Via Afrika Physical Sciences

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Our Teachers. Our Future.

Grade 10 Study Guide

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Contents

Revision

When revising, many people find it helpful to write as they work. You are more likely to remember something that you have written than something that you have just looked at in a book. You will also find that you can concentrate better and learn faster if you revise hard for a few short sessions rather than for one long one. You will find that you get more revision done in three half-hour sessions with five minute breaks in-between than in one session of 1½ hours. When you take a break, do something completely different – preferably physical. Go for a walk, jump up and down, run around the garden or kick a ball.

Your memory recall of the work you have learned will be improved immensely if you go through it at regular intervals. People who have studied memory talk about the 'forgetting curve'. Suppose you have done an hour's revision and have learned a summary of a topic. The forgetting curve shows that whatever you are going to forget of that summary, you are likely to forget as much as half of it in the next 24 hours. If you spend just five minutes quickly going through that same summary the next day, and another five minutes a few days later, your memory recall at a later date when you write the exam will be much better.

How to tackle exam questions

Multiple choice questions

You probably will have to answer the questions by filling in blocks on an answer sheet. Use a pencil to fill in the blocks, so that you can rub it out if you wish to change an answer. If the examination requires you to use a pen, go over them again at the end when you are satisfied with your answers.

There will usually be four options to choose from in a multiple choice question. When you read the question, try to answer it in your mind without looking at the choices, then see if your answer is one of them. Sometimes the wrong choices can confuse you. There is always only one correct answer, so never fill in two blocks. If you do that, your answer will be marked wrong.

You do not lose marks if you get a multiple choice question wrong, so never leave out a question simply because you are not sure of an answer. Try to eliminate some choices that you think are definitely wrong, and then guess and hope for the best. Do not go on to the next question without committing yourself to an answer to the previous question, even if you are not sure of it. Answer it, but make a mark on the question paper so that, if you have time, you can come back to it when you have finished the rest of the examination.

Calculations

Any answer to a question that requires a calculation must start with a statement of the principle, law or equation that is required for the calculation. If you do not state the formula first and only write down numbers and an answer, you will get *no marks*, even if your answer is correct.

We use the SI system of units. If you are given a value in another unit, it first must be converted into the relevant SI unit before you substitute it into the equation. It is not necessary to write the unit with each substitution in the equation, provided each is in the correct SI units. You must write the correct SI unit with you final answer.

So the procedure is as follows:

- Ensure that all given quantities are in SI units.
- Write the relevant equation for the calculation. If necessary, change the subject of the formula.
- Substitute the given values. It is not necessary to write the unit with the substitution.
- Carry out the calculation.
- Write the answer, with the correct SI unit. If the quantity is a vector quantity, write the direction.

Mark allocation

Marks are usually allocated as follows:

- One mark for the equation for the calculation.
- One mark for each correct substitution, in SI units.
- One mark for the correctly calculated answer, with the unit. If the unit is missing or incorrect, this mark is lost.
- One mark for the statement of the correct direction, if it is a vector quantity.

Positive marking

Very often questions requiring calculations are structured so that an answer to one part of the question is used in another part of the question. If you make a mistake in the first part so that the answer to that part is wrong, you will not be penalised for an incorrect answer in the later part, provided your calculations are correct. This is often called 'positive marking'. Nevertheless, what should you do if you have no idea how to answer (say) question 2.1, but know that if only you had the answer to 2.1 you could answer 2.2? *Simply assume an answer* to 2.1. Write '2.2 Assume the answer to 2.1 is ...'. Write any number with the correct unit and carry on.

How to use this study guide

Each topic is presented as a summary followed by a selection of examination-type questions. The summaries are the 'bare bones' of what you need to know for each topic. Do not try simply to learn the summaries off by heart. You must make sure that you understand each statement in the summary. If not, then refer to the Learner's Book and study the relevant section. Once you are sure that you *understand* the statements, you can concentrate on learning the summary. It will be useful for you to write down the key words as they appear in the summary, then test yourself to see if you can state what is in the summary. Then work through the questions set on the topic. The answers are given at the back of the book, with an indication of how marks would be allocated in an exam.

A full sample Physics examination and a full sample Chemistry examination are also provided, with answers for you to test yourself before the final exams at the end of the year.

Prefixes and units

You will encounter the prefixes given in the table below as you study Physical Science. You will see from the table that the prefixes that are used in science all relate to exponents that are multiples of 3. While there are prefixes for numbers bigger than 10^6 and also smaller than 10^{-15}, it is sufficient for you to learn only those that are in this table.

Prefix	mega-	kilo-	unit	milli-	micro-	nano-	pico-	femto-
Factor	$\times 10^6$	$\times 10^3$	1	$\times 10^{-3}$	$\times 10^{-6}$	$\times 10^{-9}$	$\times 10^{-12}$	$\times 10^{-15}$
Symbol	M	K		m	μ	n	p	f
Example	MW º megawatt	kW kilowatt	W Watt	mW milliwatt	μW microwatt	nW nanowatt	pW picowatt	fW femto-watt

- Micro uses the Greek symbol μ (pronounced 'mew').
- All prefix symbols are small letters except for mega. This is to distinguish mega from milli.
- When writing the symbol for the prefix with the symbol for the unit (for instance, mW) there is no space or dot between the prefix and the unit.

SI units used in the Grade 10 curriculum

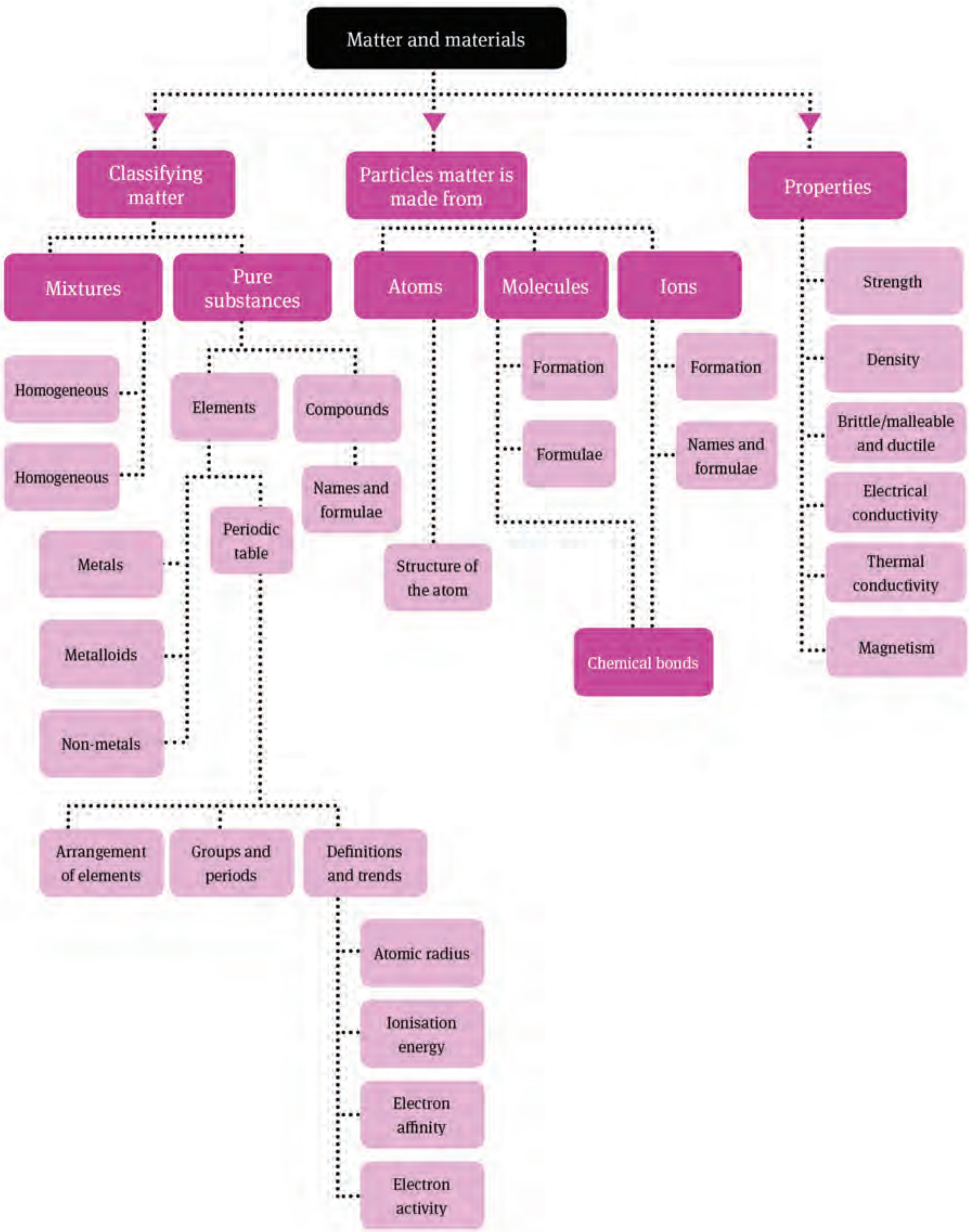
Here is a list of the symbols and SI units for quantities that you will come across in the Grade 10 curriculum. Test yourself to see that you know the symbol and unit for the quantity and the quantity for the unit.

Temperature	T	K (kelvin)
Distance	D	m
Amplitude	A	m
Frequency	f	Hz (hertz)
Time	t	s
Period	T	s
Speed, velocity	v	$m.s^{-1}$
Wavelength	λ	m
Energy	E	J (joule)
Planck's constant	h	J.s
Charge	Q	C (coulomb)
Potential difference	V	V (volt)
Emf	E	V (volt)
Current	I	A (ampere)
Resistance	R	Ω (ohm)
Quantity of matter	n	mol
Volume	V	m^3 (or dm^3 for concentration)
Concentration	c	$mol{\cdot}dm^{-3}$
Pressure	p	Pa (pascal)
Acceleration	a	$m.s^{-2}$

Topic 1

Matter and materials

Overview



Summary

1 Revision of matter (Grade 9)

1.1 Matter and classification

- Matter is made up of particles (atoms or molecules) and it is the properties of the atoms or molecules that determine the characteristics and reactivity of that matter.
- The properties of matter include: strength; density; melting and boiling points; whether the material is brittle, malleable or ductile; whether it is magnetic or not; and its electrical and thermal conductivity.
- Elements and compounds are classified as pure because they contain particles that are all the same. Substances can be classified as pure – elements and compounds – or mixtures. Pure substances contain particles that are all the same. Elements and compounds can be represented by symbols and formulae. Some of the names, symbols or formulae of a number of common elements and compounds that you should have learnt are the following:
  - Elements: S for sulphur; C for carbon; P for phosphorus (note the spelling); H for hydrogen; O for oxygen; He for helium; N for nitrogen; F for fluorine; Mg for magnesium; Ca for calcium; Zn for zinc.
  - Compounds: H_2O for water; H_2SO_4 for sulphuric acid; HCl for hydrochloric acid; NaCl for sodium chloride (table salt); $CaCO_3$ for calcium carbonate; KNO_3 for potassium nitrate; Na_3PO_4 for sodium phosphate.
- You will notice that the naming of compounds follows these rules:
  - The metal or hydrogen is always named first, then the non-metal (potassium iodide: KI; hydrogen chloride: HCl (also called hydrochloric acid)).
  - The name of a non-metal ion of an element always ends in –ide (for instance, sodium chloride: NaCl).
  - The name of a non-metal complex ion (more than one element in the ion) usually ends in –ate or –ite (for instance, copper sulphate: $CuSO_4$; potassium sulphite: K_2SO_3). An exception to this is hydroxide (for instance, sodium hydroxide: NaOH).
- Mixtures consist of different substances, and can be homogeneous (have the same 'look' throughout) or heterogeneous (you can see the different substances). They can be separated in various ways, for instance filtering, sieving, chromatography, distilling or dissolving one constituent.
- Some of the properties of metals are that they conduct electricity and heat, and they are malleable and ductile.
- Non-metals are non-conductors of electricity and heat. They are gases, liquids or brittle solids, and bond with each other.
- Metalloids are elements on the border between metals and non-metals, and they have both metal and non-metal properties.

2 States of matter and the kinetic molecular theory

- The kinetic molecular theory, together with an understanding of intermolecular forces, explains how matter can exist as solids, liquids or gases. The kinetic molecular theory can also be used to explain diffusion and Brownian motion.
- The kinetic molecular theory says that:
  - Matter is made up of particles that are constantly moving.
  - Particles have energy that varies according to whether they are in the gas (most energy), liquid or solid (least energy) phase.
  - The temperature of a substance is a measure of the average kinetic energy of its particles.
  - A change in phase may occur when the energy of the particles is changed by heating or cooling.
- There are spaces between the particles. These are greatest in the gas phase and least in the solid phase.
- Melting (solid ⇢ liquid or liquid ⇢ solid) points and boiling (liquid ⇢ gas or gas ⇢ liquid) points are the temperatures at which phase changes happen. They are also specific to pure substances.
- Sublimation is the change from solid to gas without going through the liquid phase, for instance, solid CO_2 (dry ice) sublimates to CO_2 (gas).
- Brownian motion is the random movement of gas and liquid particles. ('Random' means that any one particle can be moving in any possible direction at that instant.)
- Diffusion occurs mostly in gases and liquids. It is the movement of particles of one kind from an area where there are many to an area where there are few. This can happen because of the random movement of all particles and because there are large spaces between particles in the gas and liquid phases.

3 The atom – the basic building block of matter

3.1 The models of the atom

Matter is any substance that has a mass and occupies a volume. A number of models have been developed by different scientists explaining the structure of these atoms. Some of these models are described below:

- Democritus – developed the particle theory of matter. He stated that if you kept dividing something, eventually you would get to a point where it can no longer be divided. He called this indivisible substance 'atomos'.
- Dalton – said all matter consists of atoms that cannot be made or destroyed. Atoms of the same element are all the same and atoms can be joined together.
- Thomson – developed the 'currant bun' model. An atom consists of a solid, positively charged mass in which tiny negatively charged particles are scattered.
- Rutherford – said an atom contains a central, positively charged mass known as the nucleus.

- Bohr – said negatively charged electrons are contained within certain areas in the atom known as 'energy shells'.
- Schrödinger – developed the 'wave model' of the atom in which atoms behave as waves rather than as particles.

3.2 The structure of the atom

The atom consists of a central nucleus containing positively charged protons and neutral neutrons. Together these are known as nucleons.

Surrounding the nucleus is a number of energy shells containing negatively charged electrons.

The number of protons in the nucleus is called the atomic number (Z). In a neutral atom, the number of protons is equal to the number of electrons.

The number of protons and neutrons (added together) in the nucleus is called the mass number (A).

A	=	Z	+	N
Mass number		Atomic number		Number of neutrons

- An atom can either gain or lose electrons in order to form a charged particle, known as an ion. A positive ion is formed when an atom loses electrons, while a negative ion is formed when an atom gains electrons.
- The mass of an atom (atomic mass) is determined by the number of protons and neutrons. Mass of a proton = mass of a neutron = 1 mass unit.

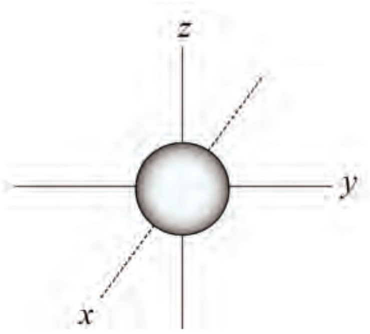
3.3 Isotopes

- Isotopes are atoms of the same element that contain the same number of protons, but different numbers of neutrons. They have the same atomic number, but different mass numbers.
- In the periodic table, two numbers are given with the symbol of each element. These numbers are the atomic number and the average atomic mass.
- In any element, the ratio of the isotopes is constant. The atomic mass is given as the average mass of all the atoms in the sample of the element.
- We can use the percentage composition of the isotopes of an atom to determine the average mass of the element.
  - Example: 75% of all naturally occurring chlorine atoms have an atomic mass of 35, while 25% have an atomic mass of 37. We can use these values to calculate the average atomic mass that will appear on the periodic table. We do this by multiplying the percentages of each isotope by their respective atomic masses

and then dividing the answer by 100. Atomic mass of chlorine = [(75 × 35) + (25 × 37)] / 100 = 35,5.

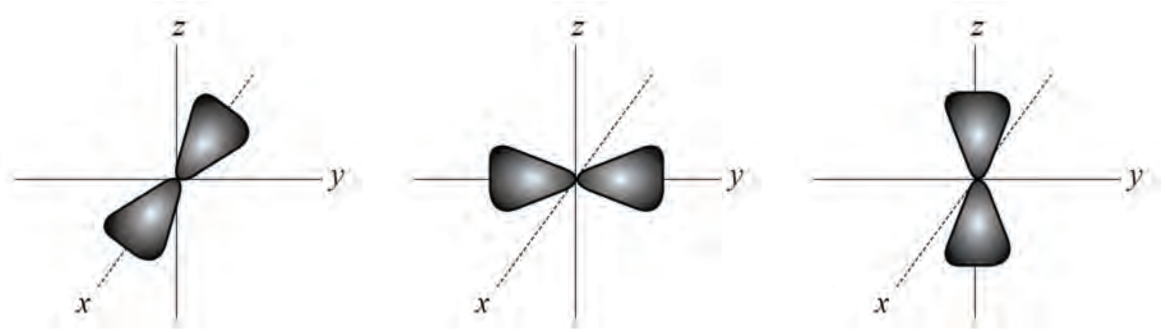
3.4 Electron configuration

- Electron configuration refers to the arrangement of electrons in an atom. Electrons occupy orbitals arranged within energy shells (numbered 1, 2, 3 ...) around the nucleus. These correspond to the periods in the periodic table.
- Orbitals are regions where electrons spend most of their time. Each orbital can contain a maximum of two electrons.



The s-orbital is spherical (ball-shaped).

Each energy shell has only one s-orbital.



p-orbitals are shaped like dumb-bells.

There are no p-orbitals in the first shell.

The other shells each contain three p-orbitals, named p_x, p_y and p_z.

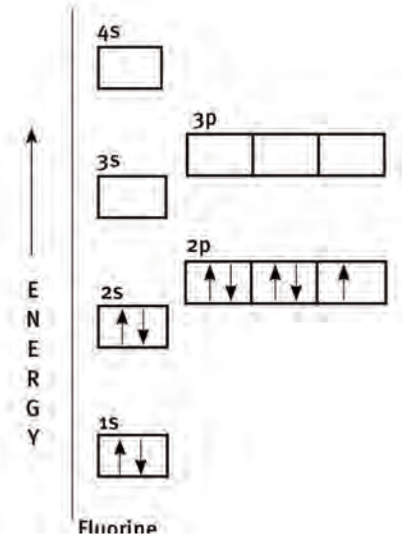
Each orbital can hold two electrons, which means that the three p-orbitals in a shell can hold six electrons in total.

- Scientists use Aufbau diagrams (arrows in boxes) to represent the electron configuration of an atom.
- The shell closest to the nucleus is number 1, the next number is 2, and so on.

Energy level	Types of orbitals	Maximum number of electrons contained
1	Only an s-orbital	2 electrons in the s-orbital
2	An s- and 3 p-orbitals	2 electrons in the s-orbital and 6 electrons in the p-orbitals
3	An s- and 3 p-orbitals	2 electrons in the s-orbital and 6 electrons in the p-orbitals

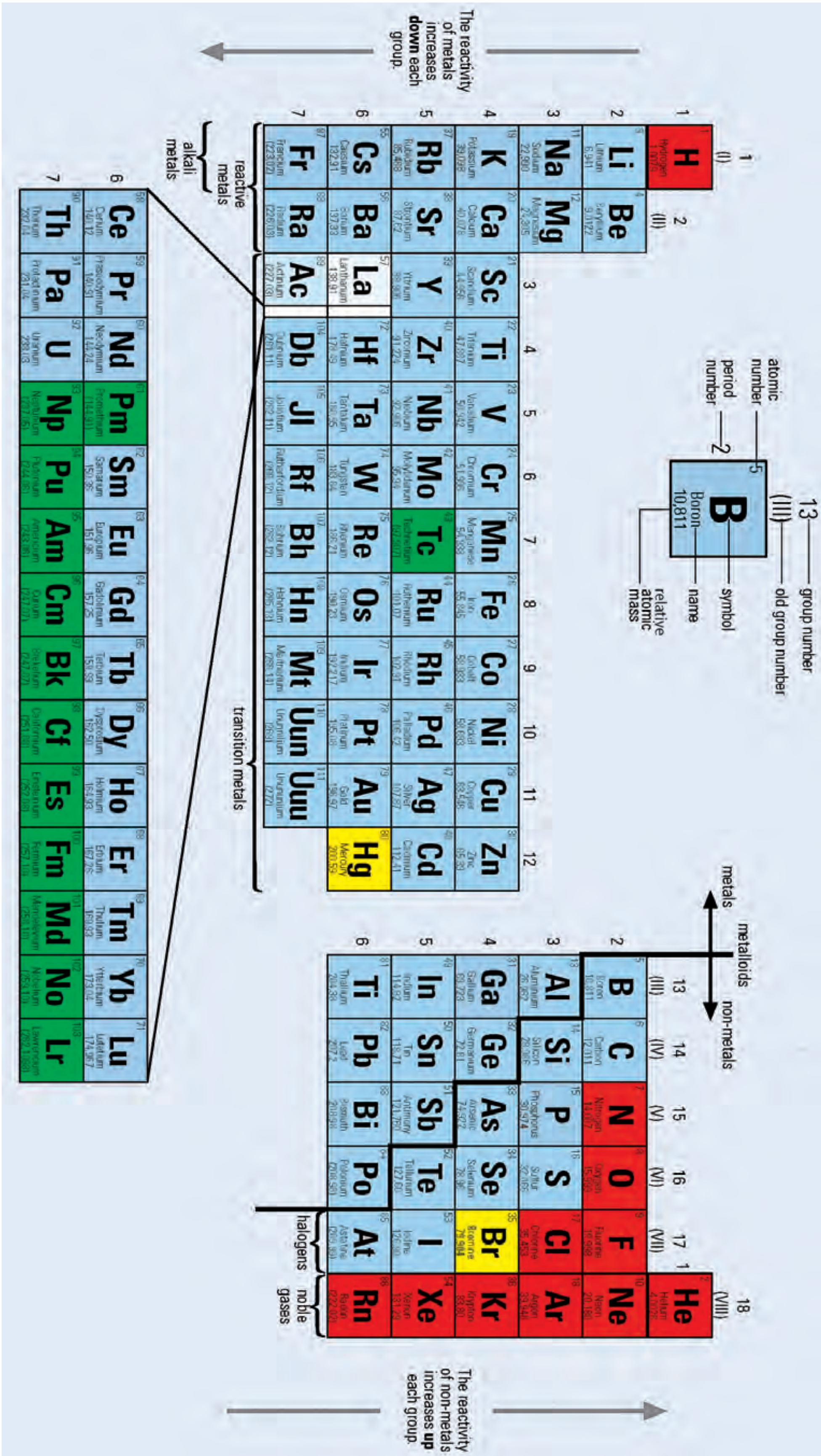
Example: An Aufbau diagram for fluorine

- Fluorine contains nine electrons. This means its electron configuration is $1s^2 2s^2 2p^5$. Each orbital must contain the maximum number of electrons before you can move on to the next orbital.



- As you can see, each electron is represented by an arrow.
- Rules for drawing Aufbau diagrams:
  - You must always fill up the lower orbitals before you can move on to the next energy level.
  - Pauli's exclusion principle: 'Each orbital may contain a maximum of 2 electrons, spinning oppositely'. This is why in each orbital the one arrow faces up, while the other faces down.
  - Hund's rule: 'Electrons occupy equivalent orbitals (like the p-orbitals in a shell) singly, before pairing takes place'.

4 The periodic table



- The elements are arranged in order of increasing atomic number.
- The zig-zag (step) line separates the metals (on the left) from the non-metals (on the right).
- The numbered columns are called groups and are numbered from I to VIII. If the transition metals are included, then the numbers run from 1 to 18.
- The numbered rows are called periods. This number tells you how many energy levels or electron shells there are.
- In some groups the properties of the elements in the group are similar (for instance, the alkali metals of group I, the non-metal halogens of group VII)
- The properties change gradually as you move across a period (for instance, change from metal to non-metal).
- Characteristics that change across the periodic table include the following:
  Atomic radius: This is the distance from the centre of the nucleus to the outer energy shell, and it increases down a group and across a period.

  Ionisation energy: This is the energy needed to remove an electron from an atom of that element in the gas phase, and it increases across a period but decreases down a group.

  Electron affinity: This is the energy change when an electron is added to an atom of an element in the gas phase, and it increases across a period and down a group.

  Electronegativity: This is the ability of an atom to attract the electrons making a bond it is involved in, and it increases across a period but decreases down a group.

5 Chemical bonding

- The electrons found in the outermost energy shells are known as valence electrons and they control how an atom reacts.
- The number of valence electrons equals the group number.
- All atoms try to get a full outer shell of electrons. They can achieve this by gaining electrons from another atom, losing electrons to another atom or sharing electrons with another atom.
- Covalent and ionic bonding are shown using Lewis diagrams.

5.1 Lewis diagrams (dot-cross diagrams)

- Dots or crosses are used to represent the valence electrons of an atom.
- Rules for drawing Lewis diagrams:
  - Write the symbol for the element and then draw a cross or dot on top of the symbol.
  - Work in a clockwise direction.
  - The electrons are only paired once the first four dots or crosses have been drawn.

5.2 Formation of ions

- An ion is a charged particle that forms when a neutral atom either gains or loses electrons.
- Atoms lose or gain electrons in order to obtain a full outer energy shell.

Group	Charge on the ion
I	+1
II	+2
III	+3
IV	These elements do not form ions.
V	−3
VI	−2
VII	−1

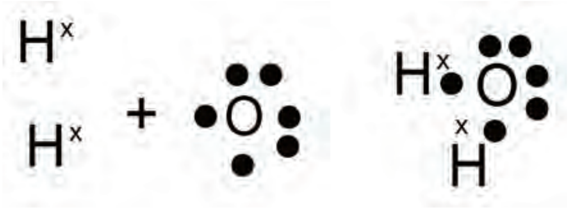
Elements in group VIII will not form ions, as they already have a full outer shell of electrons.

5.3 Ionic bonding

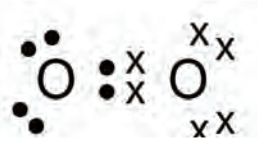
- Ionic bonding occurs between metals, which form positive ions, and non-metals, which form negative ions. Ionic bonding follows these rules:
  - The metal will form a positive ion with a charge equal to the number of electrons it has lost.
  - The non-metal ion is written in square brackets. Its charge is equal to the number of electrons gained.
  - The square brackets must contain the transferred electrons as well as those of the non-metal ion.

5.4 Covalent bonding

- A covalent bond is formed by overlapping orbitals that share of a pair of electrons. In this way, both atoms obtain a full outer energy shell.
- Water is an example of a covalent compound. Each oxygen atom requires two electrons in order to obtain a full energy shell. This means that two hydrogen atoms are needed. In this case, two single bonds are formed.



- An oxygen molecule contains a double bond, as each oxygen atom shares two electrons. It can be written as O=O.



5.5 Metallic bonding

- The valence electrons of metals are loosely held by the nucleus. They move out of position, and become 'delocalised' or free electrons.
- The structure is held in place by the strong electrostatic force between the positively charged metal ions and the negatively charged delocalised electrons.

5 Particles that make up substances

6.1 Covalent molecular substances

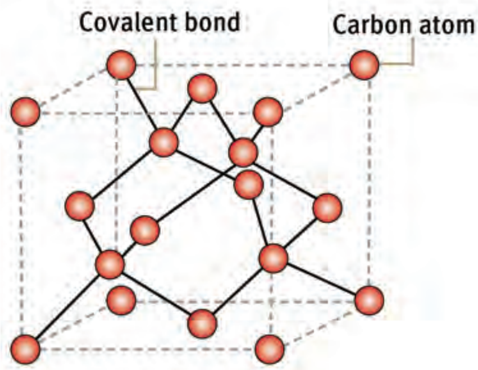
- Molecules are formed when non-metal atoms are covalently bonded together.
- We can represent molecules by using different circles. Each atom is represented by a circle of a different colour and size.

6.2 Ionic substances

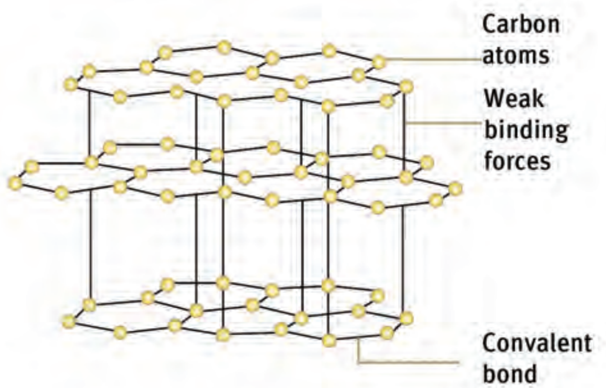
- Ionic substances, also known as salts, are formed when a metal atom transfers electrons to a non-metal atom.
- The electrostatic attraction between the positive and negative ions is what holds the crystal lattice together.

6.3 Covalent network structures

- Covalent network structures are giant molecular compounds formed by a large number of atoms that are covalently bonded together to form a highly regular lattice.
- Diamond and graphite are examples of such covalent network structures.



Structure of a diamond



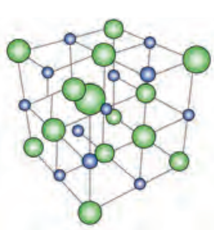
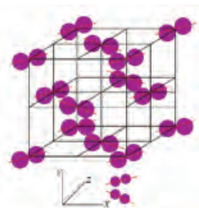
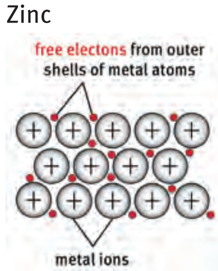
Structure of graphite

- In diamonds, each carbon atom is attached to four other carbon atoms.
- Graphite consists of layers of carbon atoms. Each carbon atom is attached to three other atoms within the layer. The layers are weakly bonded together and can slide apart easily, which means that graphite is soft. Graphite is used in pencils and as a lubricant in machinery.

6.4 Metallic substances

- A metal substance is one that forms when a group of atoms has a pool of delocalised electrons that surround a lattice of regularly spaced positive ions.
- Most metals are shiny and hard.

6.5 Summary

Bonding:	**Ionic (between metals and non-metals)**	**Covalent (between non-metals)**		**Metallic (between metals)**
Structure:	**Giant ionic**	**Covalent network**	**Molecular**	**Giant metallic**
Example:	Sodium chloride 	Diamond 	Iodine 	Zinc 

Questions

Question 1: Multiple choice

Choose the correct answer. Only write the letter of the answer you select.

1.1 Where are metals found on the periodic table?
- A At the bottom
- B To the right
- C To the left
- D At the top (3)

1.2 What is the name given to the group VII elements?
- A Alkali metals
- B Alkaline earth metals
- C Halogens
- D Nobel gases (3)

1.3 What change to a neutral atom will result in the formation of a negative ion?
- A It gains an electron.
- B It gains a proton.
- C It loses an electron.
- D It loses a proton. (3)

1.4 Which statement about the numbers of particles in atoms is correct?
Apart from hydrogen, most atoms contain:
- A more neutrons than protons.
- B more protons than neutrons.
- C more electrons than protons.
- D more protons than electrons. (3)

1.5 Metal atoms form:
- A positive anions.
- B negative anions.
- C negative cations.
- D positive cations. (3)

1.6 Which are the correct formulae for sodium chloride and calcium carbonate?
- A $NaCl$ and $CaCO_3$
- B SCl and $CaCO_3$
- C $NaCl$ and $CaCO_2$
- D $NaCl$ and $CmCO_3$ (3)

1.7 Which of the elements below has an electron configuration of $1s^2 2s^2 2p^4$?
- A sodium
- B chlorine
- C oxygen
- D fluorine (3)

1.8 Which of the following terms describes the change in state that occurs when a liquid changes into a solid?

A condensation
B evaporation
C freezing
D sublimation (3)

1.9 Copper has two isotopes; 69,1% of copper isotopes have a mass of 63 and 30,9% have a mass of 65. What is the average mass of a copper atom?

A 65
B 66
C 64,4
D 63,6 (3)

1.10 In which of the following compounds are electrons shared between atoms?

1 sodium fluoride
2 nitrogen dioxide
3 iron bromide

A 1 only
B 2 only
C 1 and 3
D 1, 2 and 3 (3)

1.11 Which compound contains two double bonds in which electrons have been shared?

A hydrogen bromide
B carbon dioxide
C sodium iodide
D water (3)

1.12 In the molecules CH_4, HBr and H_2O, which atoms use all of their outer shell electrons in bonding?

A C and Br
B C and H
C Br and H
D H and O (3)

1.13 The following statement is about chemical bonding. Covalent bonds are formed by the ... of electrons. Covalent bonds occur between ... Which combination of words completes the statement? (3)

A	transfer	two non-metals
B	transfer	a non-metal and a metal
C	sharing	two metals
D	sharing	two non-metals

1.14 Which of the elements below is most likely to form a positive ion?
A zinc
B chlorine
C oxygen
D fluorine (3)

1.15 Which substance when combined with oxygen will form a covalent bond?
A sodium
B magnesium
C boron
D aluminium (3)

[45]

Question 2: Matching pairs

Choose an item from column B that matches the description in column A. Write only the letter of your choice (A–J) next to the question number.

Column A	Column B
2.1 formation of positive ions	A – the number of protons and neutrons added together
2.2 mass number	B – loss of electrons
2.3 group VIII elements	C – when a substance changes from a liquid to a solid state
2.4 chromatography	D – the number of protons and electrons added together
2.5 condensation	E – halogens
	F – gain of electrons
	G – separation of mixtures of pigments/colours
	H – when a substance changes from a gas to a liquid state
	I – separation of a solid from a liquid
	J – noble gases

[5]

Question 3: True/false

Indicate whether the following statements are true or false. If the statement is false, write down the correct statement.

3.1 Isotopes are elements with the same number of protons, but different numbers of electrons. (2)

3.2 Isotopes contain the same number of electrons in their outermost energy shell. (2)

3.3 Sodium has an electron configuration of $1s^2 2s^2 2p^6 3s^1$. (2)

3.4 Calcium and magnesium both form anions with a charge of +2. (2)

3.5 A mixture can be separated into its component substances by physical means. (2)

[10]

Question 4: One-word answers

Provide one word or term for each of the descriptions. Write only the word or term next to the question number.

4.1 The movement of particles from a region where there are many to a region where there are fewer. (1)

4.2 The basic building block of matter. (1)

4.3 The electrons found in the outermost energy shell. (1)

4.4 A mixture in which the different substances that make up that mixture can be seen. (1)

4.5 The type of chemical bonding that occurs when electrons are transferred from one atom to another. (1)

[5]

Question 5: Long questions

Mixtures can be homogeneous or heterogeneous.

5.1 What is the difference between a homogeneous mixture and a heterogeneous mixture? (2)

5.2 Give one example of each. (2)

5.3 How do mixtures differ from compounds? (2)

5.4 Which of the following substance is pure?

sugar

sea water

steel (1)

[7]

Question 6: Long questions

The following are the melting points of the metals in group II on the periodic table:

beryllium	1278 °C
magnesium	649 °C
calcium	839 °C
strontium	769 °C
barium	725 °C

6.1 What is the general trend in melting points as you go down the group? (1)

6.2 One metal does not fit this trend. Which one is it? (1)

6.3 Does this information support the idea that beryllium atoms are held together more strongly than barium atoms? (1)

6.4 Explain your answer to question 6.3. (2)

[5]

Question 7: Long questions

Use the table below to answer the questions that follow.

Substance	Melting point (°C)	Boiling point (°C)
lead	317	174
radon	−71	−62
ethanol	−117	78
cobalt	1492	2900
nitrogen	−210	−196
propane	−188	−42
ethanoic acid	16	118

7.1 Define the boiling point of a substance. (2)

7.2 Which two substances are gaseous at –50 °C? (2)

7.3 Which substance is a liquid at 2500 °C? (1)

7.4 Is nitrogen a liquid, solid or gas at 35 °C? (1)

[6]

Question 8: Long questions

The table below shows information about two isotopes of chlorine.

Atom	Number of protons	Number of electrons	Number of neutrons
Chlorine-35	A	17	18
Chlorine-37	17	B	C

8.1 Replace the letters with the correct numbers to complete the table. (3)

8.2 Define isotopes. (2)

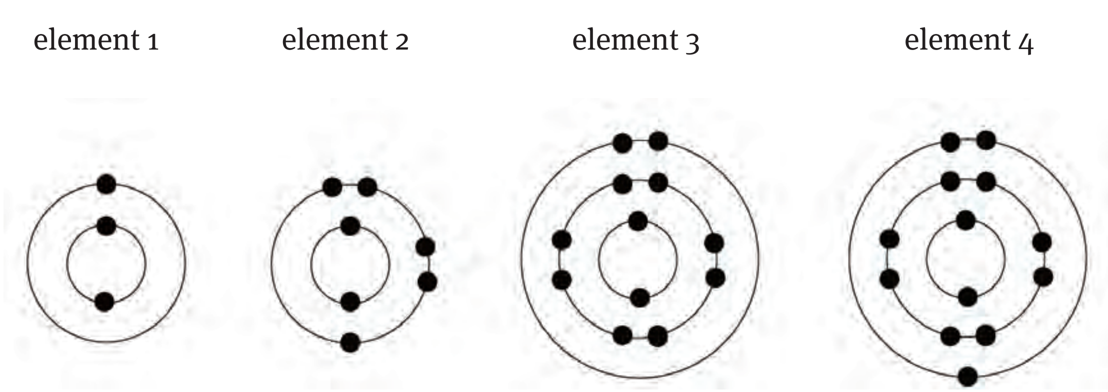
8.3 Draw an Aufbau diagram of a chlorine atom. (2)

8.4 A chlorine ion has a charge of –1. Write down the electron configuration for a chlorine ion. (1)

[8]

Question 9: Long questions

The diagram below shows the electron configuration of four different elements.



9.1 Which element has an atomic number of 3? (1)

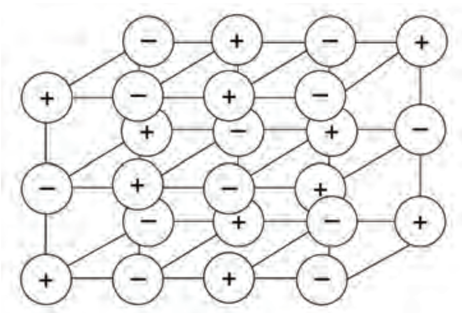
9.2 Which atom has the electron configuration $1s^2 2s^2 2p^6 3s^2$? (1)

9.3 Which element is nitrogen? (1)

[3]

Question 10: Long questions

The structure of a typical ionic compound is a regular arrangement of positive and negative ions.



10.1 What is the name of this regular arrangement of particles? (1)

10.2 Name an ionic substance. (1)

10.3 Ions are formed by electron loss or gain.

10.3.1 Give the formula of the magnesium ion. (1)

10.3.2 Give the formula of the oxide (oxygen) ion. (1)

10.3.3 Why are these two ions attracted to each other? (1)

10.3.4 Draw a Lewis diagram to show the bonding that takes place between a magnesium and oxygen atom. (3)

[8]

Question 11: Long questions

The table below describes the number of protons, neutrons and electrons found in three different substances: A, B and C.

Particle	Number of protons	Number of electrons	Number of neutrons
A	15	15	16
B	15	18	16
C	15	15	17

Use the information in the table to explain why the following statements are true.

11.1 Particle A is a neutral atom. (1)

11.2 They are all particles of the same element. (1)

11.3 Particle B is a negative ion. (1)

11.4 Particles A and C are isotopes. (2)

11.5 What is the charge on particle B? (1)

11.6 Is particle B a metal or a non-metal? Give a reason for your answer. (2)

[8]

Topic 1

Answers to questions

Answers to questions

Question 1: Multiple choice

1.1 C ✓✓✓
1.2 C ✓✓✓
1.3 A ✓✓✓
1.4 B ✓✓✓
1.5 D ✓✓✓
1.6 A ✓✓✓
1.7 C ✓✓✓
1.8 C ✓✓✓
1.9 D ✓✓✓
1.10 B ✓✓✓
1.11 B ✓✓✓
1.12 B ✓✓✓
1.13 D ✓✓✓
1.14 A ✓✓✓
1.15 C ✓✓✓

[45]

Question 2: Matching pairs

2.1 B ✓
2.2 A ✓
2.3 J ✓
2.4 G ✓
2.5 H ✓

[5]

Question 3: True/false

3.1 False ✓ – Isotopes have the same number of protons, but different numbers of neutrons. ✓
3.2 True ✓✓
3.3 True ✓✓
3.4 False ✓ – Sodium and calcium both form cations with a charge of +2. ✓
3.5 True ✓✓

[10]

Answers to questions

Question 4: One-word answers

4.1 diffusion ✓

4.2 atom ✓

4.3 valence electrons ✓

4.4 heterogeneous ✓

4.5 ionic ✓

[5]

Question 5: Long questions

5.1 In a homogeneous mixture, the substances that make up the mixture are not visible as separate substances ✓ whereas in a heterogeneous mixture they are. ✓

5.2 Homogeneous – sea water, fruit juice, tea, coffee, steel (any correct one) ✓

Heterogeneous – granite, nuts and raisins, smoke, oil and water, box of biscuits (any correct one) ✓

5.3 In mixtures, the substances that make up that mixture can be in variable proportions. ✓ In compounds, the elements combine in fixed ratios. ✓ Mixtures can be separated by physical means, while compounds can only be separated by chemical means. ✓

5.4 Only sugar is a compound. The rest are mixtures. ✓

[7]

Question 6: Long questions

6.1 melting points decrease ✓

6.2 magnesium ✓

6.3 yes ✓

6.4 because the melting point of beryllium is much higher,✓ so more energy is needed to melt it ✓

[5]

Question 7: Long questions

7.1 The boiling point of a substance is the temperature ✓ at which that substance changes from a liquid into a gas. ✓

7.2 radon ✓ and nitrogen ✓

7.3 cobalt ✓

7.4 gas ✓

[6]

Answers to questions

Question 8: Long questions

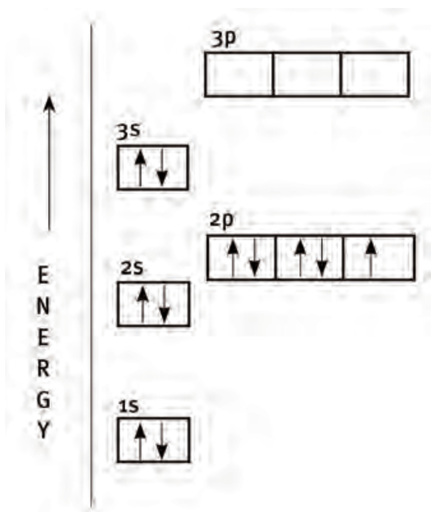
8.1 A 17 ✓

B 17 ✓

C 20 ✓

8.2 Elements with the same atomic number, ✓ but different mass numbers. ✓

8.3



- correct number of electrons ✓
- correct placement of electrons ✓

8.4 $1s^2 2s^2 2p^6 3s^2 3p^6$ ✓

[8]

Question 9: Long questions

9.1 element 1 ✓

9.2 element 3 ✓

9.3 element 2 ✓

[3]

Question 10: Long questions

10.1 crystal lattice ✓

10.2 Any metal atom combined with a non-metal atom. ✓

10.3 10.3.1 Mg^{+2} ✓

10.3.2 O^{-2} ✓

10.3.3 The electrostatic attraction between oppositely charged ions. ✓

Answers to questions

10.3.4

- correct number of valence electrons ✓
- correct placement of valence electrons ✓
- correct charges of ions ✓

[8]

Question 11: Long questions

11.1 It has the same number of protons as electrons. ✓

11.2 They all have the same number of protons. ✓

11.3 It has more electrons than protons. ✓

11.4 They have the same number of protons, ✓ but different numbers of neutrons. ✓

11.5 –3 ✓

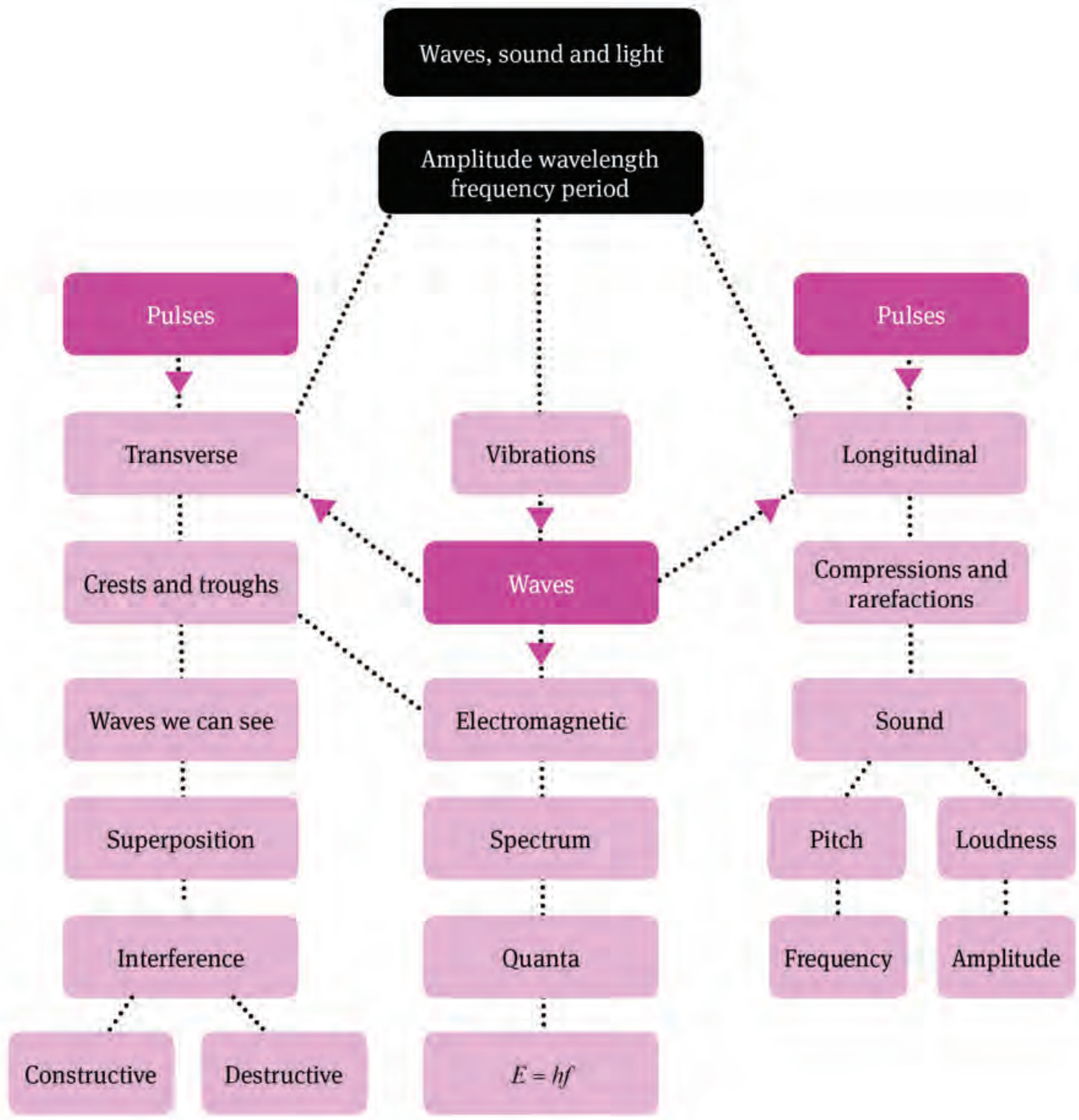
11.6 It is a non-metal,✓ as it has formed a negative ion. ✓

[8]

Topic 2

Waves, sound and light

Overview



Summary

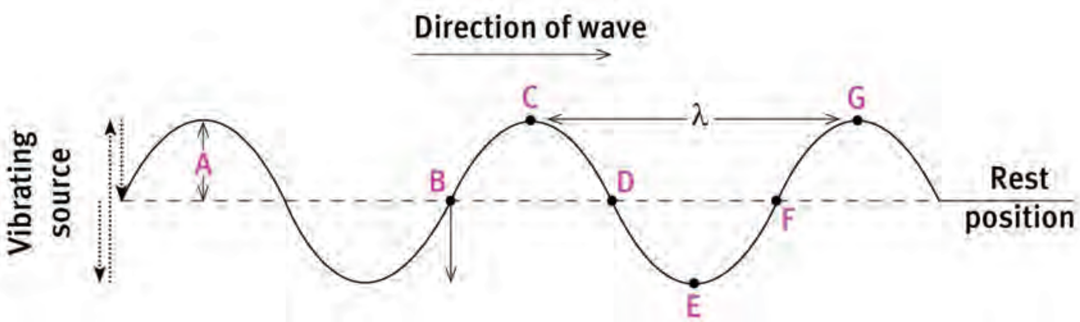
1 Transverse pulses and waves

1.1 Properties of transverse pulses and waves

- A pulse is a single disturbance in a medium. A single crest is a transverse pulse. A single trough is also a transverse pulse.
- In a transverse pulse or wave, the particles of the medium vibrate at 90° to the direction in which the pulse or wave moves.
- The amplitude of a pulse is the maximum displacement from the position of rest of a particle in the medium.
- A wave is made up of one pulse after another.
- The 'hump' in a transverse wave is called a crest.
- The 'hollow' in a transverse wave is called a trough.
- Continuous transverse waves are produced by continuous vibrations of the medium.
- A vibration is a regular to-and-fro movement (up-and-down or forwards-and-backwards).
- The rest position of a vibrating object (also called the equilibrium position) is the position that it would be in when not vibrating.
- One complete vibration (also called one oscillation) is one complete to-and-fro movement. It is the movement from the rest position to the furthest point in one direction, then to the furthest point in the opposite direction, then back to the rest position.
- One complete vibration (or one oscillation) of the end of a slinky spring will produce one wavelength in the spring.
- Particles in a medium are in phase if they are vibrating perfectly in step with one another.
- Particles in a medium that are not vibrating perfectly in step with one another are out of phase. Two particles are completely out of phase if they are moving oppositely, with one reaching the crest at the same instant that the other reaches the trough.

1.2 Wavelength, frequency, amplitude, period, wave speed

- Wavelength (λ) is the distance between two consecutive points that are in phase. For transverse waves, wavelength is the distance between two successive crests or two successive troughs. The unit is metres (m). If the wavelength is given in any other unit (for instance, mm or nm), it must be converted to metres when doing a calculation.
- Frequency *(f)* is the number of wavelengths passing per second. It equals the frequency of the vibration making the waves. The unit is s^{-1} (per second). 1 s^{-1} is called a hertz (Hz).
- The amplitude of a wave is the maximum distance that a point in a wave moves from its rest position. This equals the distance from the rest position to the top of a crest or to the bottom of a trough. The unit is metres (m).



Distance A is the amplitude of the wave. Each point in the medium simply vibrates up and down. Point B must be moving down for the wave to be moving to the right. Points B and F and points C and G are in phase. Points B and D and points c and E are completely out of phase. Distance CG and distance BF are equal and are the wavelength.

- The speed of a wave (v) is the distance moved by any pulse in the wave per second. The speed can change as the medium changes. The unit is metres per second ($m.s^{-1}$). If the speed is given in any other unit (for instance, $km\ hr^{-1}$), it must first be converted to $m.s^{-1}$ before doing a calculation.
- Speed is calculated using the formula: speed (in $m.s^{-1}$) = $\dfrac{\text{Distance moved (in m)}}{\text{time taken (in s)}}$
- The wave equation relates the above three quantities: $v = f\lambda$
- The period (T) of a wave is the time taken for one wavelength to pass. The unit is seconds (s). $T = 1 / f$
- Period and frequency are inversely proportional to each other. If the frequency is doubled, the period is halved. It also equals the period of the vibration making the wave.
- If $T = 1 / f$, it follows that $f = 1 / T$.
- If we take the wave equation $v = f\lambda$ and substitute $1 / T$ for f, we have $v = \lambda / T$.

1.2.1 Worked example

A transverse wave is set up in a slinky spring lying on a long table. The wavelength is 540 mm. One wavelength passes a mark on the table every 0,8 s.

Calculate:

1 the frequency of the wave
2 the speed of the wave.

Answers:

1 $T = 0{,}6\ \text{s}$ $\qquad f = ?$

$f = \dfrac{1}{T} = \dfrac{1}{0{,}8}$

$= 1{,}25$ Hz

2 $f = 1{,}25$ Hz $\lambda = 540$ mm $= 0{,}54$ m $v = ?$

$v = f\lambda$

$= 1{,}25 \times 0{,}54$

$= 0{,}675$ m.s^{-1}

1.3 Superposition of pulses

- Superposition is the addition of the amplitudes of two pulses that occupy the same space at the same time. If a crest is considered positive, then a trough is negative.
- When waves meet, they interfere.
- Crest meeting crest or trough meeting trough results in a bigger amplitude – constructive interference.
- Crest meeting trough results in a smaller amplitude – destructive interference.
- Two pulses will cancel out to produce zero amplitude only if:
  - one is a crest, the other a trough
  - their amplitudes are equal
  - their pulse lengths are equal.

2 Longitudinal waves and sound

2.1 Longitudinal pulses and waves

- A pulse is a single disturbance in a medium. A single compression (particles close together) or a single rarefaction (particles far apart) are each longitudinal pulses.
- The amplitude of a pulse is the maximum displacement from the position of rest of a particle in the medium. So it is the distance from the rest position to the centre of a compression, or the distance from the rest position to the centre of a rarefaction.
- In a longitudinal wave, the particles of the medium vibrate in line with the direction in which the wave moves.
- Longitudinal waves are made up of alternate compressions (particles close together) and rarefactions (particles far apart).
- Wavelength (λ) is the distance between two consecutive points that are in phase. For longitudinal waves, wavelength is the distance between two successive compressions or two successive rarefactions. The unit is metres (m). If the wavelength is given in any other unit (for instance, mm or nm), it must be converted to metres when doing a calculation.
- Frequency (f) is the number of wavelengths passing per second. It equals the frequency of the vibration making the waves. The unit is s^{-1} (per second). 1 s^{-1} is called a hertz (Hz).
- The amplitude of a wave is the maximum distance that a point in a wave moves from its rest position. For a longitudinal wave, it is the distance from the rest position to the centre of a compression or to the centre of a rarefaction. The unit is metres (m).

- The period and frequency of a longitudinal wave have the same meaning as for a transverse wave. Period is the time taken for one wavelength to pass, for instance, the time between two successive compressions, measured in seconds. Frequency is the number of wavelengths that pass per second, measured in Hz.
- The equations $T = 1 / f$ and $v = f\lambda$ are applied as for transverse waves.

2.2 Sound waves

- Only vibrating objects produce sound. Energy is therefore needed to produce sound.
- A material medium is required for sound to move. Sound cannot pass through a vacuum.
- Sound energy moves through a medium as longitudinal waves. Alternate compressions and rarefactions pass through the medium.
- The speed, frequency and wavelength of sound are related by the equation:
  Speed = frequency × wavelength
  $v = f\lambda$
- The speed of sound in air is approximately 340 $m.s^{-1}$. The speed is dependent on the medium and its temperature.
- Solids transmit sounds best, gases worst. The same sound is heard loudest through solids, next loudest through liquids and softest through gases.
- Sound moves fastest through solids and slowest through gases. In gases, the greater the mass of the gas molecules, the slower the sound. In air, the higher the temperature the faster the sound.

2.3 Pitch and loudness

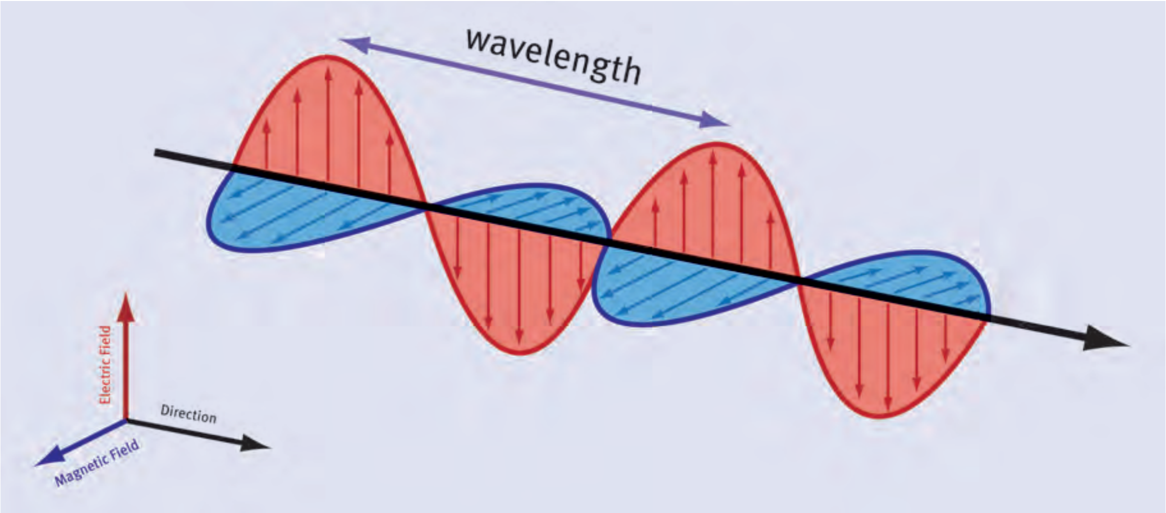
- The frequency of a sound wave is determined by the frequency of the vibration that causes it. If the sound wave passes into another medium, say from air into water, the speed of the wave changes, but the frequency stays the same.
- The pitch of a note is its position on a musical scale. As the frequency of a sound wave increases, so the pitch rises.
- Loudness is determined by the amplitude of the sound wave. The greater the amplitude, the louder the sound.
- Ultrasound has frequencies between 20 kHz and 100 kHz, higher than the range of human hearing. Ultrasound is used to produce internal images of the body (for instance, of a baby in the womb). The sound is reflected differently by the different layers in the body.

3 Electromagnetic radiation

3.1 Wave nature and spectrum

- The spectrum of visible light is only a small part of a broad range of waves that travel through a vacuum at the speed of light. The full range is called the electromagnetic spectrum.

- Electromagnetic waves are produced by accelerating charges. For example, in a radio aerial, changing electric fields accelerate electrons back and forth. This produces a changing magnetic field at right angles to the aerial. This in turn produces changing electric fields at right angles, and the process continues with each field generating the other. The crests and troughs in the wave indicate points where the electric or magnetic fields are strongest.



- Electromagnetic waves are transverse and consist of changing electric fields and magnetic fields at 90° to each other.
- Electromagnetic waves travel through space at 3×10^8 m.s^{-1}. The wave equation $c = f\lambda$ applies.
- Different sections of the spectrum have different names. In order of increasing wavelength (or decreasing frequency), these are: gamma rays, X-rays, ultraviolet light, visible light, infrared, microwave, TV and radio.
- Gamma rays are produced by radioactive material. They have the highest frequency and the highest energy and are the most penetrative and the most dangerous. They can destroy human cells and cause cancer. Radio waves at the opposite end of the spectrum are far less penetrative and not dangerous.
- X–rays are produced when high-speed electrons strike a metal plate. They can be used to produce a photographic image of the human body. They cannot pass through lead.
- Ultraviolet radiation is produced by very hot objects. Ultraviolet rays are very harmful to the eyes, cause tanning and can cause skin cancer. Some chemicals fluoresce in UV light.
- Infrared radiation is heat radiation, produced by vibrating atoms and molecules in hot objects. TV remotes work by sending out infra-red pulses.

3.2 The wave and particle nature

- Electromagnetic waves are radiated in packages, called quanta. A quantum of light is called a photon.

- Electromagnetic radiation has both a wave nature (transverse electric and magnetic fields) and a particle nature (quanta of energy). Radio waves have such long wavelengths that their particle nature is negligible. Gamma rays have such short wavelengths that their wave nature is negligible. Visible light (in the middle of the electromagnetic spectrum) behaves both as waves and as particles. This is known as the dual nature of light.
- The energy of a quantum can be calculated using the equation:

$$E = hf = hc / \lambda$$

where $h = 6{,}63 \times 10^{-34}$ J.s (Planck's constant) and $c = 3 \times 10^{8}$ m.s^{-1}

3.2.1 Worked examples

1 The energy of a photon of light is $5{,}3 \times 10^{-19}$ J. Calculate the frequency of the light waves.

2 Calculate the energy of a microwave quantum of wavelength 0,2 m.

Answers:

1 $E = 5{,}3 \times 10\text{-}19$

$E = hf \qquad f = E / h = 5{,}3 \times 10\text{-}19 / 6{,}63 \times 10^{-34}$

$f = 7{,}99 \times 1014$ Hz

2 $E = hc / \lambda = \dfrac{(6{,}63 \times 10^{-34}) \times (3 \times 108)}{0{,}2}$

$E = 9{,}95 \times 10^{-25}$ J

Questions

Question 1: Multiple choice

Choose the correct answer. Write down only the letter of the answer you select.

1.1 What is the angle between the electric and magnetic fields in an electromagnetic wave?

A 0°

B 90°

C 180°

D 360° (3)

1.2 What is the period of a wave with a frequency of 5 Hz?

A 0,2 s

B 5,0 s

C 2,0 s

D 20,0 s (3)

1.3 Two transverse pulses meet and cancel out through a process called:

A diffraction.

B reflection.

C constructive interference.

D destructive interference. (3)

1.4 In order to calculate the speed of a wave, which formula would you use?

A wavelength ÷ frequency

B frequency ÷ wavelength

C wavelength ÷ period

D frequency × period (3)

1.5 The speed of a water wave is 4 $m.s^{-1}$. If the frequency is 8 Hz, what is the wavelength?

A 32 m

B 2 m

C 12 m

D 0,5 m (3)

1.6 A vibrating hacksaw blade completes 40 oscillations (complete vibrations) in 5 s. What is its period?

A 8 s

B 0,125 s

C 0,2 s

D 0,025 s (3)

1.7 The speed at which water molecules are moving in a wave in a ripple tank:

A is greatest in a trough.

B is greatest in a crest.

C is smallest in the rest position.

D is greatest in the rest position. (3)

1.8 Sound travels fastest through a:

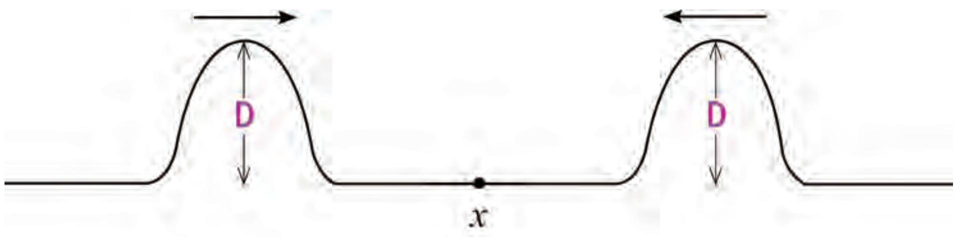
A solid.

B liquid.

C gas.

D vacuum. (3)

1.9 The sketch shows a rope with two pulses of equal amplitude approaching each other. When the two pulses pass through point X, what is the maximum amplitude of the pulse?



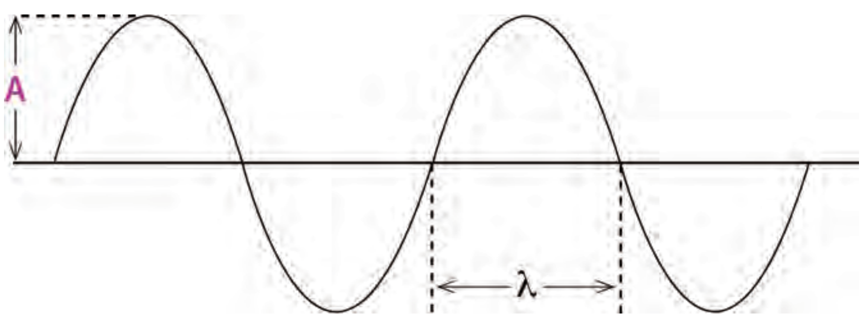
A D

B 0

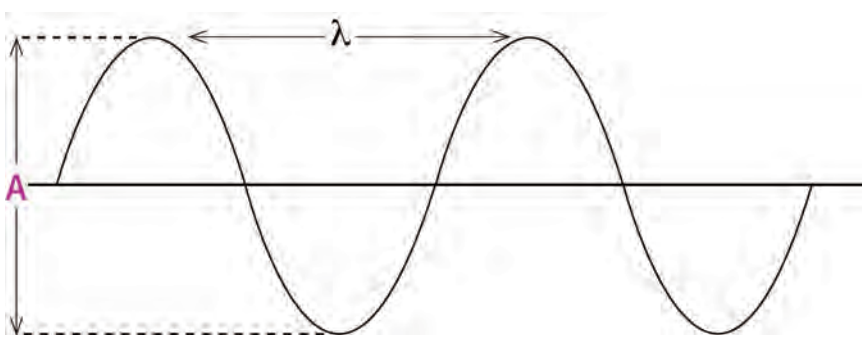
C 2 D

D ½ D (3)

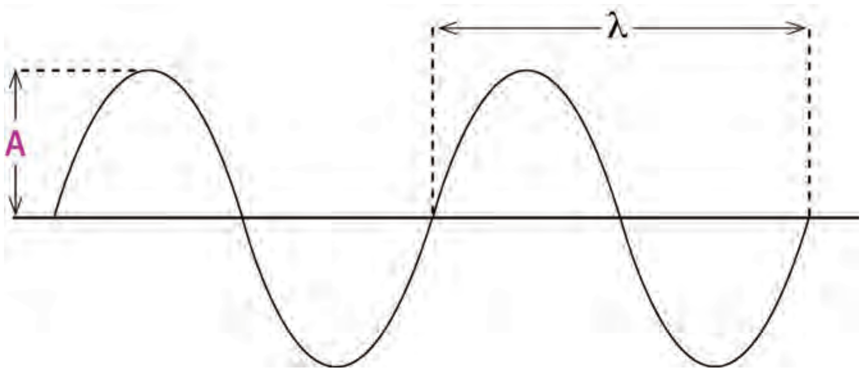
1.10 Which diagram below has both the wavelength (λ) and the amplitude (A) labelled correctly?



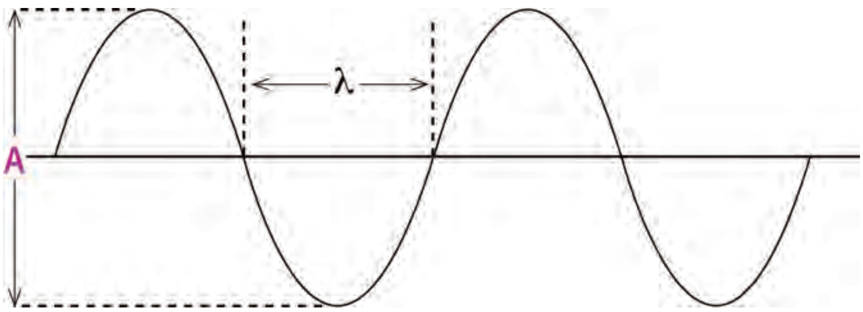
A



B



C



D

(3)

1.11 Sound is:

1 a series of moving compressions and rarefactions.

2 an example of a transverse wave.

3 able to travel through a vacuum.

4 an example of a longitudinal wave.

Which of the above statements about sound is/are correct?

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 1 and 4 (3)

1.12 The wavelength of a particular form of electromagnetic radiation in a vacuum is 10^{-12} m. The wavelength of a form of electromagnetic radiation of twice the frequency is:

A $2,5 \times 10^{-13}$ m.

B 10^{-6} m.

C 5×10^{-13} m.

D 2×10^{-12} m. (3)

1.13 The energy of a photon of electromagnetic energy can be calculated using the equation:

A $E = hf$.

B $E = h \div f$.

C $E = \lambda \div hc$.

D $E = h\lambda \div c$. (3)

[39]

Question 2: True/false

Indicate whether the following statements are true or false. If the statement is false, write down the correct statement.

2.1 In a longitudinal wave, each particle in the medium is travelling fastest as it passes through the rest position. (2)

2.2 In a transverse wave, a pulse length is equal to a wavelength. (2)

2.3 Wavelength is the maximum displacement from the position of rest. (2)

2.4 An increase in frequency of a sound wave and a simultaneous increase in amplitude will cause a note that is louder and has a lower pitch. (2)

2.5 The energy of electromagnetic radiation is directly proportional to the wavelength of the radiation. (2)

[10]

Question 3: One-word answers

Provide one word or term for each of the following descriptions. Write only the word or term next to the question number.

3.1 The colour of visible light that has the shortest wavelength, highest frequency and greatest energy. (1)

3.2 A region in a longitudinal wave where the particles of the medium have been pulled far apart. (1)

3.3 The type of electromagnetic radiation that is responsible for us feeling the heat from the sun. (1)

3.4 The distance between two consecutive points in a longitudinal wave that are in phase. (1)

3.5 A quantum of visible light. (1)

[5]

Question 4: Matching pairs

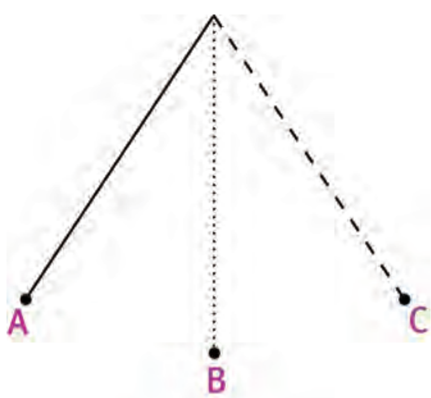
Choose an item from column B that matches the description in column A. Write only the letter of your choice (A–J) next to the question number.

Column A	Column B
4.1 released during nuclear reactions	A S
4.2 a unit for frequency	B electric field
4.3 a charged particle experiences a force	C gamma rays
4.4 distance moved per second	D speed
4.5 a quantum of visible light	E s^{-1}
	F photon
	G magnetic field
	H microwaves
	I proton
	J frequency

[5]

Question 5: Long questions

The sketch below shows a pendulum consisting of a weight attached to the end of a length of string. The pendulum was set in motion by pulling the weight to position A and releasing it.



Explain the meaning of each of the following terms, making use of the positions shown in the sketch where appropriate.

5.1 one oscillation (or complete vibration) (2)

5.2 the rest position (or equilibrium position) (2)

5.3 frequency (2)

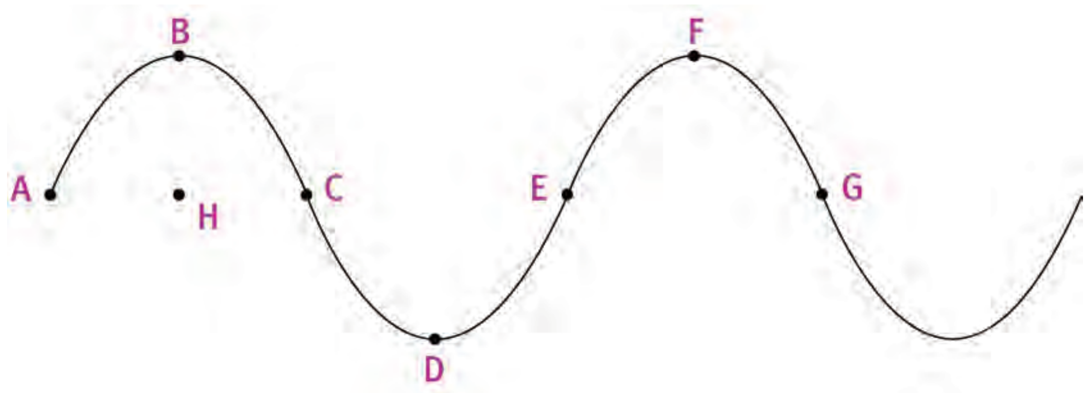
5.4 amplitude (2)

5.5 period (2)

$5 \times 2 =$ [10]

Question 6: Long questions

The sketch below shows a transverse wave in a medium.



Use the letters supplied in the sketch to indicate the following:

6.1 the rest position (position of equilibrium) (2)
6.2 two points that are in phase (2)
6.3 a crest 2)
6.4 amplitude (2)
6.5 two points completely out of phase (2)
6.6 wavelength (2)

$6 \times 2 =$ [12]

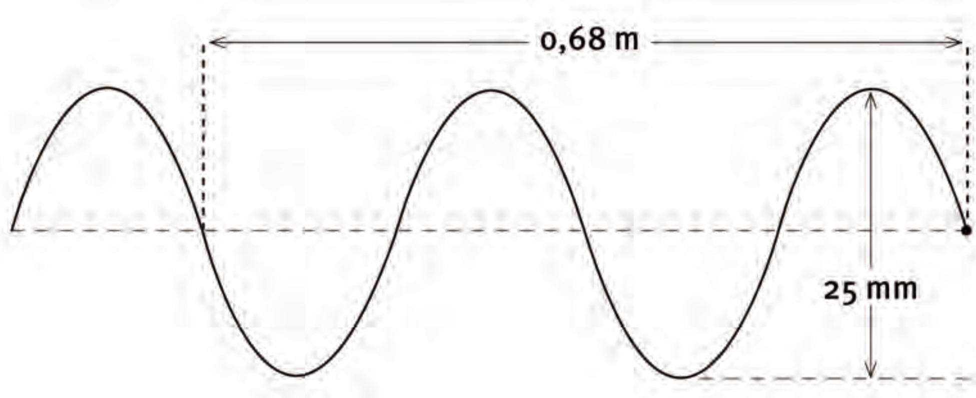
Question 7: Long questions

Refer again to the illustration in question 6. Ten wavelengths pass point B in 2 seconds. The distance between points B and F is 300 mm. Calculate (in SI units):

7.1 the frequency (2)
7.2 the period (3)
7.3 the speed of the waves. (4)

[9]

Question 8: Long questions



Each particle in the wave shown above completes one vibration (oscillation) in 0,4 s.

8.1 How long will it take eight wavelengths to pass a specific point in the medium? (2)

8.2 What is the amplitude of this wave? (2)

8.3 What is the period of this wave? (2)

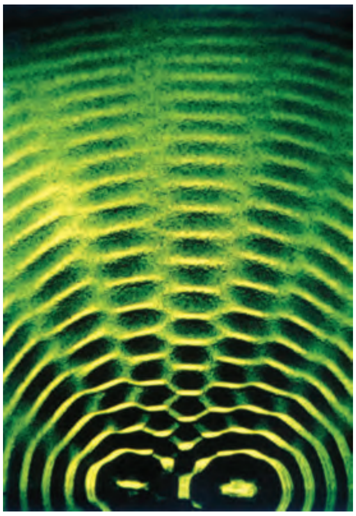
8.4 What is the wavelength of this wave? (2)

8.5 Calculate the frequency of the wave. (3)

8.6 Calculate the speed of the wave. (4)

[15]

Question 9: Long questions



Two beads are attached to the vibrator of a ripple tank and are positioned so that they dip into the water, as shown in the photo above. The resultant pattern is shown in the second photograph.

9.1 What is the phenomenon in the tank called? (2)

9.2 What do the fan-shaped lines in the second photo represent? (2)

9.3 How are these lines formed? (2)

[6]

Question 10: Long questions

10.1 What type of wave is a sound wave that reaches your ear? (2)

10.2 Explain briefly how you would use a slinky spring to demonstrate this type of wave to a friend. (4)

10.3 What is meant by the 'wavelength' of this type of wave? (2)

[8]

Question 11: Long questions

A typical sound wave associated with human speech has a frequency of 500 Hz, while the frequency of yellow light is about 5×10^{14} Hz. Assuming that sound travels at 340 $m.s^{-1}$ and light at 3×10^8 $m.s^{-1}$:

11.1 Calculate the wavelength of the sound wave. (4)
11.2 Calculate the wavelength of yellow light. (3)
11.3 Express the wavelength of yellow light in nanometres. (1)
[8]

Question 12: Long questions

2.1 Describe an experiment or demonstration that shows that sound cannot travel in a vacuum. (5)
12.2 Why is the moon sometimes referred to as 'the silent planet'? (2)
12.3 The speed of sound in air is 340 $m.s^{-1}$. Calculate the wavelength of the sound produced by a tuning fork of frequency 156 Hz. (4)
12.4 Calculate the period of this sound wave. (3)
12.5 What is the sound called that has a frequency higher than the human ear can hear? (1)
12.6 Describe one use for this type of high-frequency sound wave. (2)
[17]

Question 13: Long questions

Vibrations of frequency 2,0 Hz are produced by a generator attached to a spring. These vibrations are at 90° to the spring. The waves that it produces have a wavelength of 0,45 m.

13.1 What type of wave is passing along the spring? (1)
13.2 How many complete wavelengths pass a point in the spring in 3 seconds? (2)
13.3 What is the speed of the waves along the spring? (4)
13.4 Calculate the time taken for three complete wavelengths to pass a point in the spring. (5)
13.5 What is the wavelength of the waves along the spring if their frequency is increased to 6,0 Hz, without changing the tension (stretch) of the spring? (4)
[16]

Question 14: Long questions

Sunlight is a form of electromagnetic radiation.

14.1 What is an 'electromagnetic wave'? (3)
14.2 What causes electromagnetic waves? (2)

14.3 What is the speed of all electromagnetic waves in a vacuum? (1)

14.4 Assume that the sun is 1,5 × 10^8 km from the Earth. Calculate the time taken for sunlight to travel to the Earth. (5)

[11]

Question 15: Long questions

A gamma ray has a period of 2 × 10^{-24} s.

15.1 What is a gamma ray? (2)

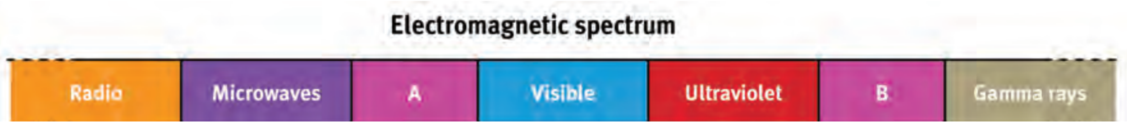
15.2 Why is it dangerous for humans to be exposed to gamma rays? (2)

15.3 What is the frequency of this gamma ray? (3)

15.4 Calculate the wavelength of the gamma ray in metres. (4)

[11]

Question 16: Long questions



16.1 What types of radiation are A and B? (2)

16.2 Which type of radiation can cause tanning of the skin? Give another use for this type of radiation. (4)

16.3 Which type of radiation next to A in the spectrum has a longer wavelength than A? Give one use for this type of radiation. (3)

[9]

Question 17: Long questions

Max Planck proposed that there is a relationship between the energy of a quantum of electromagnetic radiation and the frequency of the wave.

17.1 What is meant by a 'quantum' of electromagnetic radiation? (2)

17.2 What is a quantum of visible light called? (2)

17.3 What is the relationship between E and f as proposed by Max Planck? (2)

17.4 If we were to draw a graph of the energy of a quantum vs. the frequency of the quantum, what would the shape of the graph be? (2)

[8]

Question 18: Long questions

Calculate the energy content of a quantum of each of the following types of electromagnetic radiation:

18.1 a radio wave of frequency 600 kHz (4)

18.2 a green light wave of wavelength 500 nm in air (5)

18.3 an X-ray of wavelength 12 pm in air (5)

[14]

Question 19: Long questions

In a totally dark room, the human eye is only able to detect a flash of red light if the flash consists of at least 50 photons and if the flash is directed straight into the eye. Red light has a wavelength of 450 nm. Calculate the total minimum energy of a flash of red light that can be detected by the human eye.

[7]

Answers to questions

Answers

Question 1: Multiple choice

1.1 B ✓✓✓

1.2 A ✓✓✓

1.3 C ✓✓✓

1.4 C ✓✓✓

1.5 D ✓✓✓

1.6 B ✓✓✓

1.7 D ✓✓✓

1.8 A ✓✓✓

1.9 C ✓✓✓

1.10 C ✓✓✓

1.11 D ✓✓✓

1.12 C ✓✓✓

1.13 A ✓✓✓

Question 2: True / false

2.1 True ✓✓

2.2 False. In a transverse wave, a pulse length is half as long as a wavelength. OR In a transverse wave, a wavelength is twice as long as a pulse length. ✓✓

2.3 False. Amplitude is the maximum displacement from the position of rest. OR Wavelength is the distance between two consecutive points that are in phase. ✓✓

2.4 False. An increase in frequency of a sound wave and a simultaneous increase in amplitude will cause a note that is louder and has a higher pitch. ✓✓

2.5 False. The energy of electromagnetic radiation is directly proportional to the frequency of the radiation. ✓✓

Question 3: One-word answers

3.1 violet ✓

3.2 rarefaction ✓

3.3 infrared ✓

3.4 wavelength ✓

3.5 photon ✓

Topic 2

Answers to questions

Question 4: Matching pairs

4.1 C ✓

4.2 E ✓

4.3 B ✓

4.4 D ✓

4 5 F ✓

Question 5: Long questions

5.1 movement from B to C to B to A and back to B ✓✓

5.2 position B ✓✓

5.3 number of oscillations per second ✓✓

5.4 horizontal distance from B to A (or B to C) ✓✓

5.5 time taken for one oscillation ✓✓

Question 6: Long questions

6.1 line through points AHCEG ✓✓

6.2 A and E (or B and F) (or C and G) ✓✓

6.3 B (or F) ✓✓

6.4 distance BH ✓✓

6.5 A and C (or B and D) (or C and E) (or D and F) (or E and G) ✓✓

6.6 straight-line distance AE (or BF) (or CG) ✓✓

Question 7: Long questions

7.1 Frequency is the number of wavelengths that pass a point per second. If 10 pass in 2 seconds, 5 must pass in one second.

f = 5 Hz ✓✓

7.2 $T = 1 / f$ ✓

$= 1/5$ ✓

$= 0{,}2$ s ✓

7.3 Distance BF is one wavelength.

$\lambda = 300$ mm $= 0{,}3$ m ✓

$v = f\lambda$ ✓

$= 5 \times 0{,}3$ ✓

$= 1{,}5$ m.s^{-1} ✓

Topic 2

Answers to questions

Question 8: Long questions

8.1 One oscillation of a particle produces one wavelength. So one wavelength passes a point in 0,4 s. Eight wavelengths pass in $8 \times 0{,}4$ s ✓ = 3,2 s. ✓

8.2 Amplitude is distance from rest position to crest = 12,5 mm = 0,0125 m. ✓✓

8.3 0,4 s ✓✓

8.4 The given distance is for 2 wavelengths.

$\lambda = 0{,}68 / 2 = 0{,}34$ m ✓

8.5 $f = 1 / T$ ✓

$= 1 / 0{,}4$ ✓

$= 2{,}5$ Hz ✓

8.6 $v = f\lambda$ ✓

$= 2{,}5 \times 0{,}34$ ✓✓

$= 0{,}85\ \text{m.s}^{-1}$ ✓

Question 9: Long questions

9.1 constructive and destructive ✓ interference ✓

9.2 flat water ✓✓ (or areas of destructive interference)

9.3 These are areas where crests and troughs meet, and cancel out to produce flat water. ✓✓

Question 10: Long questions

10.1 longitudinal wave ✓✓

10.2 Fix one end of the spring or have the friend hold it still. Stretch the spring. ✓ Hold the other end of the spring and push it forward and backwards rapidly and continuously ✓✓ along the straight line of the spring. ✓

10.3 It is the distance between two consecutive crests ✓✓ (or two consecutive troughs or two consecutive points that are in phase).

Question 11: Long questions

11.1 $v = f\lambda$

$\lambda = v / f$ ✓✓

$= 340 / 500$ ✓

$= 0{,}68$ m ✓

11.2 $\lambda = v / f$

$= 3 \times 10^8 / 5 \times 10^{14}$ ✓✓

Answers to questions

$= 6 \times 10^{-7}$ m ✓

11.3 6×10^{-7} m = 600 nm ✓

Question 12: Long questions

12.1 For the demonstration you will need an electric bell or buzzer with a switch, a suitable power supply, and a glass jar that can be connected to a vacuum pump that is able to pump the air out of the jar to produce a near vacuum. Connect the bell or buzzer to the power supply. ✓ Place it in the jar and switch on. You will hear the bell ringing loudly. ✓ Switch on the vacuum pump to extract air. ✓ The sound gets fainter and fainter. In a total vacuum, the sound would be inaudible. ✓

12.2 The moon does not have an atmosphere, ✓ so no sound can be heard on the moon. ✓

12.3 $v = f\lambda$ ✓ $\lambda = \frac{v}{f} = \frac{340✓}{156✓}$

$= 2{,}18$ m ✓

12.4 $T = \frac{1}{f}$ ✓ $= \frac{1}{256✓}$

$= 3.9 \times 10^{-3}$ s✓ (or 0,0039 s)

12.5 Ultrasound✓

12.6 Used in medicine to observe internal organs such as a baby in the womb.✓✓

OR Used in industry to detect cracks in metals.

Question 13: Long questions

13.1 Transverse wave ✓

13.2 f = 2 Hz, so two wavelengths pass a point in one second. Therefore, in three seconds, six wavelengths pass a point. ✓✓

13.3 $v = f\lambda$ ✓

$= 2 \times 0{,}45$ ✓✓

$= 0{,}9$ m.s^{-1} ✓

13.4 $T = 1/f$ ✓

$= 1/2$ ✓

$= 0{,}5$ s ✓

One wavelength passes in 0,5 s, so three wavelengths pass in 1,5 s. ✓✓

13.5 If the tension of the spring does not change, speed of the wave is constant. Frequency and wavelength are inversely proportional to each other. ✓ So, if frequency is made three times larger, wavelength must be made three times smaller.✓ So the wavelength is 0,15 m. ✓✓

OR

$\lambda = v / f$ ✓

$= 0{,}9 / 6$ ✓✓

$= 0{,}15$ m ✓

Question 14: Long questions

14.1 A changing electric field produces a changing magnetic field, which in turn produces a changing electric field. An electromagnetic wave is a transverse wave consisting of electric and magnetic fields at 90° to each other. ✓✓ The crests and troughs represent points where the electric or magnetic fields are strongest. ✓

14.2 Accelerating charges produce electromagnetic pulses. ✓ A continuous electromagnetic wave is produced by vibrating charges, as in alternating current. ✓

14.3 3×10^8 m.s^{-1} ✓

14.4 First convert to SI units. $1{,}5 \times 10^8$ km $= 1{,}5 \times 10^{11}$ m ✓

time = distance / speed ✓ $= 1{,}5 \times 10^{11} / 3 \times 10^8$ ✓✓

$= 500$ s ✓ (This is 8 minutes and 20 seconds.)

Question 15: Long questions

15.1 Gamma rays are very high-frequency and high-energy electromagnetic radiation emitted by radioactive material. ✓✓

15.2 They can destroy human tissue and cause cancer. ✓✓

15.3 $f = 1 / T$ ✓

$= 1 / 2 \times 10^{-24}$ ✓

$= 5 \times 10^{23}$ Hz ✓

15.4 $c = f\lambda$

$\lambda = c / f$ ✓

$= 3 \times 10^8 / 5 \times 10^{23}$ ✓

$= 6 \times 10^{-16}$ m ✓

Topic 2

Answers to questions

Question 16: Long questions

16.1 A – infrared ✓
B – X-rays ✓

16.2 ultraviolet ✓

Certain chemicals fluoresce in ultraviolet light. ✓ For example, chemicals in washing powder will fluoresce under the ultraviolet light from the sun, making garments look whiter than they actually are. ✓✓

16.3 microwaves ✓

In microwave ovens, water in the foodstuffs are made to vibrate faster by the microwaves, thereby getting hotter. ✓✓

Question 17: Long questions

17.1 'Quantum' means a discreet amount or 'package'. So, the radiation is not in continuous waves, but small packages of energy, each made up of electromagnetic waves. ✓✓

17.2 photon ✓✓

17.3 E is directly proportional to f. This means that if f is doubled, E is doubled. ✓✓

17.4 a straight line through the origin ✓✓

Question 18: Long questions

18.1 f must be expressed in Hz. 600 kHz = 6×10^5 Hz ✓

$$E = hf \checkmark$$
$$= 6{,}63 \times 10^{-34} \times 6 \times 10^5 \checkmark$$
$$= 3{,}98 \times 10^{-28}\ \text{J} \checkmark$$

λ must be expressed in metres. 500 nm = 500×10^{-9} m ✓

$$E = hc / \lambda \checkmark$$
$$= \frac{(6{,}63 \times 10^{-34}) \times (3 \times 10^8) \checkmark}{500 \times 10^{-9} \checkmark}$$
$$= 3{,}98 \times 10^{-19}\ \text{Hz} \checkmark$$

λ must be expressed in metres. 120 pm = 120×10^{-12} m ✓

$$E = hc / \lambda \checkmark$$
$$= \frac{(6{,}63 \times 10^{-34}) \times (3 \times 10^8) \checkmark}{120 \times 10^{-12} \checkmark}$$
$$= 1{,}66 \times 10^{-15}\ \text{J} \checkmark$$

Answers to questions

Question 19: Long questions

First calculate the energy of one photon of red light. 450 nm = 450×10^{-9} m ✓

$$E = hc/\lambda ✓$$

$$= \frac{(6{,}63 \times 10^{-34}) \times (3 \times 10^{8}) ✓}{450 \times 10^{-9} ✓}$$

$$= 4{,}42 \times 10^{-19}\ \text{J} ✓$$

Minimum number of photons = 50

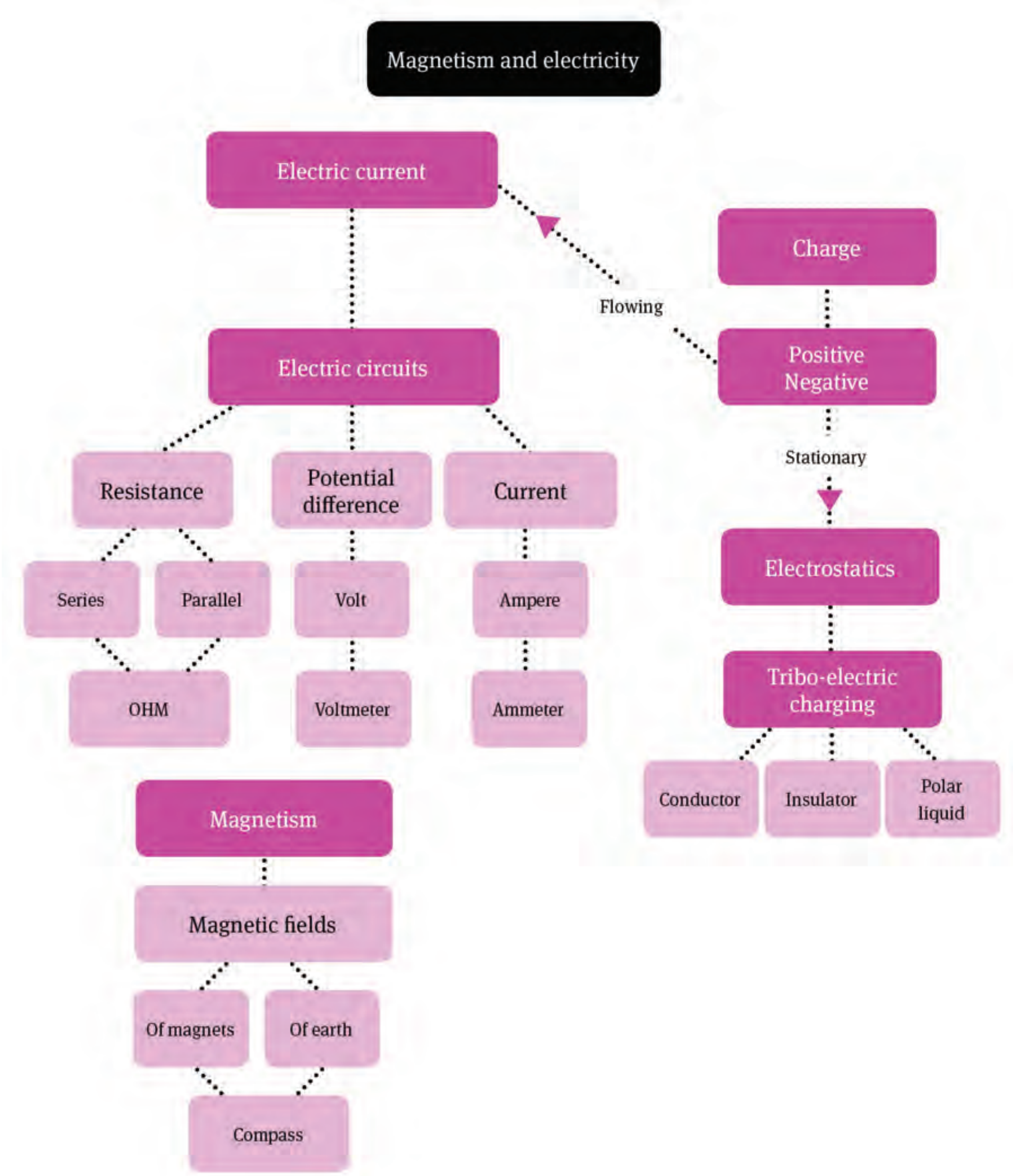
Minimum energy of the flash = $(4{,}42 \times 10^{-19}) \times 50$ ✓

= $2{,}21 \times 10^{-17}$ J ✓

Topic 3

Magnetism and electricity

Overview

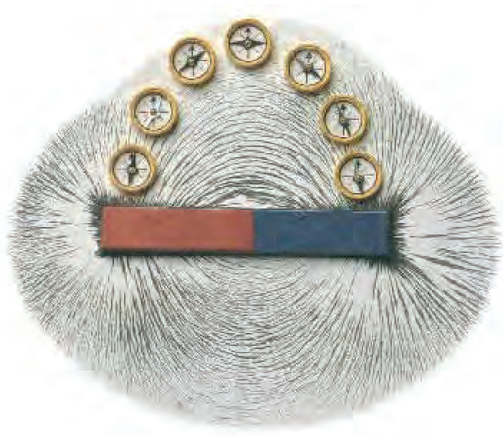


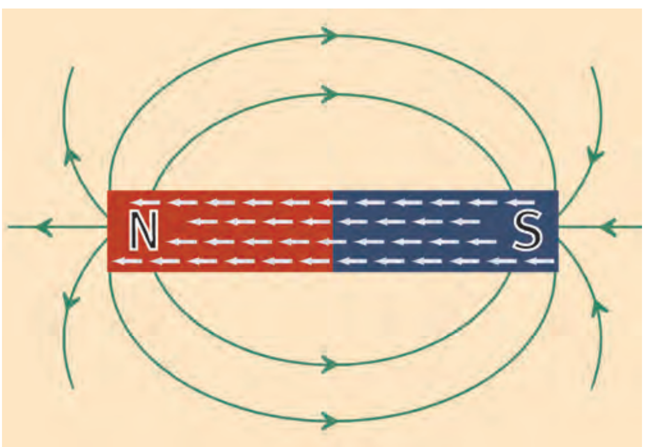
Summary

1 Magnetism

1.1 Magnetism

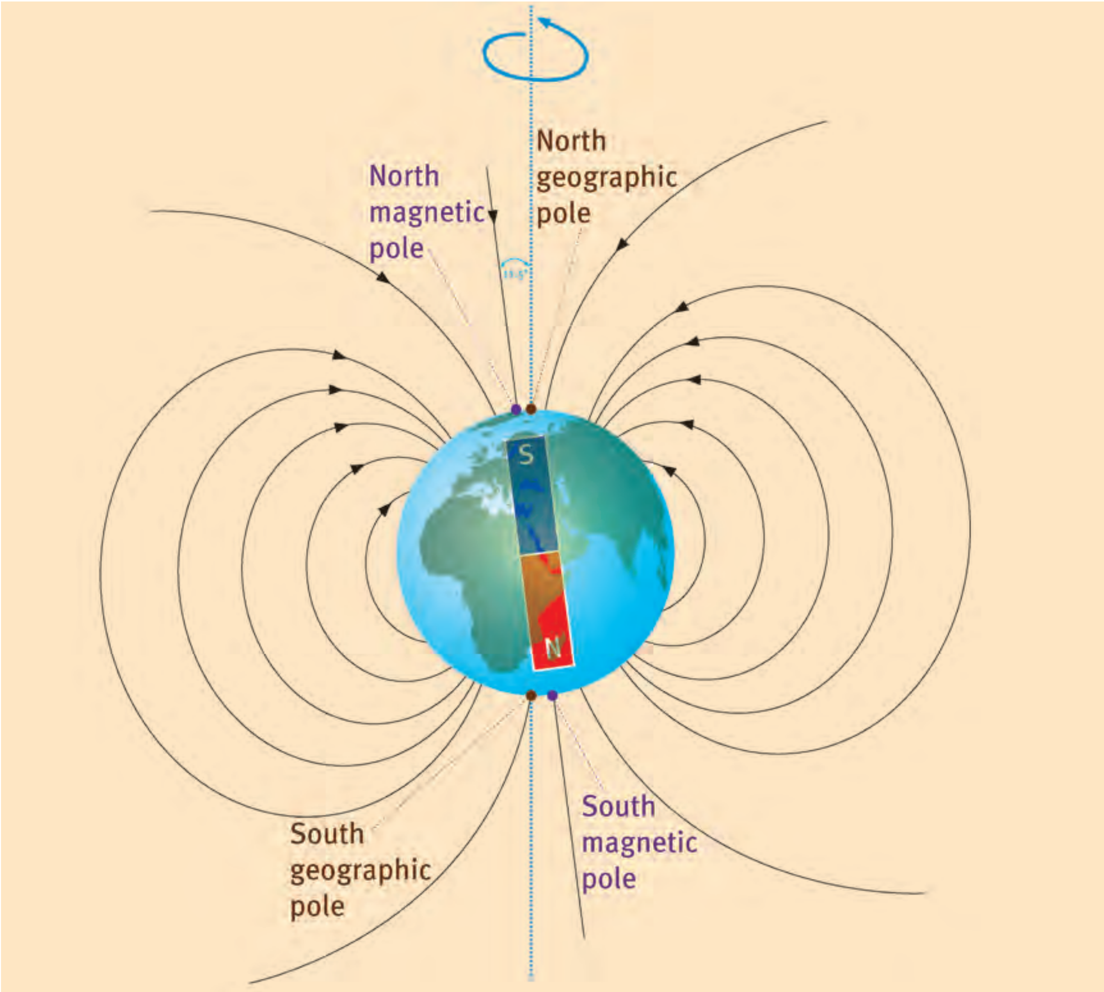
- A magnetic field is a region in space in which a magnet or ferromagnetic substance (iron, nickel or cobalt) will experience a force.
- The poles of a magnet are at the two ends of the magnet. The magnetic force is strongest at the poles.
- If a magnet is cut in half, each half will be a magnet with a north pole at one end and a south pole at the other.
- If a magnet is suspended at its centre so that it can turn freely, it will be affected by the magnetic field of the earth and settle in a north-south direction. The pole of a magnet that points towards the Earth's north pole is called the north-seeking pole (or simply the north pole) of the magnet.
- Like poles of two magnets repel, unlike poles attract. So north repels north, but north attracts south.
- A compass is a magnet that is free to turn at its centre.
- A magnet is surrounded by a magnetic field – a region in which magnetic materials such as iron will experience a force.
- A compass is used to show the direction of a magnetic field.
- A magnetic field line shows the shape of the field and the direction that the north pole of a compass will point when placed in the field.
- Magnetic field lines point from north to south of a magnet.





- The more closely spaced the field lines are at a point, the stronger is the field at that point, that is, the stronger the force will be on a magnetic object.
- Field lines never cross. They surround a magnet in three dimensions. For simplicity, we draw field lines in two dimensions only.
- The geographical north and south poles are the points around which the Earth rotates.

- The magnetic field of the Earth is similar to that of a bar magnet, with poles at the magnetic north and magnetic south of the Earth.
- The imaginary bar magnet inside the Earth must have its north pole at the south geomagnetic pole.
- The angle between the geographic north pole and the geomagnetic north pole is 11,5°.



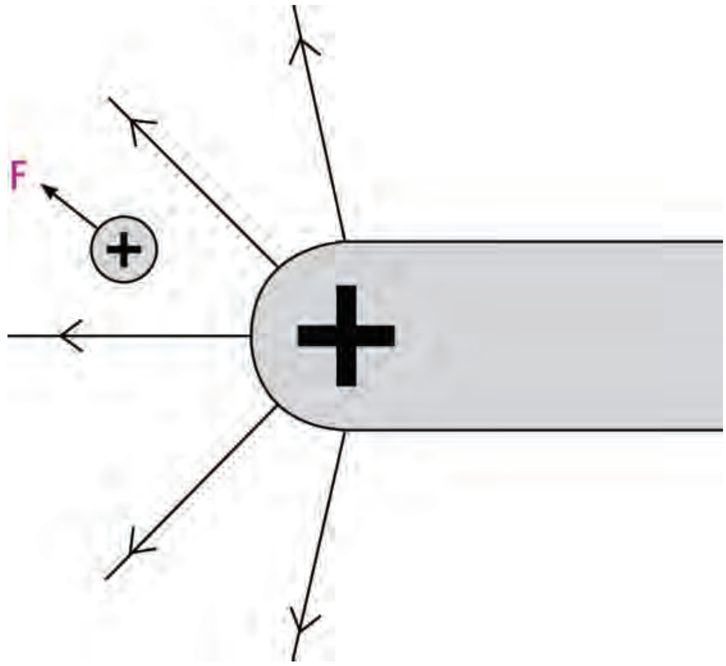
- The magnetic field of the Earth protects the Earth from harmful ions of hydrogen and helium, as well as electrons emitted by the sun (solar wind). These are deflected to the poles by the magnetosphere, where they collide with the atmosphere and produce an aurora.

2 Electrostatics

2.1 Two kinds of charge

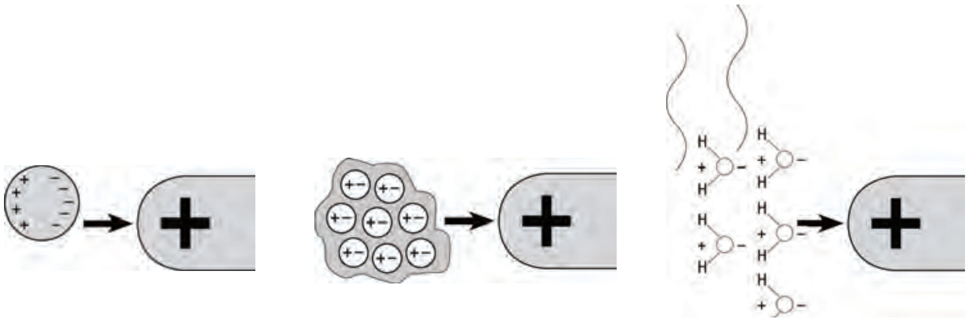
- The property of particles in atoms that enables them to attract and repel is called charge. There are only two types of charge.
- Like charges repel, unlike charges attract.
- Charges are called positive and negative because when the two types come together they cancel out to produce zero charge.

- Atoms are made up of a central nucleus comprised of positively charged protons and neutral neutrons. The nucleus is surrounded by a number of negatively charged electrons that are much smaller than protons.
- Objects become charged when electrons are either removed from them or added to them. This can be done by rubbing two materials together, called tribo-electric charging.
- An object that has an equal number of positive and negative charges is neutral.
- Conductors allow a flow of charge through them. Conductors contain charges that are free to move.
- Insulators do not allow a flow of charge through them. They do not contain charged particles that are free to move.



An electric field is a region in space in which an electric charge will experience a force. All charged objects are surrounded by electric fields.

- An electric field line is a line drawn with an arrow to show the direction in which a positive charge will experience a force if placed in the field.



Attraction of a conductor.

Attraction of an insulator. The atoms become polarised.

Attraction of water. H_2O molecules are polarised.

- An uncharged conductor can be attracted by a charged object. In the process, the conductor becomes polarised. Free electrons in the conductor move under the action of the electric field, making one side of the conductor negative and the other positive.
- An uncharged insulator (for instance, dust or paper) can be attracted by a charged object. Here each atom becomes polarised. Electrons in each atom move under the action of the electric field, making one side of the atom negative and the other positive.
- Water is made up of polarised molecules. The oxygen end is slightly negatively charged, and the hydrogen end slightly positively charged. A thin stream of water is attracted by a charge rod. The molecules rotate under the action of the electric field so that one side of the stream is negative and the other positive.

2.2 Conservation and quantisation

- Charge is measured in coulombs, where one coulomb is the charge carried by $6{,}25 \times 10^{18}$ electrons.
- The principle of conservation of charge states that the net charge of an isolated system remains constant during any physical process.
- When two identical conductors that are charged are brought into contact, electrons will flow from the more negative object to the other until both have the same charge. To calculate the charge on each, simply add together the original charges and divide by two.
  $Q = (Q_1 + Q_2) / 2$
- The charge on one electron (q_e) is called the elementary charge.
  $q_e = 1{,}6 \times 10^{-19}$ C
- The principle of quantisation of charge states that every charge in the universe must be a multiple of the charge on one electron.
  $Q = nq_e$ where $q_e = 1{,}6 \times 10^{-19}$ C.

2.2.1 Worked examples

1 Two identical metal spheres A and B on insulated stands are charged. The charge on A is +6,4 µC. The charge on B is –24,6 µC. The two spheres are brought into contact, then separated.

1.1 Express each charge in C, using scientific notation.

1.2 Calculate the charge on each sphere after separation.

Answers:

1.1 A: $+6{,}4 \times 10^{-9}$ C

B: $-24{,}6 \times 10^{-9}$ C. For scientific notation only one figure must be before the decimal comma, so B: $-2{,}46 \times 10^{-8}$ C.

1.2 $Q = (Q_1 + Q_2) / 2$

$= [(+6{,}4 \times 10^{-9}) + (-2{,}46 \times 10^{-8})] / 2$

$= 9{,}1 \times 10^{-9}$ C

2 A glass rod is charged positively by rubbing it with a silk cloth. The charge on the rod is $1{,}12 \times 10^{-11}$C. Calculate the number of electrons that were rubbed off the glass rod.

Answer:

$Q = nq_e$

$n = Q / q_e$

$= 1{,}12 \times 10^{-11} / 1{,}6 \times 10^{-19}$

$= 7 \times 10^7$ electrons

3 Electric circuits

3.1 Potential difference

- An electric current is a flow of charge, positive or negative.
- A battery supplies electrons to a circuit at its negative terminal and draws them in at the positive terminal by means of a chemical reaction in the battery. So, there is a conversion of chemical potential energy in the battery to electrical potential energy of the electrons.
- The voltage measured across the terminals of a battery when it is not providing current to a circuit is called the emf of the battery.
- The voltage measured across the terminals of a battery when it is providing current to a circuit is called the potential difference across the circuit. This is always smaller than the emf, due to the fact that the battery has some resistance.
- Emf and potential difference are measured in volts with a voltmeter, which has a very high resistance and is always connected in parallel across the circuit or resistor.

3.2 Current

- Current (I) is the rate of flow of charge.
- $I = Q/\Delta t$
- While an electric current can be a flow of negative or positive charge, current direction is shown as the direction in which positive charge would move in the circuit – from positive to negative. This is referred to as 'conventional current'.
- Current is measured in amperes (A). 1 ampere = 1 coulomb per second
- Definition of an ampere: The current in a conductor is one ampere when one coulomb of charge passes through the conductor per second.
- $I = Q/\Delta t$

- Current is measured with an ammeter, which has a very low resistance and is always connected in series.

3.2.1 Worked example

Calculate the total charge that passes through a light bulb in 2 minutes when the current is 4 amperes.

Answer:

$$Q = I \times \Delta t \text{ (}\Delta t\text{ must be expressed in seconds: 2 minutes = 120 s)}$$

$$= 4 \times 120$$

$$= 480\ \text{C}$$

3.3 Resistance

- Resistance (R) is the extent to which a resistor limits the flow of charge in it. When connected to the same potential difference, the higher the resistance of the resistor, the smaller the current.
- Resistance is measured in ohms (Ω).
- Definition of an ohm: A resistor has a resistance of 1 ohm if it allows a current of 1 ampere when the potential difference across it is 1 volt. So, an ohm is a volt per ampere.
- Factors affecting resistance: Resistance depends on the type of metal, length, thickness and temperature.
- A metal will have a higher resistance if its outer electrons are held more tightly by the nucleus of the atom. So, for instance, nichrome (an alloy of nickel and chromium) has a much higher resistance than copper.
- Current in metals is a flow of loosely bound electrons in the metal. The battery sets up an electric field in the circuit. The loosely bound electrons move under the action of this field. There is a conversion of electrical potential energy into kinetic energy of the moving electrons. The electrons collide with the atoms of the metal, causing them to vibrate faster. So, there is a conversion of kinetic energy of the electrons to vibrational kinetic energy of the atoms in the metal. The faster the atoms vibrate, the hotter they are. If very hot, they could give out light.
- Energy conversions:
  - Chemical potential energy in battery → electrical potential energy of electrons → kinetic energy of electrons → vibrational kinetic energy of atoms of metal → heat energy and possibly light energy.
- Resistance increases as the length of the resistor increases.
- Resistance decreases as the thickness of the resistor increases.
- Resistance increases as the temperature of the resistor is increased.
- When a resistor is added in series to an identical one, the total resistance is doubled.

- When a resistor is added in parallel to an identical one, the total resistance is halved.
- To calculate the total resistance (equivalent resistance) R_s of a number of resistors connected in series, simply add them together:

  $R_s = R_1 + R_2 + R_3 \ldots\ldots$

- Current is the same at all points in a series circuit.
- Resistors in series divide the potential difference in proportion to the resistance. They are voltage dividers. Add the potential differences across each resistor together to get the potential difference across the whole circuit.
- Resistors in parallel divide the current – they are current dividers. Add the currents together to get the mainstream current.
- The voltage across each resistor in a parallel connection is the same.
- To calculate the total resistance (equivalent resistance) R_p of a number of resistors in parallel, apply the formula:

  $1 / R_p = 1 / R_1 + 1 / R_2 + 1 / R_3 \ldots\ldots$

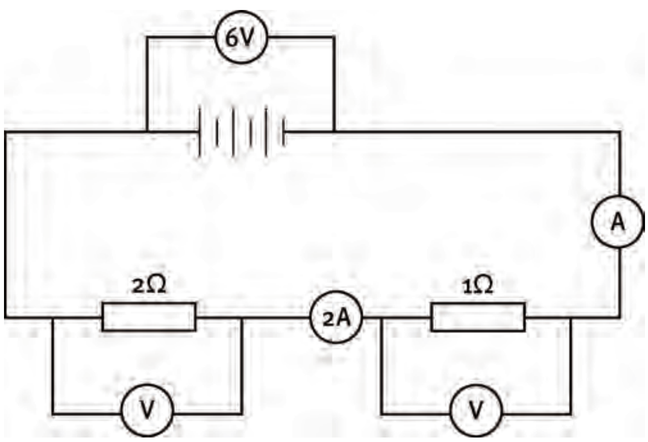
  After calculating the right-hand side of the equation, remember to invert both sides.

- For two resistors in parallel, the equation can be written as:
  $R_p = R_1R_2 / (R_1 + R_2)$ (remember: product ÷ sum)

- Remember that this equation can only be used for two resistors in parallel.

3.1.1 Worked examples

1 In the circuit diagram below, what is:



1.1 the total resistance?
1.2 the reading on voltmeter V?
1.3 the reading on ammeter A?

Answers:

1.1 $R_s = R_1 + R_2$

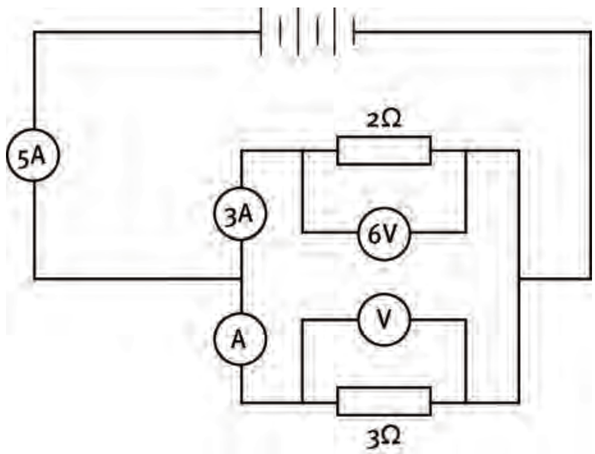
$= 2 + 1$

$= 3\ \Omega$

1.2 The two resistors divide the voltage of the battery. If one voltmeter reads 4 V, the other must read 2 V.

1.3 Current is the same at all points in a series circuit, so the ammeter reads 2 A.

2 In the circuit diagram below, what is:



2.1 the equivalent resistance of the two resistors in parallel?

2.2 the reading on ammeter A?

2.3 the reading on voltmeter V?

Answers:

2.1

$1 / Rp = 1 / R1 + 1 / R2$	OR	$Rp = R1R2 / (R1 + R2)$
$= 1 / 2 + 1 / 3$	OR	$= 2 \times 3 / (2 + 3)$
$= (3 + 2) / 6$	OR	$= 6 / 5$
$Rp = 6 / 5 = 1{,}2\ \Omega$	OR	$= 1{,}2\ \Omega$

2.2 Resistors in parallel divide the current. The mainstream current is 5 A, and the current in one branch is 3 A. So the ammeter A must read 2 A.

2.3 The voltage must be the same as the voltage across the 2 Ω resistor. So the voltmeter V reads 6 V.

Questions

Question 1: Multiple choice

Choose the correct answer. Write only the letter of the answer you select.

1.1 Which of the following statements about magnetic field lines is/are true?

1 They surround a magnet in two dimensions.
2 They cannot cross.
3 They represent the direction in which the south pole of a compass will point.

A 1 and 2 only
B 2 and 3 only
C 2 only
D 1, 2 and 3 (3)

1.2 Which one of the substances below will be attracted by a magnet?

A copper
B water
C lead
D cobalt (3)

1.3 A small, neutral, metal sphere becomes charged when it is brought into contact with a positively charged rod. In the process the sphere ...

A loses electrons.
B loses protons.
C gains protons.
D gains electrons. (3)

1.4 An insulated metal sphere carries a charge of –7 μC. An identical sphere carries a charge of –9 μC. The spheres are brought together to touch and are then separated. What is the charge on each sphere now?

A –16 μC
B –8 μC
C –1 μC
D +8 μC (3)

1.5 Two identical metal spheres, X and Y, are mounted on insulating stands. Sphere X has a charge of +8 μC and sphere Y is neutral. The spheres are allowed to touch and are then separated. What is the charge on X?

A 0
B –8 μC
C +4 μC
D +8 μC (3)

1.6 An insulator can be attracted by a charged plastic ruler because ...

A the insulator atoms are always polarised.

B the insulator atoms become polarised when close to the charged ruler.

C an insulator contains free electrons.

D electrons in the insulator move to one side of the insulator, thereby polarising the whole insulator. (3)

1.7 The SI unit for current is ...

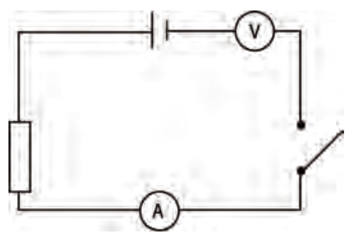
A ampere.

B coulomb.

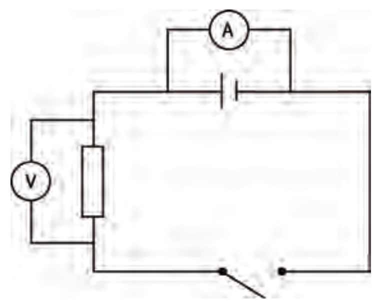
C ohm.

D volt. (3)

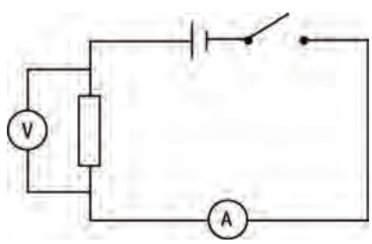
1.8 You wish to connect a circuit to measure the current in a resistor and the potential difference across it. Which circuit below is connected correctly?



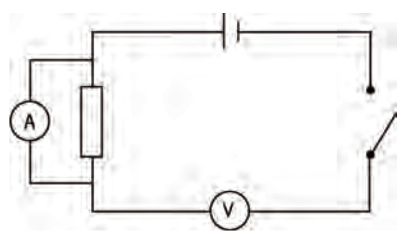
A



B



C



D

(3)

1.9 A volt can be described as a ...

A coulomb per second.

B joule per ampere.

C ampere per second.

D joule per coulomb. (3)

1.10 A conductor carries a current of 2 A. What is the total charge that passes through the conductor in 4 minutes?

A 480 C

B 8 C

C 2 C

D 0,5 C (3)

1.11 Three resistors each have a resistance of 6 Ω. Which of the following correctly gives their equivalent resistance when first connected in series, then in parallel?

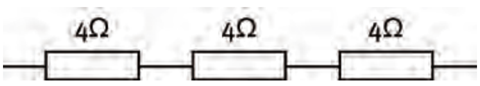
A 18 Ω and 3 Ω
B 18 Ω and 2 Ω
C 2 Ω and 18 Ω
D 18 Ω and 0,5 Ω (3)

1.12 Which pair of words, in order, correctly completes the following statements?

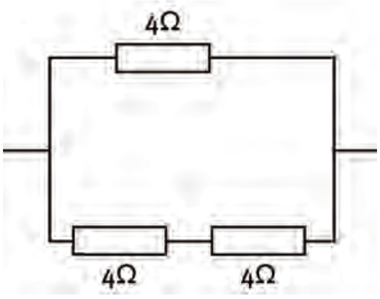
When the length of a resistor is increased, its resistance ...
When the thickness of a resistor is decreased, its resistance ...

A increases, increases
B increases, decreases
C decreases, decreases
D decreases, increases (3)

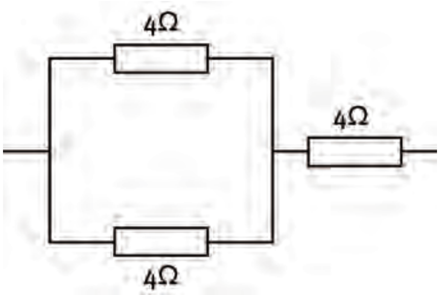
1.13 Three resistors, each of resistance 4 Ω, are to be used to make a 6 Ω combination. Which arrangement will achieve this?



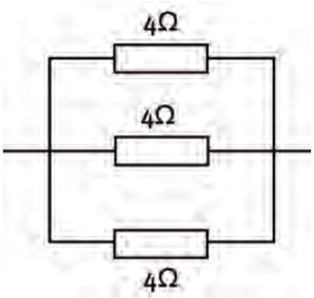
A



B



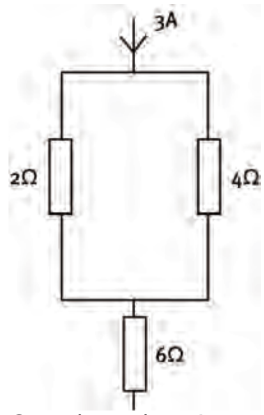
C



D

(3)

1.14 You are given this section of an electric circuit
Which of the following statements is/are correct?



1 The current in the 2 Ω resistor is 2 A.

2 The current in the 4 Ω resistor is 1 A.

3 The current in the 6 Ω resistor is 3 A.

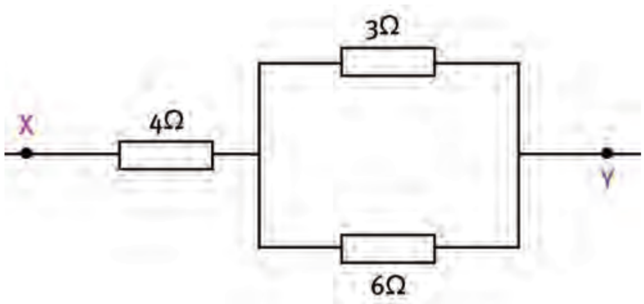
A 3 only

B 2 and 3 only

C 1 and 2 only

D 1, 2 and 3 (3)

1.15 In the given circuit, the equivalent resistance between X and Y is ...



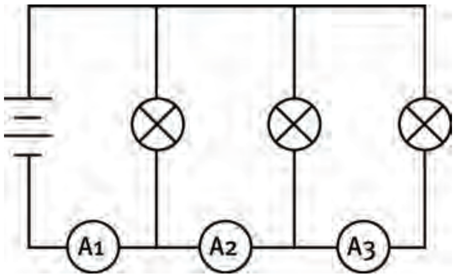
A 4,5 Ω

B 5 Ω

C 13 Ω

D 6 Ω (3)

1.16 The bulbs in this circuit are all identical. If the reading on ammeter A_1 is 6 A, what is the reading on ammeter A_2?



A 2 A

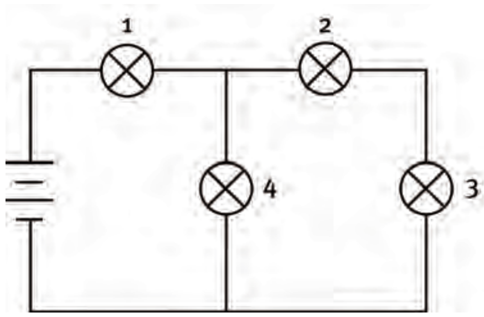
B 3 A

C 4 A

D 6 A (3)

1.17 The resistance of a conductor does not depend on …
A length.
B potential difference.
C temperature.
D type of material. (3)

1.18 One of the bulbs in this circuit breaks and that causes all the other bulbs to go out as well. Which bulb broke?



A 1
B 2
C 3
D 4 (3)

$18 \times 3 = [54]$

Question 2: True/false

Indicate whether the following statements are true or false. If the statement is false, write down the correct statement.

2.1 When a bar magnet is broken in half, one half is a north pole only and the other half is a south pole. (2)
2.2 The SI unit for resistance is the volt per coulomb, given the name ohm. (2)
2.3 In any series electrical circuit we will find the biggest potential difference across the resistor with the biggest resistance. (2)
2.4 The voltage across the terminals of a battery always decreases when the battery starts to deliver current to the circuit, due to the resistance of the battery. (2)
2.5 The total potential difference across three resistors connected in parallel is equal to the sum of the potential differences across each resistor. (2)

$5 \times 2 = [10]$

Question 3: One-word answers

Provide one word or term for each of the following descriptions. Write only the word or term next to the question number.

3.1 A region where a magnetic substance will experience a force.
3.2 A substance that will not allow a flow of charge through it.

3.3 The voltage measured across the terminals of a battery when it is not providing current to a circuit.
3.4 The SI unit for charge.
3.5 The rate of flow of charge.

$5 \times 1 = [5]$

Question 4: Matching pairs

Choose an item from column B that matches the description in column A. Write only the letter of your choice (A–J) next to the question number.

Column A	Column B
4.1 axis on which Earth spins	A plastic
4.2 charging by rubbing	B voltage dividers
4.3 polarised molecules	C geographic N and S poles
4.4 resistors in parallel	D ammeter
4.5 measuring instrument that is connected in series	E induction
	F water
	G current dividers
	H magnetic N and S poles
	I voltmeter
	J tribo-electric

$5 \times 2 = [10]$

Question 5: Long questions

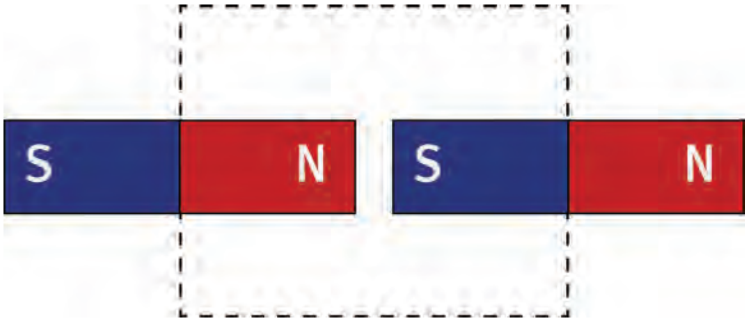
You are given a painted metal rod and a magnet. Explain how you could show whether the painted metal rod is ...

5.1 non-magnetic (for instance, copper). (2)
5.2 magnetic, but not a magnet. (2)
5.3 a magnet. (2)

$3 \times 2 = [6]$

Question 6: Long questions

6.1 Explain the difference between a magnetic field and a magnetic field line. (4)
6.2 What is meant by the 'north pole' of a magnet? (2)
6.3 You are given two identical magnets of equal strength. You place them with the north pole of one facing the south pole of the other, as shown.



6.3.1 Draw the magnets in the area of the dotted line box, then sketch the magnetic field pattern in the area of the box. (4)

6.3.2 How would the pattern change if both magnets were much weaker? (2)

[12]

Question 7: Long questions

7.1 Explain the difference between the geographic north pole and the magnetic north pole of the Earth. (4)

7.2 What is the angle between the lines drawn between the geographic N and S, and the magnetic N and S? (1)

[5]

Question 8: Long questions

8.1 Name the three particles that make up an atom, and state the charge on each. (3)

8.2 Why are the names 'positive' and 'negative' used for the two types of charge? (3)

[6]

Question 9: Long questions

Plastic carrier bags are made of polythene. A strip is cut from a carrier bag and rubbed with a cloth or by pulling it through your fingers. When it is then hung from a string as shown, the ends push apart. Explain why this happens. (4)

[4]

Question 10: Long questions

10.1 Explain why a water molecule is said to be 'polarised'. Draw a labelled sketch of a water molecule to illustrate your answer. (4)

10.2 A plastic rod is charged positively by rubbing it with cloth. When it is brought near to a thin stream of water from a tap, the water is attracted to the rod.

10.2.1 Explain in terms of transfer of charge how the rod became positively charged. (2)

10.2.2 What name if given to the process of charging an object by rubbing? (1)

10.2.3 The charge on one electron is $1,6 \times 10^{-19}$ C. If $3,6 \times 10^{6}$ electrons were transferred in the rubbing process, calculate the charge on the rod. (4)

10.2.4 Explain why the water is attracted. (4)

[15]

Question 11: Long questions

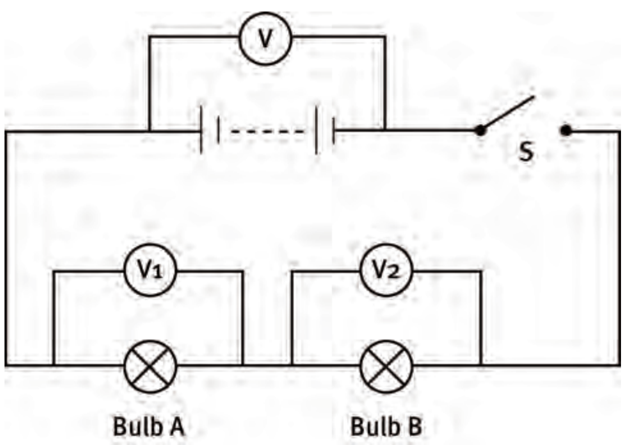
11.1 How would you measure the emf of a battery? Explain why this works. (2)

11.2 Why is the emf of a battery always slightly higher than the potential difference that it can provide to an electric circuit? (4)

[6]

Question 12: Long questions

Study the circuit diagram and answer the questions below.



12.1 Is the resistance of a voltmeter very high or very low? Explain how this affects the measurement of voltage. (4)

12.2 When switch S is open, as shown, the reading on voltmeter V is 10 V. Switch S is then closed and the voltmeter reading drops to 9 V. Explain why. (5)

12.3 How much energy does the battery give to each coulomb of charge that it pushes out into the circuit? (1)

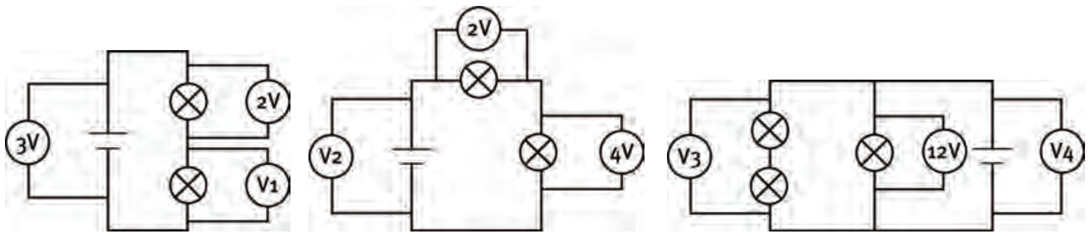
12.4 If the reading on voltmeter V_1 is 4 volts, what is the reading on V_2? (2)

12.5 How much energy is lost by each coulomb of charge as it passes through bulb A? (2)

12.6 Into what two forms of energy is it transformed in bulb A? (2)

[16]

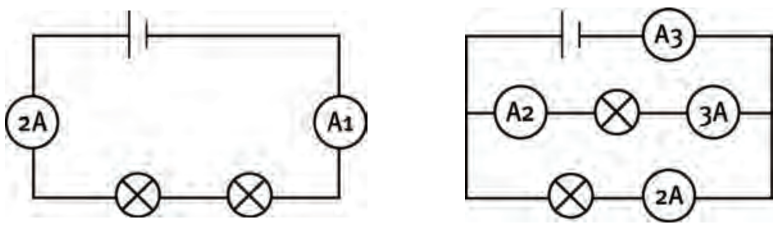
Question 13: Long questions



In the above circuits, the bulbs and cells are not all identical. The readings on some of the voltmeters are given. What are the readings on the other voltmeters V_1 to V_4?

[8]

Question 14: Long questions



In the above circuits, the light bulbs are not all identical. The readings on some of the ammeters are given. What are the readings on the other ammeters A_1 to A_5?

[10]

Question 15: Long questions

15.1 Define current. (2)

15.2 Name the instrument used to measure current. (1)

15.3 Does this instrument have a very high or a very low resistance? Give the reason for your answer. (3)

15.4 An electric light bulb carries a current of 0,25 A. Calculate the time taken for 30 C of charge to pass through the bulb. (4)

[10]

Question 16: Long questions

16.1 State the four factors that determine the resistance of a resistor. (4)

16.2 Why are metals good conductors of electricity? (2)

16.3 Explain why a metal can get hot when carrying an electric current. (4)

[10]

Question 17: Long questions

17.1 What name is given to a 'volt per ampere'? (1)

17.2 When an electric heater is connected to the electricity mains of 240 volts, the current is 5 amperes.

17.2.1 How many volts are required to produce a current of one ampere in the bulb? (3)

17.2.2 What is the resistance of the bulb? (1)

[5]

Question 18: Long questions

An electric circuit consists of a battery of four cells connected to two resistors and an ammeter all connected in series. The resistances are 6 Ω and R (representing an unknown resistance). The ammeter reads 1 A. The potential difference across the 6 Ω resistor is 6 V. A voltmeter connected across the battery reads 8 V.

18.1 Draw the circuit diagram, entering all the given information. (4)

18.2 What is the potential difference across R? Explain your answer. (3)

18.3 Is the resistance of R greater than or less than 4 Ω ? Explain your answer. (3)

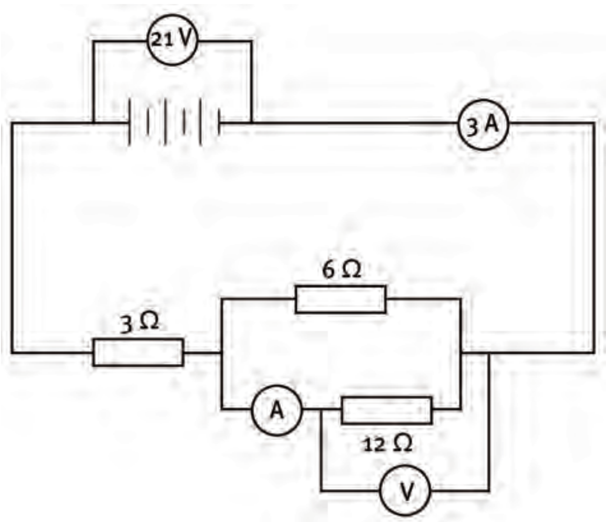
18.4 What is the current in R? Give a reason for your answer. (2)

18.5 How much charge passes through the 6 Ω resistor in 1½ minutes? (4)

[16]

Question 19: Long questions

Consider the circuit given in the diagram below.



19.1 Calculate the equivalent resistance of the parallel combination. (4)

19.2 What is the total resistance of the whole circuit? (2)

19.3 If the potential difference across the 3 Ω resistor is 9 V, what is the reading on voltmeter V? (2)

19.4 If the current in the 6 Ω resistor is 2 A, what is the reading on ammeter A? (2)

19.5 How much charge passes through the 3 Ω resistor in 20 s? (4)

[14]

Topic 3

Answers to questions

Answers

Question 1: Multiple choice

1.1 C ✓✓✓
1.2 D ✓✓✓
1.3 A ✓✓✓
1.4 B ✓✓✓
1.5 C ✓✓✓
1.6 B ✓✓✓
1.7 A ✓✓✓
1.8 C ✓✓✓
1.9 D ✓✓✓
1.10 A ✓✓✓
1.11 B ✓✓✓
1.12 A ✓✓✓
1.13 C ✓✓✓
1.14 D ✓✓✓
1.15 D ✓✓✓
1.16 C ✓✓✓
1.17 B ✓✓✓
1.18 A ✓✓✓

$18 \times 3 = [54]$

Question 2: True/false

2.1 False. When a bar magnet is broken in half, each half remains being a magnet, each with a north pole and a south pole. ✓✓

2.2 False. The SI unit for resistance is the volt per ampere, given the name ohm. ✓✓

2.3 True. ✓✓

2.4 True. ✓✓

2.5 False. The total potential difference across three resistors connected in series is equal to the sum of the potential differences across each resistor. ✓✓

$5 \times 2 = [10]$

Question 3: One-word answers

3.1 magnetic field ✓
3.2 insulator ✓

Answers to questions

3.3 emf ✓

3.4 coulomb ✓

3.5 current ✓

$5 \times 1 = [5]$

Question 4: Matching pairs

4.1 C ✓✓

4.2 J ✓✓

4.3 F ✓✓

4.4 G ✓✓

4.5 D ✓✓

$5 \times 2 = [10]$

Question 5: Long questions

5.1 Hold the magnet close to the painted metal rod. If there is no attraction, the painted rod is not magnetic. ✓✓

5.2 If the painted rod is attracted by both poles of the magnet, the painted rod is magnetic, but not a magnet. ✓✓

5.3 If the one end of the painted rod is attracted by the north pole of the magnet, while the other end of the rod is repelled by the north pole, then the painted rod is a magnet. ✓✓

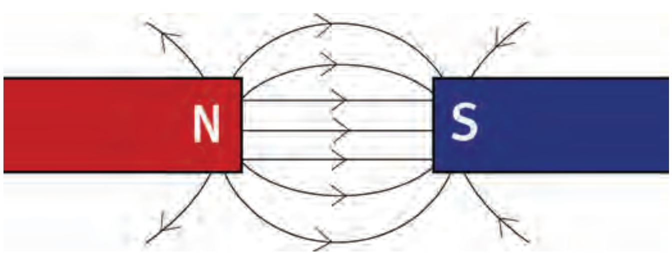
$3 \times 2 = [6]$

Question 6: Long questions

6.1 A magnetic field is simply a region where a magnet or magnetic material will experience a force. ✓✓ Magnetic field lines are imaginary lines that are drawn to show the direction in which the north pole of a compass would point if placed at any point on the lines. ✓✓

6.2 If the magnet is suspended so it can swing freely, the north pole of the magnet is the end that will point towards to north pole of the Earth under the action of the magnetic field of the Earth. ✓✓

6.3.1



Shape of field ✓✓

Answers to questions

Direction of arrows ✓✓

6.3.2 All field lines would be further apart. ✓✓

[12]

Question 7: Long questions

7.1 The geographic north pole is the northern point of the axis around which the Earth spins. ✓✓

The magnetic north pole is the point towards which the north pole of a compass will point. ✓✓

7.2 11,5° ✓

[5]

Question 8: Long questions

8.1 proton – positive ✓

electron – negative ✓

neutron – neutral ✓

8.2 The charge on a proton equals that on an electron, but when a proton and an electron are brought together, the charge cancels to give a total charge of zero. ✓✓ This is the same as considering a proton to have a charge of +1 and an electron –1, so if added together equals zero. ✓

[6]

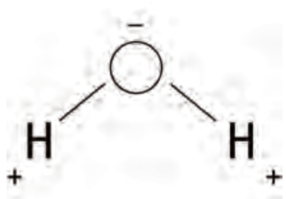
Question 9: Long questions

When the polythene strip is rubbed, electrons are transferred onto the strip making the whole strip negatively charged. ✓✓ When hung over the string, the two ends of the strip repel each other, as negative repels negative. ✓✓

[4]

Question 10: Long questions

10.1 The oxygen atom attracts electrons in the molecule more strongly than the hydrogen atoms. ✓ This makes the oxygen end of the molecule slightly negatively charged and the hydrogen end slightly positively charged. ✓



✓✓

Answers to questions

10.2.1 Negatively charged electrons were rubbed of the rod onto the cloth. ✓ This left more protons than electrons on the rod, making the whole rod positively charged. ✓

10.2.2 tribo-electric charging ✓

10.2.3 $Q = nq_e$ ✓

$= (3{,}6 \times 10^{6}) \times (1{,}6 \times 10^{-19})$ ✓✓

$= 5{,}76 \times 10^{-13}$ C ✓

10.2.4 The positive rod attracts oxygen atoms in the water molecules and repels the hydrogen atoms. ✓ This causes the molecules to rotate, so that the whole stream is polarised with the side of the stream closest to the rod being negative and the side furthest from the rod positive. ✓✓ Because all oxygen atoms are now closer to the rod than hydrogen atoms, the force of attraction is stronger than the force of repulsion, so the whole stream is attracted. ✓ [15]

Question 11: Long questions

11.1 Connect a voltmeter directly to the battery. ✓ Because the voltmeter has very high resistance, the current is effectively zero. The reading on the voltmeter is the emf. ✓

11.2 The resistance of the circuit is much lower than that of the voltmeter, so the current in the battery is now large. ✓ The battery has resistance, ✓ so some of the energy provided to the charge by the battery is used up in the battery itself, ✓ leaving less available for the circuit. ✓ [6]

Question 12: Long questions

12.1 Very high.✓ A voltmeter is connected in parallel across the resistor(s) where it measures potential difference. ✓ By having a very high resistance, very little current passes through the voltmeter.✓ So the voltmeter does not affect the current in the circuit. ✓

12.2 When the switch is open, current from the battery passes only through the voltmeter of very high resistance. This current is so small that it is effectively zero. So the emf is 10 V. ✓✓ When the switch is closed, the current through the battery is now the same as the current in the circuit and is much larger. ✓ Because the battery has resistance, some of the energy supplied by the battery is transformed into heat inside the battery, so only 9 V is available for the external circuit. ✓✓

12.3 9 J ✓

12.4 5 V ✓✓

12.5 4 J ✓✓

12.6 heat ✓ and light ✓

[16]

Answers to questions

Question 13: Long questions

V_1 = 1 V ✓✓
V_2 = 6 V ✓✓
V_3 = 12 V ✓✓
V_4 = 12 V ✓✓

[8]

Question 14: Long questions

A_1 = 2 A ✓✓
A_2 = 3 A ✓✓
A_3 = 5 A ✓✓
A_4 = 2 A ✓✓
A_4 = 1,5 A ✓✓

[10]

Question 15: Long questions

15.1 Current is the rate of flow of charge. ✓✓

15.2 Ammeter ✓

15.3 Very low resistance. ✓ An ammeter is connected in series in a circuit. ✓ It must have a very low resistance so that it does not affect the current in the circuit. ✓

15.4 $I = Q / \Delta t$ ✓ $\Delta t = Q / I = 30 / 0{,}25 = 120$ s ✓✓✓

[10]

Question 16: Long questions

16.1 type of material; ✓ length; ✓ thickness; ✓ temperature ✓

16.2 Some of the electrons in a metal are held loosely by the nucleus, so they are free to move. ✓✓

16.3 The battery sets up an electric field in the circuit. This forces all loose electrons in the circuit to move from the negative towards the positive terminal. ✓✓ The electrons collide with the atoms of the metal, causing them to vibrate faster and heat up. ✓✓

[10]

Question 17: Long questions

17.1 ohm ✓

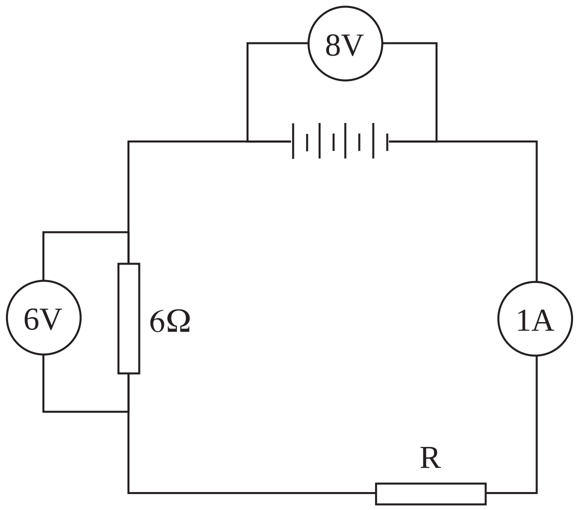
17.2.1 If a voltage of 240 volts produces a current of 5 amperes, 1 ampere will be produced by (240 ÷ 5) ✓✓ = 48 volts ✓

17.2.2 48 Ω ✓

[5]

Answers to questions

Question 18: Long questions



18.1 The 6 Ω resistor, resistor R and the ammeter can be connected in any order. ✓✓✓✓

18.2 2 V ✓ The resistors in series are voltage dividers – they divide the voltage of the battery in proportion to the resistances of the resistors. The voltages across the two resistors together must add up to 8 V. ✓✓

18.3 Less than 4 Ω. ✓ Voltage is divided in proportion to the resistance. R has the smaller proportion of the voltage, so must have the smaller resistance. ✓✓

We can actually predict that the resistance of R is 2 Ω, because the ohm is defined as a volt per ampere. The current in R is 1 ampere and the potential difference across it is 2 volts, therefore 2 V A^{-1} = 2 Ω. We can calculate the resistance another way. The voltage of the battery is divided in proportion to the resistance. R takes ¼ of the voltage of the battery, so must have ¼ of the total resistance. If the 6 Ω resistor is ¾ of the total resistance, the other ¼ must be 2 Ω.

18.4 1 A. ✓ Current is the same at all points in a series circuit. ✓

18.5 Time must be expressed in seconds. 1½ minutes = 90 s.

$Q = I \Delta t$ ✓ $= 1 \times 90$ ✓✓

$= 90$ C ✓

[16]

Answers to questions

Question 19: Long questions

19.1 $R_p = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $= \frac{1}{6} + \frac{1}{12}$ OR $R_p = \frac{R_1R_2}{R_1 + R_2}$ ✓

$= \frac{2+1}{12} = \frac{3}{12}$ $= \frac{6 \times 12}{6 + 12}$ ✓✓

$R_p = \frac{12}{3}$ $= 4\ \Omega$ ✓ $= 4\ \Omega$ ✓✓

19.2 $R_s = R_1 + R_2$ ✓

$= 3 + 4$

$= 7\ \Omega$ ✓

19.3 9 V ✓✓ (Must add up to the potential difference provided by the battery.)

19.4 1 A ✓✓ (Branched currents must add up to mainstream current.)

19.5 $Q = I\,\Delta t$ ✓

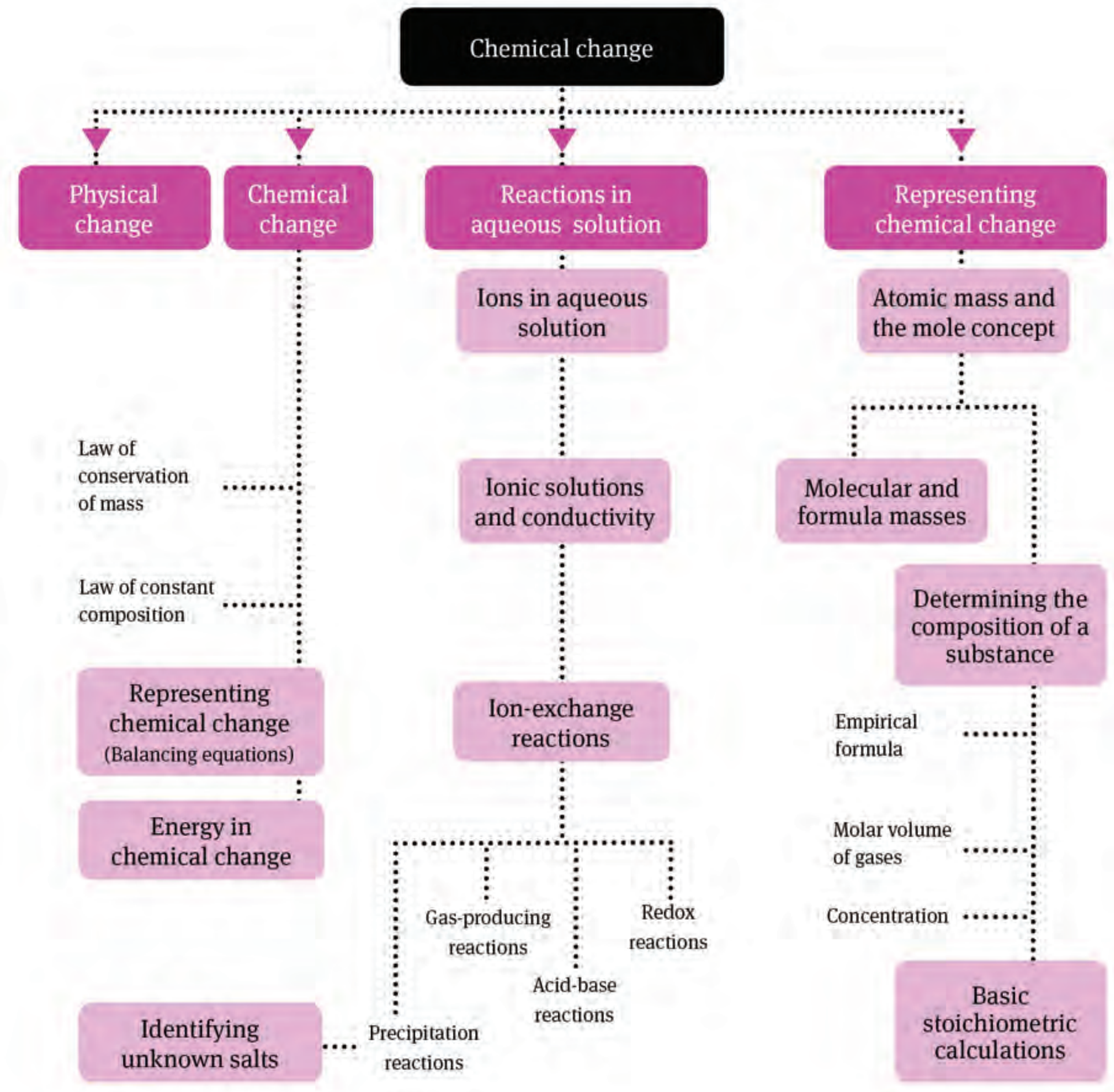
$= 3 \times 20$ ✓✓

$= 60\ \text{C}$ ✓

Topic 4

Chemical change

Overview



Summary

1 Physical and chemical change

1.1 Characteristics of physical and chemical change

- A physical change is usually easy to reverse. No new chemical substance is formed; usually only a small amount of energy is involved.

- During a physical change, the mass, the number of atoms and the number of molecules remain constant. Only intermolecular forces are broken.
- An example of physical change is ice melting.
- A chemical change is usually hard to reverse. New substances are formed that have different properties from the original substances. Usually, a large amount of energy is involved in the change.
- During a chemical change, mass and the number of atoms remain constant but the number and type of molecules will change. The atoms break apart and rearrange to form new compounds.
- An example of chemical change is iron sulphide being formed from the heating together of iron and sulphur.
- When only a physical change is involved, separation methods such as filtration, distillation and paper chromatography can be used to separate a mixture. Once a chemical change has occurred, these methods cannot be used.

1.1.1 Law of conservation of matter

- The total mass of any isolated system is constant and is independent of any chemical and physical changes taking place within the system.

1.1.2 Law of constant composition

- A particular chemical compound always contains the same elements combined in the same fixed proportions by mass.
- You can work out the ratio in which the elements combine by looking at their atomic masses.

1.2 Representing chemical change

- Chemical change can be represented or shown by balanced chemical equations. A balanced chemical equation is one in which the number and type of atoms present in the reactants (the substances on the left of the arrow) equal the number and type of atoms present in the products (the substances on the right of the arrow).
- State symbols like (s), (aq), (l) and (g) are put in brackets after each substance.
- To balance a chemical equation the formulae of the substances must not be changed. This means the small numbers in a formula, for example, the 2 in H_2O, may not be changed. Only the number that represents the number of molecules or formula units may change. This is the number in front of the formula.

1.3 Energy transfer in chemical change

- Just as mass and the number of atoms are conserved during a chemical change, so too is the amount of energy of the system.
- During a chemical reaction, energy is needed to break old bonds between atoms, and energy is released when new bonds form between atoms.
- If the energy released is greater than the amount needed to break the old bonds, the extra energy is given out as heat. The container in which the reaction occurs gets hot. This type of reaction is called an exothermic reaction.

- If the energy required to break the bonds is greater than the energy released when the new bonds form, energy must be put into the system. The container in which the reaction happens gets cold. This type of reaction is called an endothermic reaction.

2 Reactions in aqueous solution

2.1 Ions in aqueous solution

- Ions are elements (or groups of elements) that have lost or gained electrons.
- Negative ions are called anions and positive ions are called cations.
- An aqueous solution is a solution in which the solvent (the liquid that dissolves the solid (the solute)) is water.
- Ions in general dissolve easily in water. This process is called dissolution.
- When an ionic solid (a solid made from the bonding of positive and negative ions) is placed in water, dissolution (or the dissolving process) happens in two steps:
    the ionic solid breaks up into positive and negative ions
    the ions become hydrated.
- Dissolution can be shown by means of state symbols.
    Example: $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$
- In a water molecule, the hydrogen atoms are slightly positively charged, and the oxygen ions are slightly negatively charged. This is called a polar molecule.
- When the ions come into contact with the water, water molecules surround the negative ions. There is an attraction between the negative ion and the hydrogen atoms.
- Positive ions become surrounded because of the attraction between the positive ion and the negative oxygen of the water molecule.
- As a result, the ions cannot come together again, and so they remain in solution.

2.2 Electrolytes and ionisation

- An electrolyte is a solution that can conduct electricity. Ionic solutions are electrolytes.
- To measure the conductivity of an ionic solution, carbon electrodes are used that are attached to either end of a battery. An electrode is defined as a solid object through which electricity enters or leaves a substance.
- Cations flow towards the negative electrode and anions flow towards the positive electrode.
- The more dissolved ions there are in a solution, the greater the current that will flow in it.
- Non-ionic solutions such as sucrose (even though they can dissolve in water) cannot act as an electrolyte and conduct electricity. Solid ionic compounds also cannot conduct electricity. They have to be molten (melted) or in solution.

2.3 Precipitation reactions

- While many ionic compounds are soluble in water, some are not. There are some general rules we can use to predict whether a particular ionic compound will dissolve or not.

Compound	Solubility
All nitrates	All are soluble.
Salts containing potassium, sodium or ammonium	All are soluble.
Chlorides	All are soluble, except silver, lead and mercury chloride.
Sulphates	All are soluble, except lead sulphate, barium sulphate and calcium sulphate.
Carbonates	All are insoluble, except those with potassium sodium or ammonium.
Silver bromide and silver iodide are insoluble.	

- If two different ionic solutions are mixed, an ion from the one compound can change places with an ion from the other compound. A chemical reaction occurs. If the water from the solution is removed, two new substances will be present.

  Example: $BaNO_3(aq) + K_2SO_4(aq) \rightarrow BaSO_4(s) + KNO_3(aq)$

  The NO_3^- ion has changed places with the SO_4^- ion. A reaction like this is called an ion-exchange reaction.
- If one of the new substances that forms is insoluble, it will form a solid and sink to the bottom of the solution. The solid that forms in such a reaction is called a precipitate.
- Chlorides, bromides and iodides (halides) will all form a precipitate if they are mixed with soluble silver nitrate. Chlorides form a white precipitate. Bromides and iodides both form creamy yellow precipitates, but the precipitate of bromides dissolves in ammonium hydroxide solution.
- Sulphates will form a precipitate if mixed with soluble barium chloride.

  Example: $MgSO_4(aq) + BaCl_2(aq) \qquad MgCl_2(aq) + BaSO_4(s)$
- Carbonates will also form a precipitate with barium chloride. In the case of carbonates, the precipitate that forms will dissolve, producing bubbles, if some nitric acid is added to it.

2.2 Other chemical reaction types

- Precipitation reactions – the driving force is the formation of an insoluble salt.

  Example: $NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

  As you can see from the state symbols, the insoluble salt silver chloride forms during the reaction.
- Gas-forming reactions – the driving force is the formation of a gas.

  Example: $Mg(s) + 2\,H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$

  The water splits into H^+ and OH^- ions and the OH^- ions join with the magnesium so that hydrogen is released to form hydrogen gas.

- Acid-base reactions – the driving force is the transfer of protons (H^+ ions).
  Example: $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$
  The H^+ ion in the acid reacts with the OH^- ion in the base, causing the formation of water. Generally, the product of this reaction is some ionic salt and water.
- Redox reactions – the driving force is the transfer of electrons. (You will learn much more about these reactions in a later grade.)
  Example: $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

3 Quantitative aspects of chemical change

3.1 Atomic mass and the mole concept

- In chemistry, a 'mole' is the unit used to measure the quantity (the number of particles) of a substance.
- One mole of any substance = $6{,}02 \times 10^{23}$ particles. This number is known as 'Avogadro's number.'
- A mole is also defined as being that quantity of a substance that contains exactly the same number of particles as there are carbon atoms in 12 g of carbon. Therefore, one mole of any element has a mass (molar mass) equal to its relative atomic mass in grams.
- The relative formula mass (of an ionic substance) or the relative molecular mass of a molecule (a covalent substance) is the sum of the atomic masses of all the atoms in its formula. Therefore, the molar mass of a molecular substance is equal to its molecular mass and the molar mass of an ionic substance is equal to its formula mass.

3.2 Molecular and formula masses

3.2.1 Relationship between moles, mass and molar mass

$$\text{The number of moles} = \frac{\text{total mass of substances}}{\text{relative atomic mass of one atom of the substance}}$$

OR n = m / M where n = number of moles; m = the mass of a substance in grams and M is the atomic/formula mass.

3.2.2 Water of crystallisation

- 'Water of crystallisation' refers to water molecules that are trapped in some crystals as their crystal lattice forms. Although they are not bonded to the crystal, they add to its mass. Therefore, the water of crystallisation must be added in when the formula mass is calculated.
  Example:
  Formula mass of $CuSO_4{\cdot}5H_2O$ is $4 \times (65{,}5 + 32 + 16) + 5 \times (1 \times 2 + 16) = 252$

3.3 Determining the composition of substances

3.3.1 Percentage composition

- The percentage composition of a compound is the percentage of the total mass of the substance that is made up of each element.
- To calculate the percentage mass of an element in a compound, use the following formula:

$$\% \text{ mass} = \frac{\text{atomic mass + number of atoms of that element}}{\text{formula mass of the whole compound}} \times 100$$

[Example: to find the % sodium in Na_2CO_3

$$\% \text{ sodium} = \frac{23 \times 2}{(23 \times 2) + 12 + (16 \times 3)} \times 100 = \frac{46}{106} \times 100 = 43{,}4\%$$

3.3.2 Empirical formula

- The empirical formula of a compound is the simplest ratio of all the elements present in that compound. Sometimes the empirical formula and the molecular formula are the same (for example, in H_2O), but if the molecular formula can be divided by one common factor (for example, in C_4H_8), the molecular and empirical formulas are different.
- To find the molecular formula from the empirical formula and the molecular mass:
  1. Calculate the relative formula mass of the empirical formula.
  2. Divide this into the molecular mass.
  3. Take that answer and multiply each subscript in the empirical formula by that number.

     Example: The empirical formula is HO and the molecular mass is 34. The relative molecular mass of the empirical formula is (1 + 16). 34 ÷ 17 = 2. Therefore HO × 2 = H_2O_2, which is the molecular formula.

3.3.3 Molar volume

- Molar volume of gases refers to the fact that one mole of any gas at the same temperature and pressure has the same volume as one mole of any other gas at that temperature and pressure.
- It has been found that one mole of any gas at standard temperature (which is 273 K or 0 °C) and standard pressure (which is $1{,}013 \times 10^5$ Pa) has a volume of 22,4 dm^3. Therefore, the volume of any gas (at STP) = n × 22,4 dm^3, where n = the number of moles.

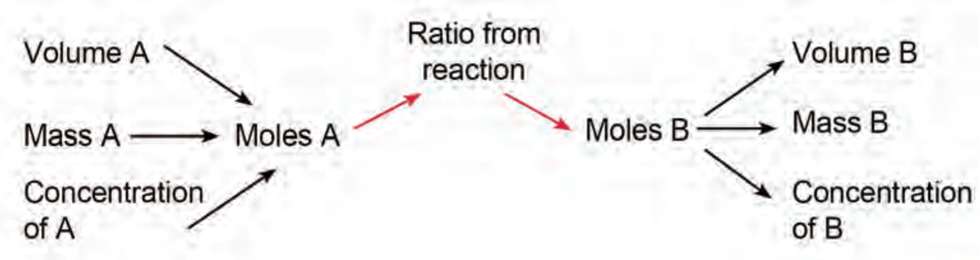
3.3.4 Concentration

- The concentration of a solution is usually given in 'moles per dm^3' or $mol.dm^{-3}$.
- Concentration c = n / v where:

  c = concentration in $mol.dm^{-3}$; n = number of moles and v = volume in dm^{-3}. (Note that 1000 cm^3 = 1 dm^3 = 1000 ml or 1 litre.)

3.4 Basic stoichiometric calculations

- Using balanced chemical equations and what you have learnt about moles, it is possible to find out how much of a certain product can be made from a certain amount of reactant.
- A balanced reaction gives you the ratio (in moles) in which substances react.
- Example: $2\ H_2 + O_2 \rightarrow 2\ H_2O$ tells us that 2 moles of hydrogen react with 1 mole of oxygen to form 2 moles of water.
- If you are given the mass of reactants and have to find the mass of the products, use the formula (n = mass / M) to convert mass of reactant to moles of reactant.
- Use the ratio given by the reaction to find the number of moles of product formed.
- Convert the number of moles of product to mass of product, again using (n = mass / M).
- If you are given dm^3 of a gas at STP, you must first convert this to the number of moles, using the formula volume in $dm^3 = n \times 22{,}4$. (One mole of any gas at STP has a volume of 22,4 dm^3.)
- If you are given the concentration of a reactant, convert this to moles using the formula $n = c \times V$.



Questions

Question 1: Multiple choice

Choose the correct answer. Only write the letter of the answer you select.

1.1 In the compound SO_2, the ratio of the mass of sulphur to oxygen is always ...
A 1:2.
B 2:1.
C 8:16.
D 1:1. (3)

1.2 The formula $3\ Al_2O_3$ represents ...
A 3 atoms of aluminium and 6 atoms of oxygen.
B 3 atoms of aluminium and 2 atoms of oxygen.
C 3 formula units of Al_2O_3.
D 6 atoms of aluminium and 3 atoms of oxygen. (3)

1.3 You are given the unbalanced reaction $Mg(OH)_2 + HCl \rightarrow MgCl_2 + H_2O$
The balanced reaction would be:
A $2\ Mg(OH)_2 + 2\ HCl \rightarrow 2\ MgCl + 2\ H_2O$.
B $Mg(OH) + 2\ HCl \rightarrow MgCl + 2\ H_2O$.

C $Mg(OH)_2 + 2\,HCl \rightarrow MgCl_2 + 2\,H_2O$.

D $2\,Mg(OH)_2 + 4\,HCl \rightarrow 2\,MgCl_2 + 4\,H_2O$. (3)

1.4 In a physical change, which one of the following statements is true?

A The mass is conserved but energy is used up.

B The mass is not conserved but the energy is conserved.

C The number of molecules remains constant during the reaction.

D Only the number of atoms remains constant during the reaction. (3)

1.5 Which of the following will NOT cause a precipitate if added to a solution of silver nitrate?

A sodium chloride

B copper chloride

C magnesium sulphate

D magnesium nitrate (3)

1.6 The reaction that could be used to prepare a bromide salt is:

A copper oxide and sulphuric acid.

B silver nitrate and potassium bromide.

C ammonium chloride and potassium bromide.

D ammonium nitrate and potassium carbonate. (3)

1.7 An unknown salt forms a creamy yellow precipitate with silver nitrate. The precipitate does not dissolve in ammonium hydroxide solution. The salt probably is:

A potassium iodide.

B potassium nitrate.

C potassium bromide.

D potassium chloride. (3)

1.8 The ion-exchange reaction $HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + 2H_2O(l)$ is an example of:

A an acid-base reaction.

B a gas-forming reaction.

C a redox reaction.

D a precipitation reaction. (3)

1.9 One mole of SO_2 contains:

A 1 molecule.

B $6{,}02 \times 10^{23}$ molecules.

C 3 atoms.

D $18{,}06 \times 10^{23}$ molecules. (3)

1.10 The formula mass of $C_2O_4H_2{\cdot}2H_2O$ is:

A 110.

B 126.

C 90.

D 108. (3)

1.11 Which of the following has the greatest mass?

A 1 mole of Fe

B 0,5 mol $FeCl_2$

C 0,1 mol $FeSO_4$

D 0,2 mol Fe_2O_3 (3)

1.12 The number of moles of water molecules in 126 g of ice is:

A 18.

B 7.

C $7 \times 6{,}02 \times 10^{23}$.

D $6{,}02 \times 10^{23}$. (3)

1.13 If you had 20 g each of the following compounds, which sample would have the largest number of moles?

A H_2O

B NO_2

C N_2

D NH_3 (3)

1.14 What is the number of atoms in 8 g of helium?

A $2 \times 6{,}02 \times 10^{23}$

B $6{,}02 \times 10^{23}$

C $4 \times 6{,}02 \times 10^{23}$

D $8 \div 6{,}02 \times 10^{23}$ (3)

1.15 Which of the following does NOT represent one mole of hydrogen gas at STP?

A 2 g

B 22,4 dm^3

C $6{,}02 \times 10^{23}$ molecules

D $2 \times 6{,}02 \times 10^{23}$ molecules (3)

Question 2: True/false

Indicate whether the following statements are true or false. If the statement is false, write down the correct statement.

2.1 The melting of ice is an example of a physical change. (2)

2.2 The mass ratio of carbon to oxygen in a molecule of CO_2 will always be 1:2. (2)

2.3 All nitrates are soluble. (2)

2.4 The SI unit for measuring the quantity of a substance is kilogram. (2)

2.5 The number that is equal to one gram of a substance is called Avogadro's number. (2)

Question 3: One-word answers

Provide the missing word or term in the sentences below. Write only the word or term next to the question number.

3.1 A positive ion is called a(n) ... (1)

3.2 If solutions of barium chloride and magnesium sulphate are mixed, the solid that will form is ... (1)

3.3 HO is the ... formula of hydrogen peroxide. (1)

3.4 The state symbol for mercury at room temperature is ... (1)

3.5 The souring of milk is an example of a ... change. (1)

Question 4: Matching pairs

Choose an item from column B that matches the description in column A. Write only the letter of your choice (A–J) next to the question number.

Column A	Column B
4.1 an electrolyte	A mole
4.2 mass ratio of 3:1	B 6,02 × 1023
4.3 number of particles in 8 g of helium gas	C a physical change
4.4 $N_2 + 3H_2 \rightarrow 2\ NH_3$	D CO
4.5 mass ratio of 3:4	E sucrose
4.6 SI unit of quantity	F ammonium sulphate
4.7 a non-electrolyte	G kilogram
4.8 number of particles in 22,4 dm^3 of helium gas at STP	H CH_4
4.9 SI unit of mass	I a chemical change
4.10 glass breaking	J 2 × 6,02 × 1023

[10]

Question 5: Long questions

5.1 Calculate the empirical formula of a substance that consists of 30,4% nitrogen, and 69,6% oxygen by mass. (7)

5.2 If the formula mass of the substance in 5.1 is 92, what is the molecular formula of the substance? (3)

[10]

Question 6: Long questions

6.1. If a gas is collected at STP, under what conditions of temperature and pressure is it collected? (2)

6.2 A sample of calcium carbonate ($CaCO_3$) was reacted with HCl in a closed container according to the following equation:

$CaCO_3 + 2\ HCl \rightarrow CaCl_2 + CO_2 + H_2O$

The carbon dioxide gas produced was collected at STP and occupied a volume of 33,6 dm^3. Calculate the mass of calcium carbonate that reacted with the HCl. (7)

[9]

Question 7: Long questions

7.1 Calculate the mass of potassium sulphate produced by 10 g of potassium hydroxide according to the equation:

$2\ KOH + H_2SO_4 \dashrightarrow K_2SO_4 + 2\ H_2O$ (7)

7.2 What volume of hydrogen gas, measured at STP, would be produced when 4 g of magnesium reacts completely with excess H_2SO_4 according to the equation:

$Mg + H_2SO_4 \dashrightarrow MgSO_4 + H_2$ (6)

[13]

Question 8: Long questions

Aluminium oxide (Al_2O_3) is the starting compound for making high-temperature-resistant ceramic products.

8.1 What is the percentage of aluminium in aluminium oxide? (4)

8.2 How much aluminium sulphate $Al_2(SO_4)_3$ is required to make up 250 ml of a 0,1 $mol.dm^{-3}$ solution of this compound? (6)

[10]

Question 9: Long questions

9.1 What is a precipitate? (2)

9.2 Complete the following ion-exchange reactions:

9.2.1 $KCl(aq) + NaNO_3(aq) \dashrightarrow$ (2)

9.2.2 $CaSO_4(aq) + MgCO_3(aq) \dashrightarrow$ (2)

9.2.3 $BaCl_2(aq) + Na_2SO_4(aq) \dashrightarrow$ (2)

9.2.4 $K_2SO_4(aq) + Pb(NO_3)_2(aq) \dashrightarrow$ (2)

9.3 For each reaction in 9.2, state if any precipitate is formed. If a precipitate is formed, give its formula. (4)

[14]

Question 10: Long questions

10.1 You are given three unlabelled test tubes. One contains sodium bromide, one contains potassium iodide and one contains magnesium carbonate. List the steps you would take to identify what compound was in each sample. (8)

10.2 Give a balanced equation for the reaction that helped you to identify which sample contained magnesium carbonate. (3)

[11]

Question 11: Long questions

11.1 If 4,5 g of calcium burns in oxygen to form calcium oxide (CaO), what mass of CaO will form from that amount of calcium? (5)

11.2 Balance the following chemical reactions:

11.2.1 $CH_4 + O_2 \dashrightarrow CO_2 + H_2O$ (2)

11.2.2 $Al + Cl_2 \dashrightarrow AlCl_3$ (2)

11.2.3 $CO_2 + H_2O \dashrightarrow C_6H_{12}O_6 + O_2$ (2)

[6]

Question 12: Long questions

The substance adenosine triphosphate (ATP) is important because it provides a way of transferring energy in living cells.

12.1 A sample of 1,6270 g of ATP was analysed and found to contain 0,3853 g carbon, 0,0518 g hydrogen, 0,2247 g nitrogen and 0,2981 g phosphorus. The rest was oxygen. Calculate the number of moles of each element present in the sample of ATP. (Express answers correct to 4 decimal places.) (7)

12.2 The empirical formula of ATP is $C_{10}H_{16}O_{13}N_5P_3$. If the relative molecular mass of ATP is 507, what is its molecular formula? (3)

[10]

Question 13: Long question

When solutions of potassium chloride (KCl) and silver nitrate ($AgNO_3$) are mixed together, a precipitate of silver chloride is formed.

13.1 Write down a balanced equation for this reaction. (3)

13.2 In a certain experiment, 24 cm^3 of 0,05 $mol.dm^{-3}$ silver nitrate solution exactly reacts with 15 cm^3 of potassium chloride solution. How many moles of KCl would react with the given amount of $AgNO_3$? (5)

13.3 Calculate the concentration of the potassium chloride solution. (3)

[11]

Question 14: Long questions

You are given three test tubes, labelled A, B and C, each containing an unknown sodium salt. The following observations were made during a practical investigation to identify the salt in each test tube.

1. When the salt in C was dissolved in water and silver nitrate ($AgNO_3$) was added, a yellow precipitate formed. This precipitate did not dissolve when an ammonium hydroxide solution was added to it.
2. When the salt in A was dissolved in water and barium chloride ($BaCl_2$) was added, a white precipitate formed.
3. The salt in B dissolved in HCl and a gas was released.

14.1 Use the above information to identify the salt in each of the test tubes A, B and C. In each case explain how you made your choice. (7)

14.2 Write a balanced chemical equation for the reaction that took place in test tube A when barium chloride was added. (2)

14.3 Write a balanced chemical equation for the reaction that took place in test tube B when HCl was added. (2)

[11]

Answers to questions

Answers

Question 1: Multiple choice

1.1 D ✓✓✓
1.2 C ✓✓✓
1.3 C ✓✓✓
1.4 C ✓✓✓
1.5 D ✓✓✓
1.6 B ✓✓✓
1.7 A ✓✓✓
1.8 A ✓✓✓
1.9 B ✓✓✓
1.10 B ✓✓✓
1.11 B ✓✓✓
1.12 B ✓✓✓
1.13 D ✓✓✓
1.14 A ✓✓✓
1.15 D ✓✓✓

Question 2: True/false

2.1 True ✓✓
2.2 False. The mass ratio of carbon to oxygen in a molecule of CO_2 will always be 3:8. ✓✓
2.3 True ✓✓
2.4 False. The SI unit for measuring quantity of substance is mole. ✓✓
OR The SI unit for measuring mass is kilogram.
2.5 False. The number that is equal to one mole of a substance is Avogadro's number. ✓✓

Question 3: One-word answers

3.1 cation ✓
3.2 barium sulphate ✓
3.3 empirical ✓
3.4 (l) ✓
3.5 chemical ✓

Answers to questions

Question 4: Matching pairs

4.1 F ✓
4.2 H ✓
4.3 J ✓
4.4 I ✓
4.5 D✓
4.6 A ✓
4.7 E ✓
4.8 B ✓
4.9 G ✓
4.10 C ✓

Question 5: Long questions

5.1 N 30,4% O 69,6%

In 100 g of compound; 30,4 g is N and 69,6 g is O.
Therefore, the mole ratio in 100 g is:

N $\frac{30,4}{14}$ ✓ = 2,17 ✓ O $\frac{69,9}{16}$ ✓ = 4,35 ✓

Reduced to whole numbers:

N $\frac{2,17}{2,17}$ = 1 ✓ O $\frac{4,35}{2,17}$ = 2 ✓

Ratio N:O = 1:2
Empirical formula is NO_2. ✓

5.2 Formula mass of NO_2 = (14 + 16 + 16) = 46 ✓ $\frac{92}{46}$ = 2 ✓

Therefore, molecular formula = N_2O_4. ✓

Question 6: Long questions

6.1 Temperature 0 °C (or 273 K) ✓ Pressure 101, 3 kPa = 1,013 × 10^5 Pa✓

6.2 $n_{CO_2} = \frac{Vol}{22,4} = \frac{33,6}{22,4}$ ✓ = 1,5 moles ✓

According to the equation, 2 mol HCl reacts with 1 mol $CaCO_3$ ✓
Therefore, 1,5 mol HCl reacts with x mol Ca CO_3

x = $\frac{1,5}{2}$ = 0,75 mol $CaCO_3$ ✓

Mass of $CaCO_3$ = n × M = 0,75 × (40 + 12 + 48) ✓

Mass $CaCO_3$ = 75 g ✓

Question 7: Long questions

7.1 $n_{KOH} = \frac{mass}{M} = \frac{10 ✓}{(39 + 16 + 1)}$ = 0,179 mol ✓

According to the equation, 2 mol KOH → 1 mol K_2SO_4 ✓

Therefore, 0,179 mol KOH → ($\frac{0{,}179}{2}$ × 1) mol K_2SO_4

= 0,089 mol K_2SO_4 ✓

Mass = n × M = 0,089 × (2 × 39 + 32 + 64) ✓ = 15,5 g K_2SO_4 ✓

7.2 $n_{Mg} = \frac{mass}{M} = \frac{0{,}4}{24}$ ✓ = 0,167 mol ✓

According to the equation, 1 mol magnesium → 1 mol hydrogen ✓
Therefore, 0,167 mol hydrogen would be produced ✓
Volume at STP = n × 22,4 = 0,167 × 22,4 ✓ = 3,74 dm^3 ✓

Question 8: Long questions

8.1 M of Al = 27 M of O = 16

M of Al_2O_3 = (27 + 27 + 16 + 16 + 16) = 102 ✓

% Al = $\frac{54}{102}$ ✓ × 100 ✓ = 52,9% ✓

8.2 n = c × v ✓ = 0,1 × 0,25 ✓ = 0,025 mol ✓

Mass = n × M = 0,025 × [54 +(32 × 3) + (16 × 12)] = 0,025 × 342 ✓

Mass = 8,55 g ✓

Question 9: Long questions

9.1 A precipitate is a solid ✓ that forms when two solutions are mixed ✓ and form an insoluble salt.

9.2.1 KCl(aq) + $NaNO_3$(aq) → KNO_3(aq)✓ + NaCl(aq) ✓

9.2.2 $CaSO_4$(aq) + $(NH_4)_2CO_3$ → $CaCO_3$(s) ✓ + $(NH_4)_2SO_4$(aq) ✓

9.2.3 $BaCl_2$(aq) + Na_2SO_4(aq) → $BaSO_4$(s) ✓ + 2 NaCl(aq) ✓

9.2.4 K_2SO_4(aq) + $Pb(NO_3)_2$(aq) → 2 KNO_3(aq) ✓+ $PbSO_4$(s) ✓

9.3.1 No precipitate ✓

9.3.2 $CaCO_3$ ✓

Answers to questions

9.3.3 $BaSO_4$ ✓

9.3.4 $PbSO_4$ ✓

Question 10: Long questions

10.1 Add some HCl to a small amount of each of the three samples. ✓ The one that bubbles and dissolves is the magnesium carbonate.✓ Take the remaining two samples and make them into solutions. ✓ Add some $AgNO_3$ solution to each one. ✓ A creamy yellow precipitate forms in both. ✓ Add some NH_4OH solution to each. ✓ The test tube containing the precipitate that dissolves when treated with the ammonium solution is the bromide. ✓ Therefore, the other tube must be the potassium iodide.✓

10.2 $MgCO_3 + 2\,HCl \rightarrow MgCl_2 + CO_2 + H_2O$

correct reactants ✓ correct products ✓ balanced correctly✓

Question 11: Long questions

11.1 M of Ca = 40 M of O = 16

Mass ratio of Ca:O in CaO must be 40:16✓or 5:2 ✓

But we have 4,5 g Ca, so mass ratio Ca:O = 4,5:x

$5\,x = 2 \times 4,5$ (cross multiply)

$x = 2 \times 4,5 / 5$ ✓

$= 1,8$ g O ✓

Therefore, total mass of CaO formed = 4,5 + 1,8 = 6,3 g CaO ✓

OR

$2\,Ca + O_2 \rightarrow 2\,CaO$ ✓

2 mol Ca → 2 mol CaO

So 1 mol Ca → 1 Mol CaO

40 g Ca → 56 g CaO ✓

4,5 g Ca → x g CaO ✓

$x = 4,5 \times \frac{56}{40} = 6,3$ g CaO ✓

11.2 $CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$ ✓✓

$2\,Al + 3\,Cl_2 \rightarrow 2\,AlCl_3$ ✓✓

$6\,CO_2 + 6\,H_2O \rightarrow C_6H_{12}O_6 + 6\,O_2$ ✓✓

Answers to questions

Question 12: Long questions

12.1 Mass of oxygen = 1,6270 g – (0,3853 + 0,0518 + 0,2247 + 0,2981) = 0,6671 g ✓

$n = \frac{mass}{M}$ ✓

carbon $n = \frac{0,3853}{12} = 0,0321$ mol ✓

hydrogen $n = \frac{0,0518}{1} = 0,0518$ mol ✓

nitrogen $n = \frac{0,2247}{14} = 0,0161$ mol ✓

phosphorus $n = \frac{0,2981}{31} = 0,0096$ mol ✓

oxygen $n = \frac{0,6671}{16} = 0,0417$ mol ✓

12.2 M of ATP = (10 × 12 + 16 × 1 + 13 × 16 + 5 × 14 + 3 × 31) = 507 ✓

Relative formula mass of empirical formula = 507

Relative molecular mass = 507 ✓

The molecular formula is the same as the empirical formula. ✓

Question 13: Long questions

13.1 $KCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + KNO_3(aq)$ ✓✓

13.2 number of moles of $AgNO_3 = c \times v$ ✓

$= 0,05 \times 0,024$ ✓

$= 0,0012$ mol ✓

According to the equation, 1 mol of KCl reacts with 1 mol $AgNO_3$.✓

Therefore, 0,0012 mol KCl is required. ✓

13.3 $c = \frac{n}{v}$ ✓✓ $= \frac{0,0012}{0,015}$ ✓ $= 0,08 \text{ mol.dm}^{-3}$ ✓

Question 14: Long questions

14.1 C – Yellow precipitate formed when $AgNO_3$ is added does not dissolve in NH_4OH ✓ Must be an iodide (sodium iodide) ✓

A – A white precipitate formed when barium chloride is added indicates a sulphate. ✓ Must be sodium sulphate.✓

B – A substance that dissolves in acid and forms a gas indicates the production of CO_2 ✓ Must be sodium carbonate. ✓

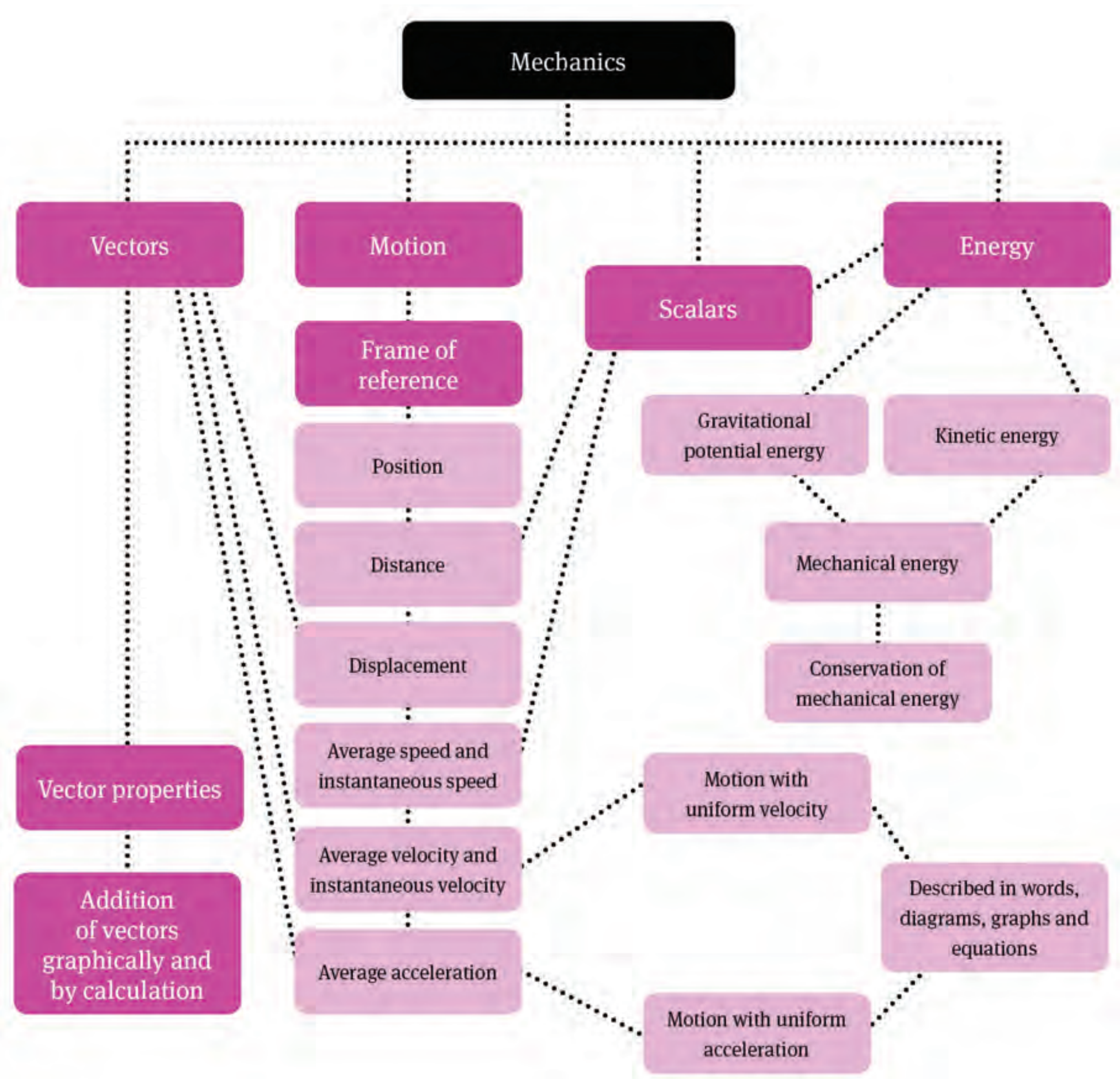
14.2 $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2\,NaCl(aq)$ ✓✓

14.3 $Na_2CO_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + CO_2(g) + H_2O(l)$ ✓✓

Topic 5

Mechanics

Overview



Summary

1 Motion and forces

Mechanics is the branch of physics that focuses on the motion of objects and the forces that act on them. Not all physical quantities can be treated in the same way. Two 2 kg masses lumped together give a bigger mass of 4 kg, but the combined effect of two forces acting on an object in different directions cannot be found by simple addition. It is important to learn how to work with physical quantities such as force before meeting similar difficulties in your study of motion.

When speaking of motion, many people use the words ‘velocity’ and ‘acceleration’ to describe the same thing, but this is a mistake. For example, it is quite common for a moving object to have a high velocity and very little or no acceleration. Getting correct ideas about concepts like this from the start makes things much easier later on. Some aspects of motion can be quite tricky to analyse. So you will be pleasantly surprised to find that straight-line motion at constant speed or with speed that changes by the same amount every second is relatively easy to describe in words, diagrams, graphs and equations.

The study of motion leads on to the energy transfers that cause all the excitement on a roller coaster. Our interest is in the energy possessed by an object because of its position above the ground and the energy it has when it is moving. We will study the interchange between these two energies in roller coasters and some other frictionless systems.

2 Vectors and scalars

- Scalar quantities (for instance, mass, charge, energy, time, distance and speed) have magnitude only.
- Vector quantities (for instance, force, weight, displacement, velocity and acceleration) have both magnitude and direction.
- Vector quantities are represented by arrows called vectors.
- In a drawing to scale, the magnitude of a vector quantity is represented by the length of the vector and its direction is indicated by the arrowhead.
- Equal vectors have the same length and direction.
- Negative vectors act in the opposite direction to the chosen positive direction.
- Vectors can be added and subtracted and their magnitudes can be multiplied.
- A resultant vector is the single vector that has the same effect as a number of separate vectors acting together.
- Resultant vectors can be determined:
  - graphically, using the tail-to-head and tail-to-tail methods
  - by calculation.

3 Motion in one dimension

- Motion is measured relative to a frame of reference. A frame of reference has an origin (or reference point) and a set of directions.
- Motion in one dimension is straight-line motion in the forward or backward direction.
- Position is always stated relative to a reference point and may be positive or negative. For position, usually use the symbol x; if motion is vertical, use the symbol y.

- Displacement (Δx or Δy) is change in position. It is a vector quantity: the straight-line distance from a starting position to a new position, together with the direction.
- Distance (D) is the length of the actual path taken between a starting position and a new position. It is a scalar quantity.
- Average speed (v) is a scalar quantity: the distance travelled divided by the time taken (Δt).
  $$v = \frac{D}{\Delta t}$$
- Average velocity is a vector quantity: the displacement divided by the time taken.
  $$v = \frac{\Delta x}{\Delta t}$$
- Average acceleration (a) is the change in velocity divided by the time taken.
  $$a = \frac{\Delta v}{\Delta t}$$

3.1 Worked examples

1 Sara runs a 200 m race in 30 s. Calculate her average speed.

Answer:

$$v = \frac{D}{\Delta t}$$
$$= \frac{200}{30}$$
$$= 6{,}67 \text{ m.s}^{-1}$$

2 Calculate Simo's average velocity if it takes him 8 minutes to walk 400 m east and then 160 m west.

Answer:

$$v = \frac{\Delta x}{\Delta t}$$
$$= \frac{240}{480}$$
$$= 6{,}67 \text{ m.s}^{\Delta 1} \text{ east}$$

The direction east is chosen as the positive direction.

$\Delta t = 8 \times 60 = 480$ s $\Delta x = 400 - 160 = 240$ m east

3 A cyclist moving at 12 m.s^{-1} stops pedalling at the bottom of a gentle slope and coasts to a stop. If this takes 5 s, calculate his acceleration.

Answer:

The initial direction of motion is chosen as the positive direction.

$$\Delta v = \text{final velocity} - \text{initial velocity} = (0 - 12) = -12\ \text{m.s}^{-1}$$

$$a = \frac{\Delta v}{\Delta t}$$

$$= \frac{12}{5}$$

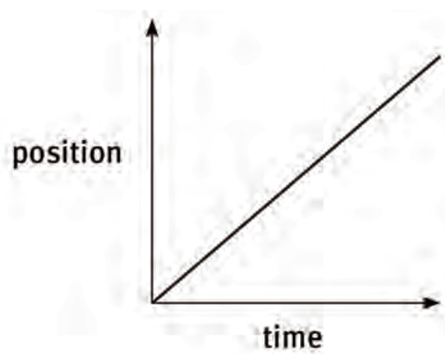
$$= \Delta 2{,}4\ \text{m.s}^{\Delta 2}\text{, that is, } 2{,}4\ \text{m.s}^{-2} \text{ in the opposite direction to the initial motion}$$

- Acceleration indicates how quickly the velocity is changing, but provides no information about the direction of motion.
- Acceleration is produced by a force, and always has the same direction as the force that is causing it.
- If we take the direction in which a car is facing as the positive direction, then:
  positive acceleration means there is a forward force acting, which will *increase* its velocity
  negative acceleration means there is an opposing force acting on it, which will either *decrease* its velocity (for instance, if the brakes are applied, or it coasts uphill) or *increase* its velocity backwards (if the car accelerates in reverse gear).
- Instantaneous velocity is the displacement divided by a very small time interval.
- Instantaneous speed is the magnitude of the instantaneous velocity.

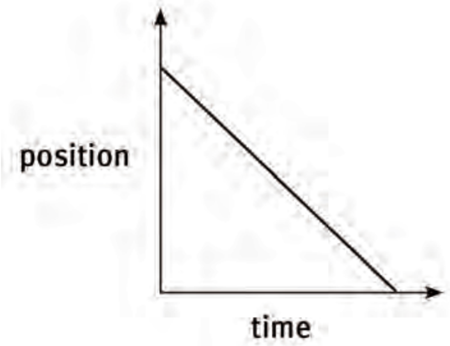
4 Motion described in words, diagrams, graphs and equations

4.1 Motion with uniform velocity

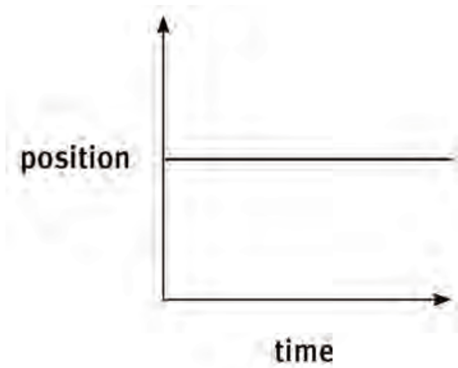
- An object moving in a straight line with uniform velocity changes its position by the same amount in equal time intervals.
- A position–time graph for motion with uniform velocity is always a straight line with a positive or negative gradient.
- For motion in the positive direction, the graph has a positive gradient.



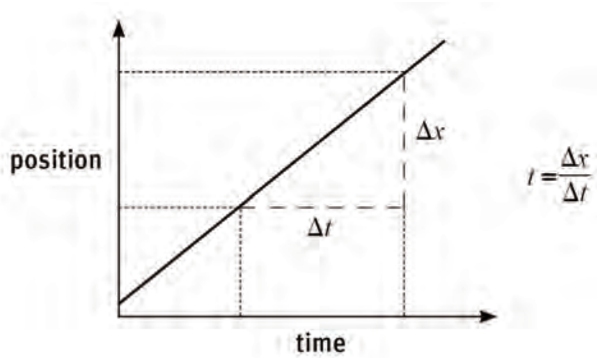
When motion is in the negative direction, the gradient is negative.



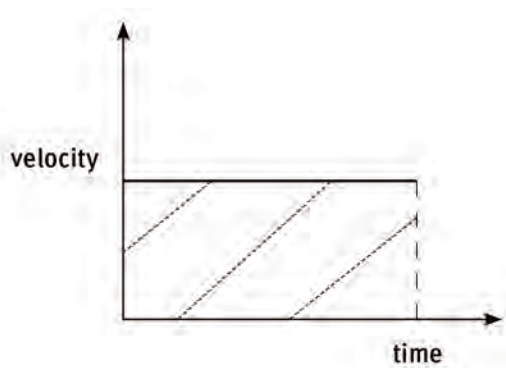
A position–time graph of a stationary object is horizontal.



- The gradient of a position–time graph is equal to the uniform velocity.



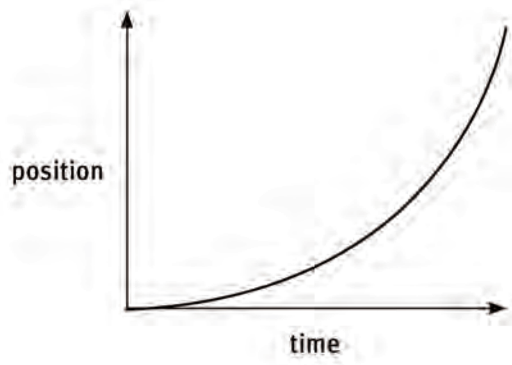
- A velocity–time graph for motion with uniform velocity is horizontal.



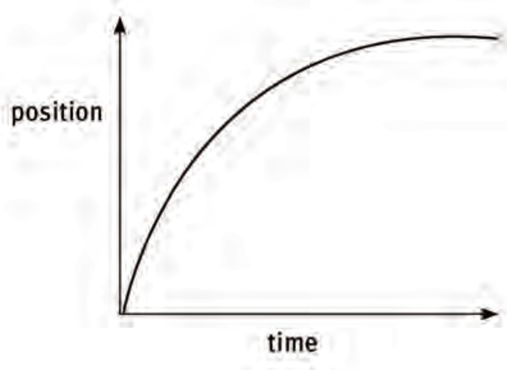
- The area under a velocity–time graph is equal to the displacement. The area under the graph is rectangular in shape. Motion is in the positive direction when the area under the graph is positive (above the horizontal time axis) and motion is in the negative direction when the area under the graph is negative (below the time axis).

4.2 Motion with uniform acceleration

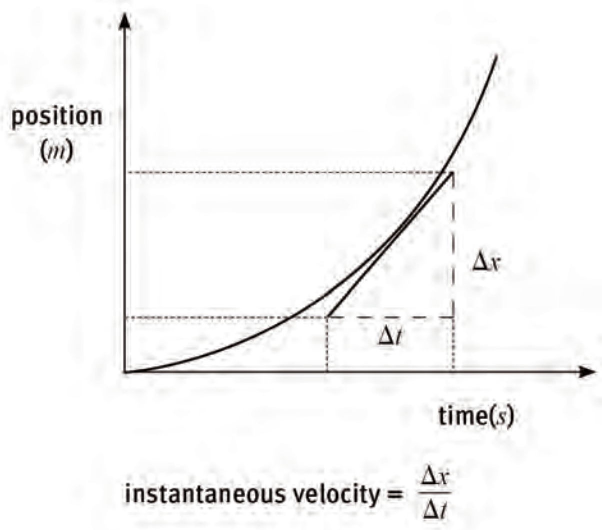
- An object moving with uniform acceleration has a velocity that changes in magnitude by the same amount in equal time intervals.
- A position–time graph for motion with uniform acceleration is never a straight line. The gradient of the graph changes at a constant rate.
- For motion in the positive direction, the gradient of the graph increases steadily if the velocity is increasing.



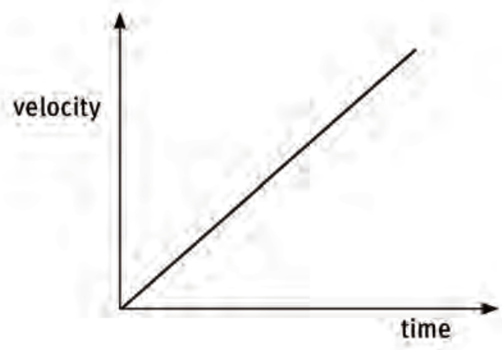
- For motion in the positive direction, the gradient of the graph decreases steadily if the velocity is decreasing.



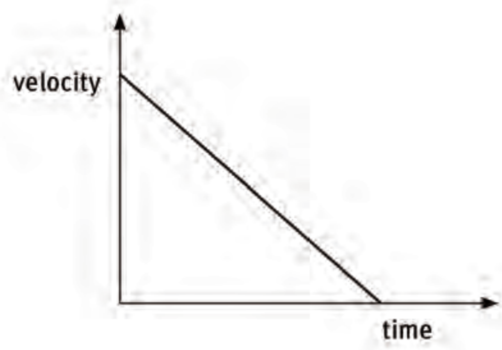
- The gradient of the tangent drawn to a position–time graph at a particular time is equal to the instantaneous velocity.



- A velocity–time graph for motion with uniform acceleration is always a straight line with a positive or negative gradient.
- For motion in the positive direction, the graph has a positive gradient if the velocity is increasing.

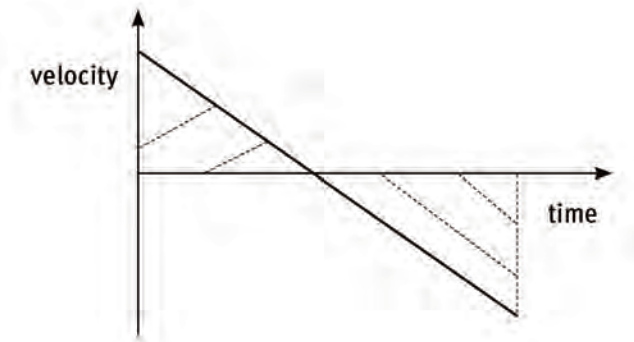


- For motion in the positive direction, the graph has a negative gradient if the velocity is decreasing.

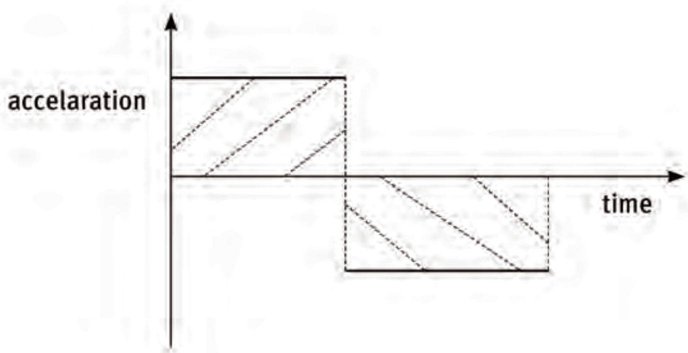


- The gradient of a velocity–time graph is equal to the uniform acceleration.
- The area under a velocity–time graph is equal to the displacement. For motion with uniform acceleration, the area under the graph is triangular in shape. Motion is in

the positive direction when the area under the graph is positive and motion is in the negative direction when the area under the graph is negative.



- An acceleration–time graph for motion with uniform acceleration is horizontal.
- The area under an acceleration–time graph is equal to the change in velocity. The area under the graph is rectangular in shape. For motion in the positive direction, the change in velocity is positive when the area under the graph is positive and the change in velocity is negative when the area under the graph is negative.



- Roads are safer when drivers understand the relationship between speed and stopping distance, when drivers are in full control of their faculties, when brakes are in good condition, when road conditions are favourable and when vehicles are fitted with safety features.

4.3 Kinematics equations

- Equations of uniform motion are used to solve problems involving motion in one dimension.
- The symbols used in the equations are:
  - Δx: displacement (or use Δy it the change in position is vertical)
  - Δt: time $\quad$ a: unifom acceleration

  v_f : initial velocity v_f: final velocity

- The equations are:

$$v_f + v_i + a\Delta t \qquad \Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2 \qquad v_f^2 = v_f^2 + 2a\Delta x \qquad \Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$$

4.3.1 Worked examples

1 Jane cycles along a straight, level road at 4 m.s⁻¹. Then she accelerates uniformly at 0,5 m.s⁻² for 12 s. Calculate:

1.1 the final velocity

1.2 the displacement while she accelerates.

Answers:

Take the initial direction of motion as the positive direction.

1.1 $v_i = 4\ \text{m.s}^{-1}$ $\quad a = 0{,}5\ \text{m.s}^{-2}$ $\quad \Delta t = 12\ \text{s}$

$v_f = v_i = a\Delta t^2$

$= 4 + (0{,}5 \text{ x } 12)$

$= 10\text{m.s}^{-1}$ in the direction of motion

1.2 $v_i = 4\ \text{m.s}^{-1}$ $\quad a = 0{,}5\ \text{m.s}^{-2}$ $\quad \Delta t = 12\ \text{s}$

$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$

$= (4\ 12) + \{0{,}5 \times 0{,}5 \times (12)^2\}$

2 Joe cycles along a straight, level road at 15 m.s⁻¹. Then he stops pedalling and slows down uniformly over a displacement of 52 m. If his velocity falls by 1 m.s⁻¹ every second, calculate:

2.1 the final velocity after 52 m

2.2 the time that he takes to cover the 52 m.

Answers:

Take the initial direction of motion as the positive direction.

2.1 $v_i = 15\ \text{m.s}^{-1}$ $\quad a = -1\ \text{m.s}^{-2}$ $\quad \Delta x = 52\ \text{m}$

$v_f^2 = v_i^2 + 2a\Delta x$

$= (15)^2 + \{2 \times (-1) \times 52\}$

$= 225 - 104$

$\therefore v_f = \sqrt{121}$

$= 11\text{m.s}^{-1}$ in the direction of motion

2.2 $v_i = 15\ \text{m.s}^{-1}$ $\quad vf = 11\ \text{m.s}^{-1}$ $\quad a = -1\ \text{m.s}^{-2}$

$$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$$

$$\therefore \Delta t = \left(\frac{2}{v_i + v_f}\right)\Delta$$

$$= \left(\frac{2}{15 + 11}\right)52$$

$$= 4\ s$$

5 Energy

- The gravitational potential energy of an object is the energy it has because of its position in the Earth's gravitational field relative to a selected reference point.
- Gravitational potential energy is calculated using the formula:
  $E_P = mgh$
- Kinetic energy is the energy possessed by an object as a result of its motion.
- Kinetic energy is calculated using the formula:
  $E_K = ½\ mv^2$
- Mechanical energy (E_M) is the sum of gravitational potential energy and kinetic energy:
  $E_M = E_K + E_P$
- Energy cannot be created or destroyed. It can only be changed from one form into another.
- In the absence of air resistance, the mechanical energy of an object moving in the Earth's gravitational field is conserved.
- When energy transfers happen and mechanical energy is conserved, use the equation:
  $E_{K1} + E_{P1} = E_{K2} + E_{P2}$

5.1 Worked examples

1 A boy of mass 50 kg is ready to jump from a bridge into the water 4,9 m below. What is his potential energy:

1.1 relative to the bridge?

1.2 relative to the water surface?

Answers:

1.1 0

1.2 $m = 50$ kg $g = 9{,}8\ m.s^{-2}$ $h = 4{,}9$ m

$E_P = mgh$

$$= (50 \times 9,8 \times 4,9)$$
$$= 2401 \text{ J}$$

2 After falling for 1 s, the boy in the previous example splashes into the water with a speed of 9,8 m.s^{-1}. Calculate his kinetic energy as he strikes the water surface.

Answer:

$m = 50$ kg $\quad v = 9,8$ m.s^{-1}

$$E_K = \tfrac{1}{2} mv^2$$
$$= [0,5 \times 50 \times (9,8)^2]$$
$$= 2401 \text{ J}$$

3 Calculate the mechanical energy of a sledgehammer of mass 3 kg moving downwards at 6 m.s^{-1} and 0,5 m above the ground.

Answer:

$m = 3$ kg $\quad v = 6$ m.s^{-1} $\quad g = 9,8$ m.s^{-2} $\quad h = 0,5$ m

$$E_M = E_K + E_P$$
$$= \tfrac{1}{2} mv^2 + mgh$$
$$= [0,5 \times 3 \times (6)^2] + (3 \times 9,8 \times 0,5)$$
$$= 68,7 \text{ J}$$

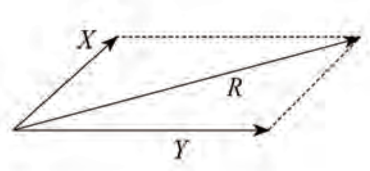
Questions

Question 1: Multiple choice

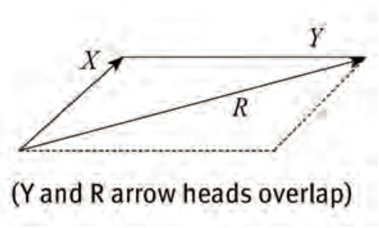
Choose the correct answer. Only write the letter of the answer you select.

1.1 When vectors X and Y are added, the resultant R is incorrectly represented in diagram:

A



B



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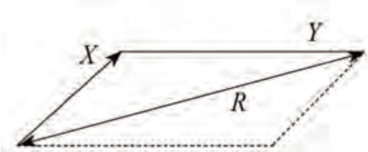

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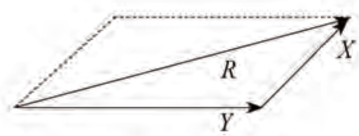


(X and R arrowheads overlap)

(3)

1.2 An athlete completed one lap of a 400 m oval track in 60 s. The magnitude of her average velocity for the race was:

A 6,67 $m.s^{-1}$.

B 15 $m.s^{-1}$.

C 0 $m.s^{-1}$.

D 4,8 $m.s^{-1}$. (3)

1.3 A car starts from rest and travels in a straight line for 10 s with a uniform acceleration of 2 $m.s^{-2}$. From the end of one second to the end of the next second, the car goes:

A 2 m further than in the previous second.

B 3 m further than in the previous second.

C 6 m further than in the previous second.

D 9 m further than in the previous second. (3)

1.4 A trolley moves to the right with increasing velocity and uniform acceleration. The ticker tape that it pulls through a ticker timer looks like this:

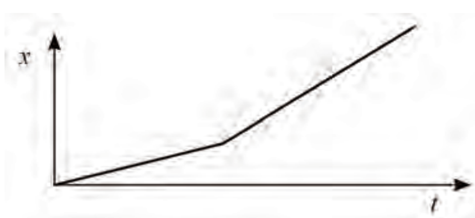
A .   .   .   .

B . . . .

C . . . .

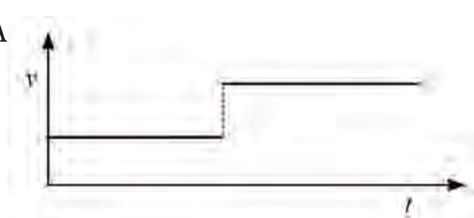
D .   .   .   .   (3)

1.5

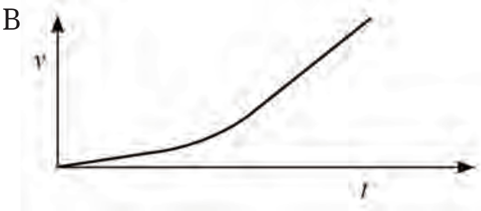


The velocity–time graph that corresponds with the above position–time graph is:

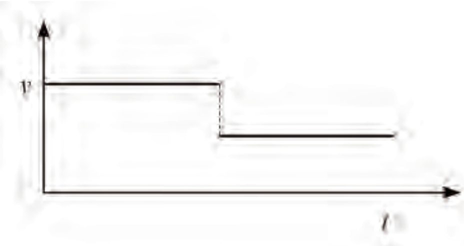
A



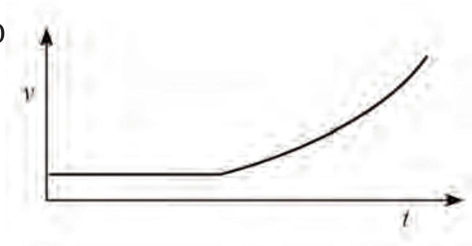
B



C

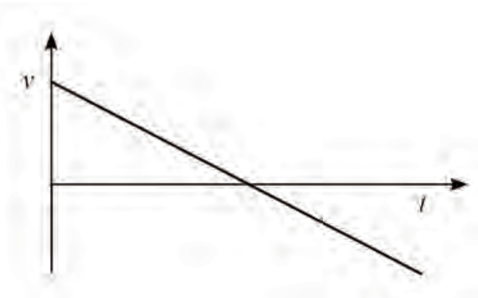


D



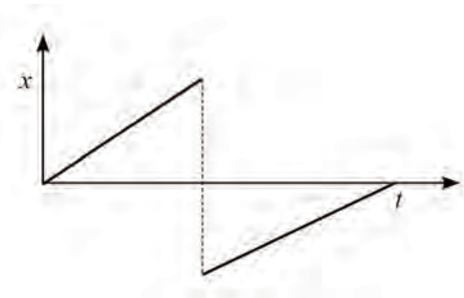
(3)

1.6



The position–time graph that matches the above velocity–time graph is:

A



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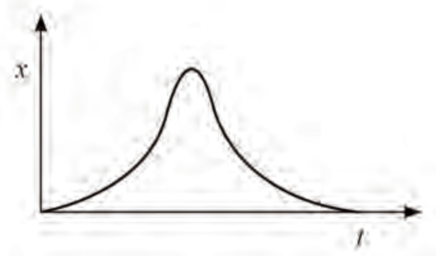
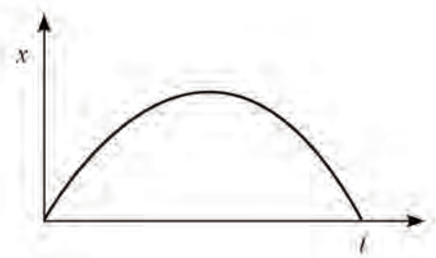
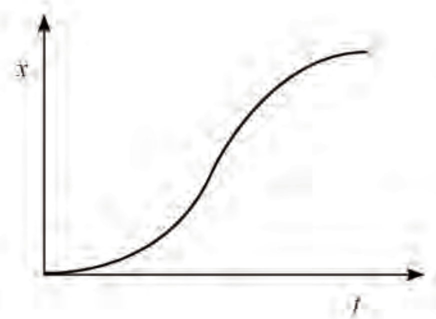


C

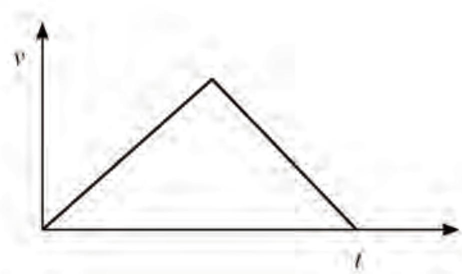


D



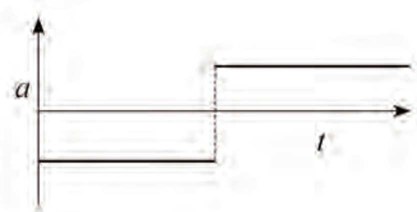
(3)

1.7

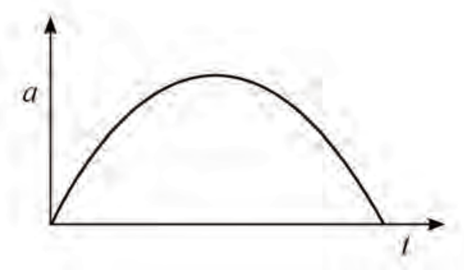


The acceleration–time graph that corresponds with the above velocity–time graph is:

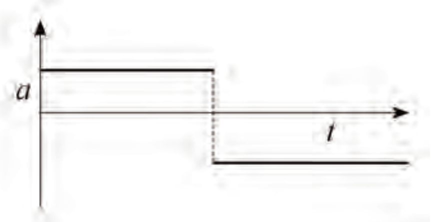
A



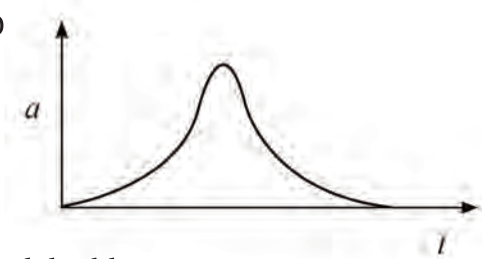
B



C



D



(3)

1.8 When a car's speed doubles:
- A the stopping distance is about twice as long.
- B the thinking distance is about four times as long.
- C the braking distance is about four times as long.
- D the stopping distance is about four times as long.

1.9 An object with potential energy E_p is a height h above the Earth's surface. It is then raised to a height 2 h. The new potential energy is:
- A $\frac{3}{2}E_P$.
- B $2\,E_P$.
- C $3\,E_P$.
- D $4\,E_P$. (3)

1.10 A stone falls through the air from a high bridge. As it falls:
- A mechanical energy is conserved.
- B kinetic energy is conserved.
- C potential energy is conserved.
- D potential energy is transferred to kinetic energy and heat. (3)

Question 2: True/false

Indicate whether the following statements are true or false. If the statement is false, write down the correct statement.

2.1 Two force vectors, drawn to scale, are equal if they have the same length. (2)

2.2 Distance is change in position; it is a straight-line from the original position to the final position. (2)

2.3 Change in velocity is indicated by the area under a position–time graph. (2)

2.4 Acceleration is change in velocity. (2)

2.5 When a moving object doubles its speed, its kinetic energy also doubles. (2)

Question 3: One-word answers

Provide one word or term for each of the following descriptions. Write only the word or term next to the question number.

3.1 A physical quantity that has magnitude but not direction. (1)

3.2 The rate of change of displacement. (1)

3.3 Velocity at a particular time. (1)

3.4 Area under a velocity–time graph. (1)

3.5 When an object falls in the absence of air resistance, mechanical energy is ... (1)

Question 4: Matching pairs

Choose an item from column B that matches the description in column A. Write only the letter of your choice (A–J) next to the question number.

Column A	Column B
4.1 force	A 90 km.h^{-1}
4.2 area under an acceleration–time graph	B kinetic energy (E_K)
4.3 mechanical energy (E_M)	C $\frac{m}{s}$
4.4 acceleration	D mass
4.5 25 m.s^{-1}	E change in velocity
4.6 energy of motion	F $\frac{m}{s^{-2}}$
4.7 area under a velocity–time graph	G potential energy (E_P)
4.8 energy of position	H $\frac{m}{s^{-2}}$
4.9 velocity	I E_K + E
4.10 kilogram	J weight
	K 72 km.h^{-1}
	L always conserved
	M change in position

[10]

Question 5: Long questions

Consider the physical quantities mass, weight, distance, displacement, speed, velocity, acceleration and energy.

5.1 Give the name and the abbreviation of the unit (or units) in which each is measured. (6)

5.2 List those that are vector quantities and those that are scalar quantities. (4)

5.3 Using a scale of 10 mm to represent 10 m, draw vectors to represent:

5.3.1 a displacement of 50 m north. (2)

5.3.2 a displacement of 80 m east. (2)

5.4 Find the resultant of the two displacements in question 5 3 graphically:

5.4.1 by the tail-to-head method. (4)

5.4.2 by the tail-to-tail method. (3)

5.5 Check your answers to question 5.4 by calculating the resultant. Supply a rough sketch that helps to explain your calculation. (9)

[30]

Question 6: Long questions

6.1 A golf ball falls vertically from the roof of a 12 m high building. It bounces upwards to a height of 9 m above the ground. Take the upward direction as the positive direction. What is the ball's displacement, (1) when it strikes the ground; (2i) at the highest point of the bounce:

6.1.1 relative to the ground. (2)

6.1.2 relative to the top of the building. (2)

6.2 A cyclist rides halfway around a circular track with a radius of 140 m. She starts facing north and rides clockwise around the track. What is:

6.2.1 the distance that she rides? (3)

6.2.2 her displacement? (2)

[9]

Question 7: Long questions

7.1 A 707 km road journey from Durban to Johannesburg took 7 hours. Calculate the average speed for the trip:

7.1.1 in $km.h^{-1}$. (4)

7.1.2 in $m.s^{-1}$. (3)

7.2 If the displacement from the starting point in Durban to the ending point in Johannesburg was 644 km, calculate the magnitude of the average velocity for the trip (in $km.h^{-1}$). (4)

7.3 A skier, first moving at 8 $m.s^{-1}$ in a straight line on level snow, accelerates down a slope. After 10 s on the slope, she reaches a velocity of 20 $m.s^{-1}$. Calculate her average acceleration. (6)

[17]

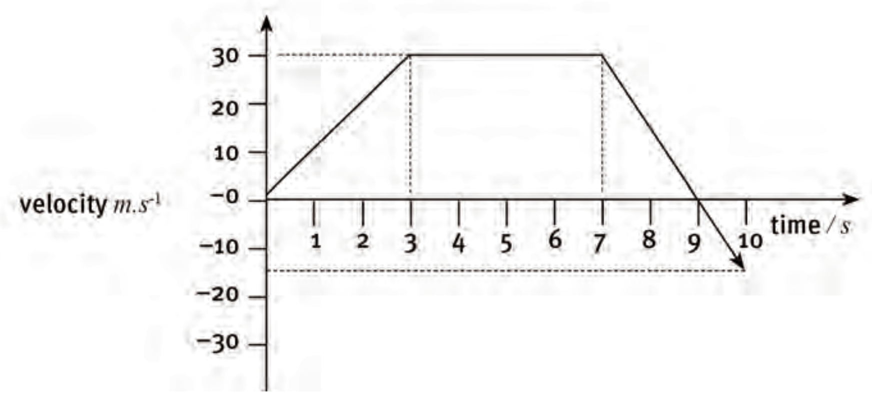
Question 8: Long questions

A train transporting iron-ore from Sishen to Saldahna Bay travels on a straight track at 40 km.h⁻¹ for 4 hours. For this part of the trip, plot:

8.1	a position–time graph.	(5)
8.2	a velocity–time graph.	(5)
8.3	A ski-jumper starts from rest and moves down the first part of a straight track with constant acceleration. Taking the direction of motion as the positive direction, show in sketch graphs:	
	8.3.1 the shape of the position–time graph.	(3)
	8.3.2 the shape of the velocity–time graph.	(3)
	8.3.3 the shape of the acceleration–time graph.	(3)
		[19]

Question 9: Long questions

The velocity–time graph of an object is shown below.



9.1	Describe the motion:	
	9.1.1 during the first 3 s.	(3)
	9.1.2 from t = 3 s until t = 7 s.	(2)
	9.1.3 from t = 7 s until t = 9 s.	(3)
	9.1.4 from t = 9 s until t = 10 s.	(2)
9.2	Use the graph to find:	
	9.2.1 the uniform acceleration during the first 3 s of the motion.	(5)
	9.2.2 the uniform acceleration during the last 3 s of the motion.	(4)
	9.2.3 the displacement during the first 3 s of the motion.	(5)
	9.2.4 the displacement of the body while it moved with constant velocity.	(3)
	9.2.5 the displacement during the last 3 s of the motion.	(5)
	9.2.6 the total displacement for the full trip.	(2)
	9.2.7 the average velocity for the full trip.	(5)
		[39]

Question 10: Long questions

The equations of uniform motion make use of the following symbols:

Δx, Δt, v_i, v_f and a.

10.1 What quantity does each symbol represent? (5)

10.2 Name the abbreviated SI unit(s) in which each quantity is measured. (4)

10.3 An object moves horizontally in a straight line from rest with a constant acceleration of 2 $m.s^{-2}$. Complete the table below by replacing the question numbers with the correct values. (Note: You should only find it necessary to calculate in one of the rows.)

After a time of exactly:	1 s	2 s	3 s	4 s
Velocity of object	10.3.1 (1)	10.3.2 (1)	10.3.3 (1)	10.3.4 (1)
Acceleration of object	10.3.5 (1)			
Displacement from starting position	10.3.6 (3)	10.3.7 (3)	10.3.8 (3)	10.3.9 (3)

[23]

Question 11: Long questions

11.1 A motor cyclist travels at 18 $m.s^{-1}$ along a straight road. He accelerates uniformly for 6 s to a velocity of 30 $m.s^{-1}$. Calculate:

11.1.1 the acceleration of the motor cycle. (6)

11.1.2 the displacement of the motor cycle while accelerating. (6)

11.2 A car moving at 12 $m.s^{-1}$ along a straight road accelerates at 2 $m.s^{-2}$ for 5 s. Calculate:

11.2.1 the car's displacement after 5 s. (6)

11.2.2 the car's velocity after 5 s. (6)

11.3 A car moving with a velocity of 15 $m.s^{-1}$ is brought to rest over a distance of 37,5 m when the brakes are applied. Calculate the magnitude of the acceleration. (6)

11.4 A bullet leaves the barrel of a rifle at 1000 $m.s^{-1}$. If the barrel is 1 m long, calculate the magnitude of the acceleration of the bullet. Assume that the acceleration of the bullet is constant. (5)

11.5 A car travelling at 20 $m.s^{-1}$ has its brakes applied and slows down at a constant rate of 10 $m.s^{-2}$. What is the stopping distance of the car? (5)

[40]

Question 12: Long questions

12.1 A man with a mass of 75 kg climbs a ladder to the flat roof of his house. If the vertical height of the roof is 3 m above the ground, how much gravitational potential energy has he gained? (5)

12.2 What is the gravitational potential energy of an object of mass 40 kg that is at a height of 30 m above the ground? (5)

12.3 Calculate the kinetic energy of a 72 kg parachutist, falling with a speed of 30 $m.s^{-1}$. (4)

12.4 An aircraft of mass 4000 kg flies with a speed of 150 $m.s^{-1}$ and maintains an altitude of 5000 m. Calculate its mechanical energy relative to the Earth's surface. (7)

12.5 An object of mass 500 kg is raised to a height of 40 m. If the object falls freely from this height, what will its velocity be just before it strikes the ground? (6)

[27]

Topic 5

Answers to questions

Answers

Question 1: Multiple choice

1.1 C ✓✓✓

1.2 A ✓✓✓

1.3 B ✓✓✓

1.4 A ✓✓✓

1.5 A ✓✓✓

1.6 C ✓✓✓

1.7 C ✓✓✓

1.8 C ✓✓✓

1.9 B ✓✓✓

1.10 D ✓✓✓

Question 2: True/false

2.1 Two force vectors, drawn to scale, are equal if they have the same length and direction. ✓✓

2.2 Displacement is change in position; it is a straight-line from the original position to the final position. ✓✓

2.3 Change in position is indicated by the area under a velocity–time graph. ✓✓

2.4 Acceleration is the rate of change in velocity. ✓✓

2.5 When a moving object doubles its speed, its kinetic energy becomes four times greater. ✓✓

Question 3: One-word answers

3.1 scalar ✓

3.2 velocity ✓

3.3 instantaneous velocity ✓

3.4 displacement ✓

3.5 conserved ✓

Question 4: Matching pairs

4.1 J ✓

4.2 E ✓

4.3 I ✓

4.4 H ✓

4.5 A ✓

Topic 5

Answers to questions

4.6 B ✓
4.7 M ✓
4.8 G ✓
4.9 C ✓
4.10 D ✓

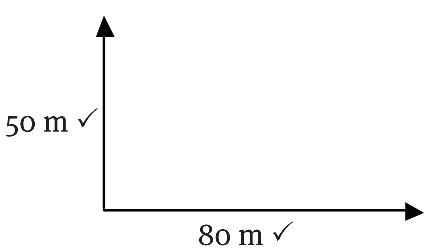
Question 5: Long questions

5.1 mass: kilogram (kg) ✓
weight: newton (N) ✓
distance and displacement: metre (m) ✓
speed and velocity: metre per second ($m.s^{-1}$) ✓
acceleration: metre per second squared ($m.s^{-2}$) ✓
energy: joule (J) ✓

5.2 vectors: weight, displacement, velocity, acceleration ✓✓
scalars: mass, distance, speed, energy ✓✓

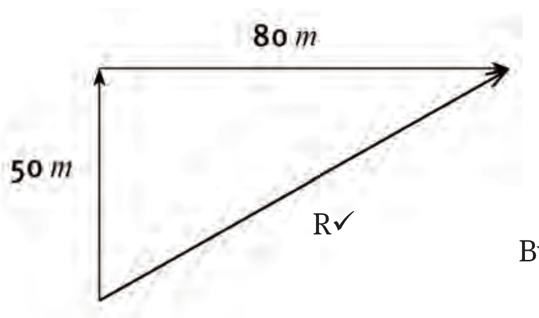
5.3.1 & 5.3.2

Scale: 10 mm represents 10 m
(Δx_N 50 mm long) ✓



(Δx_E 80 mm long) ✓

5.4.1



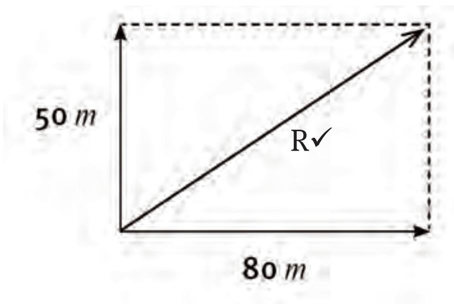
Correct triangle and arrowheads ✓

By measurement R = 94 m (± 2 m) ✓

In the direction 58° (± 1°) east of north ✓

Answers to questions

5.4.2



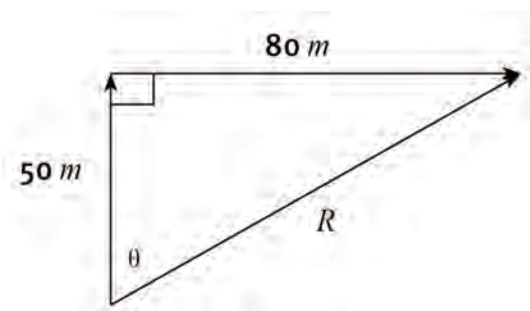
Correct rectangle and arrowheads ✓

By measurement R = 94 m (± 2 m)

In the direction 58° (± 1°) east of north ✓

5.5 By Pythagoras:

labelled sketch diagram ✓✓



$R^2 = 80^2 + 50^2$ ✓✓

$\therefore R = \sqrt{8900}$

$= 94{,}34$ m ✓

$\tan\theta = \dfrac{80}{50}$ ✓✓

$\therefore \theta = 58°$ ✓

By calculation, the resultant R = 94,34 m in the direction 58° east of north ✓

Question 6: Long questions

6.1.1 (1) 0 ✓

(2) +9 m ✓

6.1.2 (1) –12 m ✓

(2) –3 m ✓

6.2.1 Circumference of circle = 2∏r

Half circumference of circle = ∏r✓ $=2\Delta r\ \dfrac{22}{7} \times 140 = 440$m ✓

Distance = 440 m ✓

6.2.2 Displacement = 140 m ✓ east ✓

Topic 5

Answers to questions

Question 7: Long questions

7.1.1 average speed = $\frac{D}{\Delta t}$ ✓ = $\frac{707}{7}$ ✓✓ = 101 km.h^{-1} ✓

7.1.2 101 $\frac{km}{h}$ = $\frac{101000 \text{ m}}{3600 \text{ s}}$ ✓✓ = 28,06 m.s^{-1} ✓

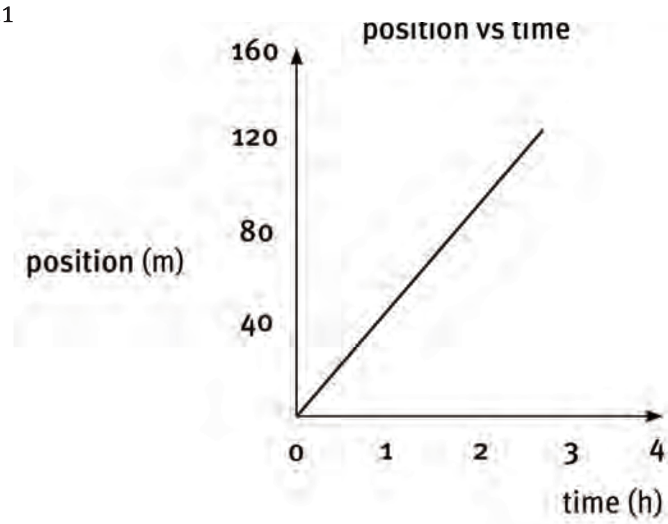
7.2 magnitude of average velocity = $\frac{\Delta x}{\Delta t}$ ✓ = $\frac{644}{7}$ ✓✓ = 92 km.h^{-1} ✓

7.3 Average acceleration = $\frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$ ✓ = $\frac{(20^{-8})}{10}$ ✓✓✓ = 1,2 m.s^{-2} ✓

The acceleration has a magnitude of 1,2 m.s^{-2} and is in the same direction as the skier's motion.✓

Question 8: Long questions

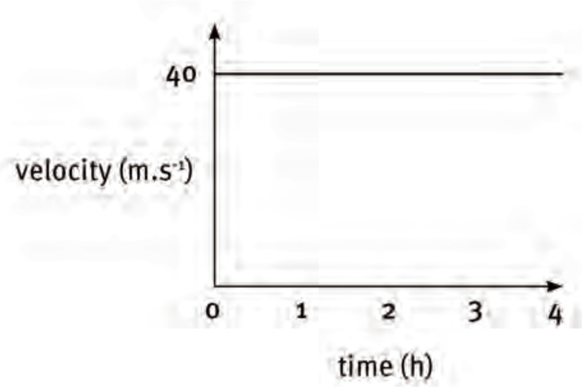
8.1



axes ✓ values on axes ✓✓

shape of graph ✓✓

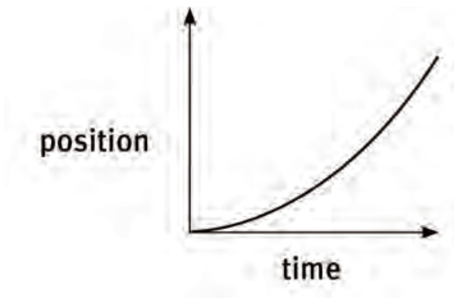
8.2



axes ✓ values on axes ✓✓

shape of graph ✓✓

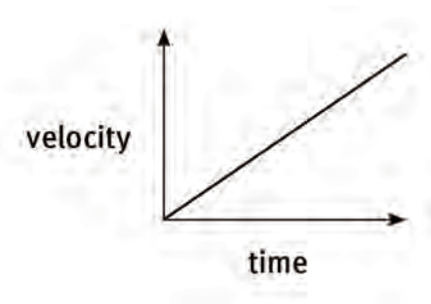
8.3.1



axes ✓

shape of graph ✓✓

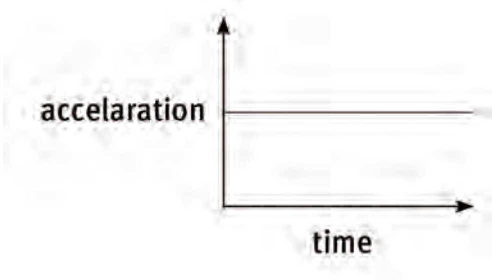
8.3.2



axes ✓

shape of graph ✓✓

8.3.3



axes ✓

shape of graph ✓✓

Question 9: Long questions

9.1.1 Uniform acceleration ✓ from rest to 30 $m.s^{-1}$ ✓ in the positive direction ✓

9.1.2 Constant velocity ✓ of 30 $m.s^{-1}$ in the positive direction ✓

9.1.3 Uniform negative acceleration ✓ from 30 $m.s^{-1}$ in the positive direction to rest ✓

9.1.4 Uniform negative acceleration ✓ from rest to 15 $m.s^{-1}$ ✓ in the negative direction ✓

9.2.1 acceleration = gradient $= \frac{(30 - 0)}{(3 - 0)}$ ✓✓ $= 10\ m.s^{-2}$ ✓

in the direction of motion ✓

9.2.2 acceleration = gradient ✓ $= \frac{\Delta x}{\Delta y}$

$= \frac{(-15 - 30)}{(10 - 7)}$ ✓✓ $= \frac{-45}{3} - 15\ m.s^{-2}$ ✓

Answers to questions

9.2.3 displacement = triangular area under graph = ½ bh ✓

= ½ × 3 ✓ × 30 ✓

= 45 m ✓ in the direction of motion ✓

9.2.4 displacement = rectangular area under graph = l × b

= 4 ✓ × 30 ✓

= 120 m ✓ in the direction of motion

9.2.5 displacement = sum of two triangular areas under graph (area = ½ bh)

= (½ × 2 ✓ × 30 ✓) + [½ × 1 ✓ × (−10) ✓]

= 30 − 5

= 25 m ✓ in the direction of motion

9.2.6 total displacement = total area under graph

= 45 + 120 + 25 ✓

= 190 m ✓ in the direction of motion

9.2.7 average velocity = $\frac{\Delta x}{\Delta y}$ ✓ = $\frac{190}{11}$ ✓✓ = 17,27 $m.s^{-2}$ ✓ in the direction of motion ✓

Question 10: Long questions

10.1 Δx displacement (change in position)✓

Δt change in time ✓

v_i initial velocity ✓

v_f final velocity ✓

a uniform acceleration ✓

10.2 Dx m ✓

Δt s ✓

v_i and v_f $m.s^{-1}$ ✓

a $m.s^{-2}$ ✓

10.3

After a time of exactly:	1 s	2 s	3 s	4 s
Velocity of object	2 $m.s^{-1}$ ✓	4 $m.s^{-1}$ ✓	6 $m.s^{-1}$ ✓	8 $m.s^{-1}$ ✓
Acceleration of object	all 2 $m.s^{-2}$ ✓			
Displacement from starting position	1 m ✓✓✓	4 m ✓✓	9 m ✓✓	16 m ✓✓

10.3.6 $v_i = 0$ $a = 2\ m.s^{-2}$ $\Delta t = 1\ s$

$$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2 \checkmark$$

$$= 0 + \left(\frac{1}{2} \times 2 \times (1)^2\right) \checkmark$$

$$= 1\ m \checkmark$$

10.3.7 $v_i = 0$ $a = 2\ m.s^{-2}$ $\Delta t = 2\ s$

$$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$= 0 + \left(\frac{1}{2} \times 2 \times (2)^2\right) \checkmark$$

$$= 4\ m \checkmark$$

10.3.8 $v_i = 0$ $a = 2\ m.s^{-2}$ $\Delta t = 3\ s$

$$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$0 + \left(\frac{1}{2} \times 2 \times (3)^2\right) \checkmark$$

$$= 9\ m \checkmark$$

6.2.9 $v_i = 0$ $a = 2\ m.s^{-2}$ $\Delta t = 4\ s$

$$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$0 + \left(\frac{1}{2} \times 2 \times (4)^2\right) \checkmark$$

$$= 16\ m$$

Question 11. Long questions

11.1.1 $v_i = 18\ m.s^{-1}$ $v_f = 30\ m.s^{-1}$ 00100 $\Delta t = 6\ s$

$$\text{Average acceleration} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} \checkmark = \frac{(30 - 18)}{6} \checkmark\checkmark\checkmark = 2\ m.s^{-2} \checkmark$$

in the direction of motion. ✓

11.1.2 $$\Delta x = \frac{(v_f + v_i)}{2}\Delta t \checkmark$$

Answers to questions

$$= \left(\frac{18✓ + 30✓}{2}\right) 6✓$$

$= 144$ m in the direction of motion✓

11.2.1 $v_i = 12 \text{ m.s}^{-1}$ $a = 2 \text{ m.s}^{-2}$ $\Delta t = 5 \text{ s}$

$$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2 ✓$$

$$= (12 \times 5)✓ + \left(\frac{1}{2} \times 2 \times (5)^2\right)✓✓$$

$= 85$ m   in the direction of motion✓

11.2.2 $v_f = v_1 + a\Delta t$ ✓

$= 12✓ + (2 \times 5)✓✓$

$= 22 \text{ m.s}^{-1}$ in the direction of motion✓

11.3 $v_i = 15 \text{ m.s}^{-1}$ $v_f = 0$ $\Delta x = 37{,}5 \text{ m}$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\therefore a = \frac{v_f^2 - v_i^2}{2\Delta x} ✓$$

$$= \frac{0 - 15^2}{2(37{,}5)} ✓✓✓$$

$\therefore a = -3 \text{ m.s}^{-2}$ ✓

The magnitude of the acceleration is 3 m.s⁻², ✓and the acceleration is negative.

11.4 $v_i = 0$ $v_f = 1000 \text{ m.s}^{-1}$ $\Delta x = 1 \text{ m}$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\therefore a = \frac{v_f^2 - v_i^2}{2\Delta x} ✓$$

$$= \frac{1000^2 - 0}{2(1)} ✓✓✓$$

$\therefore a = 5 \times 10^5 \text{ m.s}^{-2}$ ✓

Answers to questions

11.5 $v_i = 20\ \text{m.s}^{-1}$ $\quad v_f = 0$ $\quad a = 10\ \text{m.s}^{-2}$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\therefore \Delta x = \frac{v_f^2 - v_i^2}{2a} \checkmark$$

$$= \frac{0 - 20^2}{2(-10)} \checkmark\checkmark\checkmark$$

$$\therefore \Delta x = 20\ \text{m}$$

Question 12: Long questions

12.1 $m = 75\ \text{kg}$ $\quad g = 9{,}8\ \text{m.s}^{-2}$ $\quad h = 3\ \text{m}$

$$E_P = mgh \checkmark = 75 \checkmark \times 9{,}8 \checkmark \times 3 \checkmark = 2205\ \text{J} \checkmark$$

12.2 $m = 40\ \text{kg}$ $\quad g = 9{,}8\ \text{m.s}^{-2}$ $\quad h = 30\ \text{m}$

$$E_P = mgh \checkmark = 40 \checkmark \times 9{,}8 \checkmark \times 30 \checkmark = 11\,760\ \text{J} \checkmark$$

12.3 $m = 72\ \text{kg}$ $\quad v = 30\ \text{m.s}^{-1}$

$$E_K = \tfrac{1}{2} mv^2 \checkmark = 0{,}5 \times 72 \checkmark \times (30)^2 \checkmark = 32\,400\ \text{J} \checkmark$$

12.4 $m = 4000\ \text{kg}$ $\quad v = 150\ \text{m.s}^{-1}$ $\quad g = 9{,}8\ \text{m.s}^{-2}$ $\quad h = 5000\ \text{m}$

$$E_M = E_K + E_P \checkmark$$

$$= \tfrac{1}{2} mv^2 + mgh \checkmark$$

$$= [0{,}5 \times 4000 \checkmark \times (150)^2 \checkmark] + (4000 \text{ x } 9{,}8 \checkmark \times 5000 \checkmark)$$

$$= (4{,}5 \times 10^7) + (1{,}96 \times 10^7)$$

$$= 6{,}46 \times 10^7\ \text{J} \checkmark$$

12.5 $m = 500\ \text{kg}$ $\quad g = 9{,}8\ \text{m.s}^{-2}$ $\quad h = 40\ \text{m}$

Because mechanical energy is conserved:

$E_k + E_{p1}$ (just above ground level) + $E_{k2} + E_{p2}$ (at highest point)

$\frac{1}{2} mv^2 + mgh$ (just above ground level) $= \frac{1}{2} mv^2 + mgh$ (at highest point)

$\frac{1}{2} mv^2 + 0$ (just above ground level) $= 0 + mgh$ (at highest point)

Answers to questions

$$\frac{1}{2} mv^2 = mgh \checkmark$$

$$v2 = 2\,gh$$

$$\therefore v = \sqrt{2\,gh} \checkmark \checkmark$$

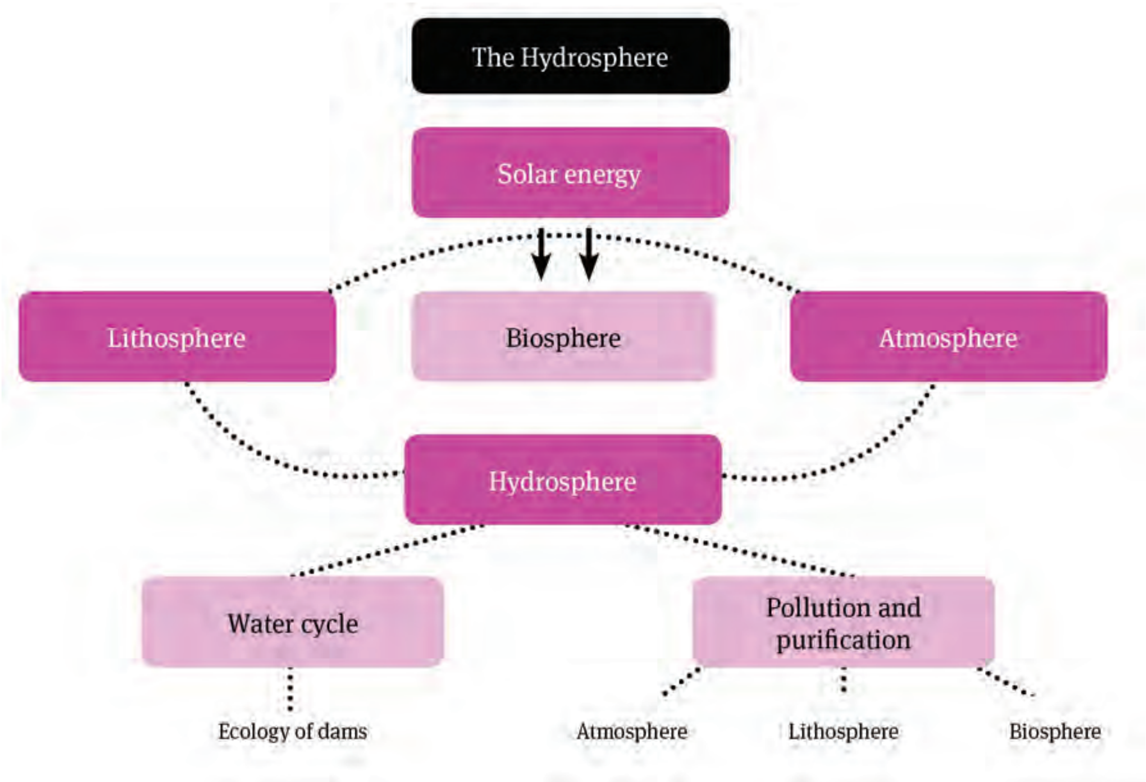
$$= \sqrt{(2 \times 9{,}8 \times 40)} \checkmark \checkmark$$

$$= 28 \text{ m.s}^{-1} \checkmark$$

Topic 6

Chemical systems

Overview



Summary

1 Interconnected systems

1.1 Interconnected systems and the water cycle

- There are four interconnected systems that make life on Earth possible. These are:
  - atmosphere – the layer of gas surrounding the Earth, mostly nitrogen, oxygen and carbon dioxide
  - lithosphere – the solid, outermost part of the Earth's crust
  - hydrosphere – all the Earth's water
  - biosphere – all living things (plants and animals) on Earth.
- Water moves through these spheres, dissolving chemicals and promoting growth of plants and animals. It also has the effect of moderating the temperature of the Earth – not allowing it to get too hot during the day or too cold during the night.
- The water cycle describes the changes water undergoes as it circulates through the different spheres. Important processes in the cycle are:
  - evaporation – liquid water turns to water vapour
  - precipitation – the condensation of water vapour to form liquid water (rain, dew)

- interception – the taking up of water by plants and animals
- transpiration – the giving off of water through the leaves of plants
- infiltration – the trickle down of water into the lithosphere to form ground water.

1.2 Pollution and purification

While water dissolves beneficial nutrients that are taken up by plants and animals, it also dissolves chemicals that are harmful.

- In the atmosphere, carbon dioxide and the oxides of sulphur and nitrogen are gases emitted by the burning of fossil fuels that pollute the atmosphere. They dissolve in the water vapour, resulting in acid rain.
- In the lithosphere, water dissolves fertilisers and pesticides, which pollute rivers and ground water. These can promote abnormal plant growth in rivers and dams, causing the depletion of oxygen. This can cause aquatic animals and organisms to die.
- In the biosphere, water can carry harmful bacteria from decaying and infected plants and animals into ground water. This can cause sickness in animals and humans.

Water can be purified by physical means (filtration), biological means (bacteria that remove waste products) and chemical means (mainly chlorination).

1.3 The ecology of dams

Dams are constructions that limit the flow of water in a river or stream. They are beneficial in providing water during drought and limiting flooding during heavy rain. They can provide hydro-electricity and boating and other leisure activities.

However, they also have an adverse effect on the ecology of the surrounding areas. Large areas are flooded, humans and animals are displaced and there is less provision of water downstream of the dam. Engineers have to strike a balance between environmental concerns, sustainability and economic and agricultural needs.

Questions

Question 1: Multiple choice

Choose the correct answer. Only write the letter of the answer you select.

1.1 The interchange of water between Earth's surface and the atmosphere is called:

A transpiration.
B precipitation.
C the water cycle.
D evaporation. (3)

1.2 The system consisting of all living things is the:
- A hydrosphere.
- B biosphere.
- C atmosphere.
- D lithosphere. (3)

1.3 What provides the energy to allow for a continuous water cycle?
- A the Sun
- B the Earth
- C wind
- D the hydrosphere (3)

1.4 The term 'hydrosphere' describes one of the Earth's spheres and it includes all:
- A of the water above and below the continents only.
- B of the water on the planet.
- C the fresh water on the planet only.
- D of the liquid water on the Earth, minus ice. (3)

1.5 Which process does not produce carbon dioxide?
- A burning of coal
- B respiration (breathing)
- C running of motor car engines
- D transpiration (3)

[15]

Question 2: One-word answers

Name the four interconnected systems that make life on Earth possible. (4)

[4]

Question 3: Long question

Describe one useful way and one harmful way in which the hydrosphere interacts with:

3.1 the lithosphere. (4)

3.2 the biosphere. (4)

3.3 the atmosphere. (4)

[12]

Question 4: Long question

Describe the ways in which water escapes from the ocean and is eventually returned to the ocean. (6)

[6]

Question 5: Long question

Describe possible causes of pollution in rivers and dams. (6)

[6]

Question 6: Long question

Describe two advantages and two disadvantages of building large dams. (8)

[8]

Topic 6

Answers to questions

Answers

Question 1: Multiple choice

1.1 C ✓✓✓

1.2 B ✓✓✓

1.3 A ✓✓✓

1.4 B ✓✓✓

1.5 D ✓✓✓

Question 2: One-word answers

hydrosphere ✓ atmosphere ✓ lithosphere ✓ biosphere ✓

Question 3: Long question

3.1 Water enters the lithosphere through rain, providing an underground water supply (aquifers). Water dissolves nutrients in the soil that enable plants to grow, in turn providing food for animals. Water runs off the land into rivers and dams. ✓✓ Water also dissolves harmful chemicals that can pollute rivers and dams. Heavy rain can cause soil erosion.✓✓

3.2 Plants and animals cannot survive without water, as it is the solvent in which all the chemical reactions of living processes take place. Water dissolves nutrients in the soil that enable plants and in turn animals to grow. ✓✓ Heavy rain can cause flooding, destroying crops and causing the death of animals and humans. Soil erosion, caused by heavy rain, can make soil less fertile. ✓✓

3.3 Water on Earth evaporates, providing water vapour in the atmosphere that can precipitate, providing water for the biosphere. ✓✓ The oxides of carbon, sulphur and nitrogen are gases given off during the burning of fossil fuels. They dissolve in the water vapour in the atmosphere, causing acid rain. ✓✓

Question 4: Long question

Ocean water evaporates forming water vapour in the atmosphere. Drops of water collect and can precipitate directly back into the ocean. ✓✓ Precipitation on land can run off to form rivers that flow back into the ocean. ✓✓ Water that collects underground can flow underground into the ocean. ✓✓

Question 5: Long question

Acid rain caused by gases such as CO_2, SO_2, N_2O and NO_2 dissolving in water vapour in the air. ✓✓ Fertilisers and other chemicals dissolving in rain water and running into rivers and dams. ✓✓ Chemicals from industry being discharged straight into rivers and dams. ✓✓

Topic 6

Answers to questions

Question 6: Long question

- Advantages of large dams: A large amount of water can be retained for irrigation and can be provided for use by people and animals in times of drought. ✓✓ The water could be used in hydro-electric schemes (to generate electricity). ✓✓
- Disadvantages: Areas below the dam may experience drought, flooding may occur when floodgates/sluices are opened ✓✓ The environment is altered and people and animals may be displaced. ✓✓

Paper 1

Exam Papers

Physics Examination (Paper 1)

Data for Physical Sciences Grade 10 Physics (Paper 1)

Physical constants

Name	Symbol	Value
Acceleration due to gravity	g	$9{,}8\ m.s^{-2}$
Speed of light in a vacuum	c	$3{,}0 \times 10^{8}\ m.s^{-1}$
Charge on electron	e^{-}	$-1{,}6 \times 10^{-19}$ C
Planck's constant	h	$6{,}63 \times 10^{-34}$ J.s

Formulae

Motion

$v_f = v_i + a\Delta t$

$\Delta x = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$

$v_f^2 = v_i^2 + 2a\Delta x$

$\Delta x = \left(\frac{v_i + v_f}{2}\right) \Delta t$

Energy

$E_p = mgh$

$E_k = \frac{1}{2} mv^2$

$E_m = E_k + E_p$

Waves, sound and light

$f = \frac{1}{T}$

$v = f\lambda$

$c = f\lambda$

$E = h\lambda$

$E = \frac{hc}{\lambda}$

Electric circuits

$$I = \frac{Q}{\Delta t}$$

$$R_s = R_1 + R_2 + \ldots\ldots\ldots$$

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

Paper 1

Exam Papers

SECTION A

QUESTION 1: ONE-WORD ANSWERS

Provide one word or term for each of the following descriptions. Write only the word or term next to the question number.

1.1 The rate of change of position.
1.2 The quantity represented by the area under a velocity vs. time graph.
1.3 The type of wave in which the vibrations of the particles is at right angles to the direction in which the wave is travelling.
1.4 The way in which a voltmeter is connected in a circuit.
1.5 A quantum of visible light.

[5]

QUESTION 2: MATCHING PAIRS

Choose an item from column B that matches the description in column A. Write only the letter of your choice (A–J) next to the question number.

Column A	Column B
2.1 the principle of adding together the amplitudes of waves that meet, so as to find the resultant amplitude	A displacement
	B superposition
	C direction from north to south
2.2 the highest frequency of electromagnetic radiation	D gamma rays
	E mechanical energy – potential energy
2.3 magnetic field lines	F direction from positive to negative
2.4 gradient of a velocity vs. time graph	G acceleration
2.5 kinetic energy of an object falling in the absence of air friction	H VHF television
	I mechanical energy + potential energy
	J interference

[5]

QUESTION 3: TRUE/FALSE

3.1 The electrical resistance of a conductor depends only on the length and the thickness of the conductor.
3.2 For a car travelling from rest and at constant acceleration, its displacement is directly proportional to its time of travel.
3.3 When resistors are connected in series they act as dividers of potential difference.
3.4 The area under a velocity vs. time graph represents the acceleration of the object.
3.5 When an object falls vertically in the absence of air friction, its mechanical energy remains constant.

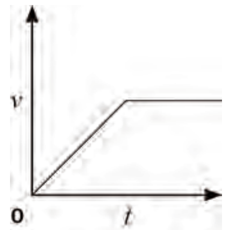
$5 \times 2 =$ [10]

QUESTION 4: MULTIPLE CHOICE

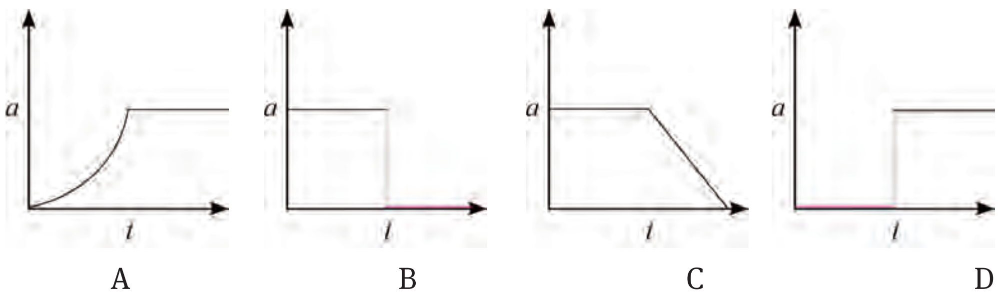
4.1 In which of the following situations will the distance covered and the magnitude of the displacement of a car be the same?

A A girl runs in a straight line across a level field.
B A car travels half the circumference of a circular race track.
C A car travels from Cape Town to Johannesburg.
D A car travels the full circumference of a circular race track. (3)

4.2 Consider the accompanying velocity–time graph of a child riding her bicycle.



The corresponding graph, representing the acceleration of the bicycle vs. the time is:



(3)

4.3 A bungi jumper of mass m falls freely from a bridge of height h. He reaches a velocity v after falling a distance x. If air resistance is negligible, his total mechanical energy at this point is:

A. $mg(h-x)$.
B $\frac{1}{2}mv^2$.
C $mgh + \frac{1}{2}mv^2$.
D mgh. (3)

4.4 When resistor R_1 and R_2 are connected in parallel, the total resistance of the combination is always:

A very much larger than either R_1 or R_2.
B equal to $R_1 + R_2$.
C equal to $R_1 \times R_2$.
D smaller than the smaller of R_1 and R_2. (3)

4.5 A source of frequency 500 Hz emits waves of wavelength 0,2 m. How long does it take the waves to travel 300 m?

A 3 s
B 12 s
C 60 s
D 100 s (3)

[15]

SECTION B

QUESTION 1

1.1 Distinguish between a vector quantity and a scalar quantity. (2)

1.2 What is meant by the 'resultant' of two forces? (2)

1.3 A box, on the floor, is being pulled by two boys by means of ropes tied to the box. The forces that they apply are 70 N and 50 N. What is the minimum resultant force that the ropes can exert on the box, and what must be the angle between the ropes in order for them to exert this minimum force? (2)

[6]

QUESTION 2

The two boys apply the same forces as in question 1 on the box by means of ropes. The 70 N force is exerted in a direction 90°, while the 50 N force is exerted in a direction 180°.

2.1 By means of an accurate scale drawing, using the tail-to-tail method, determine the magnitude and direction of the resultant force being exerted on the box. (Use a scale of 10 mm = 10 N.) (7)

2.2 Verify your answer by using mathematical and trigonometrical calculations to determine the resultant force. (6)

[13]

QUESTION 3

The brakes of a car are being tested on a straight, level tarred road. At the far end of the road is a stretch of soft sand to stop the car, should it not stop in time. The length of the road up to the sand is 192 m. The car accelerates uniformly at 9,8 $m.s^{-2}$ from rest at the start of the road. After travelling 122,5 m, the brakes are applied and the car slows down uniformly, coming to rest 10 m from the sand.

3.1 Define acceleration. (2)

3.2 Calculate the time taken for the car to travel the first 122,5 m. (4)

3.3 What is the velocity of the car at the 122,5 mark? (4)

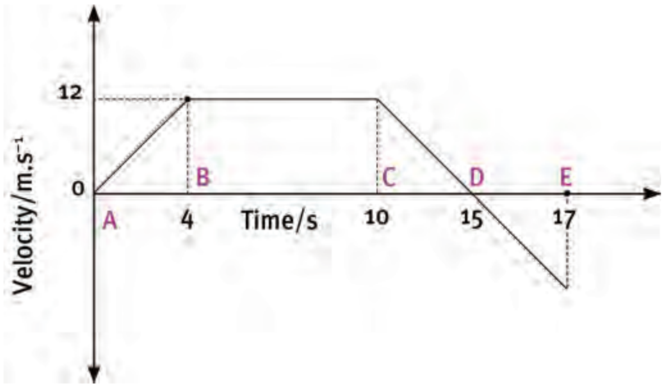
3.4 Calculate the acceleration of the car during the time that the brakes are applied. (5)

3.5 The speedometer of a car registers 'instantaneous speed'. How is instantaneous speed measured? (3)

[18]

QUESTION 4

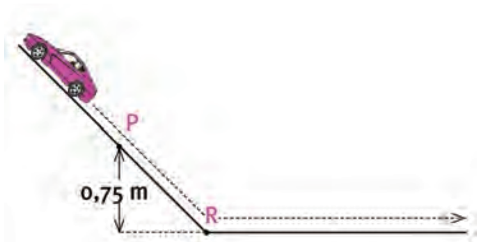
The following velocity–time graph represents the motion of a trolley on a track. In carrying out the required calculations do not use equations of motion.



4.1	Calculate from the graph the acceleration of the trolley for the time interval CD.	(4)
4.2	Describe (in words) the motion of the trolley for the interval ABC.	(3)
4.3	What happened to the trolley during time interval DE?	(3)
4.4	Calculate the displacement of the trolley during the interval ABC.	(5)
4.5	Draw a sketch of the corresponding acceleration–time graph. Show the time values (0 s to 17 s) on the time axis, but do not show any acceleration values on the Y-axis.	(6)
		[21]

QUESTION 5

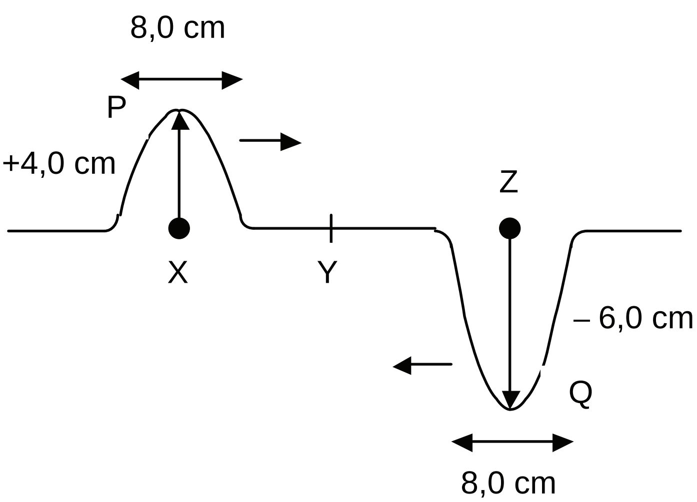
Moneeb and his little sister Moneeba are playing with a toy car of mass 3 kg on the slide in the school playground. The toy car is moving at a speed of 2,63 $m.s^{-1}$ when it passes point P. Point P is 0,75 m above point R, the lowest position of the slide. Ignore all types of friction. Express answers correct to two decimal places.



5.1	State what is meant by the 'mechanical energy' of an object.	(2)
5.2	Under what condition is the mechanical energy of a falling object conserved?	(1)
5.3	Calculate the total mechanical energy of the car at point P.	(6)
5.4	What is the kinetic energy of the car at point R?	(2)
5.5	Calculate the velocity of the car at point R.	(4)
		[15]

QUESTION 6

Two pulses, P and Q in a string, approach each other at the same speed. Pulse P has an amplitude of +4,0 cm when it is at position X. Pulse Q has an amplitude of –6,0 cm when it is at position Z. Points X and Z are the same distance from point Y. The pulses both have a length of 8,0 cm. Pulses P and Q meet at position Y. Assume that no energy is lost.



6.1 Write down the definition of a pulse. (2)

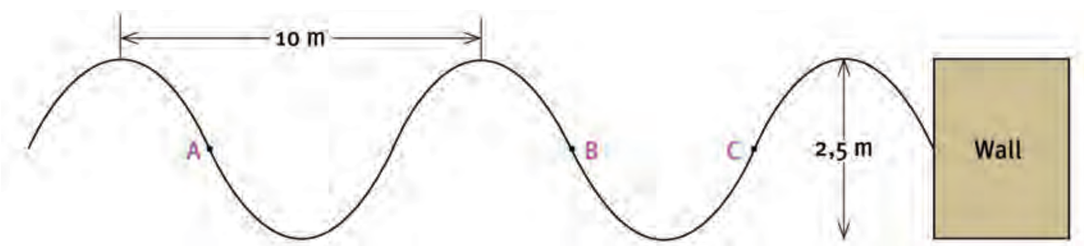
6.2 Make a labelled sketch to show what happens when the pulses P and Q meet at position Y. Also indicate the pulse length. (4)

6.3 A transverse wave is formed by a succession of pulses each with amplitude 4 cm and pulse length 8 cm (similar to P above). If the period of this transverse wave is 0,4 s, calculate the velocity of the wave in $m.s^{-1}$. (6)

[12]

QUESTION 7

Water waves are travelling towards the concrete wall of a harbour, as shown in the sketch below. Six wavelengths strike the wall in 24 seconds. The distance between successive crests is 10 m. The height of the waves from trough to crest is 2,5 m.



7.1 Are points A and C 'in phase'? Explain your answer. (3)

7.2 The waves are moving towards the wall, from left to right. In what direction is point B on the wave moving? (2)

7.3 What is the amplitude of the wave? (2)

7.4 Calculate the period of the wave. (3)

7.5 Calculate the frequency of the wave. (3)

[13]

QUESTION 8

Pianos, guitars and other stringed musical instruments have to be 'tuned'. This means that the tension in the strings must be adjusted so that they produce the correct note when struck or plucked. This is done by matching the sound produced by the instrument to that produced by a 'tuning fork'. A particular tuning fork is marked 440 Hz.

8.1 What is meant by the marking 440 Hz? (2)

8.2 What type of wave is a sound wave? (2)

8.3 The speed of sound at sunrise at a particular place is 330 $m.s^{-1}$. Would you expect the speed to be faster or slower at midday when it is much hotter? (2)

8.4 When sound travels from air into water, what happens to the speed of the sound? Give a reason for you answer. (4)

[10]

QUESTION 9

When we see a rainbow, we are seeing a small part of a very wide range of wavelengths called an 'electromagnetic spectrum'.

9.1 What are the names of the portions of the electromagnetic spectrum on either side of the visible spectrum? (2)

9.2 Explain what contribution Max Planck made to our understanding of electromagnetic waves? (4)

9.3 Explain why visible light is considered to have a 'dual nature'. (6)

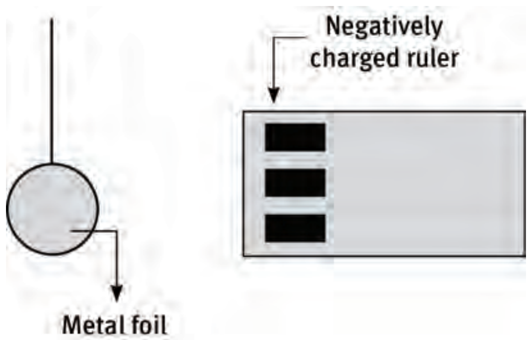
9.4 The energy of a quantum of electromagnetic radiation is $3{,}55 \times 10^{-19}$ J. Calculate the wavelength of the wave. (5)

9.5 Express the answer to 9.4 in nanometres. (2)

[19]

QUESTION 10

A plastic ruler is rubbed vigorously with a cloth. As a result, the ruler has become negatively charged. The ruler is then held close to a small bead covered with thin metal foil, as shown in the sketch.



10.1 Why has the ruler become negatively charged? (2)

10.2 The charge on the ruler is $-1{,}36 \times 10^{-12}$ C. Calculate the number of excess electrons on the ruler. (4)

10.3 The bead is attracted by the ruler. Explain why it is attracted. (4)

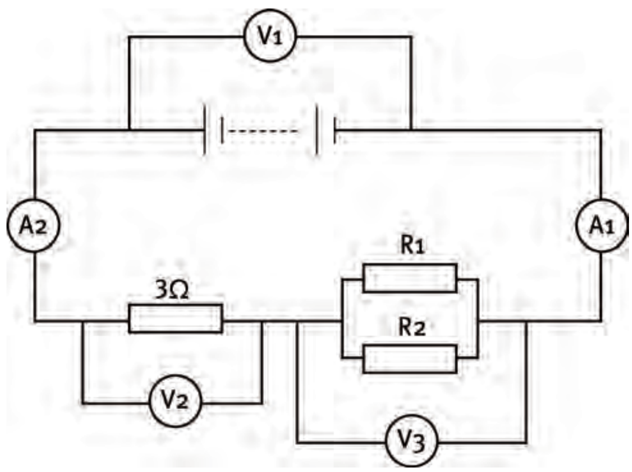
10.4 What would you expect to see after the bead has touched the ruler? (2)

10.5 Explain why this should occur. (3)

[15]

QUESTION 11

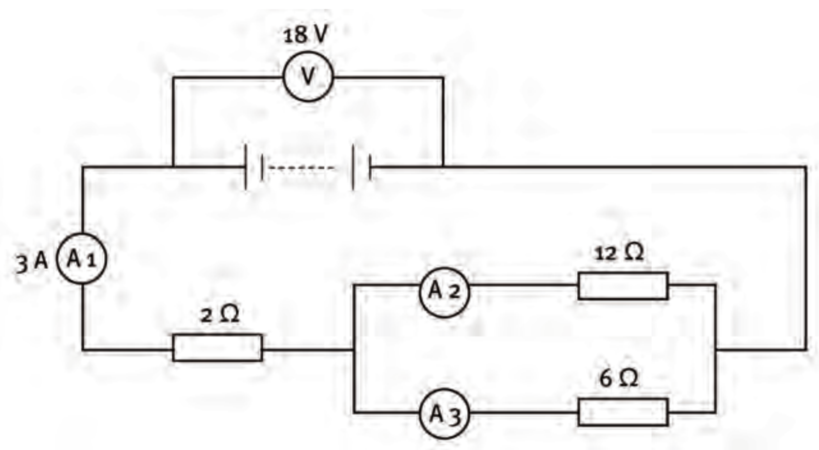
Consider the circuit diagram given below. You are given that V_1 reads 12 V, A_1 reads 3 A and V_2 reads 9 V. Resistors R_1 and R_2 are identical.



11.1 Define potential difference. (2)
11.2 What is the reading on V_2? (2)
11.3 What is the reading on A_2? (2)
11.4 You are given that the single-series resistor has a resistance of 3 Ω. Explain why the effective resistance of the parallel pair of resistors is 1 Ω. (4)
11.5 What is the resistance of R_1? (2)
11.6 Calculate the charge that passes through the 3 Ω resistor in 2 minutes. (4)
[16]

QUESTION 12

You are given this labelled circuit diagram.



12.1 Calculate the equivalent resistance of the whole circuit. (5)
12.2 If the reading on A_3 is 2 A, what is the reading on A_2? (2)
[7]

Paper 1

Answers to exam papers

Answers and mark allocation

SECTION A

QUESTION 1: ONE-WORD ANSWERS

1.1 velocity ✓
1.2 displacement ✓
1.3 transverse ✓
1.4 series ✓
1.5 photon ✓

QUESTION 2: MATCHING PAIRS

2.1 B ✓
2.2 D ✓
2.3 C ✓
2.4 G ✓
2.5 E ✓

QUESTION 3: TRUE/FALSE

3.1 False.✓ Electrical resistance depends on the type of material, length, thickness and temperature. ✓
3.2 False.✓ For a car travelling from rest and at constant acceleration, its displacement is directly proportional to the square of its time of travel. ✓
3.3 True. ✓✓
3.4 False.✓ The area under a velocity vs. time graph represents the displacement of the object. ✓
3.5 True. ✓✓

QUESTION 4: MULTIPLE CHOICE

4.1 A ✓✓✓
4.2 B ✓✓✓
4.3 D ✓✓✓
4.4 D ✓✓✓
4.5 A ✓✓✓

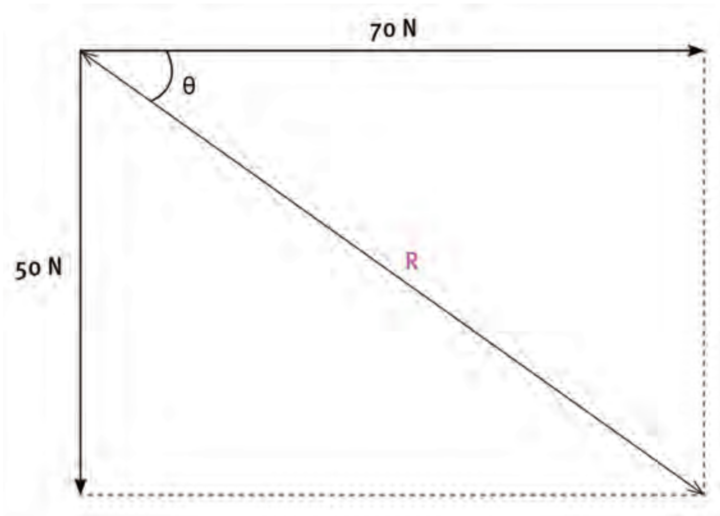
SECTION B

QUESTION 1

1.1 A vector quantity has both magnitude and direction, ✓ while a scalar quantity has magnitude only. ✓
1.2 The resultant of a number of vectors is the single vector that has the same effect as all the vectors acting together. ✓✓
1.3 20 N ✓180° ✓

QUESTION 2

2.1 Scale: 10 mm = 10 N ✓
(Correct length of 70 N) ✓
(Correct length of 50 N) ✓
Resultant force = 86 N (+ –2 N) ✓✓



$\theta = 36° (+ -2°)$ ✓✓

2.2 Using Pythagoras: $R^2 = 80^2 + 60^2$ ✓

$R = 86{,}0$ N ✓

$\sin\theta = \frac{\text{opp}}{\text{hyp}}$ ✓ $= \frac{50}{86}$ ✓

$\theta = 35{,}6°$ ✓

Direction $= 125{,}6°$ ✓

QUESTION 3

3.1 The rate of change of velocity. ✓✓

3.2 $\Delta x = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$ ✓

$122{,}5$ ✓ $= 0 + \frac{1}{2}(9{,}8)$ ✓ $(\Delta t)^2$

$(\Delta t)^2 = \frac{122{,}5}{4{,}9} = 25$

$\Delta t = 5$ s ✓

3.3 $v_f = v_i + a\Delta t$ ✓

$= 0 + (9{,}8)$ ✓ (5) ✓

$= 49$ m.s^{-1} ✓

OR

$v_f^2 = v_i^2 + 2a\Delta x$ ✓

$= 0 + 2(9{,}8)$ ✓ $(122{,}5)$ ✓

$= 2401$

$v_f = 49$ m.s^{-1} ✓

3.4 Distance travelled while brakes are applied = $192 - 122{,}5 - 10 = 59{,}5$ m ✓

$v_f^2 = v_i^2 + 2a\Delta x$ ✓

$0 = 49^2$ ✓ $+ 2(a)(59{,}5)$ ✓

$$a = \frac{-(49^2)}{119}$$

$$a = -20{,}2\ \text{m.s}^{-2}\ ✓$$

3.5 By measuring the distance travelled during a very short time interval ✓✓ and applying the formula $v = D/\Delta t$ ✓

QUESTION 4

4.1 Acceleration = gradient $= \frac{\Delta y}{\Delta x}$ ✓ $= \frac{12 ✓}{5 ✓}$

$= -2{,}4\ \text{m.s}^{-2}$✓

4.2 Accelerated uniformly ✓from rest for 4 seconds ✓ then continued at constant velocity of 12 m.s^{-1} for a further 6 s.✓

4.3 Trolley reversed ✓ from rest ✓ with a uniform acceleration ✓ for 2 seconds.

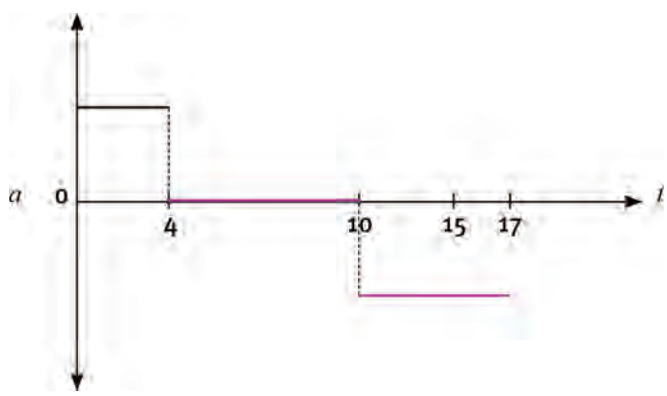
4.4 Displacement = area under graph ✓

= ½ bh + lb ✓

= ½ (4) (12)✓ + (6) (12) ✓

= 96 m ✓

4.5



Graph 0 s – 4 s correct ✓✓
Graph 4 s – 10 s correct ✓✓
Graph 10 s – 17 s correct ✓✓

QUESTION 5

5.1 The sum of the kinetic energy and potential energy. ✓✓

5.2 zero friction ✓

5.3 Mechanical energy = $E_p + E_k$

$= mgh + \frac{1}{2} mv^2$ ✓

$= 3\,(9{,}8)$ ✓ $(0{,}75)$ ✓ $+ \frac{1}{2}\,(3)$ ✓ $(2{,}63)^2$ ✓

$= 32{,}43$ J ✓

5.4 At R the $E_p = 0$. So E_k = EM = 32,43 J ✓✓

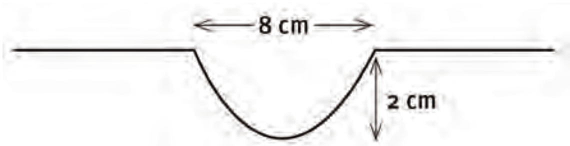
5.5 $E_k = \frac{1}{2}mv^2$ ✓

$$v^2 = \frac{2E_k}{m} = \frac{2(32{,}43)\ ✓}{3\ ✓} = 21{,}62$$

$v = 4{,}65\ m.s^{-1}$ ✓

QUESTION 6

6.1 A single disturbance in a medium ✓✓



Pulse drawn correctly ✓
Correct amplitude ✓✓
Correct pulse length ✓

6.3 $f = \frac{1}{T}$ ✓ $= \frac{1}{0{,}4} = 2{,}5$ Hz ✓

Pulse length = 8 cm. Wavelength = 16 cm = 0,16 m

$v = f\lambda$ ✓ $= (2{,}5)$ ✓ $(0{,}16)$ ✓

$= 0{,}4\ m.s^{-1}$ ✓

QUESTION 7

7.1 No ✓ They are not 'in step'. When A is moving up, C is moving down. ✓
7.2 Vertically upwards ✓✓
7.3 1,25 m ✓✓
7.4 If 6 wavelengths strike the wall in 24 s, one wavelength will strike every 4 s. ✓✓✓

7.5 $f = \frac{1}{T}$ ✓ $= \frac{1}{4}$ ✓

$= 0{,}25$ Hz ✓

QUESTION 8

8.1 440 vibrations per second ✓✓
8.2 longitudinal waves ✓✓
8.3 faster ✓✓
8.4 speed increases ✓✓ Water molecules are much closer together than air molecules, so the energy is transferred more quickly from molecule to molecule. ✓✓

QUESTION 9

9.1 infrared ✓ ultraviolet ✓
9.2 Energy is not radiated continuously but in packages named 'quanta'. ✓✓
The energy content of a quantum is directly proportional to the frequency of the wave. ✓✓

9.2 A quantum of energy is similar to a particle, but within the quantum there is an electromagnetic wave. ✓ At the radio wave end of the spectrum, the wavelength is so long that the waves are almost continuous – the 'wave nature'. ✓✓ At the gamma ray end the wavelength is so short that the wave nature is not noticeable – the quantum behaves as a particle. ✓✓ Visible light is in the middle of the whole spectrum, so both wave nature and particle nature are evident. ✓

9.4 $E = \frac{hc}{\lambda}$ ✓ $\lambda = \frac{hc}{\lambda} = \frac{(6{,}63 \times 10^{-34}) ✓ (3 \times 10^{8}) ✓}{3{,}55 \times 10^{-19} ✓}$

$= 5{,}6 \times 10^{-7}$ m ✓

9.5 560 nm ✓✓

QUESTION 10

10.1 Electrons have been rubbed off the cloth, onto the ruler. ✓✓

10.2 $Q = nqe$ ✓ $n = \frac{Q}{qe} = \frac{1{,}36 \times 10 - 12 ✓}{1{,}6 \times 10 - 19 ✓}$

$= 8{,}5 \times 10^{6}$ ✓electrons

10.3 Loosely bound electrons in the metal foil ✓ are repelled to the far side of the bead, making that side negatively charged, ✓ and leaving the side closest to the ruler positively charged ✓(that is, the bead is polarised). The force of attraction between the negative ruler and the positive side of the bead is stronger than the repulsion between the ruler and the negative side because the positive side is closer. So the bead is attracted. ✓

10.4 The bead is repelled. ✓✓

10.5 Some electrons are transferred from the ruler ✓ onto the bead, making the whole bead negatively charged. ✓ The ruler is still charged negatively. The two negatively charged objects repel. ✓

QUESTION 11

11.1 energy transferred per coulomb of charge ✓✓

11.2 3 V ✓✓

11.3 3 A ✓✓

11.4 Resistors in series divide the voltage of the battery in proportion to their resistances. ✓✓ The voltage across the parallel combination is one-third of the voltage across the 3 Ω resistor. ✓ Therefore, its resistance must also be one-third. Therefore 1 Ω. ✓

11.5 2 Ω ✓✓

11.6 $Q = I\Delta t$ ✓

$= (3)$ ✓ (120) ✓

$= 360$ C ✓

QUESTION 12

12.1 $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $= \frac{1}{12} + \frac{1}{6}$ ✓

$= \frac{1 + 2}{12}$ ✓

$R_p = 4\ \Omega$ ✓

$R_{total} = (4 + 2) = 6\ \Omega$ ✓

12.2 1 A ✓✓

Chemistry Examination (Paper 2)

Data for Physical Sciences Grade 10 Chemistry (Paper 2)

Physical constants

Name	Symbol	Value
Avogadro's number	N_A	$6,02 \times 10^{23}$
Molar gas volume		$22,4\ dm^3.mol^{-1}$
Standard temperature		273 K (0 °C)
Standard pressure		101,3 kPa

Formulae

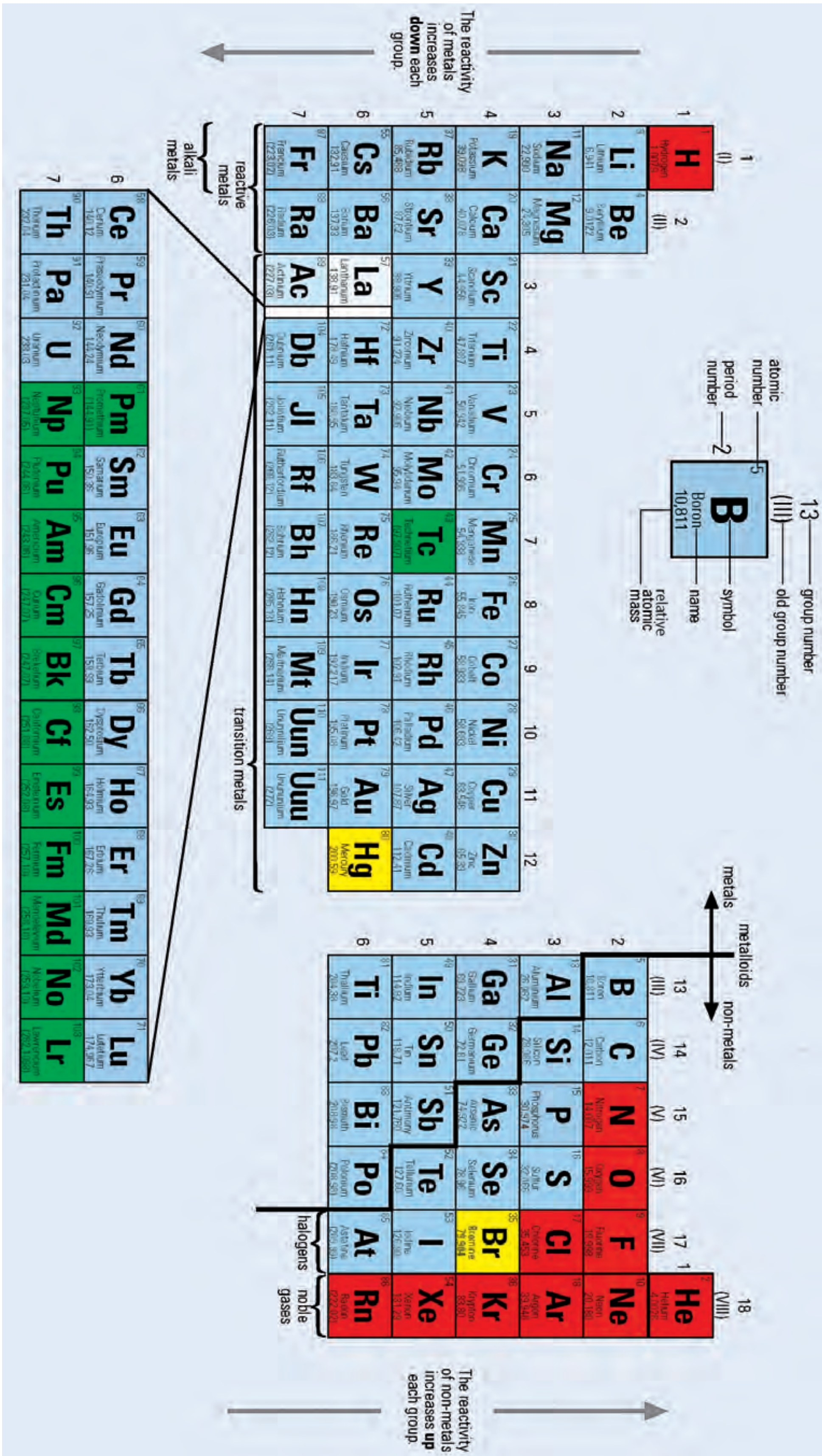
$$n = \frac{m}{M}$$

$$c = \frac{n}{V}$$

$$c = \frac{m}{MV}$$

Paper 2

Exam Papers



Paper 2

Exam Papers

SECTION A

QUESTION 1: ONE-WORD ANSWERS

Provide one word or term for each of the following descriptions. Write only the word or term next to the question number.

1.1 When a liquid changes from a liquid into a gas. (1)
1.2 All water on and around the Earth. (1)
1.3 A chemical change that causes the surroundings to get cooler. (1)
1.4 The energy required to remove one electron from an atom of an element in the gaseous phase. (1)
1.5 The attraction that exists when two atoms share the same pair of electrons. (1)

5 × 1 = [5]

QUESTION 2: MATCHING PAIRS

Choose an item from column B that matches the description in column A. Write only the letter of your choice (A–J) next to the question number.

Column A	Column B
2.1 property of a metal	A number of protons
2.2 mass number	B number of electrons in the outer shell
2.3 valency	C kilogram
2.4 $CaCO_3$ + heat → CaO + CO_2	D number of protons and neutrons
2.5 SI unit for quantity of matter	E decomposition reaction
	F ductile
	G mole
	H brittle
	I number of chemical bonds that an atom can form
	J synthesis reaction

5 × 1 = [5]

QUESTION 3: TRUE/FALSE

Indicate whether each of the following statements is true or false.

3.1 Elements in the same horizontal row in the periodic table have the same number of electrons in their outer energy levels.
3.2 Covalently bonded substances do not usually conduct electricity.
3.3 Oxidation is the process of water molecules surrounding ions when an ionic solid dissolves in water.
3.4 The chloride ion and the potassium ion have the same number of electrons.
3.5 Salt can become a conductor of electricity either by dissolving it in water or by melting it.

5 × 2 = [10]

QUESTION 4: MULTIPLE CHOICE

Choose the correct answer. Only write the letter of the answer that you select.

4.1 Atoms form bonds when valence electrons interact. When electrons are transferred from one atom to another the bond is:

A ionic.
B covalent.
C metallic.
D electronic. (3)

4.2 When sodium chloride dissolves in water, the . . . of the water molecule is attracted by the chloride ion.

A hydrogen end, which is the positive pole
B hydrogen end, which is the negative pole
C oxygen end, which is the positive pole
D oxygen end, which is the negative pole (3)

4.3 This shows a representation of the nuclei of two atoms: $^{15}_{7}X$ and $^{19}_{11}Y$. These atoms:

A have the same mass numbers.
B are isotopes of the same element.
C have the same number of neutrons.
D have the same number of electrons. (3)

4.4 X represents some imaginary element with a fixed valency. The other elements below exhibit their normal valencies. Which one of the following formulae is wrong?

A XCl_3
B X_2S_3
C X_2O_3
D $X(NO_3)_2$ (3)

4.5 Which set of coefficients will balance the following equation?

$Al + H_2O \rightarrow Al_2O_3 + H_2$

A 2 : 1 : 3 : 3
B 2 : 3 : 1 : 3
C 3 : 2 : 1 : 3
D 2 : 3 : 3 : 1 (3)

3 × 5 = [15]

SECTION B

QUESTION 1

The following table shows the first ionisation energies for the elements of periods 1 and 2.

Period	Element	First ionisation energy ($kJ.mol^{-1}$)
1	H	1 312
	He	2 372
2	Li	520
	Be	899
	B	801
	C	1 085
	N	1 402
	O	1 314
	F	1 681
	Ne	2 081

1.1 What is the meaning of the term ‘first ionisation energy’? (2)

1.2 Identify the general pattern of first ionisation energies in a period. (2)

1.3 Which two elements on the table above exert the strongest forces of attraction on their electrons? What property concerning the electrons in their outer shells is responsible for this? (4)

1.4 ‘All group 1 elements readily form positive ions’. Is this statement correct? Explain your answer by referring to the table. (3)

[11]

QUESTION 2

Ernest Rutherford carried out one of the most important experiments in the history of science. He bombarded a very thin sheet of gold with fast-moving positively charged particles. He was able to trace the paths of the particles by seeing where they hit a spherical glass screen. From the results of his experiment, he was able to propose a new model for the structure of an atom.

2.1 Briefly describe the results of his experiment. (4)
2.2 Briefly describe the model of the atom that he was able to propose, based on these results. (4)

$2 \times 4 =$ [8]

QUESTION 3

A neutral atom has 20 electrons around its nucleus.

3.1 To which element does this atom belong? (2)
3.2 How many valence electrons does it have? (2)
3.3 How many energy levels does it have? (2)
3.4 Will this atom gain or lose electrons when it forms an ionic bond? Explain. (3)
3.5 How many electrons will this atom gain or lose during ionic bonding? (2)
3.6 After this atom has gained/lost electrons, which noble gas will have the same electron structure as the ion that is formed? (2)

[13]

QUESTION 4

The element chlorine exists as three isotopes, one of which is ${}^{35}_{17}Cl$.

4.1 What are 'isotopes' of an element? (2)
4.2 How many protons does the above isotope have? (2)
4.3 How many neutrons does it have? (2)
4.4 The other isotope of chlorine has 20 neutrons. Write its structure using the same notation as above. (2)
4.5 The atomic mass of chlorine is 35,5. What does this tell us about the ratio in which the two isotopes of chlorine occur in nature? (2)

[10]

QUESTION 5

Potassium metal will burn in oxygen to form potassium oxide.

5.1 State Pauli's exclusion principle. (2)
5.2 Use the 'arrows in boxes' notation to show the electron configuration of an oxygen atom. Label the energy levels and orbitals. (4)
5.3 Use Lewis structures to show the ionic bonding between potassium and oxygen atoms. (4)
5.4 Write the balanced chemical equation for the reaction between potassium and oxygen. (3)

[13]

QUESTION 6

Sodium chloride is soluble in water.

6.1 Draw the Lewis structure for a water molecule. (3)
6.2 What is meant by the 'electronegativity' of an element? (2)
6.3 Instead of using a pair of dots or a dot and a cross to represent a shared pair of electrons in a covalent bond, a single line may be used. This method is called a Couper structure. Draw the Couper structure for a water molecule, showing the approximate bond angle in the structure. (2)
6.4 Explain why the water molecule is a dipole. Use the Couper structure sketch to illustrate your answer. (4)

6.5 Explain briefly the process that occurs when sodium chloride dissolves in water. Include in your explanation a sketch showing the positions of the water molecules around the ions. (7)

6.6 Write a chemical equation, including the phases, to represent this dissolution process. (3)

[21]

QUESTION 7

You are given the following solubility rules:

- All nitrates are soluble.
- Salts of sodium, potassium and ammonium are soluble.
- All chlorides are soluble, except silver chloride and lead chloride.
- All sulphates are soluble, except the sulphates of calcium, barium, lead and silver.
- All carbonates are insoluble, except the carbonates of sodium, potassium and ammonium.
- All hydroxides are insoluble, except the hydroxides of sodium, potassium and ammonium.

Certain chemical reactions are classified as 'precipitation reactions'.

7.1 What is a precipitate in this context? (2)

7.2 Is lead chloride soluble in water? (1)

7.3 You mix together solutions of sodium nitrate and potassium sulphate.
Will a precipitate form? (Answer simply Yes or No.) (2)

7.4 You mix together solutions of silver nitrate and potassium chloride. A precipitate is formed.

7.4.1 Write down the name of the precipitate. (2)

7.4.2 Write a chemical equation for this reaction, including the states/phases. (4)

7.4.3 This is an example of a 'precipitation reaction'. What other classification name applies to this reaction? (2)

[13]

QUESTION 8

Write chemical formulae for the following compounds:

8.1 aluminium sulphate (2)

8.2 calcium hydroxide (2)

8.3 ammonium carbonate (2)

8.4 silver phosphate (2)

8.5 beryllium sulphide (2)

$5 \times 2 =$ [10]

QUESTION 9

Write balanced chemical equations for the following reactions:

9.1 hydrogen sulphate + sodium carbonate → sodium sulphate + carbon dioxide + water (5)

9.2 potassium + hydrogen oxide (water) → potassium hydroxide + hydrogen (5)

[10]

QUESTION 10

Balance the following equations:

10.1 $P + Cl_2 \rightarrow PCl_3$ (2)

10.2 $Mg_2SiO_4 + H_2O \rightarrow Mg(OH)_2 + H_4SiO_4$ (2)

[4]

Answers to exam papers

QUESTION 11

Copper (II) sulphate ($CuSO_4$) is formed when copper (II) oxide reacts with sulphuric acid. Water is the other product in this reaction. (Express answers correct to two decimal places.)

11.1 Write a balanced chemical equation for the reaction between copper (II) oxide and sulphuric acid. (4)

11.2 Calculate the percentage copper in copper (II) sulphate. (5)

11.3 Calculate the mass of copper (II) sulphate that must be dissolved in water to make up 250 cm^3 of solution of concentration 0,4 $mol.dm^{-3}$ (5)

[14]

QUESTION 12

The empirical formula of a compound is found to be HO

12.1 What is meant by the 'empirical formula' of a compound? (2)

12.2 The formula mass of this compound is 34. What is the molecular formula of this compound? (2)

12.3 A compound was analysed by a chemist, who found that the compound contained 31,8 g potassium, 29,0 g chlorine and 39,2 g oxygen. Calculate the empirical formula of the compound. (6)

[10]

QUESTION 13

You are given the following balanced chemical equation. (Express answers correct to 2 decimal places.)

$CaCO_3 + 2\,HCl \rightarrow CaCl_2 + CO_2 + H_2O$

13.1 Calculate the mass of $CaCl_2$ that will be obtained if 17 g of $CaCO_3$ is reacted completely with HCl. (5)

13.2 Calculate the volume of CO_2, measured at STP, that will be obtained. (5)

13.3 Why is it necessary for the volume of the gas to be measured at a particular temperature and pressure? (2)

[10]

QUESTION 14

For this question, you may refer to the solubility rules given in question 7. You have a solution of barium chloride in a reagent bottle. You are given three test tubes: A, B and C. They contain the following solutions:

A copper sulphate
B sodium nitrate
C potassium carbonate

You add some barium chloride solution to each test tube.

14.1 In which two test tubes will you see a precipitate? (2)

14.2 Name the precipitates formed. (4)

14.3 What will you see if a solution of nitric acid is added to each test tube containing precipitates? (3)

14.4 Write an equation for the reaction described in 14.3. (3)

[12]

QUESTION 15

15.1 Ammonia is a gas that has a very strong smell that actually hurts your nose and throat a bit and makes your eyes water. In terms of the kinetic molecular theory, explain why diffusion takes place when ammonia gas is released in a classroom and eventually every member of the class can smell the gas. (3)

15.2 What is meant by 'sublimation'? Give an example of a substance that sublimes. (3)

[6]

Total marks: 200

Paper 2

Answers to exam papers

Answers and mark allocation

SECTION A

QUESTION 1: ONE-WORD ANSWERS

1.1 evaporates (or boils) ✓
1.2 hydrosphere ✓
1.3 endothermic ✓
1.4 ionisation energy ✓
1.5 covalent bond ✓

QUESTION 2: MATCHING PAIRS

2.1 F ✓
2.2 D ✓
2.3 I ✓
2.4 E ✓
2.5 G ✓

QUESTION 3: TRUE/FALSE

3.1 False ✓✓
3.2 True ✓✓
3.3 False ✓✓
3.4 True ✓✓
3.5 True ✓✓

QUESTION 4: MULTIPLE CHOICE

4.1 A ✓✓✓
4.2 A ✓✓✓
4.3 C ✓✓✓
4.4 D ✓✓✓
4.5 B ✓✓✓

SECTION B

QUESTION 1

1.1 First ionisation energy is the amount of energy required to remove the outermost (or first) electron from an atom in the gaseous phase. ✓✓
1.2 Increases ✓✓
1.3 He ✓ and Ne ✓. They both have full outer shells. ✓✓
1.4 No. ✓ A lot of energy is required to remove an electron from H, so H usually forms covalent bonds. ✓✓

QUESTION 2

2.1 While nearly all the charged particles went straight through the gold, ✓ some were deviated from their path ✓✓ and a very small number were even reflected straight back. ✓
2.2 The fact that nearly all went straight through meant that most of the atom must be empty space. ✓ Deviation was caused by repulsion of positive charge, so the positive charge and most of the mass of the atom is concentrated in a very small space, the nucleus. ✓✓ The electrons surround the nucleus to make up the volume of the atom. ✓

QUESTION 3

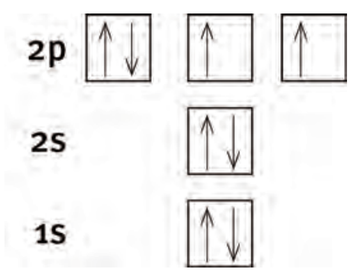
3.1 Ca ✓✓
3.2 3 ✓✓
3.3 3 ✓✓
3.4 Lose electrons. ✓ It is a metal, which has a weak attraction for outer shell electrons. ✓✓
3.5 2 ✓✓
3.6 Ar ✓✓

QUESTION 4

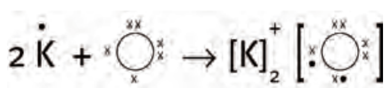
4.1 Isotopes are atoms of the same element that have the same atomic number but different mass number (or the same number of protons, but a different number of neutrons). ✓✓
4.2 17 ✓✓
4.3 18 ✓✓
4.4 $^{37}_{17}Cl$ ✓✓
4.5 The ratio of Cl^{-35} to Cl^{-37} must be approximately 1:3. ✓✓

QUESTION 5

5.1 The maximum number of electrons that an orbital can contain is 2. ✓✓
5.2 Correct arrows and boxes ✓✓ Correct labelling ✓✓



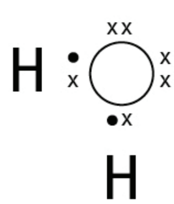
5.3 Correct reactants ✓✓ Correct product ✓✓



5.4 $2\,K + O_2$ ✓✓ → K_2O ✓

QUESTION 6

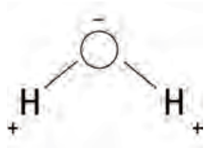
6.1 ✓✓✓



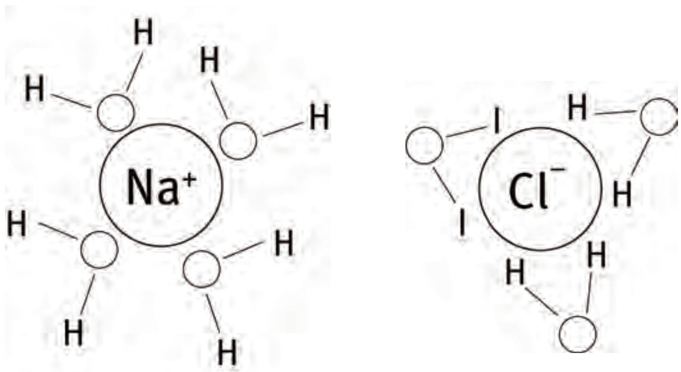
6.2 Electronegativity is the force of attraction that an atom has on a shared pair of electrons in a covalent bond. ✓✓

6.3 Show bond angle > 90° ✓✓

6.4 The electronegativity of O is greater than that of H. ✓ So, the shared pair of electrons is closer to the O than the H atoms, ✓ making the O end slightly negative and the H ends slightly positive. ✓ Couper structure ✓



6.5 The O end of water molecules attract the H^+ ions, while the H ends attract the Cl^- ions. ✓ This causes the NaCl crystals to dissociate (or separate) into Na^+ and Cl^- ions. ✓ The water molecules now surround the ions, ✓ as in the sketch. This process is called hydration.✓ Sketch ✓✓✓



6.6 NaCl(s) ✓ → Na^+(aq) ✓ + Cl^-(aq) ✓

QUESTION 7

7.1 A solid, insoluble substance ✓✓
7.2 No ✓
7.3 No ✓✓
7.4.1 Silver chloride ✓✓
7.4.2 $AgNO_3$(aq) ✓ + KCl(aq) ✓ → AgCl(s) ✓ + KNO_3(aq) ✓
7.4.3 Ion exchange✓✓

QUESTION 8

8.1 $Al_2(SO_4)_3$ ✓✓
8.2 $Ca(OH)_2$ ✓✓
8.3 $(NH_4)_2CO_3$ ✓✓
8.4 Ag_3PO_4 ✓✓
8.5 BeS ✓✓

QUESTION 9

9.1 H_2SO_4 ✓ + Na_2CO_3 ✓ → Na_2SO_4 ✓ + CO_2 ✓ + H_2O ✓

9.2 2 K ✓ + 2 H_2O ✓ → 2 KOH ✓ + H_2 ✓ (Correct balance ✓)

QUESTION 10

10.1 2 P + 3 Cl_2 → 2 PCl_3 ✓✓

10.2 Mg_2SiO_4 + 4 H_2O → 2 $Mg(OH)_2$ + H_4SiO_4 ✓✓

QUESTION 11

11.1 CuO ✓ + H_2SO_4 ✓ → $CuSO_4$ ✓ + H_2O ✓

11.2 Formula mass $CuSO_4$ = 63,5 + 32 + 64 ✓ = 159,5 ✓

$$\% \text{ Cu} = \frac{63{,}5}{159{,}5} ✓ \times 100 ✓$$

$$= 40{,}81\% ✓$$

11.3 $$c = \frac{m}{MV} ✓ \qquad m = \frac{MV}{c} = \frac{159{,}5✓ \text{ x } 0{,}25✓}{0{,}4✓}$$

$$= 99{,}70 \text{ g}✓$$

QUESTION 12

12.1 The empirical formula is the simplest ratio of the atoms in the molecule or formula unit. ✓✓

12.2 H_2O_2 ✓✓

12.3 In 100 g of the compound, we have 31,8 g K; 29,0 g Cl; 39,2 g O.

Using $n = \frac{M}{M}$ ✓ we have $\frac{31{,}8}{39}$ mol K ✓; $\frac{29{,}0}{35{,}5}$ mol Cl ✓; $\frac{39{,}2}{16}$ mol O

= 0,82 mol K; 0,82 mol Cl; 2,45 mol O ✓

Ratio = 1 : 1 : 3

Empirical formula = $KClO_3$ ✓

QUESTION 13

13.1 $CaCO_3$ + 2 HCl → $CaCl_2$ + CO_2 + H_2O

1 mol $CaCO_3$ forms 1 mol Ca Cl_2

100 g Ca CO_3 ✓ forms 111 g Ca Cl_2 ✓

17 g $CaCO_3$ forms x g $CaCl_2$ ✓

$$x = \frac{17 \times 111}{100} ✓ = 18{,}87 \text{ g} ✓$$

13.2 1 mol $CaCO_3$ forms 22,4 dm^3 CO_2 at STP

100 g $CaCO_3$ ✓ forms 22,4 dm^3 CO_2 ✓ at STP

17 g $CaCO_3$ forms x dm^3 CO_2 ✓ at STP

$$x = \frac{17 \times 22{,}4}{100} ✓ = 3{,}81 \text{ dm}^3 ✓$$

13.3 Volume increases as temperature increases and decreases as pressure decreases. ✓✓

Answers to exam papers

QUESTION 14

14.1 A ✓ and C ✓

14.2 Barium sulphate ✓✓ and barium carbonate ✓✓

14.3 Barium sulphate precipitate is not affected. ✓

Barium carbonate precipitate disappears ✓ and bubbles ✓ of gas are seen.

14.4 $CaCO_3 + 2\,HNO_3 \rightarrow Ca(NO_3)_2$ ✓ $+ CO_2$ ✓ $+ H_2O$ ✓

[12]

QUESTION 15

15.1 Gas particles are moving at high speed in all directions, ✓ colliding with one another and anything in their path. There are very big spaces between the particles of air, ✓ so the ammonia molecules move through these spaces until they are evenly spread in the classroom. ✓

15.2 Sublimation is the change from solid to gas without going through the liquid phase. ✓✓ Examples include solid CO_2 (dry ice), naphthalene, and so forth. ✓