OCR
Oxford Cambridge and RSA

Tuesday 11 January 2022 – Afternoon

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C340/2201

C340I-I-220T

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.

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 **28** pages.

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

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/15
2	/8
3	/8
4	/14
5	/14
6	/16
7	/6
8	/9
Total	**/90**

Answer **all** the questions.

1 Part of the Periodic Table is shown in **Fig. 1.1**.

The letters are not the correct chemical symbols of the elements.

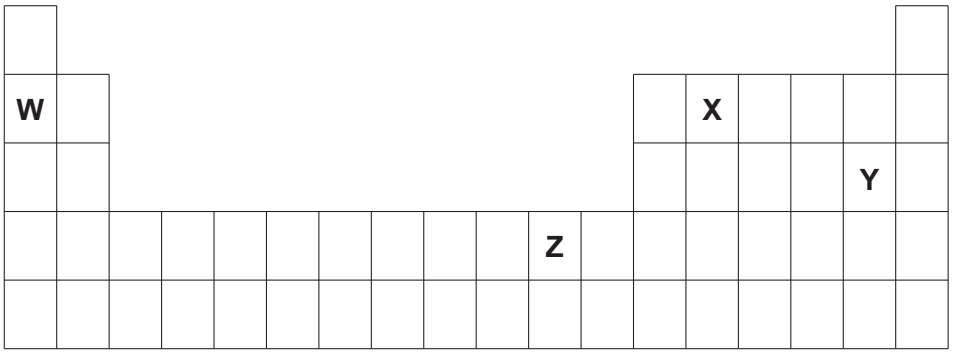


Fig. 1.1

(a) (i) Element **Y** has two isotopes.

Define the term isotope.

.....

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

(ii) Explain why the relative atomic mass of element **Y** is **not** a whole number.

.....

.....

.....

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

(iii) An isotope of **W** has four neutrons.

What is the nucleon number of this isotope?

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

(iv) Determine the number of outer shell electrons in elements **W** and **X**.

W.....

X.....

[1]

(v) Identify the name of element **Z**, using the full Periodic Table.

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

(b) Complete the sentences. Use the letters from **Fig. 1.1**.

You can use each letter once, more than once or not at all.

Two elements which combine to form a covalent compound are ..... and ..... .

Two elements which combine to form an ionic compound are ..... and ..... .

[2]

(c) **Fig. 1.2** shows the relationship between atomic radius and proton number for the first 20 elements in the Periodic Table.

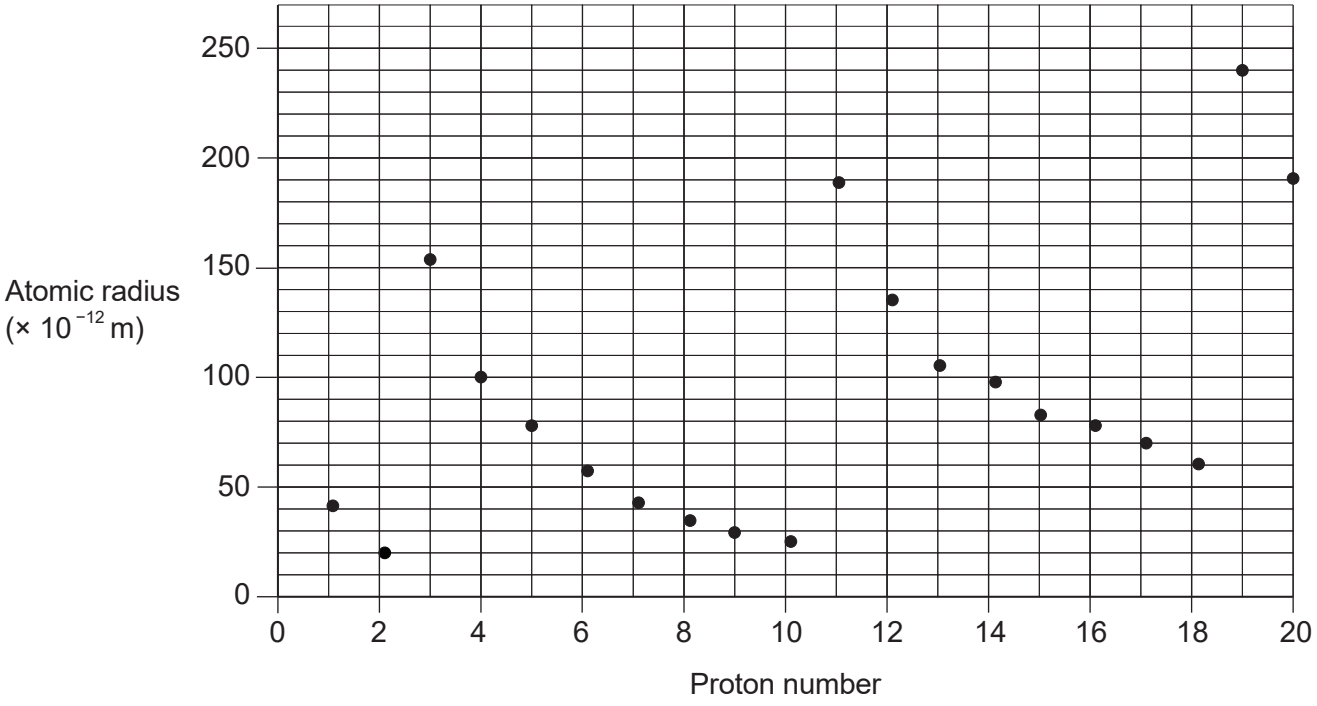


Fig. 1.2

(i) Put a (ring) around the **three** Group 1 alkali metals on **Fig. 1.2**. **[1]**

(ii) Give the names of **two** elements with an approximate radius of 80 × 10^{-12} m.

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

(iii) Explain why the atomic radius decreases from element 11 to element 18.

.....

.....

.....

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

(iv) Explain why there is a large increase in atomic radius from element 18 to element 19.

.....

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

2 Sulfur is an essential element in living cells.

- A common source of sulfur is the sulfate ion.
- Plants absorb sulfate ions which are used to form the essential amino acids, cysteine and methionine.
- When the plant dies the amino acids decompose and release sulfur and sulfate ions back into the soil.

One model of this cycle is summarised in **Fig. 2.1**.

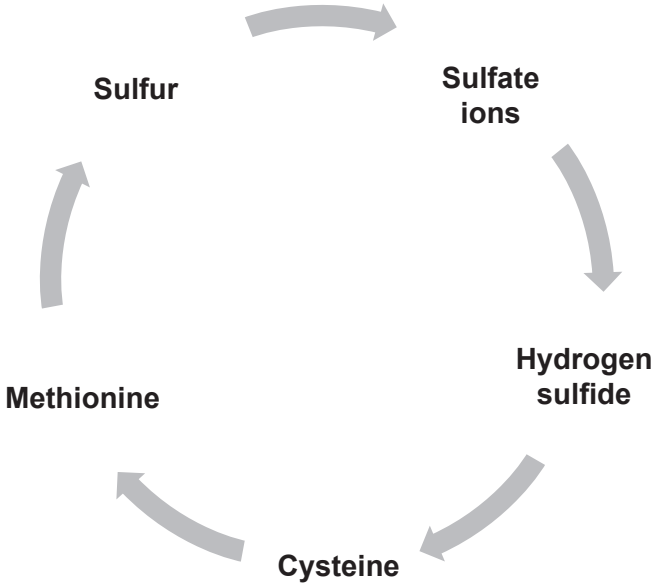


Fig. 2.1

(a) **(i)** Identify the other element present with sulfur in the sulfate ion.

Tick (✓) **one** box.

Carbon	☐
Nitrogen	☐
Oxygen	☐
Phosphorus	☐

[1]

(ii) Explain why the conversion of sulfate ions (SO_4^{2-}) into hydrogen sulfide (H_2S) in **Fig. 2.1** is an example of reduction.

.....

.....

.....

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

(b) The skeletal formula of methionine is shown in **Fig. 2.2**.

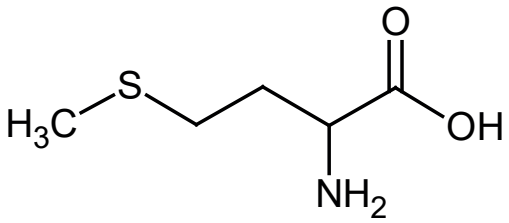


Fig. 2.2

(i) Methionine is classified as an amino acid.

Put a (ring) around the **two** functional groups in **Fig. 2.2** that are common to all amino acids. **[1]**

(ii) Each amino acid has a different R group.

Methionine has an R group of $–CH_2CH_2SCH_3$, as shown in **Fig. 2.2**.

The R group in cysteine is $–CH_2SH$.

Draw the skeletal formula of cysteine.

[1]

(c) Amino acids are joined together to form polypeptide chains. This process takes place in living cells.

- The order of amino acids found in each type of polypeptide chain is determined by the sequence of bases in DNA.
- The bases are held together in pairs along the DNA double helix.

Fig. 2.3 shows pairings for the four DNA bases adenine, thymine, guanine and cytosine.

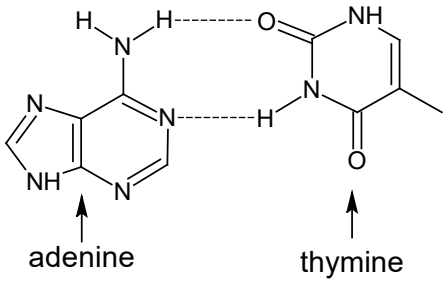
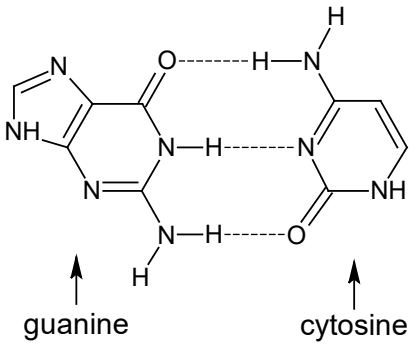
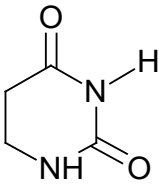
Base pairing	Structure
Adenine and thymine	
Guanine and cytosine	

Fig. 2.3

Uracil is a different base found in RNA.

Uracil is able to replace one of the four bases in **Fig. 2.3**.



Uracil

Which base in **Fig. 2.3** can be replaced by uracil?

Explain your answer.

.....

.....

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.....

.....

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

3 Many organic compounds have functional groups that contain oxygen.

Esters are organic compounds that have the functional group shown in **Fig. 3.1**.

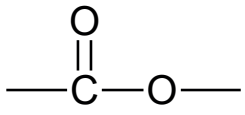


Fig. 3.1

(a) Polylactate is a polyester.

The repeating unit of polylactate is shown in **Fig. 3.2**.

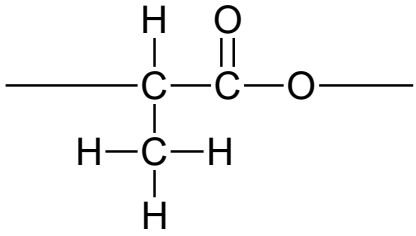


Fig. 3.2

(i) What is the empirical formula of polylactate?

Tick (✓) **one** box.

CH_2O ☐

$C_3H_4O_2$ ☐

$C_3H_6O_3$ ☐

$C_6H_8O_4$ ☐

[1]

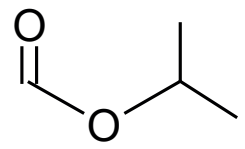
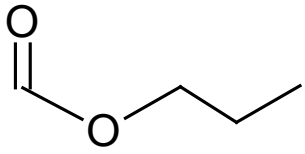
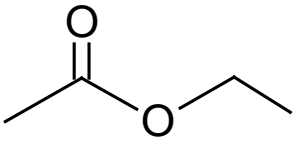
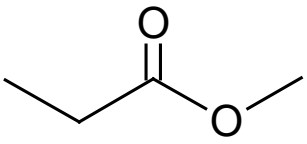
(ii) Draw the monomer that is used to make polylactate.

[1]

(b) (i) Ethyl ethanoate is also an ester.

What is the skeletal formula of ethyl ethanoate?

Tick (✓) **one** box.

[1]

(ii) Esters are produced when a carboxylic acid reacts with an alcohol.

A structural isomer of ethyl ethanoate is methyl propanoate.

Put a (ring) around the formulae of the carboxylic acid and the alcohol that form methyl propanoate.

Carboxylic acid

HCOOH CH_3COOH CH_3CH_2COOH

Alcohol

CH_3OH CH_3CH_2OH $CH_3CH_2CH_2OH$

[2]

(iii) Another structural isomer of ethyl ethanoate is shown in **Fig. 3.3**.

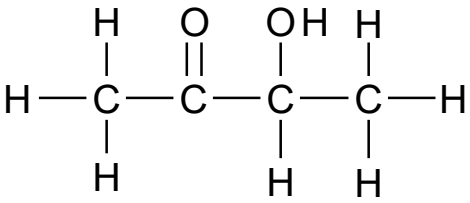


Fig. 3.3

The molecule in **Fig. 3.3** shows a different type of isomerism.

Explain the other type of isomerism shown by the structural isomer of ethyl ethanoate in **Fig. 3.3**.

.....

.....

.....

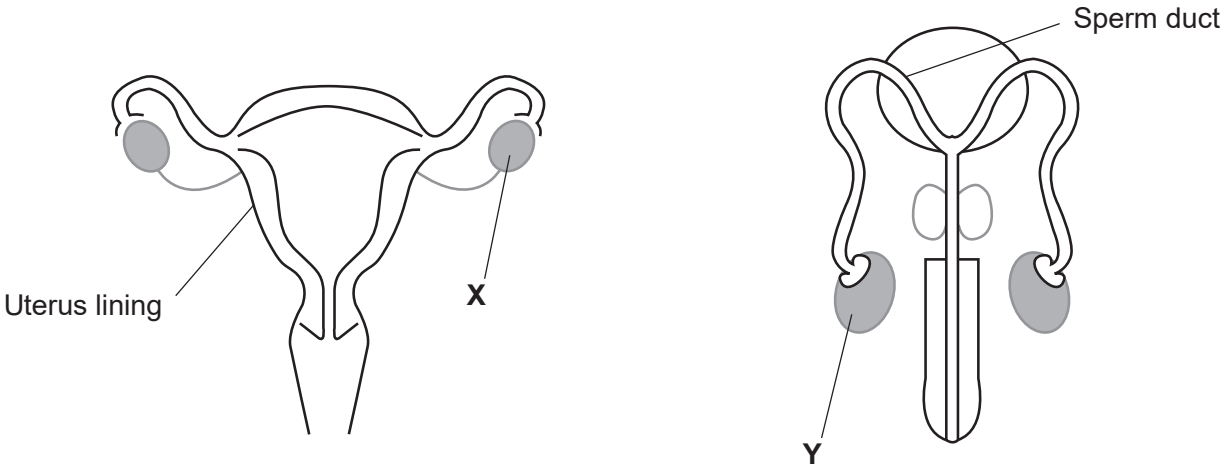
.....

.....

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

4 Simplified diagrams of the female and male reproductive systems are shown in **Fig. 4.1**.

The gonads in each reproductive system are labelled **X** and **Y**.



Female reproductive system **Male reproductive system**

Fig. 4.1

(a) Name **X** and **Y** in **Fig. 4.1**.

X .....

Y .....

[2]

(b) Gonad **X** is the sexual organ responsible for producing egg cells. Egg cells contain a large amount of cytoplasm.

State **two** functions of cytoplasm in a cell.

1 .....

.....

2 .....

.....

[2]

(c) Gonad **Y** produces sperm cells.

Fig. 4.2 shows an image of a sperm cell.

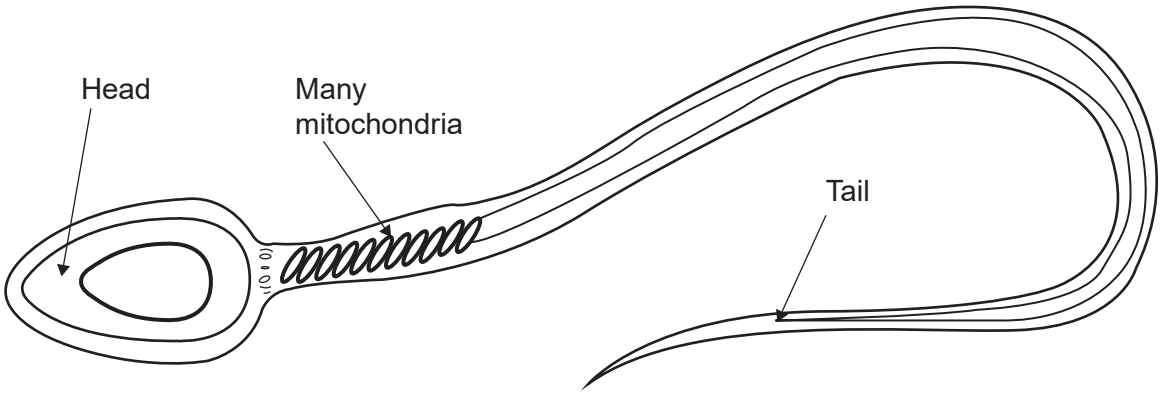


Fig. 4.2

The sperm cell has many more mitochondria than a typical human cell.

Suggest why the sperm cell needs to have a lot of mitochondria.

.....

.....

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.....

.....

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

(d) **(i)** The head of the sperm cell shown in **Fig. 4.2** contains the nucleus. The nucleus is surrounded by a nuclear envelope.

What is the characteristic feature of the nuclear envelope?

Put a (ring) around the correct answer.

Double membrane **Single membrane** **Triple membrane**

[1]

(ii) The sperm nucleus contains DNA in the form of chromosomes. The nucleus is a characteristic feature of all eukaryotic cells.

Complete the table to compare eukaryotic and prokaryotic cells.

Tick (✓) at least **one** box in each row.

The first feature has been completed for you.

Feature	**Eukaryotic cells (e.g. sperm cells)**	**Prokaryotic cells (e.g. bacteria)**
DNA in a nucleus	✓	
Membrane-bound organelles		
Cell surface membrane		
Mesosome		

[2]

(e) Gonad **X** (**Fig. 4.1**) produces two hormones called oestrogen and progesterone.

These hormones are responsible for:

- the release of the egg cell (ovulation) from gonad **X**
- the thickness of the uterus lining (shown in **Fig. 4.3**).

Fig. 4.3 shows graphs of the changing amounts of the two hormones and the changing thickness of the uterus lining over 28 days.

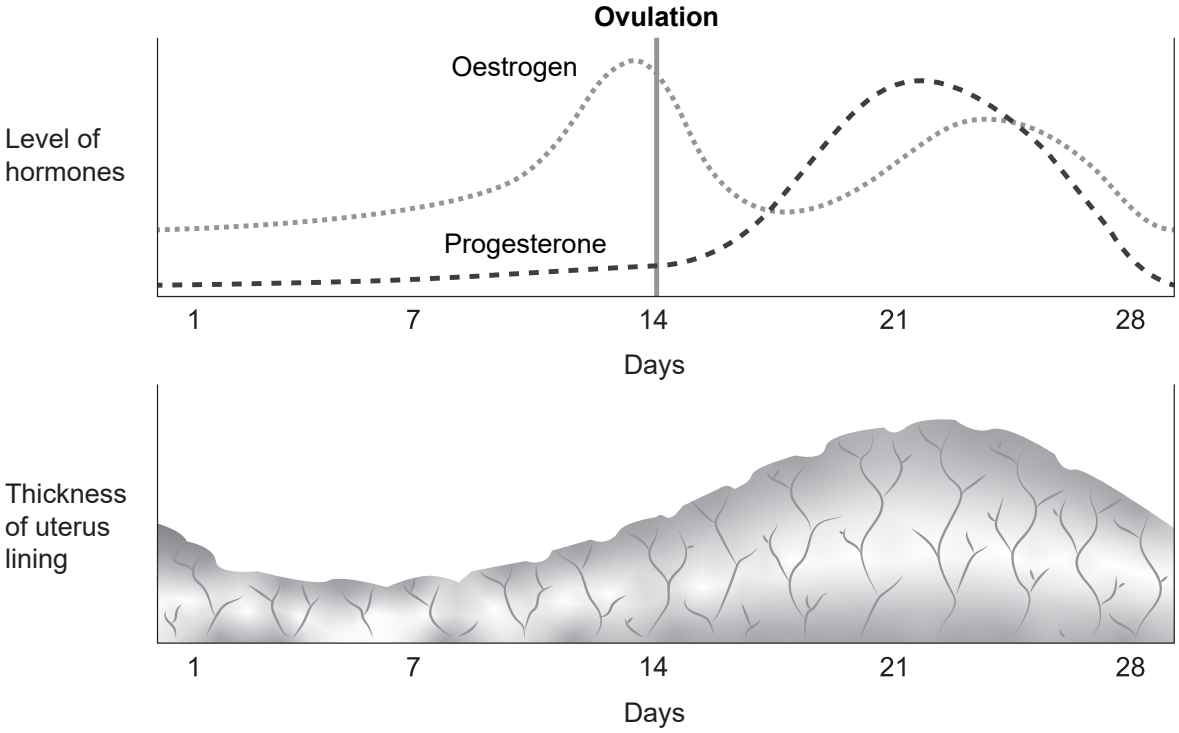


Fig. 4.3

Describe how the levels of the two hormones affect the release of the egg cell and the thickness of the uterus lining during the 28-day period.

Release of the egg cell

.....

.....

.....

.....

Thickness of the uterus lining

.....

.....

.....

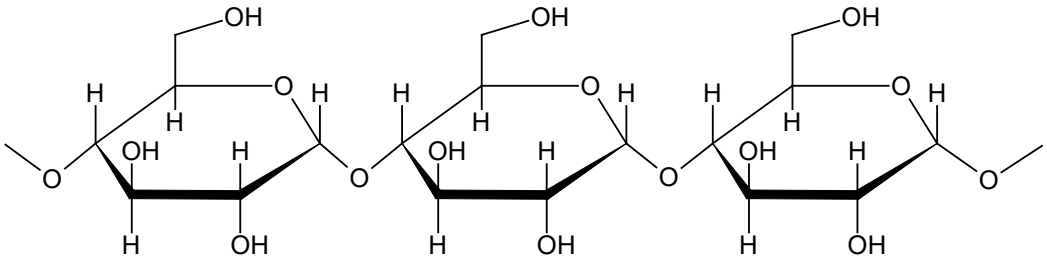
.....

[4]

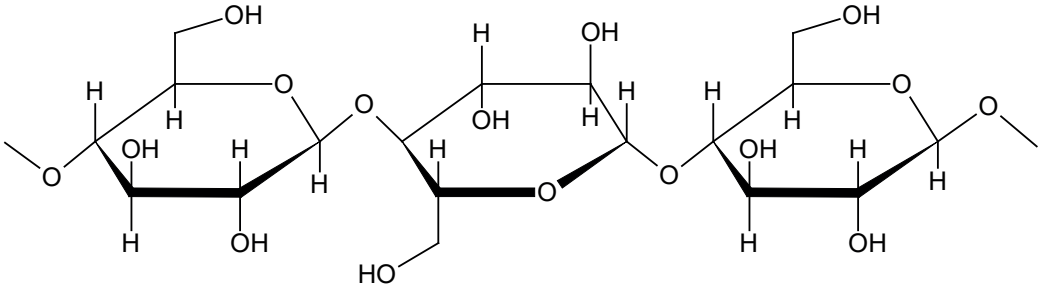
5 **(a)** Starch and cellulose are carbohydrates that are found naturally in plants.

Their structures are shown in **Fig. 5.1**.

Both contain sugar monomers linked by C–O–C bonds, but the monomers are linked in a different way.



Starch



Cellulose

Fig. 5.1

(i) What is the classification of the carbohydrates in **Fig. 5.1**?

Tick (✓) **one** box.

Polysaccharide	☐
Polypeptide	☐
Triglyceride	☐
Phospholipid	☐

[1]

(ii) What is the C–O–C link in starch and cellulose?

Put a (ring) around the correct answer.

Ester **Glycosidic** **Hydrogen** **Peptide**

[1]

(iii) What is the type of reaction that forms the carbohydrates in **Fig. 5.1**?

Put a (ring) around the **two** correct answers.

Addition **Condensation** **Hydrolysis**

Substitution **Polymerisation**

[2]

(iv) Starch and cellulose have different functions within plant cells.

Draw lines to connect each **carbohydrate** with its correct **function in a plant cell**.

Carbohydrate	**Function in a plant cell**
	Source of energy
Cellulose	Structure of cell wall
	Synthesis of protein
Starch	Active uptake of mineral ions
	Absorption of light

[2]

(b) Starch can be broken down into sugar molecules by the enzyme amylase.

This enzyme is found in human saliva.

(i) Starch is water-insoluble but when it is mixed with water, it becomes evenly dispersed.

When starch is broken down, the sugar molecules formed are soluble in water.

Complete the table to identify the type of mixture starch forms with water, and sugar forms with water.

Tick (✓) **two** boxes.

Mixture	**Starch with water**	**Sugar with water**
Colloid		
Suspension		
Solution		

[2]

(ii) The breakdown of starch by amylase depends on the pH in the mouth.

Fig. 5.2 shows a graph of the effect of pH on the breakdown of starch.

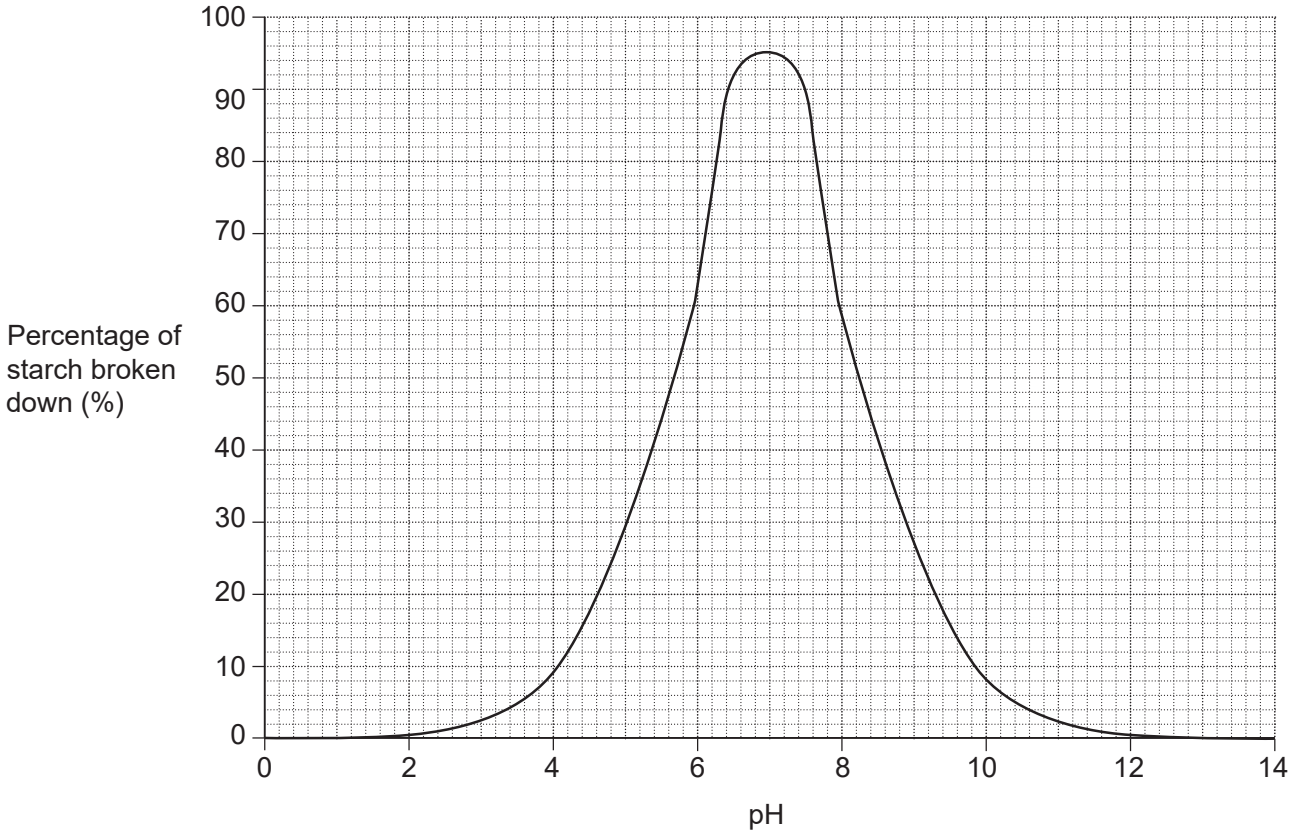


Fig. 5.2

Identify the optimum pH from **Fig. 5.2**.

pH = ... **[1]**

(iii) Explain why the percentage of starch broken down is **lower** on each side of the optimum value.

Use the lock and key hypothesis in your answer.

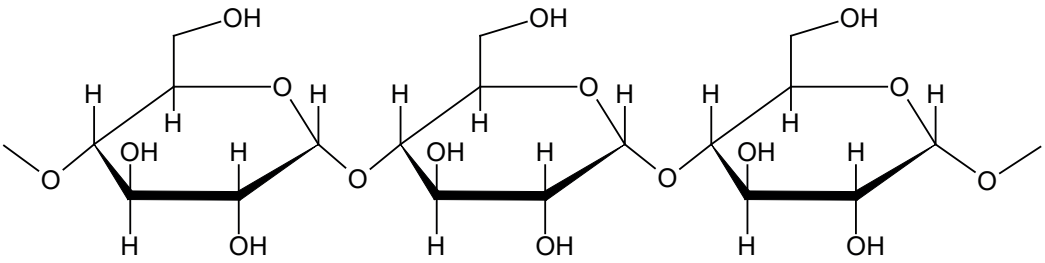
.....

.....

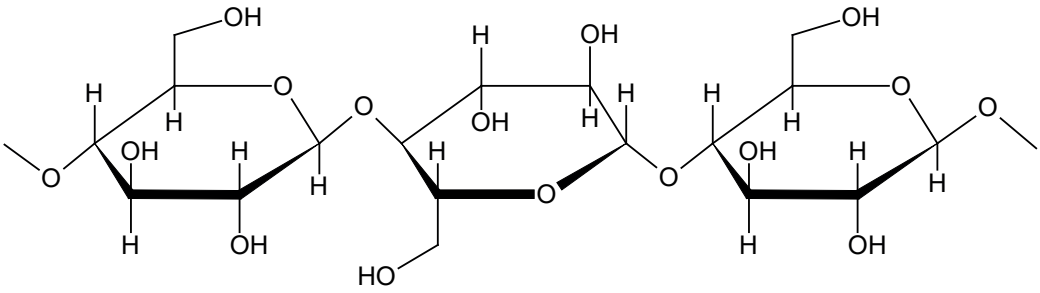
.....

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

(iv) Cellulose cannot be broken down by amylase, but starch can.



Starch



Cellulose

Fig. 5.3

Explain the difference in the reactions of starch and cellulose with amylase.

Use **Fig. 5.3** to support your answer.

.....

.....

.....

.....

.....

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

6 Manganese, nickel and platinum are transition metals.

The transition metals have important chemical and biological functions.

(a) Manganese and nickel can be mixed with other metals to improve their properties.

What is the name given to a mixture of metals?

Tick (✓) **one** box.

Aerosol	☐
Alloy	☐
Emulsion	☐
Foam	☐

[1]

(b) Nickel can act as a catalyst for the reaction shown:

$CH_2{=}CH_2 + H_2 \longrightarrow CH_3{-}CH_3$

(i) Give **two** features of this reaction that would prove that nickel is a catalyst.

1 .....

.....

2 .....

.....

[2]

(ii) The reactants in the reaction are gases.

Describe and explain the effect of reducing the pressure of the reactant gases on the rate of reaction.

Description .....

.....

Explanation .....

.....

.....

.....

[3]

(c) Manganese (II) ions (Mn^{2+}) and nickel (II) ions (Ni^{2+}) are important components of enzymes.

(i) Identify **three** biological functions of Mn^{2+} ions in the human body.

Tick (✓) **three** boxes.

The biosynthesis of choline for normal liver function	☐
The formation of bone matrix and cartilage structure	☐
The formation of myofibrils for muscle contraction	☐
The maintenance of a constant environment in cells	☐
The transport of carbon dioxide molecules	☐
The operation of some protein-based transport systems	☐

[3]

(ii) Mn^{2+} ions are present in enzymes responsible for photolysis in plants.

Where does photolysis occur in the plant cell?

Tick (✓) **one** box.

Cell wall	☐
Chloroplast	☐
Endoplasmic reticulum	☐
Golgi apparatus	☐

[1]

(iii) Nickel ions (Ni^{2+}) are an important component of some enzymes.

Complete the sentences about nickel-containing enzymes.

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

amylase	**carbon**	**hydrogen**
hydrolase	**hydrolysis**	**oxidation**
oxygen	**polymerisation**	**reductase**

Nickel-containing enzymes include hydrogenase and ..... .

Hydrogenase catalyses the ..... of

molecular ..... .

[3]

(d) Platinum (II) ions (Pt^{2+}) are used in medicine to treat illness.

Explain how Pt^{2+} is used in medicine.

.....

.....

.....

.....

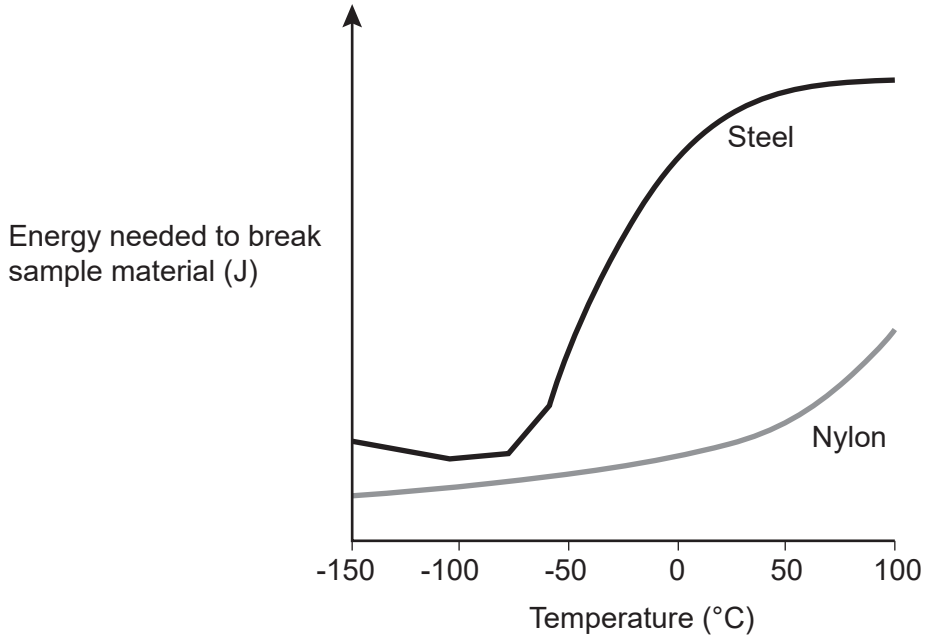
.....

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

7 The Charpy Impact Test measures the energy needed to break materials such as metals and polymers.

The results of a Charpy Impact Test comparing steel and nylon samples at different temperatures (−150 °C to 100 °C) are shown in the graph.

Steel is an alloy and nylon is a polymer.



Compare the energy needed to break samples of steel and nylon at different temperatures.

Include references to strength, brittleness and ductility in your answer.

.....

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

8 A circuit to determine the average internal resistance of a solar cell is shown in **Fig. 8.1**.

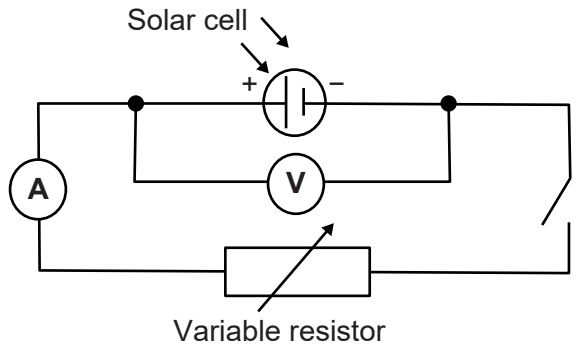

Fig. 8.1

The resistance of the variable resistor is changed and the potential difference across the solar cell and the current in the circuit are measured.

Fig. 8.2 shows a graph of the results.

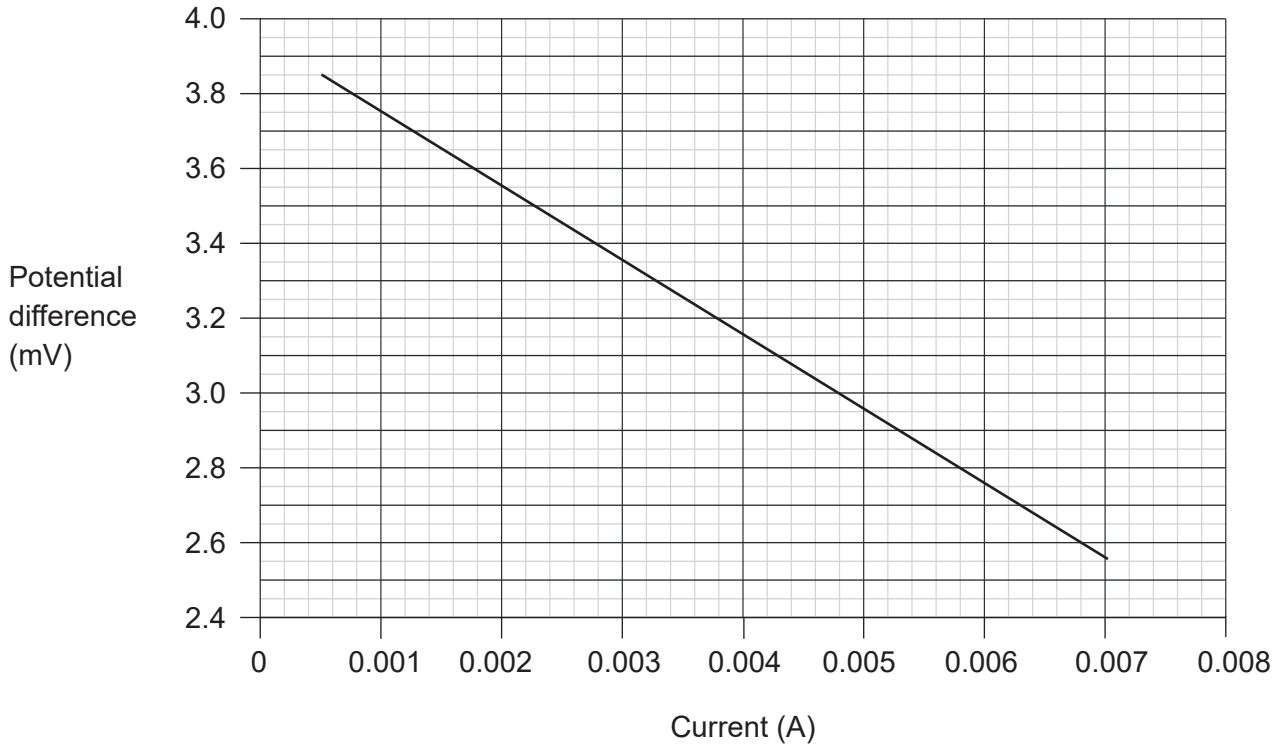

Fig. 8.2

(a) Use **Fig. 8.2** to help you answer part **(a)**.

(i) Estimate the potential difference across the solar cell at 0 A.

Potential difference = ... mV **[1]**

(ii) Calculate the change in potential difference across the solar cell between 0 and 0.007 A.

Change in potential difference = ... mV **[1]**

(iii) Calculate the average internal resistance of the solar cell.

Use your answer to **(a)(ii)** and the equation:

$$\text{Average internal resistance} = \frac{\text{change in potential difference}}{\text{change in current}}$$

Average internal resistance = ……..…… mΩ **[2]**

(b) The solar cell in **Fig. 8.1** is illuminated by a lamp.

When there is no resistor in the circuit the cell produces an e.m.f. of 3.7 V and a current of 8×10^{-3} A.

(i) Calculate the power produced by the solar cell.

Use the equation: power = potential difference × current

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

(ii) Determine the number of days it takes for the cell to transfer 1 kWh of energy.

Use your answer to **(b)(i)**.

Number of days to transfer 1 kWh of energy = ... **[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, 4(a) or 7.

The Periodic Table of the Elements

Key: atomic number / **Symbol** / name / relative atomic mass

(1) 1	(2) 2	3	4	5	6	7	8	9	10	11	12	(3) 13	(4) 14	(5) 15	(6) 16	(7) 17	(0) 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