OCR
Oxford Cambridge and RSA

Thursday 9 January 2020 – Afternoon

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C340/2001

C340-1-2001

You must have:
- the Data Sheet
- a ruler (cm/mm)

You can use:
- a scientific or graphical calculator

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.
- Answer **all** the questions.
- 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.

INFORMATION
- The Periodic Table is on the back page.
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- 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	/15
3	/16
4	/17
5	/12
6	/6
7	/9
Total	**/90**

Answer **all** the questions.

1 The electron configuration of a carbon atom is 2,4.

(a) Draw the electron configuration of a carbon atom on **Fig. 1.1**.

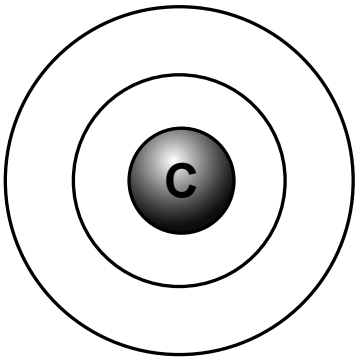

Fig. 1.1

[1]

(b) An isotope of carbon has 13 nucleons.

How many neutrons are there in an atom of carbon-13?

Put a (ring) around the correct answer.

6 **7** **12** **13**

[1]

(c) Explain why carbon atoms are neutral.

.....

.....

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

(d) **(i)** Which element is in the same Group as carbon but one Period below?

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

(ii) Explain why the element identified in **(d)(i)** is in the same Group as carbon.

.....

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

(iii) Explain why the number of electron shells increases down the Group.

.....

.....

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

(e) Methane has the molecular formula CH_4.

(i) Draw the 'dot and cross' diagram for methane.

You only need to show the outer electrons.

[2]

(ii) State the type of bonding in methane.

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

(f) The relationship between atomic radius and proton number is shown in **Fig. 1.2**.

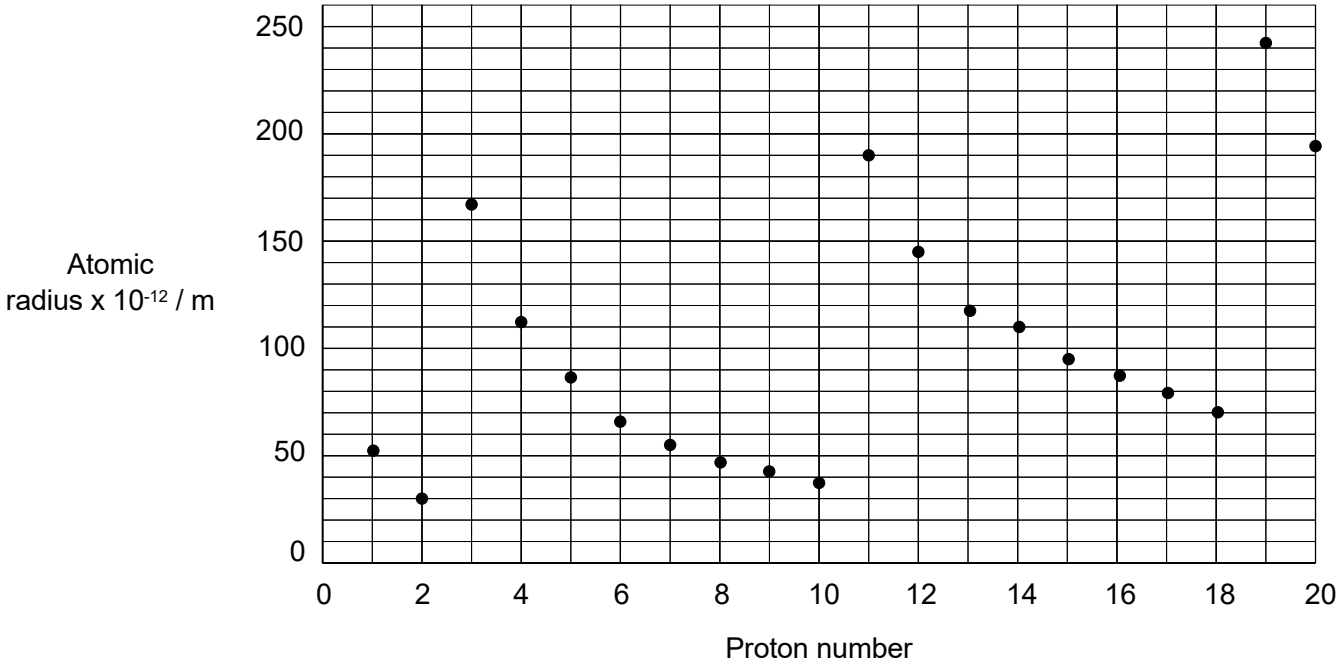

Fig. 1.2

(i) On **Fig. 1.2** draw circles around the Group 0 elements (noble gases).

[1]

(ii) Describe the trends shown in **Fig. 1.2**.

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.....

.....

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

(iii) Explain **one** of the trends you described in **(f)(ii)**.

.....

.....

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

2 **(a)** Nitrates are important inorganic compounds in plant biology.

Fig. 2.1 shows a plant crop. The crop has been supplied with sufficient levels of nitrate.

Fig. 2.1

(i) Nitrates are needed in plants to form a type of polymer.

Complete the sentences using words from the list.

amino acids	**ammonium**	**calcium**	**cellulose**	**fatty acids**	
glycerol	**lipid**	**protein**	**sodium**	**starch**	**sucrose**

When nitrates enter plant cells they are first converted into .....…..... ions.

These ions are then used to form .....…..... .

Finally, the molecules formed are used to make the polymer,

.....…..... .

[3]

(ii) Nitrates must be given to plants to avoid symptoms of deficiency.

One way that farmers increase the amount of nitrate available to their crops is to add inorganic fertiliser to their fields. However, the excessive use of inorganic fertiliser can lead to nitrate run-off into nearby streams and rivers.

Fig. 2.2 shows a graph of a study of a river that runs past a field treated with nitrate fertiliser.

The study involved measuring the fish population and the accumulation of algae bloom in the river. Algae are green aquatic plants which can grow rapidly, blocking sunlight from aquatic organisms and depleting oxygen levels.

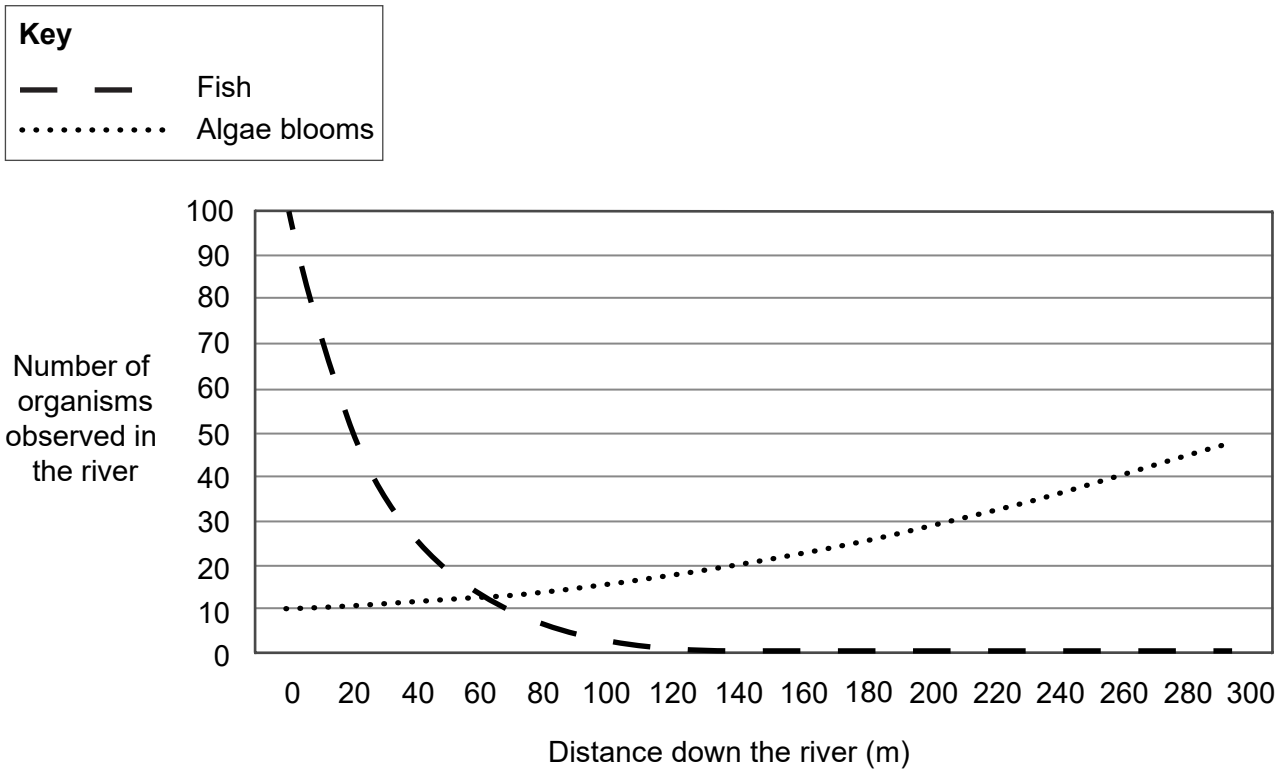

Fig. 2.2

Use the graph in **Fig. 2.2** to describe the trends in the populations of the organisms in the river.

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.....**[4]**

(iii) The study also found that the rate of algae bloom formation decreased in the winter compared to the summer.

Which factor caused the rate of algae bloom formation to decrease?

Tick (✓) **one** box.

Decreased air pressure	☐
Decreased light intensity	☐
Increased surface area	☐
Increased water temperature	☐

[1]

(b) A high intake of nitrates in infants can lead to a condition called blue baby syndrome.

This is because the red colour of blood becomes darker and the infant's skin develops a blue tinge.

(i) Suggest **one** way in which an infant could take in high levels of nitrates.

.....

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

(ii) The change in the colour of blood is a result of nitrate(III) ions reacting with the iron(II) ions that are in haemoglobin.

$Fe^{2+} + NO_2^- + 2H^+ \longrightarrow Fe^{3+} + NO + H_2O$

The reaction is a redox reaction. It involves both reduction and oxidation.

Use the equation to explain how this reaction involves **both** reduction and oxidation.

.....

.....

.....

.....

.....

.....

.....

.....**[4]**

(iii) The reaction shown in **(b)(ii)** prevents Fe^{2+} in haemoglobin from performing its function in the infant's body.

Describe the function of Fe^{2+} within haemoglobin.

.....

.....

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

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3 The human body contains many different types of tissue.

Fig. 3.1a and **Fig. 3.1b** show the same tissue type.

The tissue shown in **Fig. 3.1a** forms the lining of blood vessels and the walls of alveoli in the lungs.

The tissue shown in **Fig. 3.1b** forms the outer layer of skin covering the human body.

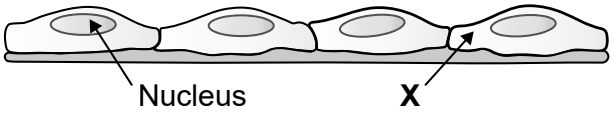


Fig 3.1a

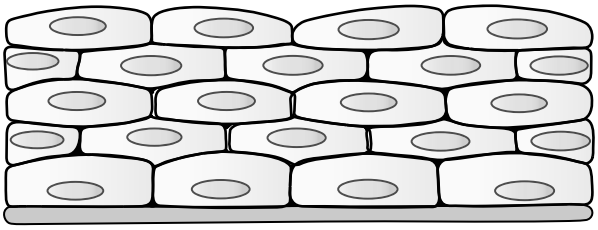


Fig 3.1b

(a) What type of tissue is shown in both **Fig. 3.1a** and **Fig. 3.1b**?

Tick (✓) **one** box.

Bone	☐
Connective	☐
Epithelial	☐
Nerve	☐

[1]

(b) Two of the main functions of this tissue type are:

- Protection of organs
- Absorption of various substances.

Using the diagrams, describe and explain how each tissue in **Fig. 3.1a** and **Fig. 3.1b** is suited to a specific function.

Fig. 3.1a .....

.....

.....

Fig. 3.1b .....

.....

.....

[4]

(c) (i) Name the region of the cell labelled **X** in **Fig. 3.1a**.

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

(ii) Give **two** functions of region **X** in the cell in **Fig. 3.1a**.

1 .....

2 .....

[2]

(iii) Region **X** is a colloidal mixture of a fluid called cytosol and various organelles.

It is sometimes considered to behave like a sol and at other times to behave like a gel.

Colloids are classified according to the phase of the dispersed substance and the medium of dispersion.

Draw a line to link each type of **colloidal mixture** to its correct **description**.

Colloidal mixture	**Description**
	Gas dispersed in a liquid
Sol	
	Liquid dispersed in a solid
Gel	
	Solid dispersed in a liquid

[2]

(d) (i) DNA (deoxyribonucleic acid) is a macromolecule which contains the genetic code for a living organism.

DNA is stored in different ways in eukaryotic and prokaryotic cells.

Identify the feature of DNA storage in each of these two types of cell.

Complete **Table 3.1**.

Type of cell	Feature of DNA storage
Eukaryotic	.....
Prokaryotic	.....

Table 3.1

[2]

(ii) RNA (ribonucleic acid) is also found in a eukaryotic cell. It is similar to DNA but there are differences.

Table 3.2 shows the components of DNA.

RNA has some of the same components as DNA but not all.

Complete **Table 3.2** with either a tick (✓) or a cross (x) to show the components found in RNA.

Component	DNA	RNA
Adenine	✓	
Deoxyribose	✓	
Cytosine	✓	
Guanine	✓	
Phosphate	✓	
Thymine	✓	

Table 3.2

[2]

(iii) RNA is able to travel out of the nucleus in the cells in **Fig. 3.1a** and into region **X**.

Explain why RNA can move out of the nucleus of a cell but DNA cannot.

.....

.....

.....

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

4 (a) Sugar molecules are simple carbohydrates.

D-fructose and D-glucose are two naturally occurring sugars.

Fig. 4.1 shows the straight chain forms of D-fructose and D-glucose molecules.

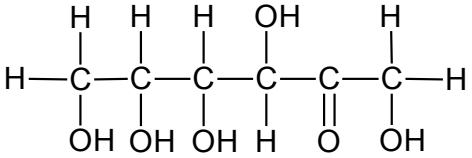
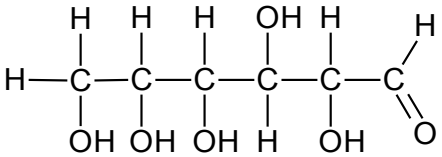
D-fructose	
D-glucose	

Fig. 4.1

(i) D-fructose and D-glucose are isomers of each other.

Use **Fig.4.1** to explain how the two sugar molecules are isomers.

.....

.....

.....

.....

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

(ii) Optical isomerism occurs in a molecule which contains at least one asymmetric carbon atom (or chiral centre).

Complete **Table 4.1** with the number of asymmetric carbon atoms present in each sugar molecule shown in **Fig. 4.1**.

Sugar molecule	Number of asymmetric carbon atoms
D-fructose	
D-glucose	

Table 4.1

[2]

(iii) Both sugar molecules in **Fig. 4.1** have –OH functional groups.

They also have a C=O bond, but the functional group containing this type of bond is different in the two sugar molecules.

Draw a line to link each **sugar molecule** to the type of **functional group** present.

Sugar molecule	Functional group
	Aldehyde
D-fructose	Alkyne
	Carboxylic acid
D-glucose	Ester
	Ketone

[2]

(b) Sugars can be fully converted into alcohols by reacting them with hydrogen.

The equation in **Fig. 4.2** shows the reaction of D-fructose with hydrogen.

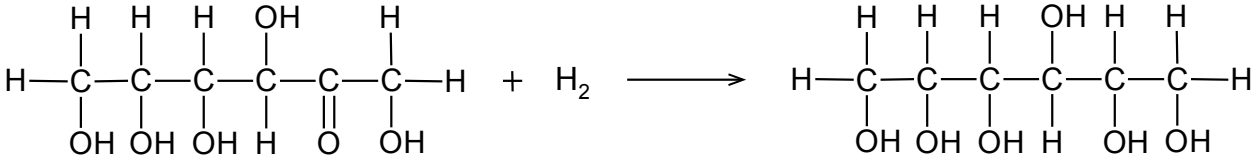


Fig. 4.2

What type of reaction is shown in **Fig. 4.2**?

Tick (✓) **one** box.

Addition ☐

Displacement ☐

Oxidation ☐

Substitution ☐

[1]

(c) The D-glucose sugar molecule also occurs in a cyclic or ring form as shown in **Fig. 4.3**.

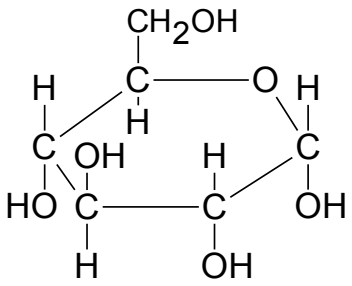
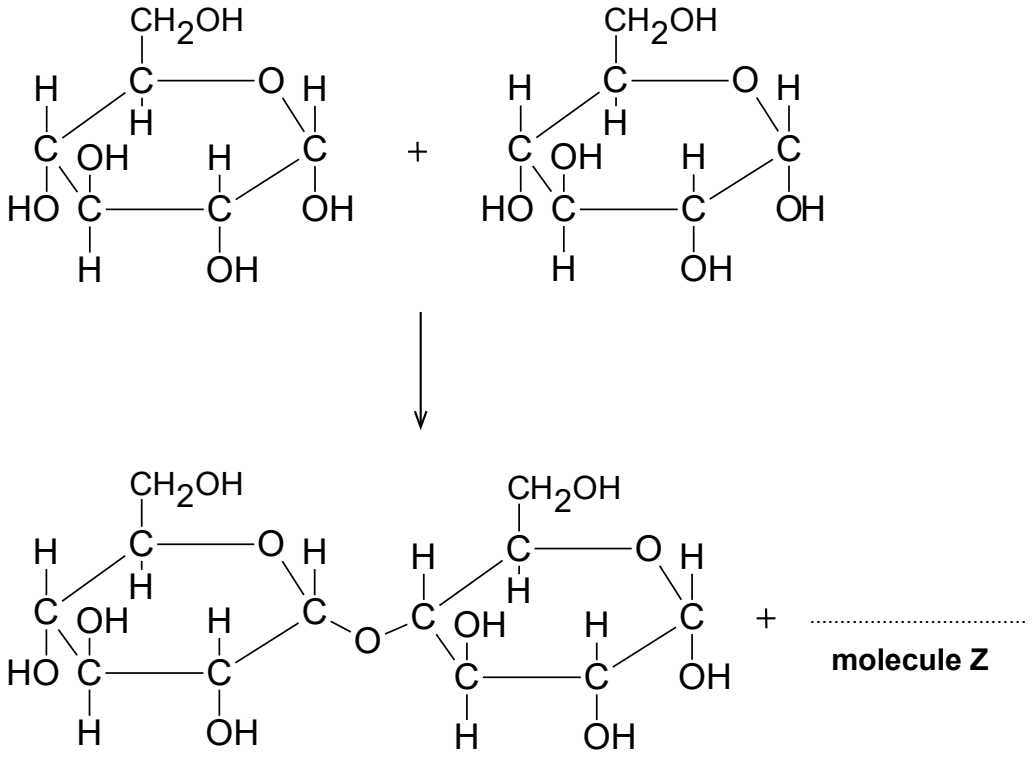


Fig. 4.3

Two cyclic or ring form D-glucose molecules can react together to form a larger carbohydrate molecule and another product.

The equation is shown in **Fig. 4.4**.



molecule Y

Fig. 4.4

(i) A single sugar molecule unit, such as D-glucose, is also known as a monosaccharide.

Give the name for the combination of two sugar molecule units as shown in **molecule Y** in **Fig. 4.4**.

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

(ii) Complete the equation shown in **Fig. 4.4** with the formula of **molecule Z**.

[1]

(d) D-glucose sugar molecules can also combine to form a long chain carbohydrate polymer called glycogen.

Fig. 4.5 shows part of a glycogen molecule.

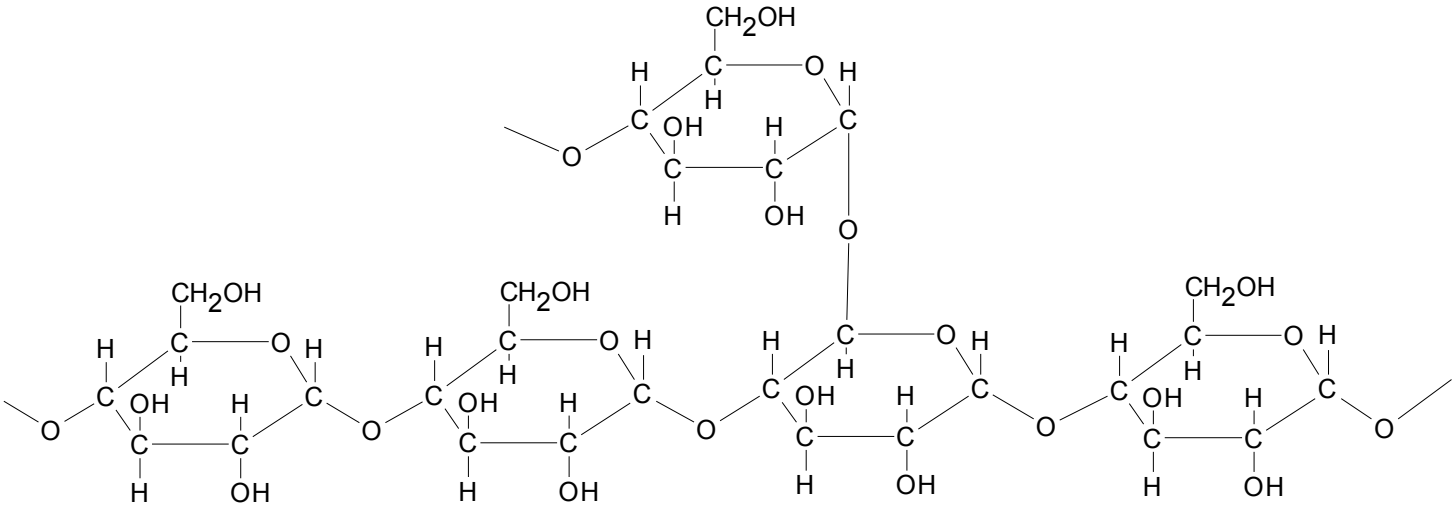


Fig. 4.5

Polypeptides are also natural polymers.

Complete **Table 4.2** to identify some of the differences between glycogen and a polypeptide.

Feature	Glycogen	Polypeptide
Type of monomer		
Type of bond between the monomers		
Atoms present		
Function in the body		

Table 4.2

[4]

(e) One synthetic polymer is polyethene.
Polyethene is made from monomers of ethene, C_2H_4.

(i) Draw a section of a polyethene chain that contains 6 carbon atoms.

[2]

(ii) Suggest why glycogen is classified as a carbohydrate but polyethene is not.

.....

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

5 Hydrogen peroxide is produced as a waste product in the human body.

(a) **(i)** What is the formula of hydrogen peroxide?

Tick (✓) **one** box.

HO	☐
HO_2	☐
H_2O	☐
H_2O_2	☐

[1]

(ii) What process produces hydrogen peroxide in the human body?

Tick (✓) **one** box.

Metabolism of amino acids	☐
Replication of DNA	☐
Transmission of a nerve impulse	☐
Treatment of hypertension	☐

[1]

(b) Hydrogen peroxide slowly decomposes into oxygen and one other product.

Complete the word equation for the decomposition of hydrogen peroxide.

Hydrogen peroxide → Oxygen + ...

[1]

(c) Hydrogen peroxide is a liquid at room temperature and pressure.

The rate of decomposition would be slower if hydrogen peroxide was a solid.

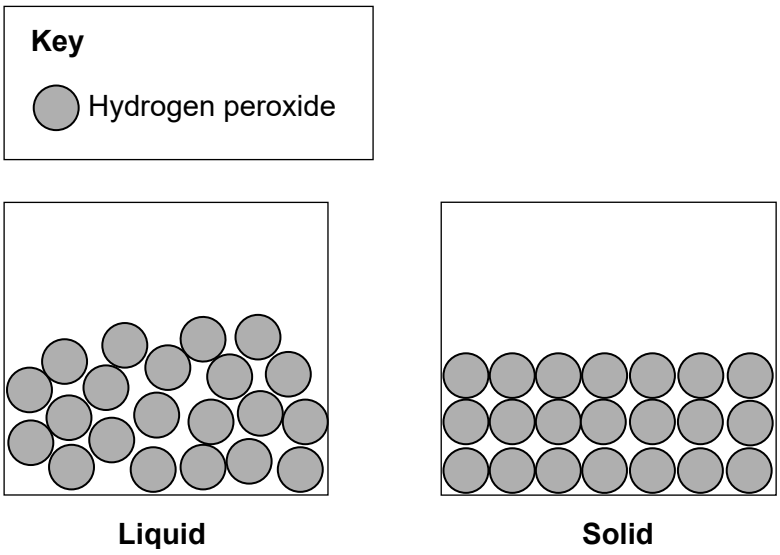


Fig. 5.1

Explain why the rate of decomposition is slower when hydrogen peroxide is in its solid state.

You may use the diagrams shown in **Fig. 5.1** in your answer.

.....

.....

.....

.....

.....

.....

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

(d) The decomposition of hydrogen peroxide happens quickly in the human body because it is catalysed by enzymes in the liver.

An experiment was conducted to see how much oxygen could be produced in 1 minute when liver was added to hydrogen peroxide at different temperatures.

Fig. 5.2 shows a graph of the experiment.

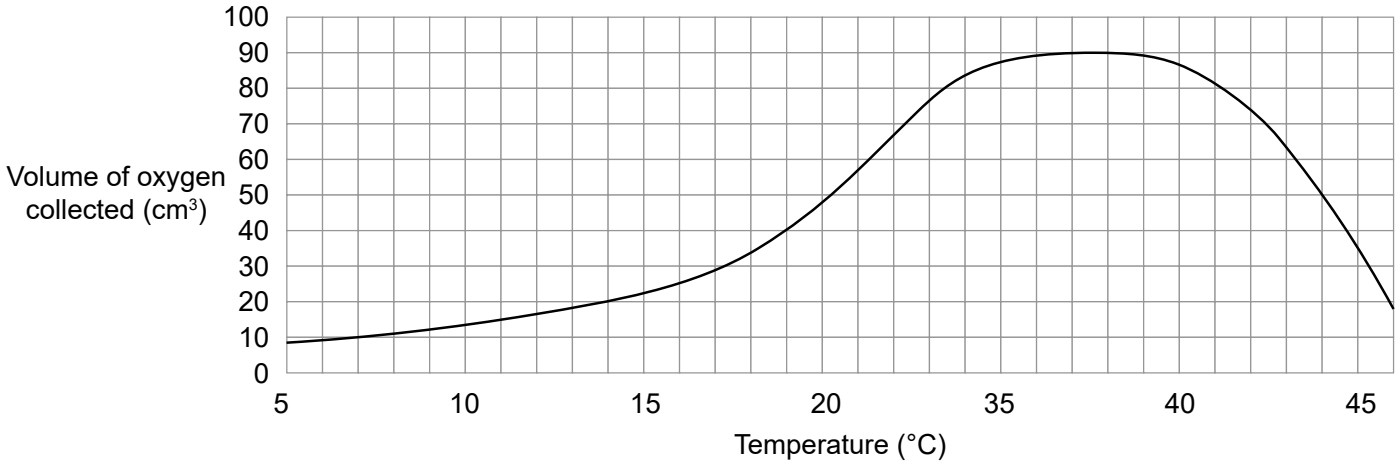


Fig. 5.2

Describe and explain the shape of the graph.

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

6 An infographic to show the ranges of some of the mechanical properties of different materials is shown in **Fig. 6.1**.

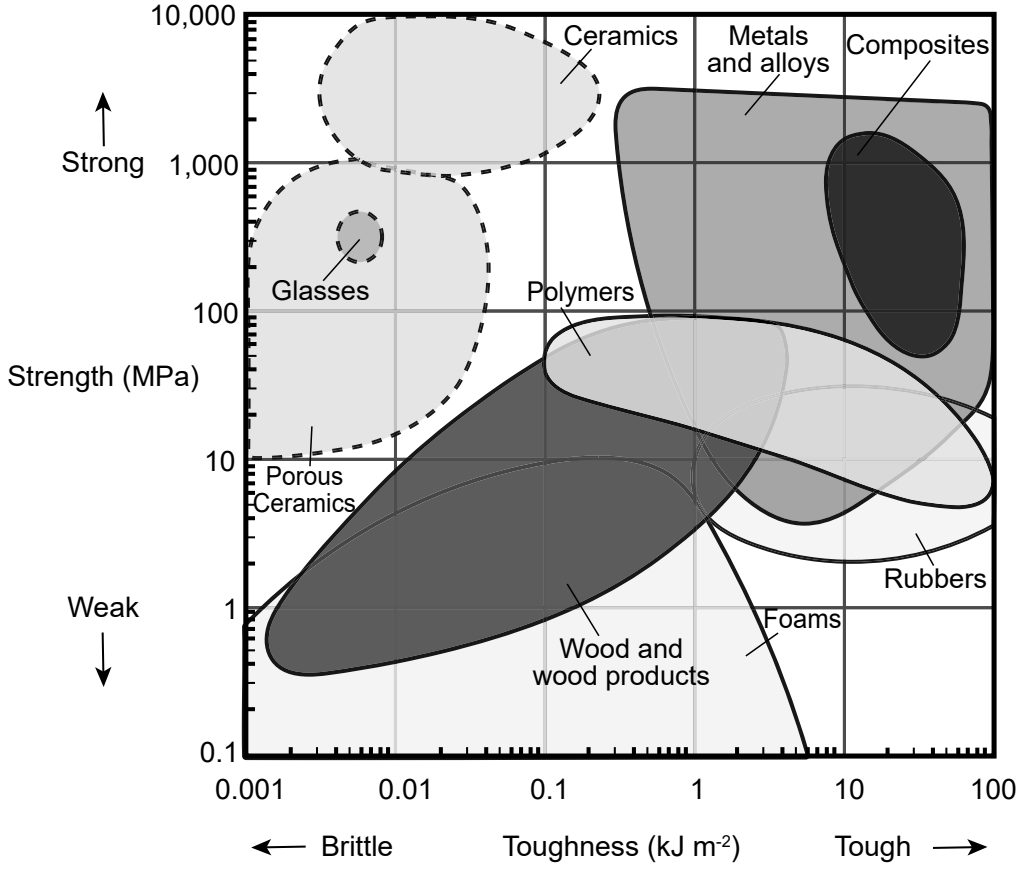

Fig. 6.1

(a) Compare the mechanical properties of the different materials shown in **Fig. 6.1**.

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.....

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

(b) Describe **three** properties of brittle materials.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

7 A small D.C. motor has a resistance of 0.6 Ω.

When connected to a power supply set to 5.0 V, a current of 0.2 A flows through the circuit.

The spindle of the motor turns rapidly.

(a) Calculate the power supplied to the motor.

Use the equation: power = potential difference x current

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

(b) **(i)** Calculate the potential difference across the motor.

Use the equation: potential difference = current x resistance

Potential difference = ... V **[2]**

(ii) Use your answer to **(b)(i)** to calculate the power dissipated in the motor.

Power dissipated = ... W **[1]**

(iii) Determine the power available for the motor to do work.

Power available = ... W **[1]**

(c) A load is attached to the spindle of the motor which now spins more slowly.

The power supply is still set to 5.0 V but the current flowing through the circuit is now 1.3 A.

(i) Calculate the power supplied to the motor when the load is attached.

Power supplied = ... W **[1]**

(ii) Calculate the power dissipated in the motor when the load is attached.

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

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 margins – for example, 1(f)(ii) or 6(b).

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

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