OCR
Oxford Cambridge and RSA

Wednesday 15 May 2024 – Afternoon

Level 3 Cambridge Technical in Applied Science

05847/05848/05849/05874/05879 Unit 1: Science fundamentals

Time allowed: 2 hours
C340/2406

C340/2406

You must have:
- the Data Sheet (inside this document)
- a ruler (cm/mm)

You can use:
- a scientific or graphical calculator
- an HB pencil

05847-01

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- The Periodic Table is on the back page.
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

1

(a) There are four fundamental forces.

Draw **one** straight line from **each** fundamental force to indicate what it is responsible for.

Fundamental force	What it is responsible for
Electromagnetic force	Attraction between masses
Gravitational force	Keeping nuclei stable
Strong nuclear force	Radioactive decay
Weak nuclear force	Repulsion between electrons

[3]

(b) $^{209}_{84}Po$ is an isotope of polonium.

(i) How many neutrons are in the nucleus of this isotope?

Number of neutrons = ... **[1]**

(ii) How many electrons are there in an atom of this isotope?

Number of electrons = ... **[1]**

(iii) $^{209}_{84}Po$ emits four nucleons as a result of radioactive decay.

An isotope of lead is formed with a mass number of 205.

Complete the nuclear notation of this isotope of lead.

.....

Pb

.....

[2]

(iv) Use the Periodic Table to find the group number and period of lead.

- group number .....
- period .....

[2]

(c) Lead nitrate is soluble in water.

Aqueous lead ions, Pb^{2+} (aq), and nitrate ions, NO_3^- (aq) are formed in the solution.

(i) Use the charges on the ions to work out the formula of lead nitrate and explain your answer.

- formula of lead nitrate

  .....

- explanation

  .....

  .....

  .....

  .....

[2]

(ii) Magnesium reacts with lead nitrate to form magnesium nitrate and lead.

Complete the ionic half equation to show how lead ions becomes atoms.

Pb^{2+} (aq) + ... $\longrightarrow$ ..... (s)

[2]

(iii) Chemical reactions can be classified according to the type of reaction.

Tick (✓) **two** boxes which apply to the reaction between lead nitrate and magnesium.

addition	☐
displacement	☐
redox	☐
substitution	☐

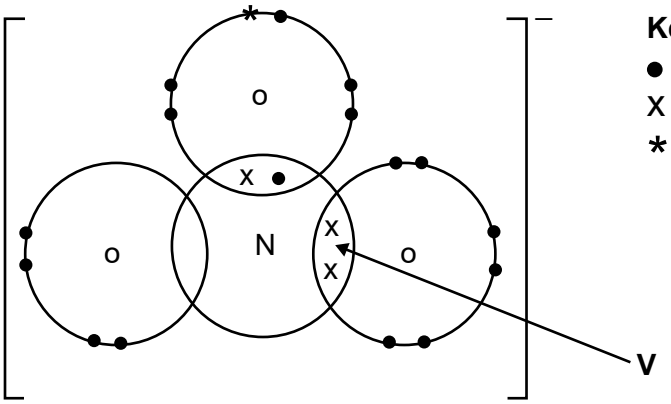
[1]

(d) Dot-and-cross diagrams are used to indicate the bonding in molecules and ions. Only the outer shell of each atom is shown.

The dot-and-cross diagram shows the electron arrangement in a nitrate ion.

The diagram is incomplete because only two of the bonds are shown.

(i) Draw the electron arrangement in the third bond between nitrogen and oxygen.



Key:

- ● Oxygen electron
- X Nitrogen electron
- * Electron donated by lead

[1]

(ii) What type of covalent bond is the bond labelled **V**?

..... **[1]**

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Turn over for the next question

2 Metals such as titanium and iron have many uses.

(a) Titanium dioxide (TiO_2) is used as a catalyst in the manufacture of polyethene from ethene.

Suggest how the catalyst affects the activation energy, the rate of reaction and the yield of polyethene.

Tick (✓) **one** box in each row.

	Decrease	**No change**	**Increase**
Activation energy			
Rate of reaction			
Yield of polyethene			

[3]

(b)

(i) Titanium alloys are used to manufacture aircraft. They contain small amounts of elements other than titanium.

Identify **one** other element that is used in many titanium alloys.

Put a tick (✓) in the correct box.

aluminium ☐

calcium ☐

carbon ☐

potassium ☐

[1]

(ii) Both pure titanium and titanium alloys have a high strength-to-weight ratio and are corrosion resistant.

Describe **one** advantage of using a titanium alloy rather than pure titanium to make aircraft turbines.

.....

..... **[1]**

(c) Iron alloys are used widely in the construction industry and in manufacturing.

Pure iron has a tendency to rust because it reacts with air and water.

The figure below shows some iron nails and an iron block of the same mass.

Iron nails

Iron block

Explain why the iron nails rust more quickly than the iron block.

.....

.....

.....

.....

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.....

.....

..... **[3]**

3 Organic compounds range in size from small molecules with only a few atoms, to macromolecules which can have hundreds or thousands of atoms.

(a) The table below shows molecular formulae of types of organic compound that have three carbon atoms per molecule.

Molecular formula	C_3H_4	C_3H_6	C_3H_8	C_3H_8O
Type of organic compound	Alkyne	Alkene	Alkane	Alcohol

(i) Identify the molecular formula of a saturated hydrocarbon.

Tick (✓) **one** box.

C_3H_4 ☐

C_3H_6 ☐

C_3H_8 ☐

C_3H_8O ☐

[1]

(ii) Draw the structural formula of the alkyne C_3H_4.

Clearly show the bonds between the carbon atoms.

[2]

(iii) Draw a skeletal formula of an alcohol with the molecular formula C_3H_8O.

[2]

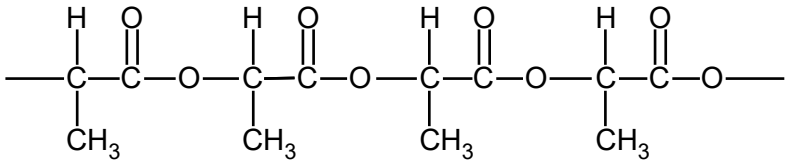
(iv) Propan-2-ol can be oxidised to a ketone, C_3H_6O.

State the name of this ketone.

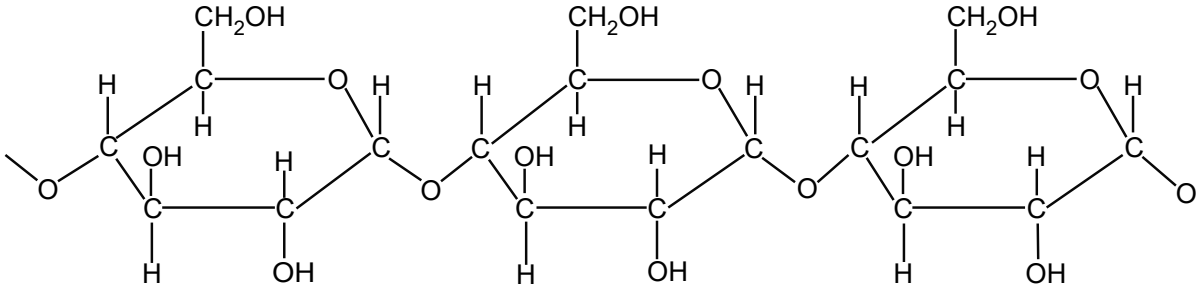
..... **[1]**

(b) The figure below shows a section of each of two polymers that contain carbon, hydrogen and oxygen.

polylactate



polysaccharide



(i) Deduce the empirical formula of polylactate from the formula shown in the figure above.

..... **[1]**

(ii) The figure above shows a section of the polysaccharide, starch.

Identify the main function of starch.

Tick (✓) **one** box.

Component of cell walls ☐

Regulation of biological reactions within cells ☐

Storage of molecules needed in respiration ☐

Transcription of genetic sequences in DNA ☐

[1]

(iii) Glycogen has a similar structure to starch.

State **three** differences between glycogen and starch.

1 .....

.....

.....

2 .....

.....

.....

3 .....

.....

.....

[3]

(iv) Polylactate and starch are formed from their monomers by the same type of reaction.

Explain how the polymers are formed from their monomers.

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.....

.....

..... **[3]**

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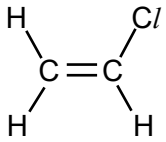
Turn over for the next question

4 Organic compounds containing chlorine have many uses.

(a) PVC is a type of chlorinated organic compound, used to make plastic gutters. This compound is useful because it is hardwearing and takes many years to break down.

PVC is a polymer formed from monomers of chloroethene.



Draw the structural formula of PVC showing **two** repeat units.

[2]

(b) The compound 2-bromo-2-chloro-1,1,1-trifluoroethane ($CF_3CHBrCl$) is another chlorinated organic compound. It is used as an anaesthetic.

$CF_3CHBrCl$ has two optical isomers because it has a chiral centre.

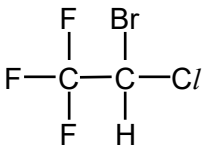
(i) Explain what **chiral centre** means.

.....

.....

..... **[1]**

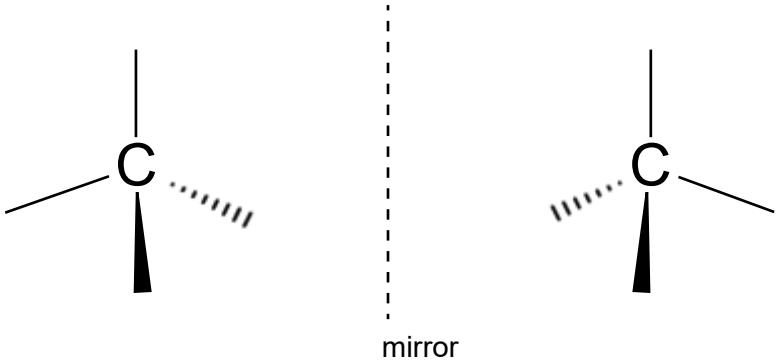
(ii) Draw a (circle) around the chiral centre on the structure below.



[1]

(iii) The two optical isomers are non-superimposable mirror images.

Complete the diagram below to show the two optical isomers of $CF_3CHBrCl$.



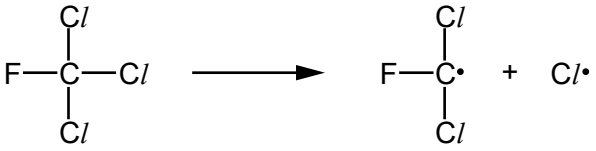
[2]

(c) Chlorofluorocarbons (CFCs) were used as a component of aerosols, some cleaning agents and in refrigerators.

They are now banned because they are responsible for depleting the ozone layer in the Earth's atmosphere.

The reaction with ozone occurs in two steps.

(i) When the CFC compound trichlorofluoromethane reaches the ozone layer, a C—C*l* bond breaks and a chlorine free radical (C*l*•) is formed.



State the condition needed to break the C—C*l* bond.

..... **[1]**

(ii) The chlorine free radicals react with ozone (O_3) as shown below.

Equation 1	C*l*• + O_3 → **X** + O_2
Equation 2	**X** + O → **Y** + C*l*•

Deduce the formulae of **X** and **Y**.

X = ...

Y = ...
[2]

(iii) Studies indicate that one chlorine free radical can destroy over 100 000 molecules of O_3.

Use **Equations 1** and **2** to explain why just one chlorine radical can react with so many molecules of O_3.

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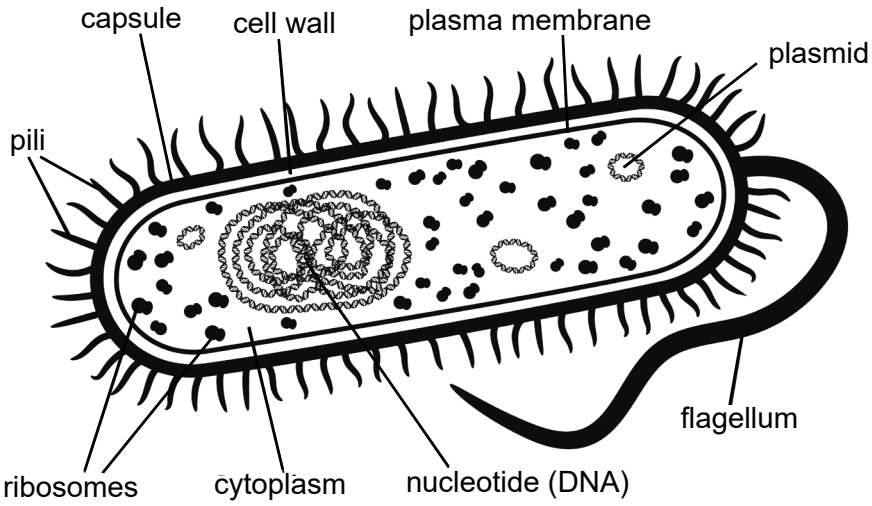
..... **[2]**

5

(a) **Fig. 5.1** shows a prokaryotic cell.

Fig. 5.1



(i) Identify the structure shown in the prokaryotic cell which is **not** found in the eukaryotic cell of a plant.

Tick (✓) **one** box.

cell wall ☐

cytoplasm ☐

plasmid ☐

ribosome ☐

[1]

(ii) Identify the structure that is **not** found in a prokaryotic cell **or** an animal cell but **is** found in a plant cell.

Tick (✓) **one** box.

chloroplast ☐

endoplasmic reticulum ☐

golgi apparatus ☐

mitochondrion ☐

[1]

(iii) Describe the purpose of the flagellum in the prokaryotic cell and identify a type of eukaryotic cell that has a similar structure.

.....

.....

.....

..... **[2]**

(iv) State **one** difference between the location of DNA in a prokaryotic cell and the location of DNA in a eukaryotic cell.

.....

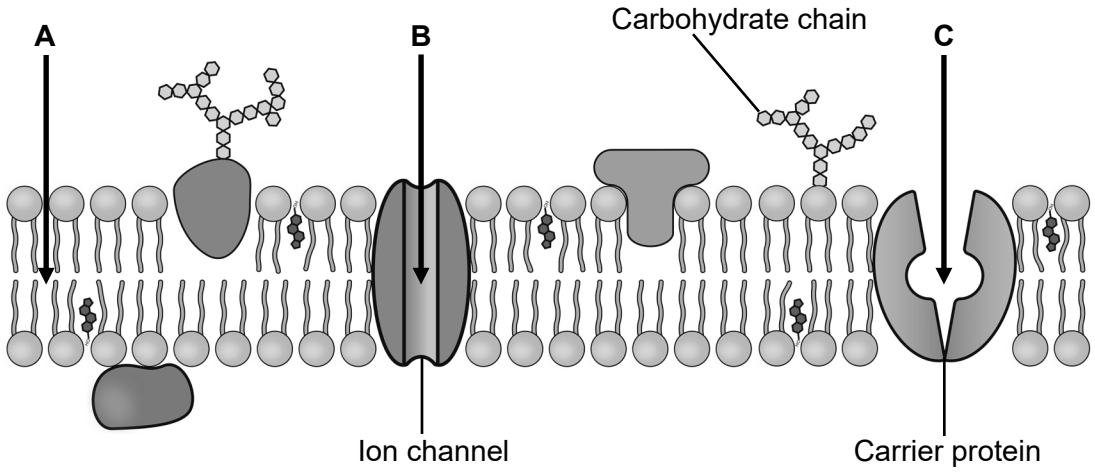
..... **[1]**

Turn over for the next question

(b) A plasma membrane is found in prokaryotic and eukaryotic cells.

Fig. 5.2 shows a diagram of a plasma membrane.

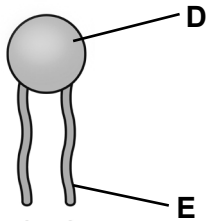
Fig. 5.2



(i) The membrane contains a 'fluid' bilayer of molecules.

The appearance of each molecule is shown in **Fig. 5.3**.

Fig. 5.3



Identify the type of molecule.

Tick (✓) **one** box.

disaccharide ☐

phospholipid ☐

protein ☐

triglyceride ☐

[1]

(ii) The molecule in **Fig. 5.3** has two distinct regions, labelled **D** and **E**.

Identify the characteristic properties of the two regions.

Tick (✓) **one** box.

Region D	Region E	
hydrophilic	hydrophilic	
hydrophilic	hydrophobic	
hydrophobic	hydrophilic	
hydrophobic	hydrophobic	

[1]

(iii) Describe **two** functions of the carbohydrate chain on the outer surface of the plasma membrane in **Fig. 5.2**.

1 .....

.....

.....

2 .....

.....

.....

[2]

(iv) **A**, **B** and **C** represent different ways in which particles can travel through the plasma membrane in **Fig. 5.2.**

The formulae of three different particles that travel through the plasma membrane are:

$C_6H_{12}O_6$ O_2 Na^+

The particles follow different routes through the plasma membrane.

State which particle travels through at routes **A, B** and **C**.

A = ...

B = ...

C = ...

[2]

(v) When Na^+ ions move into a cell across the plasma membrane, they cause an imbalance in the water distribution between the cell cytoplasm and the surrounding tissue fluid.

The cell and tissue fluid are no longer in an isotonic state.

Describe the events that take place to return the cell to the isotonic state.

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.....

..... **[3]**

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Turn over for the next question

6 Group 2 ions and compounds have important biological functions and medical uses.

(a) Complete the sentences using the words in the list.

The words can be used once, more than once or not at all.

blood	**bone**	**gamete**
muscle	**nerve**	**testis**

Calcium ions are an important component of the matrix in ..... tissue.

These important ions also enable ..... cells to contract.

Calcium ions control the release of chemical transmitters from ..... cells.

[3]

(b) Magnesium hydroxide is the main ingredient of Milk of Magnesia which is used to treat heartburn. Heartburn occurs when acid escapes from the stomach into the oesophagus.

A bottle of Milk of Magnesia is shown in the image below.

(i) Magnesium hydroxide is not very soluble in water and settles at the bottom of the bottle.

The bottle must be shaken before use.

Identify the type of mixture found in Milk of Magnesia.

Tick (✓) **one** box.

aerosol ☐

emulsion ☐

gel ☐

suspension ☐

[1]

(ii) Milk of Magnesia has a concentration of 84 mg cm^{-3}.

Typically, 60 cm^3 of stomach acid can be neutralised by a 5 cm^3 dose of Milk of Magnesia.

Calculate the mass of magnesium hydroxide that is needed to neutralise 150 cm^3 of stomach acid.

Mass of magnesium hydroxide = ... mg **[2]**

(iii) It is recommended that an adult should not consume more than 5.04 g of magnesium hydroxide in a 24-hour period.

Calculate the maximum number of 5 cm^3 doses of Milk of Magnesia that an adult should consume within a 24-hour period.

Maximum number of doses = ... **[2]**

(c) An alternative treatment for heartburn contains a mixture of carbonates and sodium alginate, a substance derived from seaweed.

(i) Sodium alginate reacts with stomach acid forming an insoluble cross-linked polymer.

The strands of the polymer are held together by an ion that is also responsible for cell adhesion.

Identify the ion.

Tick (✓) **one** box.

Ca^{2+} ☐

Cu^{2+} ☐

Fe^{2+} ☐

Pt^{2+} ☐

[1]

(ii) The carbonates neutralise the stomach acid and the reaction produces carbon dioxide.

As the carbon dioxide is released, the polymer in **(c)(i)** floats to the top of the stomach contents. This acts as a barrier to stop acid entering the oesophagus and causing pain.

Any gas would work to float the polymer.

Suggest why carbon dioxide is suitable for this purpose.

.....

..... **[1]**

(d) Gastric ulcers develop when the stomach acid damages the lining of the stomach.

To detect gastric ulcers in the stomach lining, patients are given a barium meal followed by an X-ray scan.

A barium meal contains a compound that coats the stomach and is opaque to X-rays.

Some information about the solubility of three barium compounds is shown in the table.

Compound	**Solubility (g per 100 g of water at 20 °C)**
$BaCO_3$	2.4×10^{-3}
$BaCl_2$	35.8
$BaSO_4$	2.4×10^{-4}

Aqueous barium ions are toxic to humans.

Explain which one of the three compounds of barium is safe to use as a barium meal.

.....

.....

.....

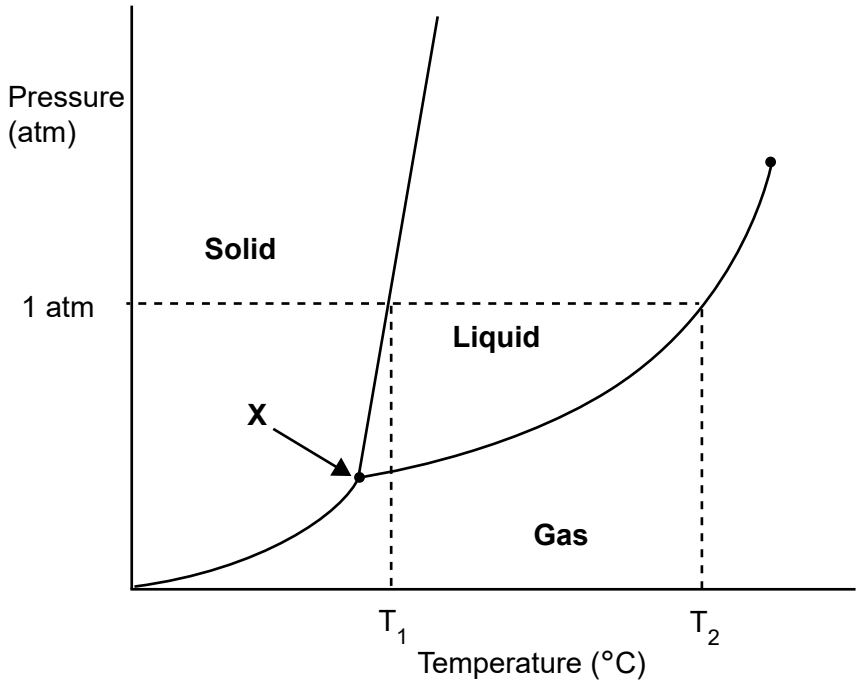
.....

..... **[2]**

7 The three states of matter are solid, liquid and gas.

The phase diagram for a typical pure substance, **Z**, is shown below. When the temperature of solid **Z** is increased at one atmosphere pressure (room pressure), it changes from solid to liquid to gas.

A few substances, such as solid carbon dioxide, change directly from solid to gas when heated at one atmosphere pressure.



- State the significance of temperatures T_1 and T_2, and the point marked **X** on the diagram.
- Use the diagram to explain the effect on the temperature at which liquid **Z** vaporises of increasing the pressure.
- Explain why solid carbon dioxide sublimes at room temperature and pressure.

[6]

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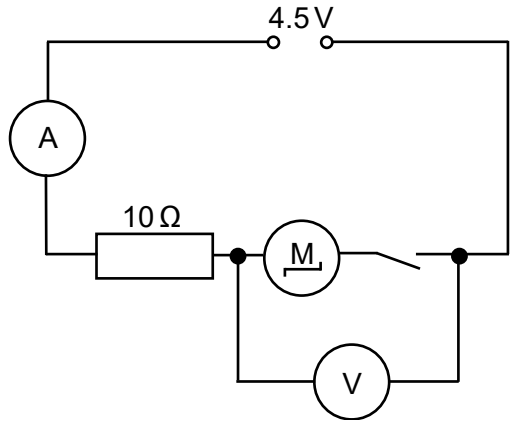
Turn over for the next question

8 The circuit diagram shows a small electric motor, **M**, in series with a resistor and connected to a power supply with a potential difference of 4.5 V.



(a)

(i) When the switch is closed the reading on the voltmeter is 2.5 V and the reading on the ammeter is 0.14 A.

Calculate the input power *P* to the motor and state the unit.

Use the equation: $P = V I$

P = ... unit = ... **[2]**

(ii) Show that the potential difference across the 10 Ω resistor is 2.0 V.

..... **[1]**

(iii) Show that the resistance of the motor and the resistance of the resistor have a combined total resistance, R_T of approximately 28 Ω.

Use the equation: $V = I R$ in your calculation.

.....

..... **[2]**

(iv) Theory suggests that the current, I in the circuit can be calculated using the potential difference of the supply and the total resistance of the circuit, R_T.

Calculate I.

$I =$ ..... A **[1]**

(b) There is a difference between the reading on the ammeter and the current calculated in **(a)(iv)**.

Explain why there is a difference.

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.....

.....

.....

..... **[3]**

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1 **H** hydrogen 1.0																	2 **He** helium 4.0
3 **Li** lithium 6.9	4 **Be** beryllium 9.0											5 **B** boron 10.8	6 **C** carbon 12.0	7 **N** nitrogen 14.0	8 **O** oxygen 16.0	9 **F** fluorine 19.0	10 **Ne** neon 20.2
11 **Na** sodium 23.0	12 **Mg** magnesium 24.3											13 **Al** aluminium 27.0	14 **Si** silicon 28.1	15 **P** phosphorus 31.0	16 **S** sulfur 32.1	17 **Cl** chlorine 35.5	18 **Ar** argon 39.9
19 **K** potassium 39.1	20 **Ca** calcium 40.1	21 **Sc** scandium 45.0	22 **Ti** titanium 47.9	23 **V** vanadium 50.9	24 **Cr** chromium 52.0	25 **Mn** manganese 54.9	26 **Fe** iron 55.8	27 **Co** cobalt 58.9	28 **Ni** nickel 58.7	29 **Cu** copper 63.5	30 **Zn** zinc 65.4	31 **Ga** gallium 69.7	32 **Ge** germanium 72.6	33 **As** arsenic 74.9	34 **Se** selenium 79.0	35 **Br** bromine 79.9	36 **Kr** krypton 83.8
37 **Rb** rubidium 85.5	38 **Sr** strontium 87.6	39 **Y** yttrium 88.9	40 **Zr** zirconium 91.2	41 **Nb** niobium 92.9	42 **Mo** molybdenum 95.9	43 **Tc** technetium	44 **Ru** ruthenium 101.1	45 **Rh** rhodium 102.9	46 **Pd** palladium 106.4	47 **Ag** silver 107.9	48 **Cd** cadmium 112.4	49 **In** indium 114.8	50 **Sn** tin 118.7	51 **Sb** antimony 121.8	52 **Te** tellurium 127.6	53 **I** iodine 126.9	54 **Xe** xenon 131.3
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57–71 lanthanoids	72 **Hf** hafnium 178.5	73 **Ta** tantalum 180.9	74 **W** tungsten 183.8	75 **Re** rhenium 186.2	76 **Os** osmium 190.2	77 **Ir** iridium 192.2	78 **Pt** platinum 195.1	79 **Au** gold 197.0	80 **Hg** mercury 200.6	81 **Tl** thallium 204.4	82 **Pb** lead 207.2	83 **Bi** bismuth 209.0	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		

57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	59 **Pr** praseodymium 140.9	60 **Nd** neodymium 144.2	61 **Pm** promethium 144.9	62 **Sm** samarium 150.4	63 **Eu** europium 152.0	64 **Gd** gadolinium 157.2	65 **Tb** terbium 158.9	66 **Dy** dysprosium 162.5	67 **Ho** holmium 164.9	68 **Er** erbium 167.3	69 **Tm** thulium 168.9	70 **Yb** ytterbium 173.0	71 **Lu** lutetium 175.0
89 **Ac** actinium	90 **Th** thorium 232.0	91 **Pa** protactinium	92 **U** uranium 238.1	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