incorrect. Whether going up the short or the steep side of the hill, the eventual elevation is the same, so the amount of energy expended going up either side will be the same. Going up the steep side of the hill would be shorter but would require a greater rate of energy consumption per unit time since a greater component of Caleb's force would be directed against the pull of gravity. For the same reason, going up the steep side of the hill slowly or quickly would require the same expenditure of energy. The rate or energy expenditure might change, but in the end, it would still be the same amount. This is perhaps more obvious when you look at the gravitational potential energy (GPE) gained by going up the hill = mass (m) $\times$ gravity (g) $\times$ height (h). It is independent of the time taken to climb and the slope of hill; only the vertical height climbed matters.

1.15. Answer: D

Statement I is wrong, because within the range between 2 and 6 hours, car 2 is further away from the starting point than car 1. This can be seen from the fact that during this period, the line for car 2 is above that of car 1.

Statement II is wrong. After three hours, car 2 stops moving (as shown by the horizontal, straight line).

1.16. Answer: A

As seen in the diagram, the distance which the skydiver falls within the same amount of time increases the longer the skydiver falls. This is why the distance from 0.2 to 0.3 s is larger than from 0 s to 0.1 s. Statement I is therefore correct.

While the speed is constantly changing, the acceleration (the change in speed) remains steady. Statement II is therefore incorrect.

1.17. Answer: B

Here, the two herbivore populations were competing for the same resources. Population B was better able to use the available resources than was population A, thus population B increased over time. Population A decreased over time due to competitive exclusion.

1.18. Answer: D

The correct answer is D. Liquid can easily disrupt attractions between solid particles if the solid particles are more strongly attracted to the particles of the liquid. This causes the bonds between the solid particles to break, and the solid to dissolve.

1.19. Answer: A

Only statement I is correct. The statement is a simplified equation and can be used for other conditions of gas. This simplified equation for the behavior of gases may not and is not intended to predict the behavior of other phases. Thus, statement II is incorrect.

1.20. Answer: D

Statement I is incorrect because the curve of sodium chloride is not a straight line. It has a slight upward direction, as the solubility of sodium chloride increases slightly when temperature increases.

Statement II is incorrect. If you compare the curve of air and the curve of oxygen at a certain temperature, for example at 20 °C, you will find that 60 ml of oxygen are soluble, while only about 35 ml of air are soluble. In fact, oxygen is more soluble than air in water for any temperature. The correct solution is therefore D.

1.21. Answer: B

According to Newton's third law, when a skater applies a force by pulling the rope (and the other skater) in, they experience an equal and opposite force: as they pull in the other skater, they are also pulling themselves in. So, each skater is experiencing the force of the other skater pulling them in, as well as the force from the efforts of their own force. This means both skaters experience the same amount of force which acts to pull them in to the center, regardless of who is stronger or weaker. If both skaters have the same mass (they are same weight), then they both experience the same acceleration and thus move the same amount ($F = m \times a$). They will meet in the center. Statement I is wrong.

Statement II is correct. As explained above, when both skateboarders pull on the rope, each one is pulled in both by their own efforts and the efforts of the other skateboarder. The force applied by pulling on the rope is the same for both people. According to Newton's 2nd law, acceleration is inversely proportional to mass ($a = F/m$). That's why the heavier skateboarder is accelerated less by the same force than is the lighter skateboarder, so he travels a shorter distance than the lighter one.

1.22. Answer: B

As mentioned, most of the mass and positive charge of an atom is concentrated in its nucleus. Due to the small size of the nucleus of a gold atom, only a small percentage of alpha particles came into direct contact with the nucleus, causing the deflection.

EXAM 2

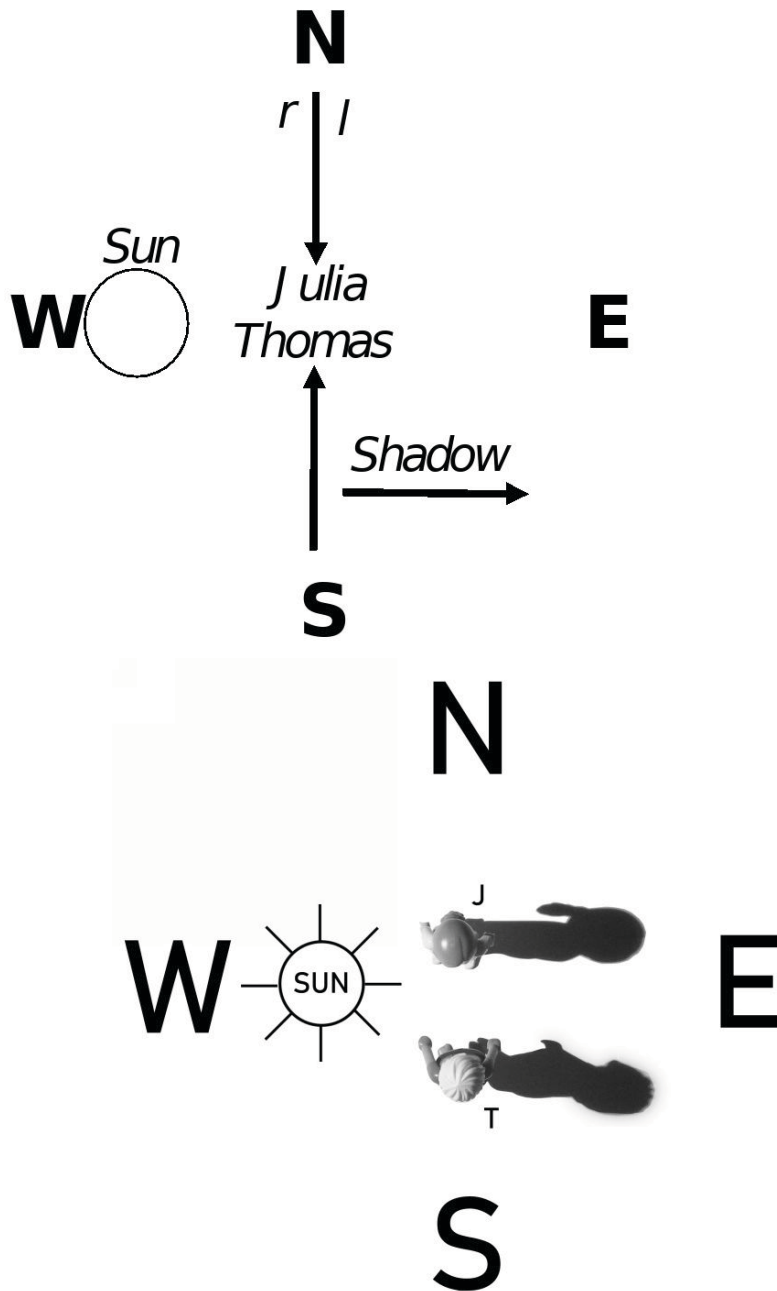
2.1. Answer: A

Condensation and evaporation both involve water changing state, but they do not involve a change in its molecular formula. While cooking meat is a chemical change, cutting up an already-cooked piece of meat is a physical change, since no change occurs on a molecular level. Respiration is a chemical change, since it involves oxygen being converted to carbon dioxide.

2.2. Answer: D

When the temperature increases, the molecules speed up and start colliding with the walls more often, which causes an increase in pressure.

2.3. Answer: A



In the evening the sun sets in the west. Hence any shadow falls in the east. Since Thomas's shadow was to Julia's left, Thomas was facing north.

2.4. Answer: D

The four parts obtained by splitting with the enzyme Ch are only possible if peptide X was cut behind amino acids Tyr and Gly.

2.5. Answer: B

As the ball is thrown up and caught, the position at the beginning ($y = 0$) and the end ($y = 0$) should be the same. Graph B is the only option depicting this and is therefore the correct answer.

2.6. Answer: D

Statement I is incorrect. Since the Moon is less massive than the earth, its gravitational force is less strong than that of the Earth. As the iron is pulled less strongly towards the Moon, a spring balance calibrated to the Earth will show less force on the Moon than it would on Earth.

Statement II is incorrect; mass remains mass and is independent of the gravity of the environment. Mass on any planet will always be the same.

2.7. Answer: B

CO₂ is dissolved in blood and is therefore connected to the circulatory system. It is also part of the respiratory system, as it is connected to the inhaling and exhaling process.

2.8. Answer: B

Statement I: The acceleration of the ball is not dependent on its mass. Acceleration on earth is always appr. 9.81m/s^2 . This statement is not correct.

Statement II: Without air resistance the ball would continue to accelerate until it hits the ground. The statement is correct.

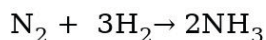
2.9. Answer: A

The change of seasons that occurs throughout the year results from changes in the tilt of the earth's axis toward or away from the sun during its annual orbit. The distance of the earth from the Sun does change throughout the year, but this difference is not large enough to cause the change of seasons. In fact, in the Northern Hemisphere, the earth is closer to the Sun during winter than it is during summer.

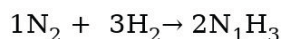
2.10. Answer: D

The answer is D. The rate of photosynthesis does increase with an increase in CO₂ and light intensity, initially, but only until a certain point. Past a level of CO₂ and light intensity, increasing these variables does not result in an increase in the rate of photosynthesis. Therefore, options A and B are incorrect. Statement D is correct because the rate of photosynthesis appears to have an optimal temperature, increasing and decreasing in rate before and after this temperature. For this reason, answer C is incorrect: after a certain temperature, a further increase in temperature causes a decrease in the rate of photosynthesis.

2.11. Answer: B



You can also rewrite the equation so that the result is clear:



Atom-calculations:

$$1 \times 2 + 3 \times 2 \rightarrow 2(1 + 3)$$

2.12. Answer: D

Statement I is false; in fact, the opposite is true. If the pump is turned on, the pressure on the outside of the balloon lessens, and in response the air within the balloon can expand so that the balloon becomes bigger. Statement I is not true.

Statement II is also false, and again the opposite is true. If a balloon filled with hot air is suddenly submerged in a container of ice-cold water, the air will quickly cool and the balloon will contract (gases take up more volume the hotter they are). Statement II is incorrect.

2.13. Answer: A

Statement I is true: As can be seen in the graphic, the normal inspiratory volume alone is smaller than all other respiratory volumes defined in the text. In the graph we see that the expiratory reserve volume and the inspiratory reserve volume are approximately three times larger than the tidal volume, the air inhaled during normal, relaxed breathing.

Statement II is false: The volume of the exhalation reserve is the air that is forcibly exhaled during a deep breath. In normal, relaxed breathing, only the tidal volume exhaled.

2.14. Answer: B

This shape sorting cube shrank homogeneously by 10 percent in all dimensions. Consequently, the circular hole shrank from 10 cm in diameter to 9 cm in diameter. The ball to be inserted is only 7 cm in diameter, so it will pass easily! Statement I is therefore incorrect.

If the overall dimensions of the toy decreased by 10 percent, then each hole of the box will have decreased by 10 percent as well. Statement II is therefore correct. The correct solution is therefore B.

2.15. Answer: A

Statement I is correct because, according to the graph, as the territory size increases the benefit gained and cost of defense both increase. So, they are directly related to the territory size.

On the other hand, statement II is incorrect. As territory size increases, the cost of defense increases. Therefore, A is the correct answer; only statement I is correct.

2.16. Answer: A

When a red blood cell is placed in water, the concentration of water is higher outside the cell because there are more solutes within the cell. This causes water to move inside the cell, diffusing from a region of higher concentration to a region of lower concentration, until the erythrocytes burst.

2.17. Answer: D

According to the introductory text, the reaction rate depends on the concentration of the substrates (such as maltose) and the corresponding enzymes (such as maltase).

If maltase is added, nothing will change in the reaction rate unless the substrate concentration (i.e. the concentration of maltose) is not also increased. And vice versa. Answer A and B are wrong because the reaction rate is not changed by these additions alone.

With the simultaneous addition of maltose and maltase, the concentration of the starting materials changes and the reaction rate increases. Answer C is therefore also wrong.

So D is correct; none of the options would reduce reaction rate.

2.18. Answer: A

Hydroxide ions (OH^-) make solutions basic while hydronium ions (H^+) make it acidic. KOH can easily release OH^- ions and is therefore a strong base.

2.19. Answer: B

Statement I is incorrect. While diagram C follows the law of reflection, diagram A does not because it depicts light moving in curved lines. The light by which we view objects on the Earth moves in straight lines.

On the other hand, statement II is correct because diagram B depicts the eye looking at a location that does not correspond to the image location. The eye must sight along a line to the image location. Therefore, B is the correct answer; only statement II is correct.

2.20. Answer: C

Chromosome number remains the same in a species and will not affect natural selection. All other factors mentioned like available niches, predators and food sources affect competition among the individuals. Those who survive and reproduce successfully will be selected for by nature.

2.21. Answer: B

Starting at 60 °C on the x axis and moving vertically to the potassium nitrate curve, we see that corresponding solubility value for potassium nitrate on the y axis approximately 118 g per 100 ml of water. Statement I is therefore incorrect.

The potassium nitrate curve is steeper than that of potassium chloride, hence the increase in temperature engenders to a stronger change in the solubility of potassium nitrate than potassium chloride. Statement II is therefore correct. The correct answer is B.

2.22. Answer: D

Statement I is incorrect because there is no evidence that the drug is the cause of the rash – it may have been caused by any

other factor. Group B may have had another hidden illness that caused their rashes and eventual deaths.

Statement II is incorrect because animal research must often be verified by further testing before conclusions can be made. We are not 100% sure that group A took the placebo rather than the drug. Perhaps the drug is what prevented group A from the rashes and eventual deaths. More research is required to make this assumption.

The correct solution is therefore D.

EXAM 3

3.1. Answer: D

The repeating subunit is $\text{CH}_2\text{CH}(\text{Cl})$.

3.2. Answer: A

In the first phase of photosynthesis, chlorophyll molecules are excited by light and this energy is used to make ATP. Thus, the first stage is light-dependent.

3.3. Answer: C

A transmembrane potential must increase by approximately 20 mV in order to reach the threshold potential that an action potential can trigger. Statement I is correct.

The difference between the highest and the lowest voltage is approx. 120 mV. Therefore, statement II is also correct.

3.4. Answer: C

After the splitting, there is no sequence in which Gly is directly after Met. Sequence A can therefore be eliminated.

Sequence B could be correct if we had seen only splitting by Ch. But looking at the splitting by Tr, this option would not be possible. There is no way to combine the chunks split by Tr into option B.

Sequence D can be excluded immediately since none of the given chunks started with Ser.

Sequence C is correct. If you look closely at this, you can see that it consists of the following parts as split by Ch: Met Ala Gly Arg, Asn Ser Arg, Pro Phe His, Met Trp

And consists of the following parts as split by Tr: Met Ala Gly, Arg Asn Ser Arg Pro, Phe His Met Trp

3.5. Answer: A

The correct answer is A because there are different types of microbes present on the external parts of the body. Skin acts as a physical barrier against the different types of microbes and is not specific. All other options are different types of immune responses staged by the body against specific microbes.

3.6. Answer: D

We should expect that the cells with the highest potential for activity would require the greatest number of energy-producing organelles. Since muscles are used to produce movement, which requires energy, it is logical to expect the number of mitochondria in muscles to be highest.

3.7. Answer: C

We are given the boiling point of nitrogen, which tells us that nitrogen boil at any temperature above 77 Kelvin. Therefore, the liquid nitrogen in the bottle must be at a temperature below 77 Kelvin. Water freezes below 273 Kelvin and, thus, water vapor around the container freezes.

3.8. Answer: B

The alkane is a heptane because the base molecule has 7 C atoms. A methane molecule is attached to the 2nd position, and an ethane molecule to the 3rd position. Therefore, the alkane is called 3-ethyl-2-methylheptane.

3.9. Answer: B

Statement I is incorrect because at maximum temperature and humidity, fitness of the organism is lowest. Fitness reaches its maximum at intermediate temperatures and humidity.

On the other hand, statement II is correct. An organism's tolerance range for relative humidity is narrower at extreme temperatures than it is at more optimal ones. Therefore, the correct answer is B.

3.10. Answer: C

$$3.00 \times 10^8 \text{ m/s} = 300,000,000 \text{ m/s} = 300,000 \text{ km/s}$$

$$\frac{150,000,000 \text{ km}}{300,000 \frac{\text{km}}{\text{s}}} = 500 \text{ s} = 8 \text{ min } 20 \text{ sec}$$

3.11. Answer: C

Statement I is correct because each frog has a definite optimal range of temperature at which maximum performance can be done. On the curve, the frog could jump about 80 to 90 centimeters between 15 °C and 20 °C. Since 80 to 90 centimeters is the high range of distances jumped by the frog on this curve, 15 °C and 20 °C is the optimal temperature for this frog.

Also, statement II is correct because the shortest distances the frog jumped were at extreme temperatures. Therefore, the correct answer is C.

3.12. Answer: D

The correct answer is D. Ethanol's solubility in water is infinite which means that any amount of ethanol can be dissolved with water. Ethanol can also act as solvent in a solution with water. In a solution with water, ethanol can act both as a solute and as a solvent.

3.13. Answer: B

One-half of the sperm will have a Y chromosome, while the other half will have an X chromosome. All female gametes contain an X chromosome. Thus, the gender is based on the type of sperm that fuse with the ovum. Since there is a 50% chance of getting XX

and a 50% chance of getting XY, the overall chance of getting a female is 50%.

3.14. Answer: A

Statement I is correct. You can see on the graph that the point for rabbit corresponds to approximately 1 ml/g/h on the y axis, which represents amount oxygen consumption.

Statement II is incorrect. Although the total amount of energy needed for maintenance increases with increasing body mass, this is not true per unit body mass. Small animals generally have much higher metabolic rates and hence have greater energy requirements per unit of body weight than do larger animals. For example, shrews have higher metabolic rates per unit body mass than do elephants.

3.15. Answer: C

According to the information, denaturation of proteins is a changing the in their shape, i.e. their structure. Heat is a possible trigger for a denaturing process. Answer C is therefore correct.

3.16. Answer: C

By looking at the x-axis, we see that after 45 minutes, anaerobic metabolism provides the greatest percentage of energy.

3.17. Answer: D

Statement I: It can be seen that the change in position is not the same at all time intervals (in particular, the position changes between 1.2 and 1.4 seconds significantly less than between 1.6 and 1.8 seconds). At a constant speed, the position would always

change by the same value at the same time intervals. Statement I is therefore incorrect.

Statement II: Since the change in position per unit time (the speed) increases with time (as demonstrated by the parabolic curve), the speed is not constant, but increasing, meaning that the object is indeed accelerating. The object is, however, traveling in the negative direction, meaning that the acceleration is negative. Therefore, statement II is wrong.

3.18. Answer: B

Statement I is incorrect. According to the graph, curve Type II is the one that represents a population in which few individuals live to adulthood. Since the shape of curve Type I (convex) is completely opposite the shape of Type III (concave), curve Type I must represent a population in which there is low infant and juvenile mortality (opposite to curve III).

On the other hand, statement II is correct because survivorship is high in the early years but decreases with age. Therefore, curve Type I represents a population in which, like humans, there is low infant and juvenile mortality. Therefore, B is the correct answer.

3.19. Answer: D

Mutualism is a positive reciprocal relationship between two species. Through this relationship both species enhance their survival, growth or fitness. In this example, the bacteria find food and shelter while helping the termite break down the wood material it ingests. Thus, both species have positive (“win/win”) interactions (+/+).

3.20. Answer: A

Statement I: If an object is heated, it expands, increasing in volume, while its mass remains unchanged. This leads to a lower density (the individual molecules have more space available than

before, expressed by the formula: $\rho = \frac{m}{V}$ Statement I is therefore correct.

Statement II: Heating leaves the mass of an object unaffected. Statement II is therefore incorrect.

3.21. Answer: A

As the formula states, high optical power corresponds to a short focal length and vice versa, so graphs should have a negative slope, going from a high D and small f to a small D and large f . Answers B and C can be eliminated. Answer D is incorrect, since this depicts a linear relationship, but the graph of $1/f$ will be hyperbolic.

3.22. Answer: D

An eclipse can occur only if there is an object between the point of view of the observer and the object to be seen, so that this object eclipses (blocks) the view. As there is no object between moon

and sun or between moon and earth, the astronaut would see no eclipse from the moon.

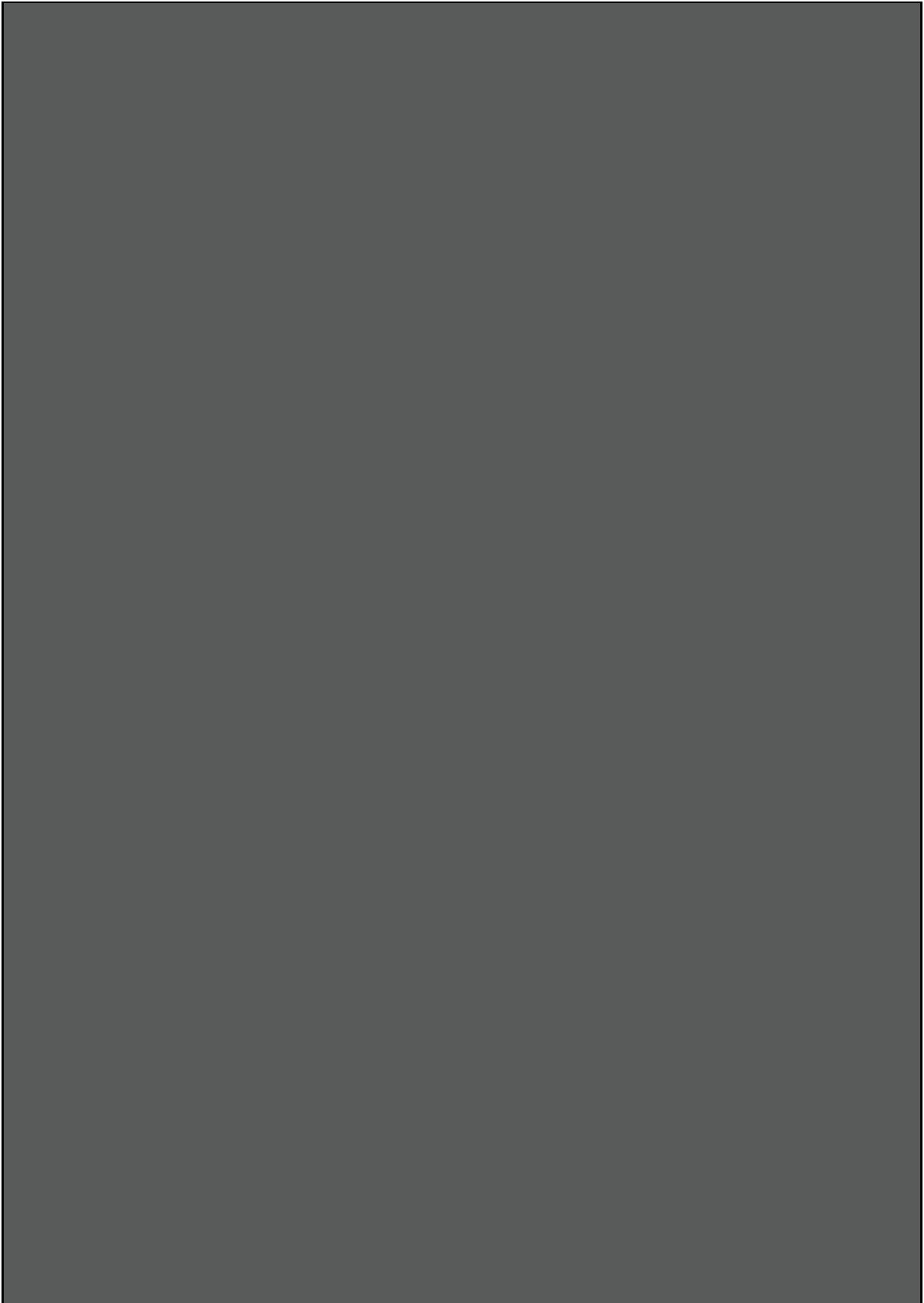
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APPENDIX:
ANSWER SHEETS

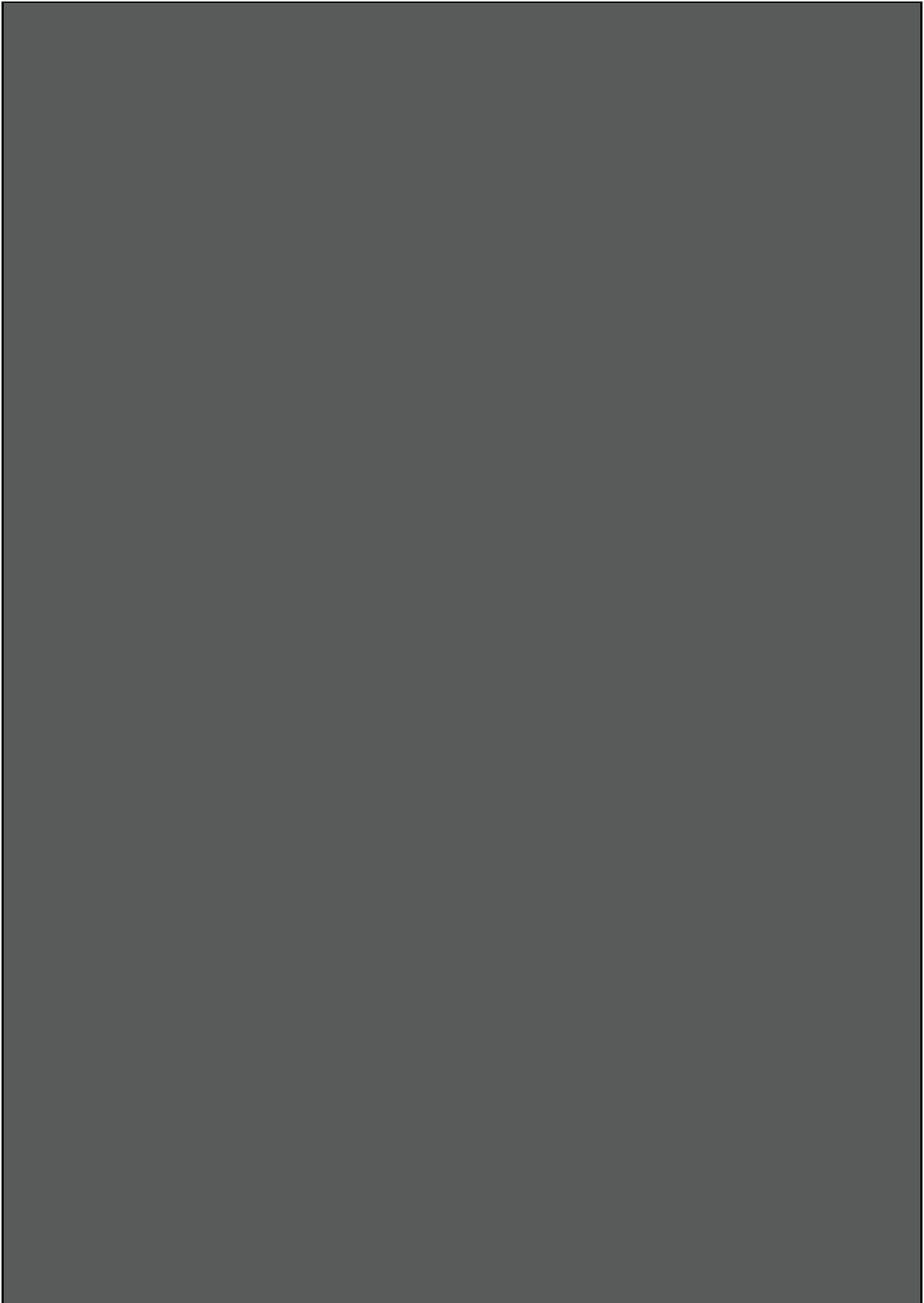
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