

Tuesday 12 January 2021 – Afternoon

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours

C340/2101



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.

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 **24** pages.

ADVICE

- Read each question carefully before you start your answer.

FOR EXAMINER USE ONLY	
Question No	Mark
1	/14
2	/14
3	/12
4	/15
5	/11
6	/6
7	/9
8	/9
Total	/90

Answer **all** the questions.

1 Elements can be identified by their atomic structure.

Table 1.1 shows the atomic structure of some elements, **V**, **W**, **X** and **Y**.

The letters **V**, **W**, **X** and **Y** are not the chemical symbols of the elements.

Element	Electronic structure	Neutron number	Nucleon number (atomic mass number)	Proton number
V	.....	10	19	.....
W	2,8,2	12	.....	12
X	2,8,4	.....	28	14
Y	.....	18	35	17

Table 1.1

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

(ii) Which **two** elements, **V**, **W**, **X** or **Y** are in the same Group of the Periodic Table?

..... and

[1]

(iii) Use the information in **Table 1.1** and the Periodic Table to deduce the chemical symbols of **W** and **Y**.

W.....

Y.....

[1]

(iv) What is the formula of the compound formed by elements **W** and **Y**?

.....[1]

- (v) State the type of bonding between **W** and **Y**, and the charges on their ions by completing the sentences using the words below.

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

attraction ionic negative positive sharing

The type of bonding between **W** and **Y** is

In the compound that is formed, **W** is a ion and

Y is a ion.

[2]

- (b) (i) Use nuclear notation to indicate the symbol of **X**, and its atomic number and mass number.

[2]

- (ii) The nucleus of **Y** has more protons and neutrons than the nucleus of **V**.

Compare the strength of the attractive and repulsive forces within the nuclei of **Y** and **V**.

Explain why both nuclei are stable.

.....

 [3]

2 Carbon compounds containing chlorine have many uses, but they are also known to cause problems for the environment.

(a) Chlorofluorocarbons (CFCs) in the upper atmosphere can destroy the ozone (O_3) layer.

The first two reaction steps in the breakdown of O_3 are outlined in **Table 2.1**.

Step	Reaction
1	$CF_3Cl \rightarrow CF_3 + Cl$
2	$Cl + O_3 \rightarrow ClO + O_2$

Table 2.1

(i) **Step 1** and **Step 2** involve free radicals.

Identify **three formulae** in **Table 2.2** that are free radicals.

Tick (✓) **three** boxes.

Formula	Free radical
CF_3Cl	
CF_3	
Cl	
O_3	
ClO	
O_2	

Table 2.2

[3]

(ii) Ultraviolet radiation from the Sun is needed to start **Step 1** in **Table 2.1**.

Suggest how ultraviolet radiation can increase the rate of reaction in **Step 1**.

.....

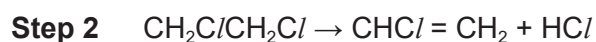
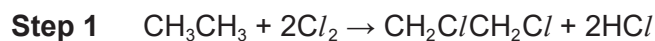
.....

.....

.....

[2]

- (b) Chloroethene is a useful organic compound and has the formula $\text{CHCl} = \text{CH}_2$.
Chloroethene is made from ethane in two reaction steps.



- (i) Identify the type of reaction shown in **Step 1**.

Tick (✓) **one** box.

Addition

Substitution

Oxidation

Reduction

[1]

- (ii) $\text{CH}_2\text{Cl}/\text{CH}_2\text{Cl}$ has a structural isomer.

Draw the structural formula for the isomer of $\text{CH}_2\text{Cl}/\text{CH}_2\text{Cl}$.

[1]

- (iii) $\text{CH}_2\text{Cl}/\text{CH}_2\text{Cl}$ and $\text{CHCl} = \text{CH}_2$ do not have geometrical isomers.

Give **one** reason why each molecule does **not** have geometrical isomers.

$\text{CH}_2\text{Cl}/\text{CH}_2\text{Cl}$

.....

$\text{CHCl} = \text{CH}_2$

.....

.....[2]

(c) Polyvinyl chloride is a polymer that can be made by the addition of many monomers of $\text{CHCl} = \text{CH}_2$.

(i) What is the empirical formula of polyvinyl chloride?

Tick (✓) **one** box.

CHCl

CH₂Cl

C₂H₂Cl

C₂H₃Cl

[1]

(ii) Draw a section of polyvinyl chloride which contains **three** repeat units.

[1]

(iii) Polylactate is a different type of polymer compared to polyvinyl chloride.

The structural formula for the repeat unit of polylactate is shown in **Fig. 2.1**.

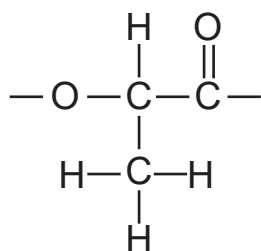


Fig. 2.1

Explain how the monomer and the polymerisation reaction that forms polylactate are **different** to those of polyvinyl chloride.

Difference in monomers

.....

Difference in polymerisation reactions.....

.....

.....

.....

[3]

3 Bone is a type of tissue found in the human body.

(a) An osteocyte is a specialised cell which is found in bone tissue.

Fig. 3.1 shows a diagram of an osteocyte.

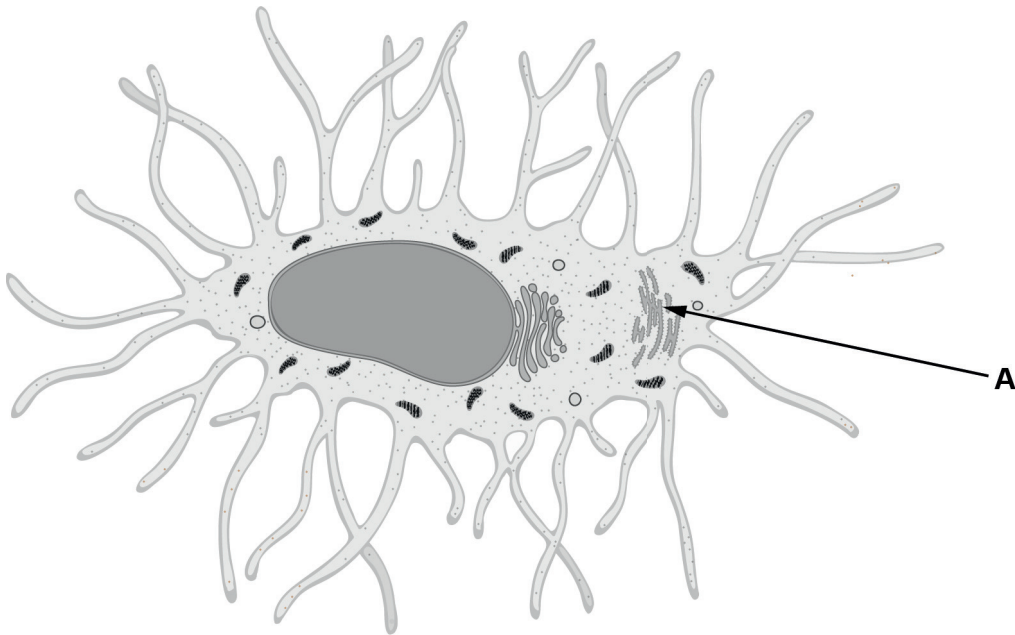


Fig. 3.1

(i) Give the name of the organelle labelled **A** in Fig. 3.1.

.....[1]

(ii) Organelle **A** can either appear as rough or smooth when observed on an electron micrograph.

Complete the following sentences.

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

carbohydrate	chloroplasts	DNA	lipid
mitochondria	protein	RNA	ribosomes

The rough type of organelle **A** has attached.

This means that the rough type is involved in synthesis.

However, the smooth type of organelle **A** is the site of and

..... synthesis.

[3]

(b) A key function of bone tissue is mineral ion storage.

(i) Which mineral ion is stored and used to form the matrix in bone tissue?



Put a **ring** around the correct answer.

- Ca²⁺** **K⁺** **Na⁺** **Ni²⁺**

[1]

(ii) Osteoporosis is a condition that affects bones.

The images in **Fig. 3.2** show normal bone and bone with osteoporosis.

Key
 = bone matrix
 = pores or gaps in bone matrix

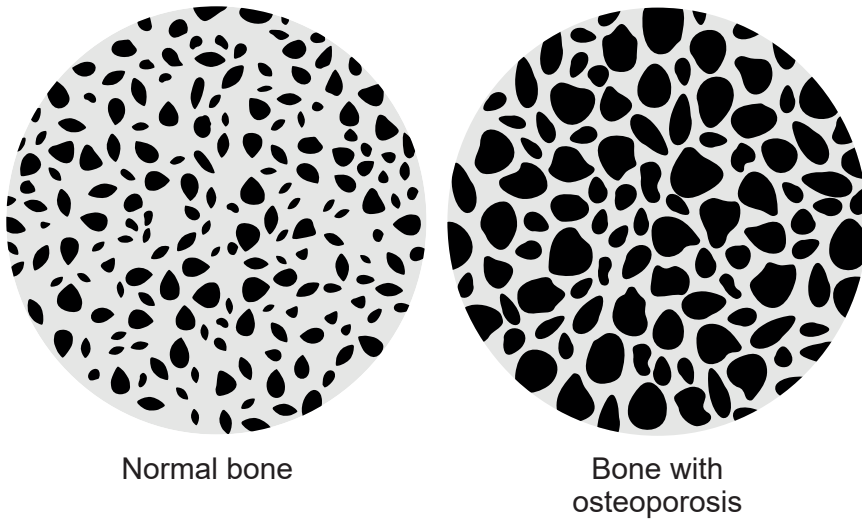


Fig. 3.2

Use **Fig. 3.2** to suggest the link between osteoporosis and the mineral ion identified in **(b)(i)**, and the effect of osteoporosis on bone function.

Link

.....

Effect

.....

.....

.....

[3]

- (c) Magnesium is another mineral ion needed for healthy bones.

It can be taken into the body via magnesium oxide supplements or in foods with a high amount of magnesium.

Table 3.1 shows some foods and the amount of magnesium that they contain.

Food	Amount of magnesium (mg per 100 g portion)
Almonds	300
Banana	29
Brazil nuts	225
Pumpkin seeds	532
Spinach	80

Table 3.1

- (i) The recommended daily amount of magnesium is **320 mg** for women.

A woman eats four 100 g portions of **one** of the foods in **Table 3.1**.

Using the information in **Table 3.1**, identify which food she would need to eat to meet her recommended daily amount of magnesium.

Food = [1]

- (ii) The recommended daily amount of magnesium is **420 mg** for men.

A man eats a 50 g portion of almonds.

Using the information in **Table 3.1**, calculate how much more magnesium a man would need to reach his recommended daily amount.

Amount of magnesium needed = mg [2]

- (d) Some enzymes need metal ions, such as magnesium, so that they can function.

What is the role of metal ions in enzyme function?

.....[1]

4 Carboxylic acids are a family of organic compounds with the functional group -COOH .

(a) Butanoic acid ($\text{C}_4\text{H}_8\text{O}_2$) has a hydrocarbon chain and a -COOH group.

Draw the structural formula for butanoic acid, showing all the bonds.

[1]

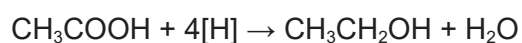
(b) Ethanoic acid, CH_3COOH , reacts with sodium hydroxide to form a salt and water.

Complete the equation for this reaction.



[2]

(c) Ethanoic acid can be reduced to other organic compounds.



What type of organic compound is formed?

Tick (\checkmark) **one** box.

Alcohol

Aldehyde

Alkyne

Ketone

[1]

(d) Fatty acids are carboxylic acids with a long hydrocarbon chain.

Fatty acids are found in the human body.

Fatty acids react with glycerol to form a lipid. A lipid contains one or more ester groups.



Fig. 4.1

(i) Draw the structural formula of a lipid that forms from the reaction of glycerol and **one** molecule of the fatty acid shown in **Fig. 4.1**.

Clearly show the structure of the ester group.

[2]

(ii) The lipid drawn in (d)(i) is also known as a monoglyceride.

State how a triglyceride is different from a monoglyceride.

.....[1]

(iii) State what is released when lipids are broken down to reform glycerol and fatty acids.

.....[1]

(iv) Explain the importance of lipids for nerve transmission in the human body.

.....

[2]

(v) Give **one** other function of lipids in the human body.

.....[1]

- (e) Sundip is a science student. She is studying the effect of temperature on the rate of reaction between a fatty acid and glycerol.

She chooses two temperatures: Temperature 1 and Temperature 2.

She plots a graph of her results for both temperatures.

The graph is shown in **Fig 4.2**.

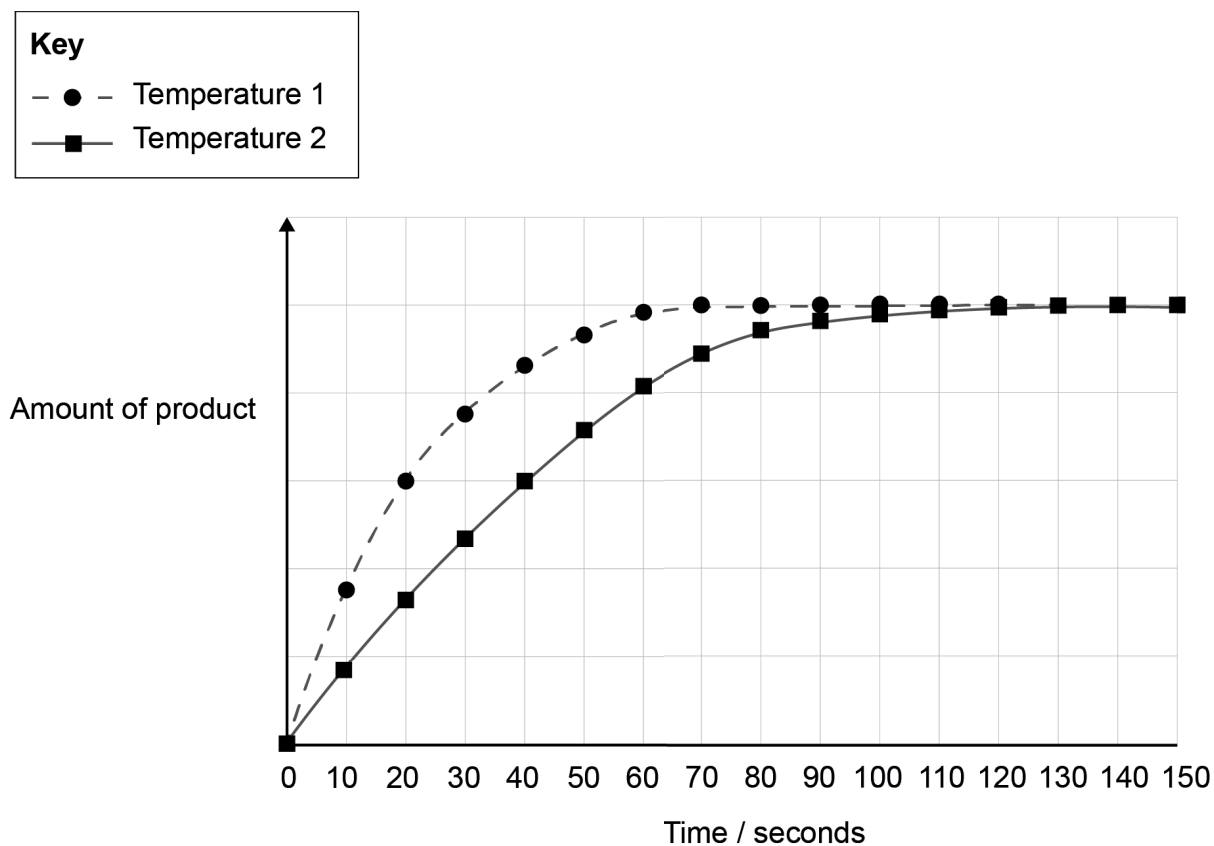


Fig. 4.2

- (i) Use the graph to deduce which temperature is higher, giving reasons for your answer.

.....

.....

.....

..... [2]

- (ii) Explain the effect of temperature on the rate of reaction.

.....

.....

.....

..... [2]

5 Phosphate is a component of phospholipids DNA and RNA.

- (a) Phospholipids are an essential part of the membranes found around organelles in cells, such as the nuclear envelope.

Complete the following sentences.

Use the words from the list. You may use each word once, more than once, or not at all.

double **eukaryotic** **flexible** **photosynthetic**
porous **prokaryotic** **single** **triple** **thin**

The nuclear envelope surrounds the nucleus and consists of a membrane.

The membrane is to allow protein molecules to be transported across the nuclear envelope.

The presence of a nuclear envelope indicates that the type of cell is

.....

[3]

- (b) Name **one** membrane-bound organelle found in cells, other than the nucleus.

.....[1]

- (c) DNA and RNA are nucleic acids.

They are made of nucleotides.

Each nucleotide contains a phosphate, a sugar and a base.

- (i) Identify the correct phosphate link between nucleotides.

Tick (✓) **one** box.

Base – Phosphate – Base

Base – Phosphate – Sugar

Sugar – Phosphate – Base

Sugar – Phosphate – Sugar

[1]

- (ii) The bases found in some nucleotides can pair with other bases.

Draw a line to link **Base 1** with its complementary **Base 2**.

Base 1	Base 2
	Adenine
Guanine	Cytosine
Thymine	Guanine
	Thymine

[2]

- (iii) Although the phosphate group is always the same, the sugars and bases are different in DNA compared to RNA.

Complete the table to compare the sugars and bases found in **DNA** and **RNA**.

Feature	DNA	RNA
Type of sugar found		
Four bases found		

[4]

(b) An important property of a metal is its strength to weight ratio.

This is a number which can be calculated by dividing the strength (in MPa) of the metal by its density in g cm^{-3} .

Table 7.1 shows the strength and density of four metal alloys.

(i) Use the information to calculate the strength to weight ratio for each alloy.

Write down the values in the table.

Give your answers to **3** significant figures.

Metal	Strength / MPa	Density / g cm^{-3}	Strength to weight ratio
Aluminium alloy	310	2.70	
Stainless steel	505	8.00	
Titanium alloy	1250	4.81	
Low-carbon steel	365	7.87	

Table 7.1

[2]

(ii) Which metal alloy in **Table 7.1** would be most suitable for constructing a racing bike?

Tick (\checkmark) **one** box.

Aluminium

Stainless steel

Titanium

Low-carbon steel

Explain why you have chosen this metal alloy.

.....

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

(iii) Suggest **two** other factors which you would need to consider when selecting the best material for a racing bike.

1.....

.....

2.....

.....

[2]

- 8 The potential difference across a resistor **X** is 5.0 V.

The current in the resistor is 0.5 A.

- (a) Calculate the resistance R_x of resistor **X**.

Use the equation: potential difference = current \times resistance

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

- (b) Resistor **Y** is placed in series with resistor **X**. The potential difference across both resistors is 5.0 V.

The current in the resistors is 0.087 A.

Calculate the resistance R_y of resistor **Y**.

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

- (c) Resistor **X** is now placed in parallel with resistor **Y**.

Calculate the combined resistance R_t of **X** and **Y** in parallel.

Use the equation: $\frac{1}{R_t} = \frac{1}{R_x} + \frac{1}{R_y}$

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

- (d) A lamp is placed in the circuit so that resistor **X**, resistor **Y** and the lamp are all in parallel.

The total current in the circuit is 0.75 A.

Show that the charge Q transferred through the lamp in one minute is about 8.6 C.

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 margins – for example, 1(b)(ii) or 2(b)(iii).

A large area of the page is filled with horizontal dotted lines, providing space for writing answers. A solid vertical line runs down the left side of this area, defining the margin for question numbers.

A series of horizontal dotted lines for writing, spanning the width of the page.

A series of horizontal dotted lines for writing, spanning the width of the page.

A series of horizontal dotted lines for writing, spanning the width of the page.

The Periodic Table of the Elements

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(0)		
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
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 101.1	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4
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
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	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganeson	119 Uue unbinilium	120 Uub unbinilium
121 Uut ununilium	122 Uuq ununilium	123 Uub ununilium	124 Uuq ununilium	125 Uub ununilium	126 Uuq ununilium	127 Uub ununilium	128 Uuq ununilium	129 Uub ununilium	130 Uuq ununilium
131 Uuh ununilium	132 Uuq ununilium	133 Uub ununilium	134 Uuq ununilium	135 Uub ununilium	136 Uuq ununilium	137 Uub ununilium	138 Uuq ununilium	139 Uub ununilium	140 Uuq ununilium
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Key
atomic number
Symbol
name
relative atomic mass



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