

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



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
---	---	---	---	---	---	---	---

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

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

[illegible]

Fig. 1.1

- Define the term isotope.

..... [2]

- [2]

- What is the nucleon number of this isotope?

..... [1]

- W.....
- X.....
- [1]

- [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.

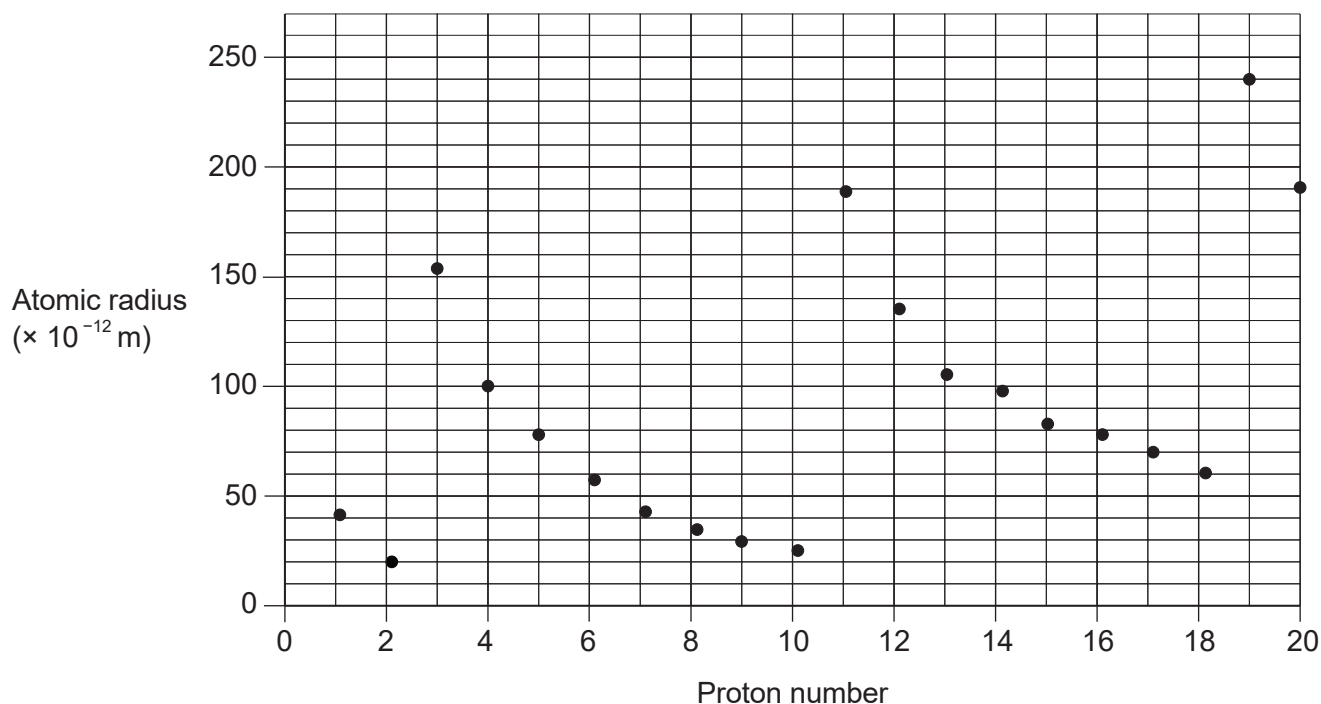


Fig. 1.2

- (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**.

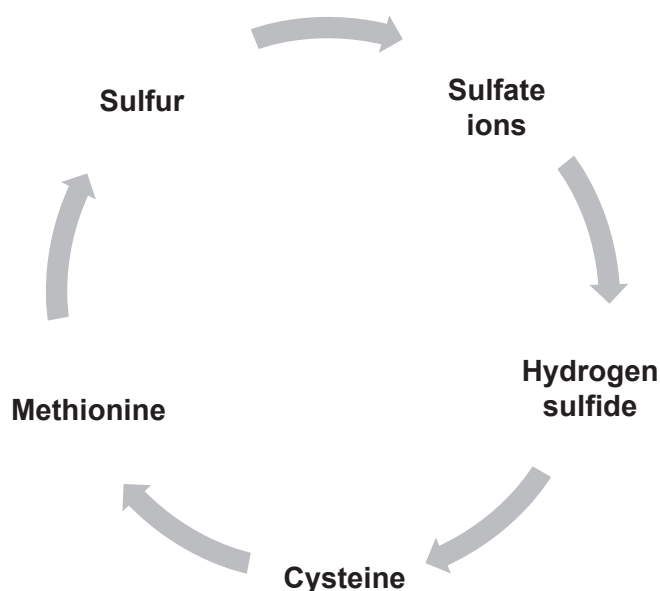


Fig. 2.1

(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**.

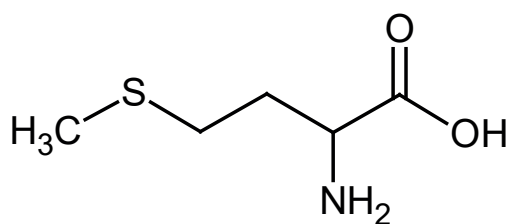


Fig. 2.2

- (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 $-\text{CH}_2\text{CH}_2\text{SCH}_3$, as shown in **Fig. 2.2**.

The R group in cysteine is $-\text{CH}_2\text{SH}$.

Draw the skeletal formula of cysteine.

[1]

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

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

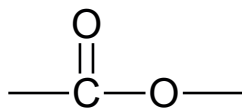


Fig. 3.1

- (a) Polylactate is a polyester.

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

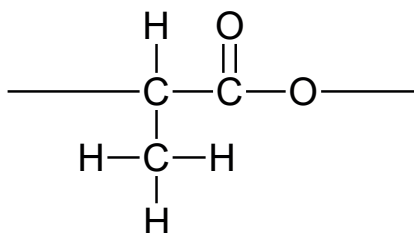
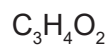
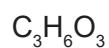
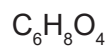


Fig. 3.2

- (i) What is the empirical formula of polylactate?

Tick (✓) **one** box.


☐

☐

☐

☐

[1]

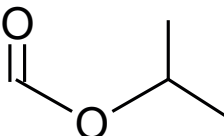
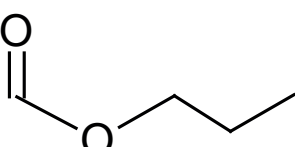
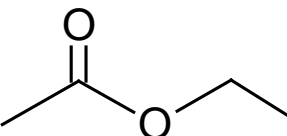
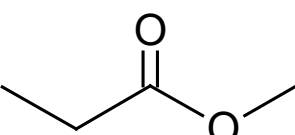
- (ii) Draw the monomer that is used to make polylactate.

[1]

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

What is the skeletal formula of ethyl ethanoate?

Tick (✓) **one** box.

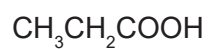
[1]

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

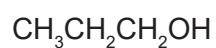
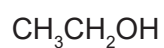
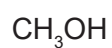
A structural isomer of ethyl ethanoate is methyl propanoate.

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

Carboxylic acid



Alcohol



[2]

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

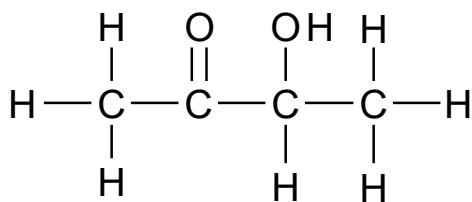


Fig. 3.3

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**.

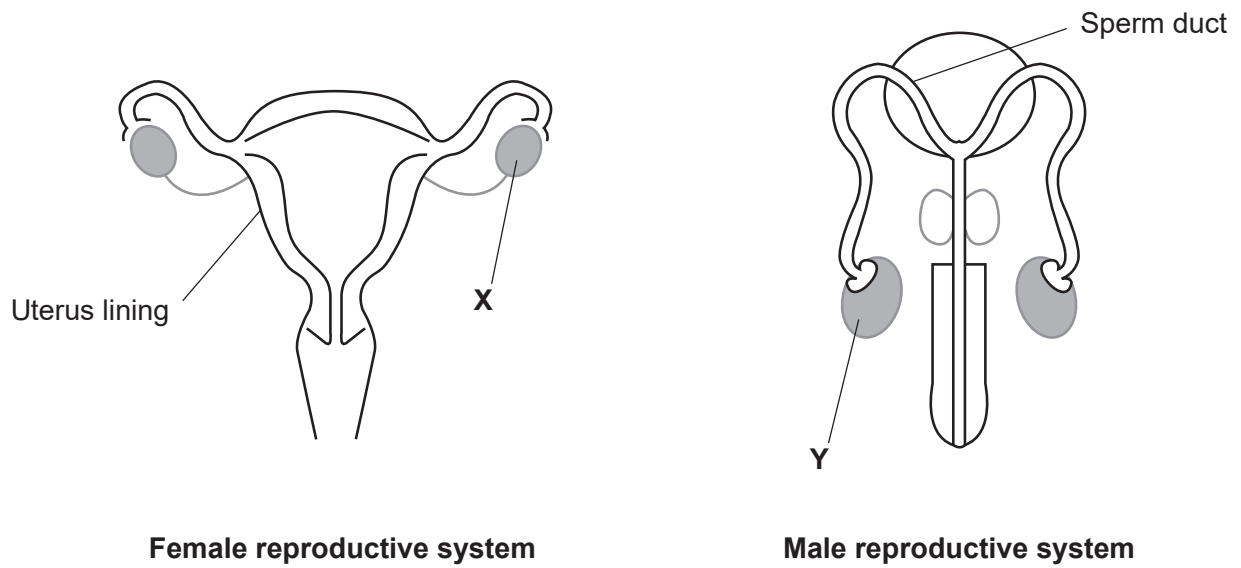


Fig. 4.1

- (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.

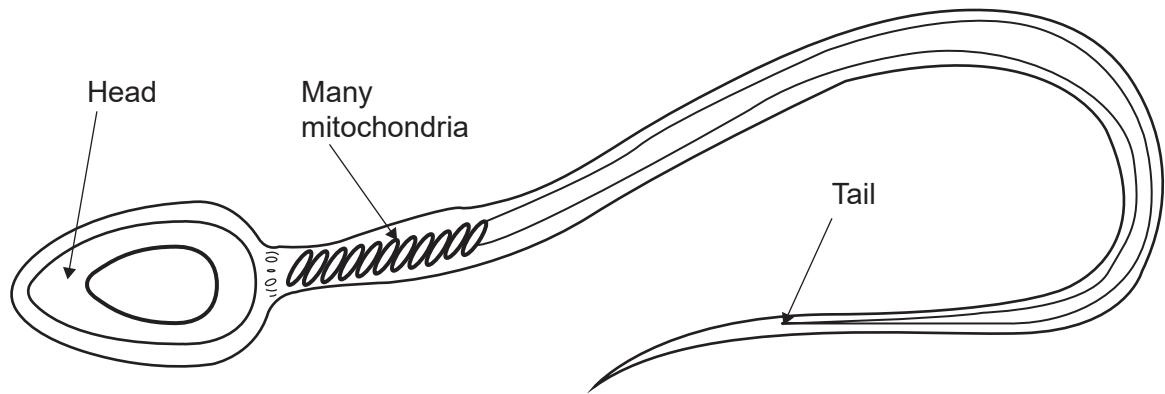


Fig. 4.2

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

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

.....

.....

.....

.....

.....

..... [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.

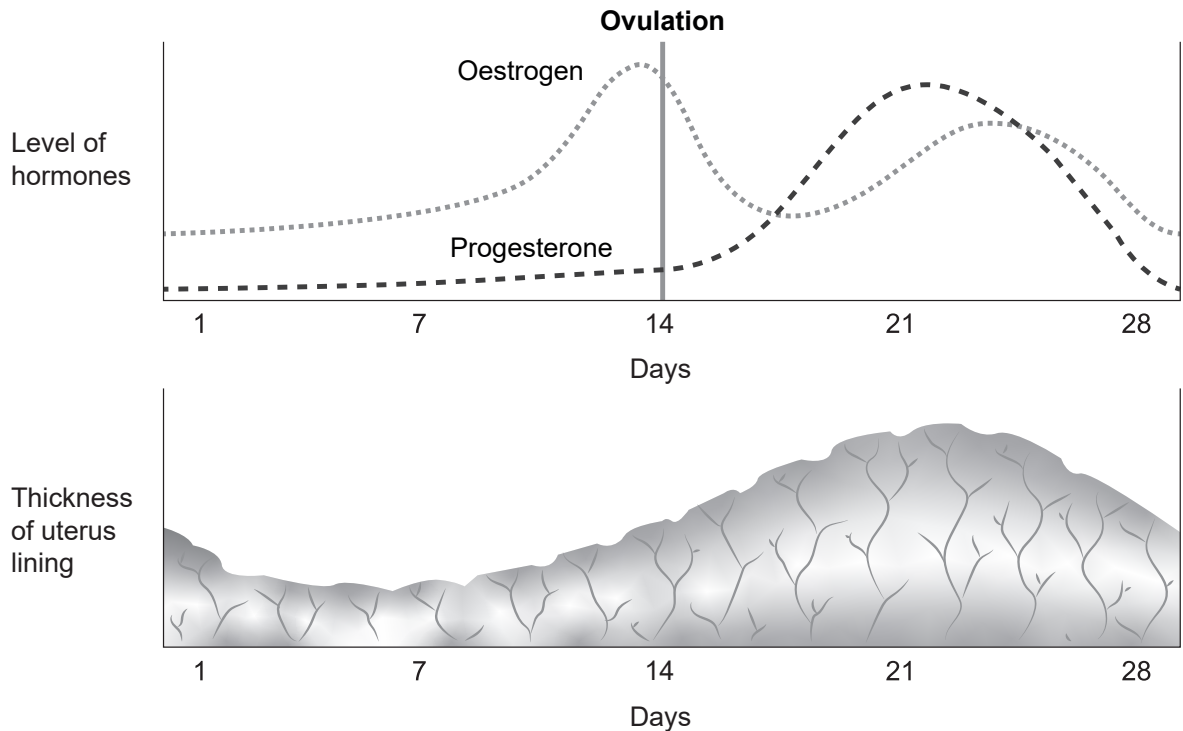


Fig. 4.3

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

.....

.....

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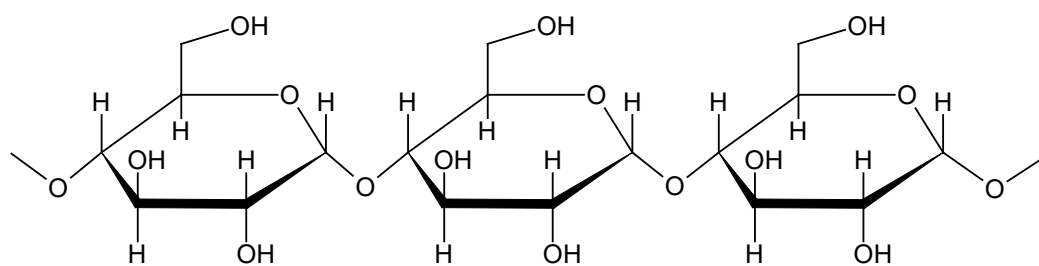
.....

[4]

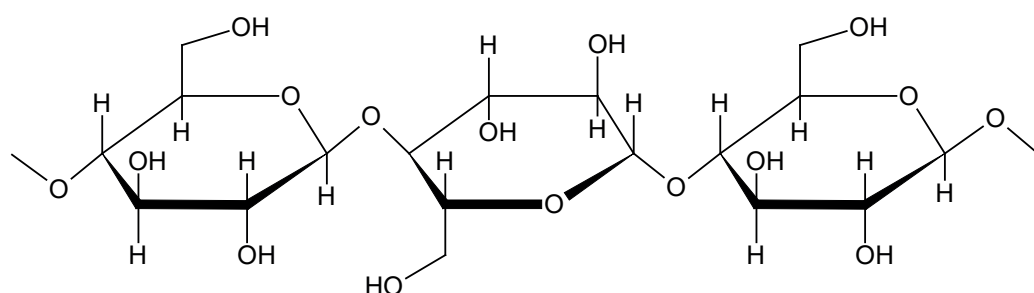
- 5 (a) Starch and cellulose are carbohydrates that are found naturally in plants.

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.

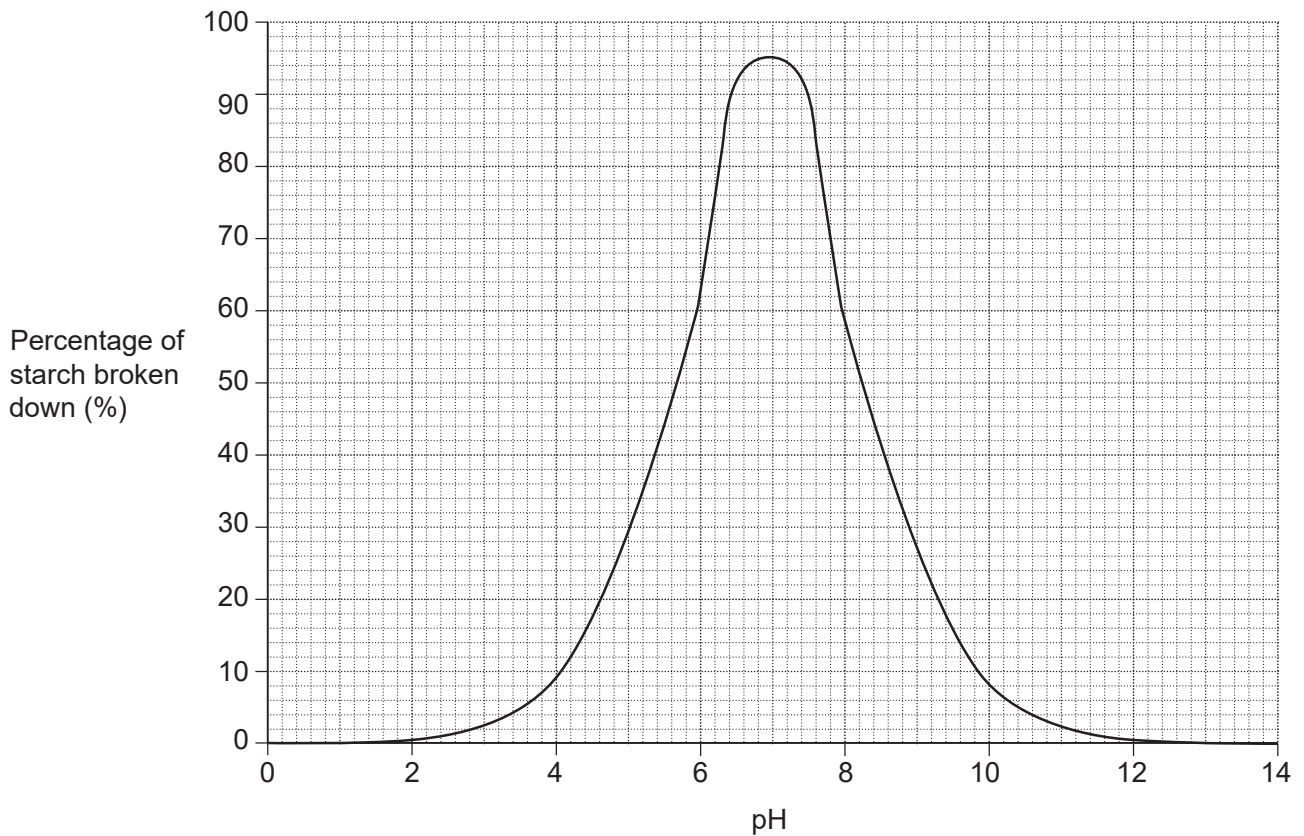


Fig. 5.2

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.

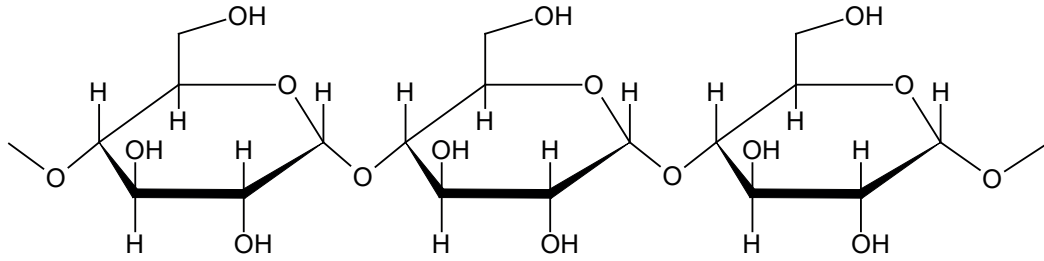
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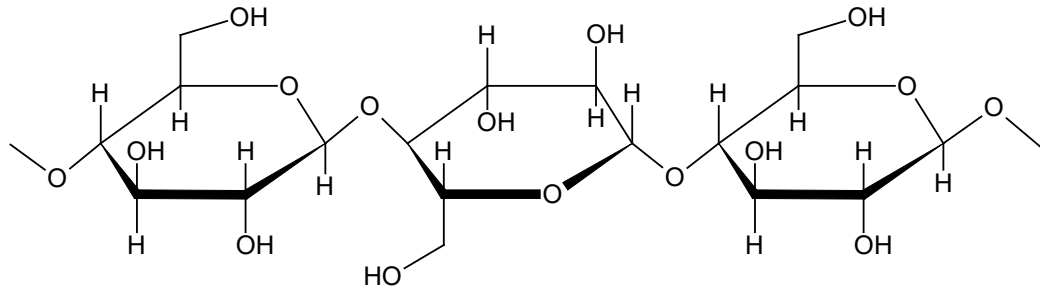
.....

..... [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

☐

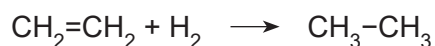
Emulsion

☐

Foam

☐

[1]

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

.....

.....

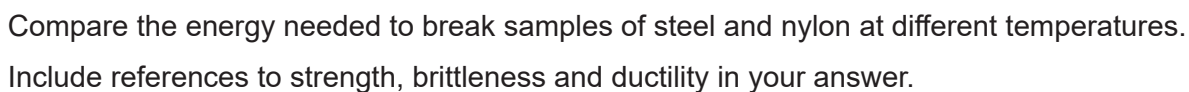
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.....

.....

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

Steel is an alloy and nylon is a polymer.



..... [6]

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

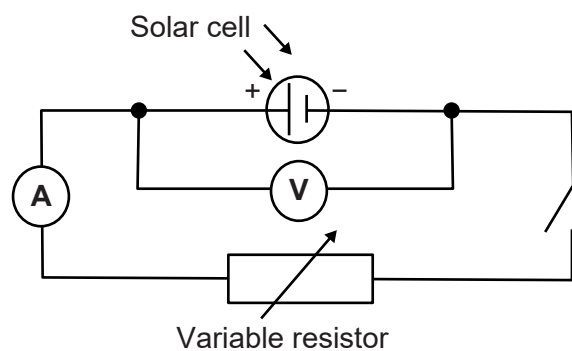


Fig. 8.1

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.

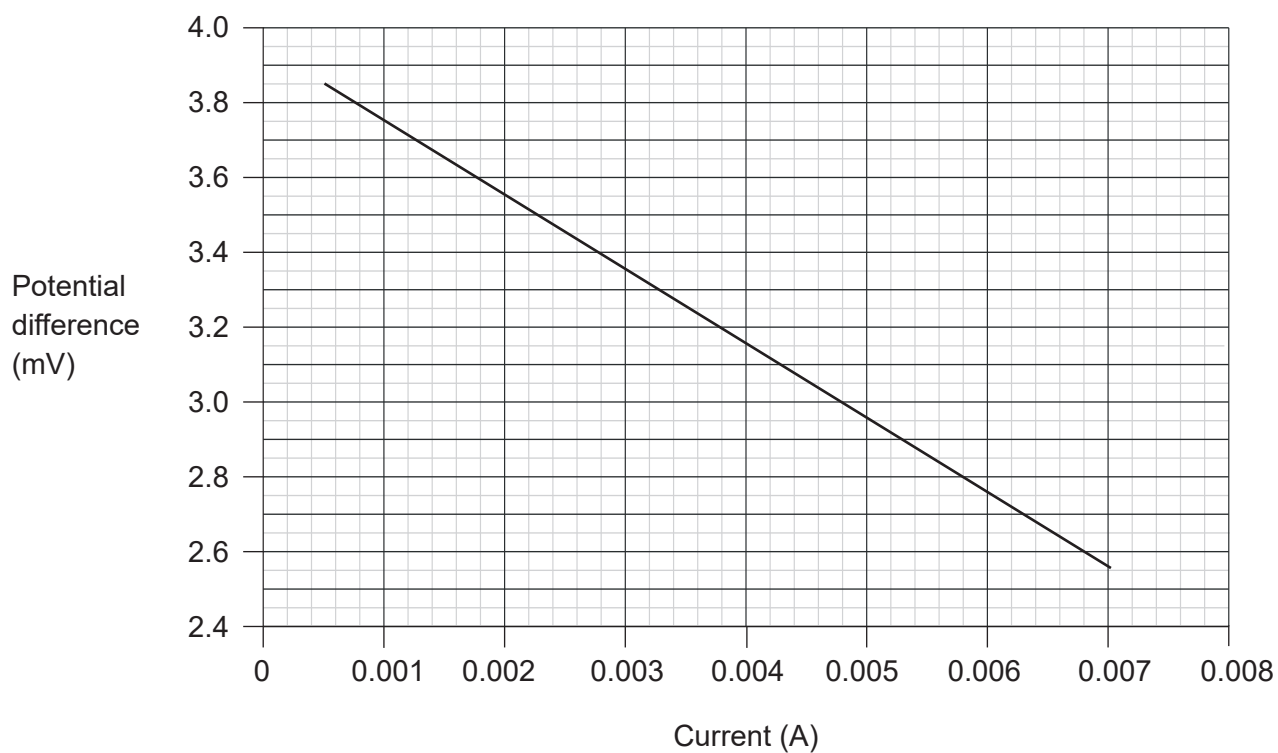


Fig. 8.2

(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 \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

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.

This image shows a single page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.

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The Periodic Table of the Elements

1

1

H

hydrogen

1.0

3

4

Li

lithium

6.9

11

12

Na

sodium

23.0

19

20

K

potassium

39.1

37

38

Rb

rubidium

85.5

55

56

Cs

caesium

132.9

87

88

Fr

francium

2

2

He

helium

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