

# Modified Enlarged 18 pt

# OXFORD CAMBRIDGE AND RSA EXAMINATIONS

## 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 plus your additional time allowance**

## You must have:

**the Insert for Question 1(c) (FIG. 1.2)**

## the Data Sheet

**a ruler (cm/mm)**

## the Periodic Table

## 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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**READ INSTRUCTIONS OVERLEAF**

## **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 [ ].**

## **ADVICE**

**Read each question carefully before you start your answer.**

**BLANK PAGE**

**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**

[illegible]

**(a) (i) Element Y has two isotopes. Define the term isotope.**

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[2]

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

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[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 on the Insert shows the relationship between atomic radius and proton number for the first 20 elements in the Periodic Table.

(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  $80 \times 10^{-12} \text{ m}$ .

\_\_\_\_\_ 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.

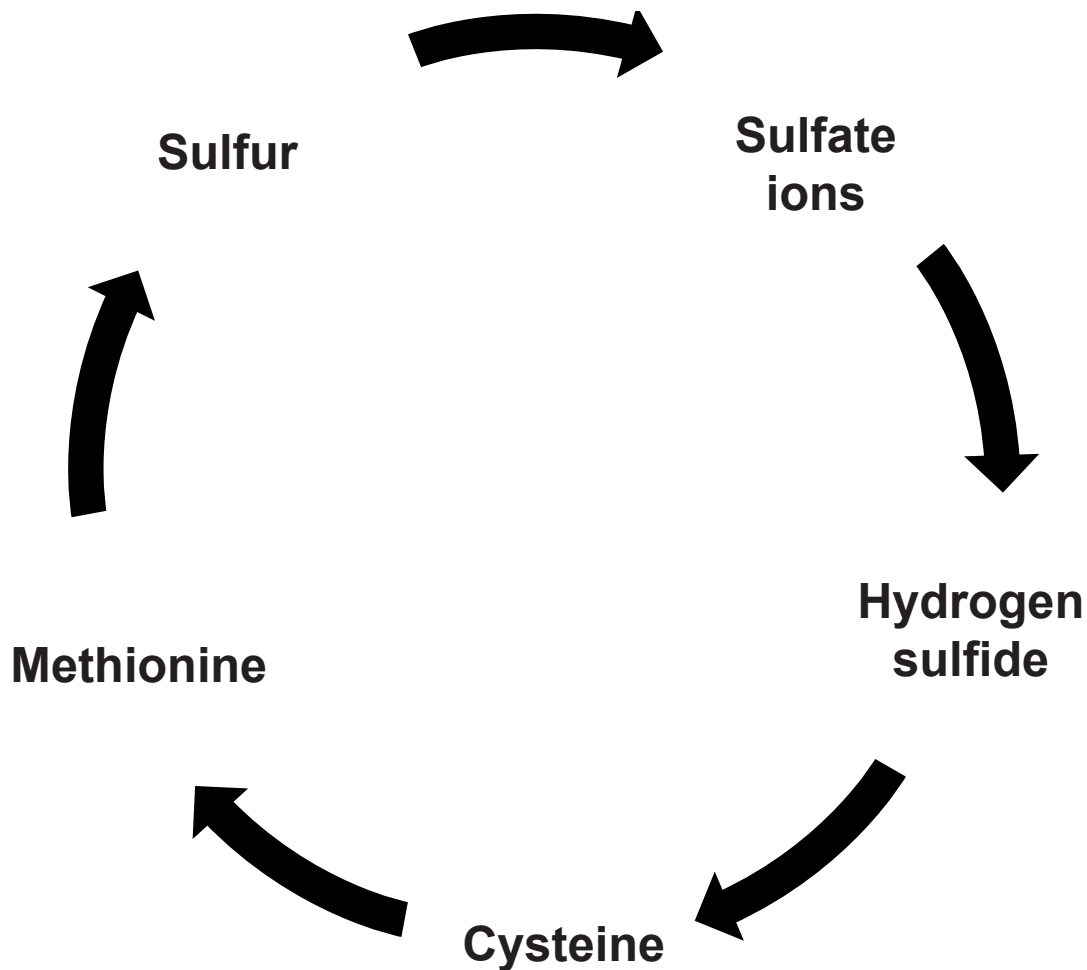
A common source of sulfur is the sulfate ion.

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. [1]

Carbon

☐

Nitrogen

☐

Oxygen

☐

Phosphorus

☐

- (ii) Explain why the conversion of sulfate ions ( $\text{SO}_4^{2-}$ ) into hydrogen sulfide ( $\text{H}_2\text{S}$ ) in FIG. 2.1 is an example of reduction.

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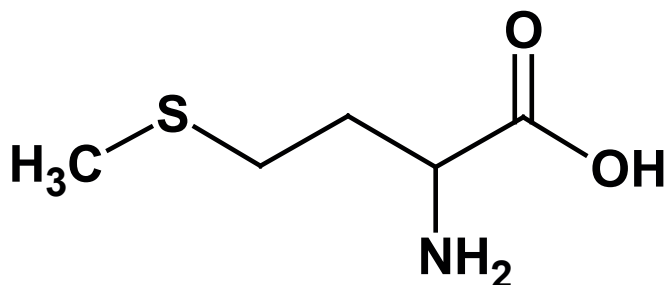
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[2]

- (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  $-\text{CH}_2\text{CH}_2\text{SCH}_3$ , as shown in FIG. 2.2. The R group in cysteine is  $-\text{CH}_2\text{SH}$ . Draw the skeletal formula of cysteine. Use the space below. [1]



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

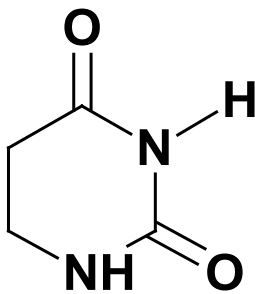
The order of amino acids found in each type of polypeptide chain is determined by the sequence of bases in DNA.

The bases are held together in pairs along the DNA double helix.

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

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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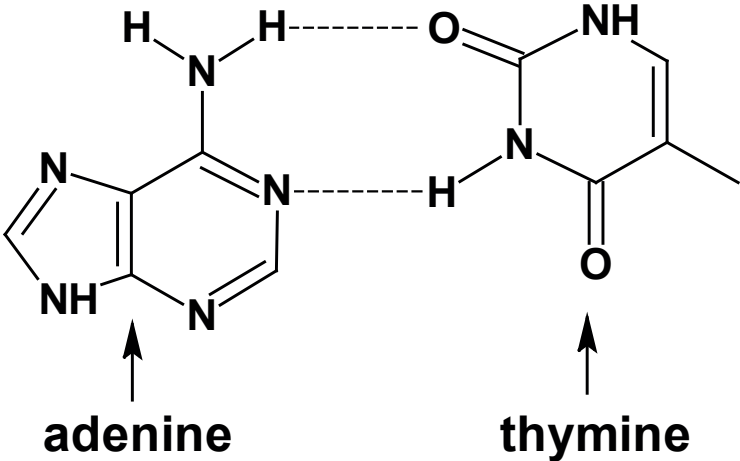
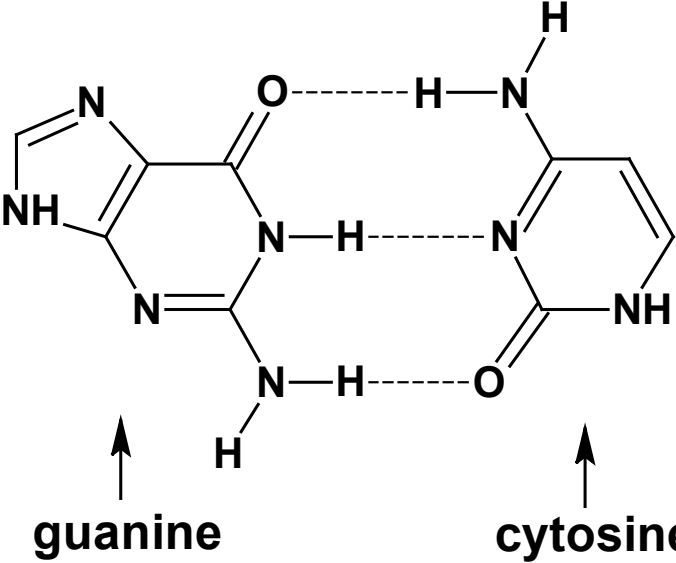
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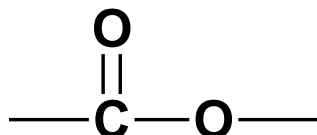
FIG. 2.3

Base pairing	Structure
<b>Adenine and thymine</b>	 <p>The diagram illustrates the chemical structures of adenine and thymine connected by two hydrogen bonds. Adenine, a purine base, is on the left, and thymine, a pyrimidine base, is on the right. The first hydrogen bond is between the amino group of adenine (NH<sub>2</sub>) and the carbonyl oxygen of thymine (C=O). The second hydrogen bond is between the ring nitrogen of adenine (N) and the ring nitrogen of thymine (NH). Arrows point from the labels 'adenine' and 'thymine' to their respective structures.</p>
<b>Guanine and cytosine</b>	 <p>The diagram illustrates the chemical structures of guanine and cytosine connected by three hydrogen bonds. Guanine, a purine base, is on the left, and cytosine, a pyrimidine base, is on the right. The first hydrogen bond is between the carbonyl oxygen of guanine (C=O) and the amino group of cytosine (NH<sub>2</sub>). The second hydrogen bond is between the ring nitrogen of guanine (NH) and the ring nitrogen of cytosine (N). The third hydrogen bond is between the amino group of guanine (NH<sub>2</sub>) and the carbonyl oxygen of cytosine (C=O). Arrows point from the labels 'guanine' and 'cytosine' to their respective structures.</p>

- 3 Many organic compounds have functional groups that contain oxygen.

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

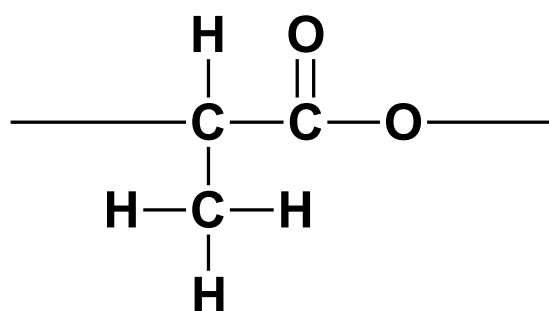
FIG. 3.1



- (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?

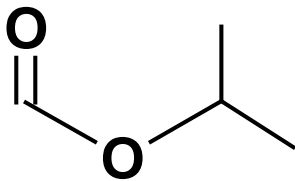
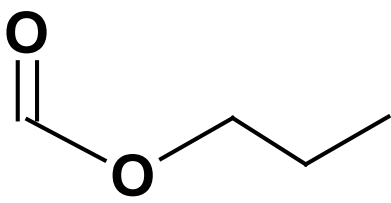
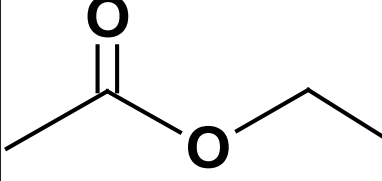
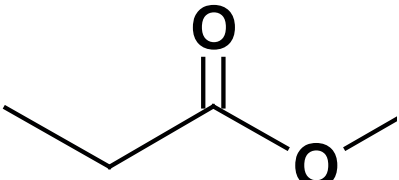
Tick (✓) ONE box. [1]


☐
☐
☐
☐

- (ii) Draw the monomer that is used to make polylactate. Use the space below. [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. [2]

**CARBOXYLIC ACID**



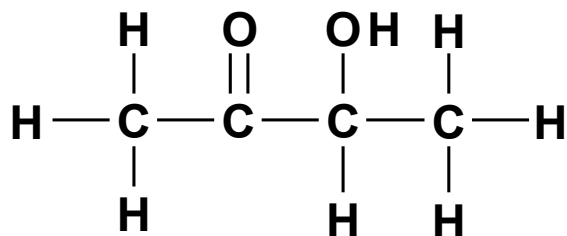
**ALCOHOL**





- (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.

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[3]

- 4 Simplified diagrams of the female and male reproductive systems are shown in FIG. 4.1 opposite. The gonads in each reproductive system are labelled X and Y.**

**(a) Name X and Y in FIG. 4.1 opposite.**

**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** \_\_\_\_\_

\_\_\_\_\_

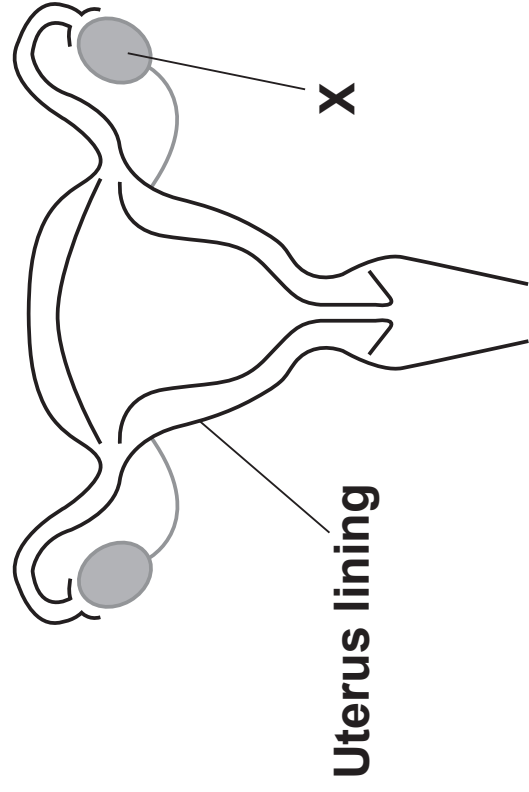
**2** \_\_\_\_\_

\_\_\_\_\_

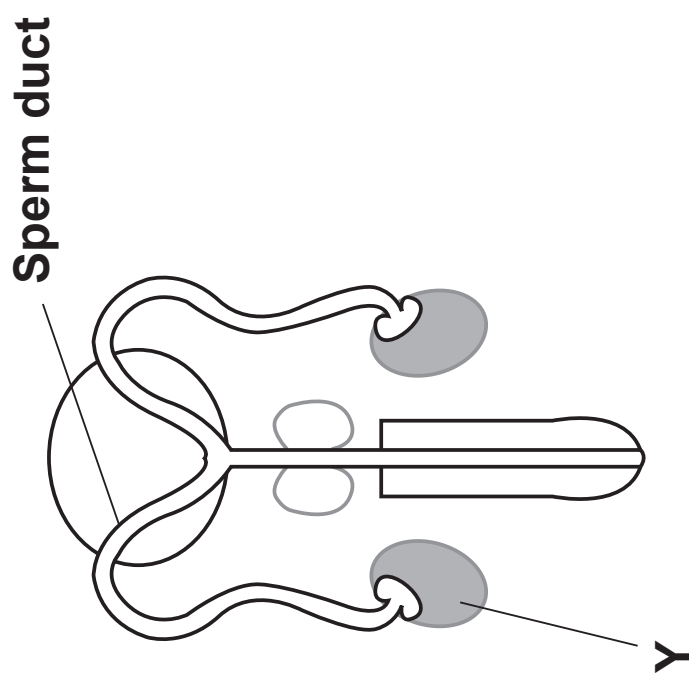
**[2]**

**FIG. 4.1**

**Female reproductive system**



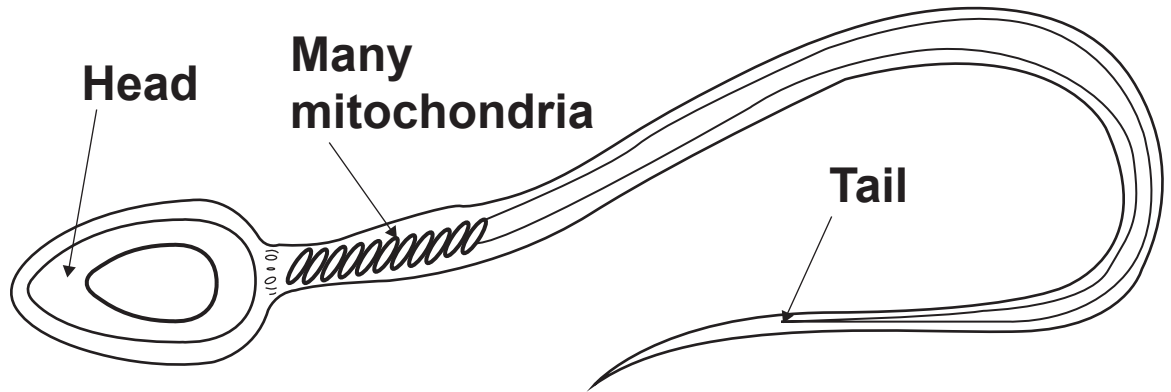
**Male reproductive system**



(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. [1]

Double membrane

Single membrane

Triple membrane

- (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. [2]

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

- (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 opposite).

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

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**

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**Thickness of the uterus lining**

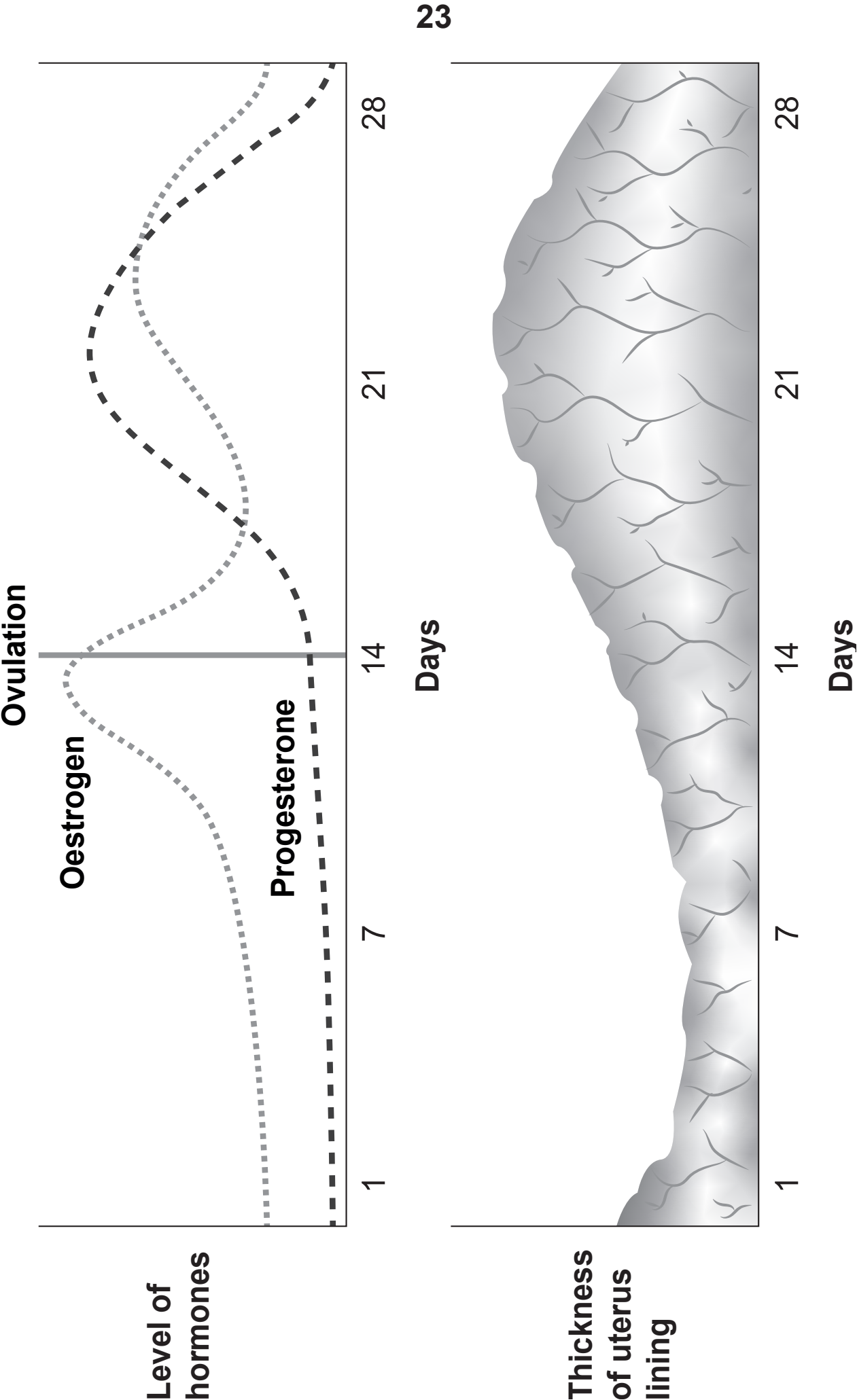
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FIG. 4.3



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

Their structures are shown in FIG. 5.1 opposite.

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

- (i) What is the classification of the carbohydrates in FIG. 5.1 opposite?

Tick (✓) ONE box. [1]

Polysaccharide

☐

Polypeptide

☐

Triglyceride

☐

Phospholipid

☐

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

Put a ring around the correct answer. [1]

Ester

Glycosidic

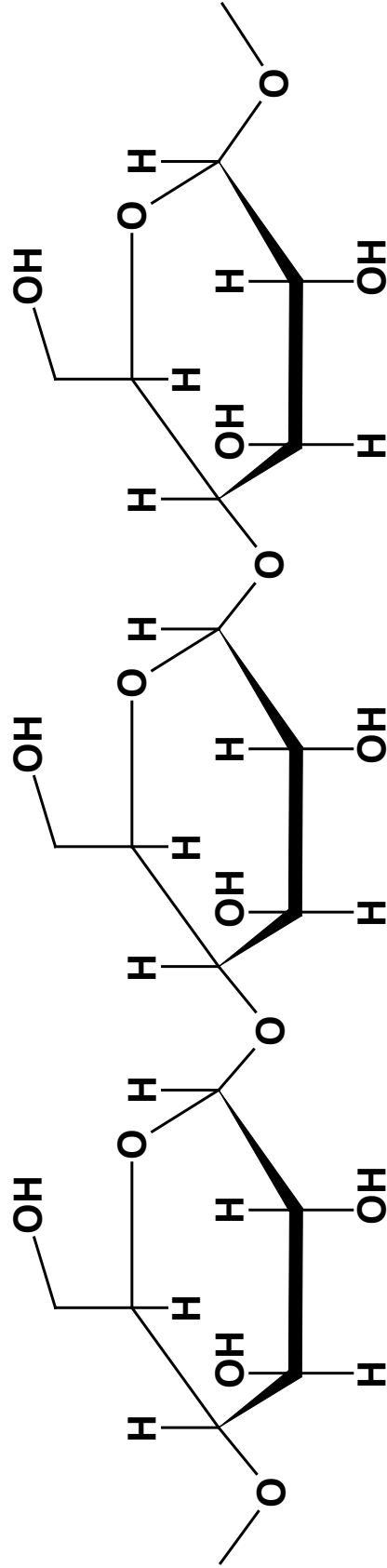
Hydrogen

Peptide

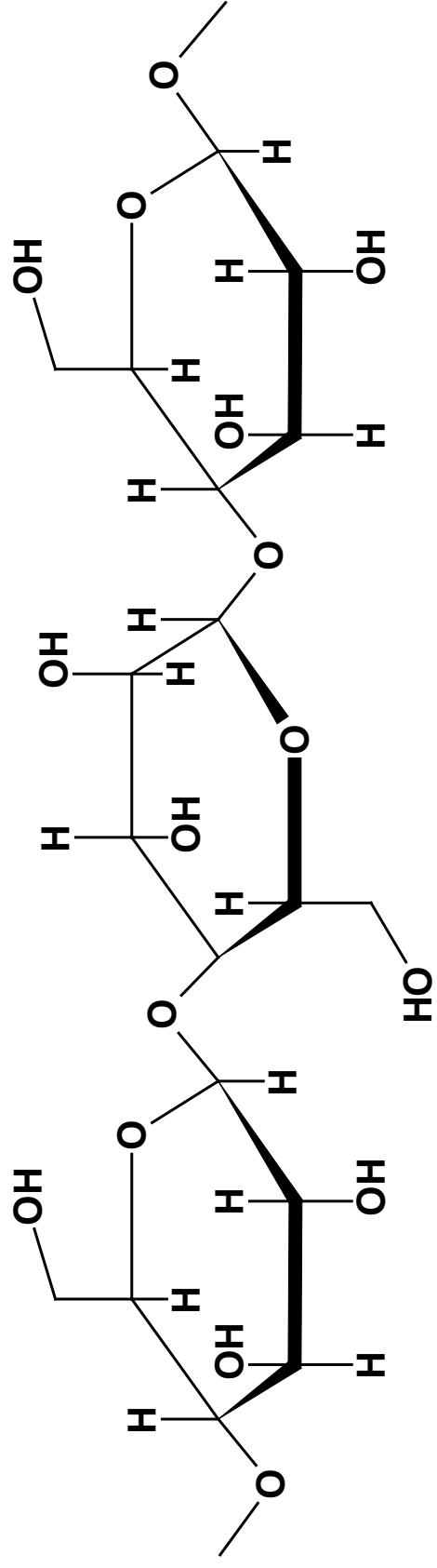


FIG. 5.1

## STARCH



## CELLULOSE



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

Put a **ring** around the TWO correct answers. [2]

Addition

Condensation

Substitution

Polymerisation

Hydrolysis

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

Draw lines to connect each CARBOHYDRATE with its correct FUNCTION IN A PLANT CELL. [2]

**CARBOHYDRATE**

**FUNCTION IN A  
PLANT CELL**

Cellulose

Starch

Source of energy

Structure of cell wall

Synthesis of protein

Active uptake of  
mineral ions

Absorption of light



- (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. [2]

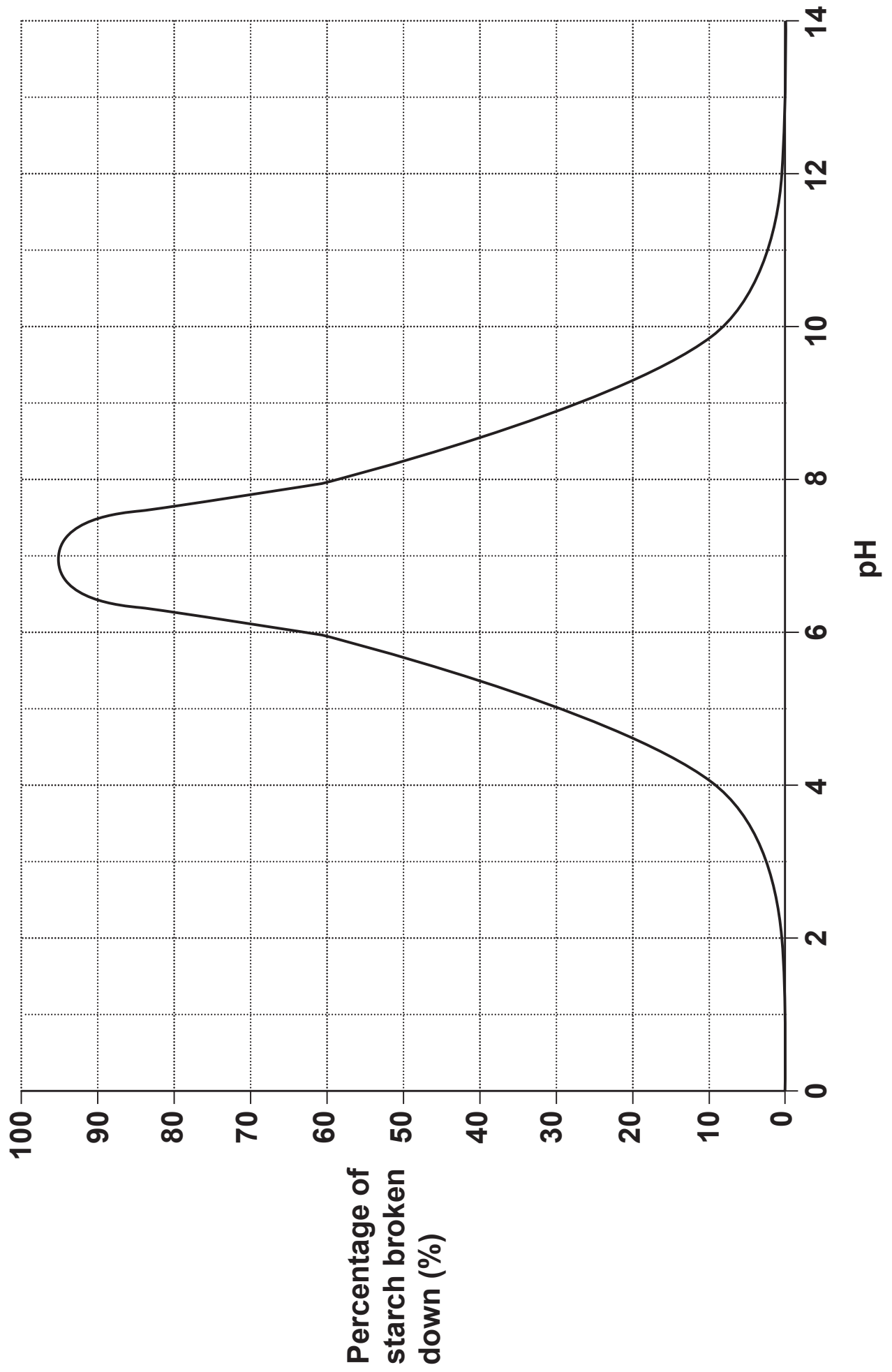
Mixture	Starch with water	Sugar with water
Colloid		
Suspension		
Solution		

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

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

Identify the optimum pH from FIG. 5.2 opposite.

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.

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[2]

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

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

Use FIG. 5.3 opposite to support your answer.

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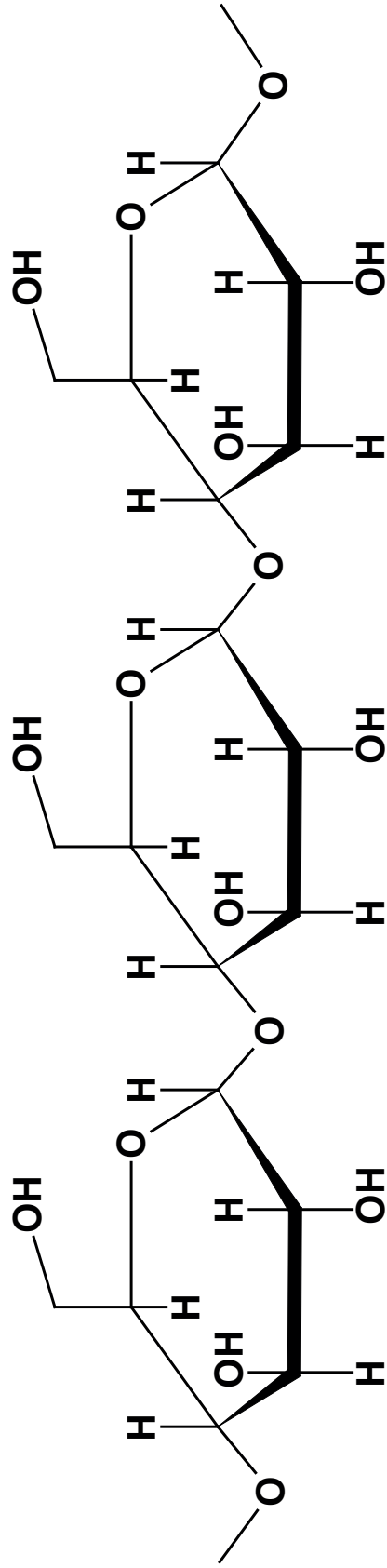
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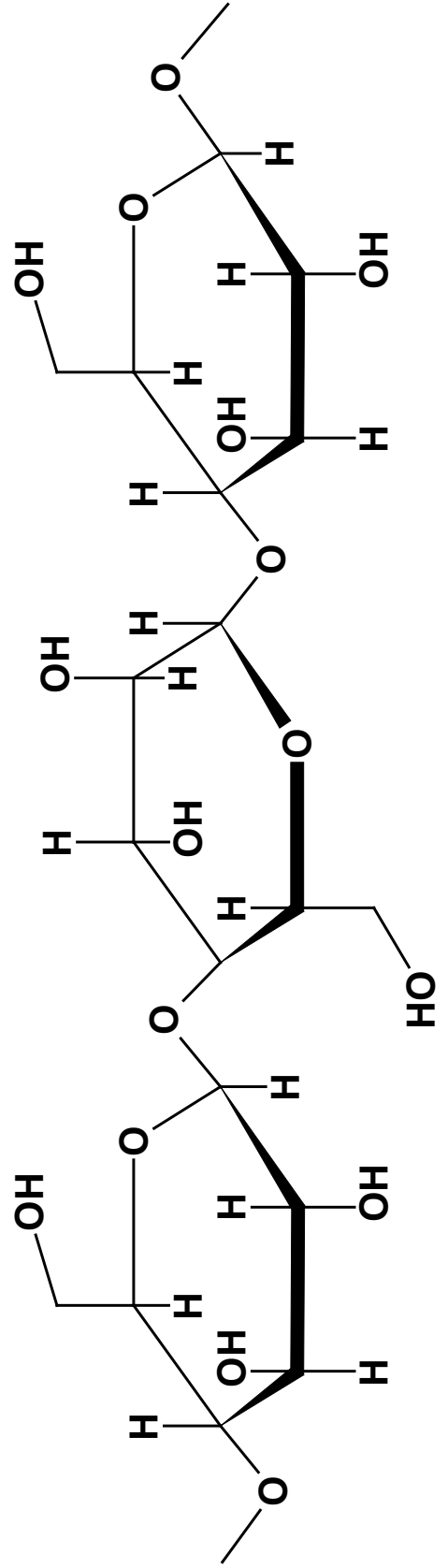
[3]

FIG. 5.3

## STARCH



## CELLULOSE



**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. [1]**

**Aerosol**

☐

**Alloy**

☐

**Emulsion**

☐

**Foam**

☐

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



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

**1**

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**2**

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**[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 ( $\text{Mn}^{2+}$ ) and nickel (II) ions ( $\text{Ni}^{2+}$ ) are important components of enzymes.

(i) Identify THREE biological functions of  $\text{Mn}^{2+}$  ions in the human body.

Tick (✓) THREE boxes. [3]

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 ☐

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

Where does photolysis occur in the plant cell?

Tick (✓) ONE box. [1]

Cell wall

☐

Chloroplast

☐

Endoplasmic reticulum

☐

Golgi apparatus

☐

- (iii) Nickel ions ( $\text{Ni}^{2+}$ ) 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 ( $\text{Pt}^{2+}$ ) are used in medicine to treat illness.**

**Explain how  $\text{Pt}^{2+}$  is used in medicine.**

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**[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 opposite.**

# 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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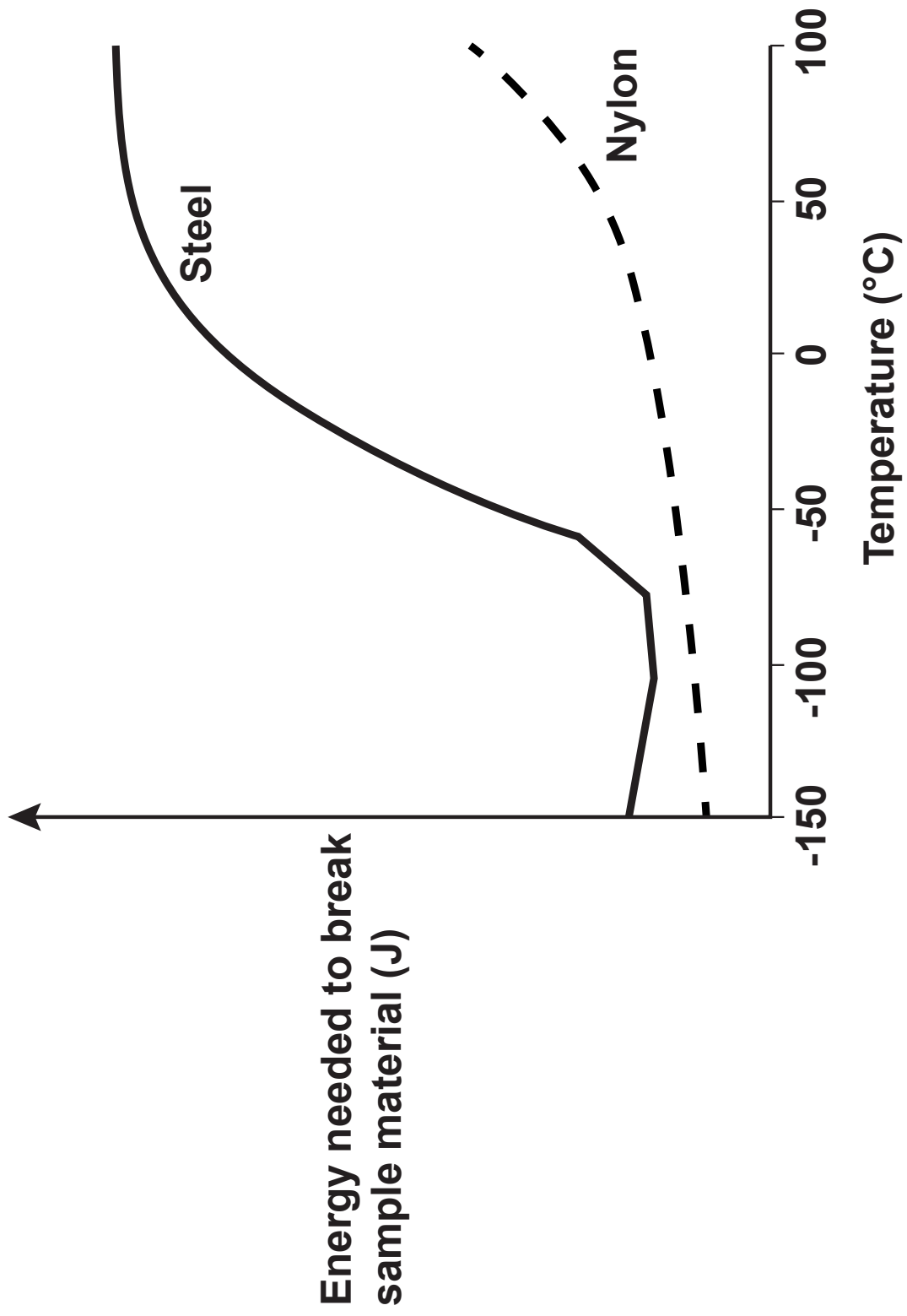
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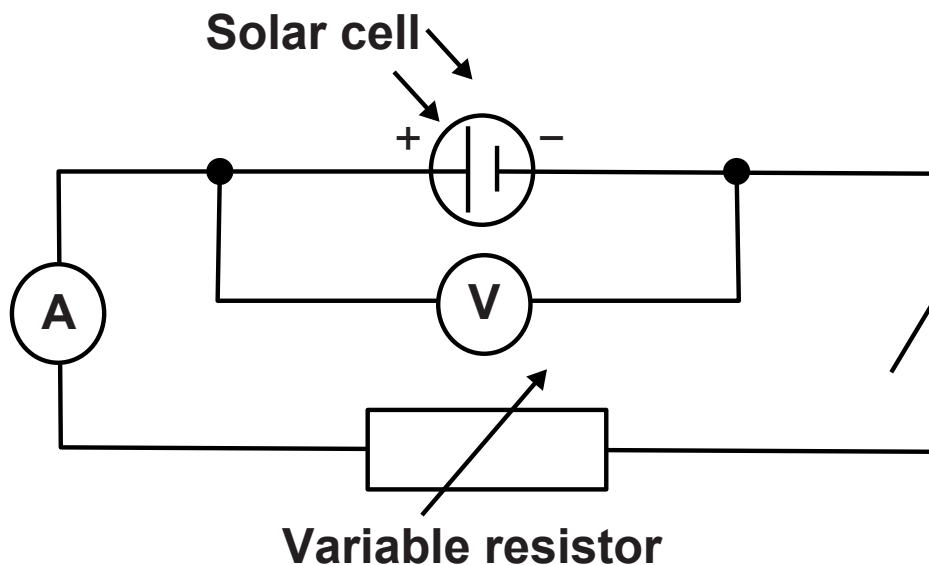
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[6]



- 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.

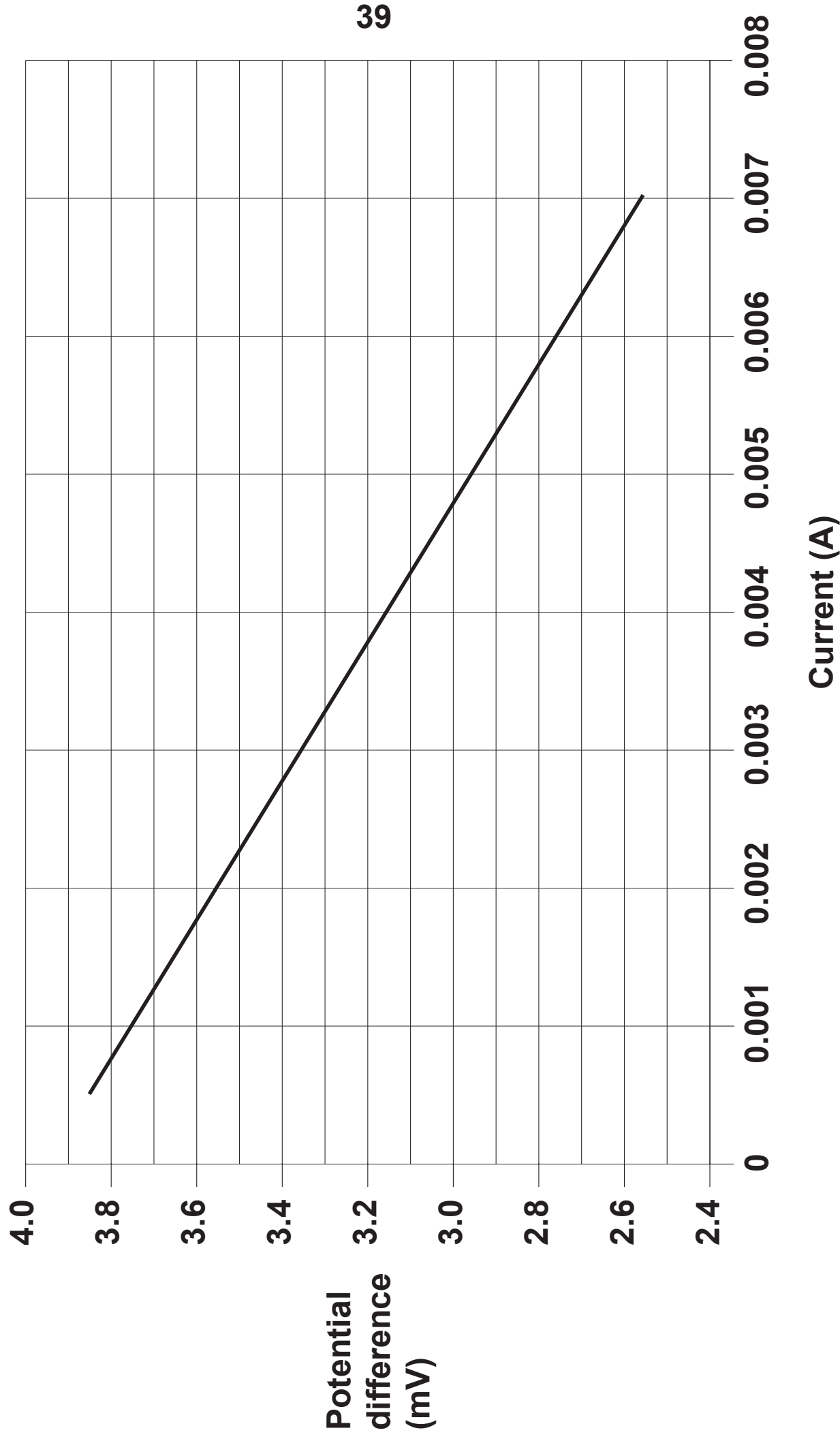
FIG. 8.2 opposite shows a graph of the results.

(a) Use FIG. 8.2 opposite to help you answer part (a).

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

Potential difference = \_\_\_\_\_ mV [1]

**FIG. 8.2**



- (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  $8 \times 10^{-3}$  A.

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

Use the equation:

power = potential difference  $\times$  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

**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.**

[illegible]













Oxford Cambridge and RSA

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