OCR
Oxford Cambridge and RSA

Tuesday 10 January 2023 – Afternoon

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C340/2301

C340-1-2301

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

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

0 5 8 4 7 – 0 1

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 **24** pages.

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

Answer **all** the questions.

1 Chemical elements are arranged in groups and periods in the Periodic Table.

Table 1.1 shows some information about four elements **W**, **X**, **Y** and **Z**.

The letters **W** to **Z** are **not** the chemical symbols of the elements.

Table 1.1

Element	Electronic structure	Group number	Period	Proton number
W	2,4	.....	.....	6
X	2,8	.....	2	.....
Y	.....	.....	.....	16
Z	2,8,8,2	.....	.....	.....

(a) (i) Complete **Table 1.1**. **[4]**

(ii) Give the letters of the **two** elements in **Table 1.1** that form a compound with a covalent bond.

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

(iii) Element **Z** reacts with chlorine to form an ionic compound.

Give the name of element **Z** and write the ionic half-equation to show how an atom of element **Z** becomes an ion.

Name of element **Z** .....

Half-equation

.....

[3]

(iv) Sodium has the electronic structure 2,8,1.

Give the formula of the ionic compound formed when sodium reacts with element **Y**.

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

(b) The heaviest isotope of element **W** in **Table 1.1** has an atomic mass number of 14.

(i) Determine the number of neutrons in one atom of this isotope.

number of neutrons ..... **[1]**

(ii) Calculate the nuclear radius, R, of this isotope using the equation:

$R = r_0 A^{1/3}$

where A is the atomic mass number and $r_0 = 1.25 \times 10^{-15}$ m.

Show your working and give your answer to **3** significant figures.

R = ...m **[2]**

(c) Complete the following sentences about forces in the nucleus using words from this list:

attraction	**electromagnetic**	**electrons**	**long**
neutrons	**protons**	**repulsion**	**short**
stable	**strong**	**unstable**	**weak**

You may use each word once, more than once or not at all.

(i) The ..... force is the force of .....

between protons in the nucleus.

[1]

(ii) Radioactive decay occurs when a nucleus is ..... .

In β decay, neutrons are converted into protons by the action of the

..... force within the nucleus.

[1]

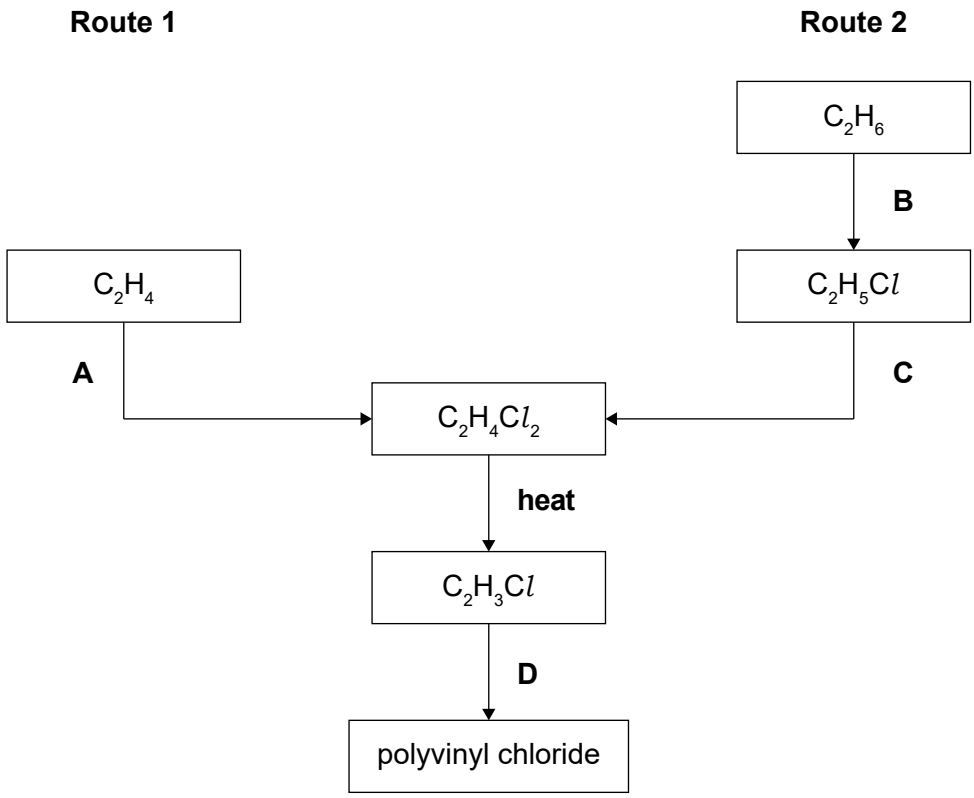
(iii) The ..... force is responsible for holding the protons and neutrons together in the nucleus.

It has a ..... range.

[1]

2 **Fig. 2.1** shows two different routes for the synthesis of polyvinyl chloride (PVC).

Fig. 2.1



(a) The starting molecules in **Route 1** and **Route 2** belong to different families of organic compounds.

Identify the family of organic compounds that each molecule belongs to.

Draw a **straight line** to link each molecule to its family of organic compounds.

Molecule	**Family of organic compounds**
	alcohols
C_2H_4	aldehydes
	alkanes
C_2H_6	alkenes
	alkynes

[2]

(b) (i) Identify the type of reaction labelled as **A** in **Fig. 2.1**.
Tick (✓) **one** box.

addition	☐
condensation	☐
displacement	☐
substitution	☐

[1]

(ii) Identify the type of reaction labelled as **B** in **Fig. 2.1**.
Tick (✓) **one** box.

addition	☐
condensation	☐
displacement	☐
substitution	☐

[1]

(c) (i) In reaction **C**, C_2H_5Cl reacts with chlorine to form $C_2H_4Cl_2$ and one other product.
Write the overall equation for this reaction.

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

(ii) Reaction **C** involves radicals.
Explain what radical means and how a chlorine radical is formed in reaction **C**.

.....

.....

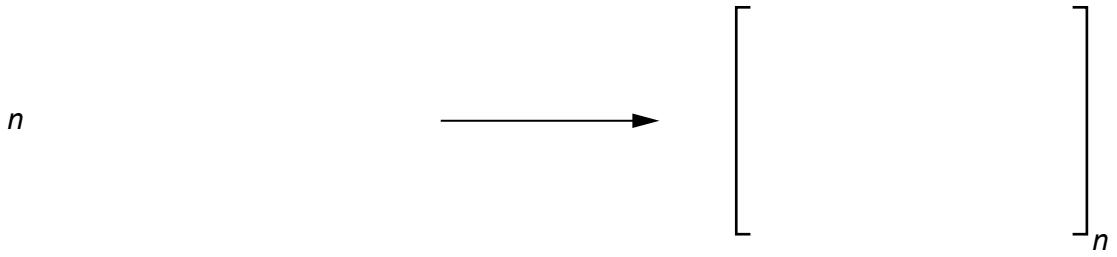
.....

.....

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

(d) Complete the equation in **Fig. 2.2** to show the formation of polyvinyl chloride (reaction **D**).
You must use structural formulae for the reactant and the product in the reaction.

Fig. 2.2



[2]

(e) Ethene, C_2H_4, can also be used to make a polymer.

(i) Give the name of the polymer made from ethene.

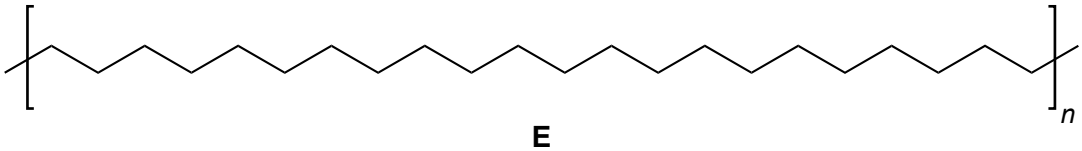
..... **[1]**

(ii) Deduce the empirical formula of the polymer.

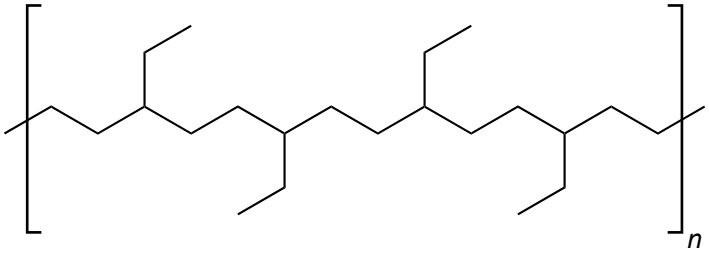
..... **[1]**

(f) **Fig. 2.3** shows the skeletal formulae of two different forms of the polymer made from C_2H_4.

Fig. 2.3



E



F

(i) The two polymers **E** and **F** shown in **Fig. 2.3** are isomers. The value of *n* is the same in both polymers.

Circle the type of isomerism shown by **E** and **F**.

geometric **optical** **structural**

[1]

(ii) One of the structures shown in **Fig. 2.3** is the high density form of the polymer.

State and justify which structure is the high density form of the polymer.

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..... **[4]**

3 **(a)** Eukaryotic cells contain endoplasmic reticulum but prokaryotic cells do not.

Name **two** other organelles present in a eukaryotic cell which are **not** present in a prokaryotic cell.

1 .....

2 .....

[2]

(b) Smooth endoplasmic reticulum is responsible for production and storage of compounds required by the eukaryotic cell.

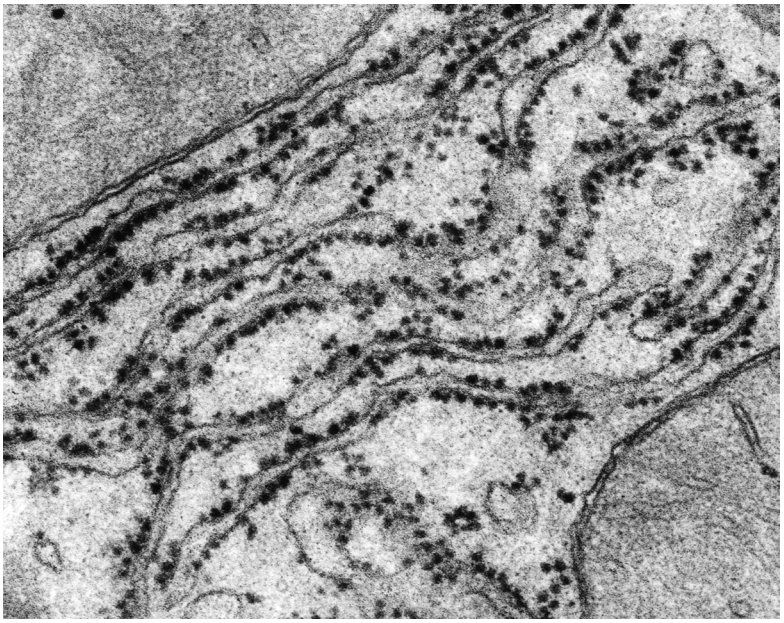
Identify the two compounds produced and stored by the smooth endoplasmic reticulum.

Tick (✓) **two** boxes.

carbohydrate	☐
chlorophyll	☐
lipid	☐
protein	☐
RNA	☐

[2]

(c) The figure below shows a highly magnified image of rough endoplasmic reticulum.
The surface of rough endoplasmic reticulum is covered in black dots.



(i) Identify the black dots in the figure.
Tick (✓) **one** box.

chromosome	☐
lysosome	☐
mesosome	☐
ribosome	☐

[1]

(ii) Describe the function of rough endoplasmic reticulum in a cell.

.....

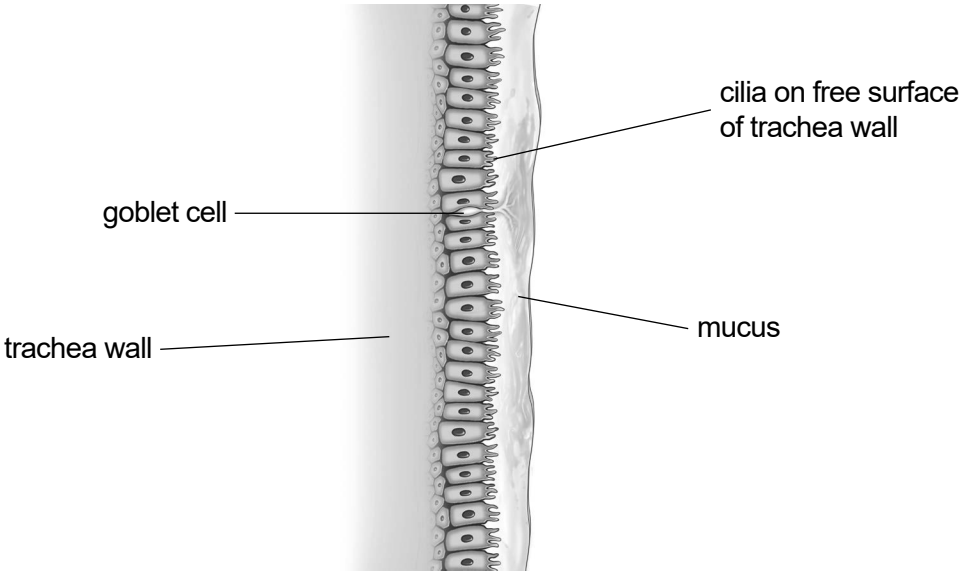
.....

.....

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

(d) Rough endoplasmic reticulum is found in large quantities in some types of epithelial tissue.

The diagram below shows ciliated epithelial tissue lining the inner surface of the trachea (windpipe), leading to the lungs of the human body.



Use the features shown in the diagram to explain how the ciliated epithelial tissue protects the lungs.

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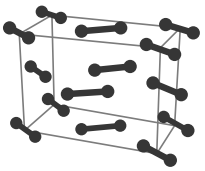
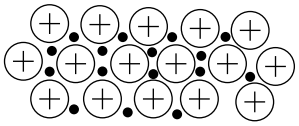
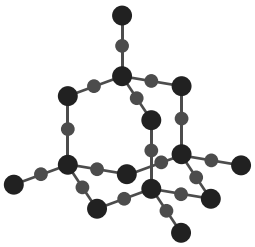
..... **[4]**

4 The melting point of a substance depends mainly on the strength of the forces between the particles: the stronger the forces, the higher is the melting point.

(a) On **Fig. 4.1** draw **a straight line** from each substance to its lattice structure **and a straight line** from each lattice structure to the type of lattice.

Fig. 4.1

Substance	Lattice structure	Type of lattice
copper		giant covalent
silicon dioxide		metallic
iodine		simple molecular

[3]

(b) The melting points of the three substances are shown in **Table 4.1**.

Table 4.1

Substance	Melting point / °C
Copper	1085
Silicon dioxide	1713
Iodine	114

Identify the types of forces present in the three substances shown in **Fig. 4.1** and explain why the substances have different melting points.

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

5 Manganese is an important trace metal for the functioning of the human body.

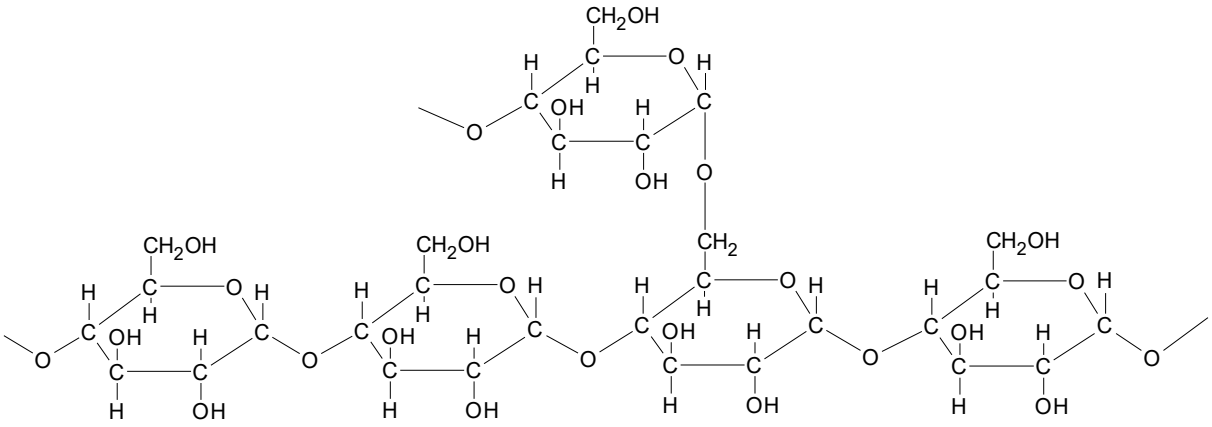
(a) One important biological role of manganese ions is the normal functioning of the liver.

(i) Identify the role of manganese in supporting the liver.
Tick (✓) **one** box.

biosynthesis of choline	☐
breakdown of unwanted amino acids	☐
maintenance of an isotonic balance	☐
transportation of oxygen	☐

[1]

(ii) One of the functions of the liver is to store glucose as glycogen.
The figure below shows part of the glycogen molecule, which is formed from glucose.



Use the figure to explain how glycogen is formed.

Your answer should include reference to the reaction and the type of link formed.

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

(iii) Glucose is a monosaccharide but when two molecules combine a disaccharide is formed.

Circle the disaccharide formed from two glucose molecules.

lactose **maltose** **sucrose**

[1]

(iv) The polysaccharide, glycogen, acts as an energy source in the human body.

Give the name of a **different** polysaccharide found in plants, which also acts as an energy source.

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

(b) Manganese is important for the maintenance of bones.

(i) Give **two** functions of bone within the human body.

1 .....

2 .....

[2]

(ii) Describe the composition of bone and the role of manganese in the formation of bone.

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..... **[4]**

(c) Metals are only required in trace amounts by the human body.

The intake of manganese for an adult should not exceed 10 mg per day.

The table below shows a range of food types that contain manganese.

Food type	Mass of one portion / g	Manganese content in one portion / mg
Almonds	95	2.2
Brown rice	195	1.8
Pinto beans	171	0.8
Spinach	30	0.3

Of the four food types shown in the table, almonds have the highest percentage by mass of manganese per portion.

(i) If an adult were to eat 500 g of almonds in a day, they would consume more than 10 mg of manganese.

Use the data in the table to calculate the mass in mg of manganese that would be consumed from eating 500 g of almonds.

Give your answer to **2** decimal places.

mass = ...mg **[2]**

(ii) Identify the food type that contains the **lowest percentage** by mass of manganese in one portion.

You must show your calculation of the percentage of manganese in each food type to support your answer.

Brown rice	Pinto beans	Spinach

Food type with lowest percentage by mass of manganese in one portion:

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

6 **(a)** Copper, iron and platinum ions are all components of compounds which are important in living systems.

(i) Draw a **straight line** to link each metal ion to the compound that it is found in.

Metal ion	Compound
Cu^{2+}	cisplatin
Fe^{3+}	haemocyanin
Pt^{2+}	myoglobin

[2]

(ii) Name **one** function of cisplatin.

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

(iii) Haemocyanin carries oxygen in some organisms.

Identify the type of organism which can use haemocyanin for this purpose.

(Circle) the correct answer.

fungus **human** **invertebrate** **plant**

[1]

(b) Metal ions are also essential components of some enzymes.

(i) Give the general name for a component that is required for an enzyme to function.

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

(ii) Nickel (II), Ni^{2+}, is one type of metal ion needed for enzyme function.

Identify the nickel-containing enzyme from the list below.

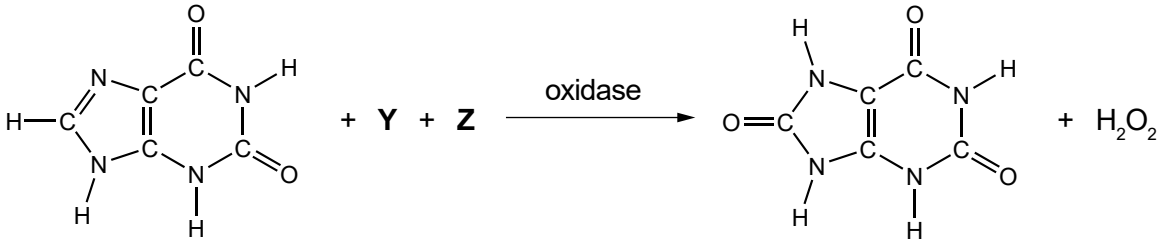
Tick (✓) **one** box.

amylase	☐
cellulase	☐
hydrogenase	☐
lipase	☐

[1]

(iii) Enzymes have many different functions.

The equation below shows one reaction that is catalysed by the enzyme oxidase.



Write the **formulae** of the two molecules that are represented by **Y** and **Z** in the equation.

Y = ...

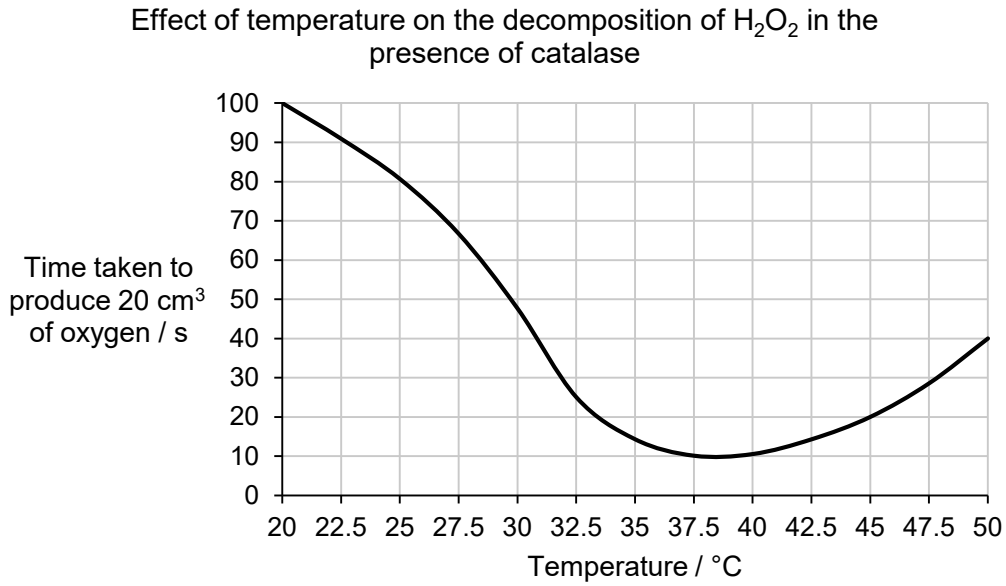
Z = ...

[2]

(iv) The enzyme, catalase, has a very different function in living things. It catalyses the decomposition of hydrogen peroxide to produce water and oxygen.

A biology student is investigating the effect of temperature on the decomposition of hydrogen peroxide in the presence of catalase.

- The student measures the time taken to collect 20 cm^3 of oxygen at 20 °C.
- They repeat the experiment at different temperatures ranging from 20 °C to 50 °C.
- They then plot a graph of time taken to collect 20 cm^3 of oxygen against temperature. The graph is shown below.



Describe and explain the data shown in the graph.

You should refer to the shape of the graph in your answer.

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..... **[6]**

7 Metals are good electrical conductors because they have high charge carrier densities.

In a metal, the charge carrier density, n, is the number of free electrons per m^3. The value of n can be calculated using the equation:

$$n = \frac{I}{Avq}$$

where I is the current, A is the area of a cross-section of the conductor, v is the drift velocity of the electrons in the conductor and q is the charge on an electron.

The current I in a 1.0 m length of wire made from silver is 2.0 A.

The cross-sectional area A of the wire is 5.0×10^{-7} m^2.

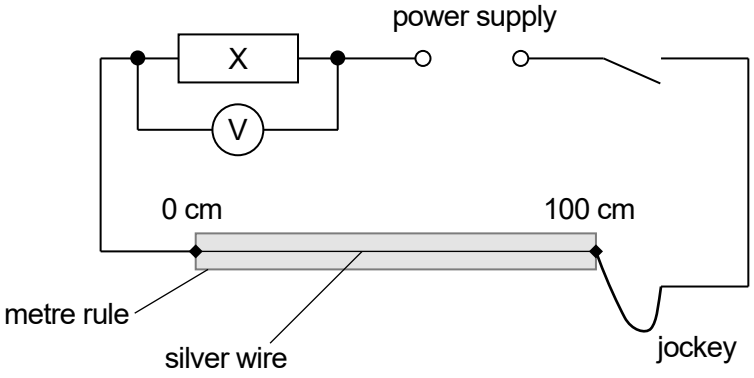
The drift velocity v of the electrons in the wire is 4.3×10^{-4} m s^{-1}.

The charge q on an electron is 1.6×10^{-19} C.

(a) Calculate the value of n.

n = ... per m^3 **[2]**

(b) The silver wire is attached to a metre rule and connected in series with a power supply, a switch and a resistor X as shown in the circuit below.



The jockey is a sliding contact which may be connected at different points along the length of the silver wire.

When the switch is closed there is a reading of 4.0 V on the voltmeter.

(i) Calculate the resistance of the resistor X.

Resistance of X = ...Ω **[2]**

(ii) Calculate the power dissipated in the resistor X.

Power dissipated = ... W **[2]**

(iii) The jockey is detached from the silver wire and re-attached at the 50 cm mark on the metre rule.

Explain why the drift velocity of the electrons in the wire increases.

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

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown in the margin – for example, 3(d) or 5(b)(ii).

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