Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

7209780698111

CO-ORDINATED SCIENCES **0654/42**

Paper 4 Theory (Extended) **February/March 2023**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 120.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **36** pages. Any blank pages are indicated.

DC (RW/FC) 312403/2

1 **(a)** Fig. 1.1 is a diagram of a wind-pollinated flower.

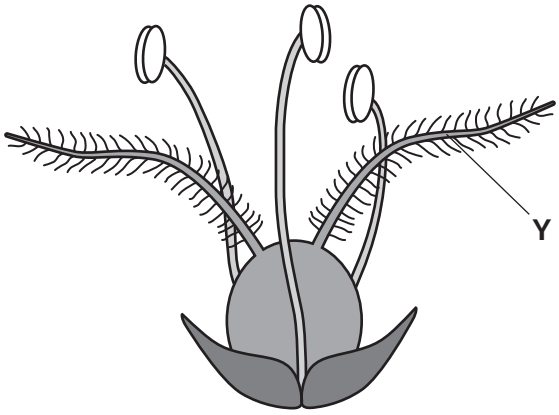


Fig. 1.1

(i) Identify the part of the flower that produces pollen. Draw a label line **and** add its correct name to Fig. 1.1. [2]

(ii) Draw an **X** on Fig. 1.1 to identify the part where fertilisation takes place. [1]

(iii) Describe **two** ways that the part labelled **Y** in Fig. 1.1 is adapted for wind-pollination.

1 .....

.....

2 .....

.....
[2]

(iv) Describe **two** ways a pollen grain from an insect-pollinated flower is different from a pollen grain from a wind-pollinated flower.

1 .....

.....

2 .....

.....
[2]

(b) Some plants are able to reproduce asexually.

Describe the **disadvantages** of asexual reproduction for plants in the wild.

.....

.....

.....

.....

..... [3]

[Total: 10]

2 Fig. 2.1 shows a person removing a damaged branch from a tree.

Fig. 2.1

(a) The damaged branch has a mass of 225 kg and is lowered 5.2 m to the ground.

Calculate the change in gravitational potential energy (GPE) of the branch as it is lowered to the ground.

The gravitational field strength, g = 10 N / kg.

change in GPE = ... J [2]

(b) The damage to the tree was caused by a lightning strike during a thunderstorm.

(i) A scientist estimates that the lightning strike transferred 6000 C of charge in 0.20 s.

Calculate the average current in the lightning strike.

current = ...A [2]

(ii) The thunderstorm produces both light and sound waves.

Explain why an observer sees the light before they hear the sound.

.....

.....

.....

..... [2]

(c) Lightning is caused by electrostatic charges in clouds.

Fig. 2.2 shows how charge can form an electric field inside the cloud.

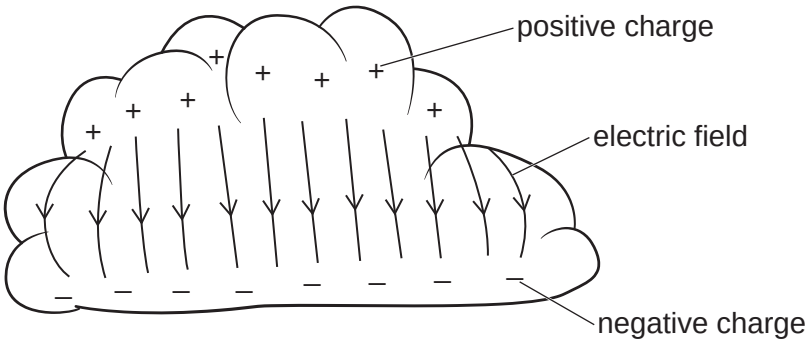


Fig. 2.2

(i) Fig. 2.2 shows negative charge at the base of the cloud.

State the name of the particles that provide this negative charge.

..... [1]

(ii) Describe what is meant by an electric field.

.....

..... [1]

(d) Thunderstorms can produce gamma radiation and X-rays as well as visible light.

Use the phrases to complete the sentences.

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

less than **more than** **the same as**

The speed of visible light is ..... the speed of X-rays.

The wavelength of gamma radiation is ..... the wavelength of visible light.

The frequency of X-rays is ..... the frequency of gamma radiation.

[2]

(e) When lightning passes through the air, it heats the air up to 10 000 °C.

State **and** explain what happens to the volume of the air when the temperature increases.
Use ideas about molecules in your answer.

.....

.....

.....

..... [2]

[Total: 12]

3 A student reacts calcium carbonate with **cold** dilute hydrochloric acid.

Fig. 3.1 shows the apparatus.

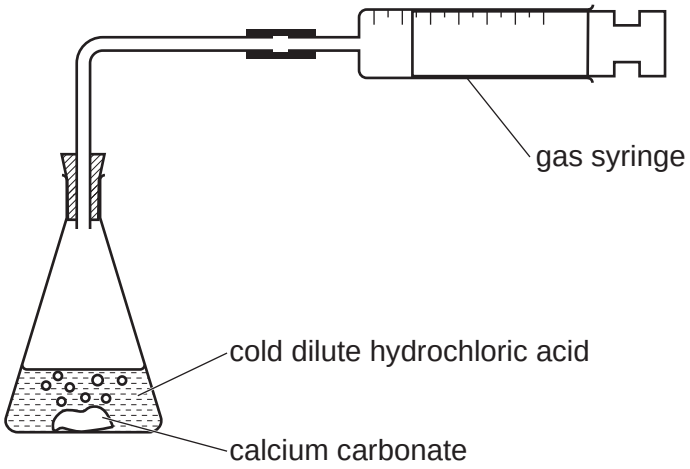


Fig. 3.1

The student measures the volume of gas in the gas syringe every five seconds for a total of fifty seconds.

Table 3.1 shows the results.

Table 3.1

time / seconds	volume of gas / cm^3
0	0
5	32
10	53
15	70
20	84
25	95
30	99
35	100
40	100
45	100
50	100

(a) State the volume of gas collected in the syringe when the reaction stops.

volume = ... cm^3 [1]

(b) (i) At the end of the experiment some calcium carbonate remains.

Describe how the rate of reaction changes during the experiment.
Explain your answer using ideas about collisions between particles.

.....

.....

.....

.....

..... [3]

(ii) The student repeats the procedure with the same amounts of calcium carbonate and dilute hydrochloric acid. The dilute hydrochloric acid has the same concentration as in part **(a)**.

This time they use **warm** dilute hydrochloric acid instead of cold dilute hydrochloric acid. The reaction is much faster.

Explain why the reaction is much faster by using ideas about collisions between particles.

.....

.....

.....

..... [2]

(c) (i) Some buildings are made from marble. Marble is a form of calcium carbonate.

Acid rain reacts very slowly with marble buildings.

Suggest why the reaction is so slow.

.....

..... [1]

(ii) Sulfur dioxide is a pollutant gas that dissolves in rainwater to form acid rain.

State **one** source of sulfur dioxide in the air.

.....

..... [1]

(d) Calcium carbonate, $CaCO_3$, and dilute hydrochloric acid, HCl, react to make a gas.

The other products are calcium chloride, $CaCl_2$, and water.

Construct the balanced symbol equation for this reaction.

..... + ... → ..... + ... + ...

[2]

[Total: 10]

4 **(a)** A student measures their breathing rate at rest and during exercise.

Table 4.1 shows their results.

Table 4.1

activity	breathing rate / breaths per minute
at rest	46
during exercise	77

Complete the sentences to describe and explain the results in Table 4.1.

Breathing rate increases between rest and exercise by ..... breaths per minute.

An increase in the breathing rate is caused by an increase in carbon dioxide concentration in the ..... .

During exercise the working ..... require more energy for contraction.

Oxygen is required for .... to release the energy required.

[4]

(b) Smoking tobacco affects the cilia of the ciliated cells that line parts of the gas exchange system.

The average length of cilia in smokers is 0.0057 mm.

The average length of cilia in non-smokers is 0.0068 mm.

(i) Suggest **two** effects on the gas exchange system caused by the difference in length of cilia.

1 .....

.....

2 .....

.....

[2]

(ii) State the names of **two** parts of the gas exchange system that are lined with ciliated cells.

1 .....

2 .....

[2]

(c) Fig. 4.1 is a graph showing the relationship between the number of cigarettes smoked and deaths caused by lung cancer between 1900 and 1980.

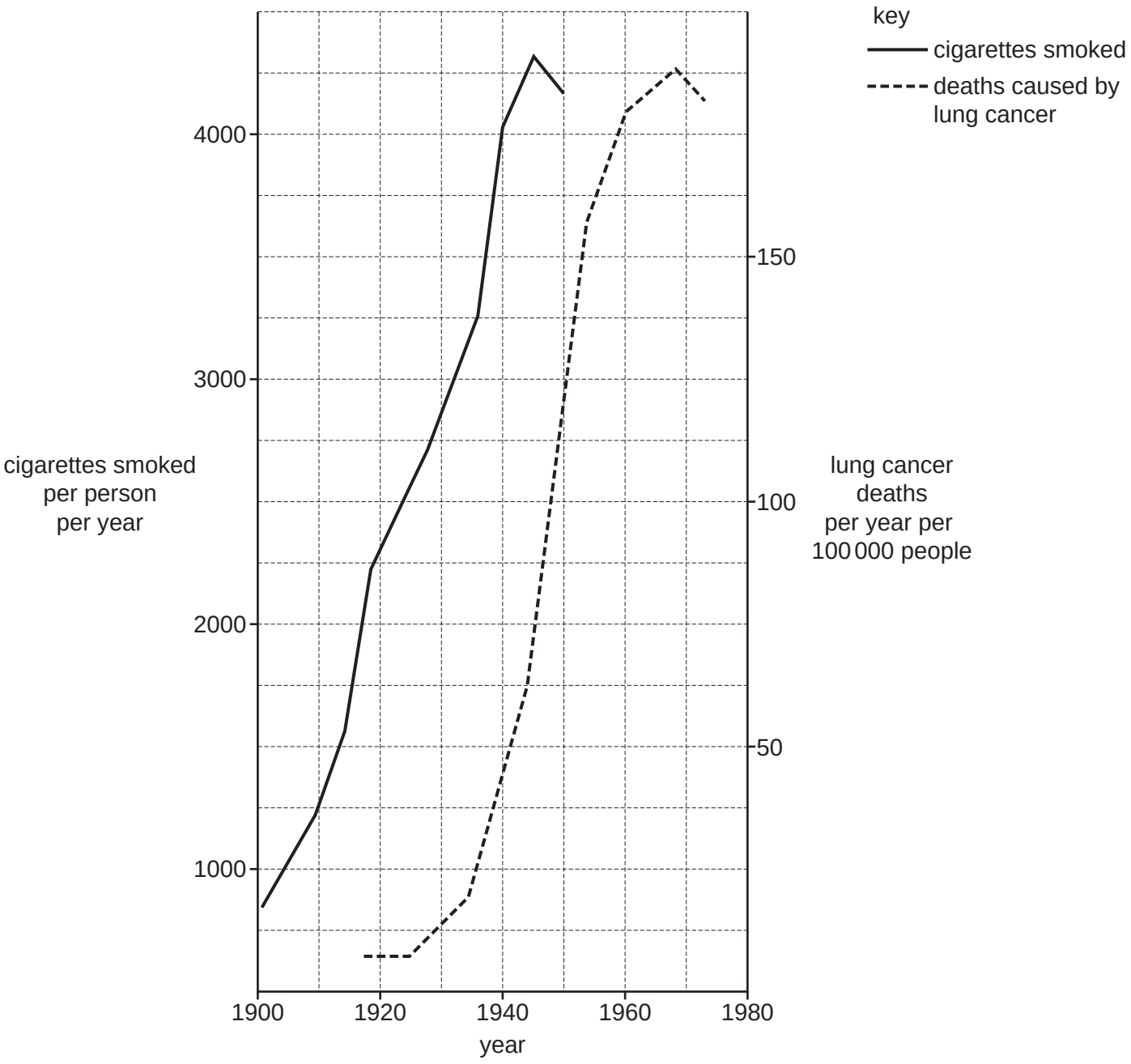


Fig. 4.1

(i) Place ticks (✓) in the boxes to show all the conclusions that can be made from Fig. 4.1.

There is a strong correlation between the number of cigarettes smoked and the number of deaths caused by lung cancer.	
The decrease in the number of cigarettes smoked and the decrease in deaths caused by lung cancer occur in the same year.	
There is a time delay between the increase in number of cigarettes smoked and the increase in number of deaths caused by lung cancer.	
The maximum number of cigarettes smoked and the maximum number of deaths caused by lung cancer is approximately the same.	
The only factor influencing deaths caused by lung cancer is the number of cigarettes smoked.	

[2]

(ii) State the name of the component of tobacco smoke that causes cancer.

..... [1]

(iii) State the name of **one** disease, other than cancer, that is caused by smoking tobacco.

..... [1]

[Total: 12]

5 This question is about chemical bonding.

(a) Put a tick (✓) in the box next to the sentence that describes a metal atom.

An atom that gains electrons to get a full outer shell and become stable. ☐

An atom that shares electrons to get a full outer shell and become stable. ☐

An atom that loses electrons to get a full outer shell and become stable. ☐

[1]

(b) Complete the sentences about **ionic** bonding.

Choose words from the list.

Each word can be used once, more than once or not at all.

chlorine	**opposite**	**similar**
lattice	**oxygen**	**sodium**
molecular	**polymer**	**strong**
negative	**positive**	**weak**

If an atom gains electrons a ..... ion is formed.

An example of an atom gaining 1 electron to complete its outer shell is ..... .

During the formation of ionic bonds there is a ..... attraction between ions because of their ..... electrical charges. The ions form a regular arrangement of alternating ions called a ..... structure.

[5]

(c) (i) Fig. 5.1 shows the bonding in a molecule of water, H_2O.

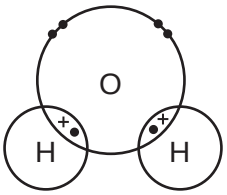


Fig. 5.1

State the name of the type of bonding in a molecule of water.

..... [1]

(ii) Complete the dot-and-cross diagram in Fig. 5.2 to show the bonding in a molecule of nitrogen, N_2.

You only need to show the outer-shell electrons.

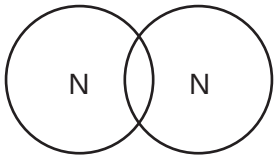


Fig. 5.2

[2]

(iii) Water and nitrogen have low melting points.

Explain why in terms of attractive forces.

.....

.....

..... [2]

[Total: 11]

6 A student investigates how different shaped objects fall.

The student makes three different shapes out of modelling clay. Each shape has the same mass.

Fig. 6.1 shows the shapes.

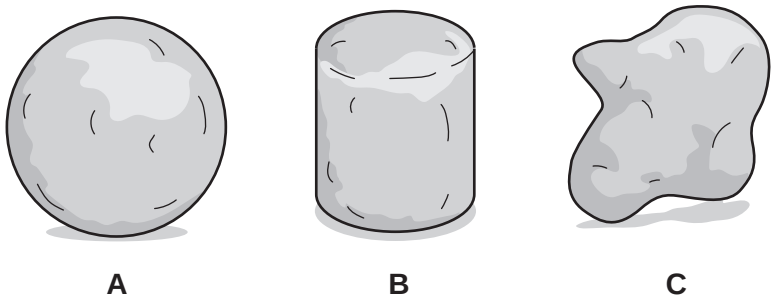


Fig. 6.1

(a) The student holds each shape 1.5 m above the ground and uses a stopwatch to time how long it takes for each shape to hit the ground.

Table 6.1 shows the results.

Table 6.1

shape	time to hit the ground / s
A	0.61
B	0.68
C	0.63

(i) Calculate the average speed of shape **B** as it falls.

speed = ... m / s [2]

(ii) Shape **A** hits the ground at a speed of 5.2 m / s.

Calculate the average acceleration of shape **A** as it falls.

acceleration = ... m/s^2 [2]

(iii) The acceleration due to gravity on Earth is 10 m/s^2.

Explain why the average acceleration of shape **A** is **not** 10 m/s^2. Use ideas about forces in your explanation.

.....

.....

..... [2]

(b) The student wants to determine the density of the clay used to make the shapes.

The mass of each shape is 135 g.

Fig. 6.2 shows the apparatus the student uses to determine the volume of shape **C**.

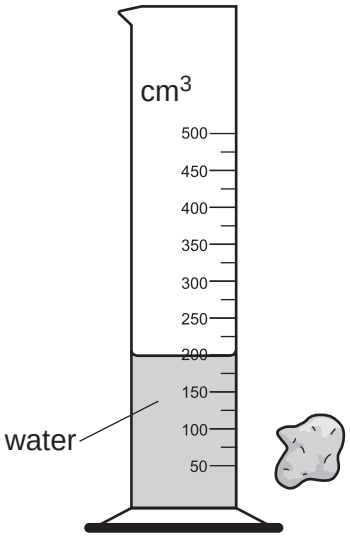


Fig. 6.2

(i) Use Fig. 6.2 to describe how the student determines that the volume of shape **C** is 75 cm^3.

.....

.....

..... [2]

(ii) Calculate the density of shape **C** in g/cm^3.

density = ... g/cm^3 [2]

[Total: 10]

7 **(a)** One cause of the pupil reflex is a change in light intensity.

Fig. 7.1a and Fig. 7.1b show the eye of a person that has been exposed to different light intensities.

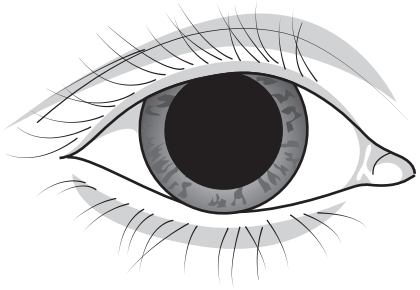


Fig. 7.1a

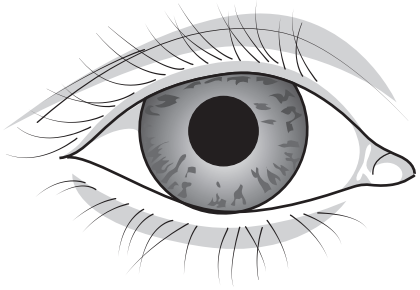


Fig. 7.1b

(i) Suggest the name of the receptor **and** the name of the effector for the reflex response shown in Fig. 7.1.

receptor .....

effector .....
[2]

(ii) State the name of **one** hormone that can cause the response seen in Fig. 7.1a.

..... [1]

(iii) State **two** reasons why the pupil reflex is described as a reflex action.

1 .....

2 .....
[2]

(b) Place ticks (✓) in the boxes to identify **all** the examples of voluntary actions.

eating	
heart beating	
sneezing	
sweating	
talking	

[1]

(c) Describe **two** ways the action of hormonal control systems is different from the action of nervous control systems.

1 .....

2 .....
[2]

(d) State the name of **one** hormone that is released from the pancreas and is involved in the control of blood glucose concentration.

..... [1]

[Total: 9]

8 Ammonium sulfate is used as a fertiliser.

(a) Ammonium sulfate contains the element nitrogen.

Explain why farmers add nitrogen-containing fertilisers to crops.

.....

..... [1]

(b) Ammonium sulfate contains the ions NH_4^+ and SO_4^{2-}.

Determine the formula of ammonium sulfate.

formula = ... [1]

(c) A student makes another fertiliser called potassium sulfate, K_2SO_4.

The reactants are potassium hydroxide, KOH, and sulfuric acid, H_2SO_4.

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

Calculate the maximum mass of potassium sulfate made from 28 g of potassium hydroxide.

Show your working.

[A_r: H, 1; K, 39; O, 16; S, 32]

mass of potassium sulfate = ... g [3]

(d) Ammonia is a chemical used to make fertilisers.
It is made by the Haber process from the reaction of nitrogen with hydrogen.

$$\text{nitrogen} + \text{hydrogen} \rightleftharpoons \text{ammonia}$$

Fig. 8.1 shows the percentage of ammonia made using different conditions of temperature and pressure.

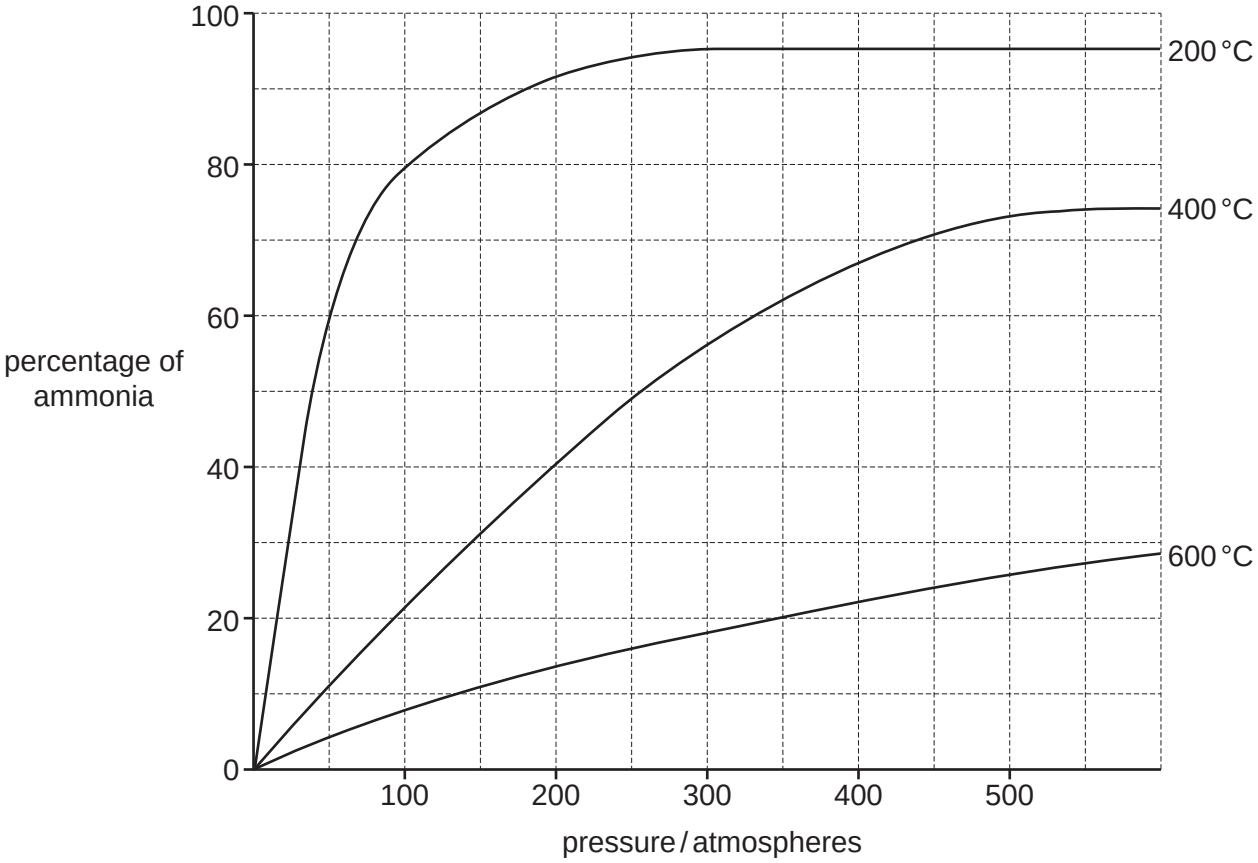


Fig. 8.1

(i) State what happens to the percentage of ammonia made when the pressure increases.

Use Fig. 8.1 and the curve drawn for the reaction at 600 °C.

..... [1]

(ii) The highest percentage of ammonia is made at 200 °C and 300 atmospheres. This is the lowest of the three temperatures shown on the graph.

Explain why a temperature of 450 °C is used in an ammonia factory.

Use ideas about the position of the equilibrium and the rate of reaction.

position of equilibrium .....

.....

rate of reaction .....

.....

[2]

[Total: 8]

9 **(a)** Fig. 9.1 shows a simple circuit containing a heater and a thermistor.

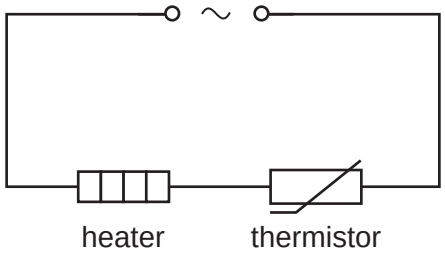


Fig. 9.1

Use Fig. 9.1 to explain how increasing the temperature of the thermistor changes the power output of the heater.

.....

.....

.....

.....

.....

..... [3]

(b) Fig. 9.2 shows an electric kettle.

Fig. 9.2

The kettle has a power rating of 3000 W.

It takes 336 kJ of energy to heat some water from room temperature to 100 °C.

Calculate the time it will take for the kettle to heat the water from room temperature to 100 °C.

time = ... s [3]

(c) Hot water is poured into two similar cups with lids. One cup is black and the other is white.

The temperature of the water in each cup is measured every minute for 15 minutes.

Fig. 9.3 shows the results.

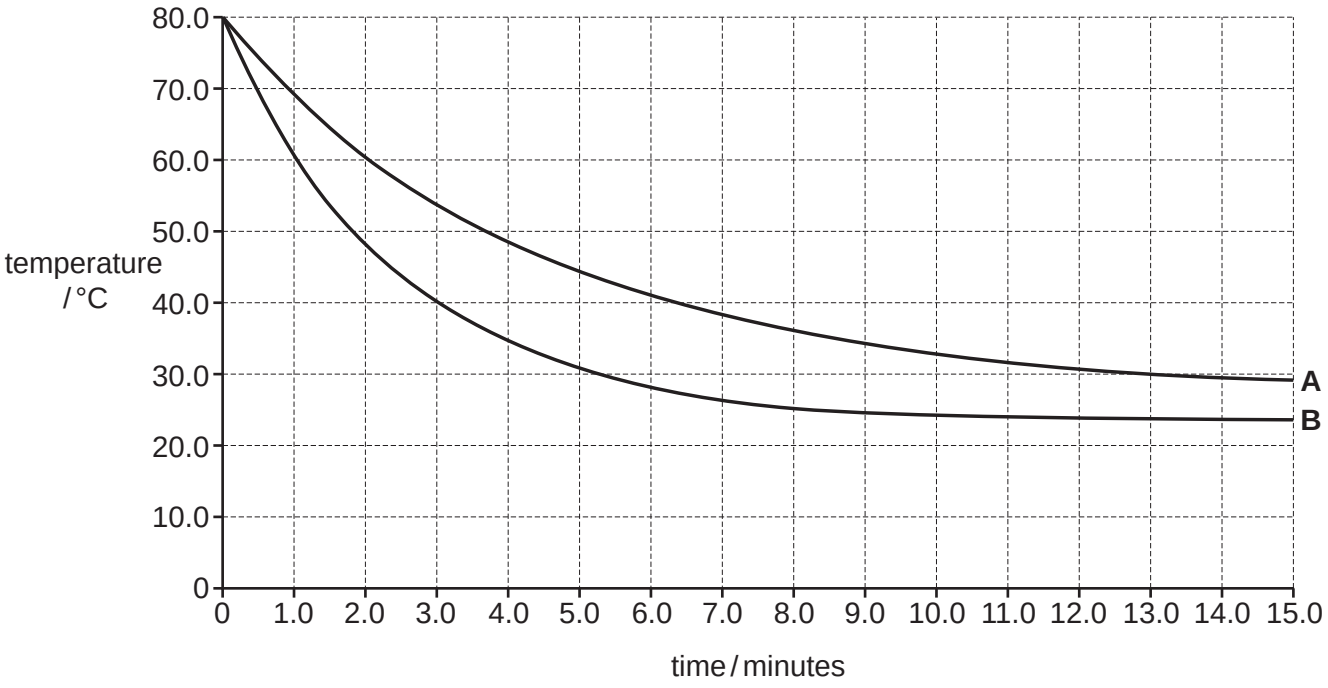


Fig. 9.3

State and explain which colour cup gives the results labelled **A**.

A shows the results for the ..... cup.

explanation .....

.....

.....

.....

[2]

(d) Some water is spilt on a table and forms a droplet which acts like a convex lens.

Convex lenses can form real and virtual images.

Describe the difference between a real image and a virtual image.

.....

.....

..... [1]

[Total: 9]

10 **(a)** Fig. 10.1 shows the effect of pH on the activity of one digestive enzyme.

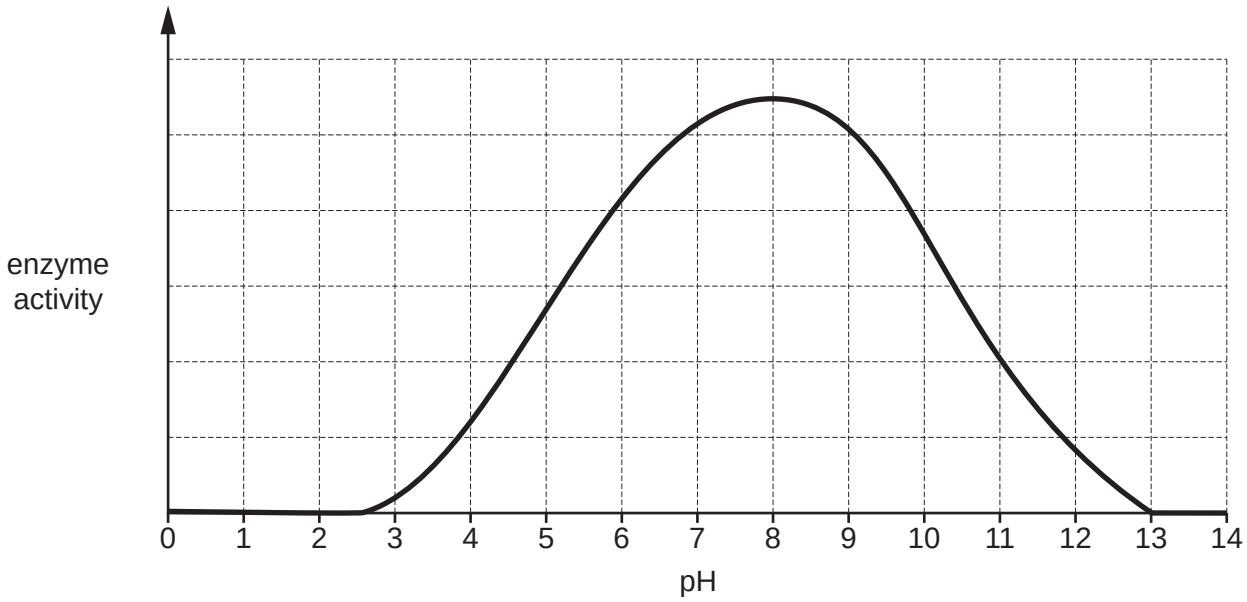


Fig. 10.1

(i) State the optimum pH for the enzyme as shown in Fig. 10.1.

..... [1]

(ii) Explain the effect on enzyme activity caused by **pH 2** as shown in Fig. 10.1.

.....

.....

.....

.....

..... [3]

(b) State the name of the digestive enzyme that breaks down starch.

..... [1]

(c) State the optimum pH for the enzyme protease which is active in the stomach.

..... [1]

(d) Digestive enzymes break down large molecules into smaller molecules.

Table 10.1 shows information about some large food molecules.

Complete Table 10.1.

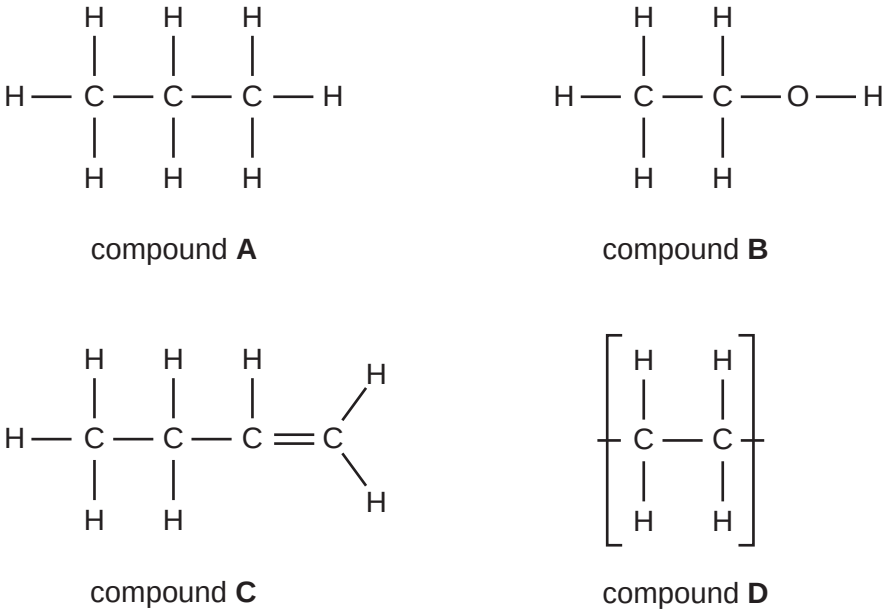
Table 10.1

large food molecule	smaller molecules they are made from	chemical test for presence of large food molecule
oil		
protein		
starch		iodine solution

[3]

[Total: 9]

11 Fig. 11.1 shows the structures of some compounds of carbon.



compound **A**

compound **B**

compound **C**

compound **D**

Fig. 11.1

(a) State which compound **A**, **B**, **C**, or **D** is unsaturated.

..... [1]

(b) State which **one** of these chemicals is used to test for unsaturation.

aqueous barium chloride	**bromine**
limewater	**sodium hydroxide**

..... [1]

(c) Compound **A** is called propane.

State the name of compound **B**.

..... [1]

(d) Compound **D** is called poly(ethene).

Poly(ethene) is a polymer made in an addition polymerisation reaction.

(i) Complete the sentence to define a polymer.

A polymer is a .... molecule formed from small units called ..... .

[2]

(ii) Draw the structure of the small unit (molecule) from which poly(ethene) is made.

[1]

(e) Fig. 11.2 shows the energy level diagram for the reaction between compound **B** and oxygen.

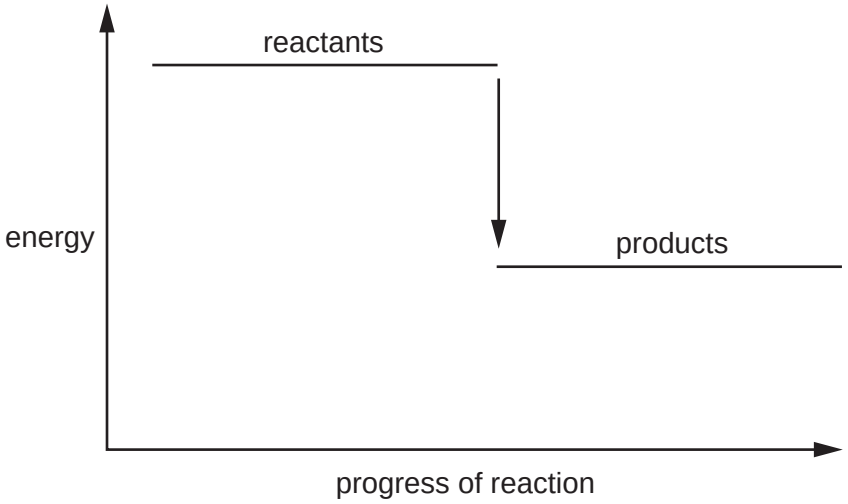


Fig. 11.2

Energy is given out in this reaction.

(i) Explain how Fig. 11.2 shows that energy is given out.

.....

..... [1]

(ii) State the name of the type of reaction that gives out energy.

..... [1]

(iii) Explain why energy is given out when compound **B** reacts with oxygen.

Use ideas about bond breaking and bond making.

.....

.....

.....

..... [3]

[Total: 11]

12 Fig. 12.1 shows a wire being moved between the poles of a magnet.

The wire is connected to an ammeter which measures the current induced in the wire as the wire is moved. When the wire moves from left to right the ammeter shows a positive reading.

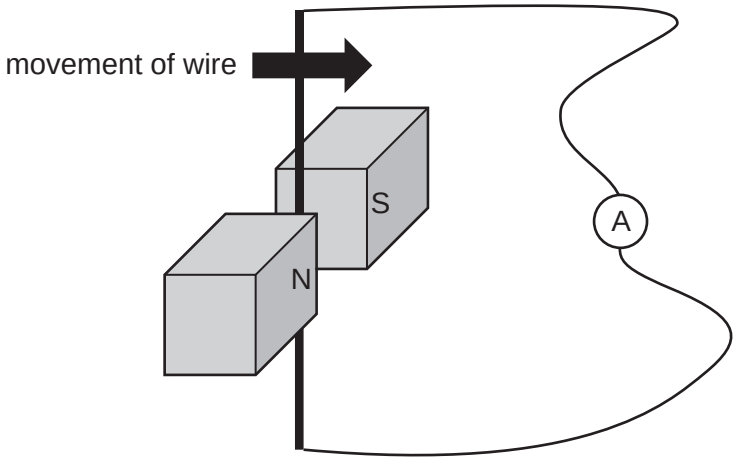


Fig. 12.1

(a) (i) Explain why a current is induced in the wire as it is moved between the poles of the magnet.

.....

.....

.....

..... [2]

(ii) Place ticks (✓) in Table 12.1 to show how the reading on the ammeter changes under different conditions.

Table 12.1

	ammeter reading			
the wire in **(a)(i)** is:	becomes zero	increases	decreases	becomes negative
moved faster				
moved from right to left				
kept stationary				
replaced with a wire of lower resistance				

[2]

(b) A magnet is used to investigate the behaviour of ionising radiation.

(i) Fig. 12.2 shows the paths taken by three types of ionising radiation as they pass through a magnetic field.

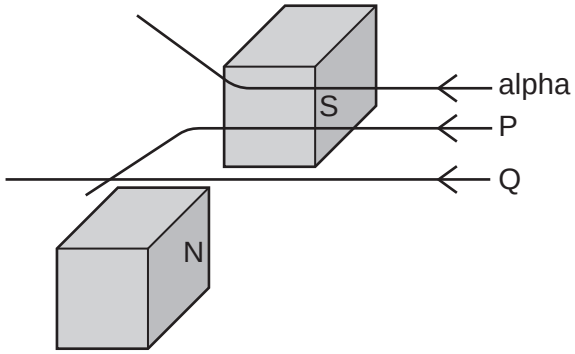


Fig. 12.2

The path taken by an alpha particle has been labelled for you.

State the types of radiation which would follow the paths labelled **P** and **Q**.

P .....

Q .....

[1]

(ii) When americium-241 ($^{241}_{95}$Am) decays it emits an alpha particle.

Use the correct nuclide notation to complete the decay equation for americium-241.

$$^{241}_{95}\text{Am} \longrightarrow {}^{\cdots\cdots}_{93}\text{Np} + {}^{\cdots\cdots}_{\cdots\cdots}\alpha$$

[2]

(iii) Americium-241 is a source of alpha particles. It is used in smoke detectors.

Fig. 12.3 shows part of the inside of a smoke detector. The alpha particles cause a current in the sensor.

When the detector fills with smoke, a change in current is detected by a sensor which sounds an alarm.

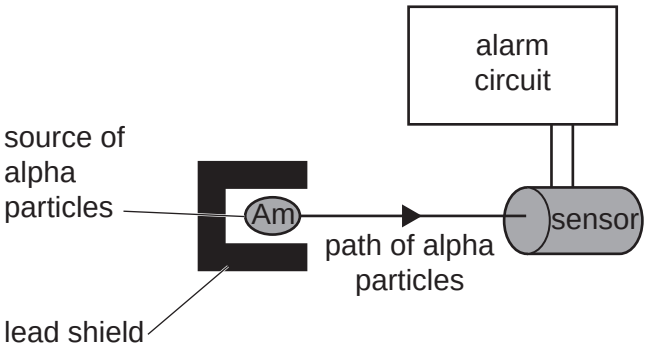


Fig. 12.3

Suggest **two** reasons why a source of alpha particles is used and not any other type of ionising radiation.

1 .....

.....

2 .....

.....

[2]

[Total: 9]

BLANK PAGE

BLANK PAGE

BLANK PAGE

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	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 –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	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 –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).