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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 ofer 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

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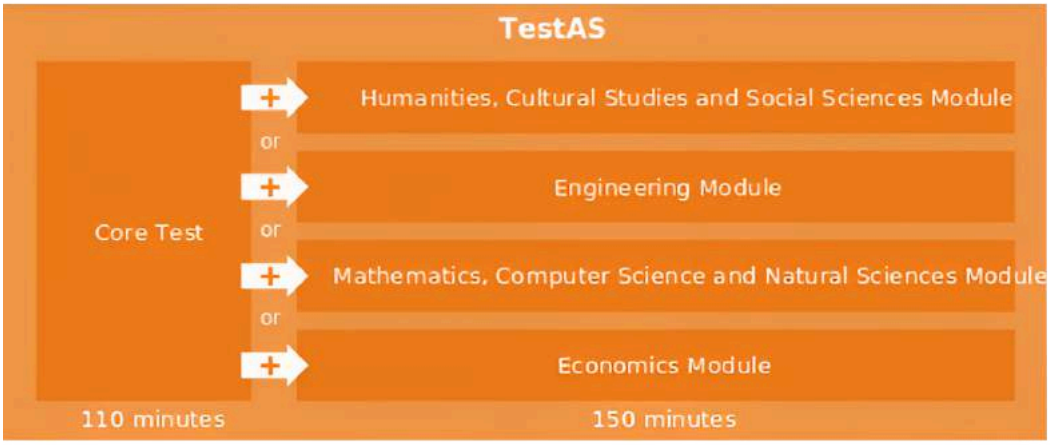
Why should I take TestAS?

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.

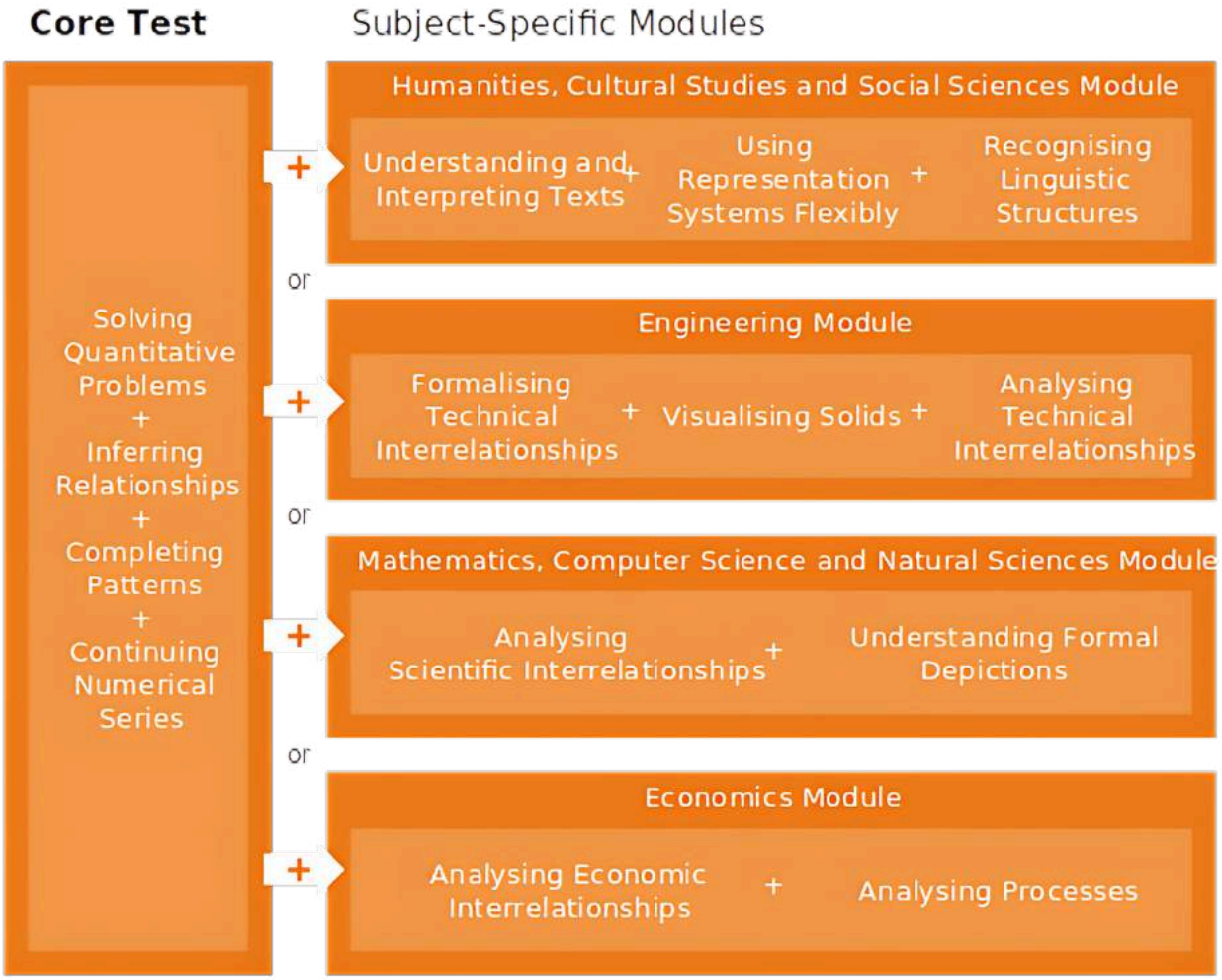
Subsequently you work through the Subject-Specific Module which analyses skills you will need in typical situations in your particular field of study.

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.

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Sample questions

Mathematics, Computer Science and Natural Sciences Module

The Mathematics, Computer Science and Natural Sciences Module is divided in two different subtests. You have a total of 145 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
Analysing Scientific Interrelationships	22	60 minutes
Understanding Formal Depictions	22	85 minutes
Total working time		**145 minutes**

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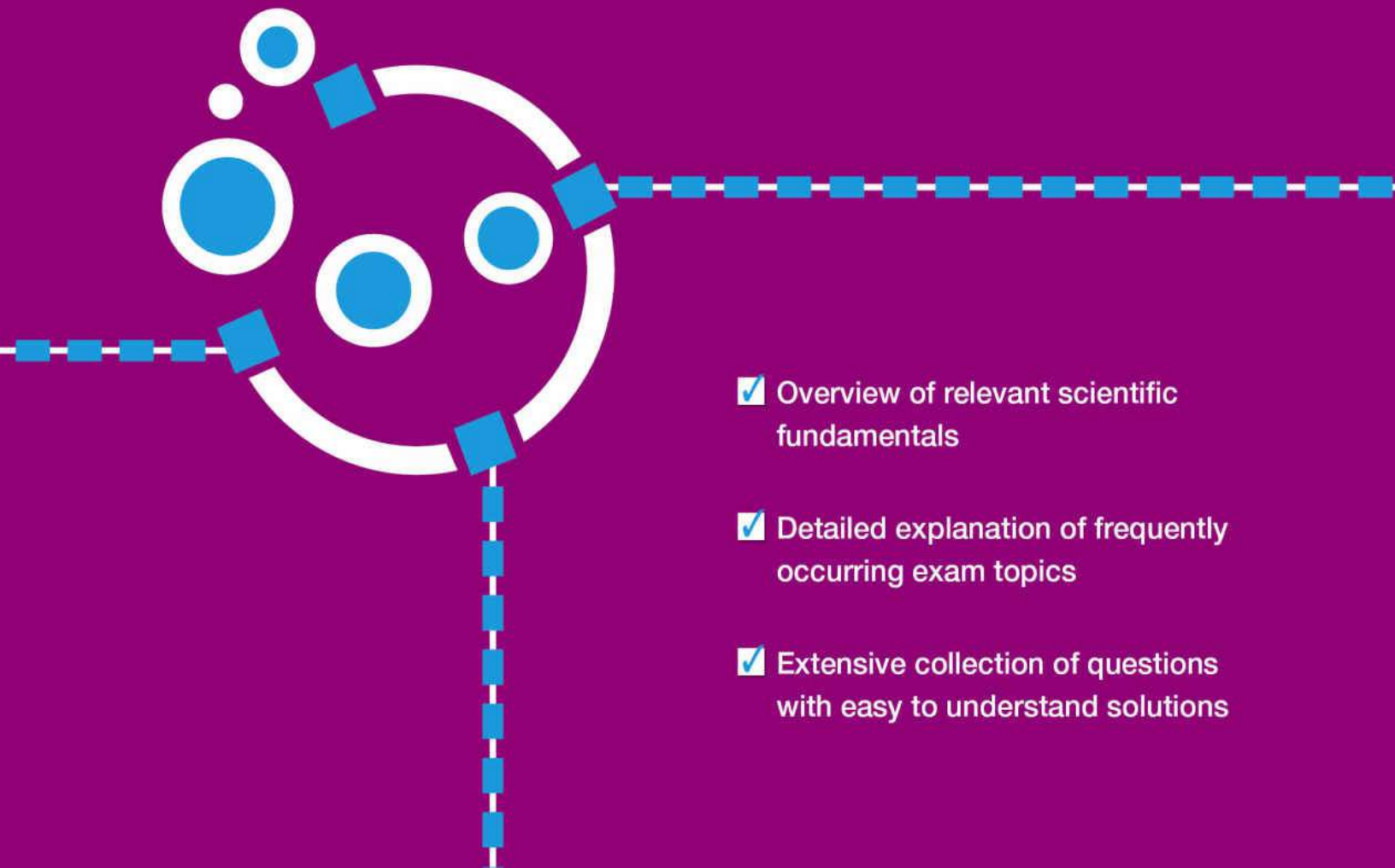
1. Preparation Book for the

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

1. Preparation Book for the TestAS Mathematics, Computer Science and Natural Sciences: Analyzing Scientific Interrelationships

WE ARE ASKING FOR YOUR HELP!

In order to keep our preparation books up to date and to ensure the best possible preparation for the TestAS, we would like to ask for your help. If you have suggestions for improvement (e.g., new questions types not included in our books or other information for more efficient preparation), please send us your feedback by emailing info@edu-link.de with the subject "FEEDBACK." We greatly appreciate your support. Please note our data protection regulations and legal information on page 268 (last page of our e-book).

As a thank you, we send a €25 Amazon voucher each month to the person who sent the most helpful feedback. This promotion runs from September 2020 to June 2021. The deadline is the last day of each month.

Thank you very much!

PREFACE

Attending university in Germany is an appealing option for many students from outside of the European Union. Germany has countless universities, many of which are recognized on an international level for their excellence. According to the 2019 Times World University Ranking, 35 of the world's 300 best universities are in Germany. As such, a Bachelor's or Master's degree from Germany can open the door to a variety of exciting career opportunities, both within Germany and worldwide. The multitude of programs offered in English, as well as the numerous funding options for international students (e.g. ERASMUS), make studying in Germany feasible for students from abroad. What's more, studying in Germany is also quite affordable: Since 2013, most universities have had no tuition fees for non-EU citizens. Therefore, it is no surprise that an ever-rising number of non-EU applicants seek admission to German universities. As a result, the application pool is more competitive than ever, and German universities have raised the difficulty of their admissions criteria for non-EU applicants. But do not despair; the fact that you are reading this book suggests that you are already on track to becoming a more ambitious applicant.

There are certain things applicants can do to increase their chance of admission into German university. One is taking the Test for Foreign Students (TestAS). Over the years, the benefit of preparing for and taking this exam has become clear: applicants with elevated scores are more likely to get accepted into to certain German universities. A higher score can set you apart from other applicants, especially if you are applying to a program related to science, economics, or medicine.

The TestAS is a standardized exam for high-school graduates from countries outside of the European Union who hope to study at a German university. The test is offered by the Society for Academic Study Preparation and Test Development and is

optional to applicants. The TestAS aims to measure cognitive and intellectual capabilities and has been used since 2007 as an aid for the application process to German universities. The test may be taken in German, English, and, in some cases, Arabic.

Competitive scores on the TestAS put applicants at an advantage when applying to certain universities. Participating universities use TestAS scores to evaluate the academic aptitude of potential students. As such, a favorable test score can greatly increase an applicant's chances of being admitted to his/her desired university and course of study. Good scores are also indicative that a student is likely to succeed in his/ her studies.

The TestAS consists of two sections: the core test and a subject module. The core test consists of four subsections and tests general cognitive skills. Every test taker completes the core test. We offer three preparation books for the core test to help you with mastering this test section. In contrast to the core test, test takers choose which subject module to take. There are four options: “Mathematics, Computer Science and Natural Sciences”, “Engineering”, “Economics” or “Humanities, Cultural Studies and Social Sciences”. Applicants should select the subject module most relevant to the degree for which they are applying. This section aims to evaluate their aptitude within this specialized area.

This book explains the subsection “Analyzing Scientific Interrelationships” of the subject module Mathematics, Computer Science and Natural Sciences. Within it, you will find detailed explanations as well as valuable tips for test-taking. Included are three complete practice exams and detailed solutions.

In our book “Preparation Book for the TestAS Core Test: Guideline and Completing Patterns” you will find detailed information about the structure and procedure of the test, as well as the section regarding “Completing Patterns”. In addition, our book “Preparation Book for the TestAS Core Test: Solving Quantitative Problems” provides detailed information about the section

“Solving Quantitative Problems”. Furthermore, our book “Preparation Book for the TestAS Core Test: Inferring Relations and Continuing Numerical Series” can help you prepare yourself for the remaining two sections of the core test.

On our homepage www.testasprep.com you will find our books for the TestAS as an ebook in German and English, as well as lots of useful information about the exam. Our preparatory books are also available in German as printed books on Amazon.

We wish you success during your preparations and on the exam!

Best regards,
Your edulink Team

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

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 identfy 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, particpants 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 effectivly.

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.

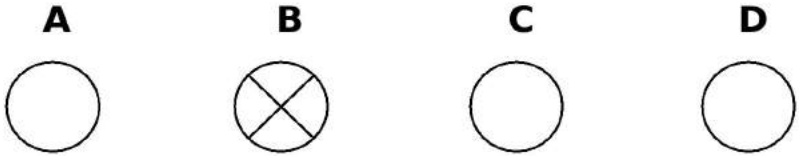
Determine which of the letters (A to D) you have selected the least on your answer sheet so far in that section. This will then be your letter-of-the-day (in past years each of the four answer letters were more or less equally often correct). Use that letter each time you guess (unless you have already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

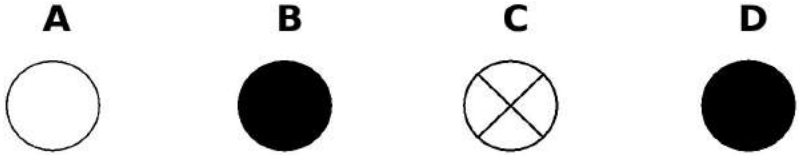
The questions of the core test and the subject-specific test modules are presented in a small exercise book. There is a **separate answer sheet** on which the answers must be marked with a ballpoint pen. Answers marked within the exercise book are not checked.

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.

ANALYZING SCIENTIFIC INTERRELATIONSHIPS

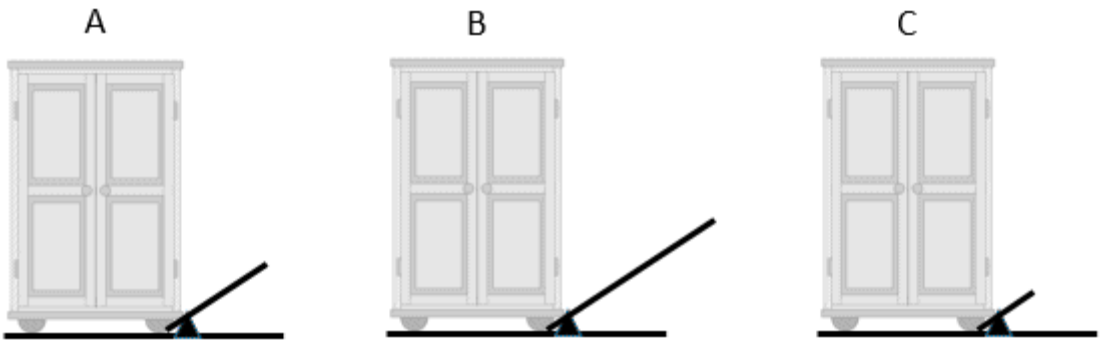
2

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

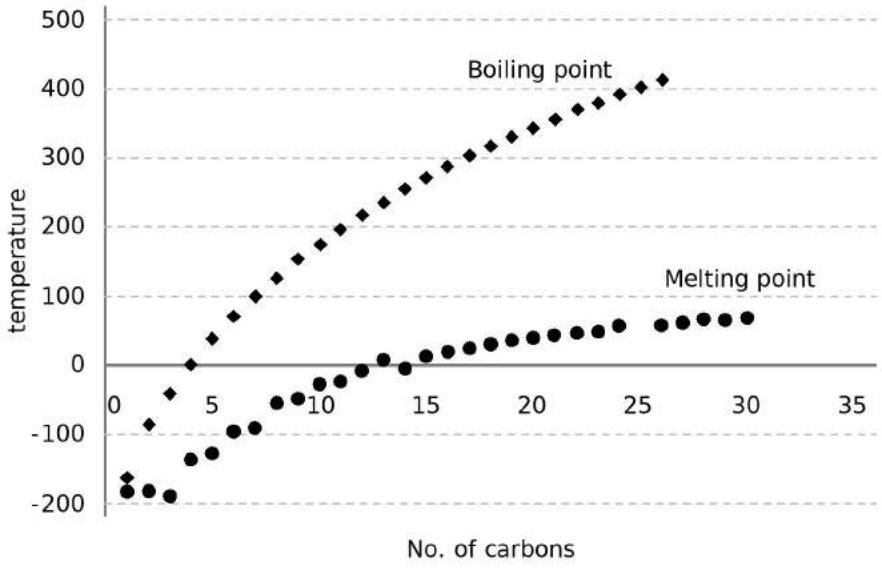
(D) Same force is required for all levers.

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 $30^{o}C$ 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° 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:

$2H_2 + O_2 \rightarrow 2H_2O$

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 ($C_3 H_8$) and oxygen gives CO_2 and water.

$C_3H_8 + \_\_O_2 \rightarrow 3CO_2 + 4H_2O$

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:

$3 \times O_2 + 4 \times O = 10\ O\text{ - atoms} \Rightarrow 5 \times O_2$

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.

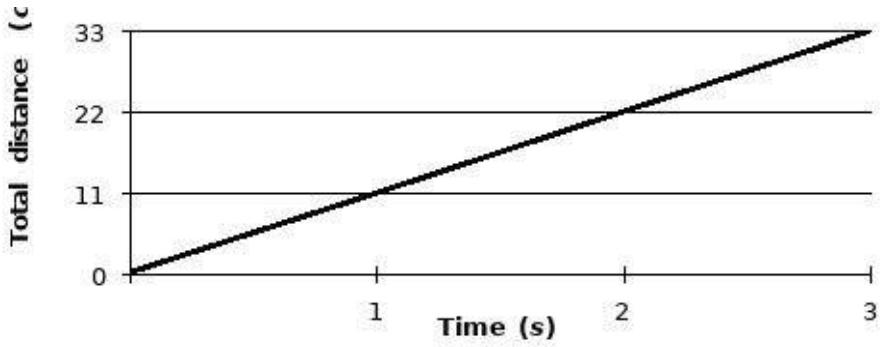
Distance – time graph:
Distance-time graphs are the most common graph used to test subject of kinematics; you need to know how to interpret these graphs. What does the area under the curve mean? What is negative speed? How does constant acceleration affect speed? How do you calculate the distance from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

EXERCISES

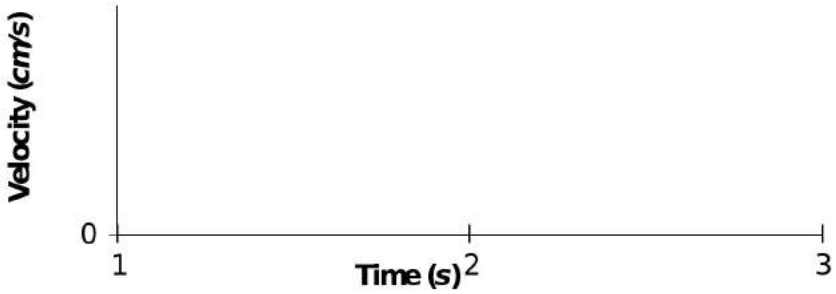
a) This example looks at an object that moves in slow motion.

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).



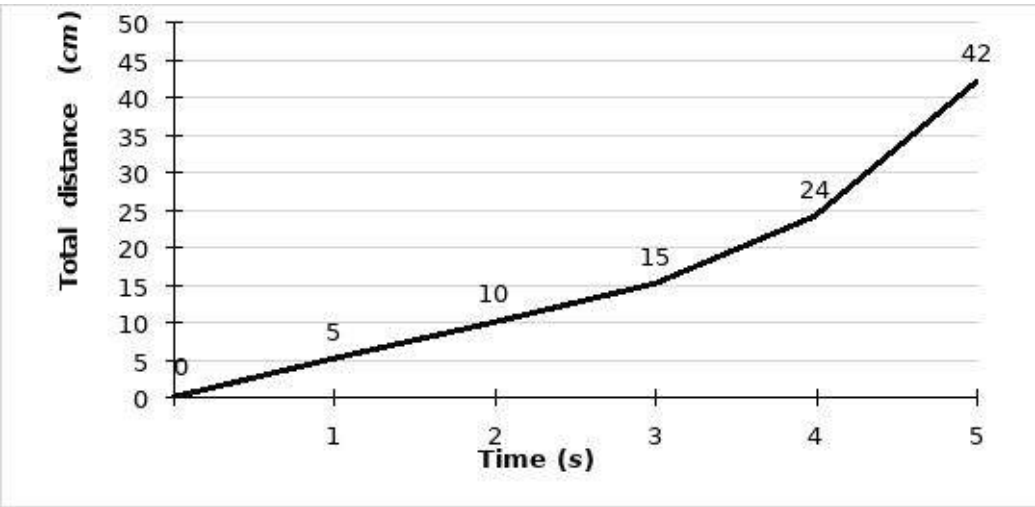
Please draw a graph showing that the object moves at the same rate (velocity) at all times and calculate the acceleration.



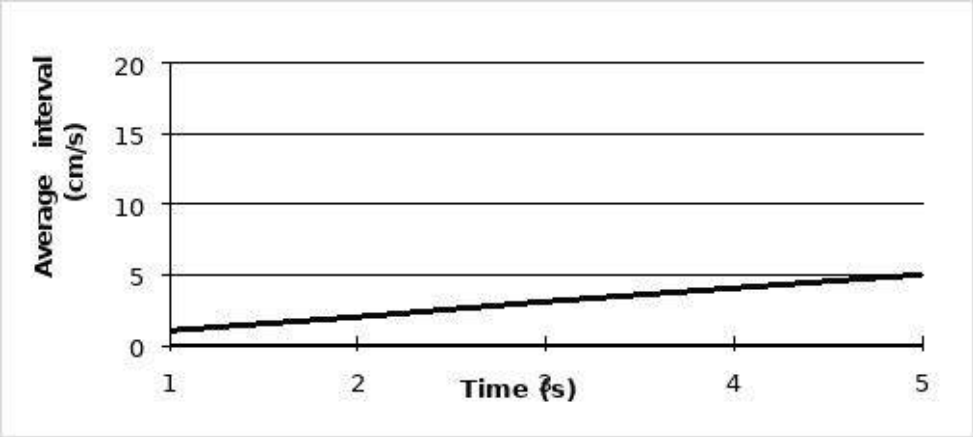
b) This example examines an object that is speeding up.

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.

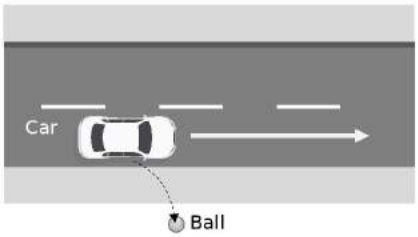
(B) Only statement II is correct.

(C) Both statements are correct.

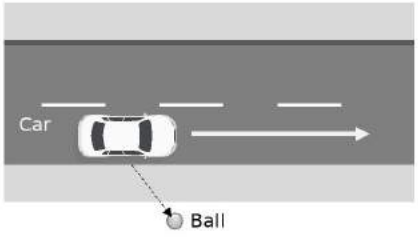
(D) Neither of the two statements is correct.

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.

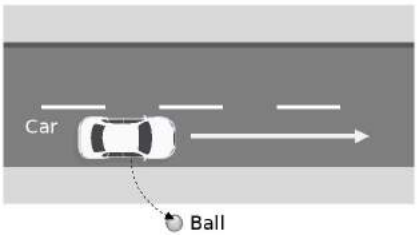
A



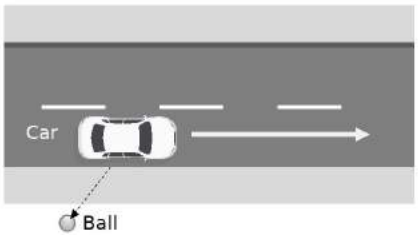
B



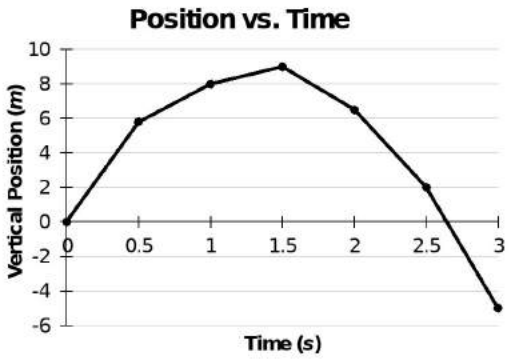
C

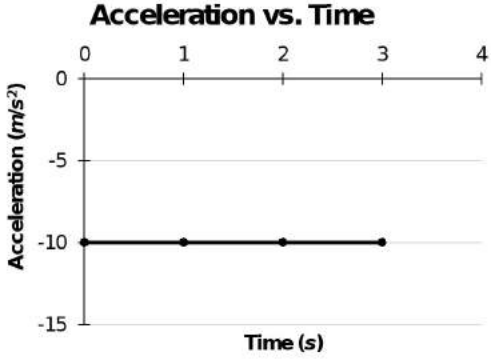


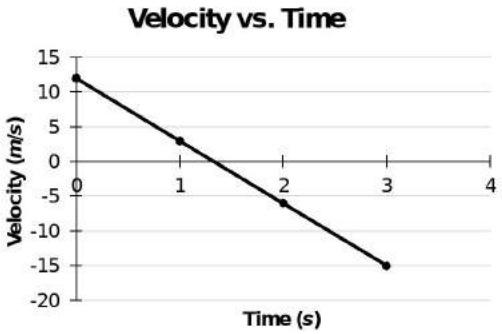
D



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?

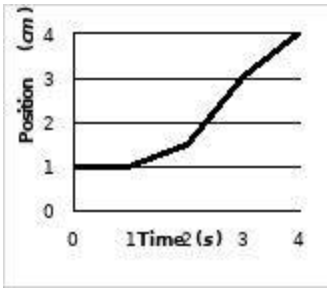
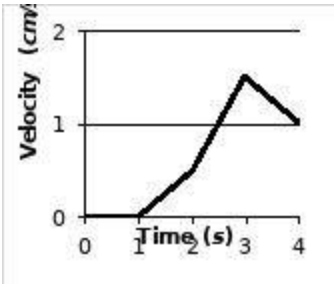
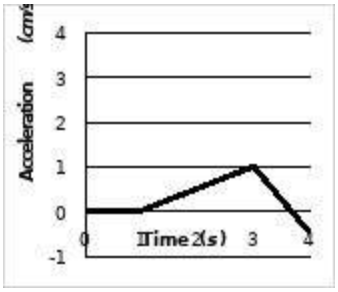
(A) The velocity of the object is constant.

(B) The acceleration of the object is constant.

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

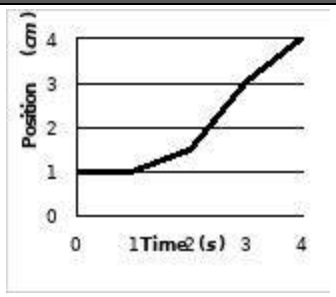
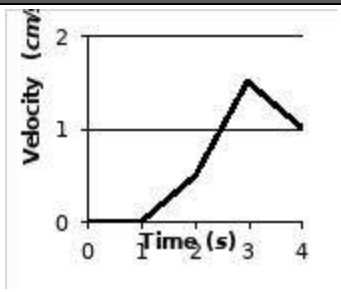
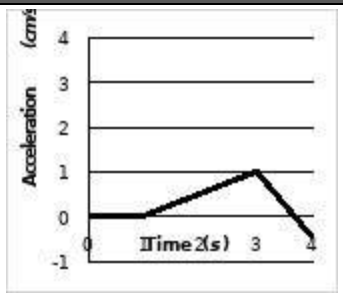
(D) The object lands 5 *m* below the initial starting position.

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?

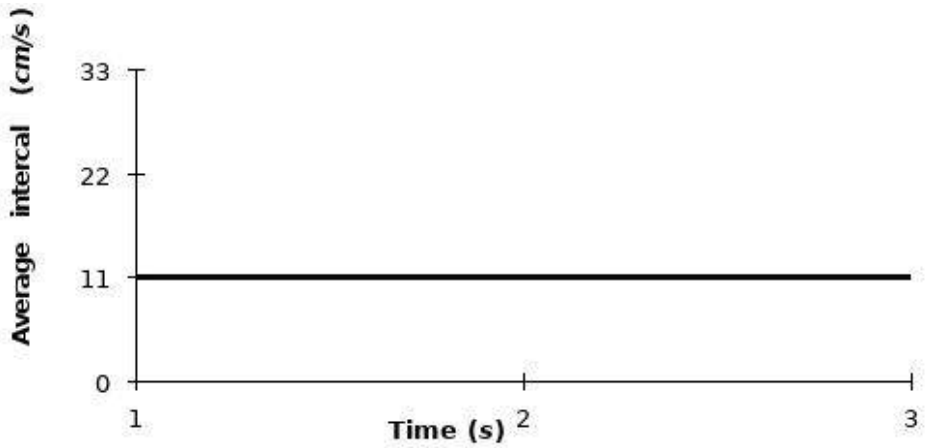
	Position-time graph	Velocity-time graph	Acceleration-time graph
6)	What is the value and meaning of the slope from 2 s to 4 s?	What is the value and meaning of the slope between 2 s and 4 s?	

Please enter your answers on the next page.

	Position-time graph	Velocity-time graph	Acceleration-time graph
			
1)			
2)			
3)			
4)			
5)			
6)			

SOLUTIONS

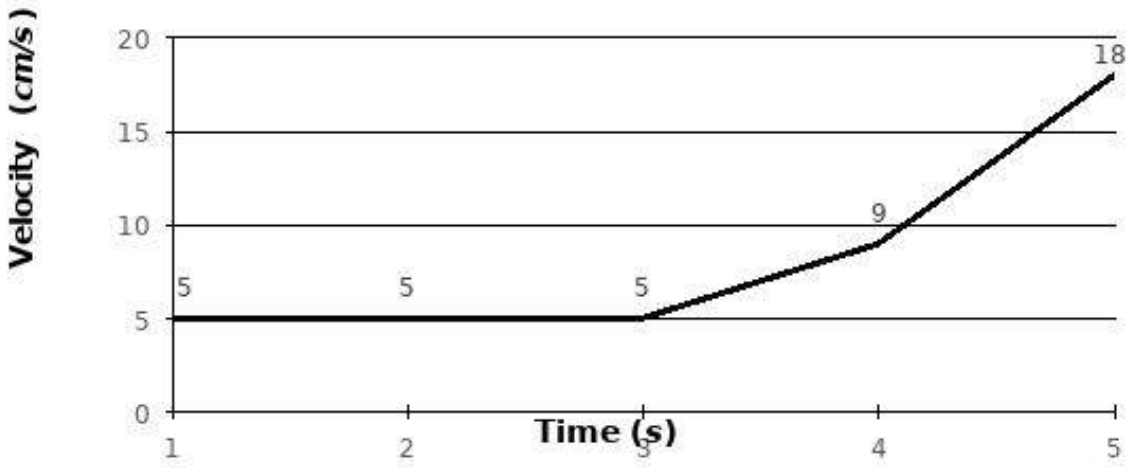
a)



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

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

b)



The slope of the graph is:

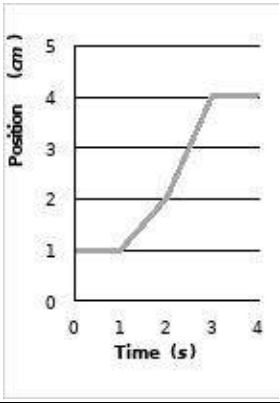
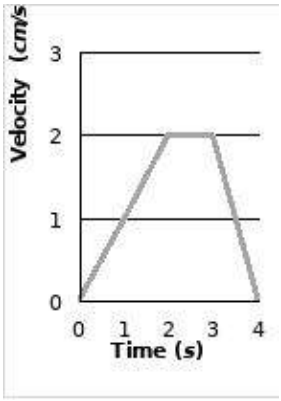
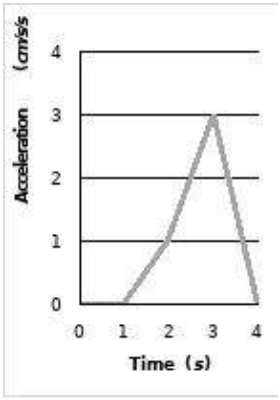
$$a = \frac{\Delta v}{\Delta t} = \frac{5 - 5}{3 - 0} = 0$$ in the first 3 seconds

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

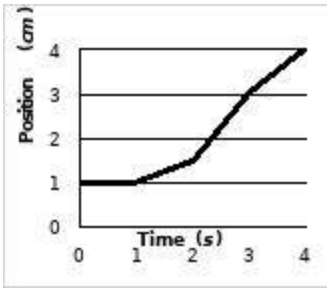
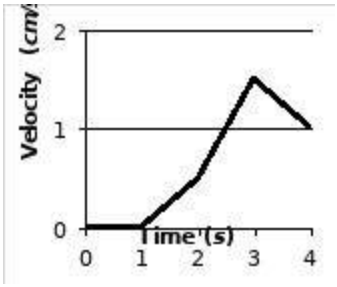
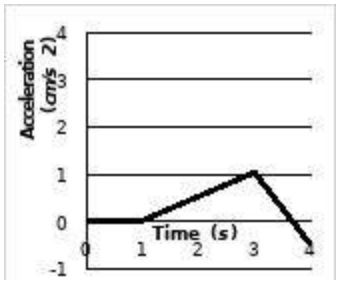
e5)

(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:* $A = \frac{0.5\frac{cm}{s} \times 1\ s}{2}$ $= 0.25\ cm$	*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:* $v = \frac{1cm\ -\ 1\ cm}{1\ s}$ $= 0\ {}^{m}/_{s}$	*The slope is the change in velocity, i.e. it indicates the acceleration. It can be calculated:* $a = \frac{0.5\ \frac{cm}{s}}{1\ s} = 0.5\ {}^{cm}/_{s^2}$	*The area under the graph (the integral of the acceleration) is the change in velocity. It can be calculated:* $A = v = \frac{0.5\ cm/s^2 \times 1\ s}{2}$ $= 0.25\ \frac{cm}{s}$

	Position-time graph	Velocity-time graph	Acceleration-time graph
5)	*The slope is the velocity.* $v = \frac{0{,}5\text{cm}}{1\text{s}} = 0{,}5\ {}^{\text{cm}}/_{\text{s}}$	*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:* $v = \frac{2{,}5\ \text{cm}}{2\text{s}} = 1{,}25\ {}^{\text{cm}}/_{\text{s}}$	*The slope is the acceleration:* $a = \frac{0.5\frac{\text{cm}}{\text{s}}}{2\text{s}} = 0.25\ {}^{\text{cm}}/_{\text{s}^2}$	

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.

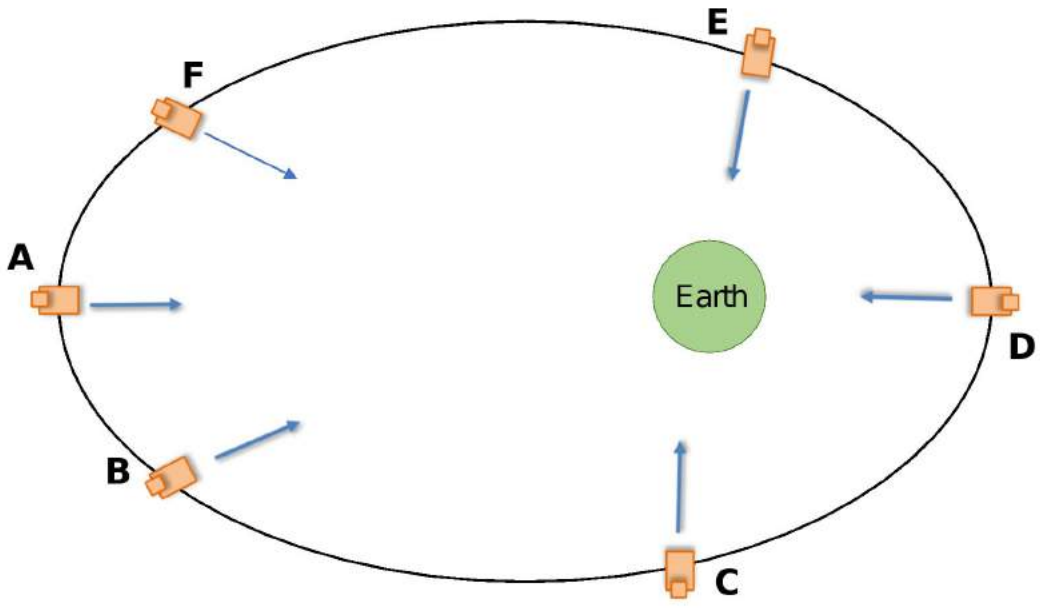
   F = Force on the object
   m = Mass of the obejct
   a = Acceleration
   $F = m \times a$

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).

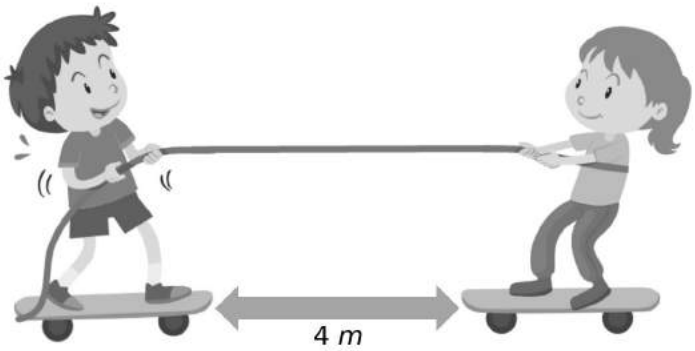
GOOD TO KNOW

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.



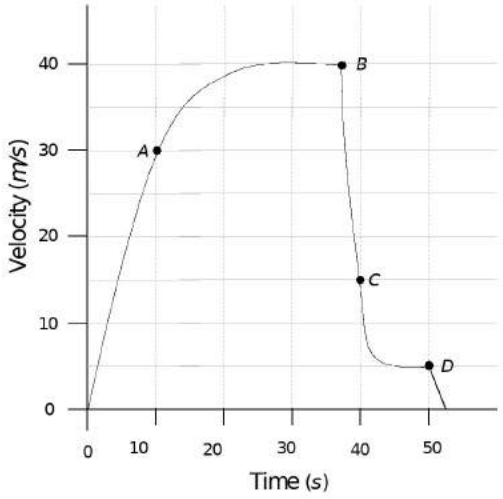
3. Newton’s Law – Tug of war



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 “actio = 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?

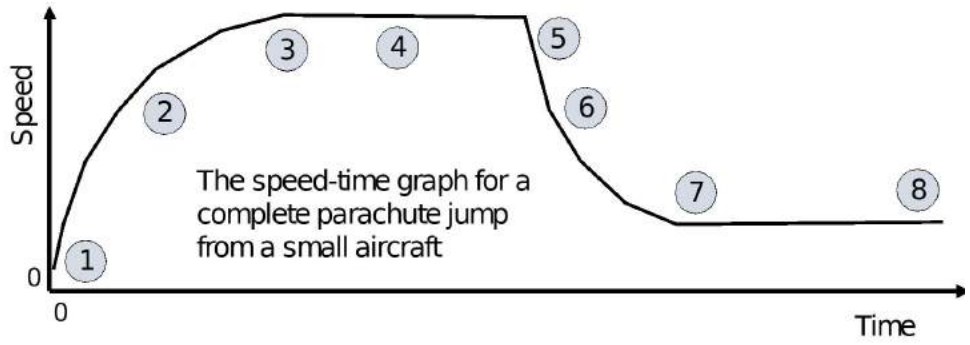
(A) 15 *s*

(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.

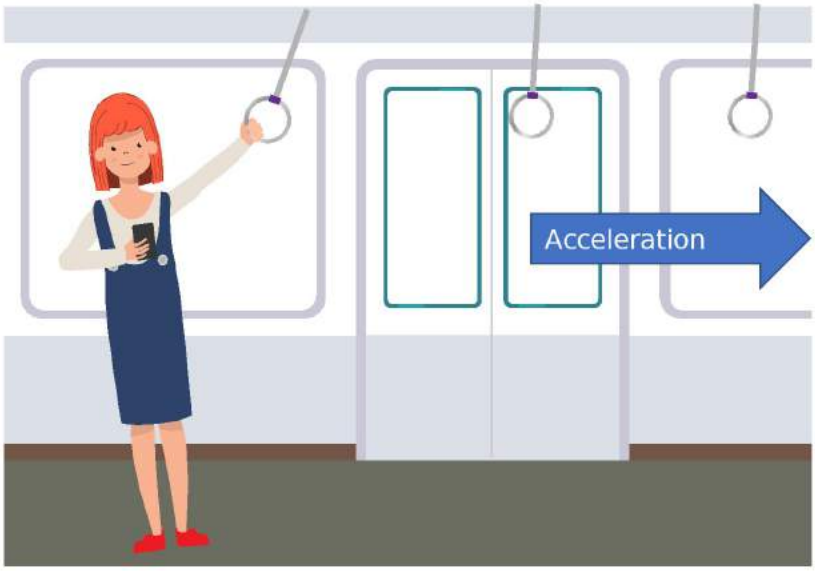
(A) Only statement I is correct.

(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

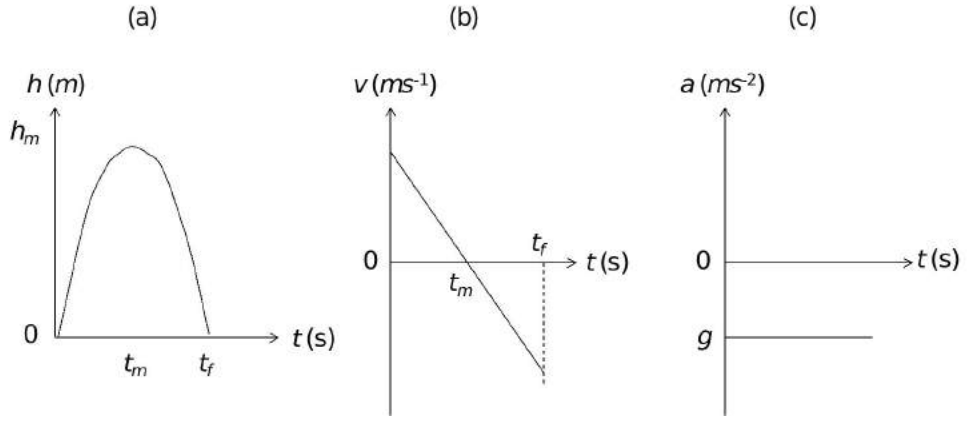
Before breaking, the bus and passengers are moving in exactly the same direction. After braking, the passengers will behave according to the law of inertia, continuing to move forward.

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}. Its value is negative as acceleration due to gravity always acts towards the ground.
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.	

Air drag

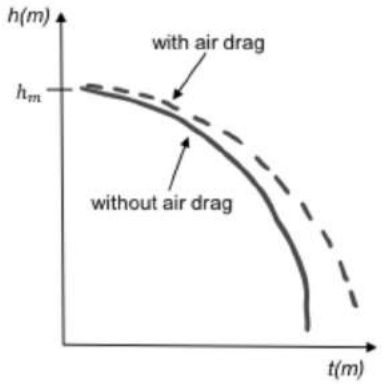
The two main factors that affect the air drag on an object are 1) the speed of the object and 2) the surface area of the object. The greater the speed and surface area of the object, the greater the air drag experienced by that object.

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.

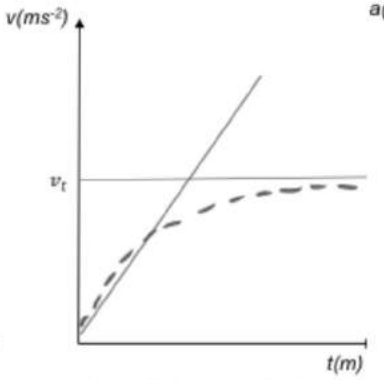
Terminal Velocity

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.

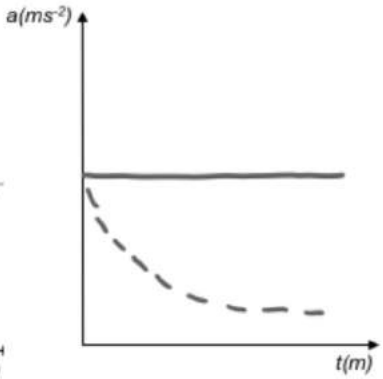
The following graphs show the effects of air drag on the free fall (starting at the height h_m) of a body):



It requires more time for the body to reach the ground when air drag is present.



Without air drag, the velocity increases constantly. When there is air drag, the velocity increases very fast at the beginning of the movement, but then it increases more slowly until it is constant (terminal velocity).



The acceleration without air drag is constant (9.8 m/s^2). With air drag, the acceleration decreases until it is 0 (when reaching the terminal velocity).

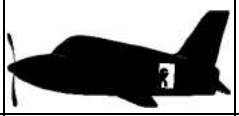
After having reviewed the ideas of gravity, air drag and terminal velocity, we'd like to show you a set of example questions to test your knowledge and understanding on your own.

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 m/s^2	From 9.8 m/s^2	0 m/s^2	-37 m/s^2	From -37 m/s^2 to

		to 0 $\mathrm{m/s^2}$			0 $\mathrm{m/s^2}$
Velocity *v*	0 $\mathrm{m/s}$	From 0 $\mathrm{m/s}$ to 50 $\mathrm{m/s}$	50 $\mathrm{m/s}$	30 $\mathrm{m/s}$	10 $\mathrm{m/s}$

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.

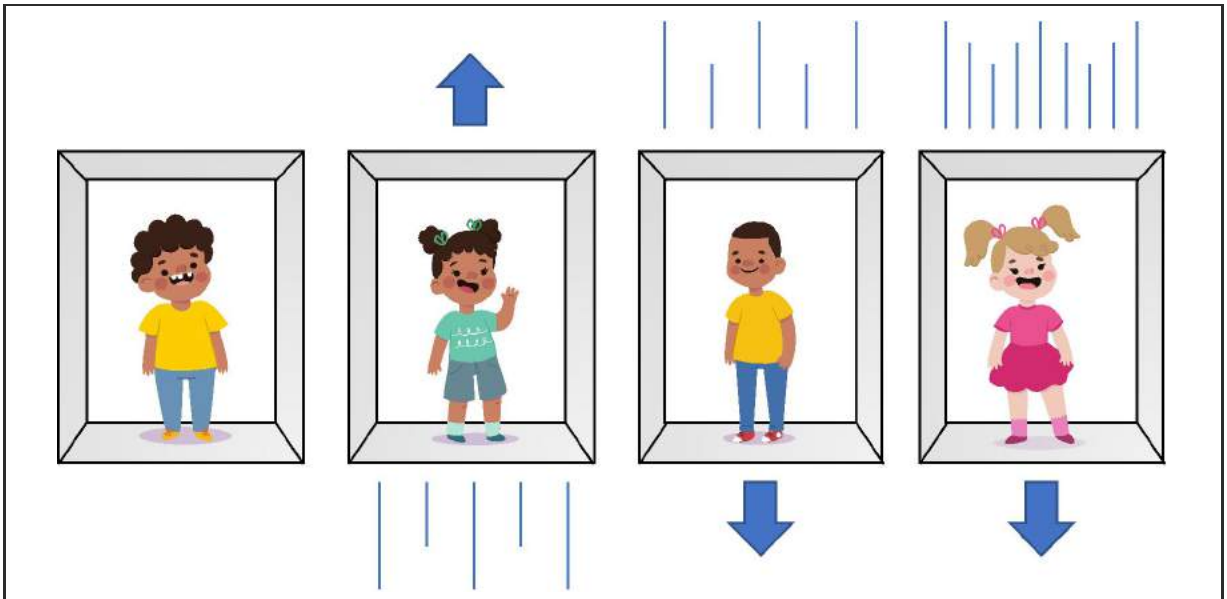
(C) Statements I and II are correct.

(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 kg $\times$ *9.8 m/s^2 = 600 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	Elevator going up	Elevator going down	Elevator falling down
Apparent weight = Normal weight Acceleration: $0\ \mathrm{m/s^2}$	Apparent weight > Normal weight Acceleration: $50\ \mathrm{m/s^2}$	Apparent weight < Normal weight Acceleration: $5\ \mathrm{m/s^2}$	Apparent weight = 0 Acceleration: $9.8\ \mathrm{m/s^2}$

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.

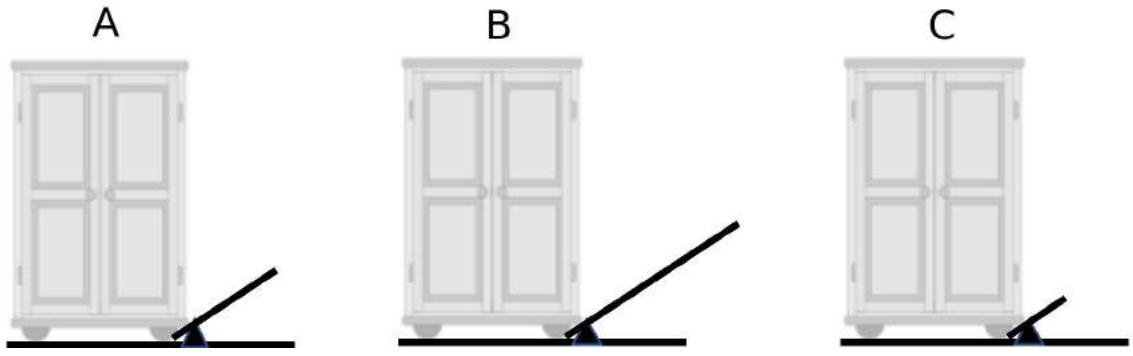
(A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

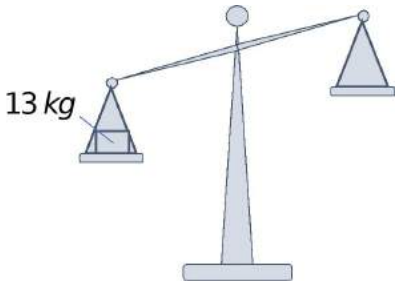
b) Which lever would require the greatest force to elevate the cupboard?



(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.

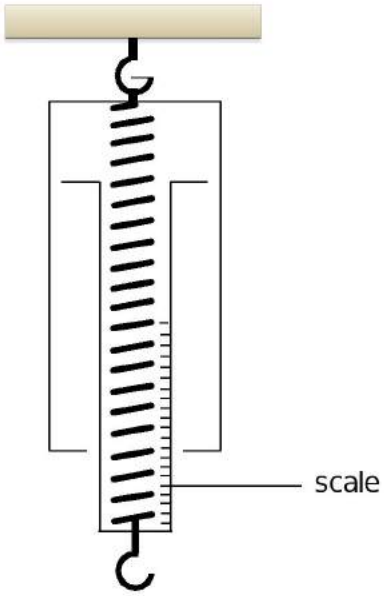
c) Answer: C

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.



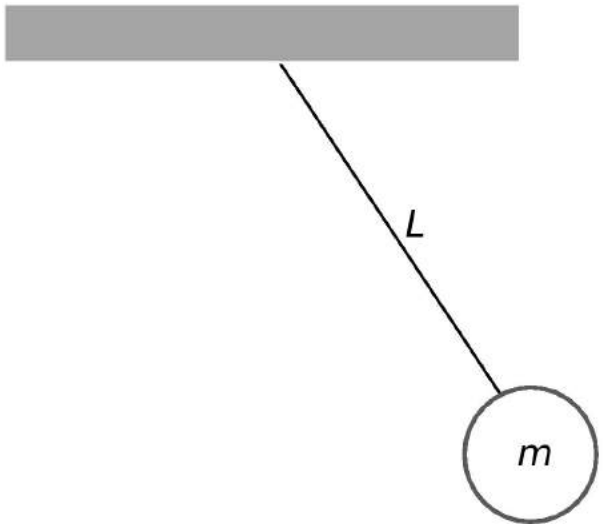
When reading the result, always look out for the unit on the printed scale. Different printed scales can be in different units, which means that even when the length of two scales is the same, the two devices may be indicating different values.

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.

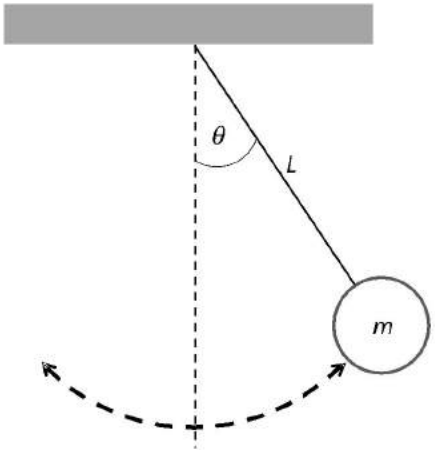
SIMPLE PENDELULUM

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)?

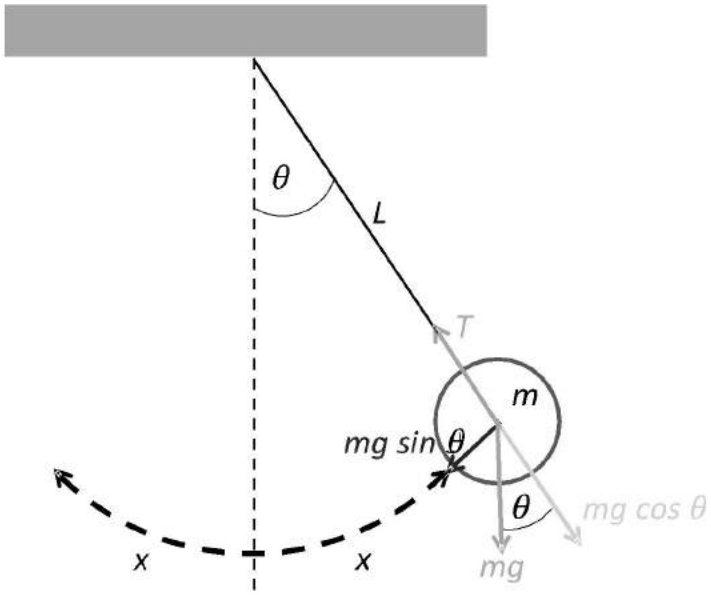
A simple pendulum consists of a small mass *m* otherwise known as bob which is hung on a light and non-elastic string (thread) of length *L* attached to a fixed and rigid support as in the figure below.



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:

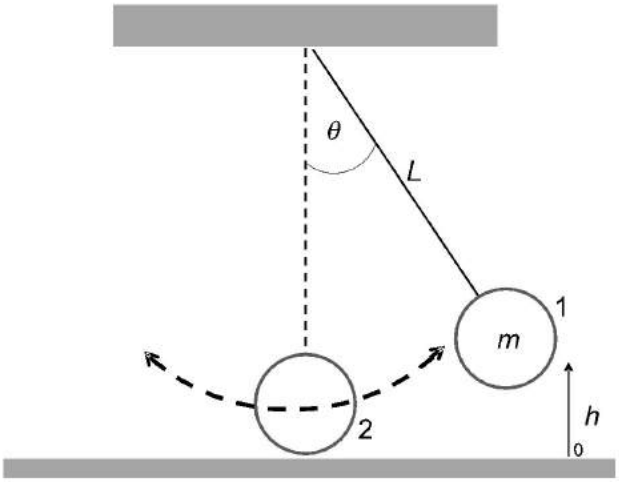
1. A pendulum with a shorter string (L is small) has a smaller period of oscillation (a smaller numerator decreases the value of fraction). This means the bob in these conditions swings faster than if the pendulum had a longer string.

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:

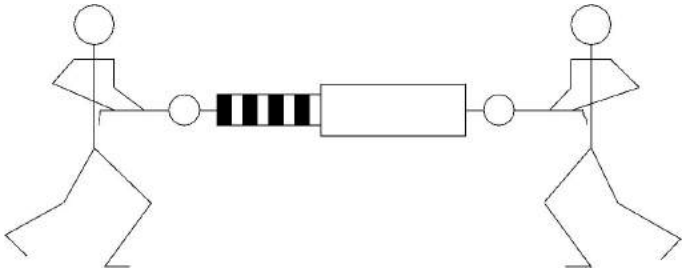
$$v = \sqrt{2gL(1 - \cos\theta)}$$

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.

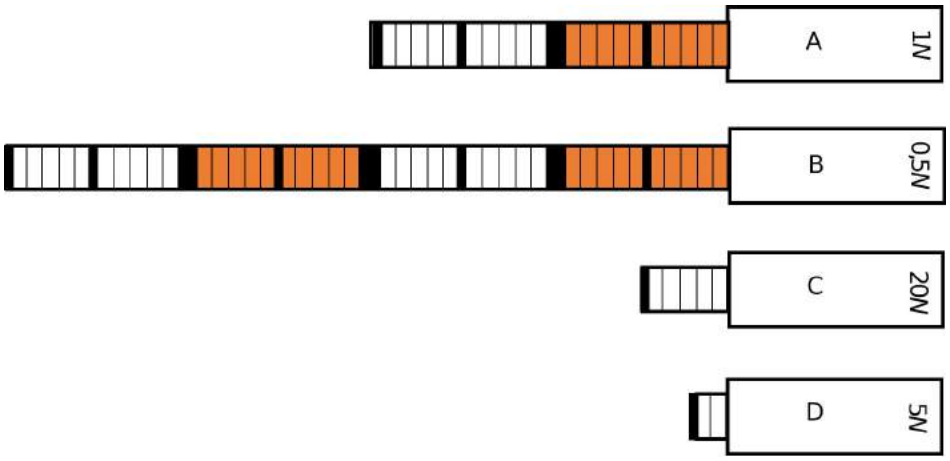
(A) Only Statement I is correct.

(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.

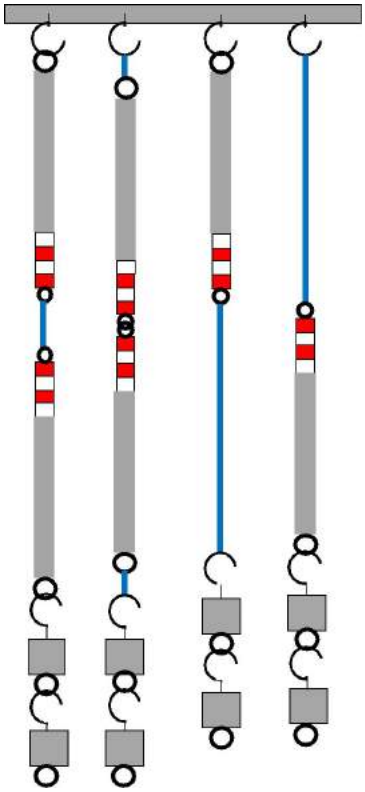
(A) Only Statement I is correct.

(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.

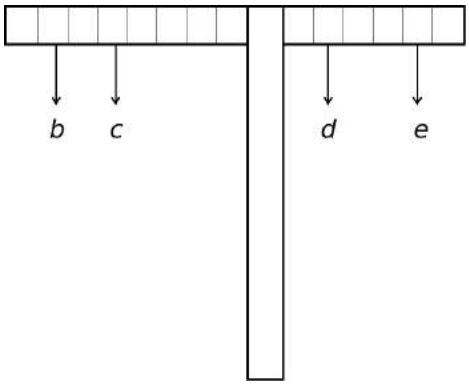
(A) Only Statement I is correct.

(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.

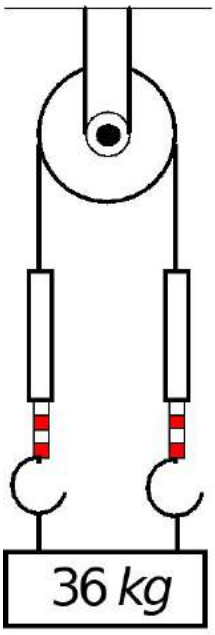
II. If all four weights weigh the same and are attached to the scale, the left-hand side of the scale will move upwards.

(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.

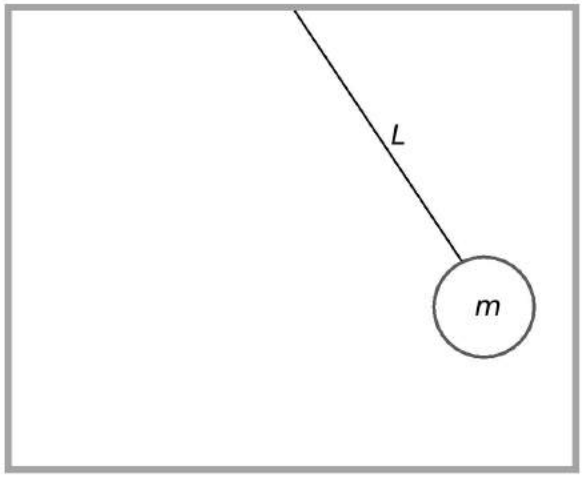
(A) Only I

(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?

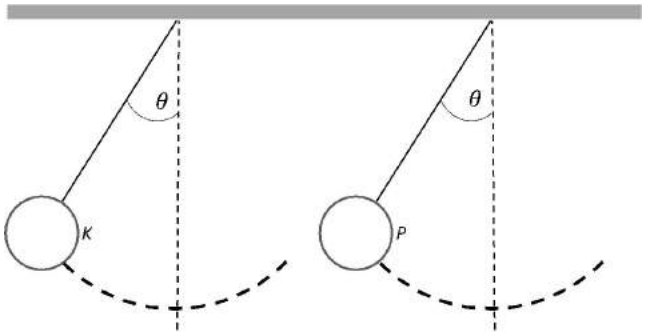
(A) Decreasing *L*

(B) Increasing *m*

(C) Pushing the bob down

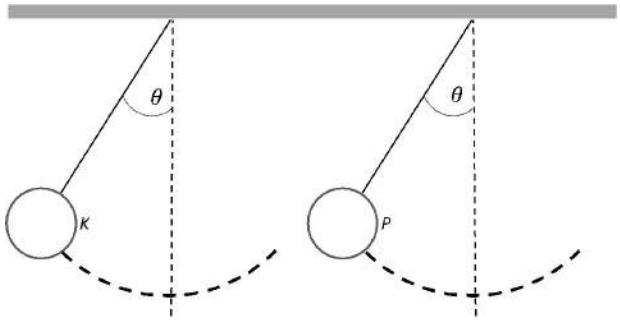
(D) Moving the bob to the right at a constant speed

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

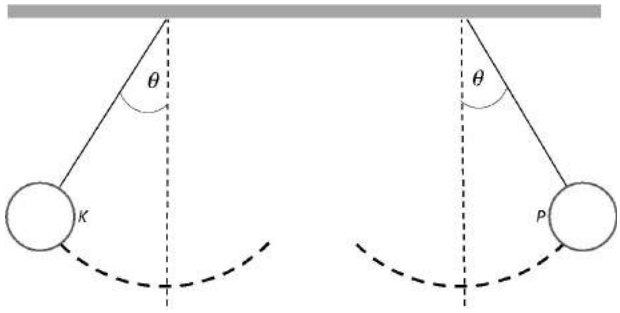


If they are released from the rest at the positions shown in the figure, what will their position be after 6 *s*?

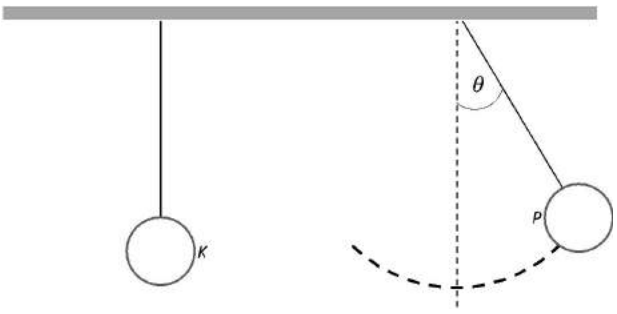
(A)



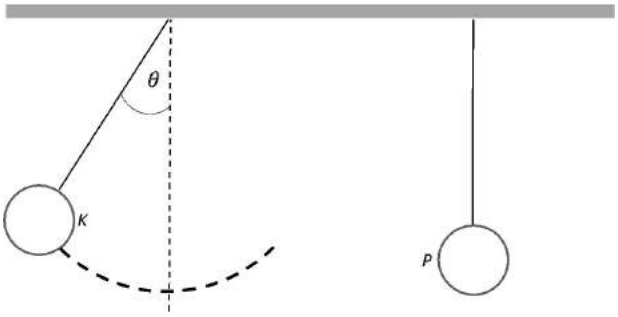
(B)



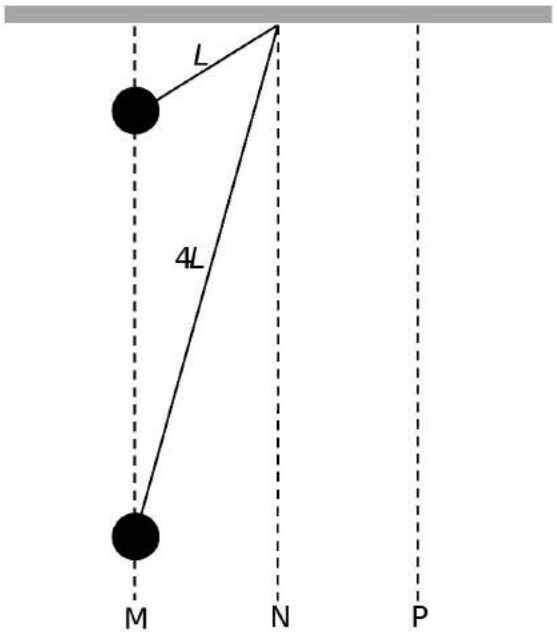
(C)



(D)



i) The pendulums with lengths *L* and 4*L* 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 × 20 N = 2 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 × 1 N = 0.4 N.

Scale B: 8/10 × 0.5 N = 0.4 N.

Scale D: 2/15 × 1/10 × 5 N = 0.2 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:

Force$_1$ × distance$_1$ from pivot = force$_2$ × distance$_2$ 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
$F_1d_b + F_1d_c = F_1d_d + F_1d_e$.

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

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 N (45 N × 8 = 360 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:

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

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

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 $^\circ\mathrm{C}$ $(1\ ^\circ\mathrm{C} = 1\ \mathrm{K} - 273.15)$

Degrees Fahrenheit F (

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

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: $\varrho = \frac{m}{V}$. 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:

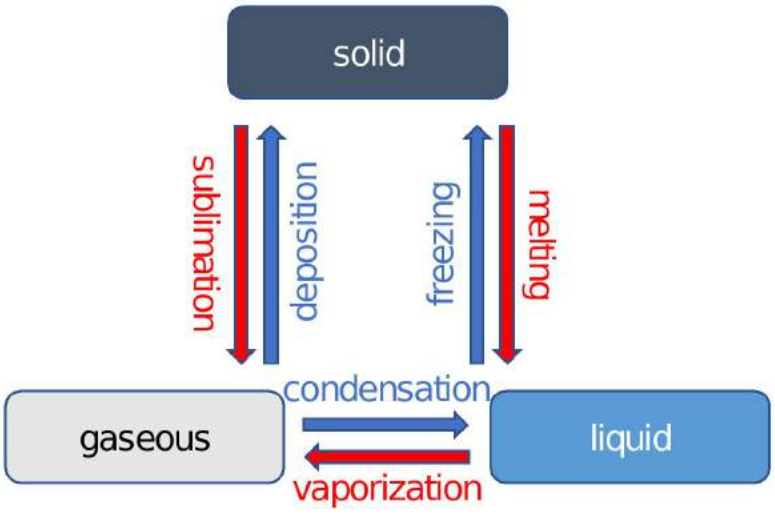
Heat can never pass from a system of lower temperature to a system of higher temperature by itself. Rather, heat can only be transferred from the higher temperature system to a lower temperature system.

3. Principle:

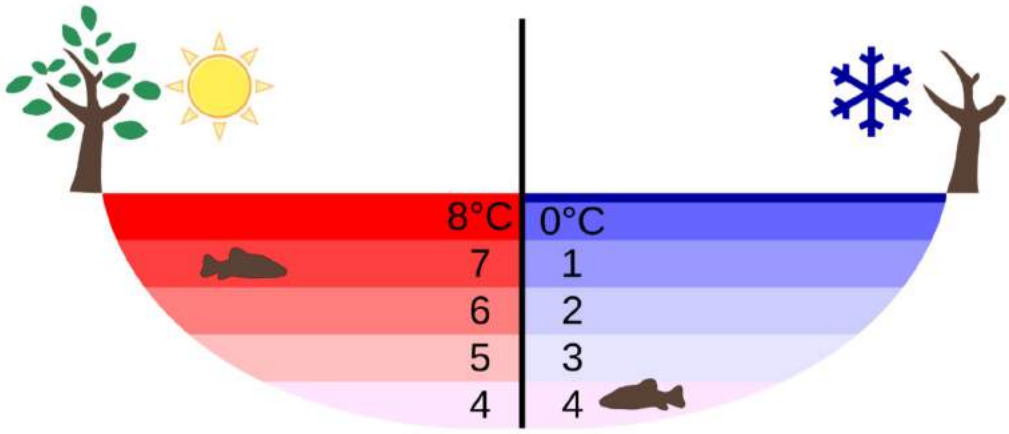
There is an absolute temperature zero, which can never actually be reached.

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 $pV = Nk_BT$

  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* $R = 8.314\,\mathrm{Jmol^{-1}K^{-1}}$, or the amount of particles N and the *Boltzmann constant* $k_B = 1.380 \times 10^{-23}\,\mathrm{JK^{-1}}$.

le’s Law: $p_1V_1 = p_2V_2$ for $T = \text{const.}$

$T_2V_1 = T_1V_2$ for $p = \text{const.}$

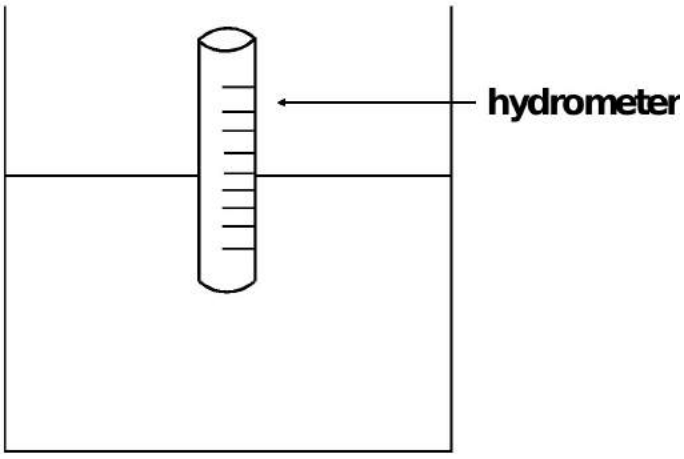
In word form: the lower the pressure of a gas, the greater its volume and vice versa, provided the temperature is constant. At constant pressure, the smaller the temperature, the smaller the volume and vice versa.

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 1 $\frac{1}{2}\rho v^2$ 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.

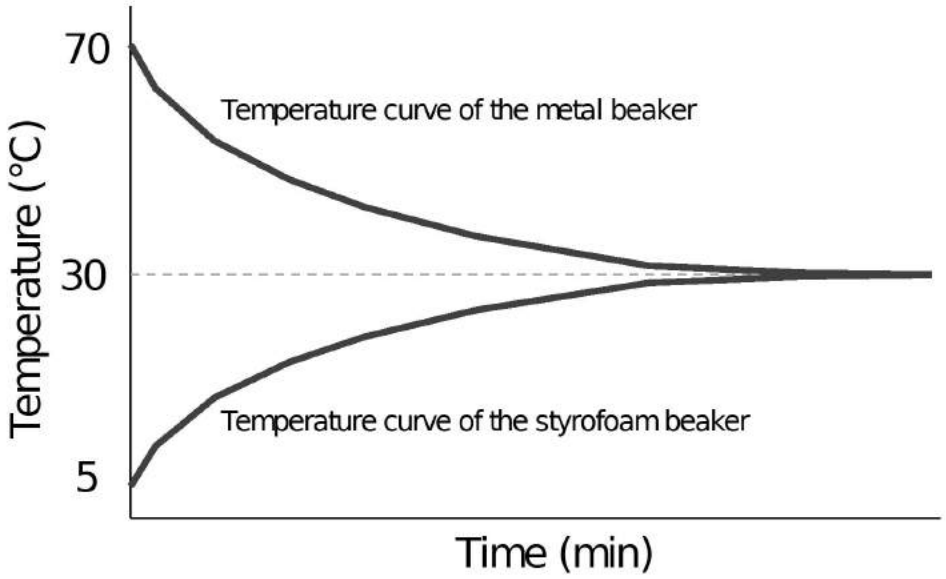
(A) Only statement I is correct.

(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:


70
30
5
Temperature (°C)
Temperature curve of the metal beaker
Temperature curve of the styrofoam beaker
Time (min)

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.

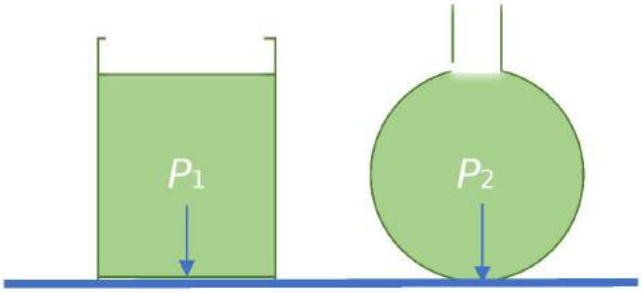
(A) Only statement I is correct.

(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?

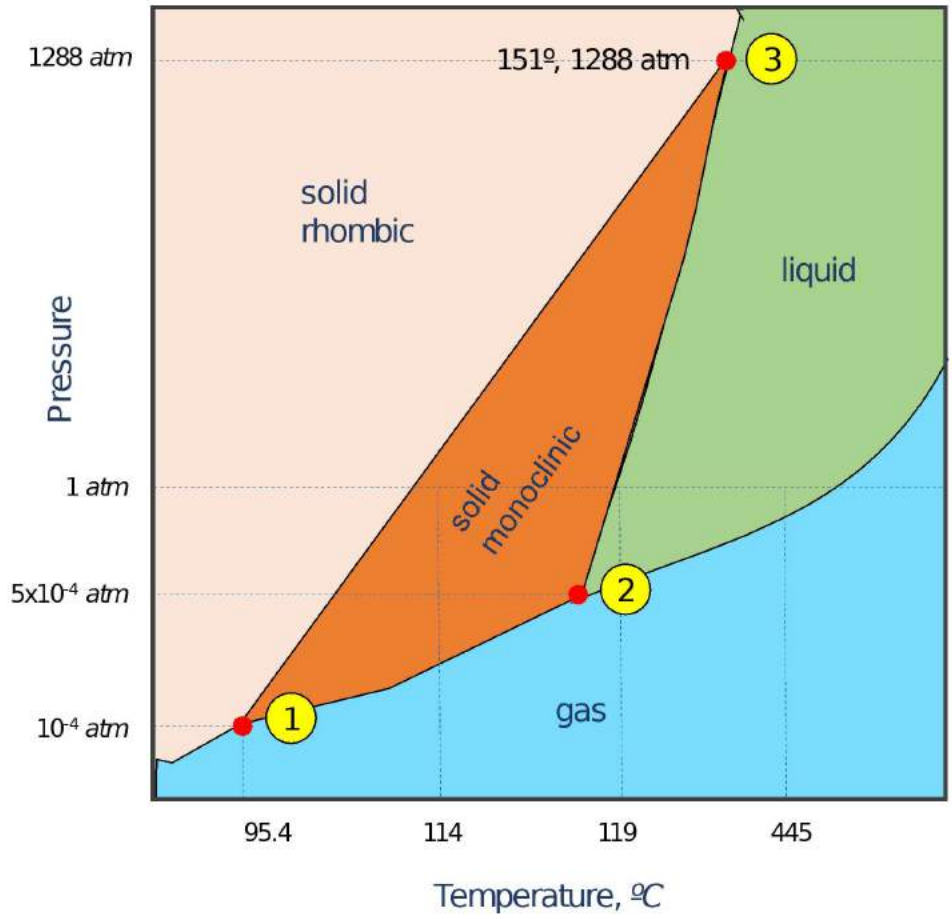
(A) The big candle goes out first.

(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

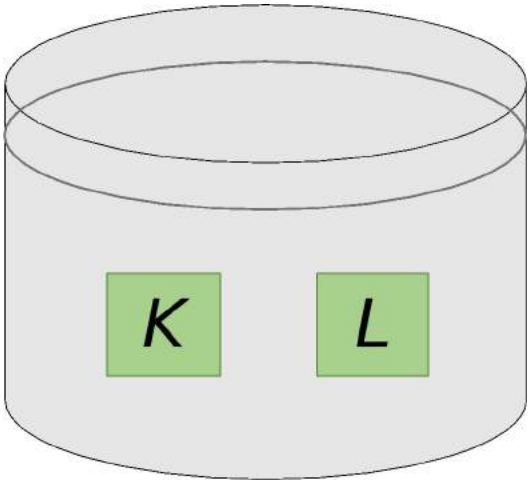
(A) 113 °*C*

(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) $a_K > a_L > a_W$

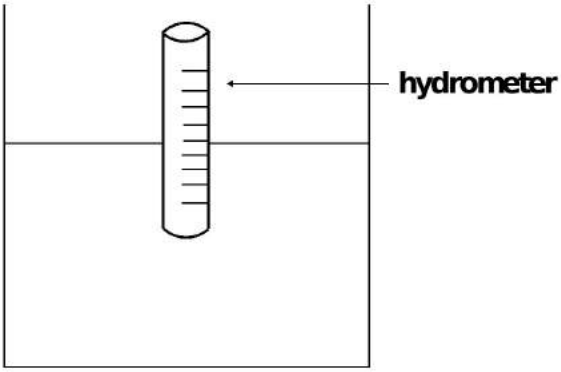
(B) $a_K = a_L = a_W$

(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: $P = \varrho \times g \times h$*. 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

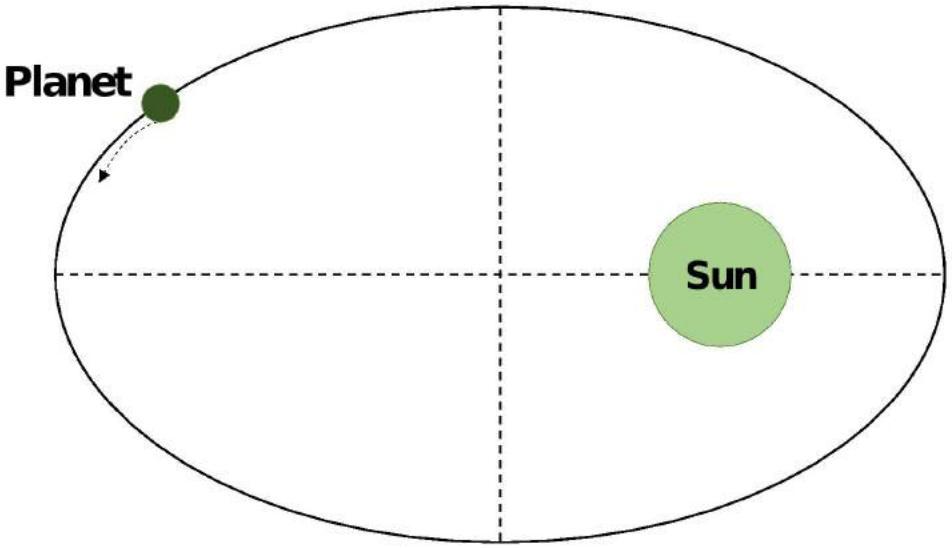
You read density from top to bottom on a hydrometer. If the liquid has a low density, the hydrometer immerses deeper in the liquid and a lower value is read. If the density is higher, the hydrometer is not immersed as deeply and a larger value is read.

ASTRONOMY

KEPLER'S LAW

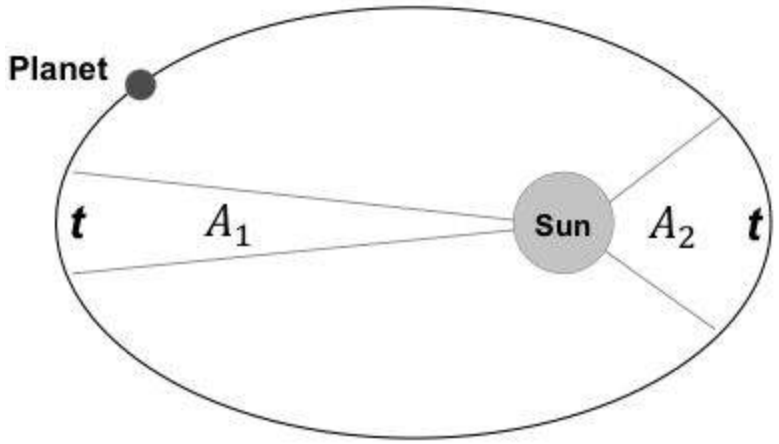
Johannes Kepler, who lived from 1571 to 1630, discovered the laws according to which planets move around the sun. They are called "Kepler's laws" in his recognition. Regarding these laws, the TestAS exam does not ask for or expect memorization of formulas, but it is helpful to be familiar with the laws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



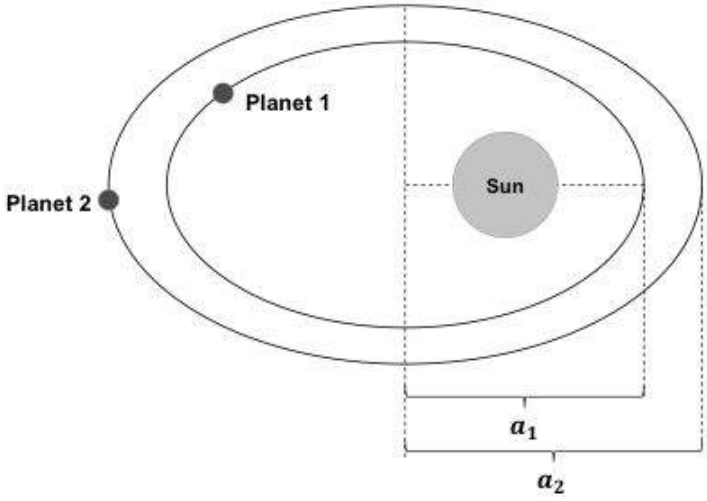
2. **Kepler's law of equal areas:** If a line is drawn from the sun to a planet, the area swept out by the planet's movement will always be the same over an equal amount of time, regardless of where in orbit a planet is. This means that the planet moves at different speeds throughout the orbit, moving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

N

W

E

S

N

Object

Sun

Shadow

W

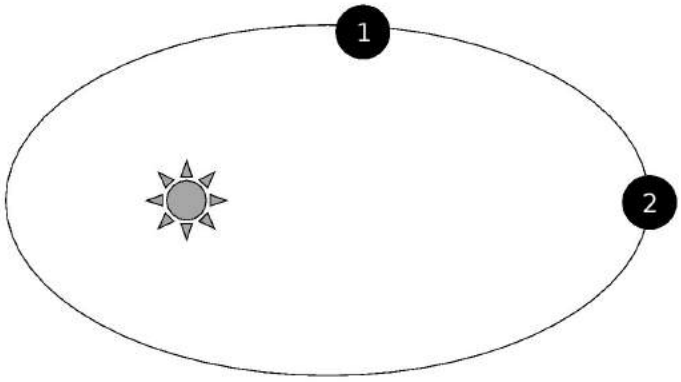
E

S

**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

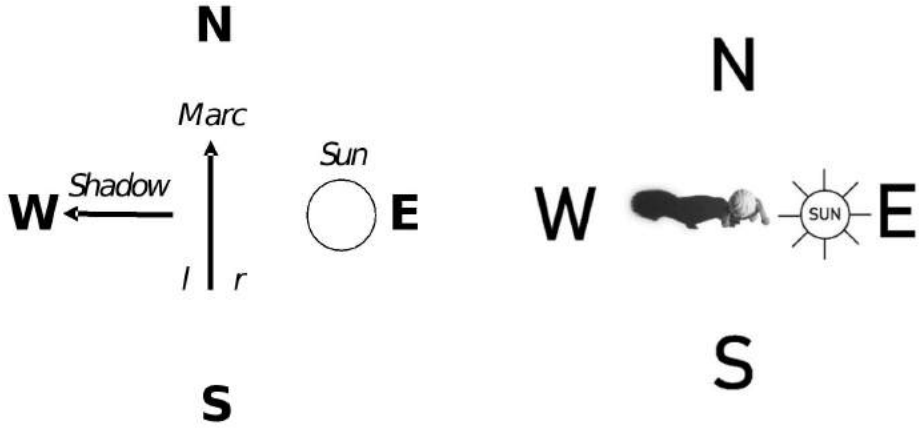
a) Answer: C

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 plant 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.

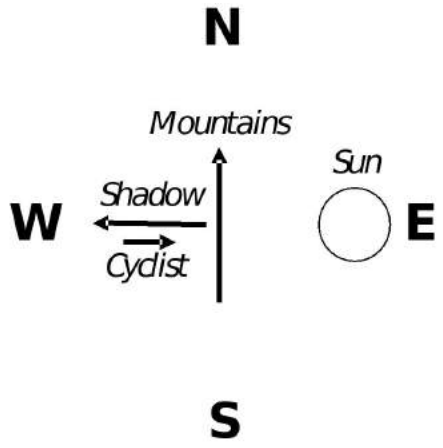
b) Answer: A

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.



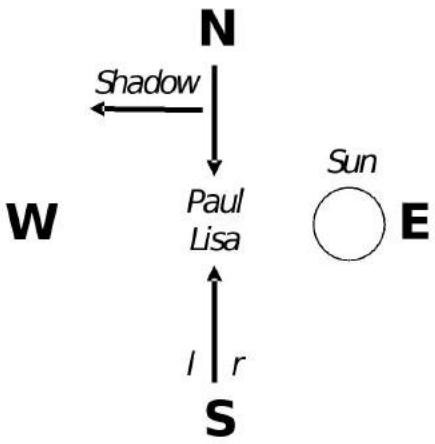
c) Answer: C

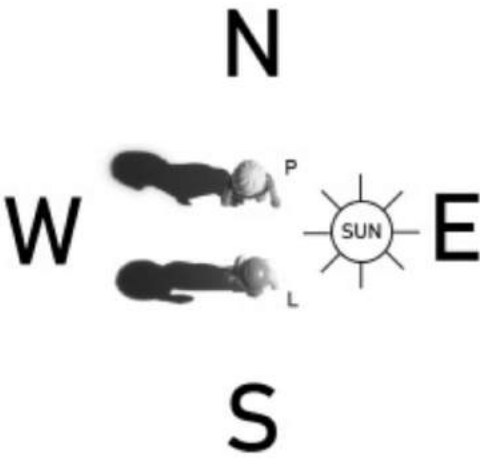
In the morning the sun rises in the east. So, the shadow falls towards the west. As the cyclist can see the shadow, he is riding towards the east. Seeing the shadow means he must be on the same side of the mountain as the shadow itself is.



d) Answer: C

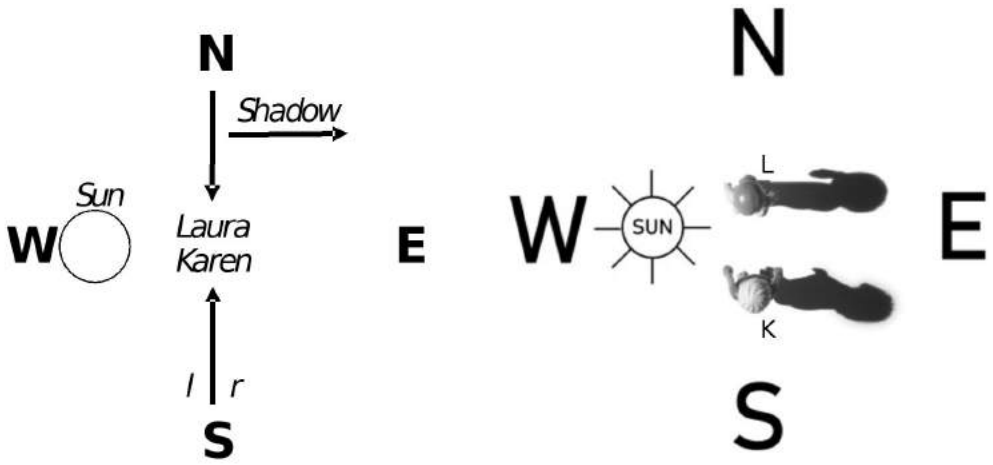
In the morning, the sun rises in the east. So, in the morning, shadows fall towards the west. Paul's shadow falls to Lisa's left. Hence Lisa is facing North.





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.

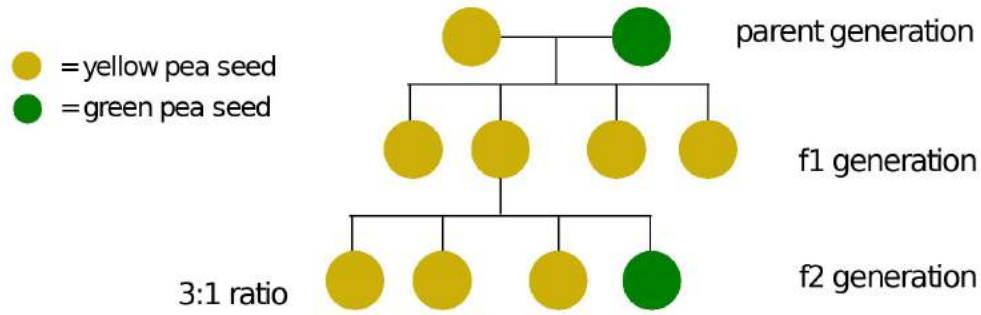
Based on these observations, whenever dominant and recessive allele are combined, it is the dominant allele that will be

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 0 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.

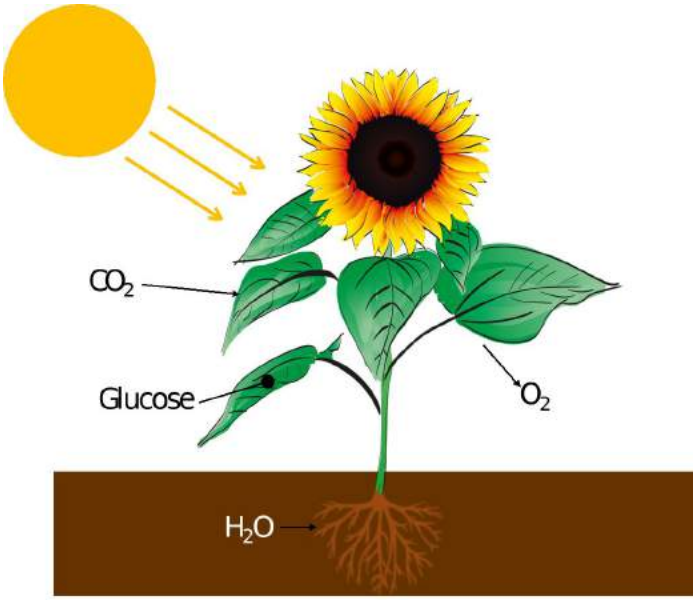
c) Answer: B

See chart below for explanation.

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

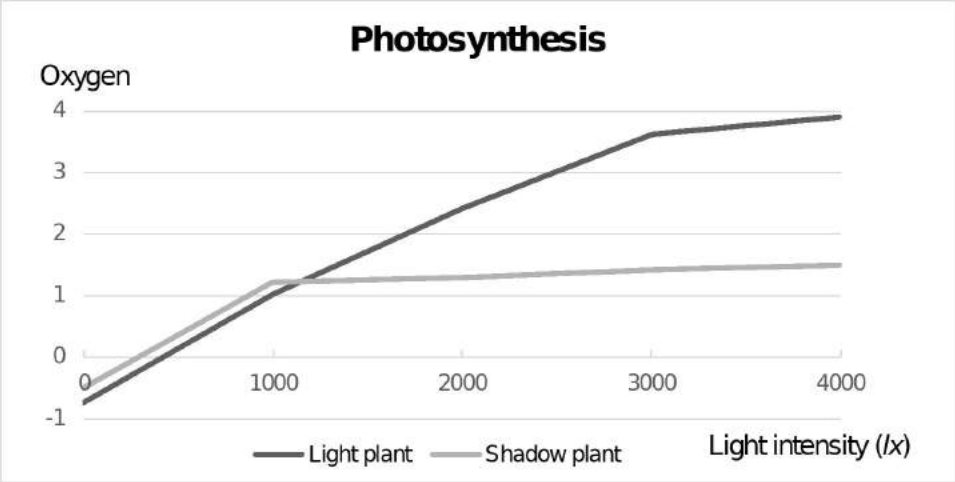
Light independent photosynthesis:

- 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 *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.

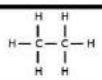
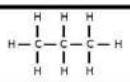
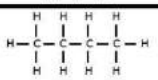
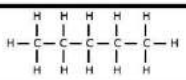
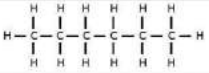
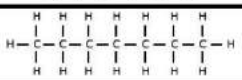
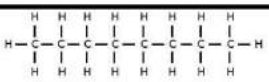
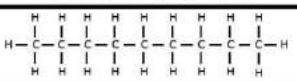
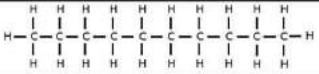
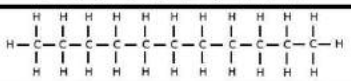
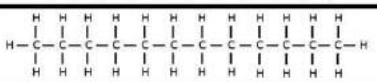
The figure shows oxygen production, not consumption. Both plants must consume oxygen photosynthesize and survive. The amount required by each plant depends on the surface size of the plant. It is therefore impossible to say whether both plants would use the same amount of oxygen to breathe.

CHEMISTRY

ALKANE

Alkanes consist only of the two elements carbon (C) and hydrogen (H). They have the general chemical formula C_nH_{2n+2}, with n = 1, 2, 3, ... The basic structure of the alkanes consists of unbranched or branched carbon chains. The unbranched compounds are called *n*-alkanes (see table) and form a homologous series. The branched alkanes are called isoalkanes (*i*-alkanes)

N-ALKANE

Number of C atoms	Name of the alkane	Formula of the alkane	Structural formula of the alkane
1	Methane	CH_4	
2	Ethane	C_2H_6	
3	Propane	C_3H_8	
4	Butane	C_4H_{10}	
5	Pentane	C_5H_{12}	
6	Hexane	C_6H_{14}	
7	Heptane	C_7H_{16}	
8	Octane	C_8H_{18}	
9	Nonane	C_9H_{20}	
10	Decane	$C_{10}H_{22}$	
11	Undecane	$C_{11}H_{24}$	
12	Dodecane	$C_{12}H_{26}$	

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.

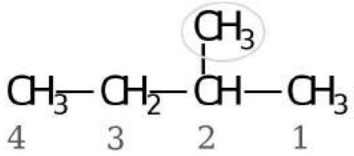
Additional rule a) If more than one alkyl group with the same name branches off the main chain, these alkyl group names are preceded by their number in Greek notation (2 = di, 3 = tri, 4 = tetra, 5 = penta, ...) as a numerical word. (These numerical words are not taken into account when sorting alphabetically.)

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

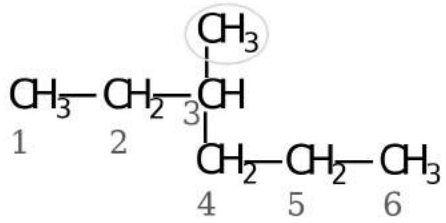
EXAMPLE



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**

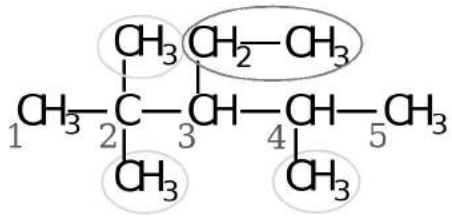
EXAMPLE



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

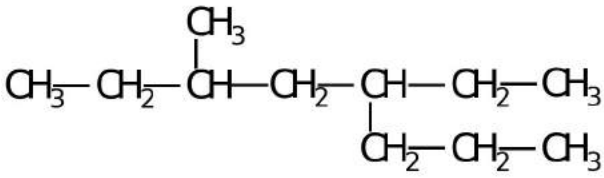


3-Ethyl-2,2,4-tri-methyl-pentane

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**.

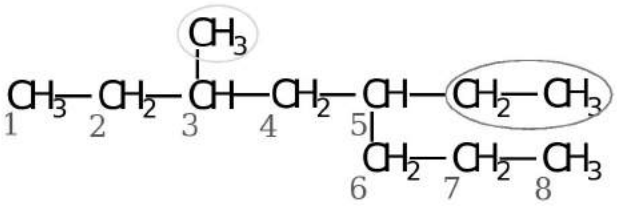
EXERCISES

1. What is the name of the following alkane?

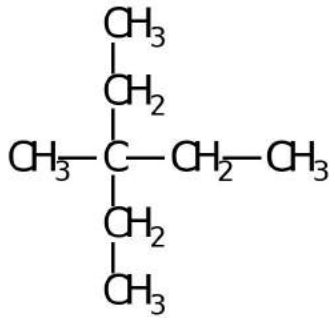


Answer:

5-Ethyl-3-methyloctane

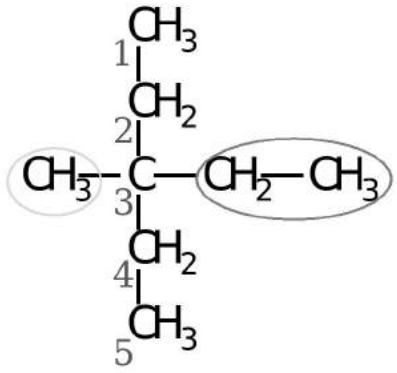

CH3
CH3—CH2—CH—CH2—CH—CH2—CH3
1 2 3 4 5
CH2—CH2—CH3
6 7 8

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	N	a	a	n	n
1	1	B	B	O	O	b	d	o	o
2	2	C	C	P	P	c	c	p	p
3	3	D	D	Q	Q	d	b	q	q
4	4	E	E	R	R	e	e	r	r
5	5	F	F	S	S	f	f	s	s
6	6	G	G	T	T	g	g	t	t
7	7	H	H	U	U	h	h	u	u
8	8	I	I	V	V	i	i	v	v
9	9	J	J	W	W	j	j	w	w
		K	K	X	X	k	k	x	x
		L	L	Y	Y	l	l	y	y
		M	M	Z	Z	m	m	z	z

EXERCISES

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

What phrase is Peter seeing?

(A) EMERGING EXIT

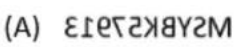
(B) EMERGENCY TAXI

(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

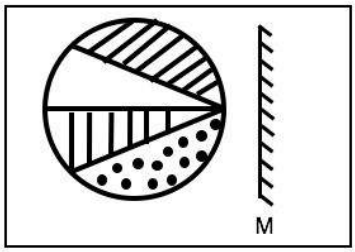
(A) 

(B)

(C)

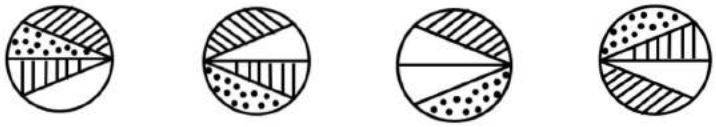
(D)

3. **Take a look at the following image:**



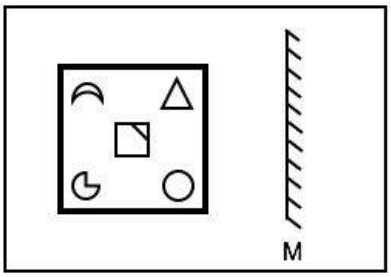
Which of the given pictures shows the correct reflection, if the mirror is placed as indicated above?

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



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?

(A)

(B)

(C)

(D)

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:

Which of the following is reflected?

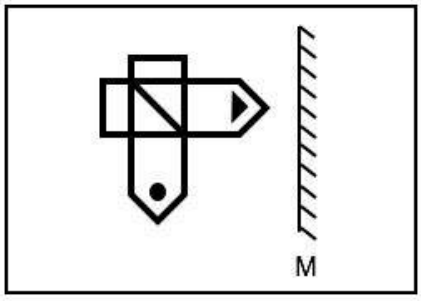
(A) SA8N96MEO

(B) SAN069MEO

(C) SA8M96MOE

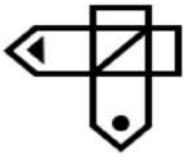
(D) SA89N6MEO

6. Take a look at the following image:

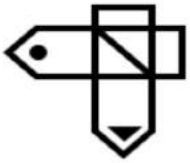


Which of the given pictures shows the correct reflection, if the mirror is placed as indicated above?

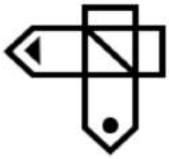
(A)



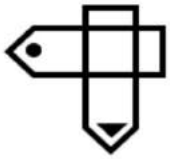
(B)



(C)

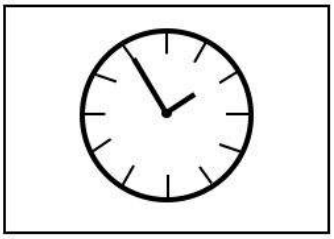


(D)



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 White Stripes

(B) The Withe Stipses

(C) Teh White Stripse

(D) The White 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.

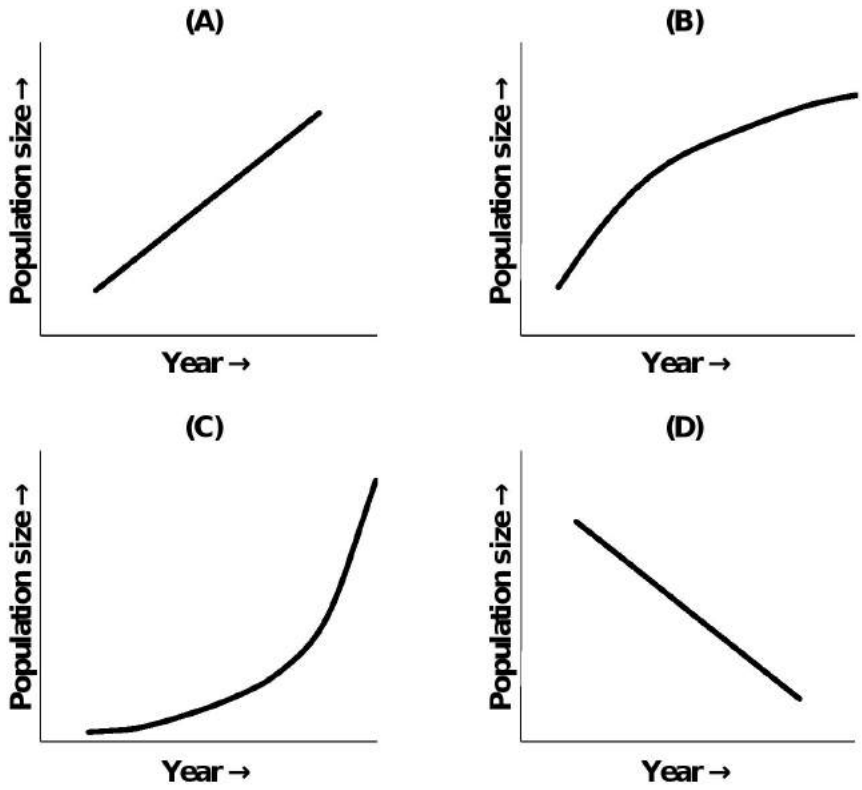
EXERCISES

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.

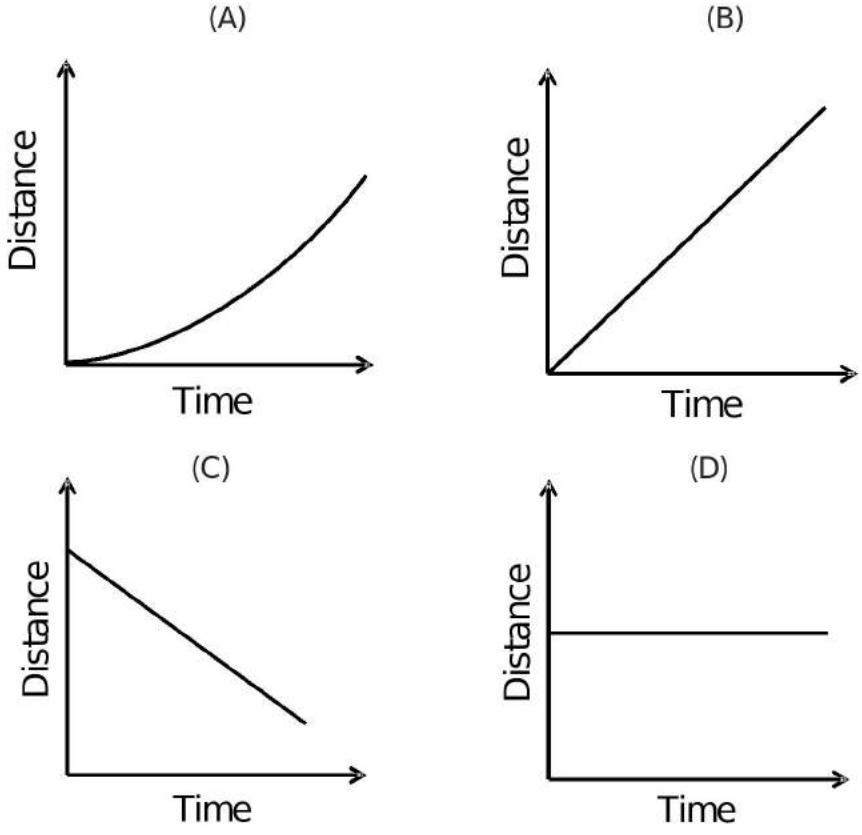
SIMPLE LINE CHART

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

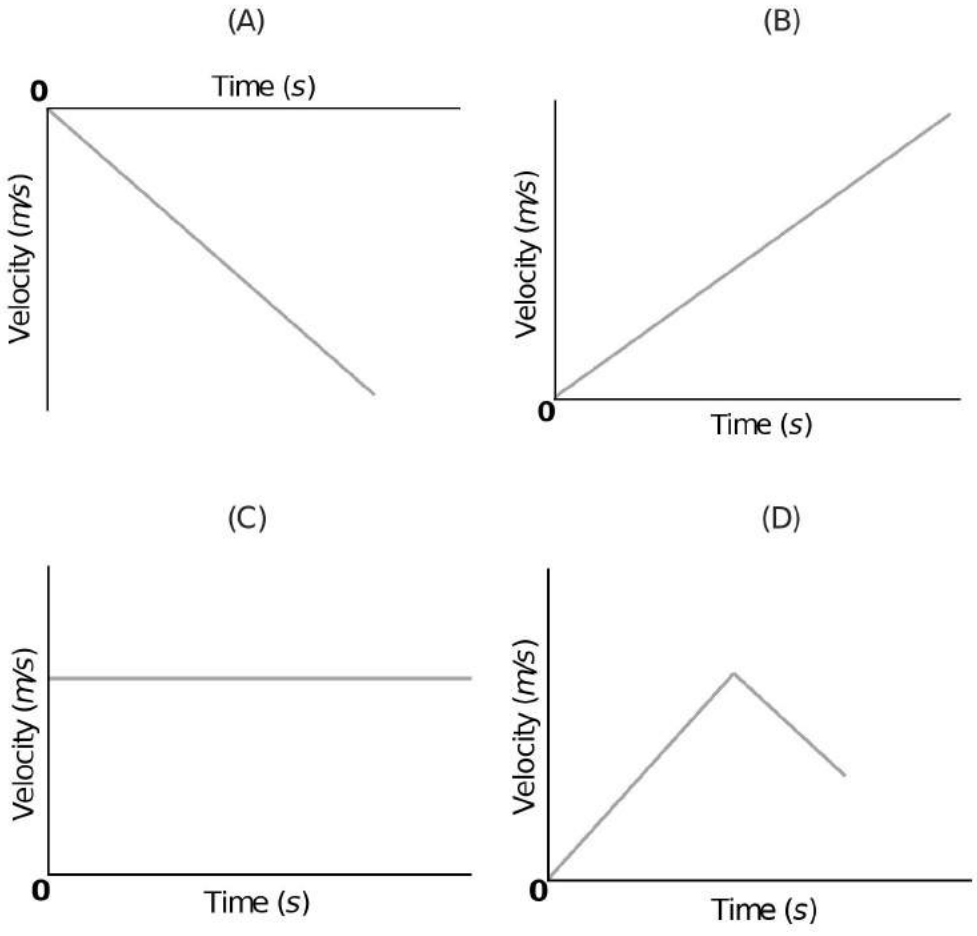
1. An object moves away from a motion detector with a constant speed. Which graph best represents the motion of the object?



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

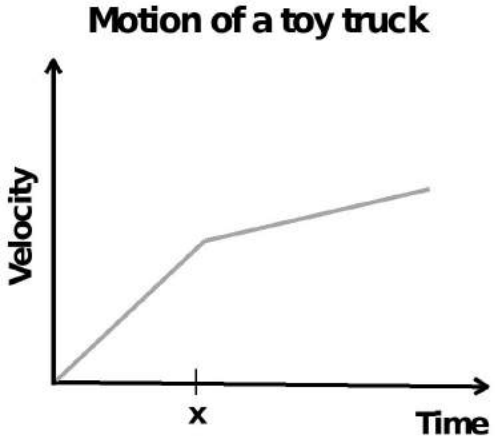
A free-falling object is undergoing an acceleration (g = 9.8 m/s/s, downward), so we are looking a graph showing a constant acceleration. In the velocity/time graphs, this is depicted with a straight, diagonal line.

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

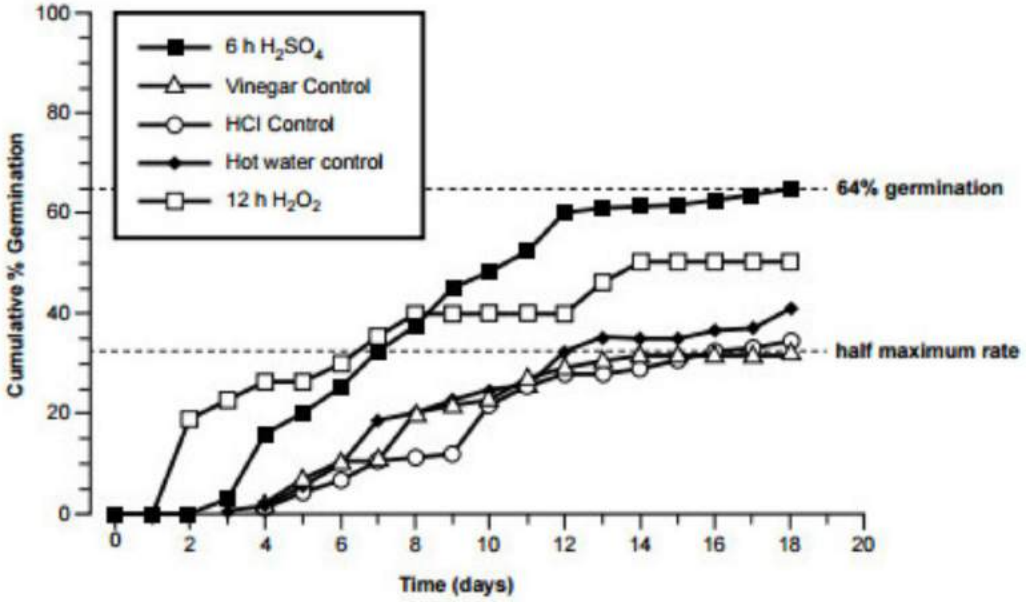
When the toy is moving in a straight to circular path, the velocity need not decrease as a constant force is still being applied. Thus, statement I is incorrect. When the toy is on a slightly sloped surface, the velocity would decrease because the toy would be moving against gravity. Thus, statement 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.

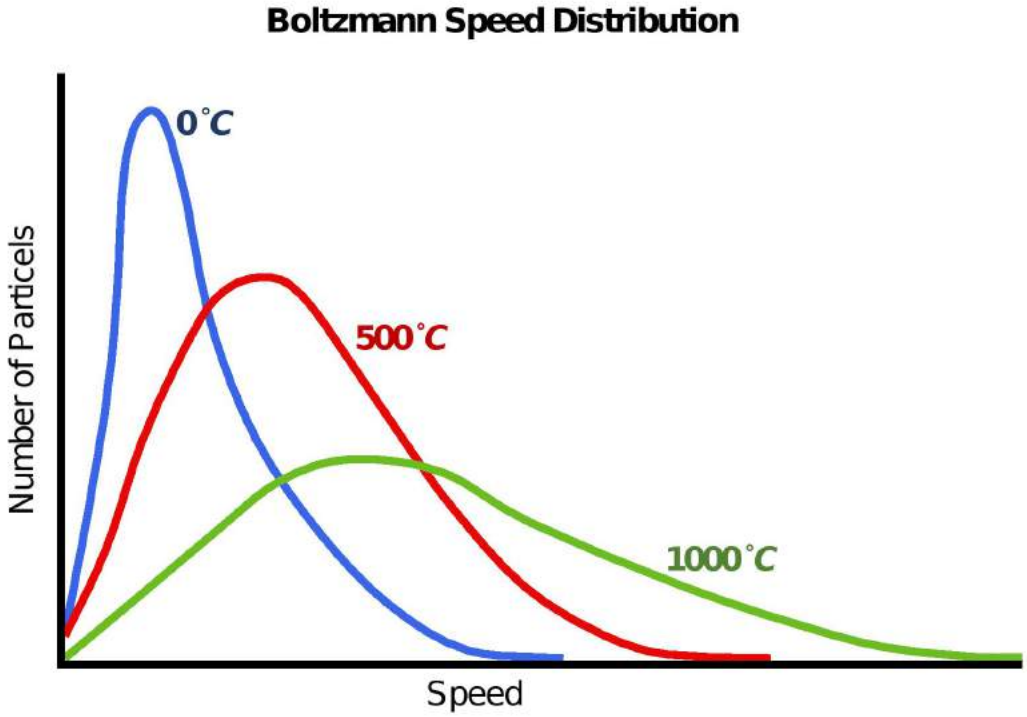
Answer: C

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.

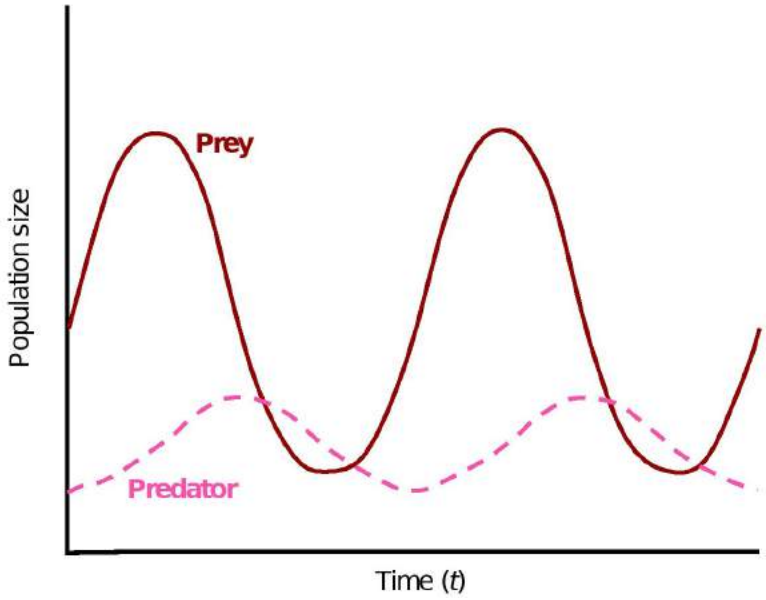
Answer: A

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.

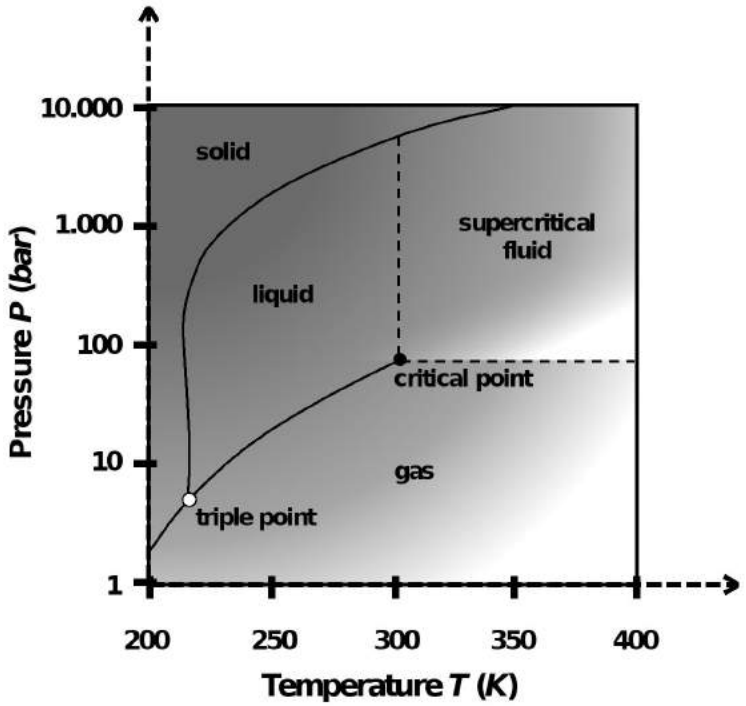
Answer : A

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 CO_2, 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

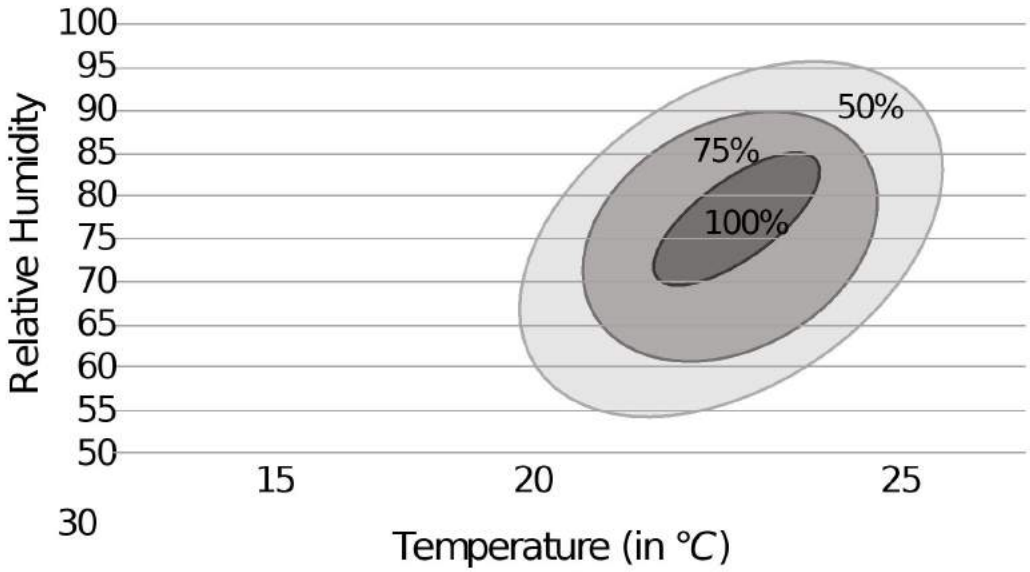
Answer: B

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

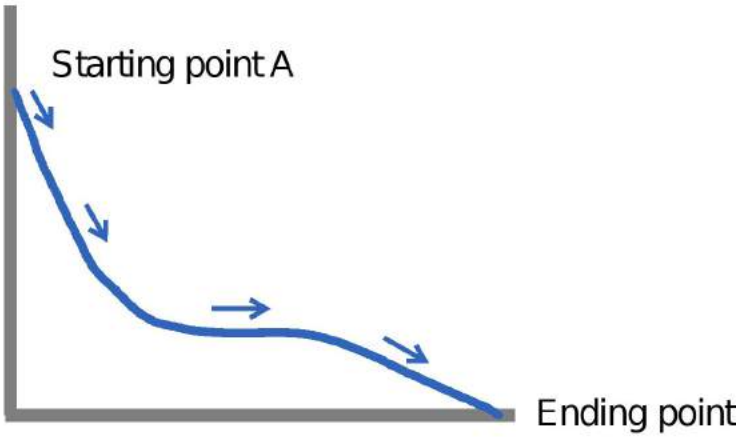
Statement I: When you check the percentage of caterpillars transforming into butterflies at a temperature close to 25°C and at humidity levels of 65% and 90%, you can see that both are at 75%. This is due to the three concentric elliptical shapes of the diagram. Statement I is correct.

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

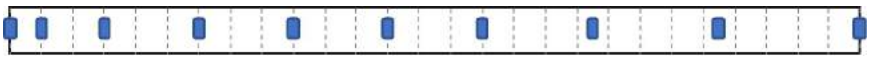
EXAMPLE

A cart is released from point A as shown in the diagrammatic representation below.

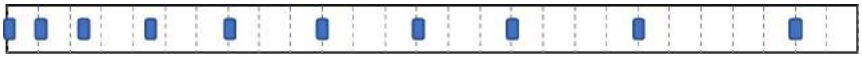


Which of the ticker tape points given below would possibly represent the pattern of movement?

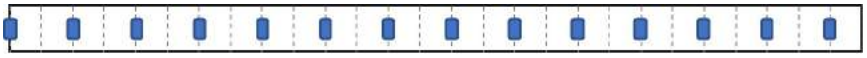
A



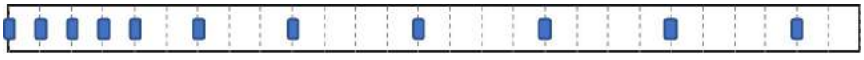
B



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.*

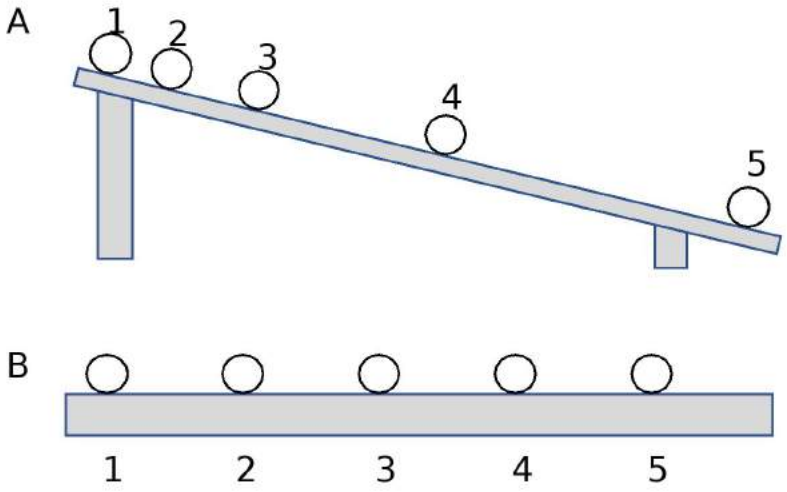
From the diagram, we can see that the slope of the line is initially very steep, then it levels off for a bit, then it increases again. The pattern, both for its acceleration and the distance between the dots, should be large increase □ no increase □ small increase. In other words, large acceleration □ 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 □ no increase □ increase. By measuring the distance between dots for both A and C, we see that A is correct, because the pattern is large increase □ no increase/small increase, whereas in C, the pattern is small increase □ no increase □ 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.

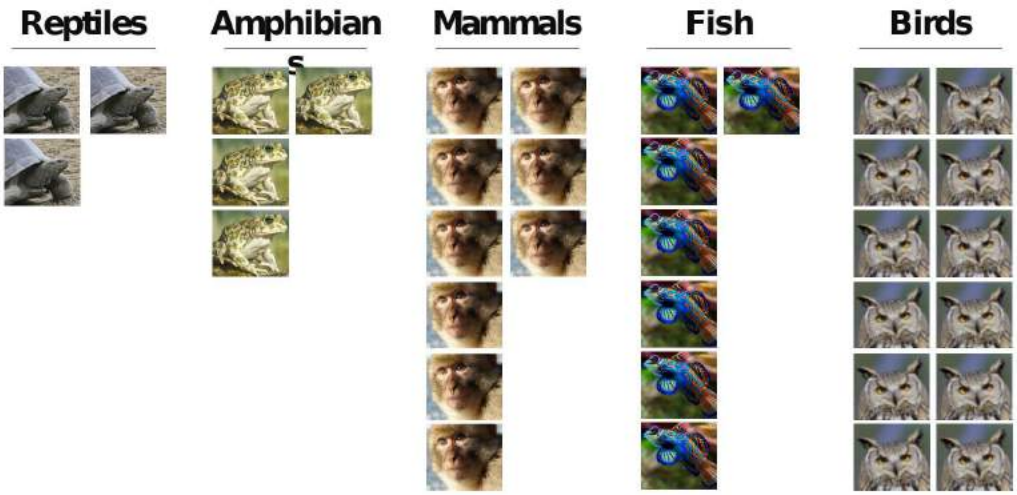
Statement II is not correct because ball A always has a higher acceleration than ball B.

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:

1st year: 100% – (100% × 10%) = 90%

2nd year: 90% – (90% × 10%) = 81%

3rd year: 81% – (81% × 10%) = 72.9% etc.

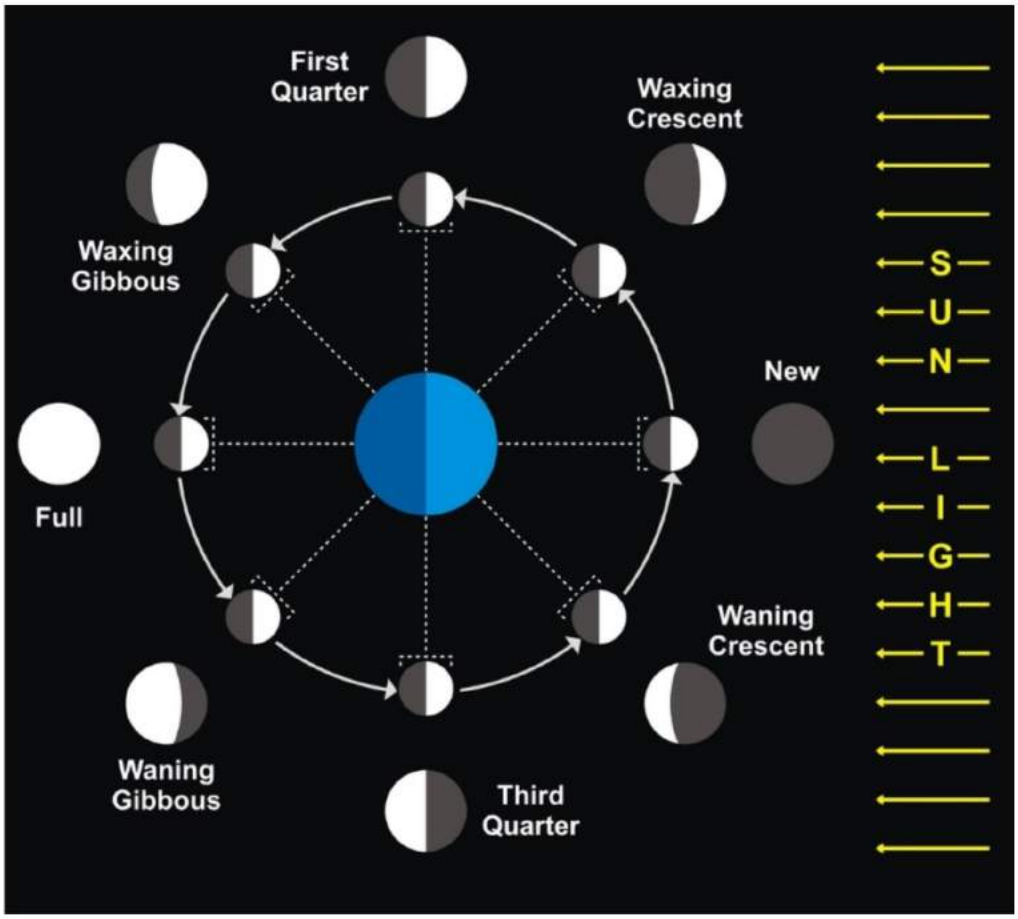
Therefore, the bird population is above 50% after 5 years' time. Thus, statement II is false.

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.

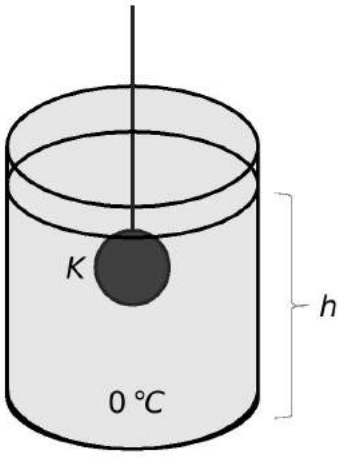
(D) Last quarter

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 °C to +4 °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 °C. Accordingly, density will increase. On the other hand, the volume of water is lowest at +4 °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 × d × g. d increases, g is a constant, and the volume of the water displaced remains equal to the volume of ball K □ F(K)

increases. As F(K) increases, G – F(K) decreases, and the tension in the rope decreases.

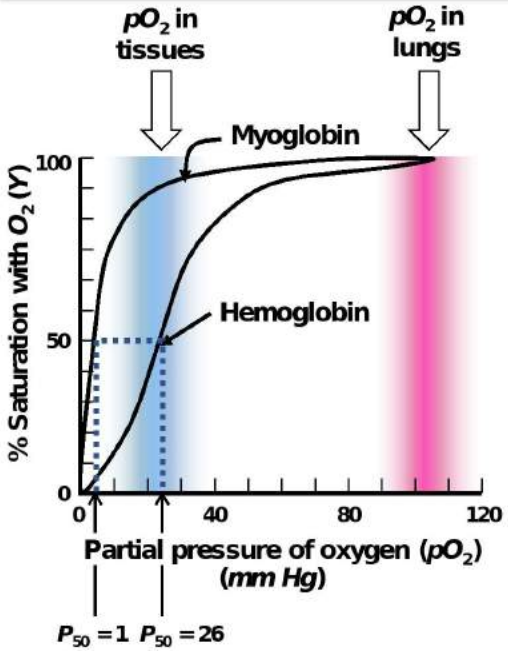
IMPORTANT VISUAL – REDUNDANT TEXT

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 t 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

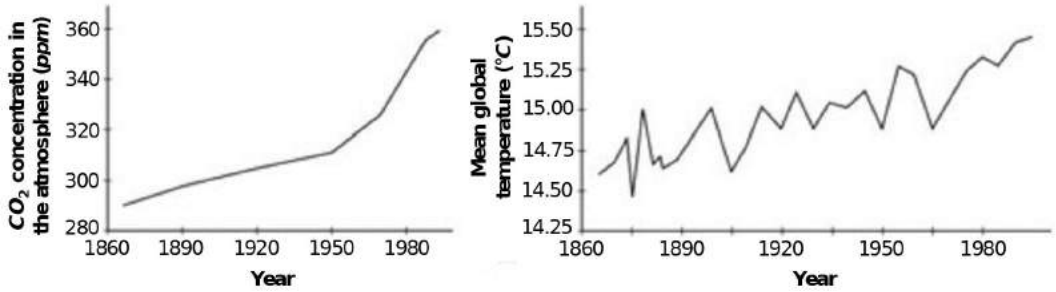
(D) 2

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

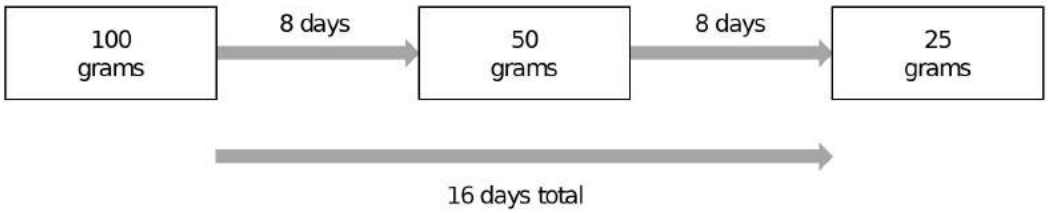
The graphs show a positive correlation between atmospheric CO_2 and mean global temperature. As the amount of CO_2 in the atmosphere increases, there is a corresponding increase in mean global temperature. A is correct. B is wrong because the two graphs are both moving in the same direction. For it to 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

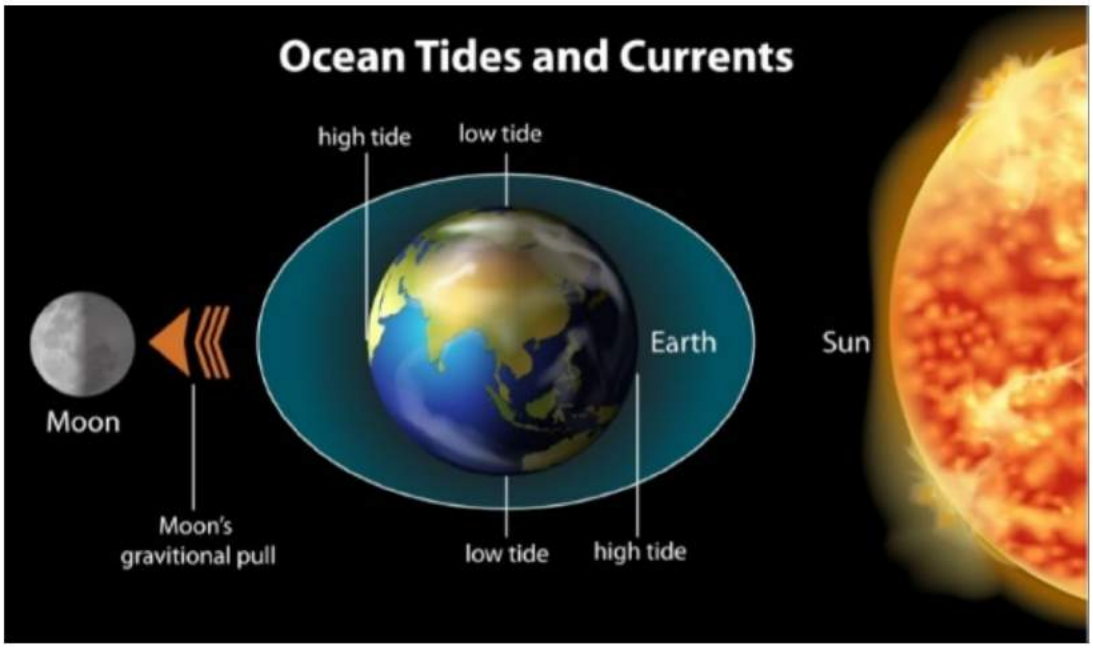
(D) 6.25 grams

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.

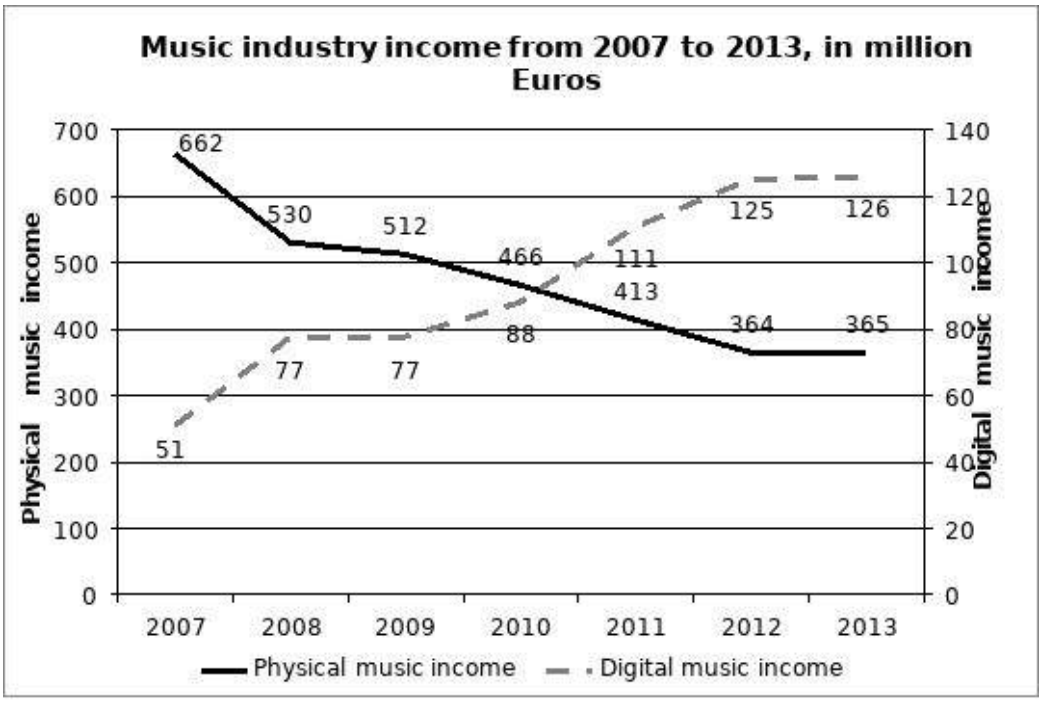
Statement II: Even though the spaceship is attracted by both celestial bodies, the force of attraction exerted by the Earth is considerably stronger due to its higher mass. The statement is not correct.

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”.

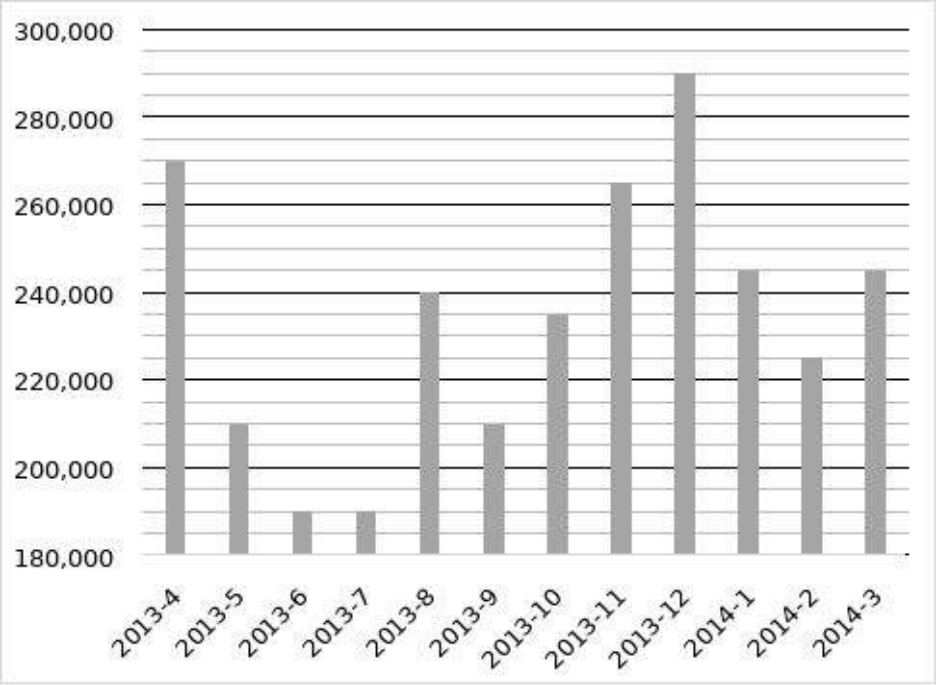
FREQUENTLY RECURRING PITFALLS

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

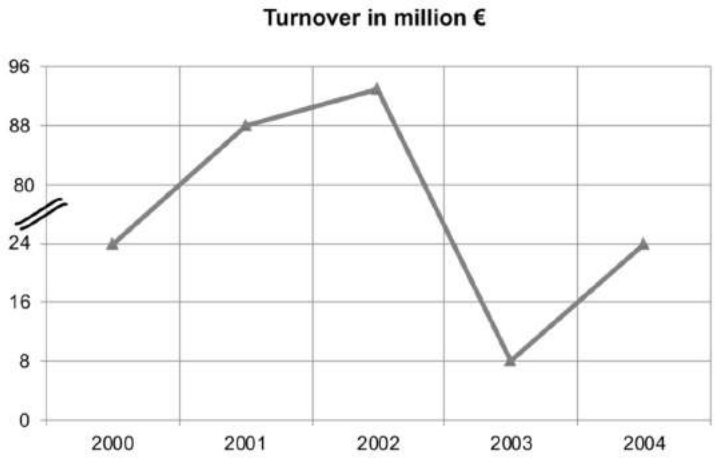
How high is the percentage change from 2013-5 to 2013-8? At first glance, it appears that the amount has doubled, indicating an increase of 100%. However, this would be a common pitfall. Before answering this question, you have to take a closer look at the y-axis: It starts with 180,000!

The percentage increase is thus (240,000 – 210,000) ÷ 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.

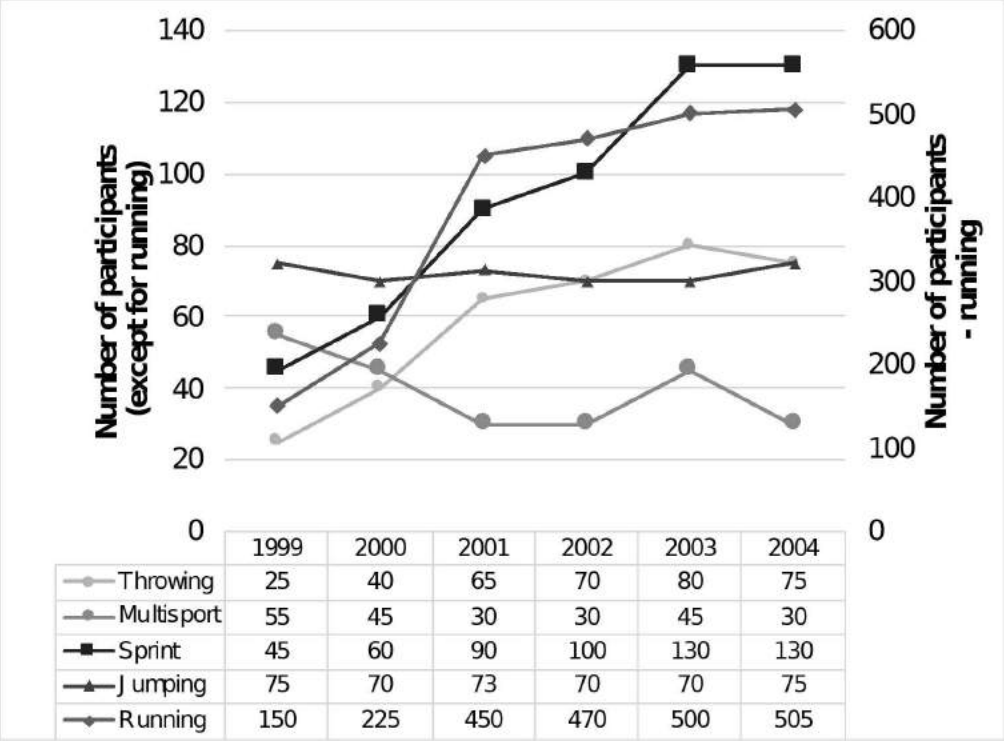
THERE ARE TWO Y-AXES.

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



	1999	2000	2001	2002	2003	2004
Throwing	25	40	65	70	80	75
Multisport	55	45	30	30	45	30
Sprint	45	60	90	100	130	130
Jumping	75	70	73	70	70	75
Running	150	225	450	470	500	505

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.

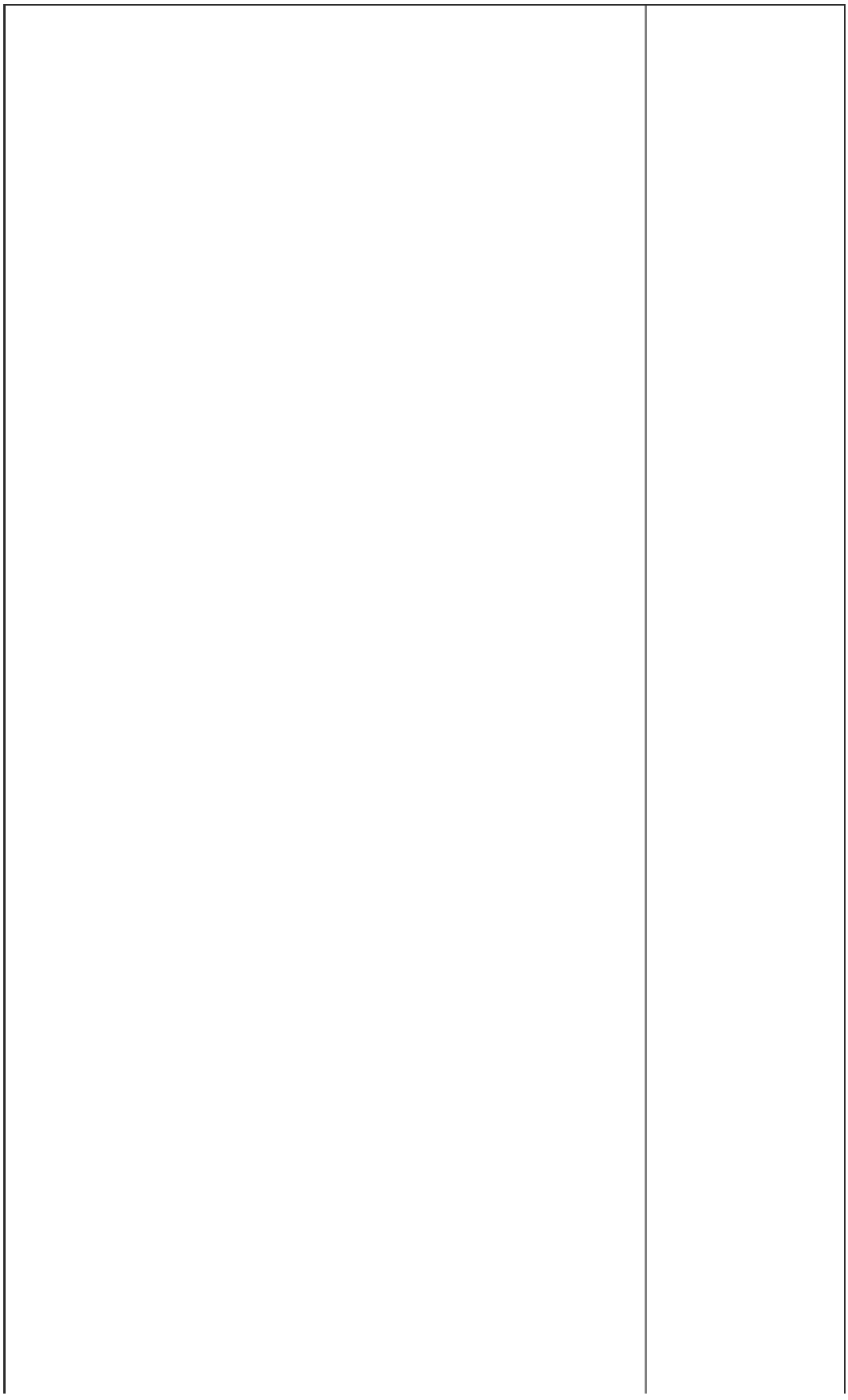
Biological interactions are effects that organisms of a community have on one another. **Competition** is a mutually detrimental interaction between individuals, populations or species. The term **symbiosis** is used only for cases where both organisms benefit from a relationship. Competition can be 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.



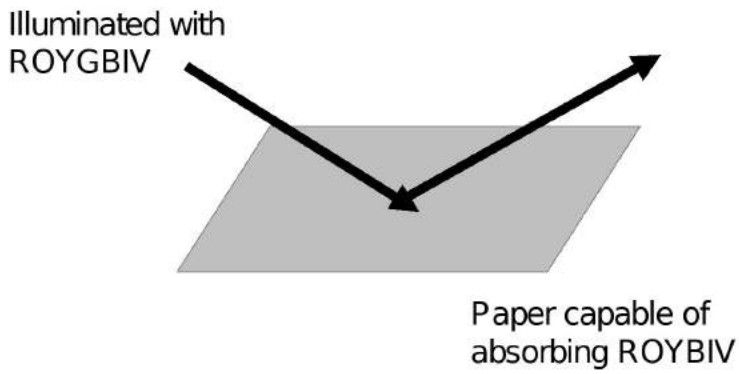
PRACTICE QUESTIONS

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.

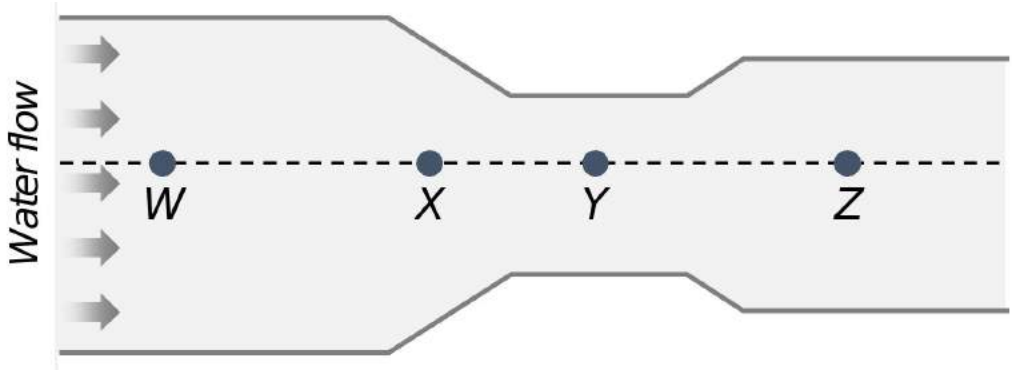
(B) Only statement II is correct.

(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

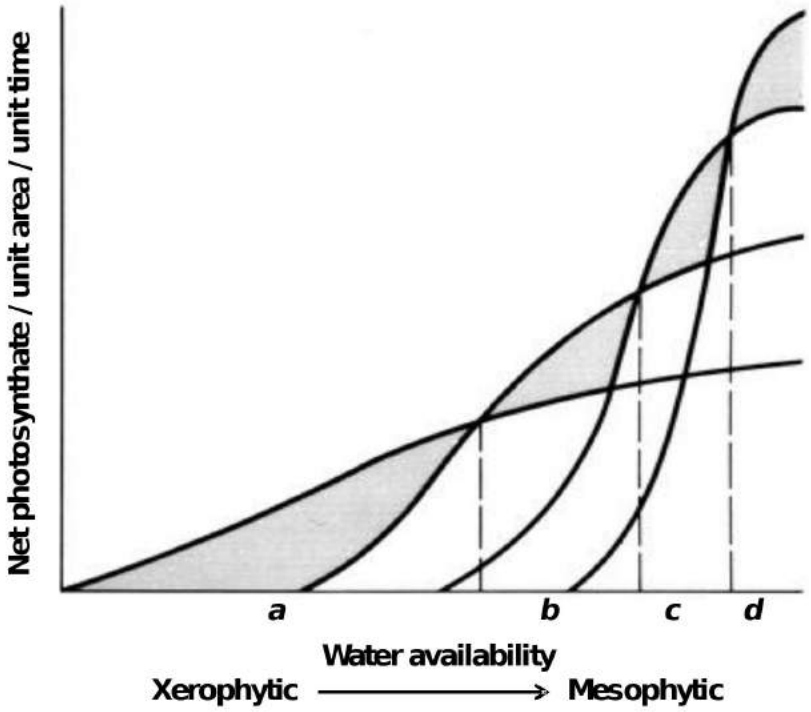
(B) Points W and Z

(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 *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) $\frac{1}{2}\,\mathrm{m}$

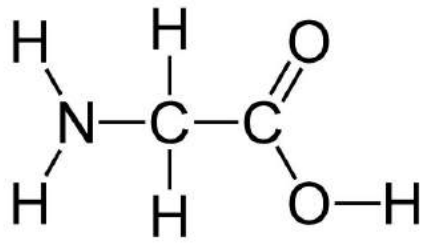
(B) $1\ \mathrm{m}$

(C) $\frac{1\ \mathrm{m}}{\pi}$

(D) $\frac{1\ \mathrm{m}}{2\ \times\ \pi}$

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

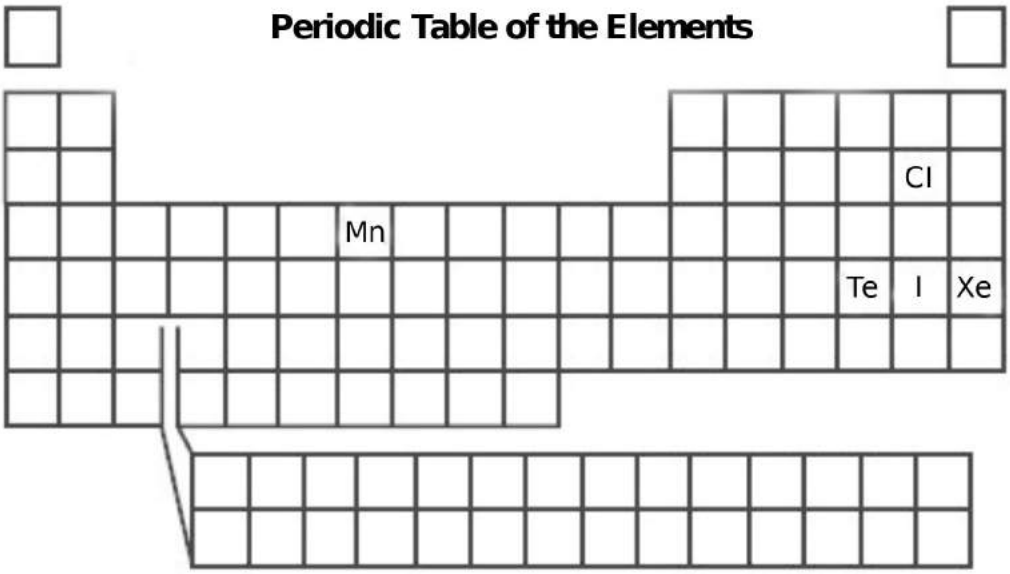
(B) 10-5-4-6

(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.



Chemical properties of Iodine (I) would be similar to that of:

(A) Chlorine (Cl)

(B) Tellurium (Te)

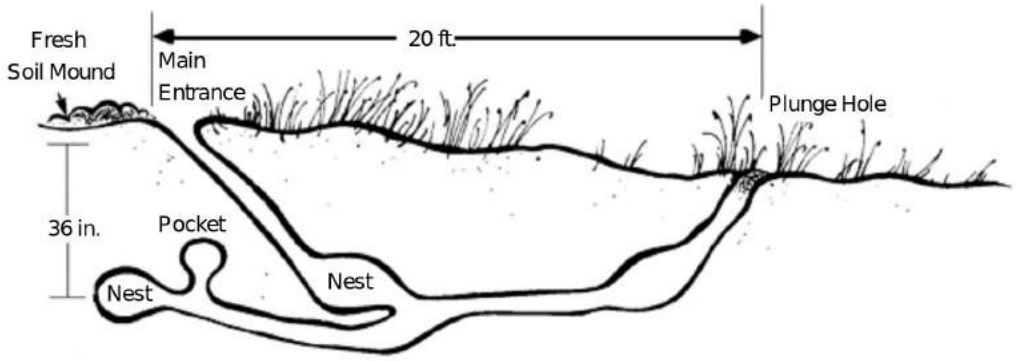
(C) Manganese (Mn)

(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:

$C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$

Which of the following changes will cause an increase in the products of the above reaction?

(A) Increasing the concentration of Br_2

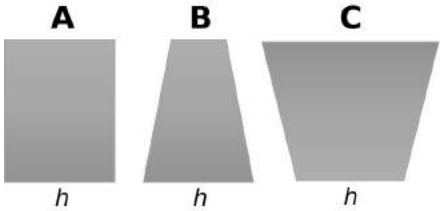
(B) Decreasing the concentration of C_6H_6

(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

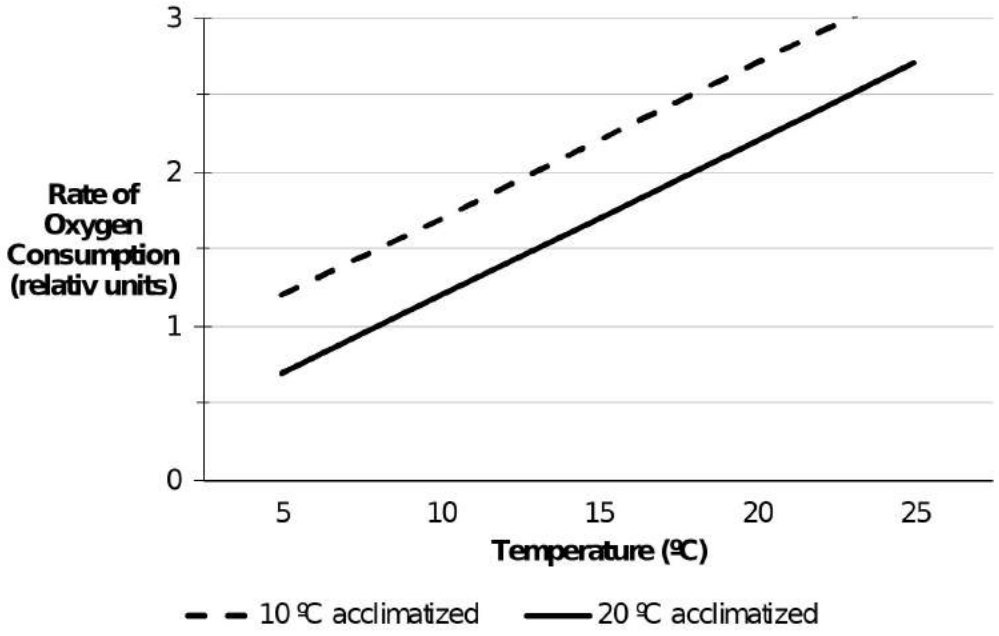
(B) B

(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.

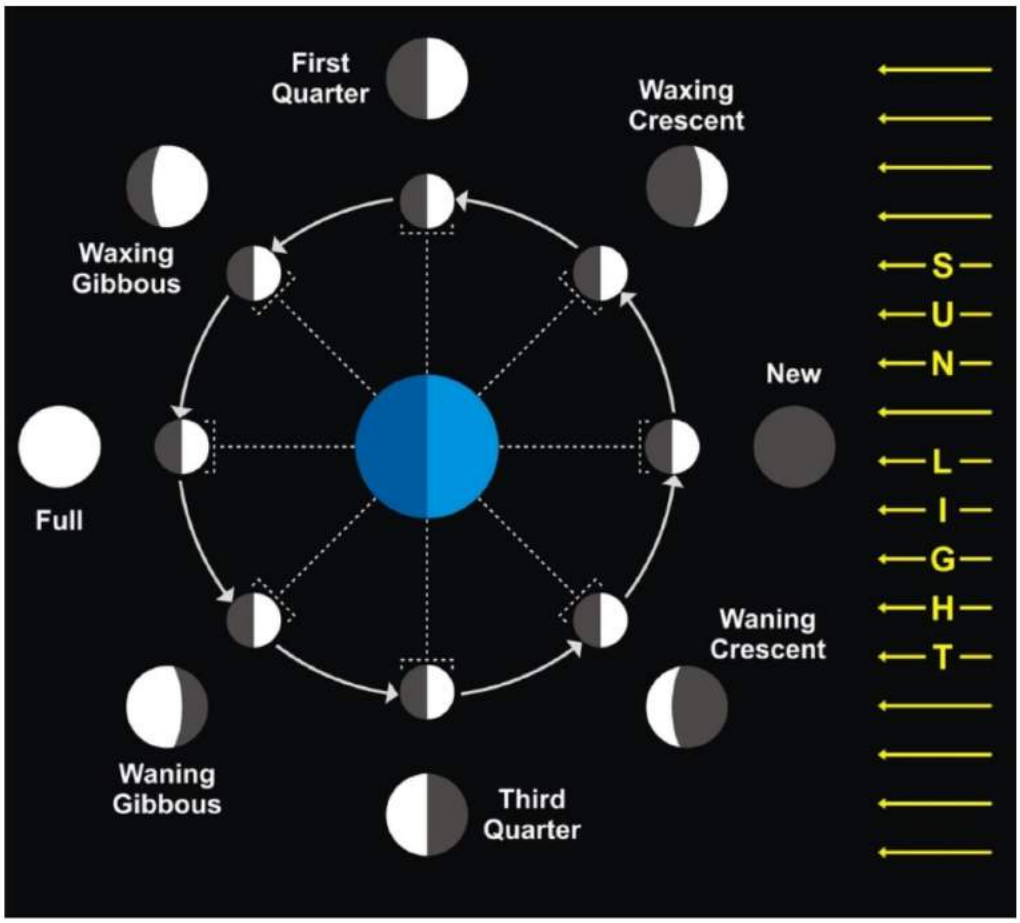
(B) Crabs have higher rates of oxygen consumption when measured at 10 °C than when measured at 20 °C.

(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.

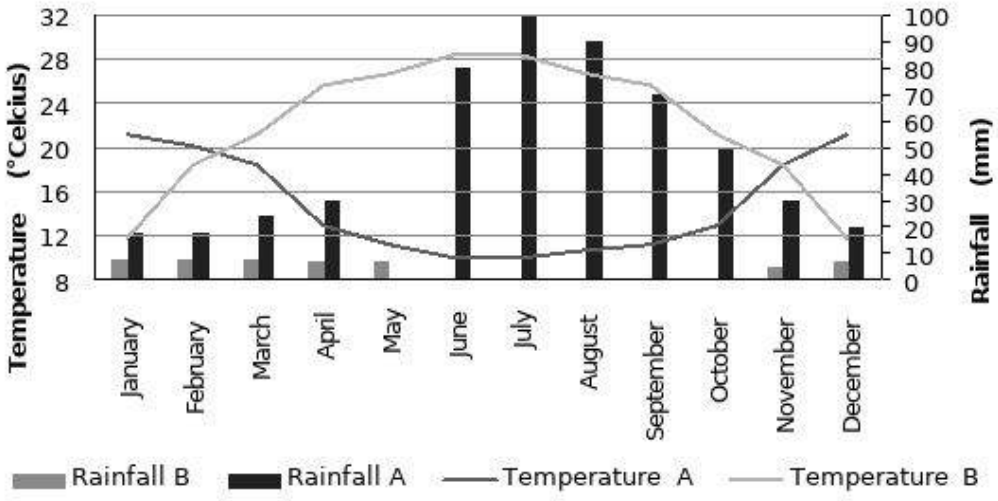
(B) The tilt of the Moon on its axis.

(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.

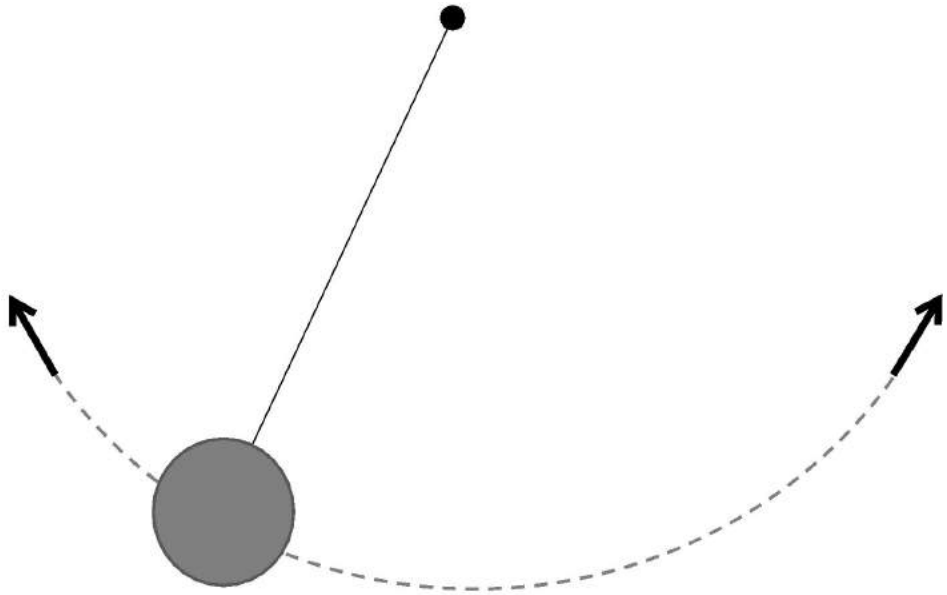
(B) Only statement II is correct.

(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.

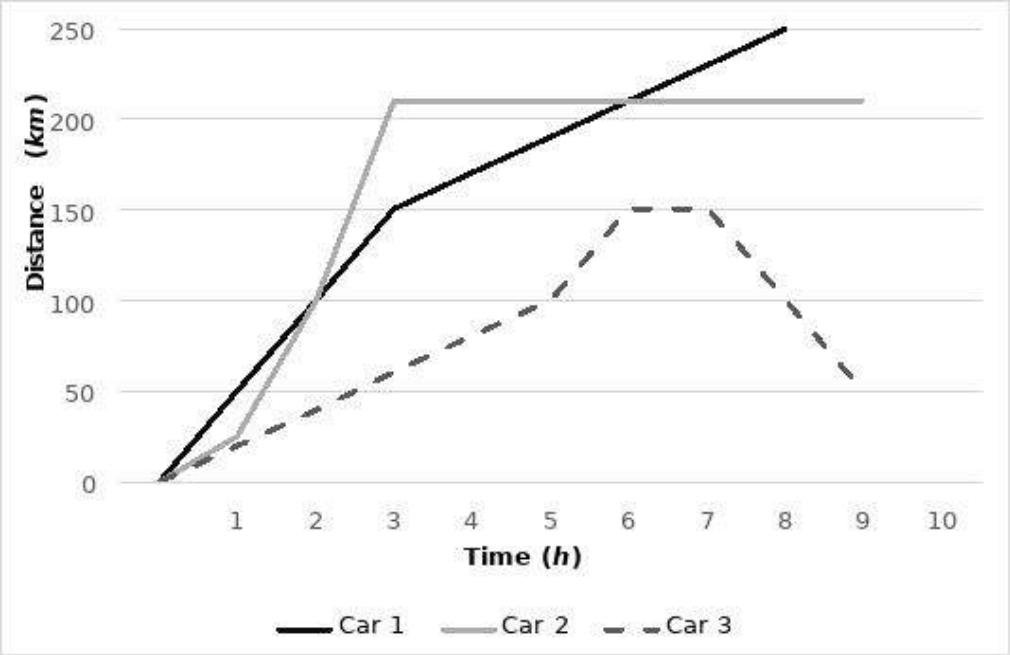
(B) Only statement II is correct.

(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.

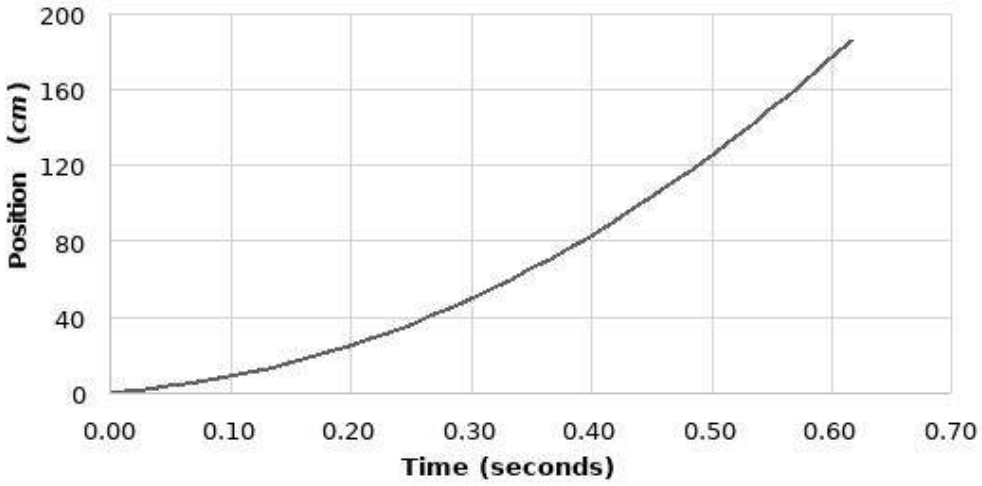
(C) Both statements are correct.

(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.

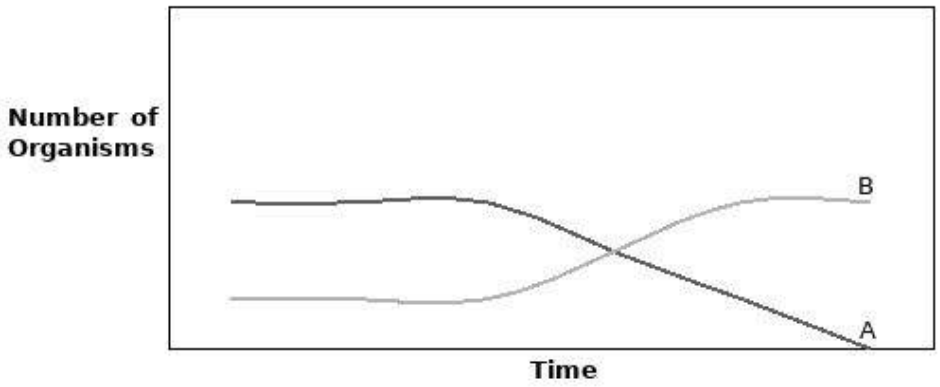
(B) Only statement II is correct.

(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.

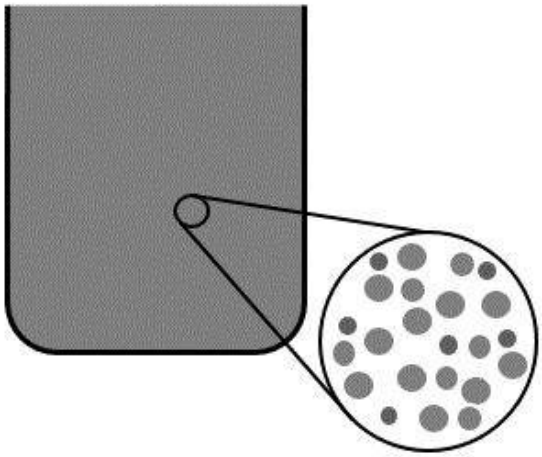
(B) population B competed more successfully for food than did population A.

(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 predicable behavior of other phases of matter.

(A) Only statement I is correct.

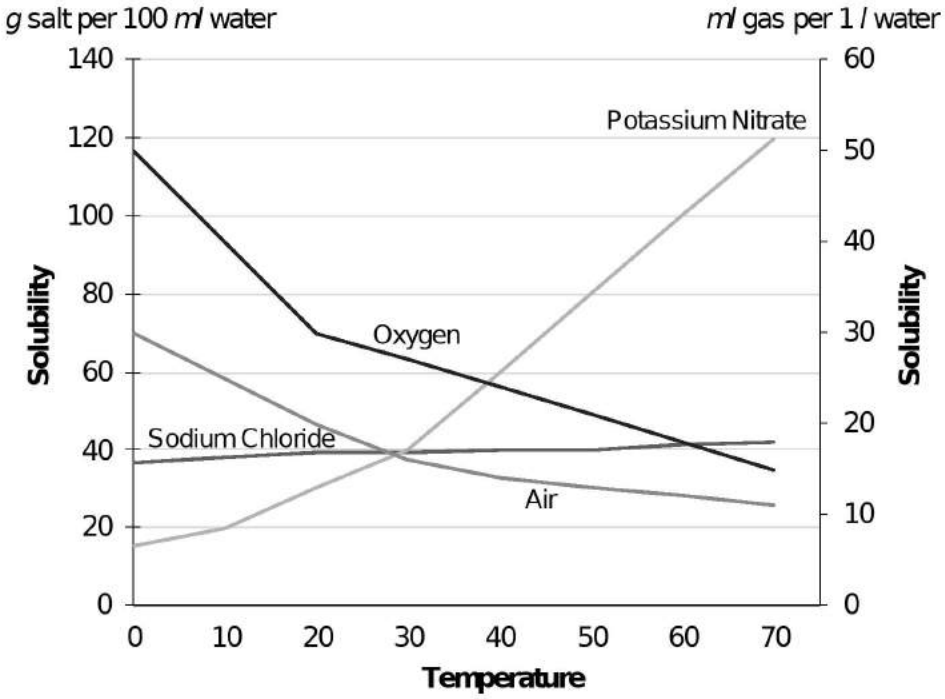
(B) Only statement II is correct.

(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.

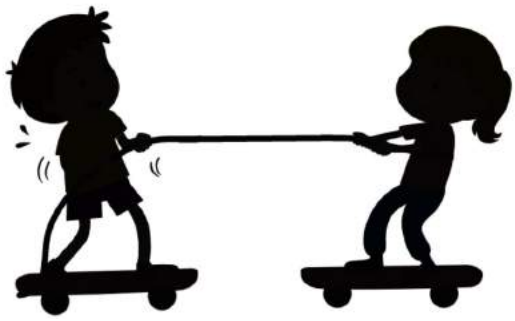
(B) Only statement II is correct.

(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

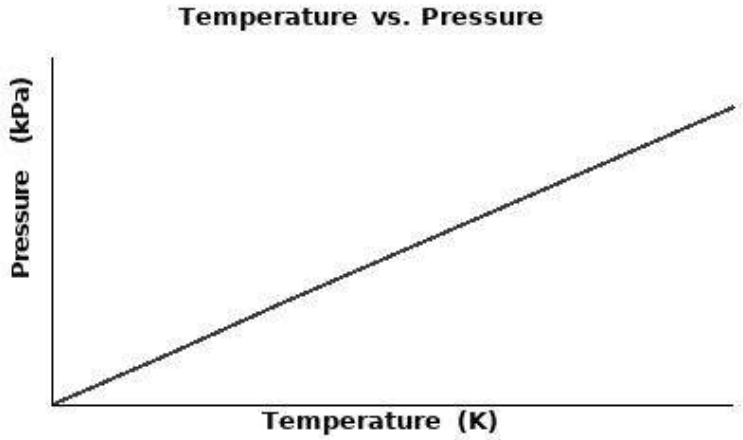
(B) Condensation

(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

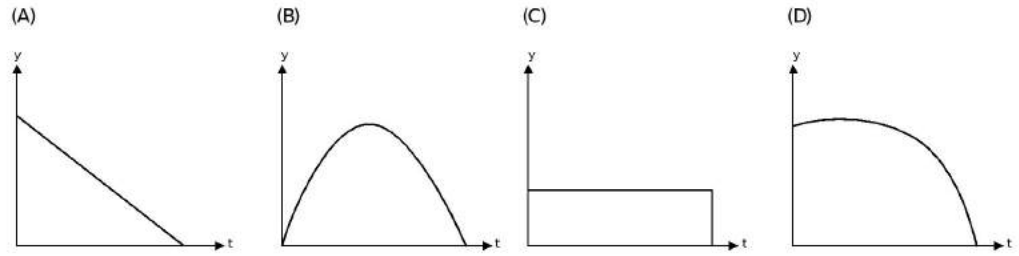
(B) Arg and Leu

(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.

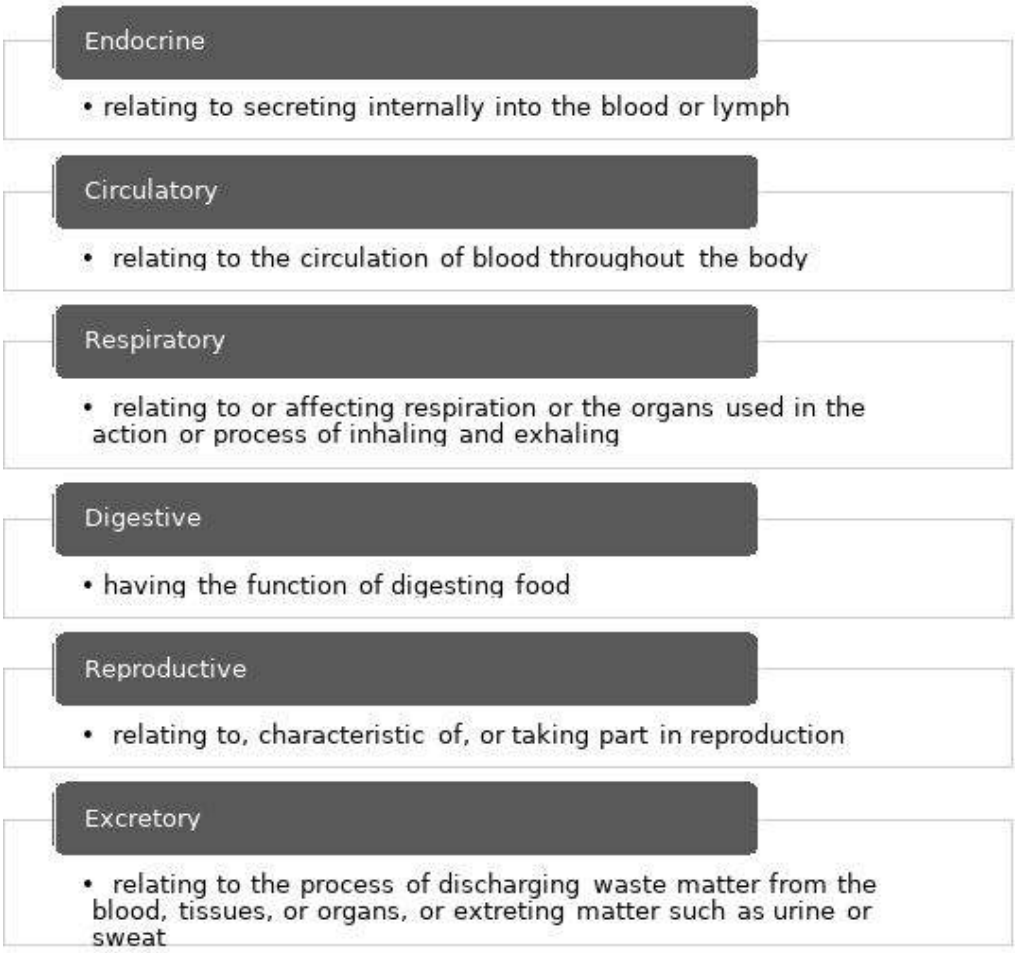
(C) Statements I and II are correct.

(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: CO_2 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:



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.

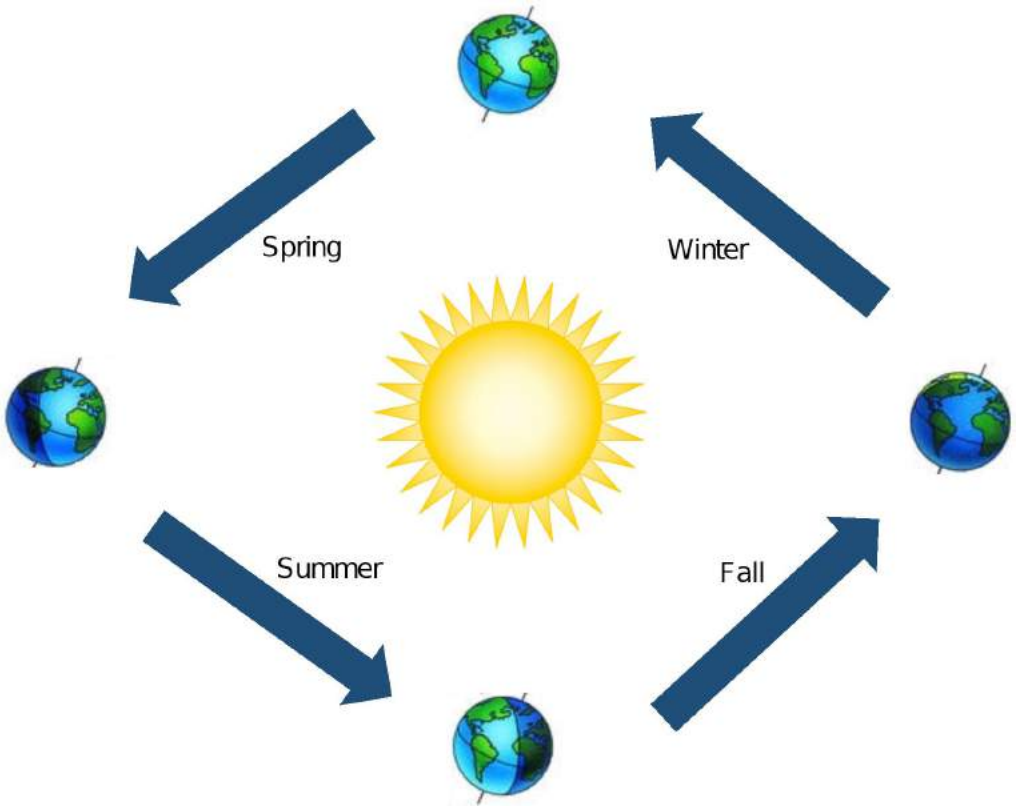
(B) Only statement II is correct.

(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.

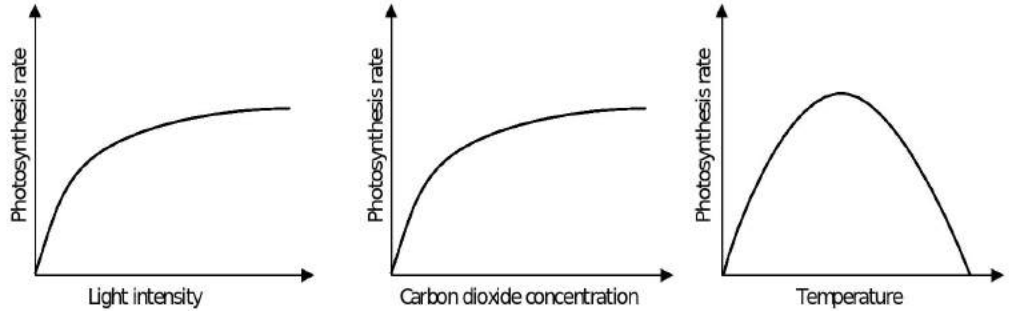
(B) Only statement II is correct.

(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 CO_2 concentration will not further increase the rate of photosynthesis when the CO_2 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: $N_2 + 3H_2$**?**

(A) $2NH_3$

(B) $3N_2H_3$

(C) $3NH_2$

(D) $2N_2H_2$

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.

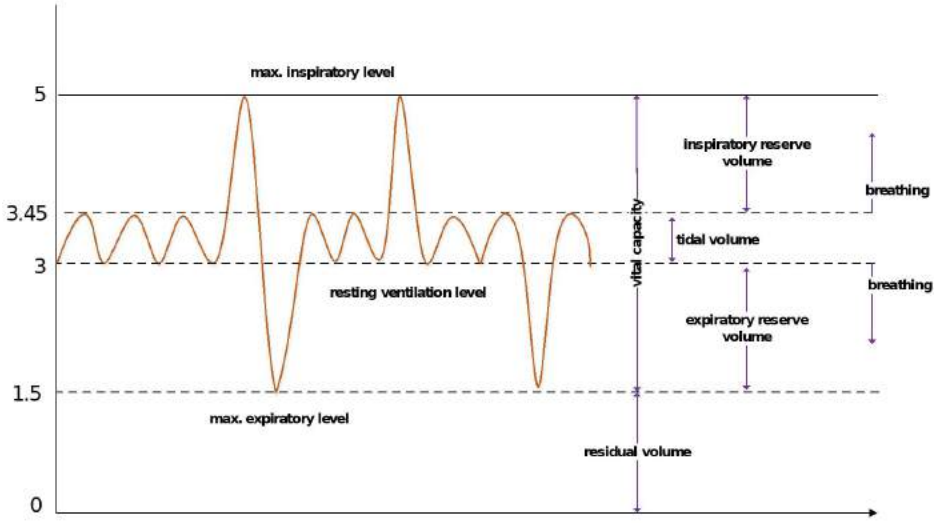
(C) Both statements are correct.

(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.

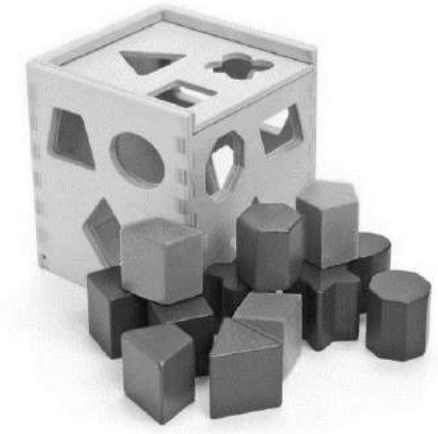
(B) Only statement II is correct.

(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.

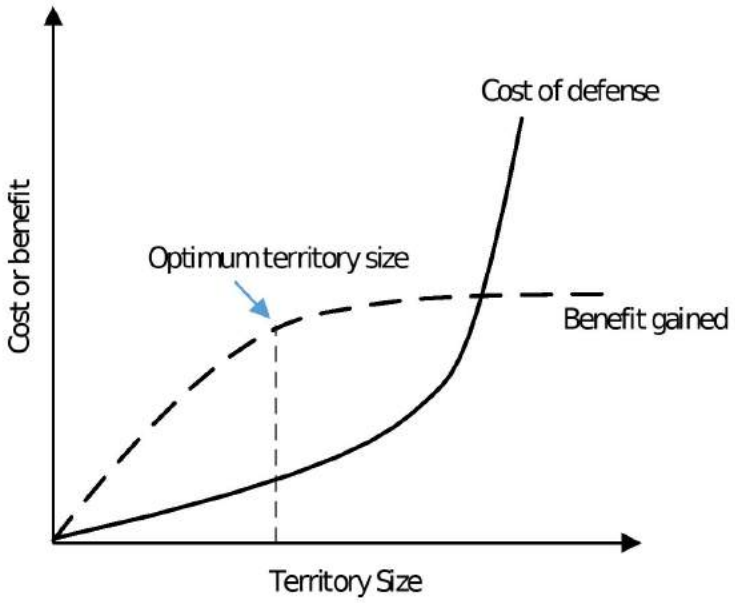
(B) Only statement II is correct.

(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.

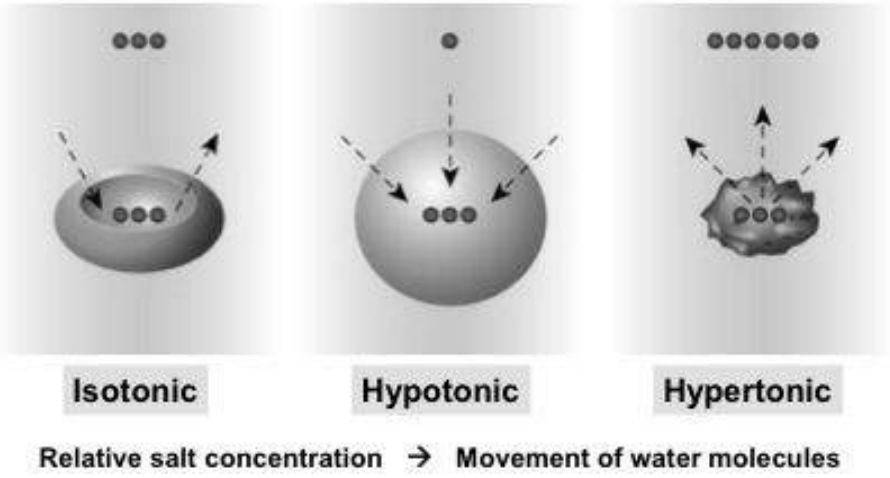
(B) Only statement II is correct.

(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:

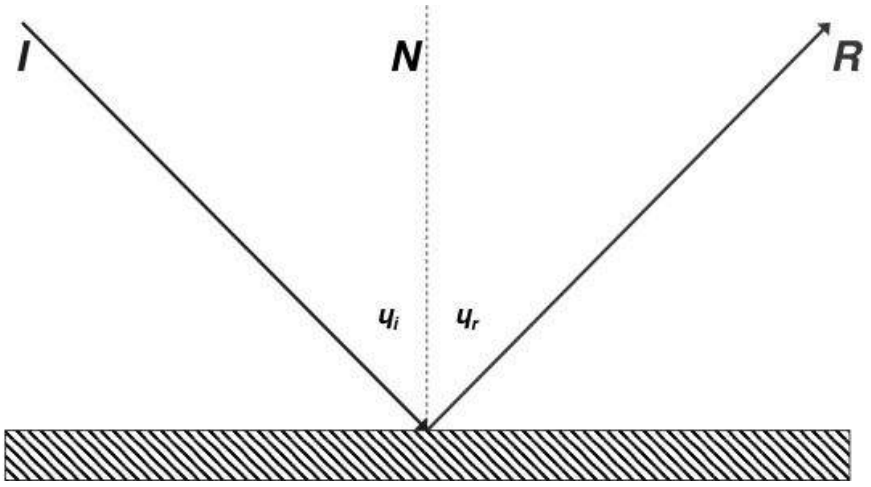
(A) easily releases hydroxide ions.

(B) does not dissolve in water.

(C) reacts to form salt crystals in water.

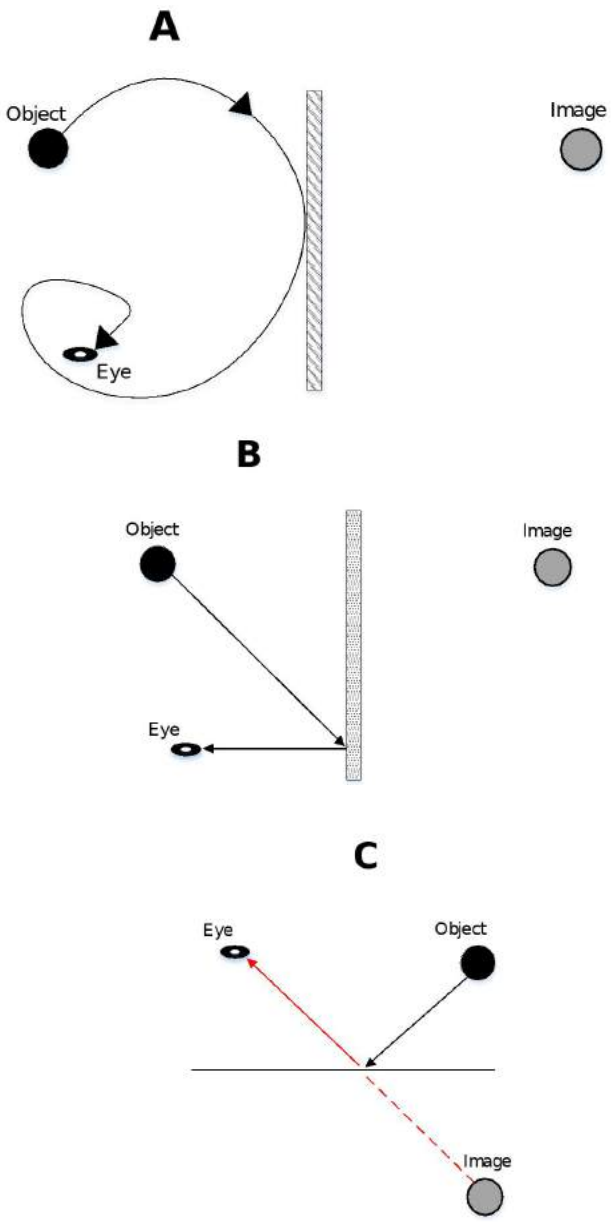
(D) does not conduct an electric current.

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

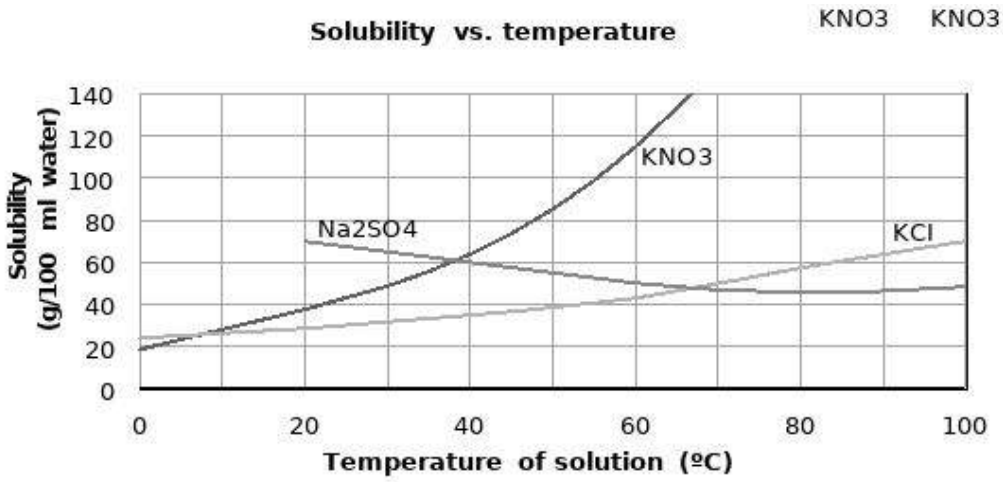
(B) Existing predators

(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: $CH_2CH(Cl)CH_2CH(Cl)CH_2CH(Cl)$**.**

Its repeating subunit is:

(A) $CH(Cl)$

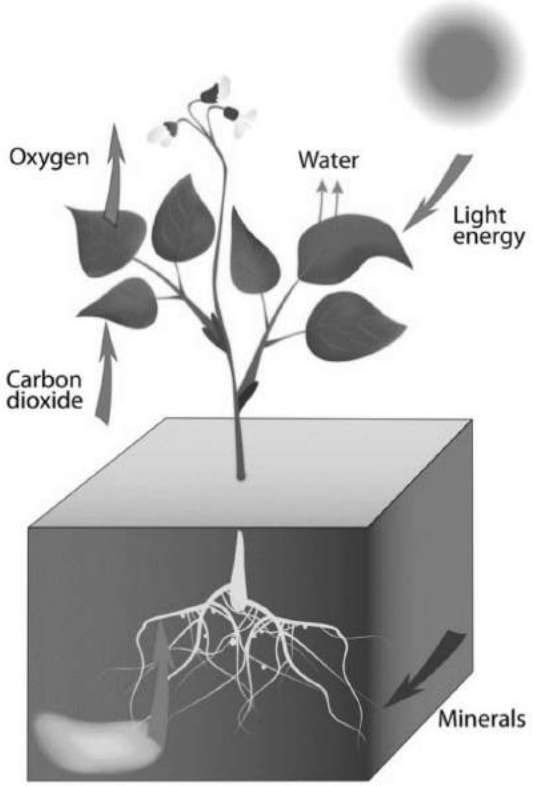
(B) $CH(Cl)CHCH_2$

(C) CH_2CH

(D) $CH_2CH(Cl)$

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

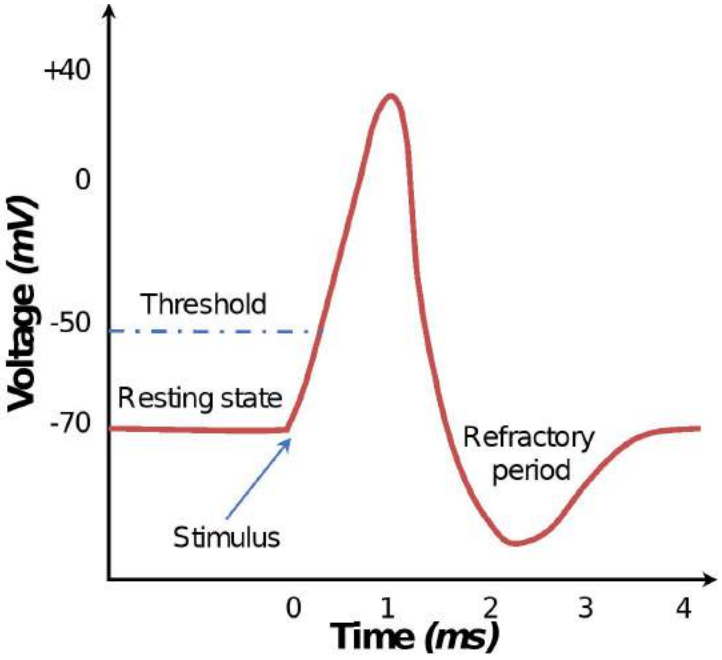
(B) water-dependent

(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?

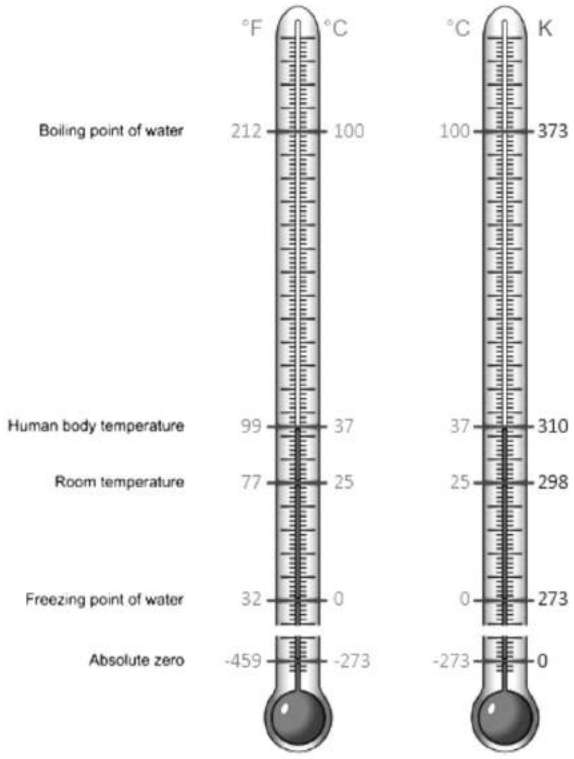
(A) Nervous

(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.

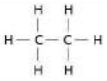
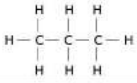
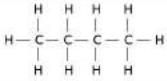
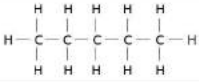
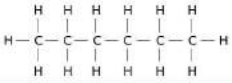
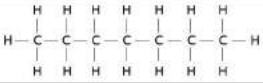
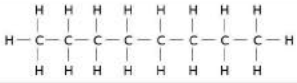
(B) the nitrogen boils and then cools to form a solid at the opening of the container.

(C) the water vapor in the air over the opening of the liquid nitrogen freezes.

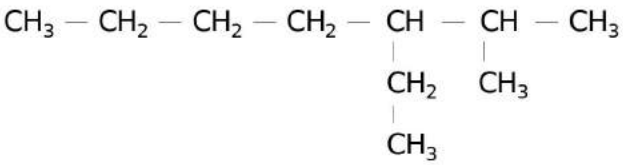
(D) water trapped in the liquid nitrogen escapes and freezes.

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	
2	Ethan	C_2H_6	
3	Propane	C_3H_8	
4	Butane	C_4H_{10}	
5	Pentane	C_5H_{12}	
6	Hexane	C_6H_{14}	
7	Heptane	C_7H_{16}	
8	Octane	C_8H_{18}	

What is the name of the following alkane?



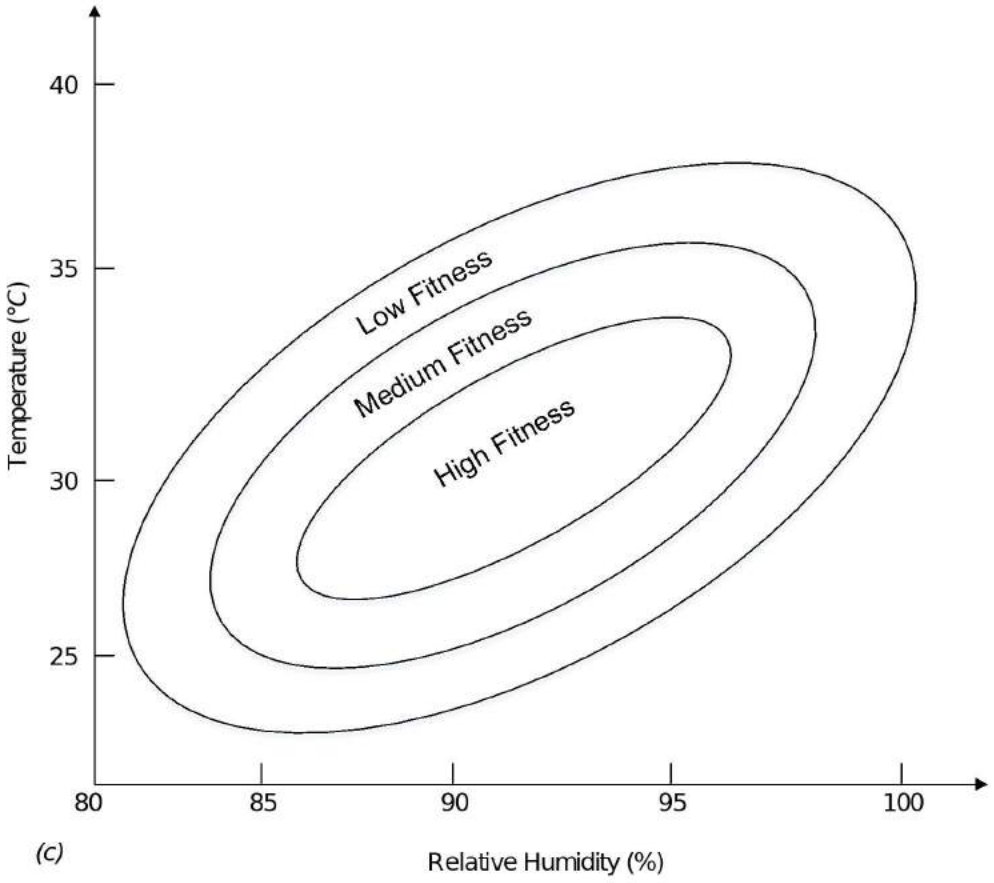
(A) 5,6-Propylhexane (B) 3-Ethyl-2-methylheptane

(C) 3-Ethlyloctane (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.

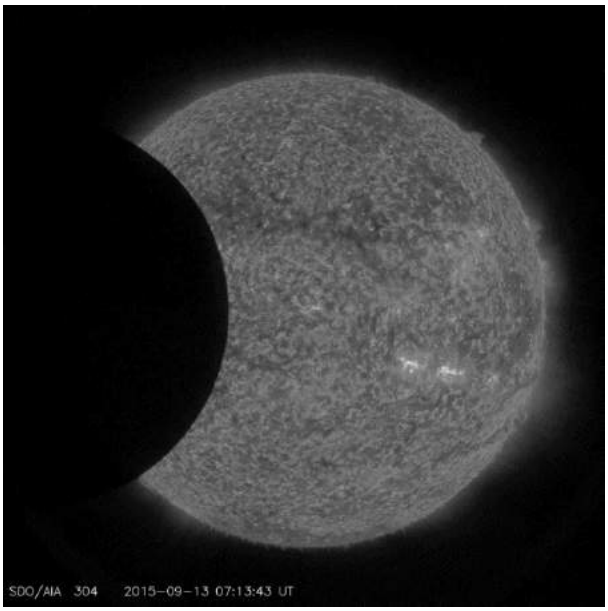
(A) Only statement I is correct.

(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

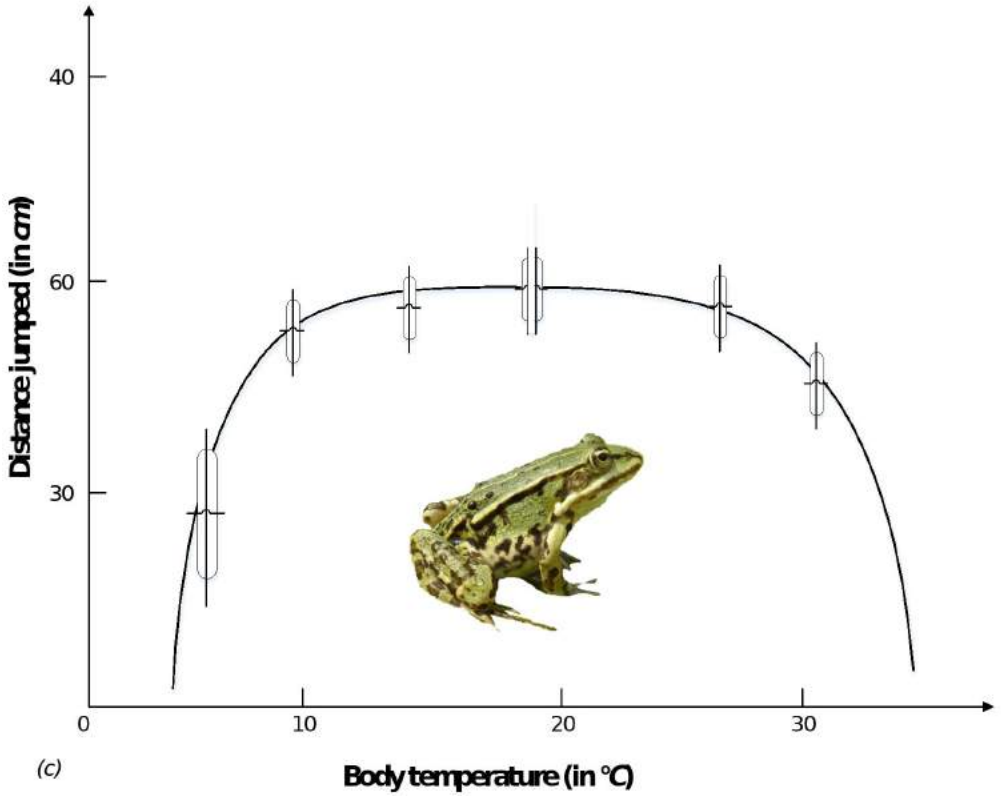
(B) Between 7 and 8 minutes

(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_20)
Magnesium chloride	$MgCl_2$ / solid	54.6
Ammonia	NH_3 / gas	34.0
Ethanol	CH_3CH_2OH / liquid	infinite
Benzoic acid	C_6H_5COOH / solid	0.29

(A) NH_3

(B) C_6H_5COOH

(C) $MgCl_2$

(D) CH_3CH_2OH

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%

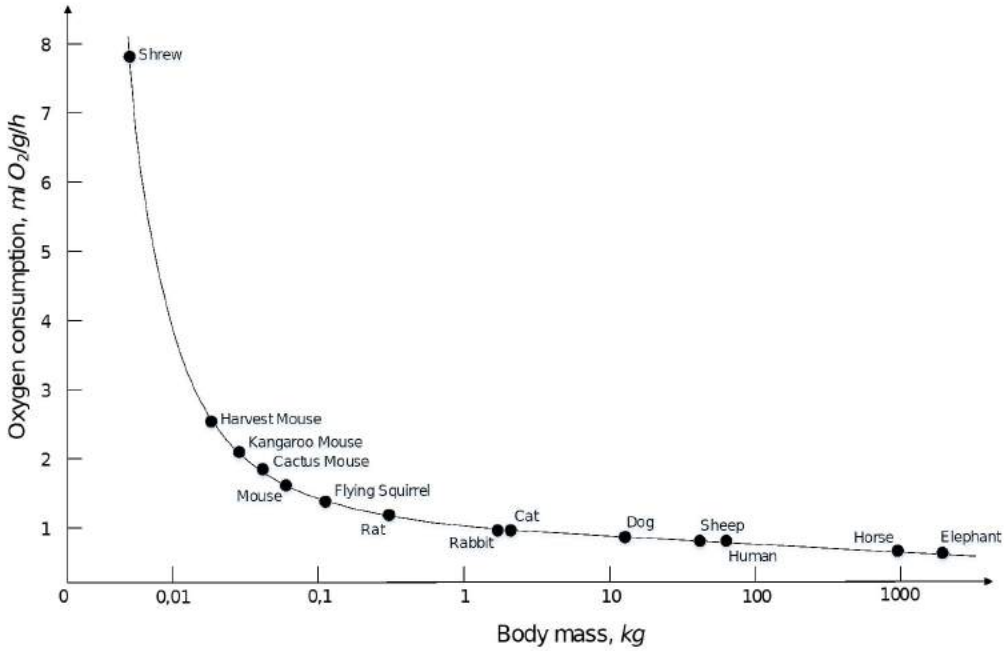
(B) 50%

(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.

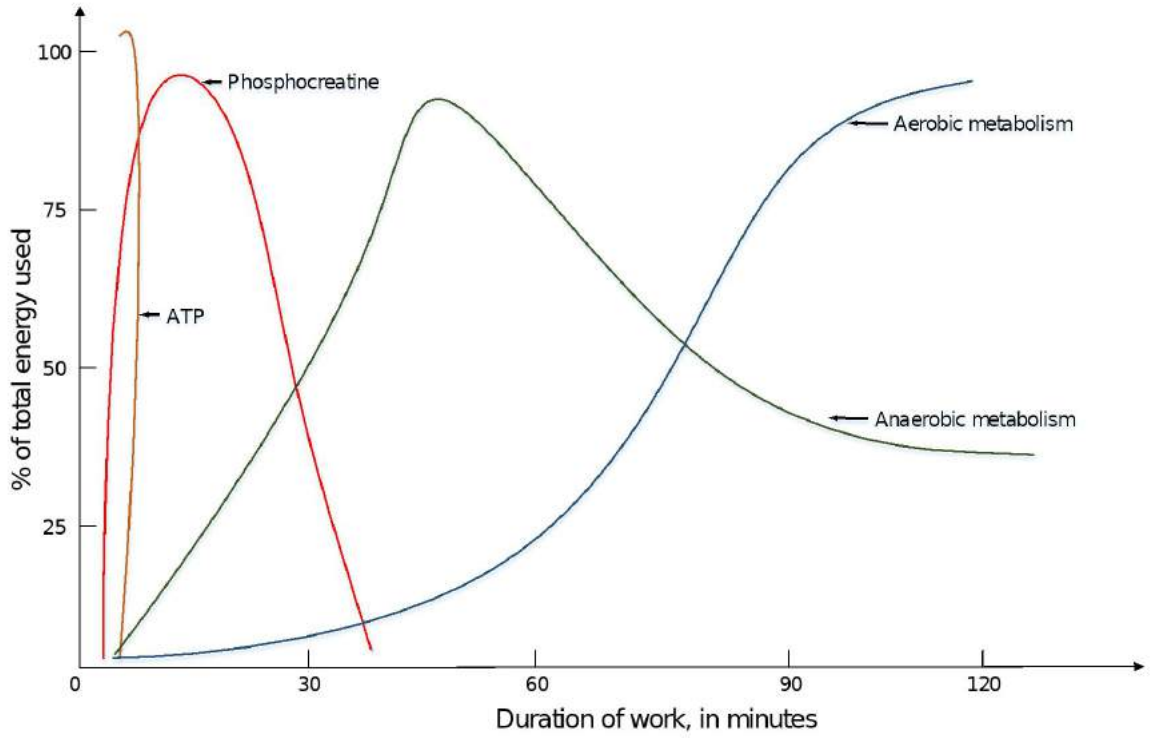
(B) turning protein into carbohydrates.

(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

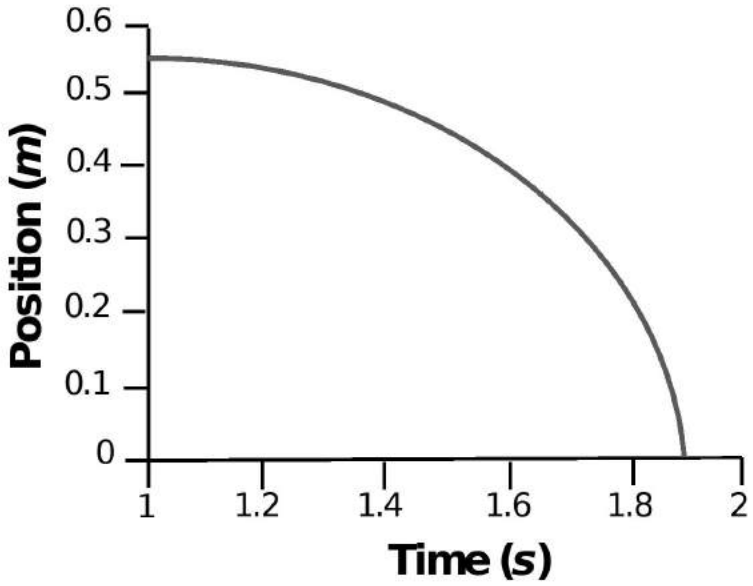
(B) Phosphocreatine

(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.

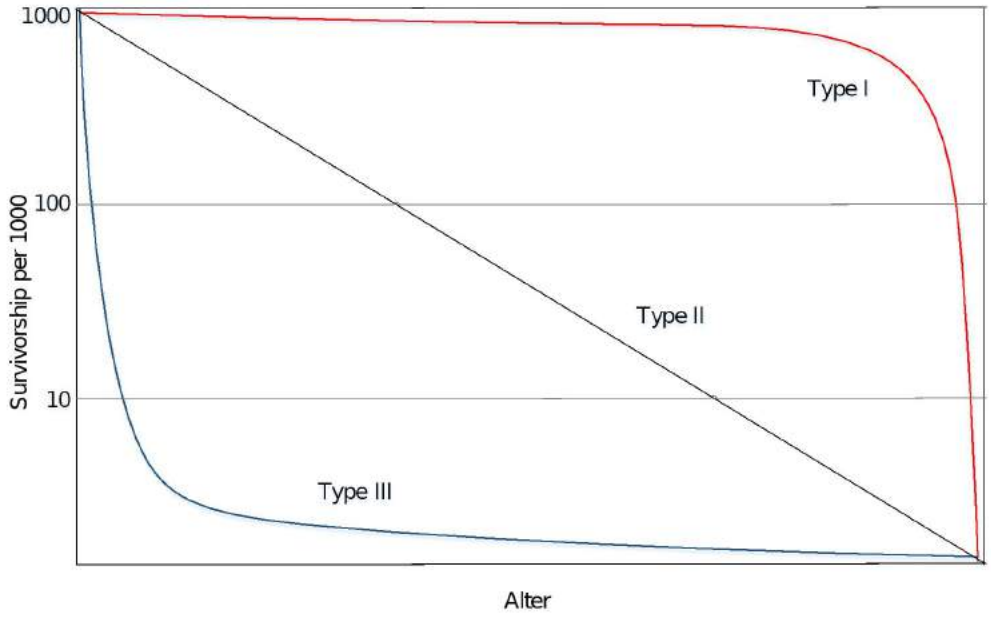
(A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

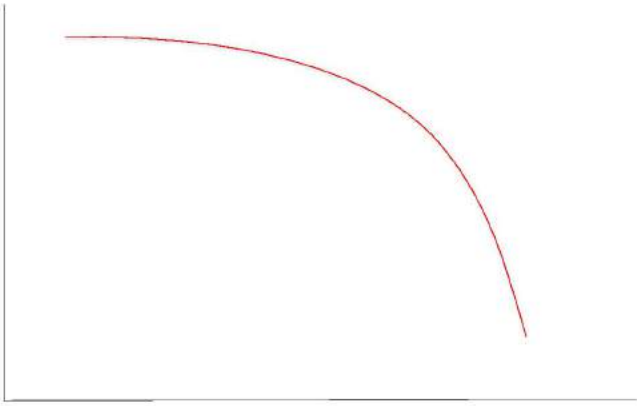
3.18.



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.

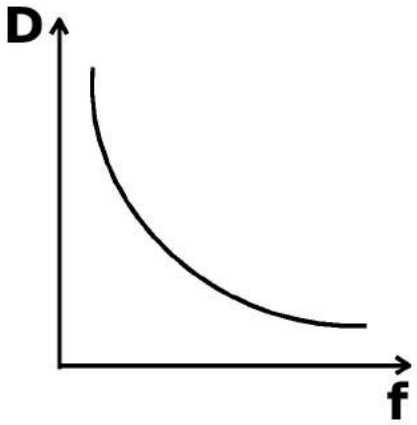
(C) Both statements are correct.

(D) Neither of the two statements is correct.

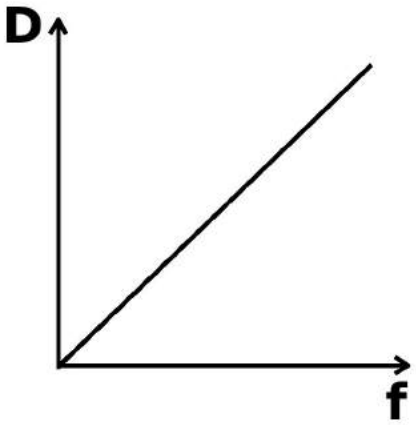
3.21.

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?

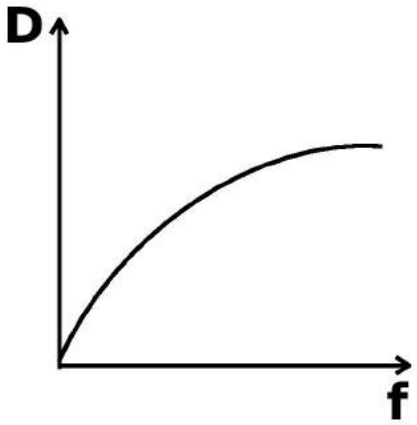
(A)



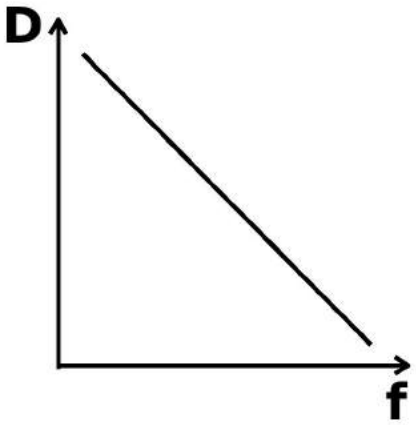
(B)



(C)

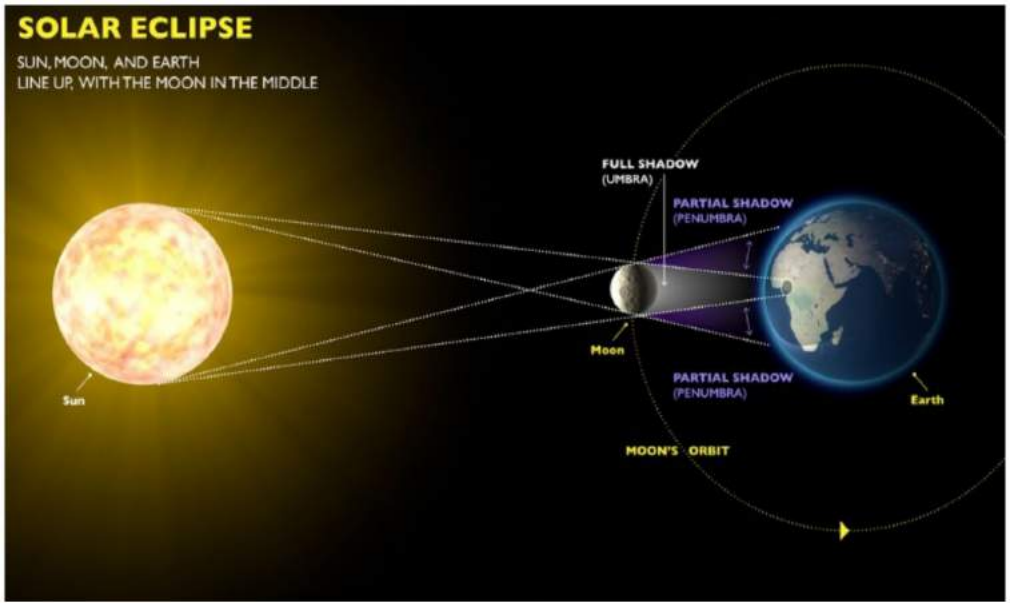


(D)



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

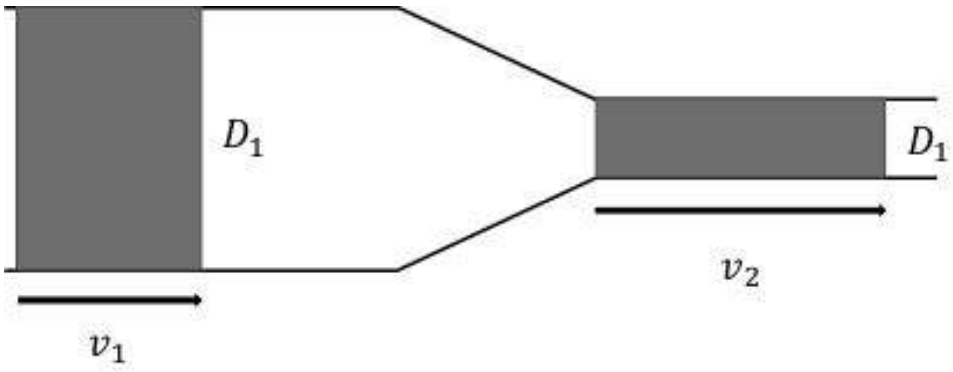
DETAILED ANSWERS

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: $U_{Earth} = 2 \times \pi \times r_{Earth}$

The band is exactly 1 meter longer than the circumference of the Earth:

$U_{Band} = U_{Band} + 1m$

$U_{Band} = 2 \times \pi \times r_{Band} = 2 \times \pi \times (r_{Earth} + x)$

$U_{Earth} + 1m = 2 \times \pi \times (r_{Earth} + x)$

$2 \times \pi \times r_{Earth} + 1m = 2 \times \pi \times r_{Earth} + 2 \times \pi \times x$

$1m = 2 \times \pi \times x \qquad x = \frac{1m}{2 \times \pi}$

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

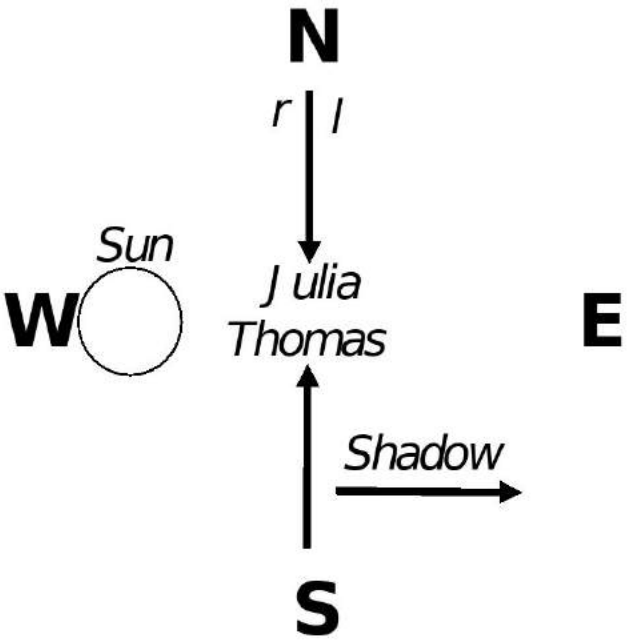
2.1. Answer: A

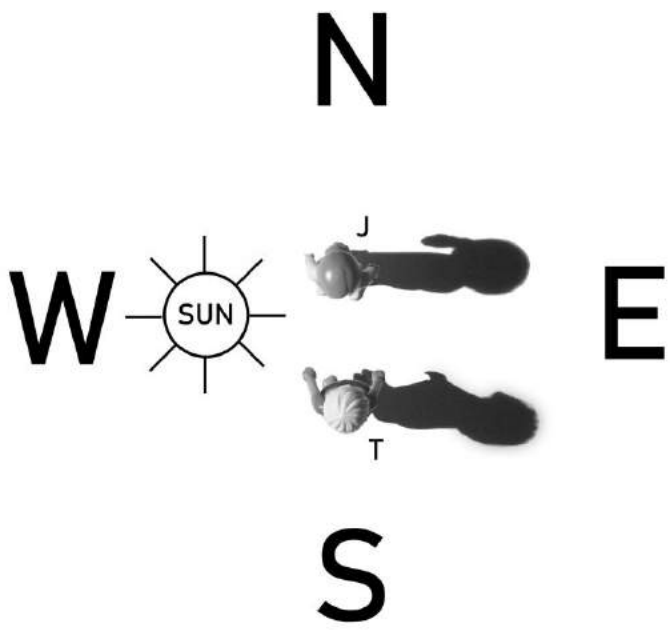
Condensation and evaporation both involve water changing state, but they do not involve a change in its molecular formula. While cooking meat is a chemical change, cutting up an already-cooked piece of meat is a physical change, since no change occurs on a molecular level. Respiration is a chemical change, 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

CO_2 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/s². 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 CO_2 and light intensity, initially, but only until a certain point. Past a level of CO_2 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 in incorrect: after a certain temperature, a further increase in temperature causes a decrease in the rate of photosynthesis.

2.11. Answer: B

$$N_2 + 3H_2 \rightarrow 2NH_3$$

You can also rewrite the equation so that the result is clear:

$$1N_2 + 3H_2 \rightarrow 2N_1H_3$$

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 easy 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 $\mathrm{CH_2CH(Cl)}$.

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 × 10^8 m/s = 300,000,000 m/s = 300,000 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 pass. 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: $\varrho = {}^{m}/_{V}$ *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.

APPENDIX: ANSWER SHEETS

4

Exam 1				
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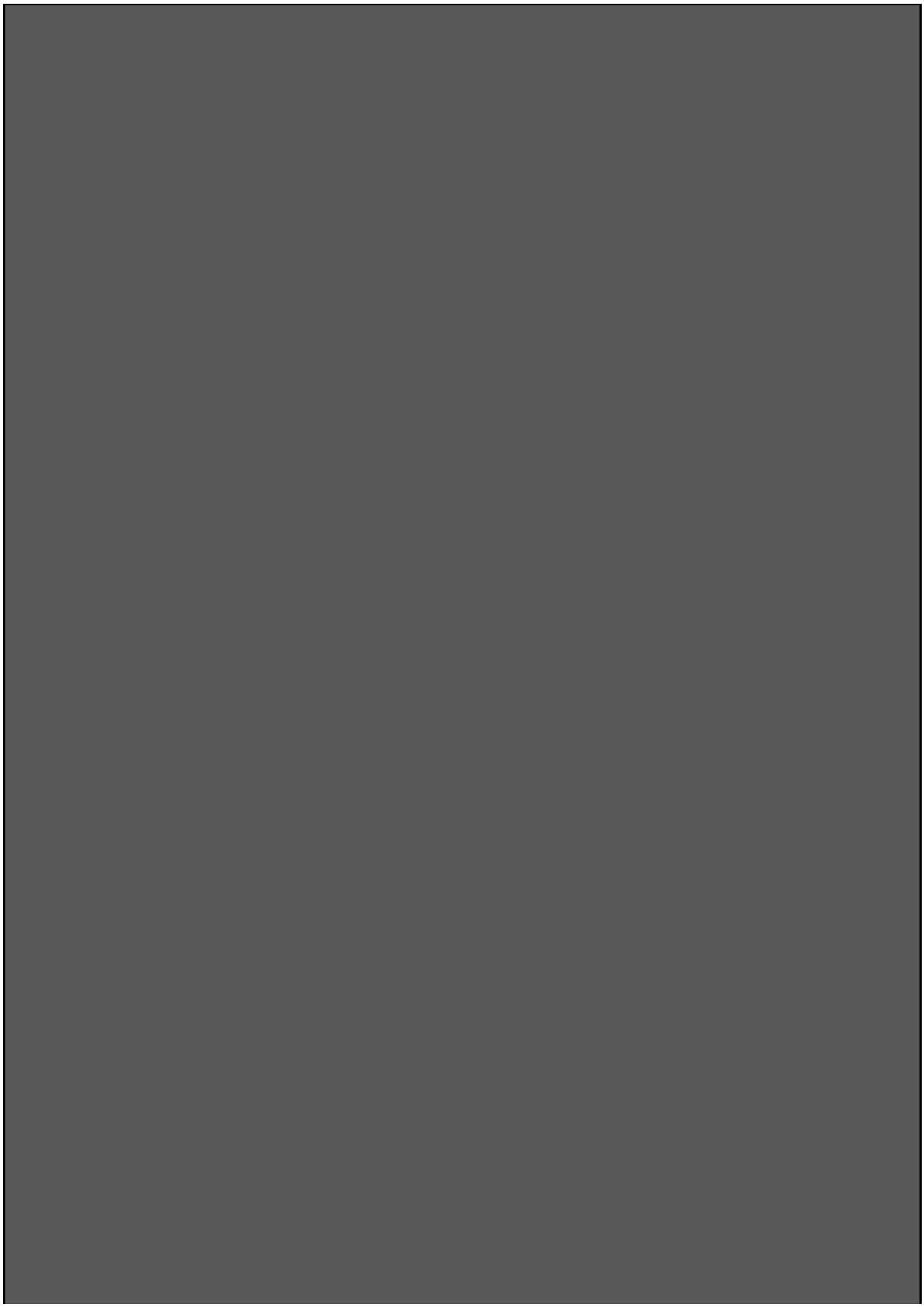

Exam 2				
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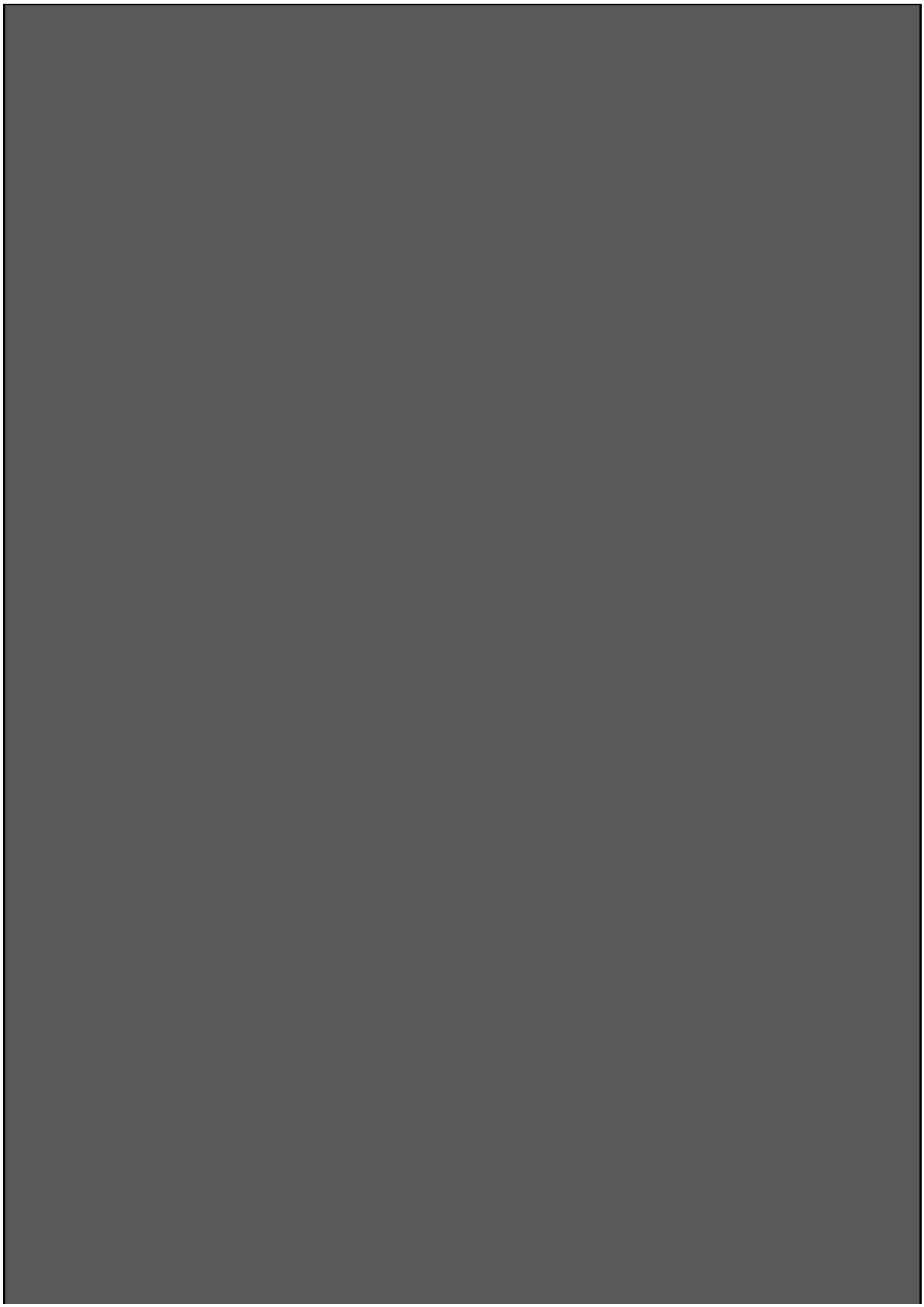

Exam 3				
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RSingermany
Chase Your Dreams

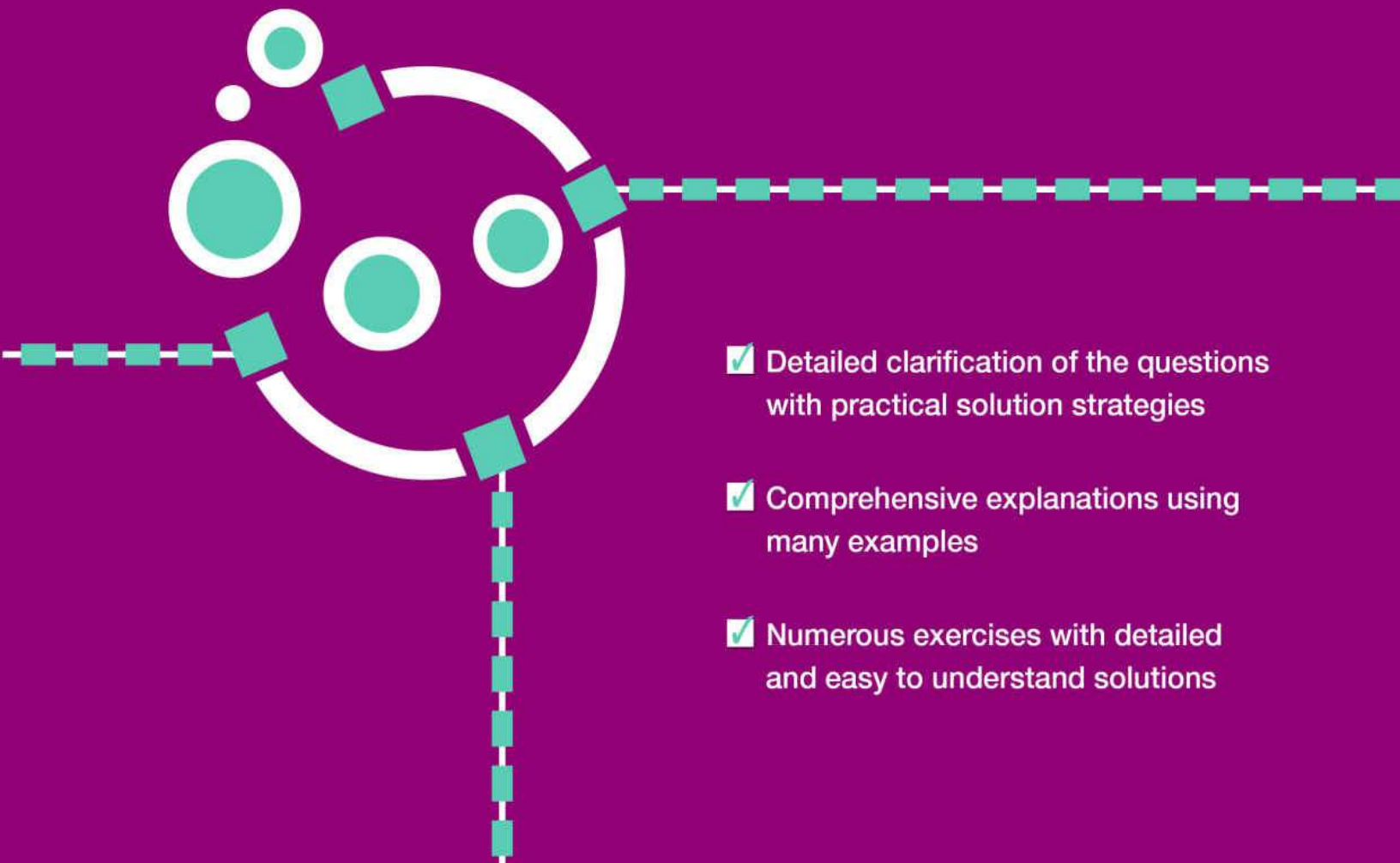
2. Preparation Book for the

TestAS

Mathematics, Computer Science and Natural Sciences

Understanding Formal Depictions

2020



- ☑ Detailed clarification of the questions with practical solution strategies
- ☑ Comprehensive explanations using many examples
- ☑ Numerous exercises with detailed and easy to understand solutions

2. Preparation Book for the TestAS Mathematics, Computer Science and Natural Sciences: Understanding Formal Depictions

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

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)

We will cover the first section “Analyzing Scientific Interrelationships” in a separate book. This book will focus on “Understanding Formal Depictions” through answering questions about a given flowchart and text. Previous knowledge is not necessary as the questions provide all required information.

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 assesses the skills which are necessary for a successful study in all courses. The second part of the exam is a subject-specific module (145-150 minutes), dependent on the field of study that you have chosen.

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 identfy 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.

STAY ALERT UNTIL THE END

Half (50%) of your grade on the Mathematics, Computer Science and Natural Sciences Module will be based on this section.

Many students struggle with this section because it is the last section of the 5-6 hours long test. Some even told us in the interviews that they guessed the last third of the questions simply out of “boredom”. Please make sure that you bring food and drinks to help you maintain your energy until the end of this section.

As with the core test, the scoring is done using a standardized curve. Your score is determined by your performance compared to the general TestAS student pool. By not giving up and scoring a few more questions correctly than the average, you can really improve your score.

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 effectivly.

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.

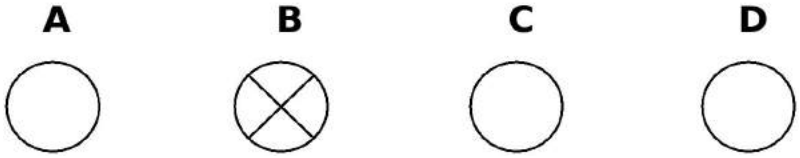
Determine which of the letters (A to D) you have selected the least on your answer sheet so far in that section. This will then be your letter-of-the-day (in past years each of the four answer letters were more or less equally often correct). Use that letter each time you guess (unless you have already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

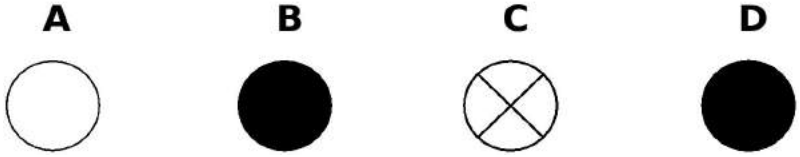
The questions of the core test and the subject-specific test modules are presented in a small exercise book. There is a **separate answer sheet** on which the answers must be marked with a ballpoint pen. Answers marked within the exercise book are not checked.

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.



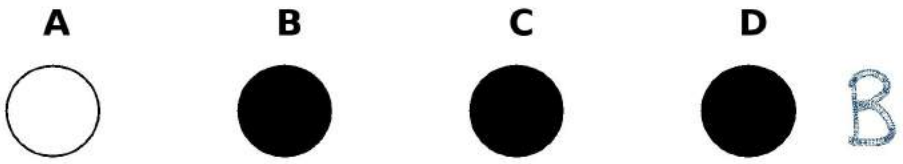
In case you need to change an answer that you already marked, fill in the entire wrong circle and put an X in your new answer choice. In the example below, D is marked.

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.

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.

UNDERSTANDING FORMAL DEPICTIONS

2 INTRODUCTION

In the subtest “Understanding Formal Depictions” you will be given different process flow charts and will need to answer questions based on the process map and the given text. The questions will likely require you to read certain information from the process chart, and you may be asked whether a certain outcome could possibly occur or not, based on the scenario in the question.

Process flow charts are frequently used to document and improve different business processes. You can think of these simply as a visual way of describing an operation. Some examples:

- A computer engineer maps out a process that he or she needs to code. Flow charts help engineers visualize the details of individual steps.
- A scientist records a sequence of tasks in an experiment. Flow charts help to establish correct experimental protocols (e.g., if the experimental procedure is particularly complicated or when multiple researchers are involved).

- A factory manager maps each step in the production of a product to identify areas for improvement.

Yet, common as they are in business life, process diagrams are quite unusual as topics for questions in a university entrance exam. Despite this, they can easily be practiced and you will quickly see that they are quite similar to a reading comprehension question, with the main difference being the reliance on a visual summary instead of a prose text.

This question type occurs in the Economics module, as well as the Mathematics, Computer Science and Natural Sciences module of the TestAS. Some of the questions use topics related to economics or natural sciences (e.g., how is a virus spread), but many others will be general questions based on decisions in your everyday life (e.g., the steps in deciding which university to apply to, how to use a payphone, or how to determine which internet provider to use).

In either case, the content of the question will not require any prior knowledge. You just need to understand the visual that is provided and answer the relevant questions.

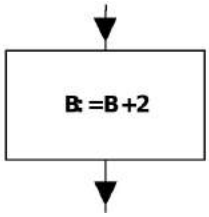
There are 22 questions in this subtest, which are given in increasing order of difficulty. You will have a total of 85 minutes to answer the questions. No additional time is given to you to read the instructions. Therefore, please refresh your memory the day before the exam by rereading the official booklet found on www.testas.de/en.

WHAT IS A PROCESS FLOW CHART?

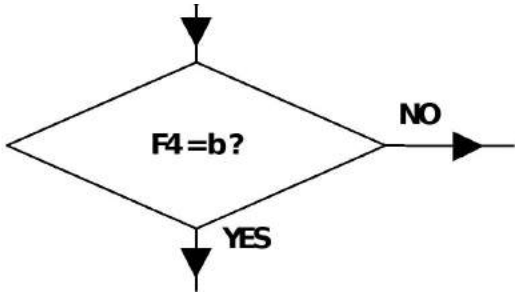
A flowchart is a visual representation of the individual steps in a sequence. In principle, it is a method in which a process or decision is described visually. Most flowcharts contain four types of symbols:

1. Ovals, which signify the start or end of a process.

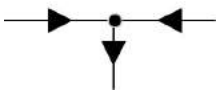
2. Rectangles, which show instructions or actions. We refer to these as **operation points**.



3. Diamonds, which highlight where you must make a decision. In this book, we refer to these as **decision points**. You need to answer the question with a yes or a no.



4. Arrows connect the symbols and show process flow. Dots show that two or more arrows are joined together to one arrow.



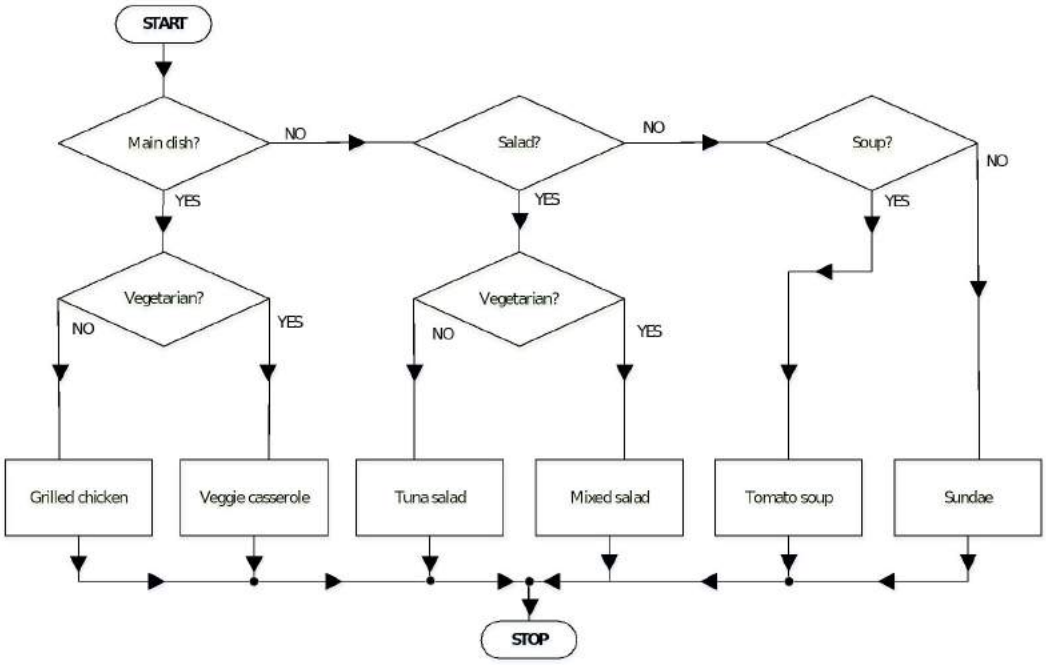
Let's look at a simple example.

EXAMPLE 1

In a restaurant there are six different meals offered. The restaurant manager would like to help the indecisive guests make a decision correctly (and quickly) and created the flow chart below.

The manager thinks that the order of the dish depends on a few different criteria. First, the customers need to determine whether they are hungry and are looking for a main dish. These customers should eat grilled chicken or veggie casserole. If they want something smaller than a main dish, a salad – which can be vegetarian or with fish – could be chosen. If the customers do not fancy salad either, they can get a soup or – for the ones wanting something sweet – a sundae.

The graphic shows the decision process of the customers, as envisioned by the restaurant manager.



EXAMPLE 1 – Question 1

Which of the following statements is or are correct?

I. If a customer is a vegetarian, veggie casserole is always chosen.

II. If a customer is a vegetarian, tomato soup is never chosen.

(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: There are other dishes for vegetarians. If a customer does not want a main dish but a salad, the mixed salad would be chosen. The statement is not correct.

Statement II: If the customer neither wants a main dish nor a salad, he will choose a tomato soup or a sundae. At this decision point it is irrelevant if the customer is vegetarian or not. The statement is not correct.

EXAMPLE 1 – Question 2

Which of the following statements is or are correct?

I. If a customer doesn't want a soup, the sundae will always be chosen.

II. If a customer is not very hungry and wants a salad, the veggie casserole will never be chosen.

(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

Statement I: There are other dishes. This statement is only correct if the customer doesn't want either a main dish or a salad. The statement is not correct.

Statement II: It doesn't matter if the customer is vegetarian or not, if he wants a salad and not a main dish, he will never choose the veggie casserole because this is a main dish and not a salad. The statement is correct.

As with some of the questions you will encounter in the exam, the text description of the question can be lengthy and rather repetitive of the visual. As seen in this question, sometimes you do not need to read the lengthy text. Rather, it is sufficient to look at the diagram and the question statements. This is especially applicable for the first few questions, which are the easiest ones.

There are different types of flowchart questions. Let’s review these.

TYPES OF QUESTIONS

TYPE 1 – JUST LIKE A PARAGRAPH

In this question type, the flow chart is the visual version of the given text. The decision and operation points in the flow chart need to be inspected to determine the relationship between them. Most of the time, there are three decision points, meaning that the decisions are not very complex. However, toward the end the questions, there may be an excess of ten decision points and a total of 16 decision and operation points.

Almost always the visual will have at least the same information, and oftentimes more information, than the long explanatory text. Because of this, you may be able to skip reading the lengthy text, but you cannot skip the flowchart. You may try the following strategy to answer the questions quickly:

- **Step 1:** Read the question statements.
- **Step 2:** Review the flowchart. You may be able to answer the questions already!
- **Step 3:** If you can't answer the questions based on the visual only, read the lengthy introductory text preceding the flowchart .

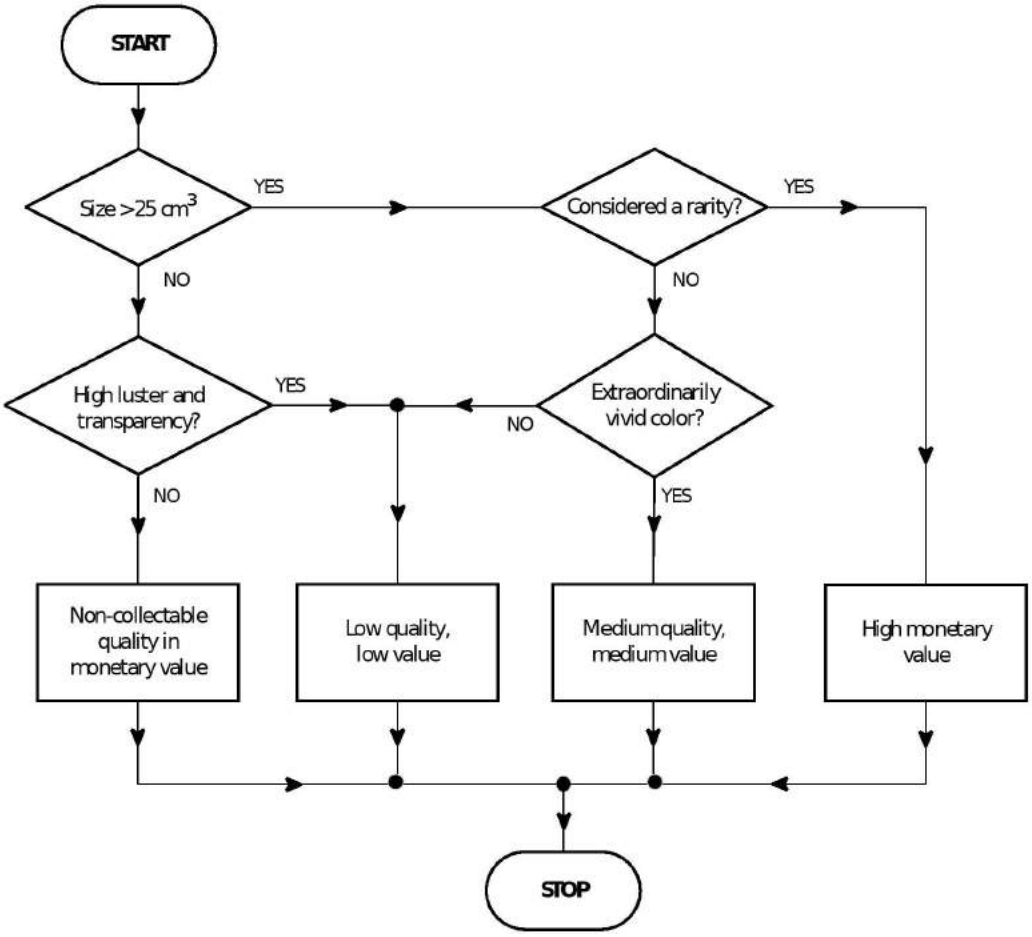
Try and see if this works for you. This approach will not work with flowchart questions when there are missing/unspecified values.

EXAMPLE 2

Mineral collecting is the hobby of systematically collecting, identifying and displaying mineral specimens. People pursue this hobby for different reasons. Some merely like the act of collecting and putting together a collection. Others collect minerals because of their beauty and some just love the thrill of hunting the perfect mineral and possibly making a good income. This last category of hobbyists have a clearly defined criteria to determine how valuable the collected minerals are.

- The size of the specimen
- Luster (=shininess) and transparency of the stone
- Color of the specimen
- Rarity of the species

The following flowchart illustrates the process used by these collectors.



Which of the following statements is or are correct?

I. If a mineral is considered a rarity, it will command a high market value.

II. There is no monetary value for collecting a stone in the shape of a sphere with a diameter of 4 cm unless its luster or color are extraordinary. (Volume of a sphere: $4/3\ \pi r^3$).

(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. If a mineral is considered a rarity, it will have a high monetary value.

Statement II is not correct. A sphere with a diameter of 4 cm has a radius of 2 cm. Entering the radius in the given formula, we get a volume of 33.5 cm^3. This is above the given size limit of 25 cm^3. According to the flow chart any stone above this size has a monetary value if its color, not its luster, is extraordinary.

As with this example, some question will require you do simple arithmetic, but there is no need to memorize anything in advance. All necessary information/formulae will be provided. Additionally, this problem could be easily solved without needing to read the text paragraph located before the flowchart.

TYPE 2 – MISSING VALUES

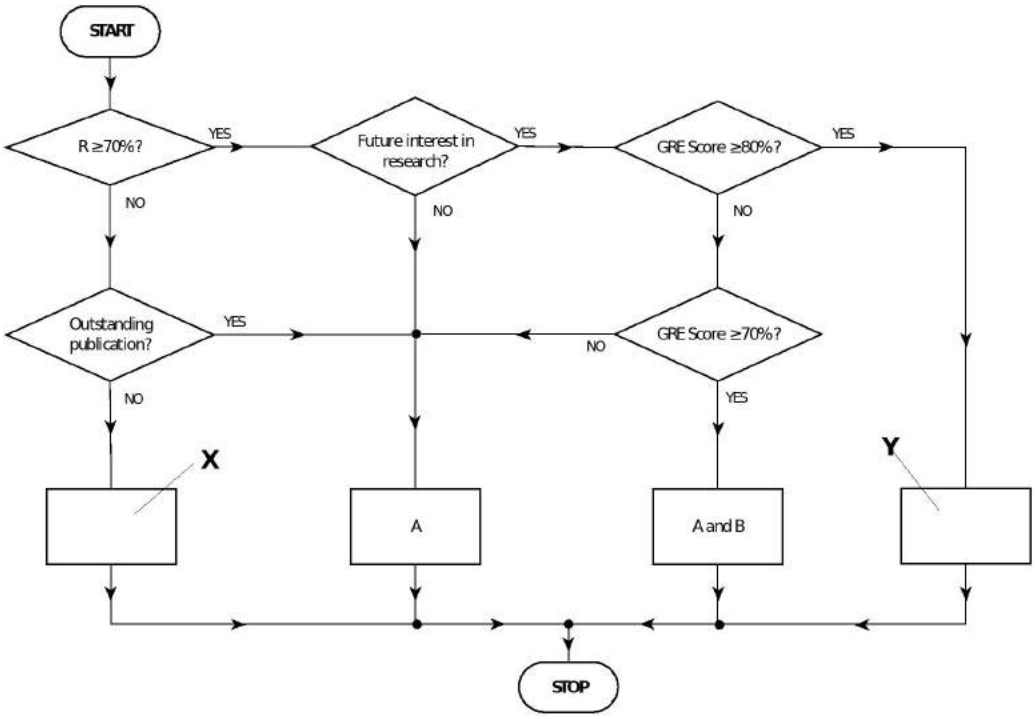
In the second frequently encountered question type, some of the information in the flow chart is missing. Oftentimes the question is whether the missing information can be substituted with the given statements. The easy questions will have one or two decision and operation points missing, while toward the end you can have six decision and operation points missing.

Below we provide an easy example.

EXAMPLE 3

While selecting students for a PhD program, US universities review a variety of prerequisites. The most important criteria are the grade point average results (R) of the last course (Master, if a Master has been completed, otherwise Bachelor), which can be a maximum of 100%, the score for the GRE exam (standardized test for admission to US graduate schools), and the student's attitude towards research (is he/she interested in research? Has he/she already published outstanding publications?). Three universities are considered in this question: A, B and C. For someone with an average final grade below 70% of the maximum number of points, it is very difficult to be accepted into a PhD program. The only exception is when the student has excellent publications. University A has the least stringent criteria of the three universities and accepts everyone who qualifies for B or C. If you want to receive all three offers, you must have good grades (at least 70% of the best possible score), be among the top 20% in the GRE exam, and show real interest in research.

The following flowchart can be used to determine which students qualify for which universities:



EXAMPLE 3 – Question 1

Which of the following statements is or are correct?

I. Here, X could mean “Acceptance by none of the universities”.

II. Y could mean “Acceptance by all of the universities”.

(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

Here you have to transfer the information from the text to the graphic and then check if it is correct. If you have difficulties doing this, you may wish to write it down in the form of a formula X = ……., Y = ……. This way, you have an overview and a better understanding of the statement.

In this example question, you know from the context that only "not accepted to any university" is possible for X since none of the prerequisites have been fulfilled. For Y, however, all of the necessary conditions have been fulfilled, so it stands for "accepted at all universities" and is therefore also correct.

EXAMPLE 3 – Question 2

Which of the following statements is or are correct?

I. To be admitted by University A, the applicant must have a GRE score of at least 70%.

II. Applicants have a chance of being admitted to University C if they graduated with grades in the top 10% of the possible range and would like to conduct research.

(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

The first statement is incorrect because the diagram shows that University A does not consider the GRE score.

The second statement is correct because the diagram shows that applicants can be admitted to University C with the stated criteria as long as the GRE score is at least in the 70th percentile. Therefore, an applicant whose grade point average is in the top 10% would also be admitted to University C.

EXAMPLE 3 – Question 3

Which of the following statements is or are correct?

I. “B” is the university where you need a research interest if you do not have a GRE score of 70%.

II. If your grades from your most recent diploma are in the top 30%, you are guaranteed a spot at University 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.

Answer: B

If you have a GRE score less than 70%, then you will not be admitted to University B. Statement I is incorrect.

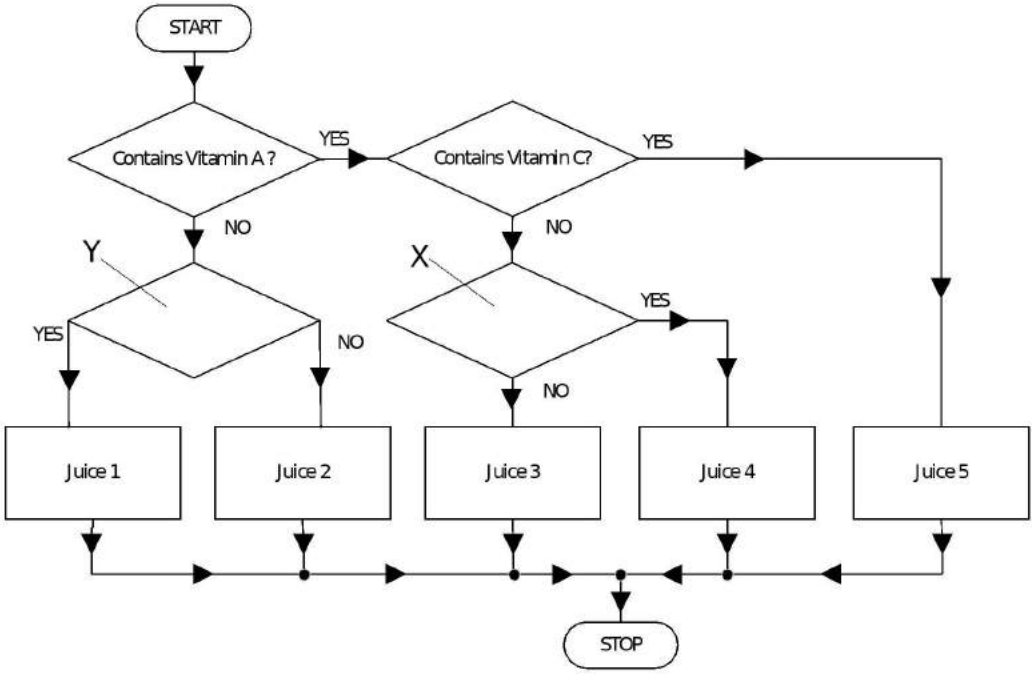
It is sufficient to have grade point average results (R) of over 70% to get admitted to University A. Statement II is correct.

EXAMPLE

There are various vitamins found in fruit juices. There are 5 fruit juices: Juice 1, Juice 2, Juice 3, Juice 4 and Juice 5. Each of the juices contains various combinations of vitamin A, vitamin B6, vitamin C, or vitamin E.

Juices 3, 4 and 5 contain vitamin A; Juices 1, 3 and 4 contain vitamin B6; Juice 5 contains vitamin C; and Juices 2, 3 and 5 contain vitamin E. (See graphic. “Vit.” is the abbreviation for vitamin).

Juice 1	Juice 2	Juice 3	Juice 4	Juice 5
Vit. B6	Vit. E	Vit. A Vit. B6 Vit. E	Vit. A Vit. B6	Vit. A Vit. C Vit. E



EXAMPLE 4 – Question 1

Which of the following statements is or are correct?

I. If decision point X is labelled “Contains vitamin E?”, the flow chart may be correct.

II. If decision point Y is labelled “Contains vitamin E?”, the flow chart may be correct.

(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: Juice 3 contains vitamin E (see description above). If “Contains vitamin E?” is found at decision point X, then Juice 3 would not have vitamin E since the arrow at Juice 3 would point to “No”. The statement is not correct.

Statement II: If “Contains vitamin E?” is found at decision point Y, then Juice 1 would have vitamin E and Juice 2 would not. In fact, it is exactly the other way around: Juice 1 does not contain vitamin E, Juice 2 contains vitamin E. The statement is not correct.

EXAMPLE 4 – Question 2

Which of the following statements is or are correct?

I. If decision point X is labelled “Contains vitamin B6?”, the flow chart may be correct.

II. If decision point Y is labelled “Contains vitamin B6?”, the flow chart may be correct.

(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

Statement I: The statement is not correct. Juice 4 contains vitamin B6 and is correctly displayed with “Yes”. However, the arrow towards Juice 3 says “No”, and in this case, this would mean that no vitamin B6 should be found within the juice. According to the introduction, the exact opposite is true: The juice contains vitamin B6. The statement is not correct.

Statement II: The statement is correct. The arrow towards Juice 1 says “YES” for vitamin B6, which Juice 1 indeed contains. For Juice 2, the arrow says “NO” for vitamin B6, which is also correct because this juice contains only vitamin E.

TYPE 3 – EQUATIONS IN THE FLOW CHART

In this question type, there are simple calculations/equations which you need to conduct to derive the answer. The following notation is used:

2 □ This means that B is now equal to 2.

M + 1 □ This means that the value of M is increased by 1. If M was 102 before, it is now 103.

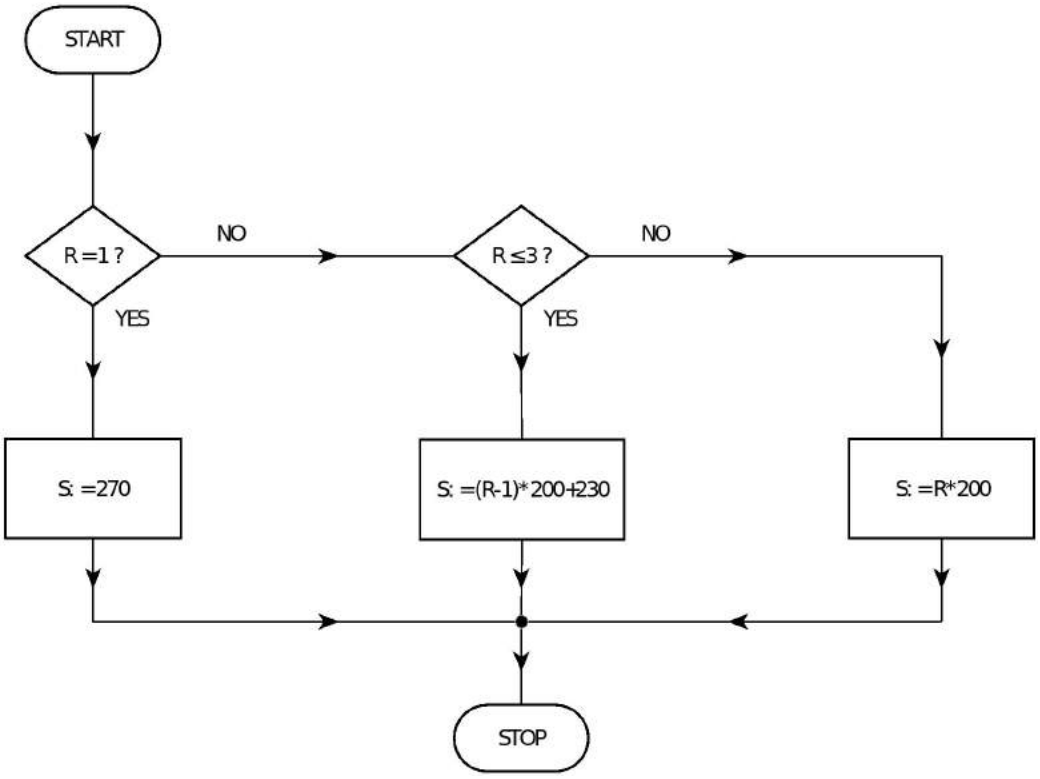
Q – R □ The value of Q is decreased by the value of R. E.g., if
Q = 22 and R = 5, after this operation point Q will be 17.

EXAMPLE 5

In country ABC, students receive a monthly scholarship from the government depending on the number of children in the family studying and receiving a scholarship.

R: The number of children in the family receiving the scholarship.

S: The total € amount of the scholarship given to the family for all children.



Which of the following statements is or are correct?

I. If a child has two siblings, the total scholarship amount for the family is 430 €.

II. If in a family a fourth child starts using the scholarship, the family will receive an additional 170 € each month.

(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

Statement I: The total amount for three children (child plus the two siblings) is

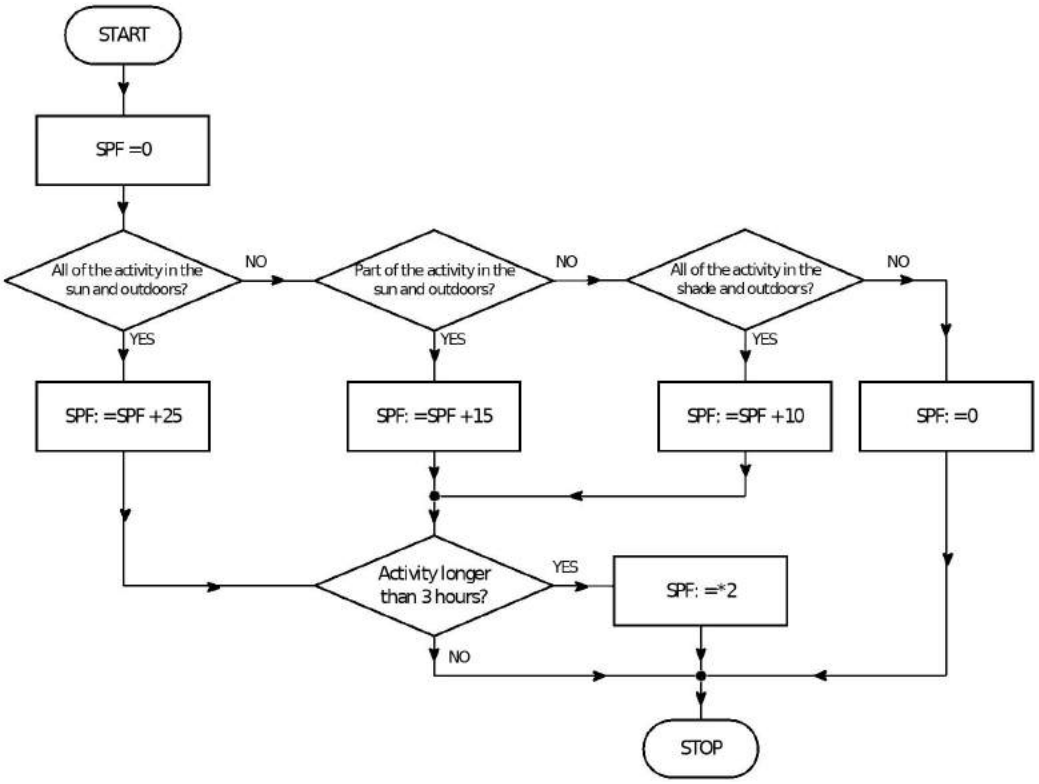
(3 – 1) × 200 € + 230 € = 2 × 200 € + 230 € = 400 € + 230 € = 630. The statement is not correct.

Statement II: The difference between scholarship for 3 children (630 €) and for 4 children (4 × 200 € = 800 €) is 170 €. The statement is correct.

EXAMPLE 6

During the summer, people spend a lot of time outside. There is seldom a better time for hiking or swimming. Too much UV radiation found in sunlight can, however, result in immediate injuries such as sunburn or, in the long-term, could lead to skin diseases. It is especially important to protect yourself appropriately, for example, by using a sunscreen lotion with a sun protection factor (SPF). Even when in the shade, you should lotion yourself anyway since almost 50% of the sun's direct rays can still reach you.

The flowchart below expresses the decision criteria that a teacher should follow for summer school.



Which of the following statements is or are correct?

I. If the activity takes place outdoors for 7 hours and is equally divided between time in the sun and time in the shade, then a sunscreen with SPF50 should be applied.

II. If the activity takes place outdoors, but only in the shade, then no sunscreen is needed as long as the time outdoors does not exceed 3 hours.

(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.

TIP

First read statements I and II. There you can see what information you need to answer. Next, look at the graphic to see where you can find this information. Information may also appear in the text before the flowchart. When you have gathered all the information, look at the relationships between the information and check whether the statements are correct or incorrect.

Answer: D

Statement I is not correct.

1st decision field □ No

2nd decision field (partly in the sun and outdoors) □ *Yes, then SPF = 15*

3rd decision field (Activity > 3 hours?) □ *Yes, then SPF 15* × *2 = SPF 30 (not SPF 50)*

Statement II is not correct. One needs a sunscreen with SPF 10 outdoors if it is shady. Only when the activity does not take place outdoors, no sunscreen is needed.

NOTE:

At this point we would like to emphasize again what we said at the beginning of this chapter:

In the test, there are several questions which consist of a long and sometimes redundant text and flow charts. It is highly recommended to first have a look at the statements and the flowchart, and then only read the text when needed.

NEW LOGIC EXERCISES

In the section “Understanding Formal Depictions” most of the questions are based on process charts. In recent tests, there have been few new questions styles (only 1-2 questions per test). They all test the ability to read a text, interpret the given visual, and make a conclusion based on the given information. Below we provide a few examples.

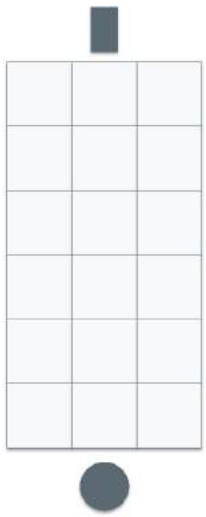
EXAMPLE 7

The drawing shows a game for two players (the circle and the rectangle). The two players begin at opposite sides of the board.

Each player is allowed to choose a starting square in the first row, from which they will start the game.

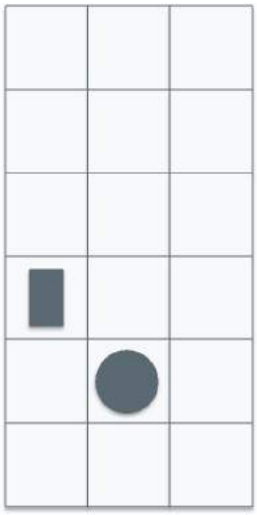
The players may only move in two directions: forward and sideways. Each player chooses one of these directions for their first move. For their second move, they must switch to the other direction. On their third move, they revert back to the original direction. One player begins by moving forward. The first move must be forward. They must then move sideways, then forward again.

The game is won when one of the players meets the other one and blocks their way, preventing them from making any more moves.



EXAMPLE 7 – Question 1

Which of the following statements describes what will happen on the next move if the rectangle must move sideways?



(A) The circle loses.

(B) The circle could lose.

(C) The rectangle loses.

(D) The rectangle could lose.

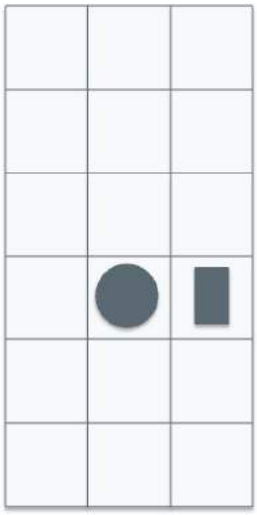
Answer: B

If the circle has to move forward The circle loses.

If the circle has to move sideways Nothing happens.

EXAMPLE 7 – Question 2

Which of these statements is true for the next move?



(A) If it is the circle's turn to move, it will not lose.

(B) If it is the circle's turn to move, it will win.

(C) If it is the rectangle's turn to move, it will lose.

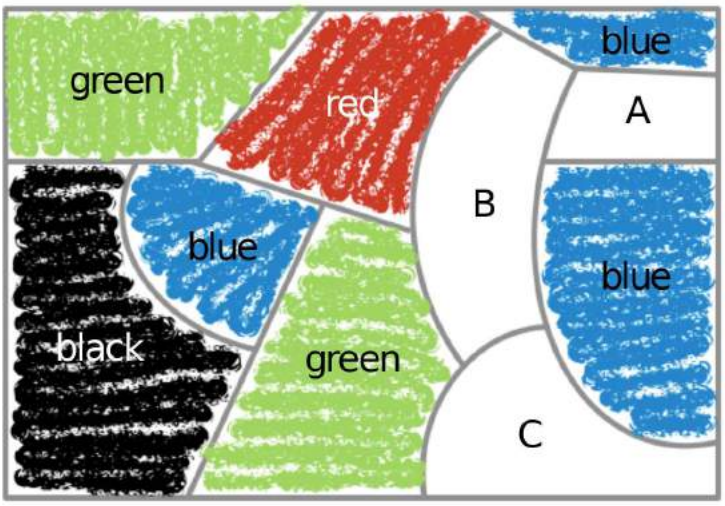
(D) The game is a draw.

Answer: A

Answer B cannot be true, since the circle must move either forward or to the left. C is not necessarily true, since it could be that the rectangle must move forwards. D is not necessarily true, since it could be that the rectangle is now required to move sideways (in which case it has lost).

EXAMPLE 8

Which statements are correct if two regions of the same color cannot be directly touching? There are four colors to choose from: red, blue, green and black.



(A) A must be red.

(B) A and C must have the same color.

(C) C could be red or black.

(D) B must be black. A and C can have the same color.

Answer: D

Start by looking at Area B since it is touching the largest number of different colors already (red, green and blue). This means that B must be black. Area C is now touching the colors green, blue and black and must therefore be red; this means that Answer C is incorrect. Area A is the only area remaining and is already

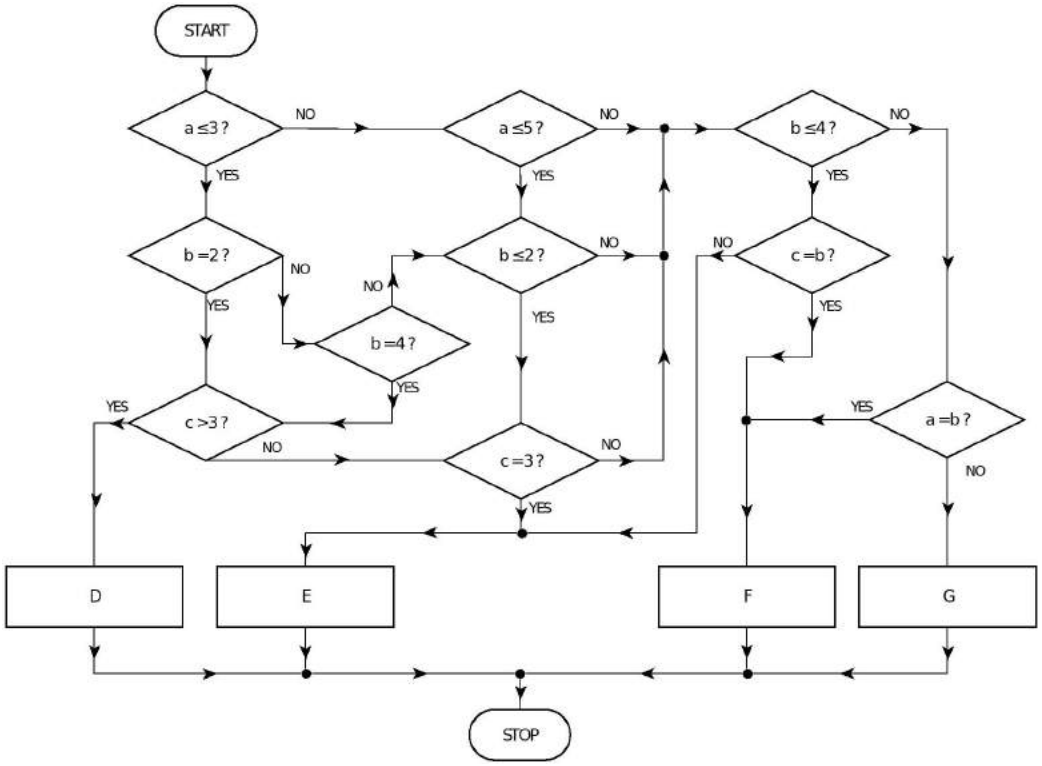
touching blue and black; this means it could be either red or green. Accordingly, Answer A and B are incorrect and Answer D is correct.

TACTIC FOR DIFFICULT QUESTIONS – BACKTRACK

In complex flow charts – if the question statement asks whether a certain output is possible, it may be easier to backtrack. So, start from the outcome and then go back step by step.

EXAMPLE 9

The graphic shows the decision for option D, E, F or G depending on the parameters a, b and c.



EXAMPLE 9 – Question 1

Which of the following statements is or are correct?

I. If a = 4 and b = 3, then only option E or F can be chosen.

II. If b = 1 and c = 4, then only option E or F can be chosen.

(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: If a = 4 and b = 3 and one follows the flow, then one ends at the decision point c=b?. If yes, then F and if no, then E. The statement is correct.

Statement II: First we run the scenario that a $\leq$ 3; b = 1; c = 4. We end with option E.

Now we need to check whether or not F can also be an outcome. We already know that b = 1 and c = 4, so we need to check the decision point, i.e. whether the question a $\leq$ 5 is answered with a Yes or No. F is not an option in these cases. The statement is not correct.

Alternatively, you can backtrack from the stopping point F. To end at F, you either need b = c, which is according to the statement not the case, or a = b to be true; this could be true according to the question statement. So, you need to go back one step further. Is

b ≤ 0? No, this is not the case. The statement cannot be correct.

NOTE: If the question mentions a precise output, it may be faster to backtrack from the end.

EXAMPLE 9 – Question 2

Which of the following statements is or are correct?

I. If c = b is true, then option F is always chosen.

II. If option F is chosen, then b is always less than 4.

(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: Another option can also be chosen, for example, D if b = c = 4 and a = 3 are true.

This question seems easy to answer when we take the decision point c = b into consideration. This is, however, misleading because this decision point is found deep within the process and we do not yet know how the 3rd decision criterion behaves. In order to answer this question, we have to test various scenarios. As soon as we find a combination of a, b and c, and when b = c F is not true, then we can disprove the statement. To solve this problem, it is best that we start systematically. This means starting at the far left with a ≤ 3 Yes.

Step 1: a ≤ 3 Yes. We assume, for example, that a = 3.

Step 2: b = 2 Yes. We assume that b = 2. Now we have to see where we would end up if c = 2. We end up at F.

Now we will start again with the next scenario. Step 1: a ≤ 3 □ Yes. Step 2: b = 2 □ No. Step 3: b = 4 □ Yes. Now let us test where we end up when b = c = 4. We end up at option D. The statement is not correct.

NOTE: It is important to test the various scenarios systematically. This way you will be fast and will not overlook possible options.

Statement II: If a = b is true, then it is possible to reach option F even when b is greater than 4. E.g. a = b = 6.

OVERVIEW OF THE MOST IMPORTANT TIPS

- **Be systematic.** If a question is complex with many decision and operation points, some students panic and look wildly at the flowcharts for hints. Instead, go systematically from the start, decision point by decision point. You will be quicker and also avoid falling into easy traps.
- **Practice for speed.** This question type is one of the easiest subtests to train for. Once you get used to reading the flow charts, you will see them as a concise way of expressing a long decision process.
- **Solve a few questions the day before the exam.** Many students forget about this question type and lose precious time reading the instructions during the test.
- **Don't give up – everyone is tired, like you.** The goal is to beat the average, so make an extra effort in this section where some test takers have already given up.
- **First read the question statements and then review the flow charts**. In questions without missing values, you may already be able to answer the questions without reading the lengthy text.
- **Don't be afraid to choose option D**, "Neither of the two statements is correct", especially if the question statement uses absolutes like "always" and "never".
- If the flow chart is complex with many nodes and the question asks for a final outcome, you can consider **starting from that end point and backtracking** to each connecting node.
- If a question asks for gaps to be filled (e.g., "if X is 10, could the flow chart be correct?"), consider **taking notes on the test booklet with a pencil**. It makes calculations easier.
- When you feel tired, it is easier to make simple mistakes in this question type. In such cases, make notes as you evaluate the flow chart. **Actively follow the move across the process chart**, either with your fingers or your pen, but not passively with just

your eyes. You will be more likely to make mistakes if you try to work from memory alone.

- In calculation flow charts, you need to make a few simple calculations as you progress through the flowchart. **If you write down the result of each calculation, you will be less likely to make mistakes.**

PRACTICE QUESTIONS

In total, you have **85 minutes** in the TestAS exam to complete the **22 questions** in the section “Understanding Formal Depictions”.

For an optimal exercise result, we recommend that you complete the exercises with a stopwatch. This will allow you to test how well you can manage under the time constraints. At the end of the chapter you will find the solution key, as well as detailed explanations for the solutions.

EXAM 1

TEXT AND FLOW CHART FOR QUESTIONS 1.1. AND 1.2.

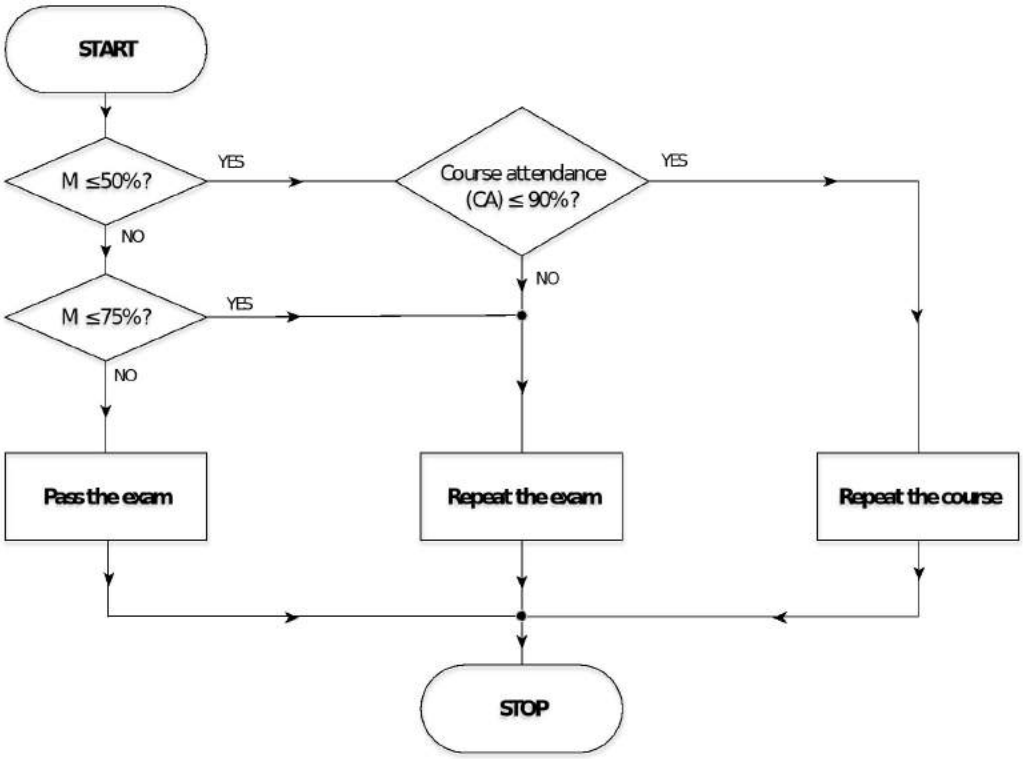
The results from one exam are divided into 3 categories (Mark = M).

M $\leq$ 50%; M $\leq$ 75% and M $\leq$ 100%.

The participant of a course has three options:

- repeat the course
- repeat the exam
- pass the exam

The following flow chart shows how a decision can be made.



1.1. Which of the following statements is or are correct?

I. If a student attended (CA) less than or exactly 90% of the course, the exam is always repeated.

II. If the CA ≤ 90% for all students, then all of the students will repeat the course.

(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. Which of the following statements is or are correct?

I. With mark M = 75%, the student always has to repeat the exam.

II. With CA = 100%, the student never has to repeat the exam.

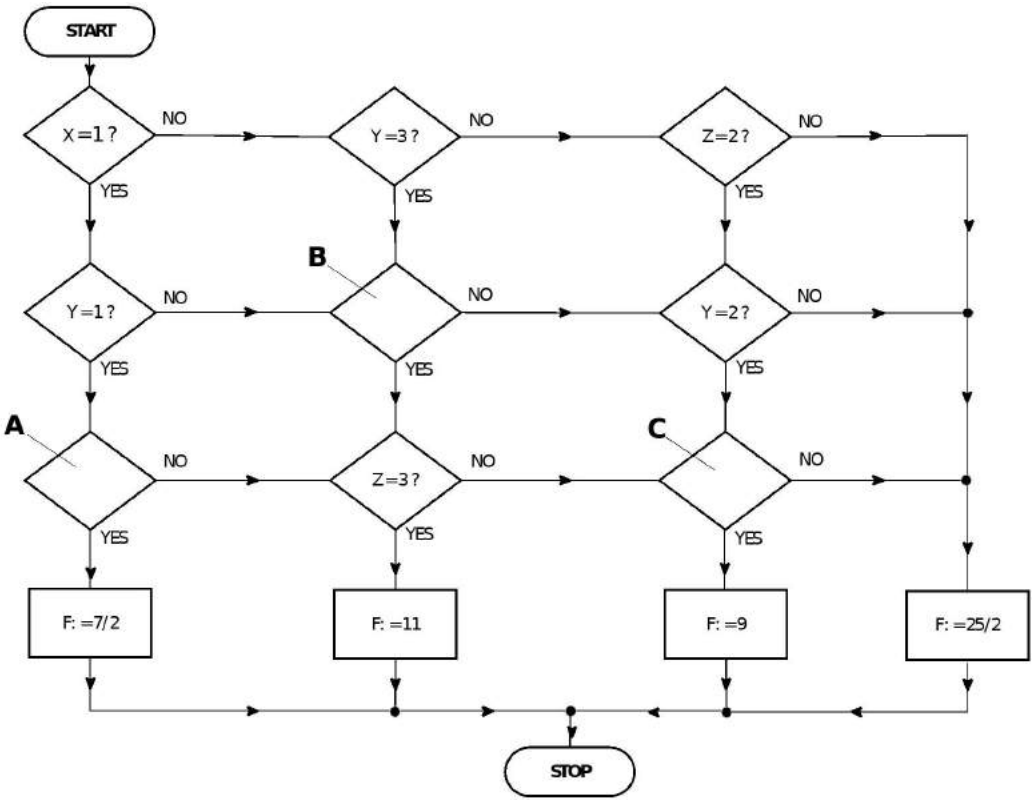
((A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

1.3. We have the following equation : F = $\frac{1}{2}$ x + y + 2z. The following flow chart shows the result of F for specific values of x, y, z.



Which of the following statements is or are correct?

I. We need to place “X = 4 ?” in decision point B to have F: = 11 as a result.

II. For F to be equal to $\frac{7}{2}$ decision point A needs to be “Z = 1”.

(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.

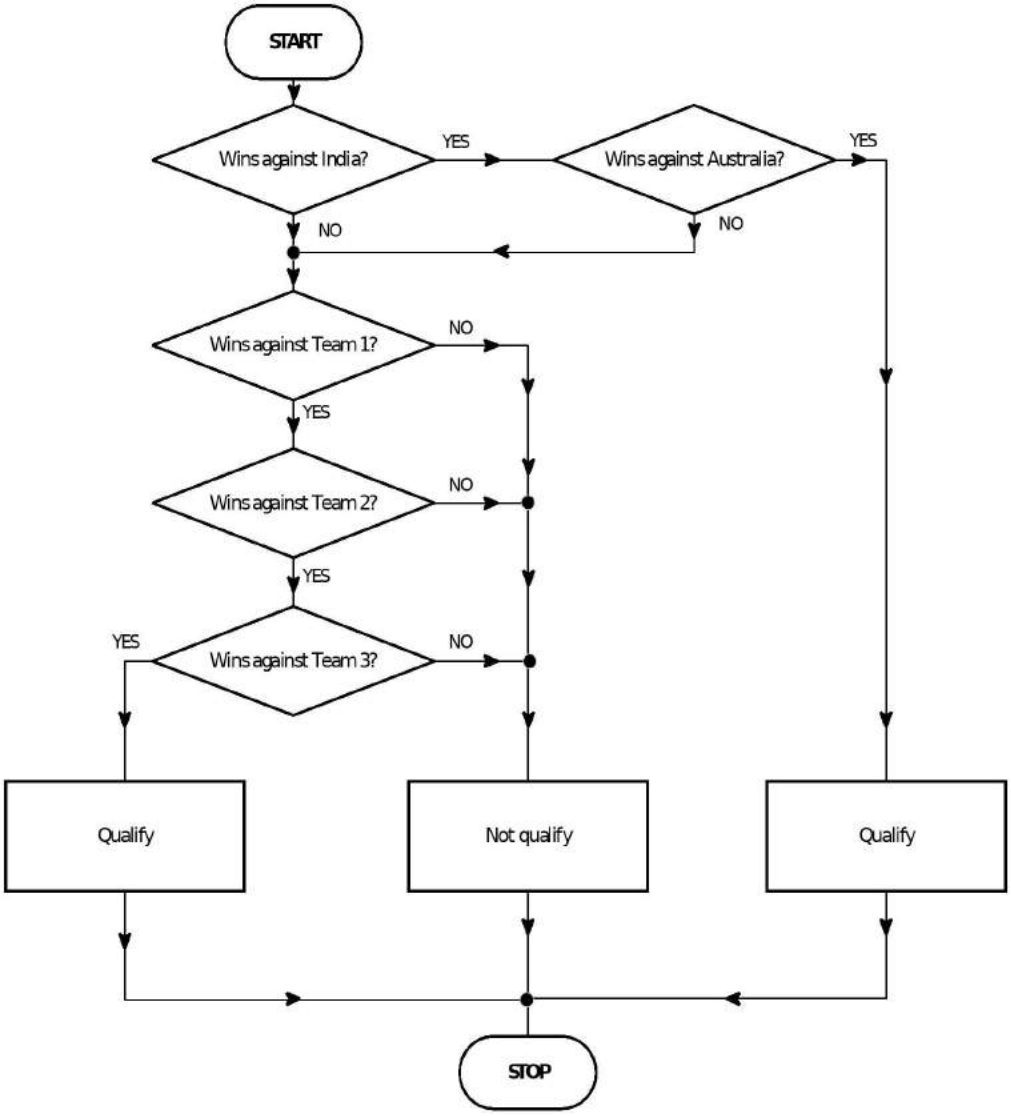
1.4.

In the last phase of Round I of ICC Cricket World Cup 2015, quarter-finalists are decided depending on the performance of cricket teams against the top players. The only two teams that have qualified include India (I) and Australia (A).

The other teams competing against each other in the same group in the tournament include South Africa (SA), Ireland (IR), Pakistan (PK), and Sri Lanka (S). The flow chart below shows how it is decided if a team qualifies or not.

Team 1, Team 2 and Team 3 stand for the other teams in the group. For example, if we look at the qualification of the South African team: Team 1, Team 2 and Team 3 would stand for Ireland, Pakistan and Sri Lanka.

Yes = Win; No = Loss


START
Wins against India?
YES
Wins against Australia?
YES
NO
NO
Wins against Team 1?
NO
YES
Wins against Team 2?
NO
YES
YES
Wins against Team 3?
NO
Qualify
Not qualify
Qualify
STOP

Which of the following statements is or are correct?

I. PK qualifies for the quarter-final if they win against I, S, SA, and IR in the first round of ICC World Cup 2015.

II. Team S qualifies for the quarter-final if the team wins its match against India, loses its matches against Australia, but manages to win two out of its remaining matches with other teams.

(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.

TEXT AND FLOW CHART FOR QUESTIONS 1.5. AND 1.6.

In a fictional university, there are four subjects: Arts, English Studies, Mechanical Engineering, and Architecture. In the German grading system, grades vary from 1 to 6. The lower the number, the better the grade! At this university, school grades determine the course.

Definition of the school marks:

1 = very good performance

2 = good performance

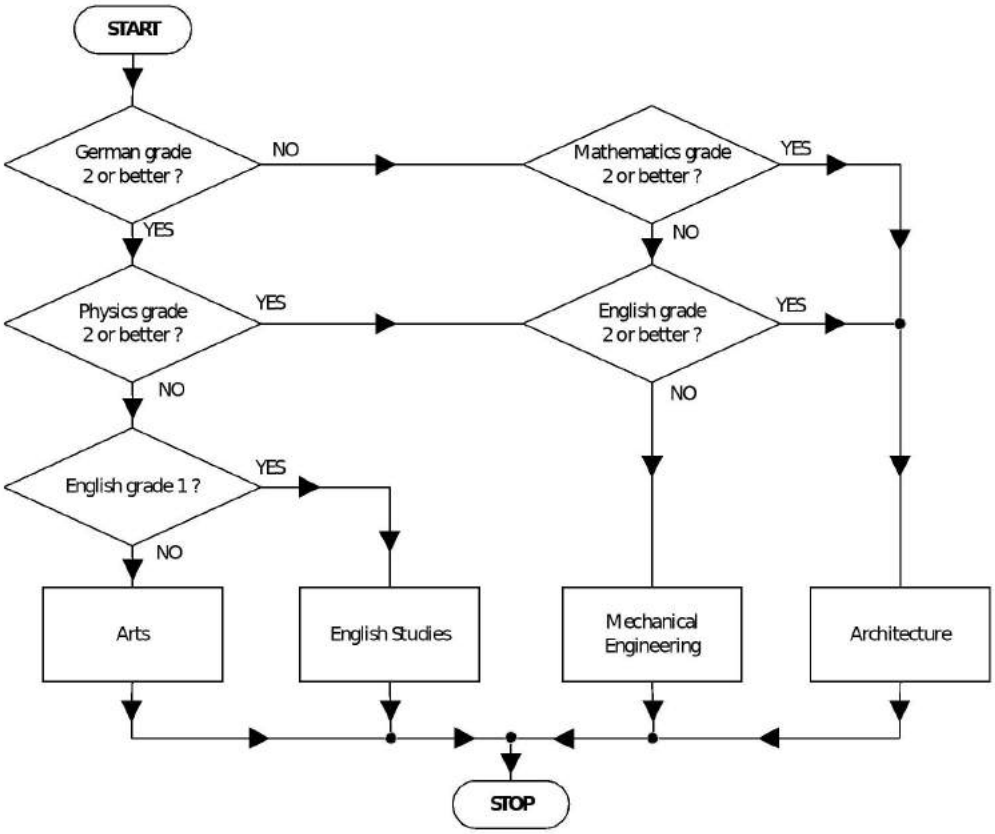
3 = satisfactory, average performance

4 = sufficient, average performance except for a few limitations

5 = unsatisfactory (failed), fundamental knowledge is however present

6 = poor (failed), expectations were not met.

The flow chart expresses which grades for the subjects of German, Mathematics, Physics and English lead to which decisions.



1.5. Which of the following statements is or are correct?

I. If the grade for German = 3, Architecture cannot be chosen.

II. If the grade for English = 1, English Studies is always chosen.

(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.

1.6. Which of the following statements is or are correct?

I. If the grade for German = 2 and the mark for Mathematics = 4, Art can be chosen.

II. If the grade for German = 3, Art cannot be chosen.

(A) Only statement I is correct.

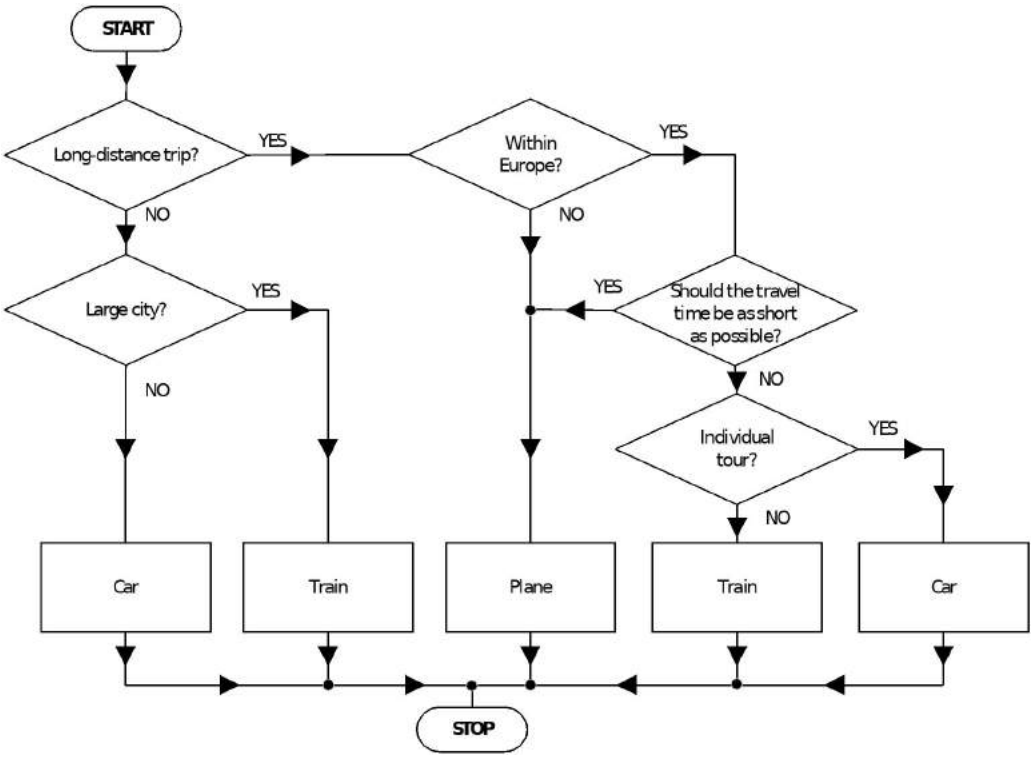
(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 1.7. AND 1.8.

The travel company XYZ from Germany wants to offer better travel packages to its customers. The flowchart shows the process of deciding which means of transportation the customer booking the trip will prefer. The company defines a long-distance trip as all destinations that are either outside of Germany or where the customer needs more than three hours by car from their starting point.



1.7. Which of the following statements is or are correct?

I. If the destination is not within Europe, one will always choose to take the plane.

II. If one does not travel far, one will never choose to take the plane.

(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.

1.8. Which of the following statements is or are correct?

I. If one wants a short travel time, then one will always choose to take the plane.

II. If one travels within Europe and plans an individual tour, then one would never choose to take the train.

(A) Only statement I is correct.

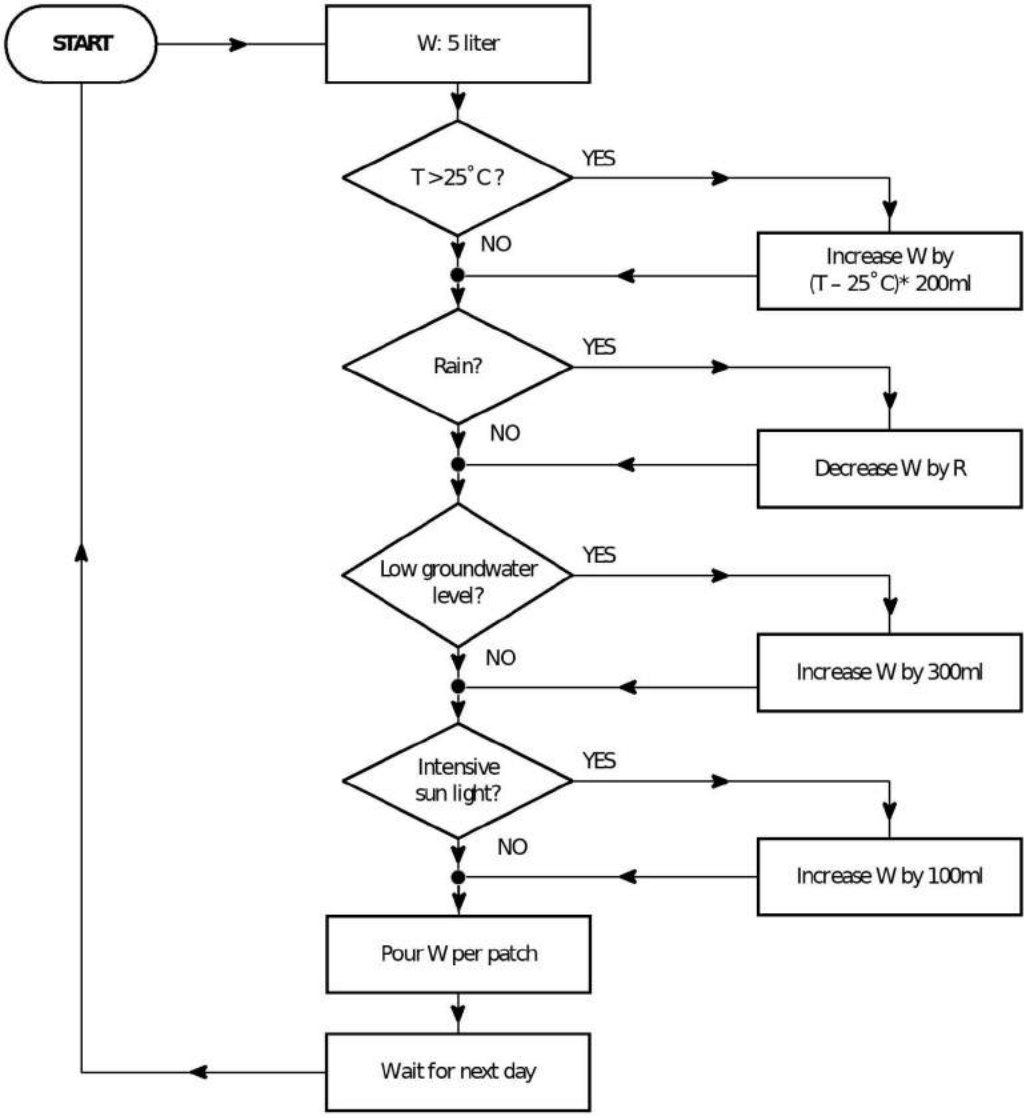
(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 1.9. AND 1.10.

A gardener has prepared eight patches. In order to give each of the plants the ideal amount of water, the gardener follows a list every day. The standard is 5 liters of water per patch. The gardener takes the temperature T in °C, rain (R) in ml/patch, ground-water level as well as sunlight into consideration. W corresponds to the water in ml per patch.



1.9. Which of the following statements is or are correct?

I. It is true for every parameter that the higher the parameter, the higher the amount of water for the patches.

II. If the ground-water level is low for a longer period, then the water is increased by 300 ml for each day passed with low groundwater level values.

(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.

1.10. Which of the following statements is or are correct?

I. It can be that on a certain day the gardener uses less than 100 ml of water per patch.

II. It can be that on a certain day the gardener uses more than 20 liters of water per patch.

(A) Only statement I is correct.

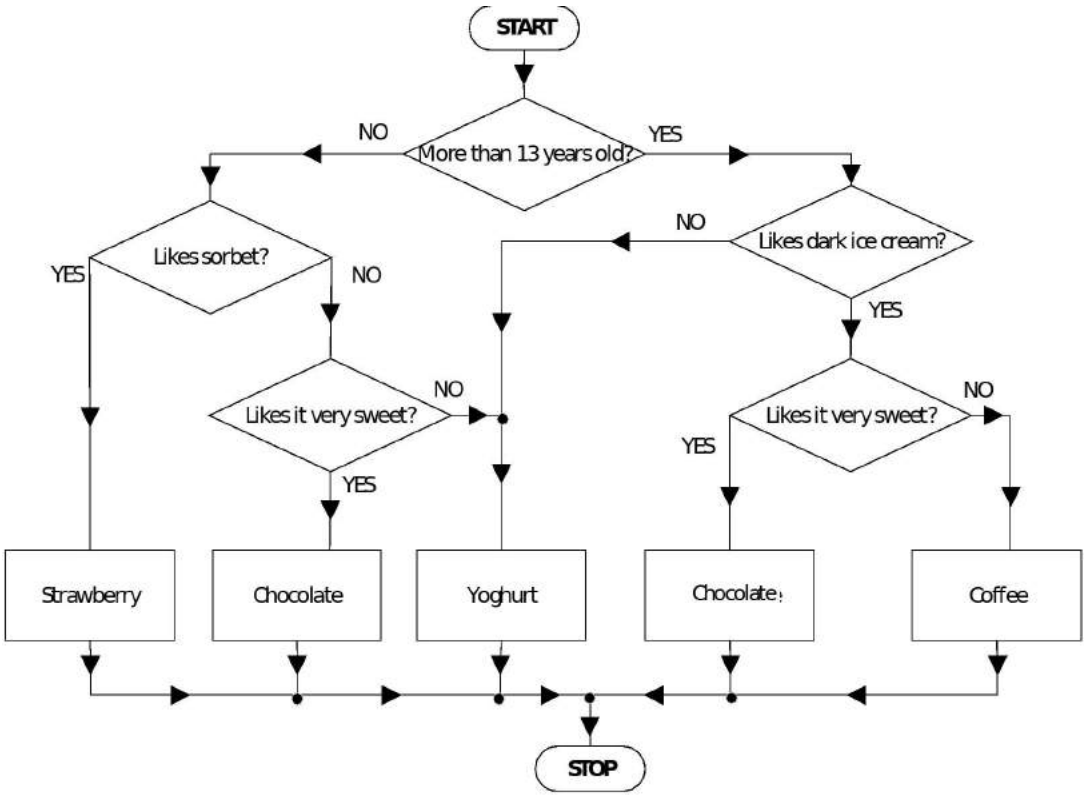
(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 1.11. AND 1.12.

An ice cream salesman has four types of ice cream. If a customer cannot decide which type to buy, the ice cream salesman helps out. The salesman has developed a procedure using several questions in order to find the perfect ice cream type for the customer. The flowchart lists the questions and decisions.



1.11. Which of the following statements is or are correct?

I. If a customer is younger than 13 years old and likes sorbet, then the decision will always lead to strawberry.

II. If the customer is older than 13 years old and likes dark ice cream, then the decision will always lead to coffee.

(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.

1.12. Which of the following statements is or are correct?

I. If the decision leads to chocolate, then the customer likes sweet ice cream flavors.

II. If the decision leads to coffee, then the customer is always older than 13 years old.

(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.

Geneticists examine four short gene sequences. They consist of three nitrogen-containing bases and can be made up of adenine (Ad), thymine (Th), cytosine (Cy) and guanine (Gu). The graphic shows the analytical process. All four bases can be used for the parameters U, V, and W.

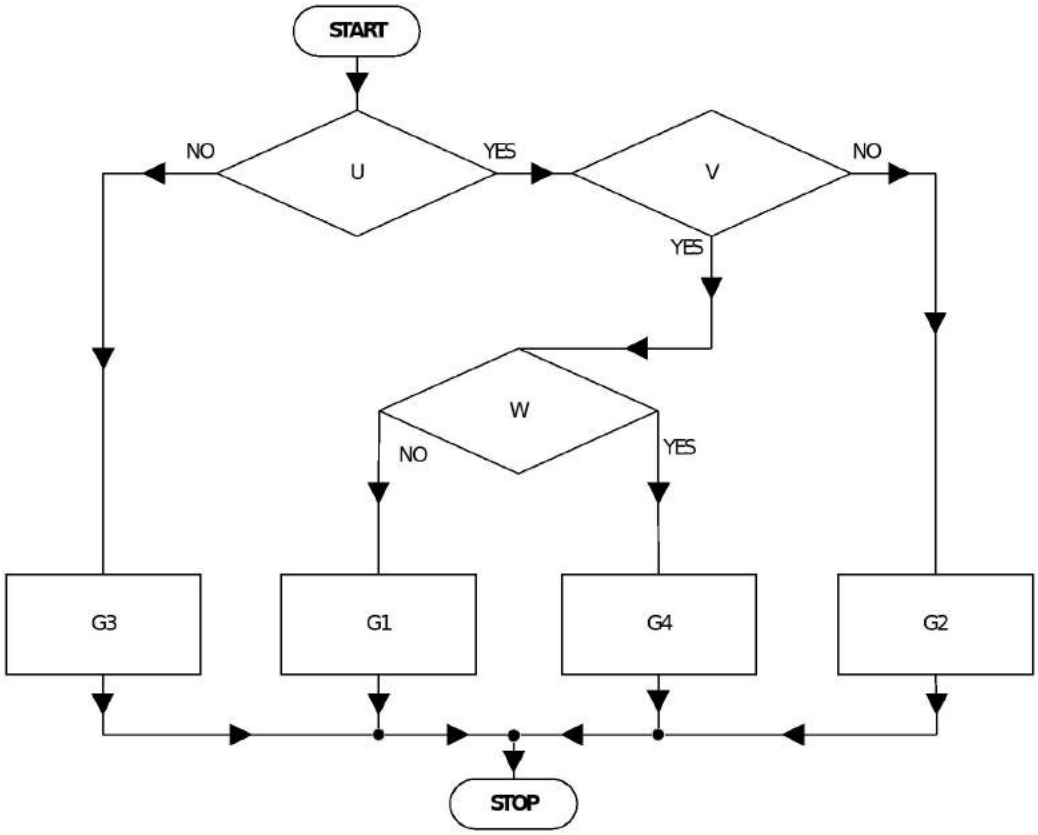
Gene sequence 1 (G1): Ad; Th; Cy

Gene sequence 2 (G2): Ad; Cy; Gu

Gene sequence 3 (G3): Th; Cy; Gu

Gene sequence 4 (G4): Ad; Th; Gu

The order of the bases cannot be changed (e.g., G1 is only Ad; Th; Cy and not Ad; Cy; Th).



Which of the following statements is or are correct?

I. If “Is the first base Ad?” is at decision point U, then the flow chart can be correct.

II. If “Does the sequence end with guanine?” is at decision point W and “Is Cytosine in the second position of the gene sequence?” is at decision point V, then the flow chart can be correct.

(A) Only statement I is correct.

(B) Only statement II is correct.

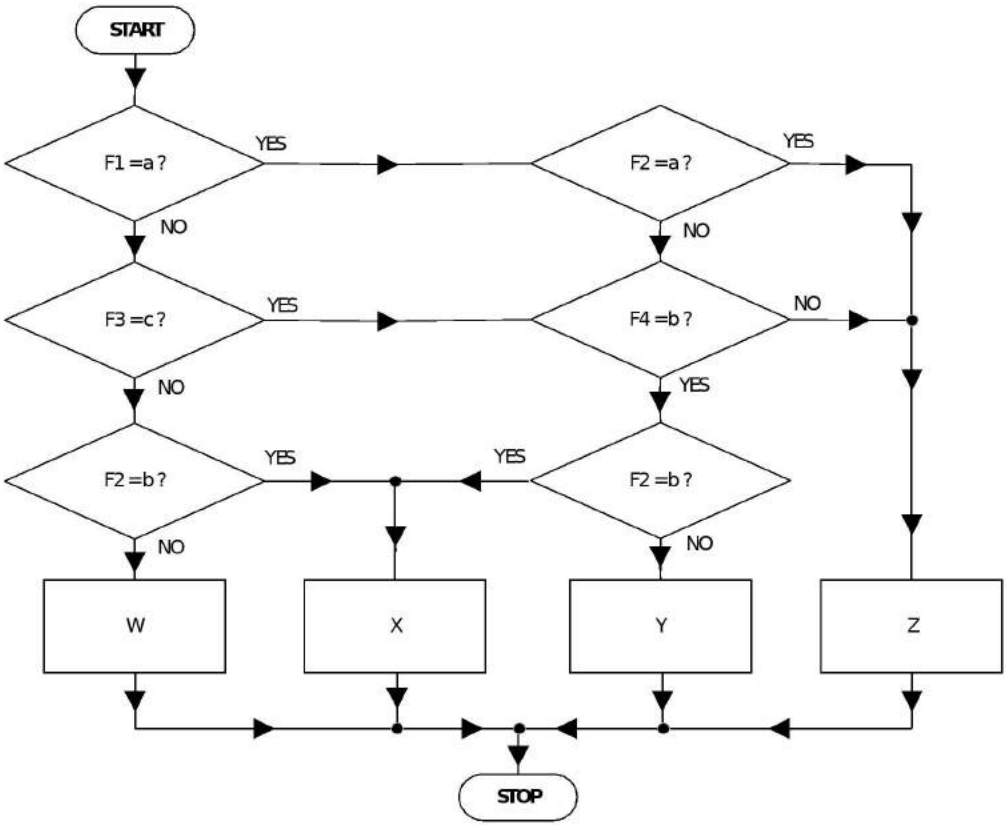
(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 1.14. AND 1.15.

There are four decision options W, X, Y and Z which are dependent upon the four factors F1, F2, F3 and F4.

F1 can have the value a or b. F2 can have the value a, b or c. F3 can have the value a or c. And F4 can have the value b or d. The flowchart expresses which factors lead to which decisions.



1.14. Which of the following statements is or are correct?

I. If F2 = a and F4 = d, then Z is always chosen.

II. If F2 = b, then neither W nor Y is chosen.

(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. Which of the following statements is or are correct?

I. If X is chosen, then it is possible to assign exactly one value to a maximum of three factors (assuming that one knows which decision path has been taken.)

II. If Z is chosen, then every factor can be assigned exactly one value (assuming that one knows which decision path has been taken.)

(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.

TEXT AND FLOW CHART FOR QUESTIONS 1.16. AND 1.17.

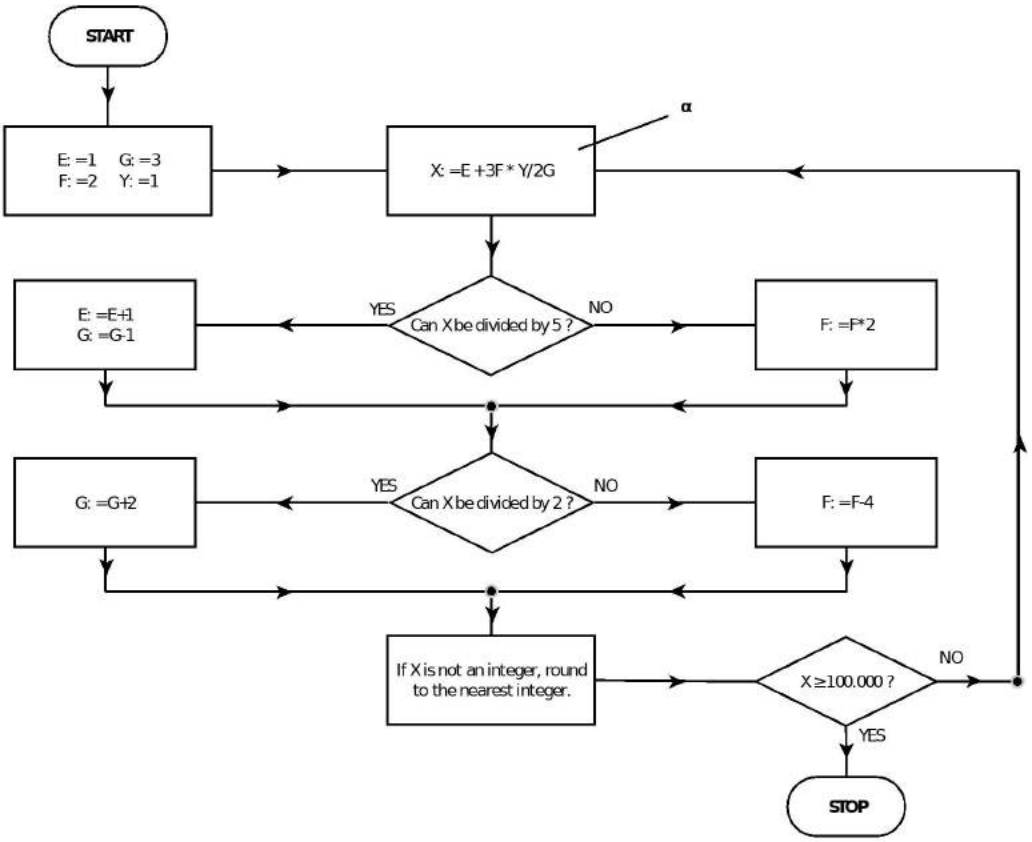
A computer science student has received the task of illustrating a number of calculations as a process. Below, you can see her error-free illustration.

In the first step, X has to be solved using an equation. The next steps depend on whether or not X can be divided by a certain number. (A number “a” can be divided by another number “b”, when there are no remainders for the division of a:b. For example, a number is divisible by 4 if its last two positions are divisible by 4. Thus, 112, 100, 60 and 36 are divisible by 4, but 11, 15 and 99 are not divisible in this way. For example: 112 ÷ 4 = 28 vs. 99 ÷ 4 = 24,75. Only whole numbers can be divided.)

Then, it is tested whether or not X is a whole number. (Whole numbers are numbers which only have a zero after the decimal point. Examples: -200, -4, -3, 0, 1, 2, 300.)

If it is not a whole number, then X is rounded to the next whole number (integer). (In order to round to the next whole number, the position behind the decimal point is taken into account. 0-4 is rounded down and 5-9 is rounded up. For example: 72,3 □ 72 and 72,8 □ 73 or 81,45 □ 81 and 81,51 □ 82.)

This calculation is performed until X is 100,000.



1.16. Which of the following statements is or are correct?

I. If F becomes negative once, then X can never again become positive.

II. If the number $\frac{1}{30}$ is obtained instead of 1 for Y, then an endless loop would be created.

(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. Which of the following statements is or are correct?

I. At the end of the first round, X = 2.

II. With the starting values for E, F, G and Y as shown in the diagram, an endless loop would be created.

(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.

1.18.

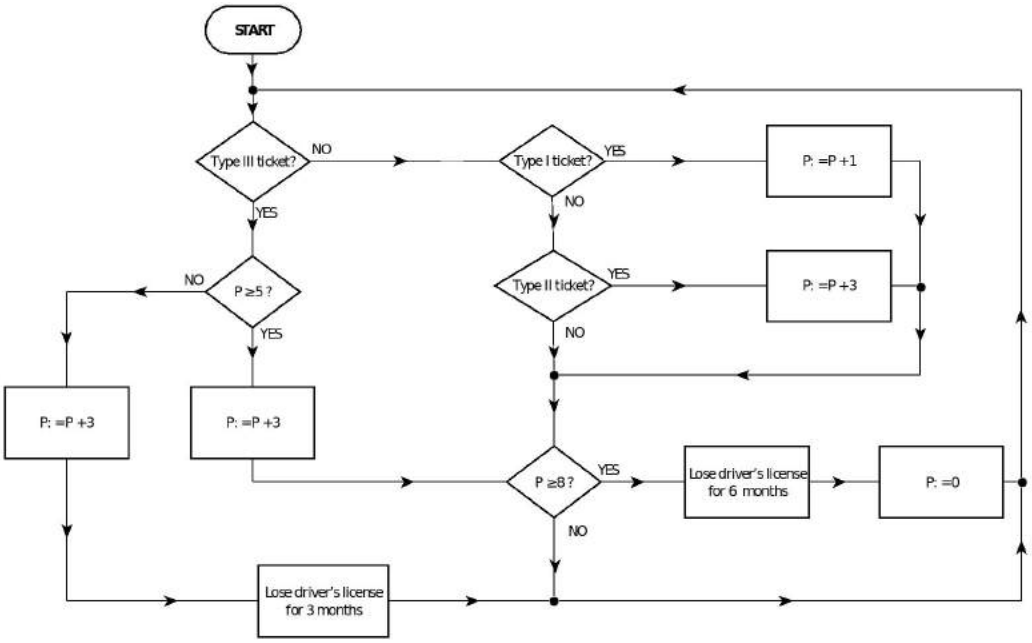
In the country of ABC, drivers get points for certain delicts, which differ depending on the seriousness of the delict. If a driver gathers a certain number of points, he or she has to surrender their driver's license for a period of time. There are three types of delicts for which the drivers are punished with points (in addition to monetary punishment.)

Type I: Delicts with low threat to the safety of overall traffic and inhabitants, e.g., holding a mobile phone while driving or driving up to 25 km/h faster than the speed limit without causing accident (1 point).

Type II: Delicts with serious threat to safety, such as driving through a red light or overtaking where forbidden (2 points without losing the driver's license).

Type III: Delicts which seriously threaten the safety of traffic and inhabitants, such as driving with a high level of alcohol or driving away from an accident (3 points, the driver loses their driver's license).

The chart summarizes the process of gathering points.


START
Type III ticket?
NO
YES
Type I ticket?
YES
NO
P: =P +1
P ≥5 ?
NO
YES
Type II ticket?
YES
NO
P: =P +3
P: =P +3
P: =P +3
P ≥8 ?
YES
NO
Lose driver's license for 6 months
P: =0
Lose driver's license for 3 months

Which of the following statements is or are correct?

I. After a Type I ticket, there is no loss of the driver's license.

II. Any given year, it is possible for a driver to have his/her driver's license removed for 6 months twice in that year.

(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.

1.19.

In mathematics there is the $\Delta = b^2 - 4ac$ discriminant.

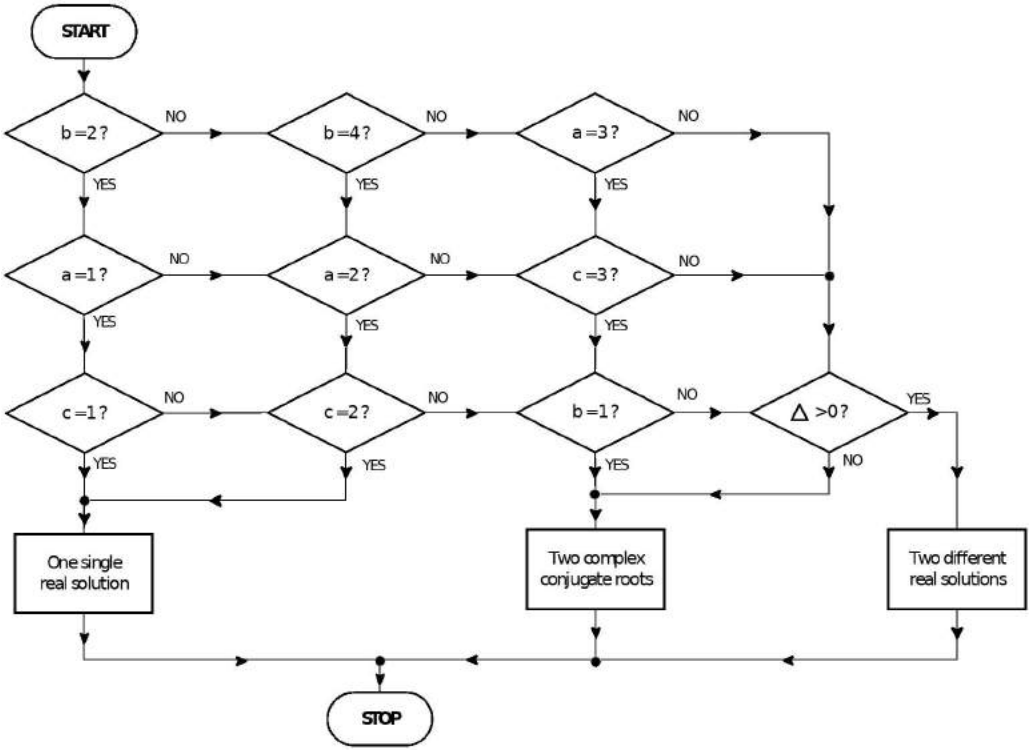
The discriminant applies for these $ax^2 + bx + c$ equations.

The discriminant can tell us information about the solution:

- It can have two different real solutions.
- It can have two (non-real) solutions with complex conjugate roots.
- It can have one single real solution.

The following flow chart shows the relations between the discriminant and the solutions of secondary equations. In our flowchart a, b and c can take specific numbers:

a: 1, 2, 3, 4, 6 b: 1, 2, 3, 4 c: ¼, 1, 2, 3, 7



Which of the following statements is or are correct?

I. The discriminant should be less than zero to get two different real solutions.

II. The discriminant must be zero to get two solutions with complex conjugate roots. ($\Delta = 0$).

(A) Only statement I is correct.

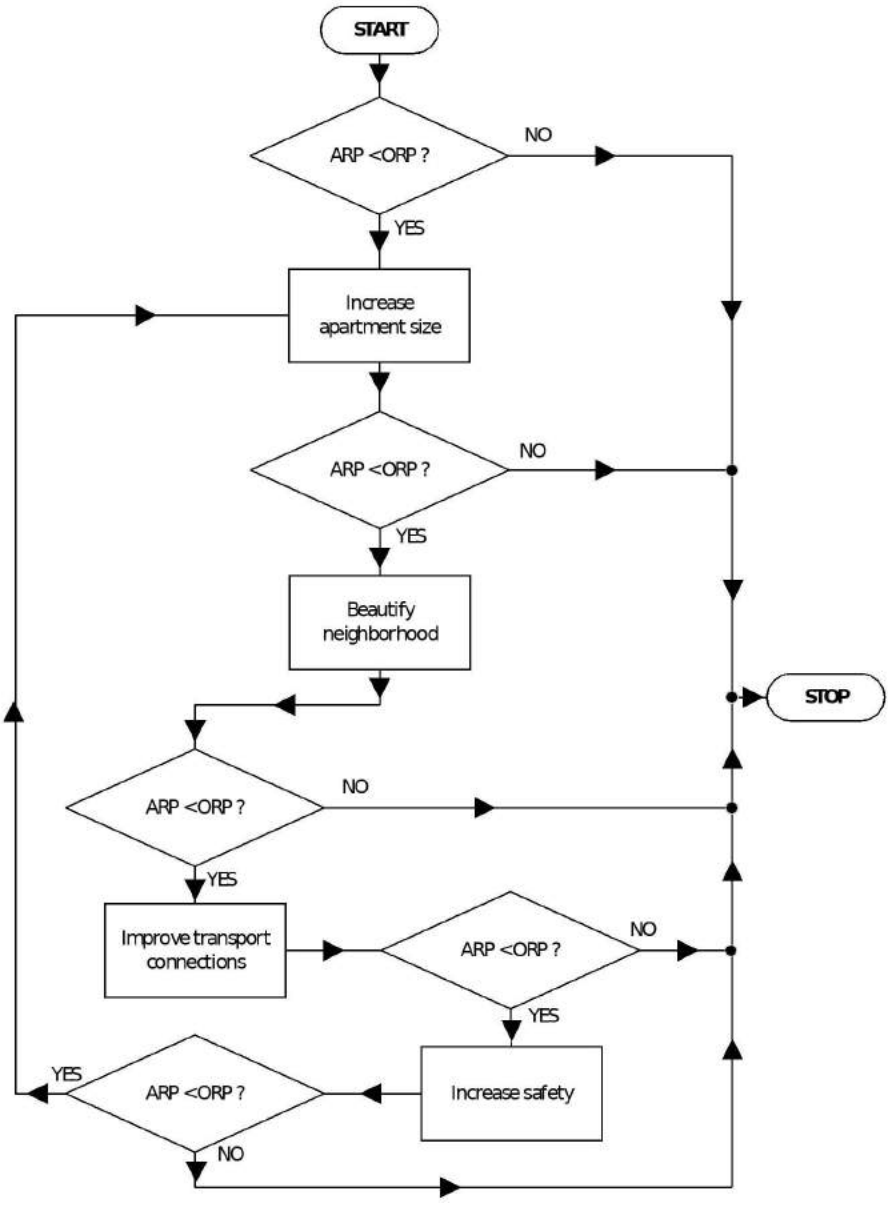
(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 1.20. AND 1.21.

A district municipality wants to improve the image of the district and demand higher rent prices. For this, various measures for improving the image of the district and the prices are calculated. The objective is to make the average residential price (ARP) equal to the optimal residential price (ORP). In the beginning, the ARP is lower than the ORP. The diagram describes the process of planning.



1.20. Which of the following statements is or are correct?

I. If larger apartments are planned, the ARP will always become equal to the ORP.

II. It can be that the ARP becomes equal to the ORP by improving the infrastructure of public transportation.

(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. Which of the following statements is or are correct?

I. It can be that the infrastructure of public transportation is improved upon without the apartments becoming bigger.

II. It can be that the ARP will not become equal to the ORP even though each measure was used once.

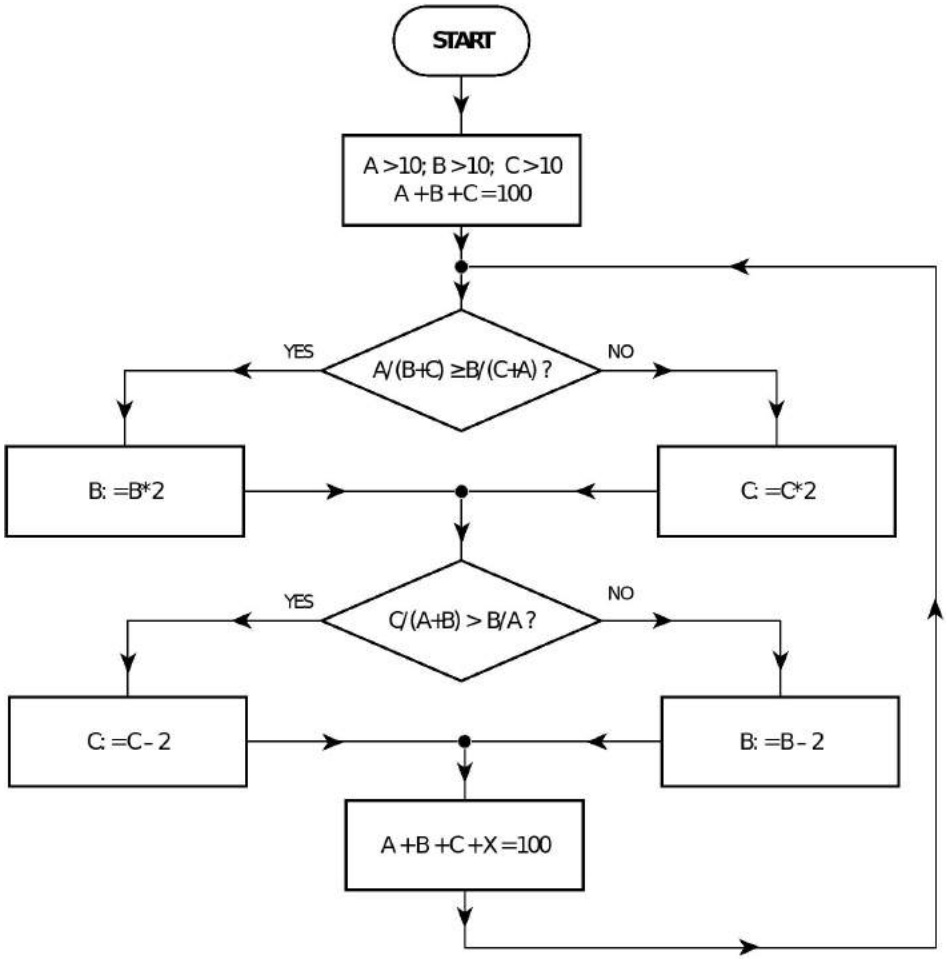
(A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

1.22. Within the following flow chart, a calculation is expressed. In the last step, X is chosen so that A + B + C + X always results in 100, meaning that X varies each round.



Which of the following statements is or are correct?

I. If A = 50, then X will be a negative number in the first run.

II. If A < B, then B will double after the $\frac{A}{B+C} \geq \frac{B}{C+A}$ field.

(A) Only statement I is correct.

(B) Only statement II is correct.

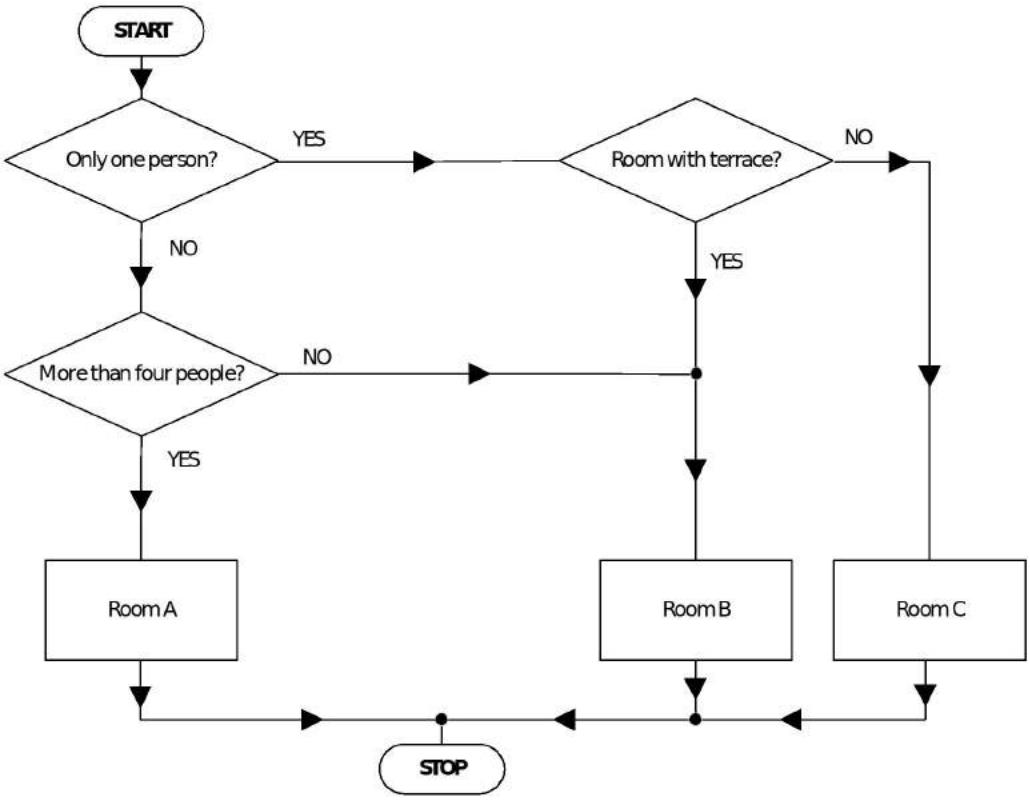
(C) Both statements are correct.

(D) Neither of the two statements is correct.

EXAM 2

TEXT AND FLOW CHART FOR QUESTIONS 2.1. AND 2.2.

In a small bed and breakfast, there are three rooms: Room A, Room B, Room C. Room A has room for six people and has a large terrace, Room B has room for four people and a small terrace and Room C is the smallest and most inexpensive room. The graphic expresses how a room is chosen.



2.1. Which of the following statements is or are correct?

I. If the room should have a terrace, then Room B is always chosen.

II. If there are more than four people, then Room A is always chosen.

(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.

2.2. Which of the following statements is or are correct?

I. Room B is only chosen when the number of people is between two and four.

II. If just one person stays the night, then Room C is always chosen.

(A) Only statement I is correct.

(B) Only statement II is correct.

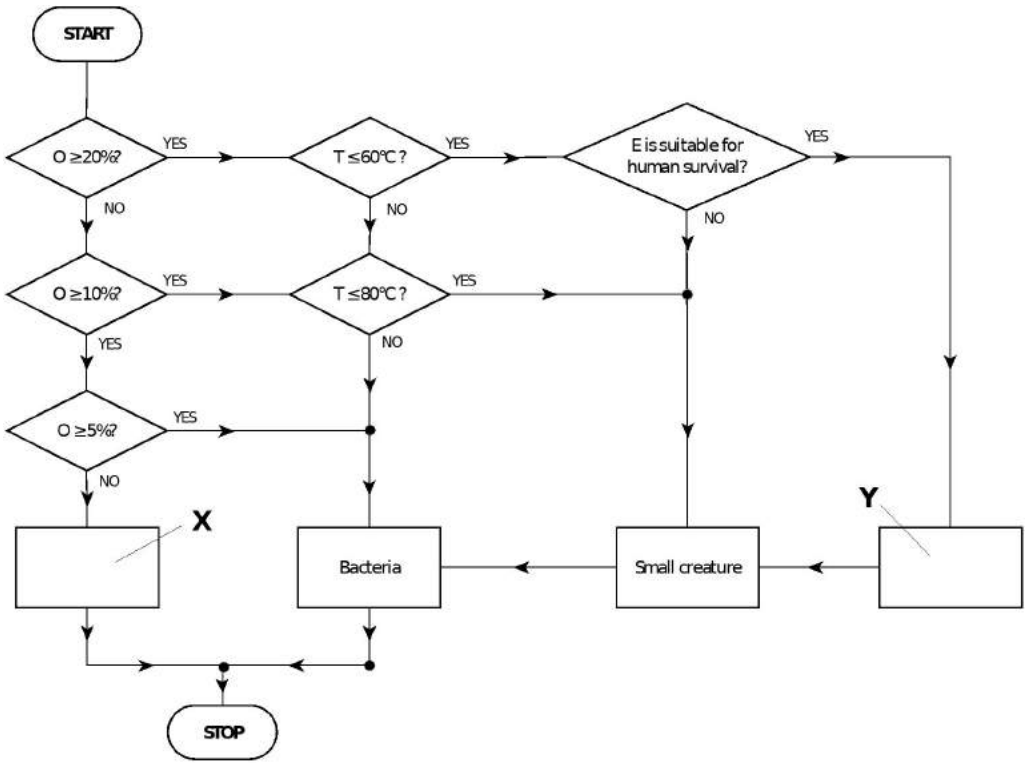
(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 2.3. AND 2.4.

Scientists are trying to find another planet where human beings can survive. They have found a number of planets that might be suitable. Based on some important criteria, such as presence of Oxygen (O) in the atmosphere, Temperature (T) and overall Environment (E), they are going to determine whether these planets are habitable for humans, smaller creatures, and bacteria. Humans can survive in temperatures up to 60 degrees Celsius and require at least 20% oxygen in the atmosphere. Smaller creatures can survive in temperatures up to 80 degrees Celsius as long as the oxygen is at least at 10% of the air. Bacteria require a much less favorable setting to survive. As long as the oxygen is at 5%, some bacterial strains will survive. This means that if humans can survive, smaller creatures and bacteria will always survive. (Please note that the values in this question are only figurative and do not indicate actual survival settings.)

The following flow chart shows how the scientists determine the planet's suitability:


START
O ≥20%?
YES
T ≤60°C ?
YES
E is suitable for human survival?
YES
NO
NO
NO
O ≥10%?
YES
T ≤80°C ?
YES
YES
NO
O ≥5%?
YES
NO
X
Bacteria
Small creature
Y
STOP

2.3. Which of the following statements is or are correct?

I. Here, Y represents a planet where nothing can survive.

II. Here, X represents a planet where all listed creatures can survive.

(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.

2.4. Which of the following statements is or are correct?

I. If the temperature is 89 degrees and oxygen is 0.5%, then bacteria can survive.

II. If bacteria can survive, then the smaller creatures may perhaps survive.

(A) Only statement I is correct.

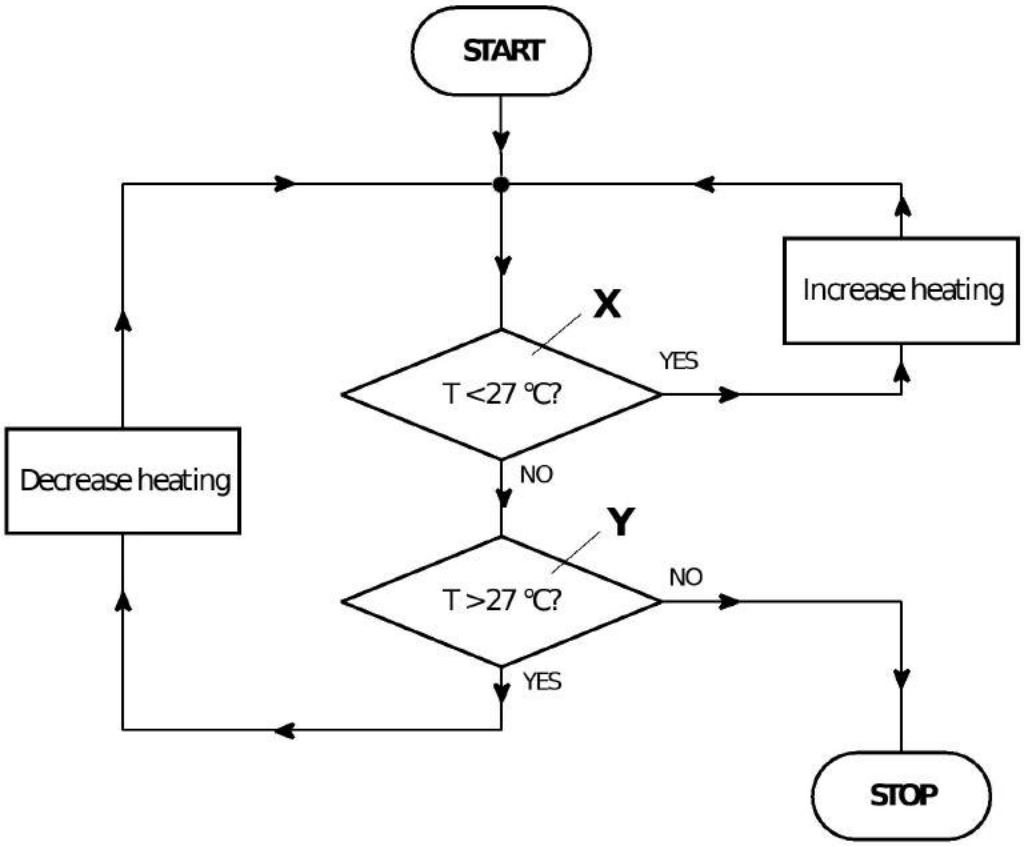
(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 2.5. AND 2.6.

The thermostat we have in our homes for central heating uses an easy algorithm to regulate the heating and the temperature of the house. One couple has put the temperature at 27 degrees Celsius and the thermostat has to reduce or increase heating according to the room's temperature. The following flowchart shows the procedure in which the thermostat affects the temperature of a house.



2.5. Which of the following statements is or are correct?

I. If the temperature is lower than 27 °C, the heating is increased.

II. If the temperature is already lower than 27 °C, the heat will be reduced even further.

(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.

2.6. Which of the following statements is or are correct when the contents of decision points X and Y are exchanged?

I. An already high temperature is further increased.

II. An already low temperature is further reduced.

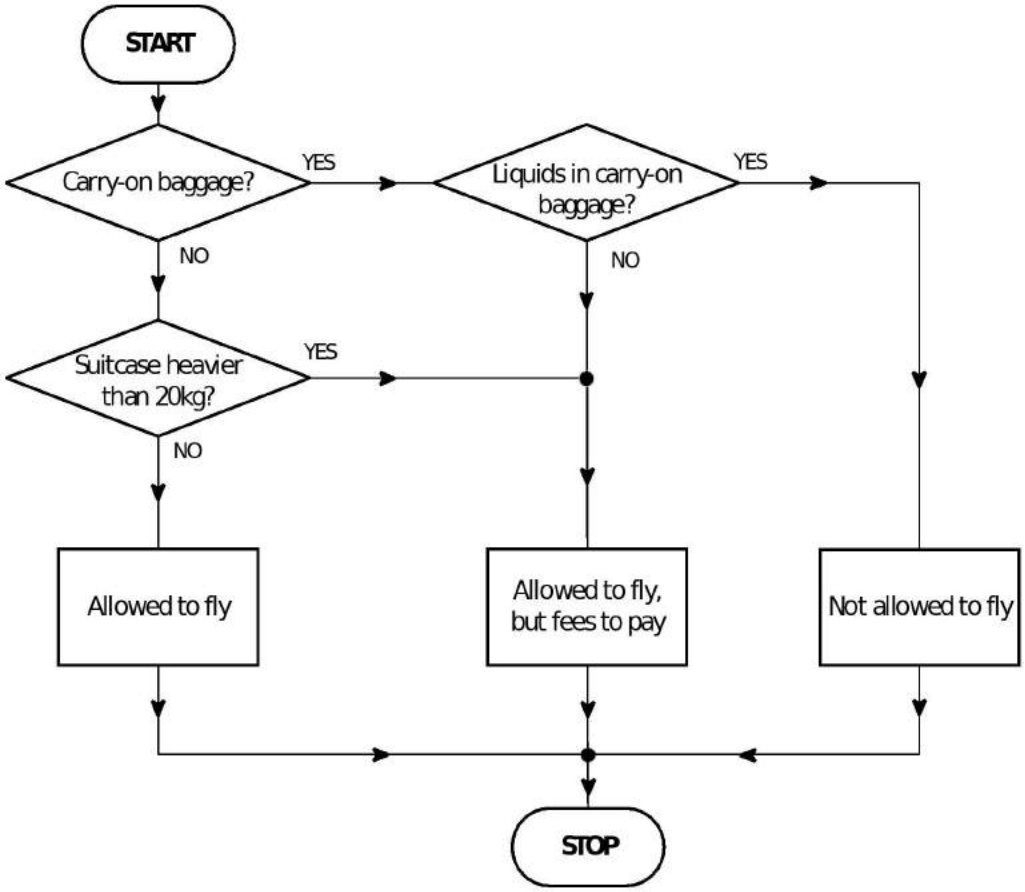
(A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

2.7. There are some rules which have to be followed in order to have permission to attend a flight. These rules may apply to customers' baggage and their contents. The following flow chart shows these rules.



Which of the following statements is or are correct?

I. If the suitcase is heavier than 20 kg, you cannot attend the flight.

II. If you want to carry a liquid in a carry-on baggage, you have permission to fly.

(A) Only statement I is correct.

(B) Only statement II is correct.

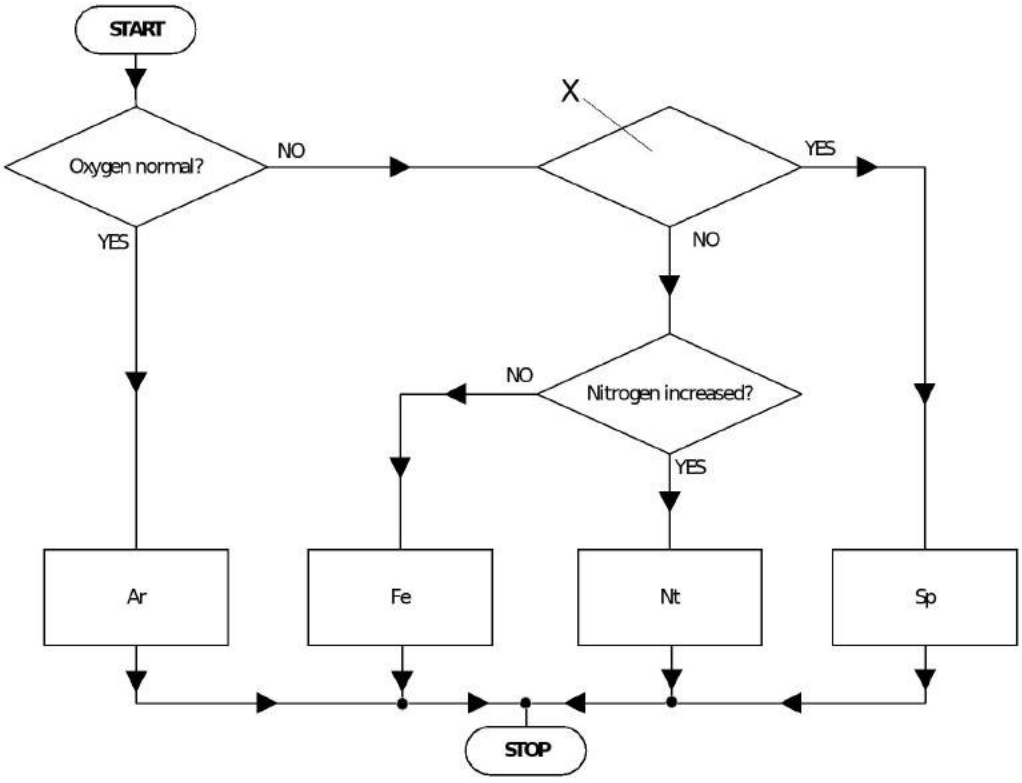
(C) Both statements are correct.

(D) Neither of the two statements is correct.

2.8. A biologist is researching an alga in water and would like to determine the algae type with a test. There are four algae types: Ar, Sp, Nt and Fe. These algae produce various substances when they are in water.

- The Nt and Sp types produce nitrogen.
- The Fe, Sp and Nt types produce oxygen.
- The Ar and Sp types produce carbon dioxide.
- The Fe type produces methane.

The graphic displays how the test works.



Which of the following statements is or are correct?

I. If at the decision point X “Normal concentration of carbon dioxide” is found, then the graphic can be correct.

II. If at the decision point X “Increased concentration of methane” is found, then the graphic can be correct.

(A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

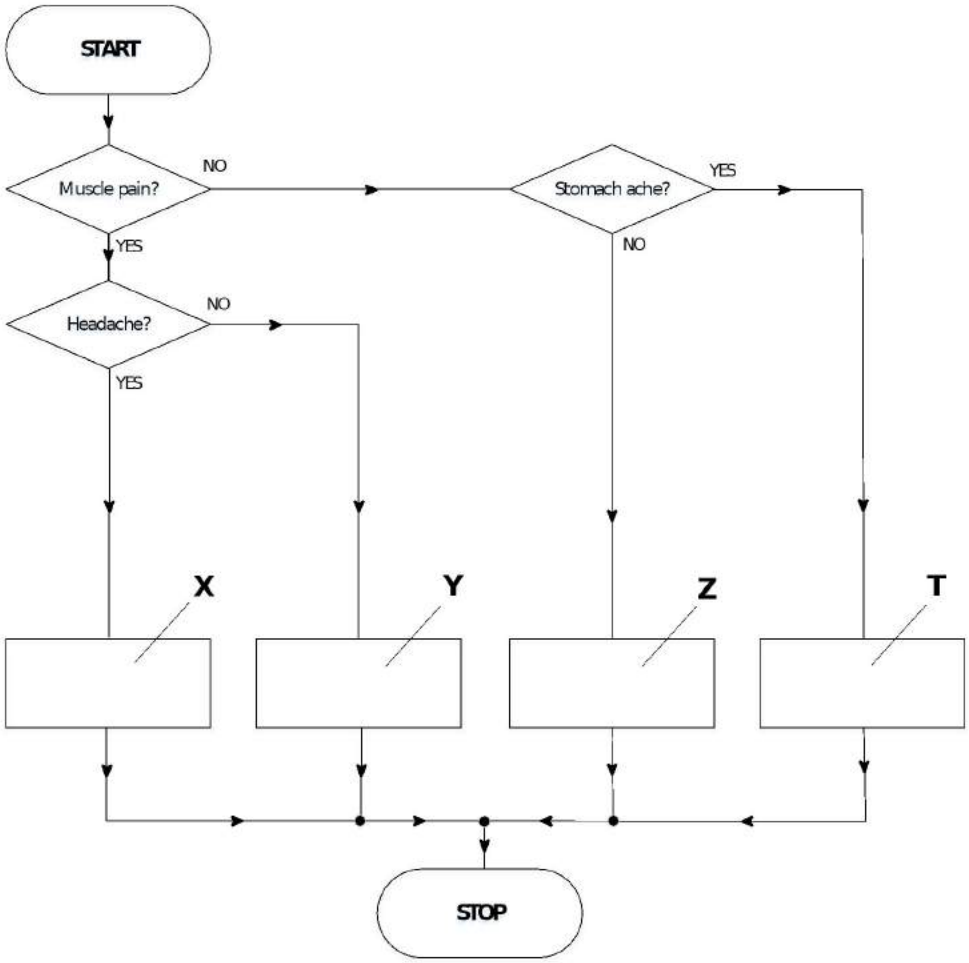
(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 2.9. AND 2.10.

Aa, Ab, Ad and Ae are substances.

- Aa and Ab help with headaches
- Aa and Ad help with stomach aches
- Ab and Ae help with muscle pains

The flow chart expresses which substances are to be taken for which symptoms. For this, the substance to be taken is always exactly the substance meant for the symptoms displayed.



2.9. Which of the following statements is or are correct?

I. If “Aa” is found at the position X, then the flow chart can be correct.

II. If “Ad” is found at the position T, then the flow chart can be correct.

(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 Which of the following statements is or are correct?

I. If “Ae” is found at position Y, then the flowchart can be correct.

II. If “None” is found at position Z, then the flowchart can be correct.

(A) Only statement I is correct.

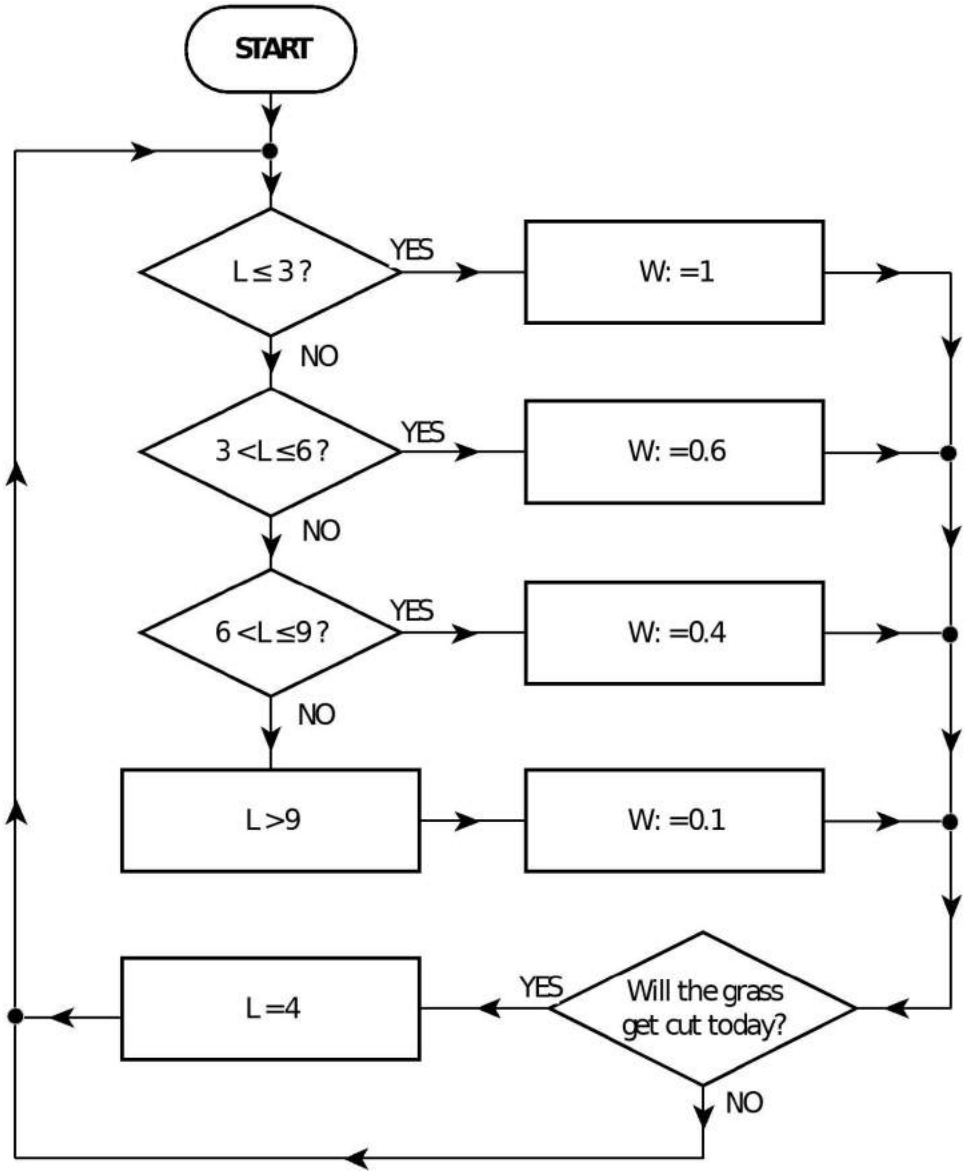
(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 2.11. AND 2.12.

The grass of a lawn grows slower the longer it gets. The following graphic illustration expresses the growth of the lawn. The length of the grass L is expressed in cm and the growth of the grass W in mm/day.



2.11. Which of the following statements is or are correct?

I. If the grass is 2.7 cm tall at the end of the day, then it will be taller than 4 cm 20 days later (assuming it will not be cut).

II. If the grass is cut from 7 cm down to 2 cm and not cut it again, then it will grow back to its original length in less than 100 days.

(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.

2.12. Half of the lawn gets fertilized. Thanks to the fertilizer, the corresponding growth rate is doubled. Which of the following statements is or are correct?

I. If there are two blades of grass of the exact same length in each lawn half, it could be that the blade of grass in the fertilized half will grow at a slower rate than the blade in the unfertilized half.

II. If two blades of grass of the exact same length start to grow, one in each half of the lawn, then the blade of grass in the fertilized half will always grow twice as fast as the other blade of grass.

(A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

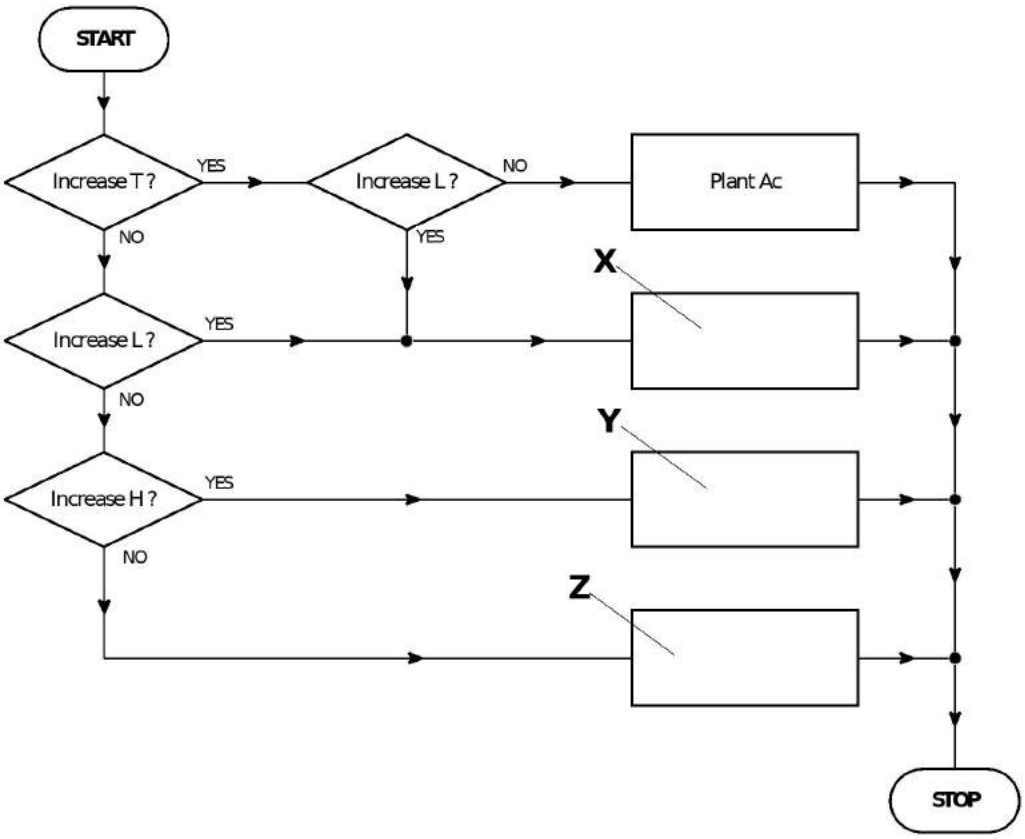
(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 2.13. AND 2.14.

Four plants react to three factors: temperature (T), light (L) and humidity (H).

- When temperature is increased, a faster rate of growth is observed in plants Pn and Ac.
- When humidity is increased, plants Ec and Ac grow much faster. Ec does not react to any other factor.
- When light intensity is increased, larger changes in growth are observed in plants Fm and Pn.

If an experiment is performed, growth depending on T, L and H can be proven. The flow chart shows several correlations.



2.13. Which of the following statements is or are correct?

I. If “Plants Fm and Pn” is found at operation X, then the flow chart could be correct.

II. If “Pn, Ac, Ec and Fm all grow at the same rate” was found at the position Z, then the flow chart can be correct.

(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. Which of the following statements is or are correct?

I. If “Plants Pn and Ac” was found in position Z, then the flow chart could be correct

II. If “Plants Ec and Ac” or “Plants Ec and Fm” was found in position Y, then the flow chart could be correct.

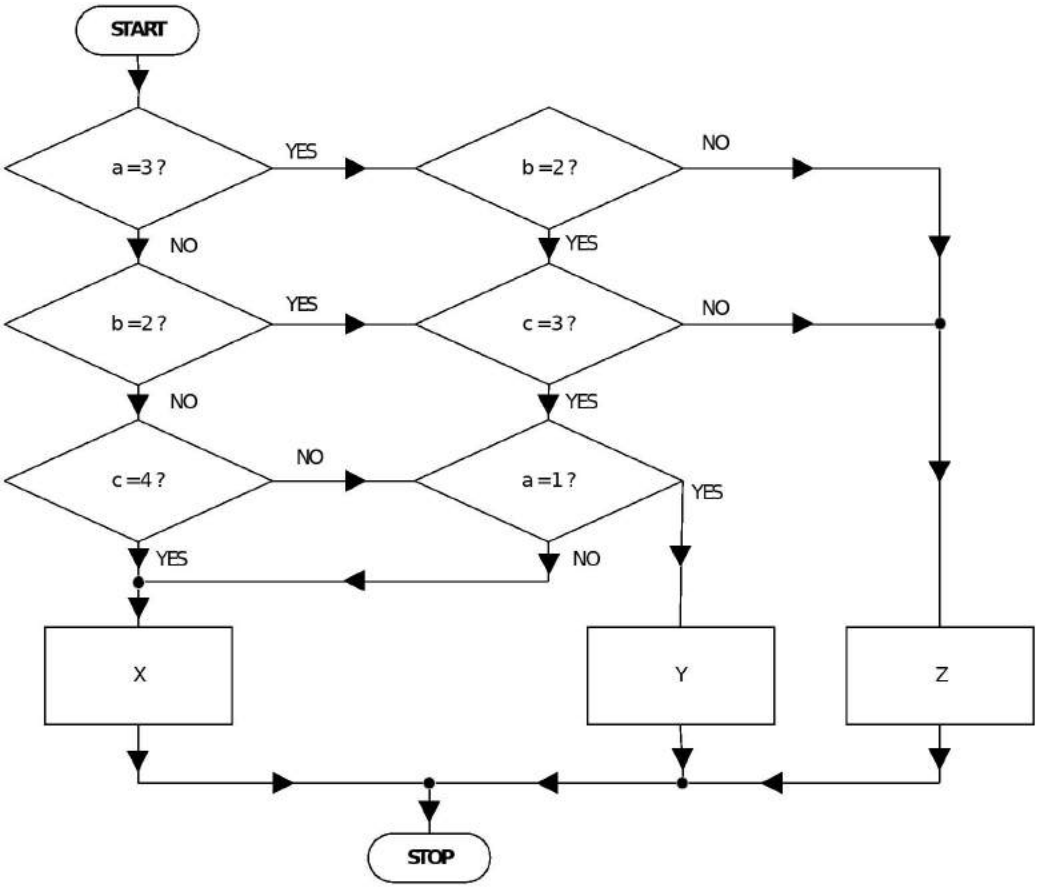
(A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 2.15. AND 2.16.



2.15. Which of the following statements is or are correct?

I. If a = 3 and b = 1, then Z is always chosen.

II. If b = 2, then Y is always chosen.

(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. Which of the following statements is or are correct?

I. If a = 2 and b = 2, then X is always chosen.

II. If b = 2, then Z is never chosen.

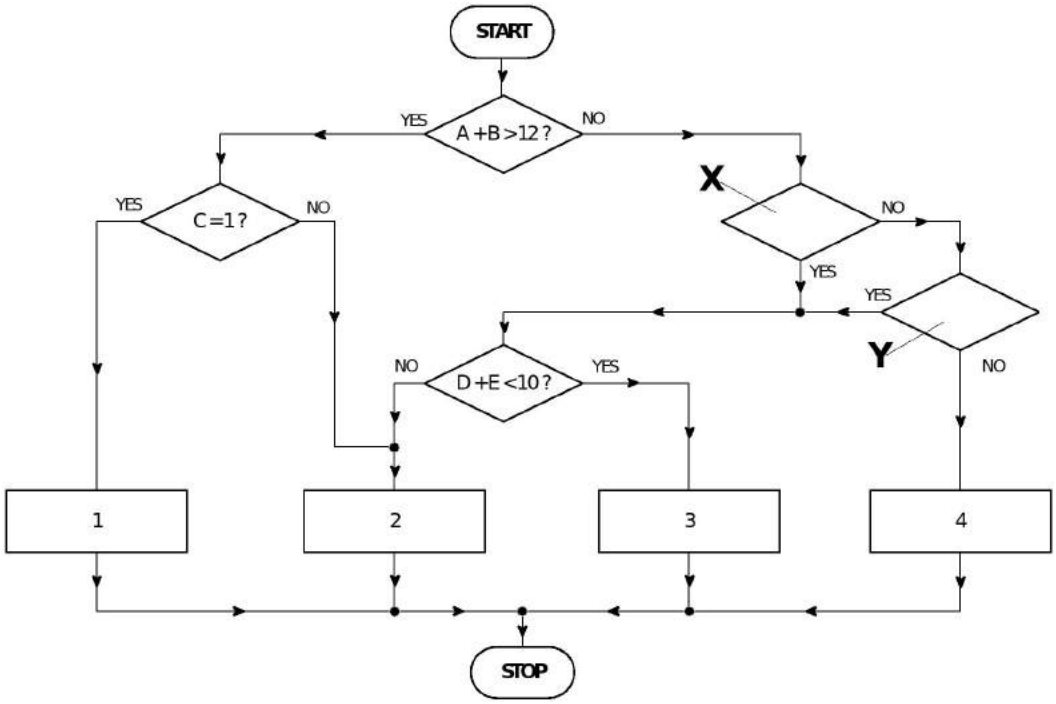
(A) Only statement I is correct.

(B) Only statement II is correct.

(C) Both statements are correct.

(D) Neither of the two statements is correct.

TEXT AND FLOW CHART FOR QUESTIONS 2.17. AND 2.18.



The parameters of the flow chart are always integers.

2.17. Based on the flow chart, which of the following statements is or are correct?

I. If (A + B + C) = 12, then you will reach operation point 1.

II. Even if C = 1, you can still reach operation 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.

2.18. Which of the following statements is or are correct?

I. It can be that you reach option 3 if the following is found in field X:
"A + B + C + D = 25 ?"

II. If "C + D > 10 ?" is found in field X and "E > 6 ?" is found in field Y, then no variable (A, B, C, D, E) can be larger than 6 in order to reach option 4.

(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.

2.19.

A manufacturer produces high quality porcelain plates. The sales price is 400 € per plate. During production, numerous costs incur such as raw materials, staff, shipping etc. The costs vary depending on the quantity produced. For example, the production costs per plate are high when a very small quantity is produced because there has to be at least one person at every part in the production chain (such as purchasing raw materials, production within the factory, packaging and shipping).

The costs can be calculated using the following formula:

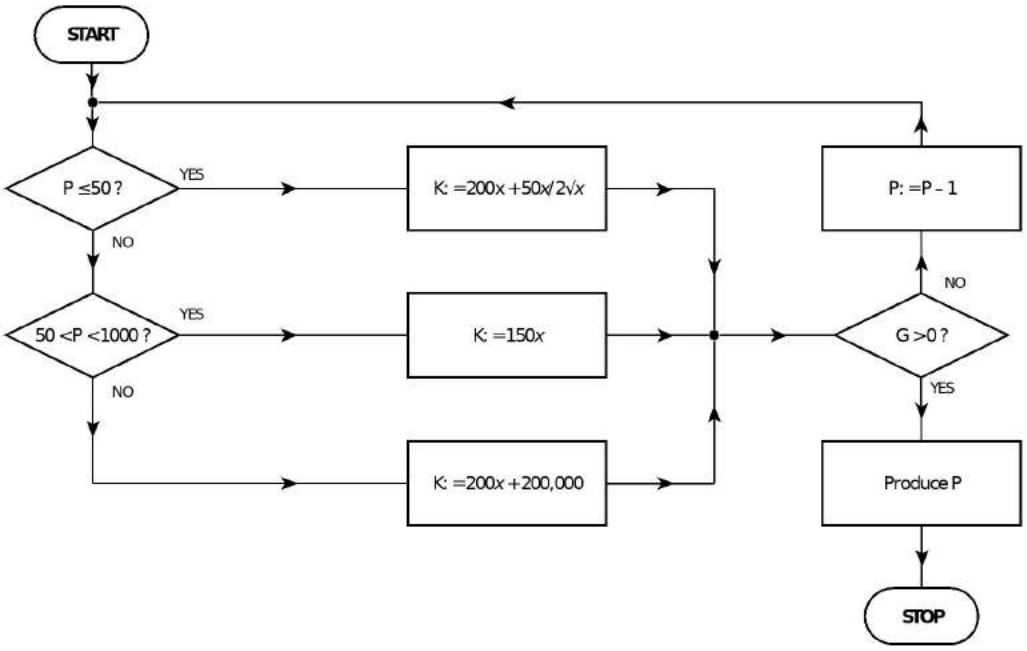
For a production volume of up to 50 plates per day: $200^{x} + \frac{50x}{2\sqrt{x}}$

For a production volume between 51 and 999 plates: 150^{x}

For a sum of more than 1,000 plates per day: 200^{x} + 200,000

x stands for the number of porcelain plates produced.

In order to achieve a positive profit, the manufacturer adapts its production according to the current demand. The profit is the sales price minus the costs of production. In the case of a negative profit, even with high demand, the manufacturer still only produces plates as long as the profit remains positive. The following flow chart expresses the procedure:



Which of the following statements is or are correct?

I. With a high profit and a constant demand in the future, it is reasonable to increase production as long as the quantity remains under 999 plates per day.

II. If the manufacturer produces twice as much due to a very high demand, then the costs of production also double.

(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.

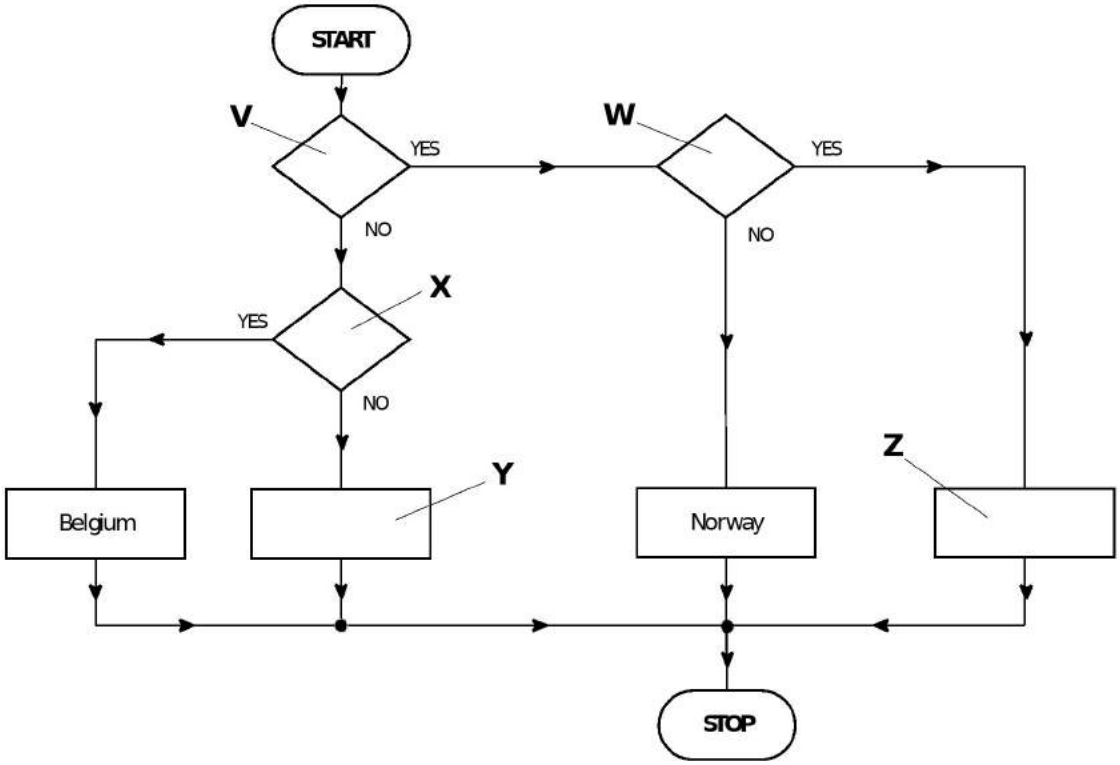
TEXT AND FLOW CHART FOR QUESTIONS 2.20. AND 2.21.

SARS and the H3N2 influenza are two diseases that have had a high mortality rate in some regions of the world in the recent years. Depending on their country of residence, inhabitants have been exposed to either both diseases, only one of the diseases, or neither of the diseases.

For our study, we randomly selected four countries. The table below shows whether these countries are affected by the two diseases, to either a high or low extent.

Algeria	Low SARS level	Low H3N2 level
Belgium	High SARS level	High H3N2 level
Malaysia	High SARS level	Low H3N2 level
Norway	Low SARS level	High H3N2 level

The following flowchart shows the statistical data according to four countries in relation to the two diseases.



2.20. Which of the following statements is or are correct?

I. Decision point V could be “SARS patients low?” and operation point Y could be “Malaysia”.

II. The flow chart can be correct if we switch the operation point Belgium with the operation point Z.

(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.

2.21. Which of the following statements is or are correct?

I. If decision point V is “SARS level low?”, then decision point X should be “H3N2 level high?” for the flow chart to be correct.

II. If decision point V is “SARS level low”, and decision point W is “H3N2 level low”, then Z should be “Algeria”.

(A) Only statement I is correct.

(B) Only statement II is correct.

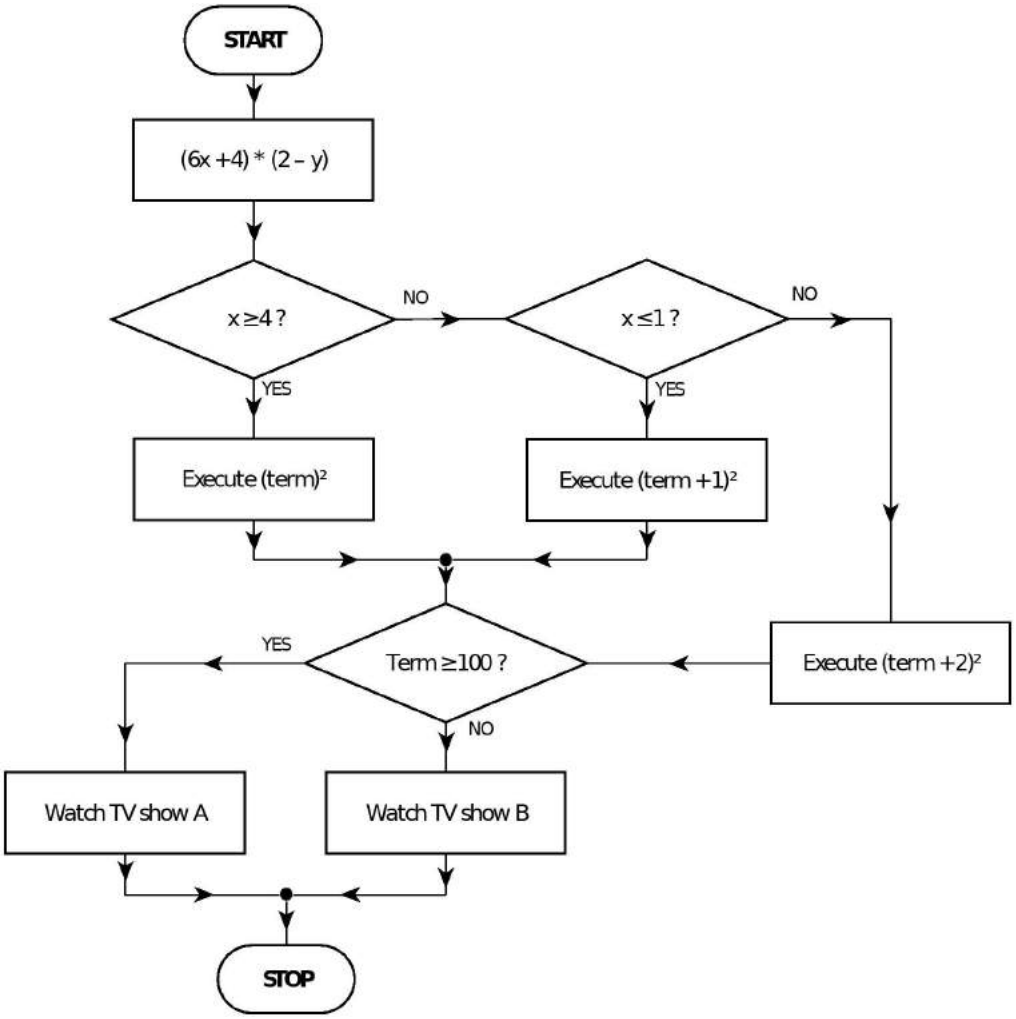
(C) Both statements are correct.

(D) Neither of the two statements is correct.

2.22.

Alin and her flat mate Jens cannot agree on which television show they should watch.

Alin prepared the following flow chart and suggested solving this decision democratically. Each day one of them determines the x value. The other then determines the y value for that day. The next day the order is changed (when Alin determines the x value today, then Jens determines the y value today and determines the x value tomorrow).



Which of the following statements is or are correct?

I. Today Jens determines the x value. If he chooses 1, Alin could choose 1 for the y value in order to reach the television show A.

II. Tomorrow Alin determines the x value. She definitely wants to watch show A, so she chooses 100 for x. This way she is guaranteed to watch show 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.

ANSWER KEYS

Exam 1			Exam 2	
Question	Answer		Question	Answer
1.1.	D		2.1.	B
1.2.	A		2.2.	D
1.3.	C		2.3.	D
1.4.	A		2.4.	B
1.5.	D		2.5.	A
1.6.	C		2.6.	C
1.7.	C		2.7.	D
1.8.	B		2.8.	D
1.9.	D		2.9.	B
1.10.	A		2.10.	C
1.11.	A		2.11.	C
1.12.	C		2.12.	A
1.13.	A		2.13.	A
1.14.	B		2.14.	D
1.15.	D		2.15.	A
1.16.	C		2.16.	D
1.17.	C		2.17.	B
1.18.	B		2.18.	A
1.19.	D		2.19.	D
1.20.	B		2.20.	C
1.21.	B		2.21.	C
1.22.	A		2.22.	A

DETAILED SOLUTIONS

EXAM 1

1.1. Answer: D

Statement I: If the student has a grade of more than 75%, then the exam is passed. It does not matter how often the student has attended the course. The statement is not correct.

Statement II: See explanation for statement I. The statement is not correct.

1.2. Answer: A

Statement I: The exam is only passed when a percentage of MORE than 75% is achieved. With exactly 75%, the exam is always repeated. Thus, the statement is correct.

Statement II: If the grade is less than or exactly 75%, then the exam has to be repeated without taking course attendance into consideration.

1.3. Answer: C

Put the values from the paths leading to the results given in the statements in F and solve for the unknown. If the result is the same number as it should stand for in point A or B, this statement is correct.

Statement I:

For y = 3, z = 3 and F = 11:

$11 = \frac{1}{2}x + 3 + 2 \times 3$

$x = 4$

Statement II:

For x = 1 and y = 1 and $F = \frac{7}{2}$*:*

$\frac{7}{2} = \frac{1}{2} \times 1 + 1 + 2z$

$Z = 1$

Both statements are correct.

1.4. Answer: A

Statement I: Since Pakistan won against SA, IR and S, represented by teams 1-3 in the flow chart, they qualified for the quarter finals. Statement II is correct.

Statement II: There are two conditions for entering the quarter-final which include winning against India and Australia or winning against the other three teams. However, team S does not qualify because it lost against Australia and won only two instead of three matches. Statement I is incorrect.

1.5. Answer: D

Statement I: The statement is not correct. Even if the grade for German is 3, one can study Architecture with a good grade in English.

Statement II: There is also the possibility of studying Architecture with a grade of 1 in English. The statement is not correct.

1.6. Answer: C

Statement I: The statement is correct. Grade 2 in German is sufficient for Arts. The Mathematics results are irrelevant.

Statement II: It is actually true that it is not possible to study Arts with a 3 in German (see first decision point “German”).

1.7. Answer: C

Statement I: If one chooses "No" at the decision point "Within Europe", then the plane will actually always be chosen. This statement is correct.

Statement II: If one chooses "No" at the decision point "Long-distance trip", then the only means of transportation are the car or train, but not the plane. This statement is correct.

1.8. Answer: B

Statement I: For short travels ("No" at "Long-distance trip"), the plane is never chosen. This statement is not correct.

Statement II: Indeed, when travelling within Europe, one can only come to the field "Train" if one chooses "No" at the decision point "Individual tour?". This is why, when one wants to plan an individual tour, one would never choose the train. This statement is correct.

1.9. Answer: D

Statement I: For the "Rain" parameter, it is the exact opposite – the more rain there is, the less water is given. The same applies to the groundwater level – if it is high, less water needs to be given. The statement is incorrect.

Statement II: Every day starts off with the base value of 5 liters of water. Even if the ground-water level is low for a longer period, each day W is only increased by 300 ml. This statement is not correct.

1.10. Answer: A

Statement I: When there is a lot of rain, the gardener may water less than 100 ml or nothing at all. Statement I is correct.

Statement II: You have to check whether there could be a combination of the parameters (T, R, groundwater levels and sunlight), where the gardener has to pour more than 20 liters of water in a single day per (flower) patch. If more water must be used due to low groundwater level and excessive sunlight, this would require an additional 400 ml = 5,400 ml. At least 14,600 ml would have to be added due to the high temperature. Now check if this is realistic. To do this, solve the following equation for T:

(T – 25 °C) 200 ml = 14,600 ml
T – 25 °C = 73
T = 98 °C

98 °C is not a realistic value for the temperature, so the statement is incorrect.

1.11. Answer: A

Statement I: If one chooses "Yes" for both the "Younger than 13?" as well as the next field "Likes sorbet?", then the decision will always be strawberry. This statement is correct.

Statement II: If the customer is older than 13 and likes dark ice cream, then the options are coffee and chocolate. This is why the decision is not always coffee. It depends upon whether or not the customer likes it sweet. This statement is not correct.

1.12. Answer: C

Statement I: For this statement, one must work "backwards". It is actually true that for chocolate the customer must always fulfil the condition of liking sweet ice cream flavors, independent of age.

This statement is correct due to the fact that a preference for sweet ice cream flavors is a prerequisite for the selection of "Chocolate".

Statement II: The “Coffee” option is not possible for the path “Customer is under 13 years old”. This is why this “backwards” deduction is also correct.

1.13. Answer: A

Statement I: If, at point U, the decision is made whether or not the sequence begins with Ad, then one can see that G1, G4 and G2 correctly begin with Ad, whereas this is not the case for G3. Since the description of the gene sequences within the introduction agrees with this statement, the statement is correct.

Statement II: At point W, the decision would be made whether or not the sequence ends with Gu. If yes, one reaches G4, if no, then one reaches G1. This corresponds to the description within the introduction. Now, we must check the second part, meaning whether or not cytosine is in the second position of the gene sequence. If we answer this with YES, only G2 and G3 are possible; however, this does not coincide with the flow chart. The statement is not correct.

1.14. Answer: B

Statement I: To get to Z, there are three options:

1) *For F1 = a? □ YES, F2 = a? □ YES*
2) *For F1 = a? □ YES, F2 = a? □ NO and F4 = b? □ NO*
3) *For F1 = a? □ NO, F3 = c? □ YES and F4 = b? □ NO*

We look at the process from the start and try to find a path which doesn't lead to Z. This applies to F1 = a? □ NO and F3 = c? □ NO. If this is the case, we will end at W for F2 = a and F4 = d. As no statement was made on the value of F1 and F3, it must be true for all possible values, for the statement to be correct.

An example to end at W would be: F1 = b, F2 = a, F3 = a, and F4 = d. Thus, the statement "If F2 = a and F4 = d, then Z is always chosen." Is incorrect.

Alternative approach: F2 = a and F4 = d are given. First, it is decided whether factor F1 has the value a or b. If F1 = b and F3 = a, then W is chosen. If F1 = a, then Z is chosen. The statement is not correct.

Statement II: Y and W are indeed only chosen when F2 is NOT b. Vice versa, if b = 2, then W or Y can never be chosen. This can be derived from each decision point immediately above W or Y. Thus, the statement is correct.

1.15. Answer: D

Statement I: There are three ways to reach X:

1) F1 = a ? □ NO F3 = c ? □ NO F2 = b ? □ YES
2) F1 = a ? □ NO F3 = c ? □ YES F4 = b ? □ YES F2 = b ? □ YES

3) F1 = a ? □ YES F2 = a ? □ NO F4 = b ? □ YES F2 = b ? □ YES

The first way involves three decision-making points. So, the maximum number of factors that can be determined is also three. At this point, there is no contradiction to the statement.

The other two ways, however, involve four decision-making points. This means that a maximum of four factors can be determined, which would contradict the statement. You need to check whether at least one of these two ways defines four factors.

Let's look at path 2). The factors F3, F4. And F2 are known, since the corresponding decision points are answered with YES; i.e. F3 = c, F4 = b, and F2 = b. At the decision point F1 = a?, NO is chosen. Since F1 can only assume the values a or b, F1 is also precisely determined; F1 = b.

So, there is at least one possibility for X, in which four factors can be precisely assigned. Statement I is wrong.

Statement II: In order to check this statement, we should follow all decision points which lead to decision option Z against the direction of the arrows back to the start. For this, we start at Z. If we follow the flowchart against the direction of the arrows, we go from Z to "F4 = b ?" and "F2 = a ?". Let's first have a look at the path which crosses F4. Here, "F4 = b ?" has to be answered with NO. Thus, F4 = d. If we continue working backwards, we will reach "F2 = a ?" which also has to be answered with NO. Thus, F2 can have the value b or c, which is not conclusive. Via the direct way to the decision point "F2 = a ?", we now check whether or not all factors can be assigned exactly one value. If "F2 = a ?" can be answered with YES, we will then reach "F1 = a ?" which also has to be answered with YES. Next, this path will take us to START. Consequently, neither F3 nor F4 can be assigned a unique value. The statement is not correct.

In short, the flowchart shows that there are a maximum of three decision points up to the result Z. Therefore, it is not possible to determine all four parameters going backwards from the field Z, since Z is independent of the value of F3.

1.16. Answer: C

Statement I: If F becomes negative once, then it can never again become positive. F is either multiplied by 2 or subtracted by 4. Both of these calculations reduce F. This statement is correct.

Statement II: In this case, the numbers are also always getting smaller because the term $\frac{3F \times Y}{2G + 1}$ *would be smaller than 1 and, thus, X would never be larger than or equal to 100,000. Statement II is correct.*

1.17. Answer: C

Statement I: We start Round 1 with:

$$X = 1 + \frac{3 \times 2 \times 1}{2 \times 3} = 2$$

X cannot be divided by 5. So, F is now 2 × 2 = 4.

X can be divided by 2. So G is now 3 + 2 = 5.

Since X is a whole number, we do not need to round it.

Statement I is correct.

Statement II: To answer this question, look at the results of the next round of calculation:

1. Round: <u>X = 2 with F = 4, G = 5</u>

2. Round: Starting values: E = 1, F = 4, G = 5, Y = 1

$$X = 1 + \frac{3 \times 4 \times 1}{2 \times 5} = 2{,}2$$

X is not divisible by 5. So, F now becomes 2 × 4 = 8

X is not divisible by 2. So, F now becomes 8 – 4 = 4

X is not a whole number. Now X is rounded: X = 2.

<u>X = 2 with F = 4, G = 5, E = 1, F = 1</u>

It can be seen that the result for X and the values of E, F, G, and Y in the second round are identical to those in the first round. In the third round, the result for X will therefore be exactly the same as in the second round. This also applies to all subsequent

rounds. X will always have the value of 2 at the end of the round, therefore, the stop point of 100,000 will never be reached and it is an eternal cycle. Statement II is correct.

1.18. Answer: B

Statement I: If the driver has already 7 points, he/she will lose his/her license even though it is just a Type I delict.

Statement II: Yes, for example the driver might lose it in January and again in September, after he/she has accumulated 8 or more points again through speeding tickets. The statement is correct.

1.19. Answer: D

Statement 1: We are at the first decision point. If b = 2, we answer "Yes", and go down. If a = 1, we answer "Yes" and go to the last decision point. If c = 1, we get the result "two different real solutions". Let's look at the discriminant: $\Delta > 0$. Therefore, Δ must be greater – and not less – than zero. The statement is incorrect.

Alternatively, you can go backwards here: In order to land in the field "two different real solutions", the decision above "$\Delta > 0$" must be answered with YES. The statement that the discriminant must be less than 0 for two different real solutions is therefore incorrect.

Statement II: We are at the decision-making point where we are asked whether a = 3. If this is the case, we answer "Yes" and go down. If c = 3, we answer "Yes" and go to the last decision point. If b = 1, we get the result "two complex conjugate roots". The value of the discriminant is $\Delta = 35 < 0$. This means that $\Delta < 0$ must apply in order to achieve two solutions with complex numbers. The statement is incorrect.

1.20. Answer: B

Statement I: Even in the case of larger apartments, the ARP can stay lower than the ORP. In this situation, additional measures will

be implemented. This statement is not correct.

Statement II: It is quite possible that, by improving upon the infrastructure of public transportation, the ARP = ORP and thus "No" will be chosen for the "ARP<ORP?" field. This statement is correct.

1.21. Answer: B

Statement I: In order to reach the "improve infrastructure of public transportation" field, it is necessary to pass the "Larger apartments" and "Beautify neighborhood" field. This statement is not correct.

Statement II: If the ARP is still lower than the ORP, even after applying each measure, the entire procedure begins with "Larger apartments" again. This statement is correct.

1.22. Answer: A

Statement I: With such complicated-looking equations, often there is the option to determine the correct answer through estimation.

In this case, we know that A, B, and C > 10 and the sum of them all is 100. In the next steps, either B or C will be doubled and then subtracted by 2. The doubling increases the value of the number more than the subtracting of 1 (it does not matter if this affects A, B or C). At the end of the first run, A + B + C has to be > 100.

This means that X must be a negative number in order for A + B + C + X = 100.

You can reach this conclusion by testing a couple of values. In order to test a conservative scenario, we assume that the smallest number among A, B, and C is to be multiplied. For example:

A = 50

B = 11

C = 39

$\frac{A}{B+C} \geq \frac{B}{C+A}$ □ *Yes*

B is doubled, so B = 22

$$\frac{C}{B+A} > \frac{B}{A}$$ *YES*

C is 37.

A + B + C + X = 100

50 + 22 + 37 + X = 100

X = -9

This question is much more difficult than others found in this test. Through such questions, you can see that, with the help of shortcuts, even difficult questions can be solved in less than 2 minutes. For many students, the time for this section of the test is not sufficient. Estimations make it possible to answer questions with less guess work:

$$\frac{A}{B+C} \geq \frac{B}{C+A}$$

$$\frac{A}{B} \geq \frac{B+C}{A+C}$$

Statement II: To answer this question, we change the formula so that the size ratios can be better compared (we multiplied crosswise):

$$\frac{A}{B+C} \geq \frac{B}{C+A}$$

$$\frac{A}{B} \geq \frac{B+C}{A+C}$$

According to the statement, A < B applies. You can see immediately that the left side of the equation must therefore be less than 1. For the right side, the following applies: If A < B, then B + C is greater than A + C. Thus, the numerator of the fraction is greater than the denominator, and the value of the fraction is greater than 1. The inequation is therefore not satisfied. Therefore the "NO" option is chosen and C is doubled. The statement is wrong.

EXAM 2

2.1. Answer: B

Statement I: Room A also has a terrace. This is why this statement is not correct.

Statement II: The only room which has enough space for more than 4 people is Room A. This statement is correct.

2.2. Answer: D

Statement I: If it is just one person, but this person wants to have a terrace, then Room B is also chosen. This statement is not correct.

Statement II: See explanation for statement I. Even one individual person can choose Room B. This statement is not correct.

2.3. Answer: D

Statement I: It is actually the other way around; Y stands for a state where all creatures can survive. Statement I is false.

Statement II: X stands for a state where nothing can survive. Statement II is wrong.

Hence, answer D is correct.

2.4. Answer: B

The first statement is false as bacteria require at least 5% oxygen, not 0.5%.

The second statement is true. For instance, if oxygen is 11% and temperature is 82 degrees Celsius, both the smaller creatures and the bacteria will survive. Therefore, answer B is correct.

2.5. Answer: A

The couple wants the room temperature to be 27 degrees Celsius. If the temperature is lower than 27, the thermostat has to increase heating in order to reach that temperature. Statement I is correct.

We are at the first decision point, which asks if the temperature is less than 27 degrees. If it is, we will answer "YES" and we will move to the "Increase heating" operation point. It will not be further reduced. Statement II is false.

2.6. Answer: C

If we exchange them, then the first decision point will ask if the temperature is greater than 27 degrees Celsius. If we answer "YES", we will move to the "Increase heating" operation point, and the temperature will be further increased. Statement I is correct.

Likewise, if the temperature is lower than 27 degrees and we answer "YES", we will move to the "Decrease heating" operation point, and the temperature will be further reduced. Statement II is correct.

2.7. Answer: D

Statement I: We are in the decision point which is asking about the weight of the suitcase. If we answer "YES", which means that the suitcase is indeed heavier than 20 kg, we go to the decision point "allowed to fly but fees to pay". The statement is not correct.

Statement II We are in the decision point which is asking about the existence of liquids in a carry-on baggage. If we answer "YES", we go to the "not allowed" decision point.

2.8. Answer: D

Statement I: The algae Ar and Sp produce carbon dioxide. In the graphic, if at position X it reads "Carbon dioxide normal?" and the path followed is "YES", you will get to the algae Sp. However, as Sp produces carbon dioxide, it should have an increased carbon dioxide level. The statement is incorrect.

Statement II: The algae Fe produces methane. If at X it reads "Increased concentration of methane?" and the answer is "YES", the path must lead to the algae that produces methane. In the diagram, the path would lead us to Sp, which does not produce methane. The statement is false.

2.9. Answer: B

Statement I: Aa helps with stomach aches and headaches but not with muscle pains. Thus, the statement is not correct.

Statement II: Ad helps with stomach aches. Thus, the statement is correct.

2.10. Answer: C

Statement I: Ae helps with muscle aches. This is expressed correctly within the flowchart. Thus, this statement is correct.

Statement II: All of the substances listed help with at least one of the symptoms. If "None" is found at the position Z, then the flow chart is correct because no symptom is present. What matters here is that "can be" is included in the statement. There may be other possibilities, but "no" is one of the correct answers. This statement is correct.

NOTE: Not all possible combinations of symptoms are shown in the flowchart. A flowchart is only incorrect if it contains illogical or incorrect processes, decision-making points, or operations. It is not always necessary to have all possible decision-making points.

It always depends on the purpose of the diagram. For example, medication in a certain group of patients may not be administered if the person only has a headache, but only if there is muscle pain or abdominal pain. Sometimes processes are deliberately simplified in order to analyze only a partial aspect.

If the statement was "The diagram is sufficient to make a decision regarding the possible treatment of all listed symptoms", then this statement would be incorrect. If this were the case and you do not have muscle pain but have abdominal pain, you would no longer be checked whether there is a headache.

The diagrams are about interpreting the information given in the question and the diagrams. The diagrams represent the processes in a very simplified manner; lifelike processes would be too complex for the purpose of this test.

2.11. Answer: C

Statement I:

There are two growth phases here, the grass grows 0.1 cm a day until it reaches a height of 3 cm. Then it grows at 0.06 cm per day. This phase lasts (6 cm – 3 cm)/0.06 cm = 50 days. Therefore, the third growth phase is never reached in this question.

phase (L ≤ 3) cm: $L = 2.7\ cm + 0.1\ cm/Day \times W \leq 3\ cm$

$W = 3\ Days$

phase (3 < L ≤ 6) cm: $L = 3\ cm + 0.06\ cm/Day \times W = 4\ cm$

$L = 3\ cm + 0.06\ cm/Day \times 17\ Days$

$L = 4.02\ cm$

After 20 days, the grass is 4.02 cm long. The statement is correct.

Statement II:

hase (L ≤ 3) cm: $L = 2\ cm + 0.1\ cm/Day \times W \leq 3\ cm\ W = 10\ Days$

hase (3 < L ≤ 6) cm: $L = 3\ cm + 0.06\ cm/Day \times W \leq 6\ cm\ W = 50\ Days$

hase (6 < L ≤ 9) cm: $L = 6 + 0.04\ cm/Day \times W = 7\ cm\ W = 25\ Days$

It takes 10 + 50 + 25 = 85 days until the grass is 7 cm high again. This is less than 100 days, so this statement is correct.

2.12. Answer: A

Statement I: Here you must pay attention to the process. To prove a statement as right or wrong, one example or counterexample