

Wednesday 17 May 2023 – Morning

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours

C340/2306



You must have:

- the Data Sheet
- a ruler (cm/mm)

You can use:

- a scientific or graphical calculator
- an HB pencil



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

Centre number

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Candidate number

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First name(s)

Last name

Date of birth

D	D	M	M	Y	Y	Y	Y
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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 **28** pages.

ADVICE

- Read each question carefully before you start your answer.

- 1 The table shows some of the atomic properties of elements **Q**, **R**, **S** and **T** in the Periodic Table.

The letters **Q** to **T** are **not** the chemical symbols of the elements.

Element	Electron configuration	Group number	Proton number	Relative atomic mass
Q	2,1	.....	3	.....
R	.....	3	.....	27.0
S	2,8,4	.....	.....	28.1
T	.....	1	19	.....

- (a) Use the Periodic Table to complete the table. [4]

- (b) (i) Give the name of the element in period 5 which is in the same group as element **T**.

..... [1]

- (ii) Element **T** forms an ionic bond with chlorine.

Describe how this ionic bond is formed.

.....

 [2]

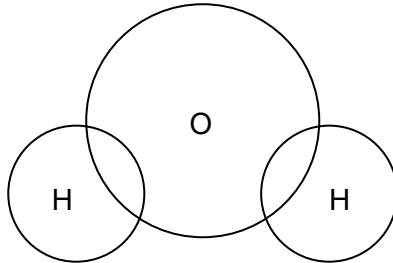
- (iii) Give **two** reasons why chlorine, bromine and iodine are placed in the same group in the Periodic Table.

1
 2 [2]

(c) Water is a covalent compound.

(i) Draw the dot-and-cross diagram to show the bonding in water by completing the figure below.

Show outer electrons only.



[2]

(ii) Water is an example of a polar solvent.

Explain why water is polar.

.....

.....

..... [1]

(d) The heaviest isotope of hydrogen is called tritium. Its symbol is ${}^3_1\text{H}$.

Tritium is radioactive and decays to form helium-3, ${}^3_2\text{He}$.

(i) Name the type of nuclear force which allows a tritium nucleus to decay.

..... [1]

(ii) Tritium and helium-3 nuclei both have three nucleons.

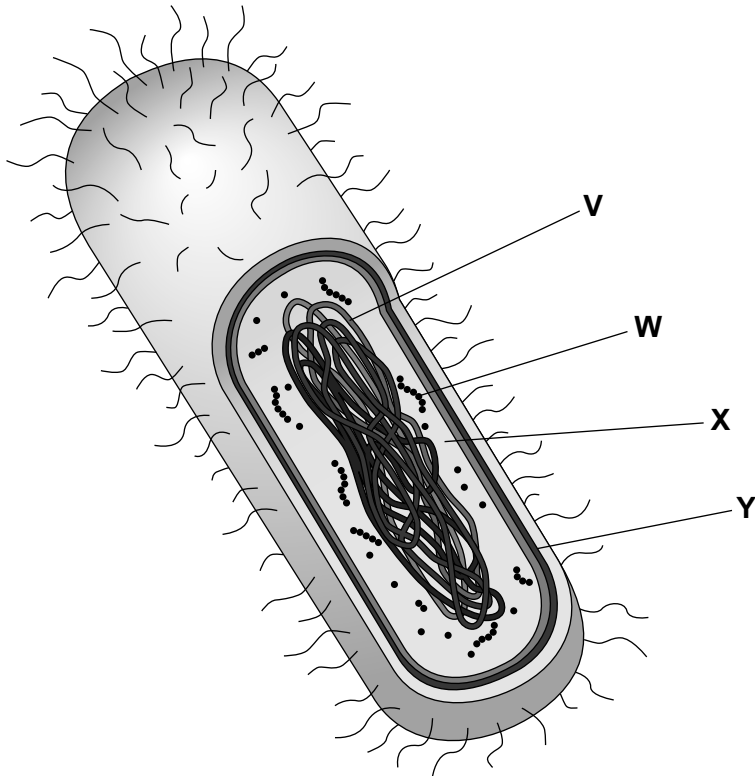
Explain in terms of the nucleons present why they are different elements.

.....

.....

..... [2]

2 (a) The diagram shows a bacterial cell, *Bacillus coagulans*.



(i) Identify **V**, **W**, **X** and **Y** in the diagram from the following list.

- | | | | |
|------------------|------------------|------------|-----------------|
| cell wall | cytoplasm | DNA | ribosome |
|------------------|------------------|------------|-----------------|

V =

W =

X =

Y =

[2]

(ii) *Bacillus coagulans* is a prokaryotic cell.

Give **one** piece of evidence from the diagram which supports the fact that *Bacillus coagulans* is a prokaryotic cell.

.....

..... [1]

(b) The genetic information held within DNA is copied by the processes of transcription and translation.

(i) Draw straight lines to connect each process with the correct molecule formed.

Process	Molecule formed
	carbohydrate
transcription	lipid
	mRNA
translation	protein
	tRNA

[2]

(ii) DNA is also found in eukaryotic cells.

The DNA in a eukaryotic cell is different from the DNA in a prokaryotic cell.

For a **eukaryotic cell**, describe:

- where the DNA is located
- the form in which DNA is found
- how the DNA is prevented from moving freely around the cell.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(iii) State the function of the nucleolus found in eukaryotic cells.

..... [1]

(c) In eukaryotic organisms, a unique combination of DNA is formed during the process of sexual reproduction.

This takes place when a female sex cell is fertilised by a male sex cell.

(i) What name is given to a sex cell?

Tick (✓) **one** box.

- erythrocyte
- gamete
- neuron
- osteocyte

[1]

(ii) The reproductive organs that produce sex cells are known as gonads.

Choose the correct words from the list to complete the sentences below.

- oocytes** **ovaries** **sperm** **testes**

Male gonads are known as

Female gonads produce

[2]

(d) Connective tissue is found in male and female gonads.

(i) State the name of **one** of the two types of fibres in connective tissue.

..... [1]

(ii) The connective tissue fibres are produced by a special type of cell.

Give the name of this cell.

..... [1]

(iii) Suggest a function of connective tissue in the gonads.

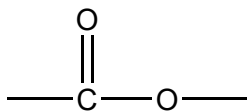
..... [1]

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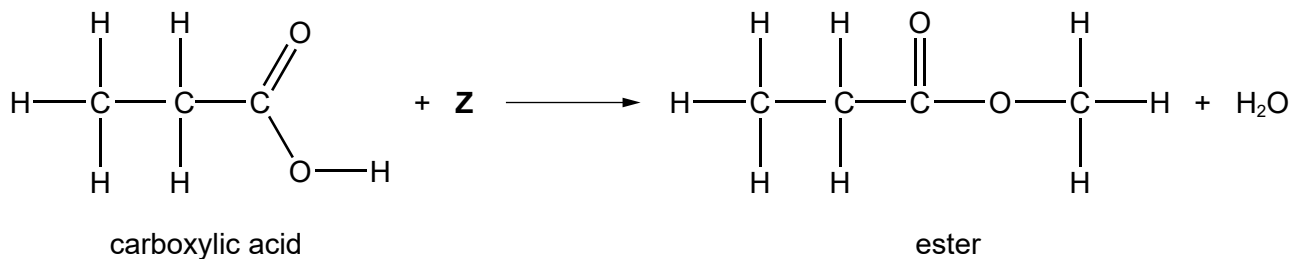
Turn over for the next question

- 3 Esters are organic compounds of commercial and biological importance and have the functional group:



- (a) Fig. 3.1 shows an equation for the reaction of a carboxylic acid to form an ester.

Fig. 3.1



- (i) Identify the type of organic compound represented by **Z** in Fig. 3.1.

Tick (✓) **one** box.

alcohol

aldehyde

alkyne

ketone

[1]

- (ii) Give the name of the ester in Fig. 3.1.

Tick (✓) **one** box.

ethyl methanoate

ethyl propanoate

methyl propanoate

propyl methanoate

[1]

(iii) The ester in **Fig. 3.1** has the molecular formula $C_4H_8O_2$ and has other structural isomers.

Draw the structural formula for one isomer that is a carboxylic acid and one isomer that is a **different** ester.

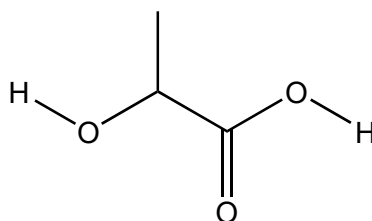
carboxylic acid
ester

[3]

- (b) Lactic acid is a naturally occurring carboxylic acid which is used to produce the polymer polylactate.

The skeletal formula of lactic acid is shown in **Fig. 3.2**.

Fig. 3.2



Lactic acid shows optical isomerism because it has a chiral centre.

- (i) Draw a **circle** round the chiral centre in **Fig. 3.2** and explain why it is a chiral centre.

.....
 [2]

- (ii) There are two optical isomers of lactic acid.

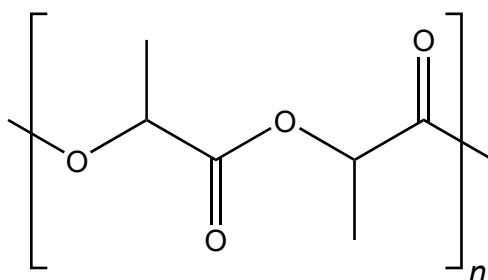
Describe the difference between the two optical isomers.

.....

 [1]

- (iii) Polylactate is a type of polymer known as a polyester. The skeletal formula of two units of polylactate is shown in **Fig. 3.3**.

Fig. 3.3

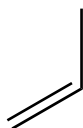


- Circle** the ester link in **Fig. 3.3** to show that polylactate is an example of a polyester.

[1]

- (iv) Polylactate is increasingly being used to replace plastics derived from crude oil such as polypropene.

The skeletal formula of propene is shown below.



Draw the skeletal formula of **two** units of polypropene.



[1]

- (v) Polylactate and polypropene are formed by different types of polymerisation reaction. Identify the type of reaction that forms each polymer.

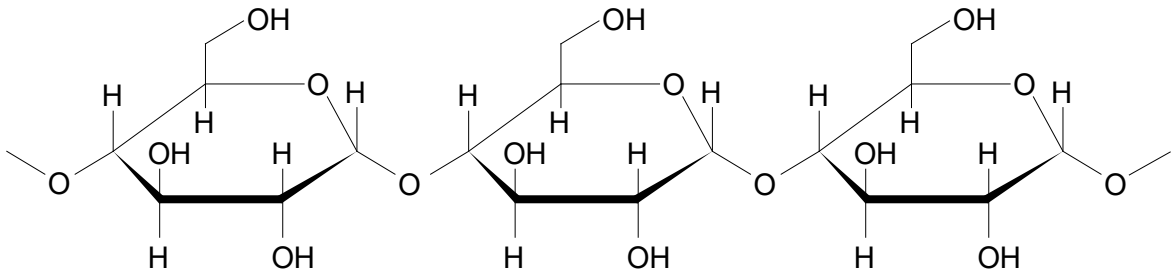
Polylactate

Polypropene

[2]

(c) Lactic acid is made from fermented plant starch.

Part of the structure of starch is shown below.



(i) The first stage of the fermentation process involves the breakdown of starch into its monomers.

Identify the name of the monomer formed from this process.

Tick (✓) **one** box.

fructose

glucose

lactose

sucrose

[1]

(ii) Starch has a specific function within a plant.

State the main function of starch.

..... [1]

(d) Lipids are biological molecules which also contain an ester group.

Lipids form part of the myelin sheath in the human body.

Explain the function of the myelin sheath.

.....

.....

.....

.....

.....

..... [3]

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Turn over for the next question

4 Inorganic compounds play an important role in biological processes.

(a) Choose the correct words from the list to complete the sentences below.

degradation

hydrolysis

metabolism

photolysis

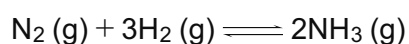
Hydrogen peroxide is produced during the of organic molecules, such as amino acids.

Hydrogen peroxide is removed by in the liver.

[2]

(b) Potassium nitrate is an important fertiliser.

(i) The first stage in its manufacture is the Haber Process in which nitrogen from the air is reacted with hydrogen. The reaction is carried out in the presence of an iron catalyst as shown in the equation.



State one economic benefit of using a catalyst and explain how a catalyst increases the rate of reaction.

Benefit

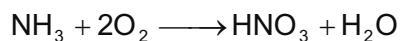
.....

Explanation of how a catalyst increases reaction rate

.....

[3]

(ii) Ammonia is then converted to nitric acid as shown in the equation.



What type of reaction is shown in the equation?

Tick (✓) **one** box.

addition

condensation

displacement

redox

[1]

(iii) Nitric acid is then converted into potassium nitrate for use in inorganic fertilisers.

What is the formula of potassium nitrate?

Tick (✓) **one** box.

P_2NO_2

KNO_2

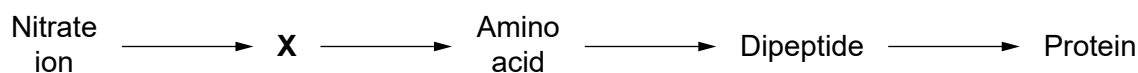
KNO_3

PNO_3

[1]

(c) Plants absorb nitrates from the soil and use these to make proteins.

The equation shows the stages which occur when a plant converts nitrates into proteins.



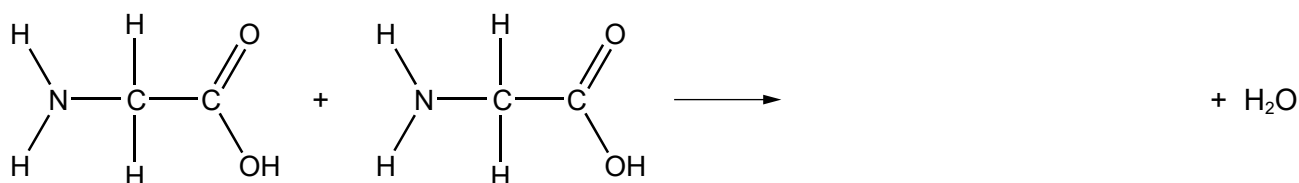
(i) Give the name of the ion **X** in the process.

..... [1]

(ii) Glycine is an amino acid. It has the formula $\text{H}_2\text{NCH}_2\text{COOH}$.

Complete the equation to show the structure of the dipeptide produced when two glycine molecules react together.

Your dipeptide structure should clearly show the peptide link.



[2]

(iii) Give **one** function of proteins in plant cells.

..... [1]

(d) Phosphorus is often found as phosphates in living things. Phosphates have important structural functions in DNA and in phospholipids.

(i) Phosphates create a structural bridge in DNA.

Identify the correct structural sequence involving phosphate within DNA.

Tick (✓) **one** box.

base – phosphate – base

base – phosphate – sugar

sugar – phosphate – base

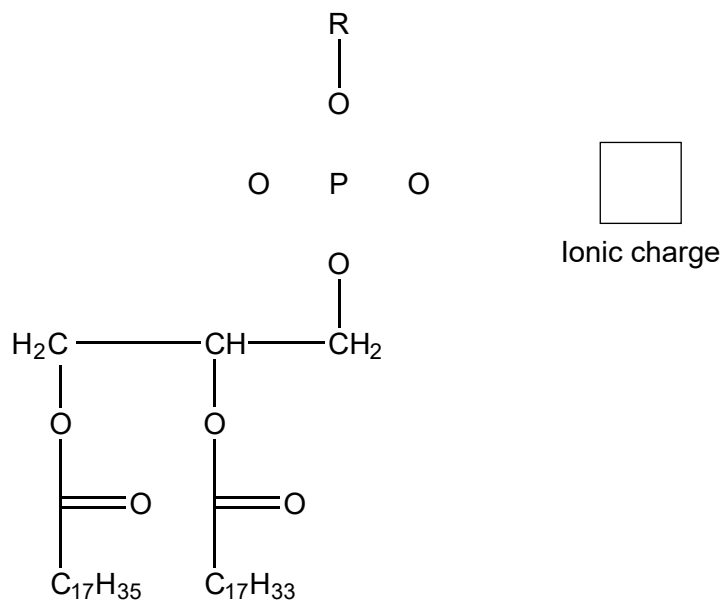
sugar – phosphate – sugar

[1]

(ii) The diagram shows the incomplete structure of a phospholipid.

Complete the diagram of the phospholipid by:

- drawing in the bonds between the phosphorus and oxygen atoms
- writing in the ionic charge in the box next to the structure.



[2]

(iii) The R group in the phospholipid in the diagram is called choline.

Identify the metal ion that is involved in the biosynthesis of choline.

Tick (✓) **one** box.

calcium ion

lithium ion

manganese ion

nickel ion

[1]

(iv) Phospholipids form bilayers in cellular membranes.

These membranes are surrounded on either side by a fluid which consists mainly of water.

Choose the correct words from the list to complete the sentences below.

cellulose DNA hydrophilic hydrophobic inside middle
non-polar outside polar protein uncharged

The bilayer of phospholipids is permeable to molecules that are small and

.....

The phosphate head of each phospholipid molecule is facing the

..... of the cell membrane.

This is because the phosphate head is

The phospholipid bilayer also containsmolecules.

[3]

5 A useful measure of the strength of a material is its stiffness, S .
Stiffness is the ratio of the Young's Modulus of the material to the density of the material.
 S is calculated using the equation:

$$S = \frac{E}{\rho}$$

where E is the Young's Modulus of the material and ρ is its density.

The table shows the values of E and ρ for an alloy of aluminium and an alloy of steel.

	aluminium alloy	steel alloy
Young's Modulus E (N m^{-2})	71×10^9	190×10^9
Density ρ (kg m^{-3})	2820	7980

Use calculations to compare the stiffness (S), density (ρ) and Young's Modulus (E) of these alloys and explain which alloy is more suitable for making a racing bike handlebar as shown below.

[6]



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- 6 (a) A mixture is a substance in which the particles of one component are dispersed throughout the other.

(i) Types of mixture include:

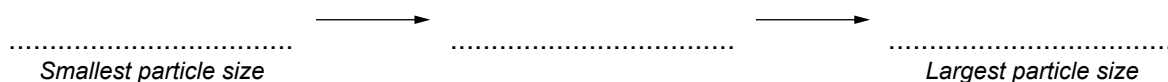
colloids

solutions

suspensions

Write the name of each of the three mixture types to complete the figure below.

Put them in order of **increasing** particle size of the dispersed component.



[1]

- (ii) Colloids are classified according to the physical states of the dispersed phase and the disperse medium.

Draw straight lines to connect each description to the type of colloid.

Description

Type of colloid

gas dispersed in a liquid

aerosol

emulsion

foam

liquid dispersed in a gas

gel

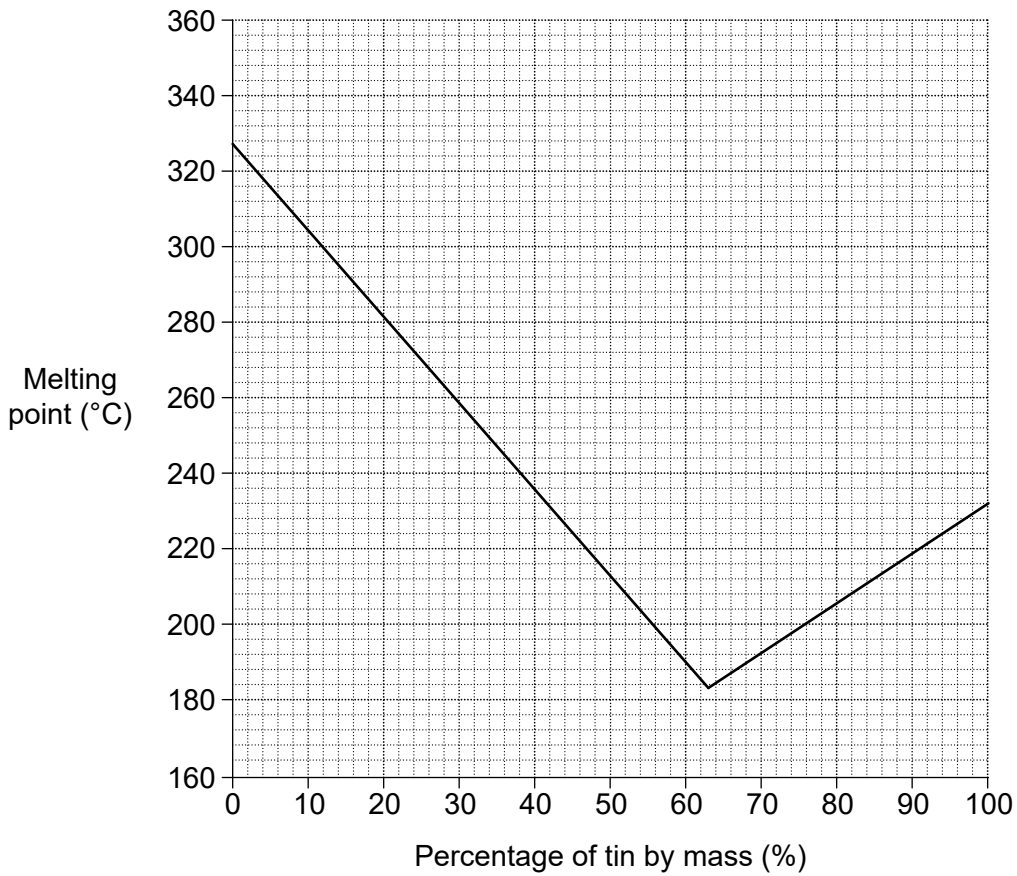
sol

[2]

(b) Alloys such as solder are mixtures of metals.

Solder is a mixture of lead and tin.

The graph shows how the melting point of solder changes as the percentage by mass of tin in the mixture is increased.



(i) Describe what happens to the melting point of solder as the percentage of tin in the mixture is increased.

You should refer to the graph in your answer.

.....

.....

.....

.....

.....

..... [2]

(ii) Use the graph to estimate:

- the melting point of a solder which contains 50% by mass of tin.

Melting point = °C

- another percentage of tin which gives a mixture with the **same** melting point as a mixture containing 50% by mass of tin.

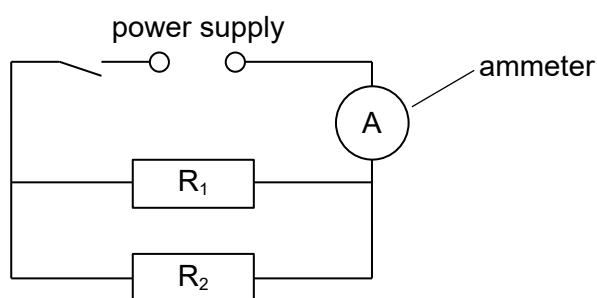
Percentage of tin =%
[2]

(iii) Use the graph to calculate the mass of tin that would need to be mixed with 7.2 g of lead to create a solder that melts at 280 °C.

Show your working and any readings that you have taken from the graph.

Mass of tin =g **[3]**

- 7 (a) Two resistors, $R_1 = 22 \Omega$ and $R_2 = 47 \Omega$ are connected in parallel and attached to a dc power supply as shown below.



You may need the following equations to answer the questions.

Potential difference (V) = current (A) \times resistance (Ω)

Charge transferred (C) = current (A) \times time (s)

Energy transferred (J) = charge (C) \times potential difference (V)

Resistors in parallel $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

- (i) Calculate the combined resistance R_t of resistors R_1 and R_2 .
Give your answer to **2** significant figures.

$$R_t = \dots\dots\dots \Omega \text{ [2]}$$

- (ii) When the switch is closed there is a current of 0.30 A in the ammeter.
Calculate the potential difference across the power supply.

$$\text{potential difference} = \dots\dots\dots \text{ V [1]}$$

(iii) The switch is closed for 1 minute and then opened.

Calculate the charge transferred in R_2 and give the name of the unit of charge.

Charge transferred in R_2 =

Name of unit =

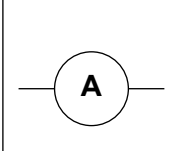
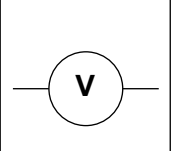
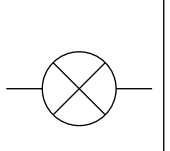
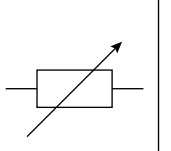
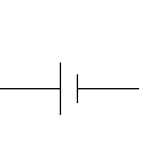
[3]

(iv) Calculate the energy transferred in R_2 in one minute.

Energy transferred in R_2 =J **[1]**

- (b) Draw a circuit diagram which could be used to investigate how the resistance of a filament lamp changes with current.

You will need to use the circuit symbols shown below.

				
Ammeter	Voltmeter	Lamp	Variable Resistor	Cell

[2]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

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

A vertical line on the left side of the page is followed by 25 horizontal dotted lines, providing a ruled area for writing answers.

The Periodic Table of the Elements

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(0)
1 1 H hydrogen 1.0	2 3 4 Li lithium 6.9	5 6 7 8 9 10 11 12 Na sodium 23.0	13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 K potassium 39.1	37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57-71 lanthanoids	58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89-103 actinoids	89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 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