

Cambridge IGCSE™

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CO-ORDINATED SCIENCES

0654/31

Paper 3 Theory (Core)

October/November 2021

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 120.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **24** pages.

- 1 (a) Scientists measure the length of sperm cells from different animals.

The animals are placed in size from animal **A** the smallest to animal **F** the largest.

Fig. 1.1 shows the results.

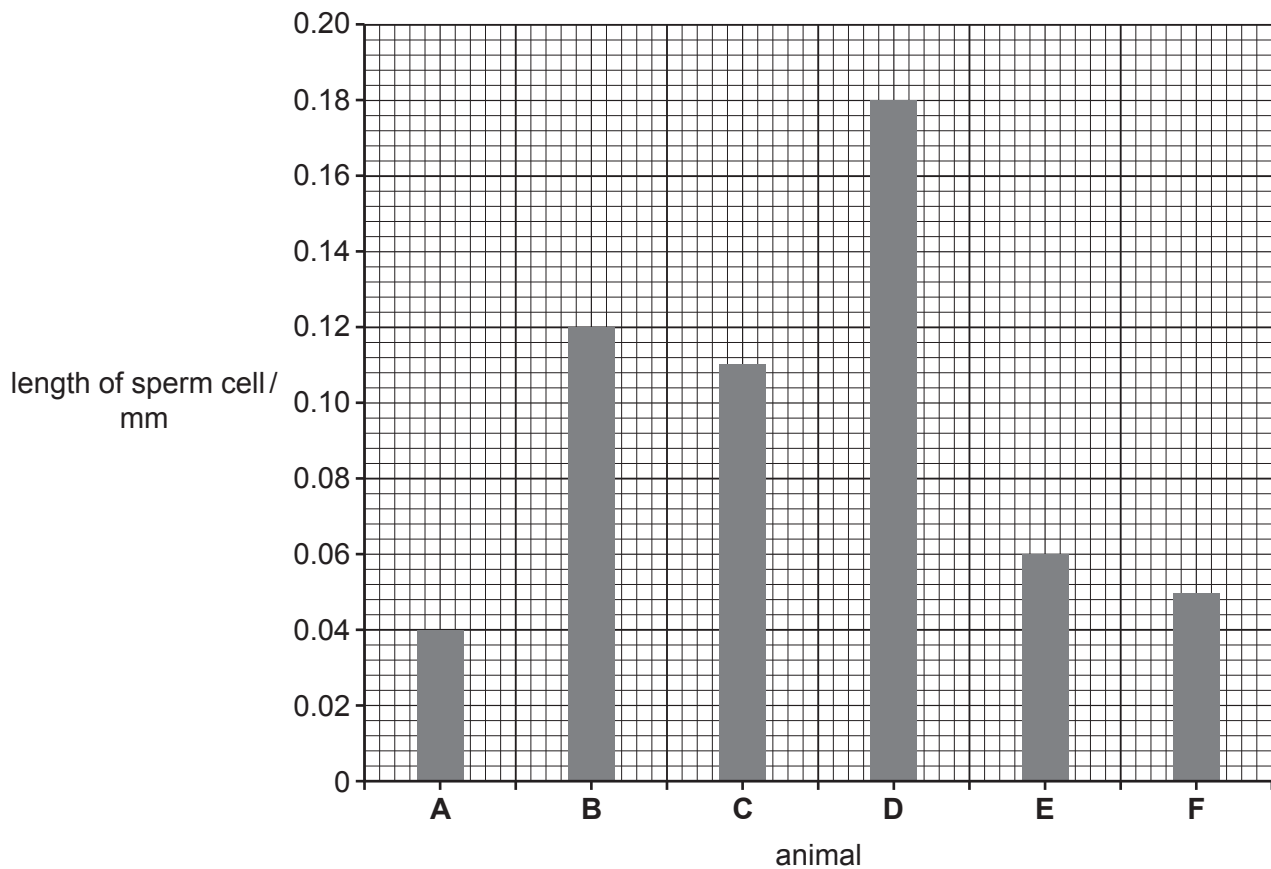


Fig. 1.1

- (i) Using Fig. 1.1, state the length of a sperm cell in animal **B**.

..... mm [1]

- (ii) State the animal with the shortest length of sperm.

..... [1]

- (iii) State evidence from Fig. 1.1 that shows that length of sperm does **not** increase with size of animal.

.....
 [1]

- (b) Plant and animal cells both contain a nucleus.

Name **two other** structures seen in both plant and animal cells.

1

2 [2]

- (c) The boxes on the left show some of the parts of a plant cell.

The boxes on the right show the functions of the parts.

Draw lines to link each part with its function.

part of plant cell

function

cell wall

contains genetic material

chloroplast

contains cell sap and supports the cell

nucleus

site of photosynthesis

vacuole

strengthens the cell

[3]

- (d) Substances enter and leave cells.

Name the process by which substances enter the cells.

..... [1]

- (e) Explain why muscle cells need high rates of respiration.

.....

.....

.....

..... [2]

[Total: 11]

2 (a) The thermal decomposition of calcium carbonate makes calcium oxide and carbon dioxide.

(i) Write the word equation for the thermal decomposition of calcium carbonate.



[1]

(ii) The production of lime (calcium oxide) from limestone (calcium carbonate) is one use of limestone.

State **one other** use of limestone.

..... [1]

(iii) Calcium carbonate has the formula CaCO_3 .

State the number of different elements present in calcium carbonate.

..... [1]

(iv) Explain why the thermal decomposition of calcium carbonate is a chemical change and not a physical change.

.....
 [1]

(v) The thermal decomposition of calcium carbonate is an endothermic reaction.

State what is meant by an *endothermic* reaction.

.....

 [1]

(b) (i) Carbon dioxide is a compound but carbon is an element.

State the difference between an element and a compound.

.....

 [2]

- (ii) Carbon is a solid and carbon dioxide is a gas.

Complete Table 2.1 to describe the differences between a solid and a gas.

One difference has been done for you.

Table 2.1

	particle separation	particle arrangement	particle motion
solid			vibrate about a fixed point
gas			move rapidly in all directions

[2]

- (c) Carbon exists in many forms including diamond and graphite.

Diamond and graphite are described as giant covalent structures.

Fig. 2.1 shows three covalent structures, **A**, **B** and **C**.

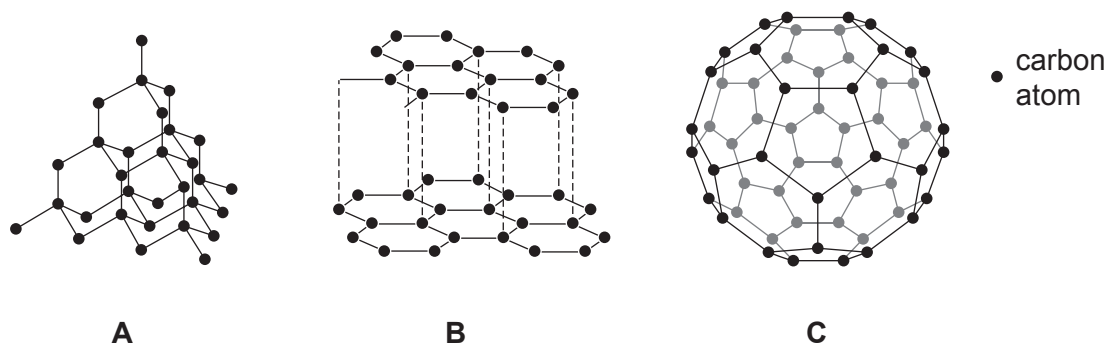


Fig. 2.1

- (i) State which structure represents diamond.

Choose from **A**, **B** or **C**.

.....

[1]

- (ii) State which structure represents graphite.

Choose from **A**, **B** or **C**.

.....

[1]

- (iii) State why the bonding between the carbon atoms in diamond is covalent and not ionic.

.....

..... [1]

[Total: 12]

- 3 (a) A student constructs a circuit containing two lamps in parallel connected across two cells in series. Each lamp is controlled by a separate switch.

(i) Draw a circuit diagram for this circuit using standard electrical symbols.

[3]

(ii) State **one** advantage of connecting the lamps in parallel rather than in series.

.....
 [1]

(b) Fig. 3.1 shows a filament lamp.

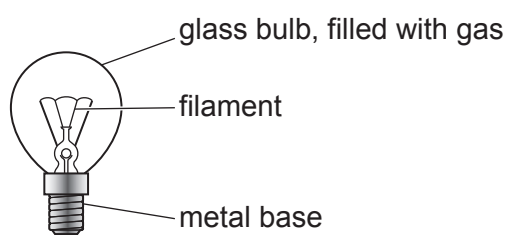


Fig. 3.1

- (i) When the lamp is switched on, thermal energy is transferred from the filament through the metal base.

Name the process that transfers the thermal energy.

..... [1]

(ii) Suggest **one** part of the electromagnetic spectrum emitted by the lamp.

..... [1]

(c) Fig. 3.2 shows a ray of light from the lamp passing through a rectangular glass block.

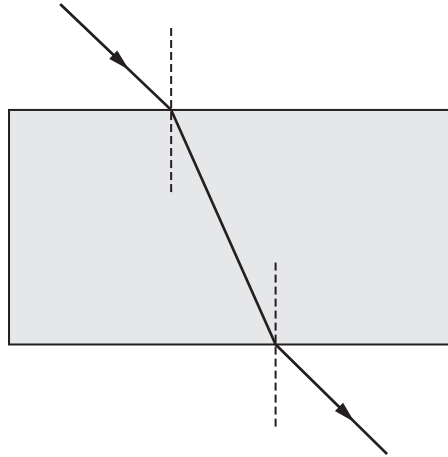


Fig. 3.2

- (i) On Fig. 3.2, label the angle of incidence with the letter i and the angle of refraction with the letter r . [2]
- (ii) Explain why the ray of light changes direction as it is refracted through the glass block.

.....

..... [1]

[Total: 9]

- 4 (a) Fig. 4.1 is a diagram of the male reproductive system in humans.

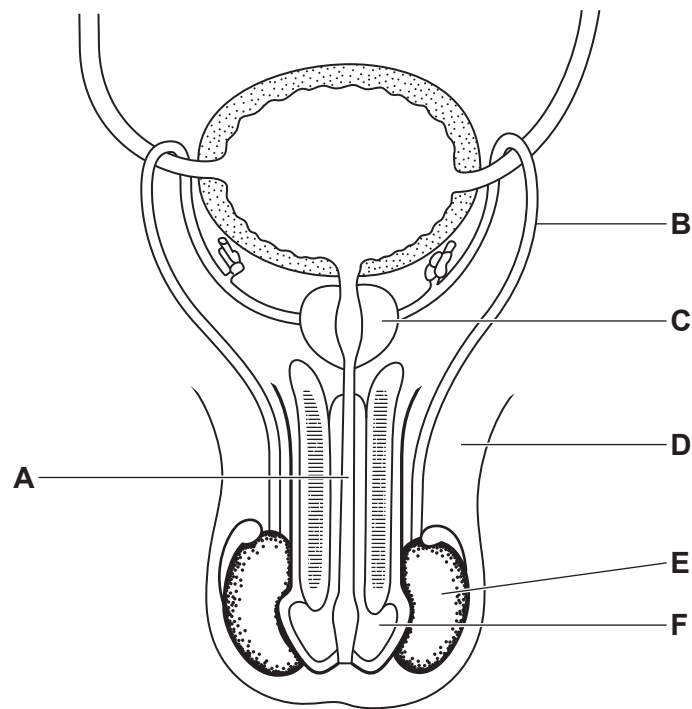


Fig. 4.1

Identify the letter from Fig. 4.1 that represents the:

part where sperm is produced,

part which secretes the fluid that sperm swim in,

tube which carries both semen and urine.

[3]

- (b) State the name of the part of the female reproductive system that releases gametes.

..... [1]

- (c) The statements in Table 4.1 describe either asexual or sexual reproduction.

Complete Table 4.1 to identify the type of reproduction each statement describes.

Table 4.1

statement	type of reproduction
offspring are genetically identical to each other	
produces zygotes	
involves the fusion of nuclei	

[2]

(d) Fig. 4.2 is a diagram representing the reproduction of a type of organism called a hydra.

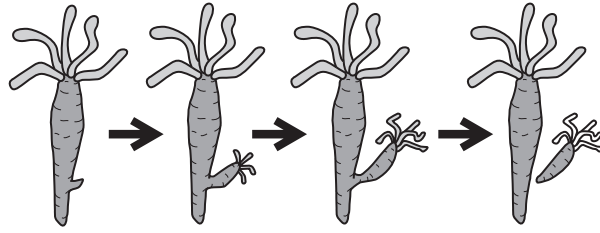


Fig. 4.2

Identify if this organism is reproducing asexually or sexually.

Use evidence from Fig. 4.2 to give a reason for your answer.

type of reproduction

reason

[1]

(e) Reproduction and respiration are characteristics of living things.

State **two other** characteristics of living things.

1

2

[2]

[Total: 9]

5 (a) Iron is an element in Period 4 of the Periodic Table.

(i) Name the collection of metals in Period 4 that contains iron.

..... [1]

(ii) An atom of iron has a proton number of 26 and a nucleon number of 56.

State the number of electrons in this atom.

number of electrons [1]

(iii) Iron is obtained from iron oxide by reaction with carbon.

The word equation for the reaction is shown.

iron oxide + carbon $\rightarrow$ iron + carbon dioxide

Name the substance that is reduced in this reaction.

Explain your answer.

substance reduced

explanation

..... [2]

(b) Steel is an alloy of iron.

(i) State what is meant by an *alloy*.

.....

..... [1]

(ii) State why steel is used rather than pure iron for making cars.

.....

..... [1]

(iii) Table 5.1 shows the percentage composition of an alloy.

Table 5.1

element	percentage
copper	33
iron	
nickel	60

Calculate the percentage of iron in the alloy.

percentage of iron = % [1]

(c) A student investigates the rusting of iron nails.

Fig. 5.1 shows the student's experiments.

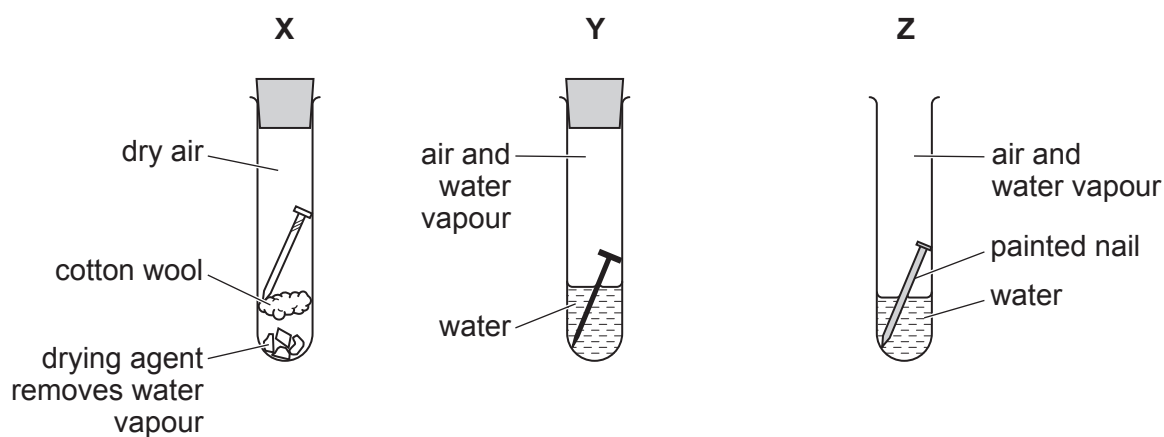


Fig. 5.1

Table 5.2 shows the student's observations after one week.

Complete Table 5.2 to explain the student's observations.

Table 5.2

test-tube	rusts/does not rust	explanation
X	does not rust	
Y	rusts	
Z	does not rust	

[3]

[Total: 10]

- 6 (a) Fig. 6.1 shows a copper wire connected to a battery and placed between the poles of a strong magnet.

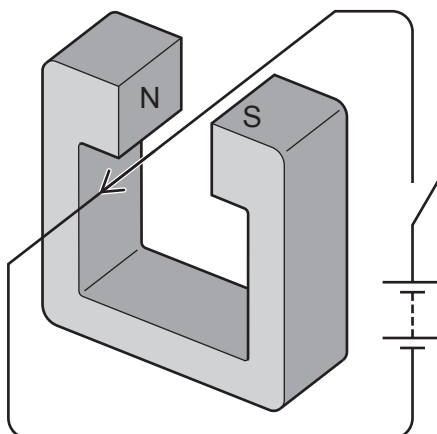


Fig. 6.1

When the switch is closed the wire moves upwards.

- (i) Describe **two** ways to change the apparatus so that the wire moves downwards when the switch is closed.

1

2 [2]

- (ii) State the term that describes a flow of electrons in a metal conductor.

..... [1]

- (b) A β -particle is an electron.

α -particles and β -particles are radioactive emissions released during the radioactive decay of isotopes.

- (i) State the meaning of the terms:

radioactive decay

.....

isotopes

..... [3]

- (ii) Complete the sentences below using the symbols α and β .

..... particles are less ionising than particles.

..... particles are less penetrating than particles.

[1]

- (c) A plastic ruler and a piece of cloth are both uncharged.

A student rubs the plastic ruler with the cloth.

The plastic ruler becomes positively charged.

- (i) Describe in terms of electrons how the plastic ruler becomes positively charged.

.....
 [1]

- (ii) State which row from Table 6.1 shows the charge on the cloth compared to the charge on the plastic ruler.

Table 6.1

row	sign of charge	magnitude of charge
1	positive	equal
2	positive	bigger
3	positive	smaller
4	negative	equal
5	negative	bigger
6	negative	smaller

row no

[1]

[Total: 9]

8 (a) Petroleum is a fossil fuel.

(i) Name **one other** fossil fuel.

..... [1]

(ii) Petroleum is separated into fractions to make it more useful.

Complete the sentences using words from the list.

Each word may be used once, more than once or not at all.

compound	distillation	electrolysis
filtration	mixture	molecule

Petroleum is a of different hydrocarbons.

Petroleum is separated by fractional [2]

(iii) Gasoline is obtained from petroleum.

State the two products of the **complete** combustion of gasoline.

1

2 [2]

(b) Ethane, C₂H₆, is an alkane. Ethene, C₂H₄, is an alkene.

(i) Explain why ethene is described as an *unsaturated* hydrocarbon.

.....
 [1]

(ii) Describe the chemical test and the positive result for an **unsaturated** hydrocarbon.

test

result

..... [2]

(c) Ethene molecules react together to form a polymer.

(i) Describe what happens to the ethene molecules when they form a polymer.

.....
 [1]

(ii) Name the polymer made from ethene.

..... [1]

[Total: 10]

- 9 Fig. 9.1 shows a refrigerator.

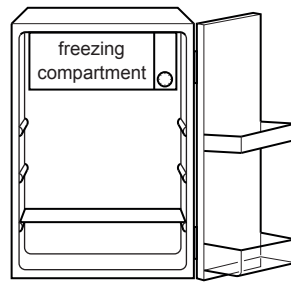


Fig. 9.1

- (a) The freezing compartment at the top of the refrigerator cools all the air in the refrigerator.

State the main method of thermal energy transfer used in this cooling process.

..... [1]

- (b) The volume of air in the refrigerator is $210\,000\text{ cm}^3$.

The density of air is 0.00126 g/cm^3 .

Calculate the mass of air in the refrigerator.

Show your working.

mass = g [2]

- (c) A liquid-in-glass thermometer is placed inside the freezing compartment to measure a temperature of -20°C .

- (i) Name a suitable liquid to use in the thermometer.

..... [1]

- (ii) State the physical property of the liquid that varies with temperature in a liquid-in-glass thermometer.

..... [1]

(d) The refrigerator emits a quiet sound with a low pitch.

(i) Describe the amplitude and frequency of this sound.

amplitude

frequency

[2]

(ii) State the unit of frequency.

..... [1]

(e) The refrigerator contains two lamps connected in series.

Lamp **A** has a resistance of $4000\ \Omega$ and lamp **B** has a resistance of $5000\ \Omega$.

(i) Calculate the combined resistance of the two lamps connected in series.

resistance = Ω [1]

(ii) The potential difference across the lamps is 240 V .

Use your answer to (e)(i) to calculate the current in the lamps.

Show your working.

current = A [2]

[Total: 11]

10 Fig. 10.1 is a diagram showing part of the carbon cycle.

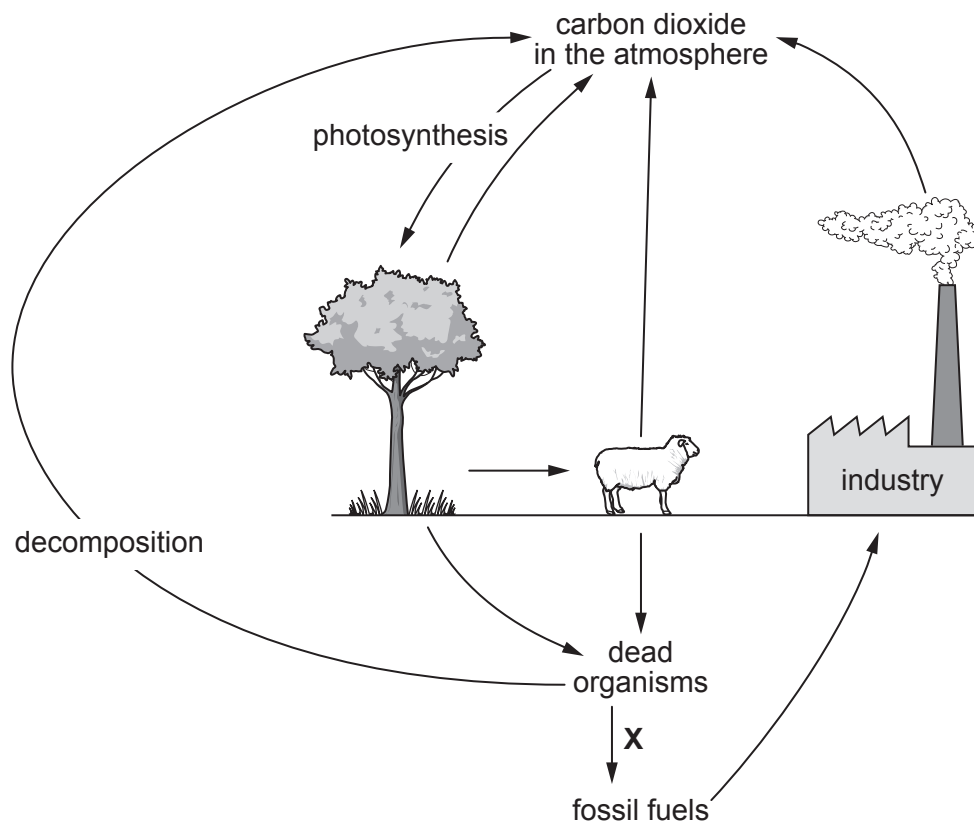


Fig. 10.1

(a) Name the process occurring at **X** in Fig. 10.1.

..... [1]

(b) When deforestation occurs there is a build-up of carbon dioxide in the atmosphere.

(i) List **two other** negative effects of deforestation.

1

2

[2]

(ii) Stopping deforestation will reduce the build-up of carbon dioxide in the atmosphere.

Use the information in Fig. 10.1 to suggest **two other** ways we can reduce the build-up of carbon dioxide in the atmosphere.

1

.....

2

.....

[2]

(c) Table 10.1 shows some features of respiration and photosynthesis.

Place ticks (✓) in the boxes to show the features of each process.

Table 10.1

process	produces carbon dioxide	produces oxygen	requires light energy	produces carbohydrates
photosynthesis				
respiration				

[4]

(d) Water is one of the substances required by plants and is also lost by plants during transpiration.

(i) State the name of the vessels that transport water through a plant.

..... [1]

(ii) Complete the sentences to define the term transpiration.

Transpiration is loss of water vapour from plant by

evaporation of water at the surfaces of the mesophyll

followed by diffusion of water vapour through the

[3]

[Total: 13]

- 11 (a) Table 11.1 shows the melting points of some Group I elements.

Table 11.1

element	melting point/°C
lithium	181
sodium	98
potassium	
rubidium	39
caesium	28

Predict the melting point of potassium.

..... °C

[1]

- (b) Potassium reacts with chlorine to make potassium chloride.

Potassium chloride is an ionic compound.

Fig. 11.1 shows the electronic structure of a potassium atom and of a chlorine atom.

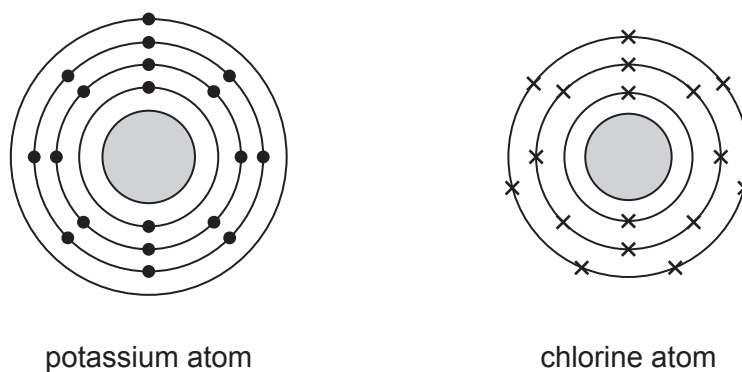


Fig. 11.1

- (i) Complete the diagrams in Fig. 11.2 to show the ions in potassium chloride.

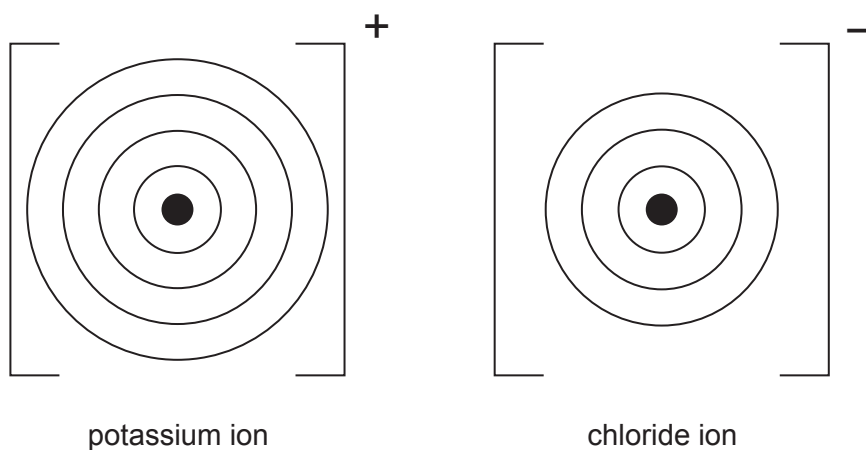


Fig. 11.2

[2]

- (ii) Balance the symbol equation for the reaction between potassium and chlorine.



- (c) Universal indicator is added to water.

The water is neutral.

- (i) State the pH of the water.

pH [1]

- (ii) A teacher reacts potassium with the water.

Potassium hydroxide solution is made in the reaction.

Suggest the pH of the resulting potassium hydroxide solution and the colour of the universal indicator.

pH

colour of universal indicator [2]

- (iii) The teacher reacts lithium with water.

Compare the reactivity of lithium with the reactivity of potassium.

.....

..... [1]

[Total: 8]

- 12 (a) An astronaut travels to the Moon in a spacecraft.

The weight of the spacecraft at take-off is 25 000 000 N. When the spacecraft blasts off from Earth, it is pushed upwards by a force of 32 000 000 N.

Calculate the resultant upward force on the spacecraft.

resultant force = N [1]

- (b) The spacecraft has solar panels to gather energy from the Sun. This energy is stored in batteries on the spacecraft.

- (i) Complete the sentences to describe the energy conversion that takes place in this process.

The Sun's light energy is transformed into energy by the solar panels.

This energy is stored as energy in the batteries. [2]

- (ii) Solar energy is a renewable energy source.

State **one other** renewable energy source.

..... [1]

- (c) The spacecraft travels 386 000 km from Earth to the Moon in 72 hours.

Calculate the average speed of the spacecraft in km/s.

Show your working.

average speed = km/s [3]

- (d) On Earth, the astronaut has a mass of 80 kg and a weight of 800 N. On the Moon the astronaut has a mass of 80 kg and a weight of 135 N.

Describe the difference between mass and weight.

.....
 [1]

(e) The astronaut communicates with Earth using radio waves.

(i) Fig. 12.1 shows an incomplete electromagnetic spectrum.

	X-rays	ultraviolet			microwaves	
--	---------------	--------------------	--	--	-------------------	--

Fig. 12.1

Place radio waves in the correct place in Fig. 12.1. [1]

(ii) Explain why it is not possible for the astronaut to communicate with Earth using sound waves.

.....

 [1]

(iii) Fig. 12.2 shows a sound wave.

On Fig. 12.2 label with a double headed arrow ($\longleftrightarrow$ or $\updownarrow$) **one** wavelength of the sound wave.

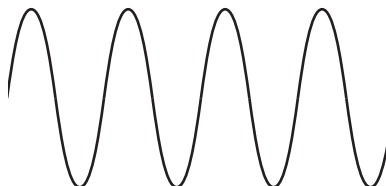


Fig. 12.2

[1]

[Total: 11]

The Periodic Table of Elements

Group																		
I	II											III	IV	V	VI	VII	VIII	
		1 H hydrogen 1																2 He helium 4
		Key atomic number atomic symbol name relative atomic mass																
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20	
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40	
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84	
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium —	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131	
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —	
87 Fr francium —	88 Ra radium —	89–103 actinoids	104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —		114 Fl flerovium —		116 Lv livermorium —			

lanthanoids	57	La	lanthanum	139	58	Ce	cerium	140	59	Pr	praseodymium	141	60	Nd	neodymium	144	61	Pm	promethium	—	62	Sm	samarium	150	63	Eu	europlum	152	64	Gd	gadolinium	157	65	Tb	terbium	159	66	Dy	dysprosium	163	67	Ho	holmium	165	68	Er	erbium	167	69	Tm	thulium	169	70	Yb	ytterbium	173	71	Lu	lutetium	175	
	actinoids	89	Ac	actinium	—	90	Th	thorium	232	91	Pa	protactinium	231	92	U	uranium	238	93	Np	neptunium	—	94	Pu	plutonium	—	95	Am	americium	—	96	Cm	curium	—	97	Bk	berkelium	—	98	Cf	californium	—	99	Es	einsteinium	—	100	Fm	fermium	—	101	Md	mendelevium	—	102	No	nobelium	—	103	Lr	lawrencium	—

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).