Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

5299140989

CO-ORDINATED SCIENCES **0654/42**

Paper 4 Theory (Extended) **May/June 2022**

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 **28** pages. Any blank pages are indicated.

1 **(a)** A student monitors his pulse rate at rest and during exercise.

Table 1.1 shows the results.

Table 1.1

activity	pulse rate / beats per minute
at rest	64
during exercise	122

(i) Calculate the difference between his pulse rate at rest and during exercise.

..... beats per minute [1]

(ii) Complete the sentences to explain the results in Table 1.1.

During exercise, the pulse rate increases because the heart is pumping

blood ..... .

The pumping action is caused by contraction of the ..... wall

of the heart.

To provide the body with more energy, the process of .....

increases.

This process requires increased blood flow to the cells to deliver more

..... and ..... .

[4]

(b) Genetic predisposition and sex are both risk factors for coronary heart disease.

(i) Describe two **dietary** recommendations to follow to reduce the risk of developing coronary heart disease.

1 .....

2 .....

[2]

(ii) Males are more likely to develop coronary heart disease than females.

State the sex chromosomes in males.

..... [1]

(c) Male gametes are produced by meiosis.

Describe two ways in which the cells produced by meiosis are different from the cells produced by mitosis.

1 .....

.....

2 .....

.....

[2]

[Total: 10]

2 Clean air contains nitrogen gas and oxygen gas.

(a) State the percentage of nitrogen gas and oxygen gas in clean air.

nitrogen gas = ...%

oxygen gas = ...%
[2]

(b) In a car engine, nitrogen gas and oxygen gas react together.

Nitrogen monoxide, NO, is made.

(i) Construct the balanced symbol equation for this reaction.

..... [2]

(ii) The rate of this reaction increases as the **temperature** inside the car engine increases.

Explain why. Use ideas about collisions between particles.

.....

.....

..... [2]

(iii) The rate of this reaction increases as the **concentration** of the oxygen gas increases.

Explain why. Use ideas about collisions between particles.

.....

.....

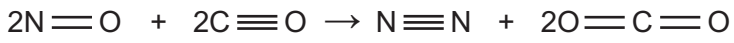
..... [2]

(c) A catalytic converter removes nitrogen monoxide from the exhaust emissions of a car.

Nitrogen monoxide reacts with carbon monoxide.

Nitrogen and carbon dioxide are made.

Look at the equation for this reaction. It shows all the atoms and all the bonds.



(i) Draw a (circle) around each set of bonds which are broken when the reaction takes place. [1]

(ii) When nitrogen monoxide reacts with carbon monoxide, the reaction is **exothermic**.

Explain why. Use ideas about bond breaking and bond making.

.....

.....

.....

..... [3]

[Total: 12]

3 Fig. 3.1 shows a 35 kg child sliding down a long wire called a zipline.

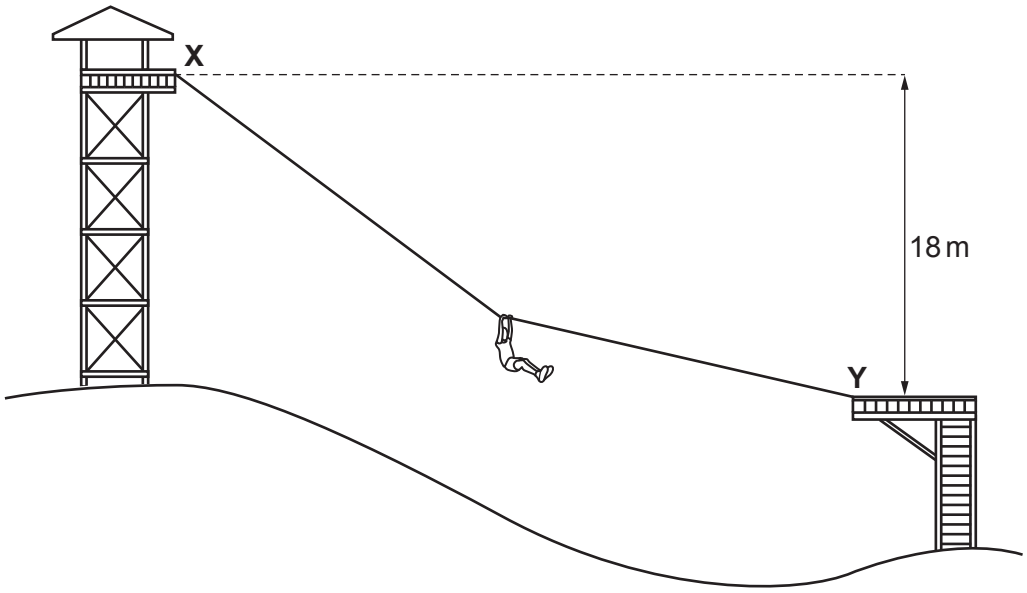


Fig. 3.1

(a) The child moves from point **X** to point **Y**.

Point **X** is 18 m vertically above point **Y**.

(i) Show that as the child moves from point **X** to point **Y**, the change in gravitational potential energy is 6300 J.

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

[1]

(ii) As the child moves from point **X** to point **Y**, she gains kinetic energy before being slowed by a braking system.

The speed of the child at point **Y** is 14 m / s.

Calculate the kinetic energy of the child at point **Y**.

kinetic energy = ... J [2]

(b) The zipline uses a thick cable made of steel.

The zipline's steel cable heats up as the child slides from point **X** to point **Y**.

(i) State the name of the force which causes the steel cable to heat up.

..... [1]

(ii) State the name of the process that transfers thermal energy in steel.

..... [1]

(iii) Describe, in terms of particles, how energy is transferred by the process named in **(b)(ii)**.

.....

.....

.....

..... [2]

(c) Fig. 3.2 shows a section of the zipline's steel cable.

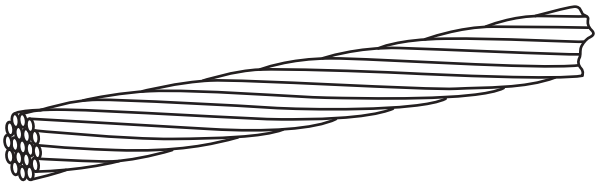


Fig. 3.2

The section of steel cable has a mass of 4.2 kg and a volume of $5.0 \times 10^{-4}\,m^3$.

Calculate the density of the steel cable.

density = ... kg/m^3 [2]

(d) Fig. 3.3 shows an extension-load graph for the steel cable.

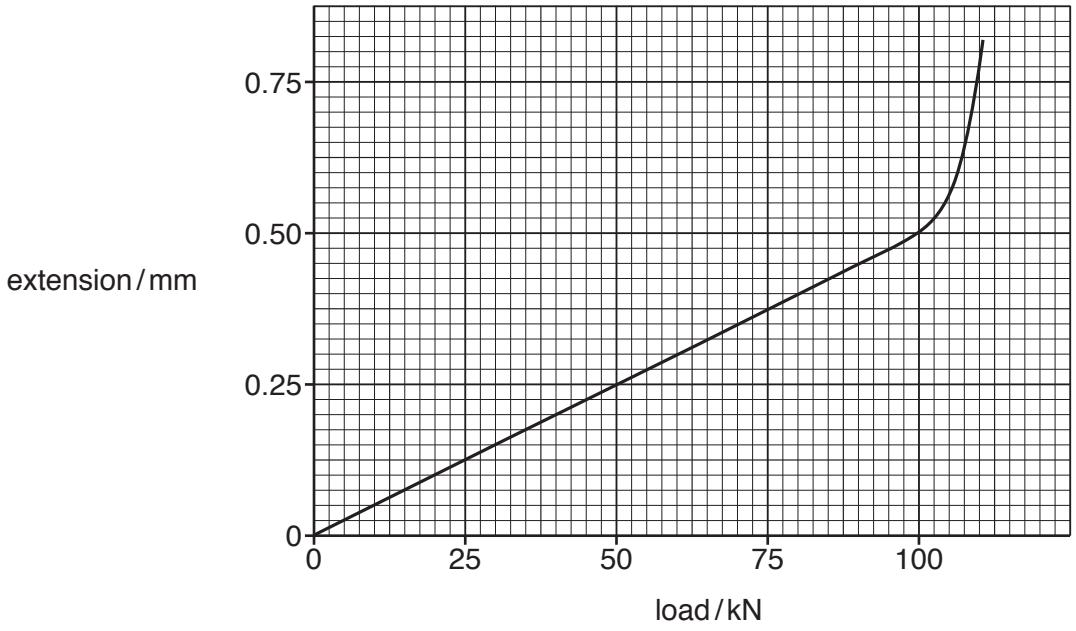


Fig. 3.3

(i) On Fig. 3.3, label the *limit of proportionality* with a **P**. [1]

(ii) Use Fig. 3.3 to calculate the spring constant of the steel cable in N / m.

spring constant = ... N / m [2]

[Total: 12]

4 **(a)** Fig. 4.1 is a diagram of the carbon cycle.

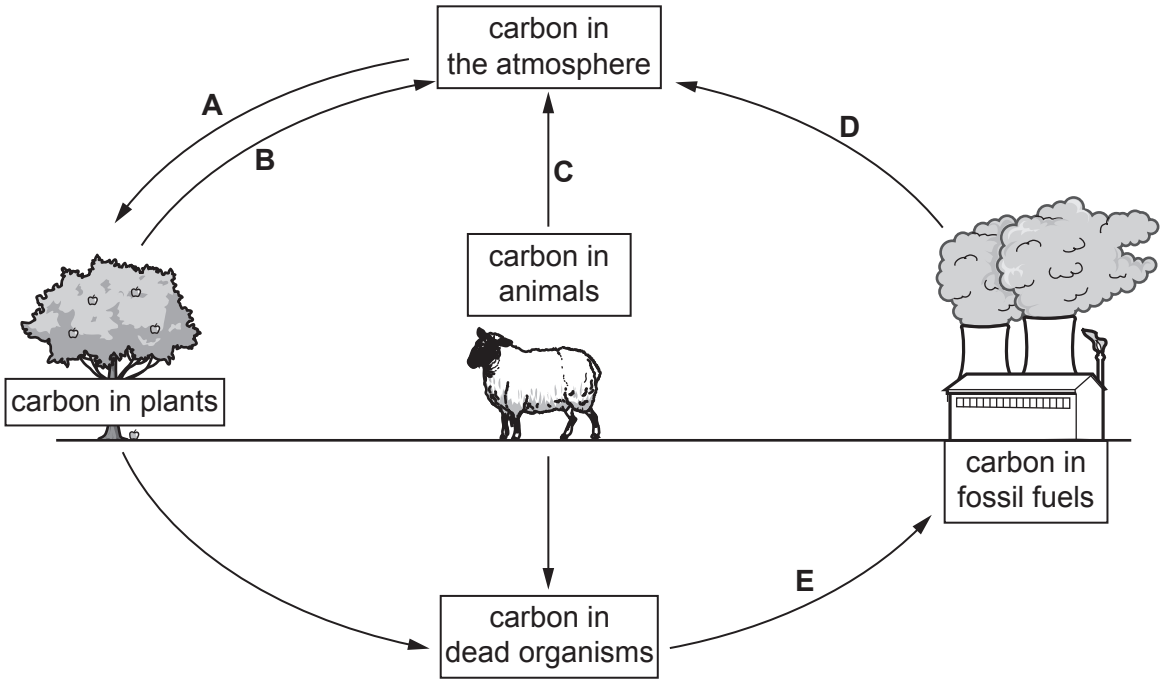


Fig. 4.1

(i) Identify process **E** in Fig. 4.1.

..... [1]

(ii) Draw **one** arrow on Fig. 4.1 to represent the process of feeding. [1]

(iii) State the balanced chemical equation for the process occurring at **A** in Fig. 4.1.

..... [2]

(iv) Name process **D** in Fig. 4.1 **and** describe its effect on the atmosphere.

name .....

effect on atmosphere .....

.....
[2]

(b) The element carbon is found in proteins.

(i) Name **one** disease caused by protein-energy malnutrition.

..... [1]

(ii) Name the smaller molecules that proteins are made from.

..... [1]

[Total: 8]

5 **(a)** Table 5.1 shows some information about particles found in atoms.

Complete Table 5.1.

Table 5.1

particle	relative mass	charge
electron	.....	.....
proton	.....	+1
neutron	1	.....

[2]

(b) Fig. 5.1 shows a sodium atom.

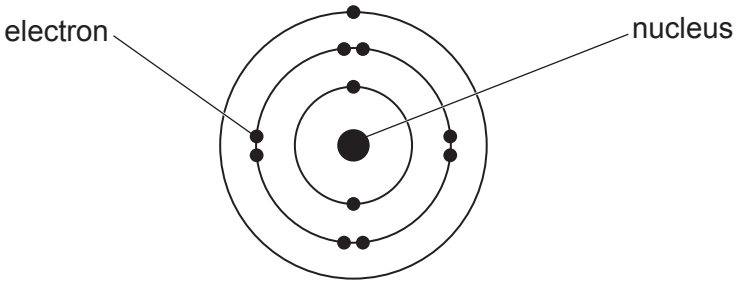


Fig. 5.1

(i) A sodium atom, Na, can form a sodium ion, Na^+.

Describe how a sodium atom forms a sodium ion.

..... [1]

(ii) Write a balanced ionic half equation to show how a sodium atom forms a sodium ion.

Use e^- to represent an electron.

..... [1]

(c) Table 5.2 gives some information about three halogens.

Complete Table 5.2.

Table 5.2

halogen	atomic number	electronic structure
fluorine	9	.....
chlorine	17	2.8.7
bromine	.....	2.8.18.7

[2]

(d) Sodium, Na, reacts with chlorine, Cl_2, to make sodium chloride, NaCl.

(i) Construct the balanced symbol equation for this reaction.

..... [2]

(ii) Sodium chloride, NaCl, is an ionic compound.

Draw a dot-and-cross diagram to show the bonding in sodium chloride.

Include the charges on the ions.

[2]

[Total: 10]

6 Fig. 6.1 shows a baby elephant born in a wildlife sanctuary.

The elephant is undergoing a routine health check.

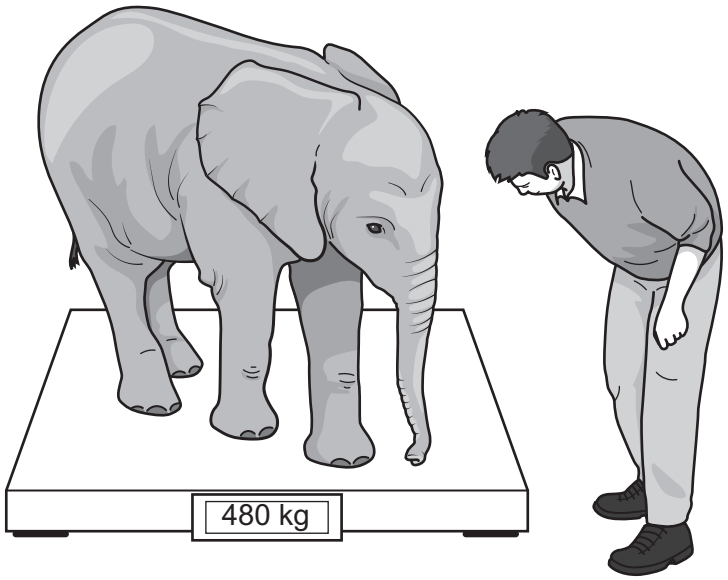


Fig. 6.1

(a) Explain what is wrong with the statement "the weight of the elephant is 480 kg".

.....

..... [1]

(b) The top speed for a fully grown elephant is 11 m / s.

Calculate the maximum distance that can be covered by an elephant in 120 seconds.

distance = ... m [2]

(c) The wildlife sanctuary uses enclosures to keep the elephants safe.

Fig. 6.2 shows an enclosure surrounded by four lamps.

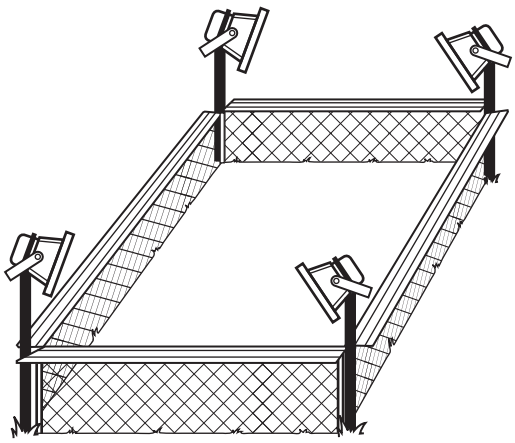


Fig. 6.2

The lamps are connected in **parallel**.

A switch controls the a.c. power supply to the lamps.

(i) Complete the circuit diagram to show the lamps connected in parallel.

Include the switch in your diagram.

The a.c. power supply has been drawn for you.

[2]

(ii) The current through the a.c. power supply is 16 A.

Draw a (circle) around the correct current through each lamp.

2 A **4 A** **16 A** **32 A** **64 A**

[1]

(iii) The potential difference across each lamp is 240 V.

Calculate the power output of each lamp.

power = ... W [2]

[Total: 8]

7 **(a)** A student investigates the effect of **temperature** on the rate of transpiration.

(i) Complete Fig. 7.1 by:

- labelling the x-axis
- drawing a line to predict the expected results.

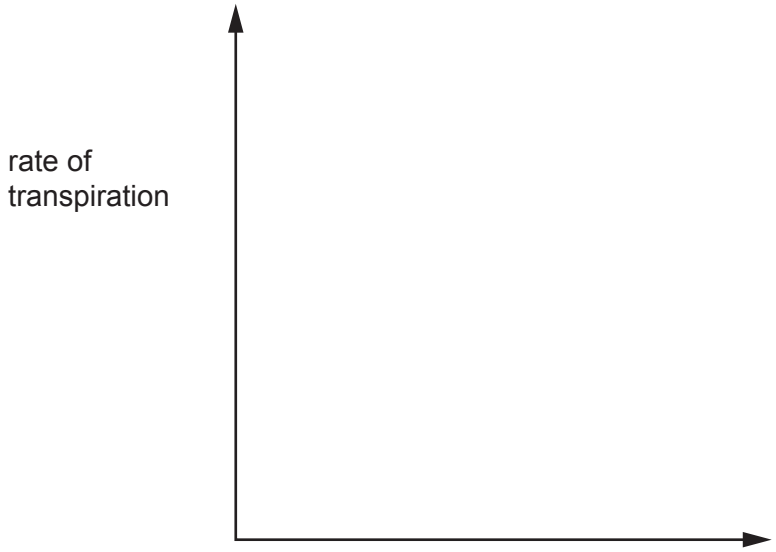


Fig. 7.1

[2]

(ii) The investigation is repeated at a greater humidity.

Explain the effect of increasing humidity on the rate of transpiration.

.....

.....

.....

.....

..... [3]

(b) Transpiration is the loss of water vapour from the leaves.

(i) Explain why transpiration causes a column of water to move upwards in the xylem.

.....

.....

.....

..... [2]

(ii) State the term that describes how water molecules are held together.

..... [1]

(c) Name two **cells** in leaves that are adapted for gas exchange.

1 .....

2 .....

[2]

(d) The process of translocation is also used in plants.

Draw **three** lines from the word translocation to the boxes on the right to make **three** correct sentences.

Translocation	occurs in the phloem.
	involves the movement of amino acids.
	only involves movement of substances from root to shoot.
	transports substances to the source in a plant.
	transports glucose.
	transports substances to regions of storage in a plant.

[3]

[Total: 13]

8 Plants need three essential elements: nitrogen, phosphorus and potassium.

These elements are found in fertilisers.

(a) Describe why it is important that farmers use fertilisers containing nitrogen, phosphorus and potassium.

.....

.....

..... [2]

(b) Potassium sulfate, K_2SO_4, is a fertiliser that contains potassium.

A student makes some potassium sulfate.

He reacts potassium carbonate, K_2CO_3, with sulfuric acid.

Look at the equation for this reaction.

$$K_2CO_3 + H_2SO_4 \rightarrow K_2SO_4 + CO_2 + H_2O$$

The student uses 2.76 g of potassium carbonate.

Calculate the mass of potassium sulfate the student makes.

Show your working.

[A_r: C, 12; H, 1; K, 39; O, 16; S, 32]

mass = ... g [2]

(c) Another student checks that a sample of fertiliser contains potassium.

She uses a flame test.

Describe how she will know if the fertiliser contains potassium.

..... [1]

(d) Ammonia is used to make some fertilisers.

Ammonia is made from nitrogen and hydrogen.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(i) The use of a **catalyst** reduces the cost of making ammonia.

Explain how.

.....

..... [1]

(ii) The reaction between nitrogen and hydrogen is reversible.

Explain what is meant by a reversible reaction.

.....

..... [1]

(e) Fig. 8.1 shows the percentage of ammonia made at different temperatures and pressures.

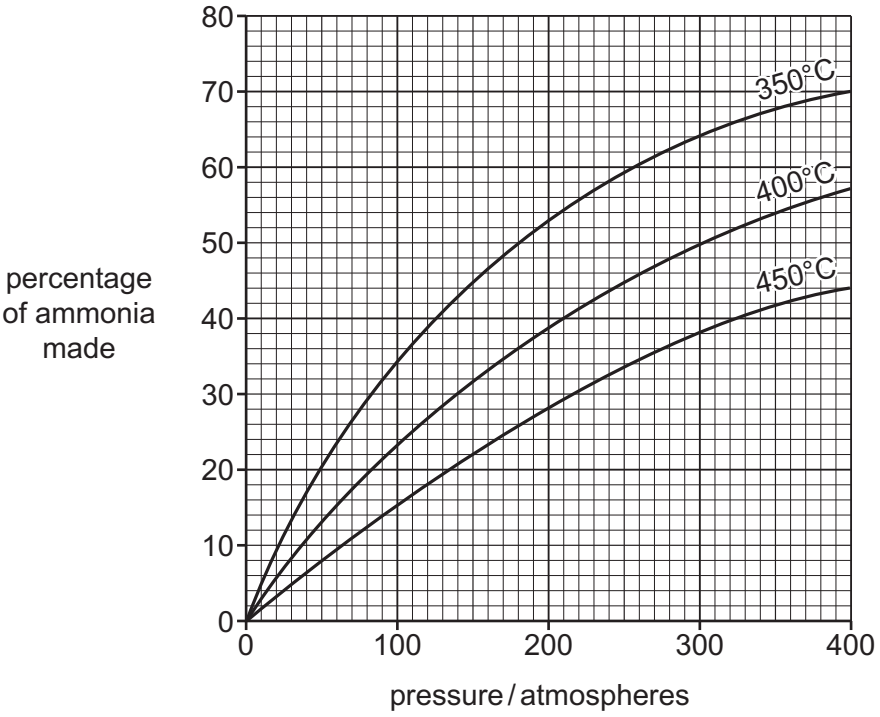


Fig. 8.1

Look at Fig. 8.1.

(i) Describe how the percentage of ammonia made changes as the **temperature** increases.

..... [1]

(ii) State a temperature and pressure which would make 40% of ammonia.

temperature = ... °C

pressure = ... atmospheres
[1]

[Total: 9]

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9 A student investigates the motion of pollen grains in water seen through a microscope.

The student observes that the pollen grains constantly move short distances in random directions.

(a) Fig. 9.1 shows the pollen grains suspended in water.

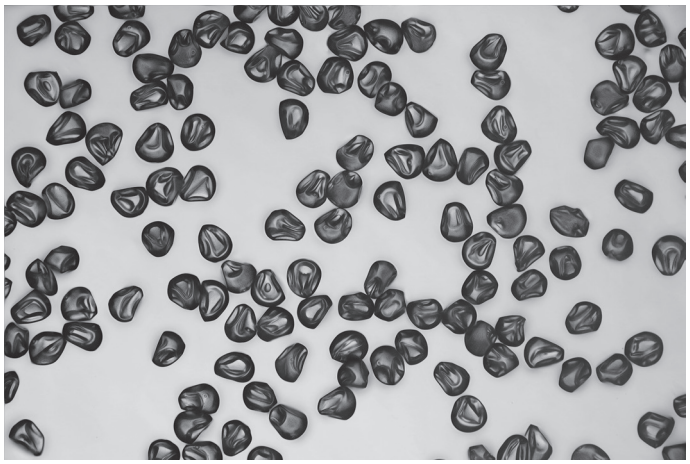

Fig. 9.1

(i) State the name given to the motion of these pollen grains.

..... [1]

(ii) Explain why the pollen grains constantly move short distances in random directions.

.....

.....

.....

..... [2]

(b) The microscope uses a thin converging lens to produce an image.

Fig. 9.2 shows a thin converging lens.

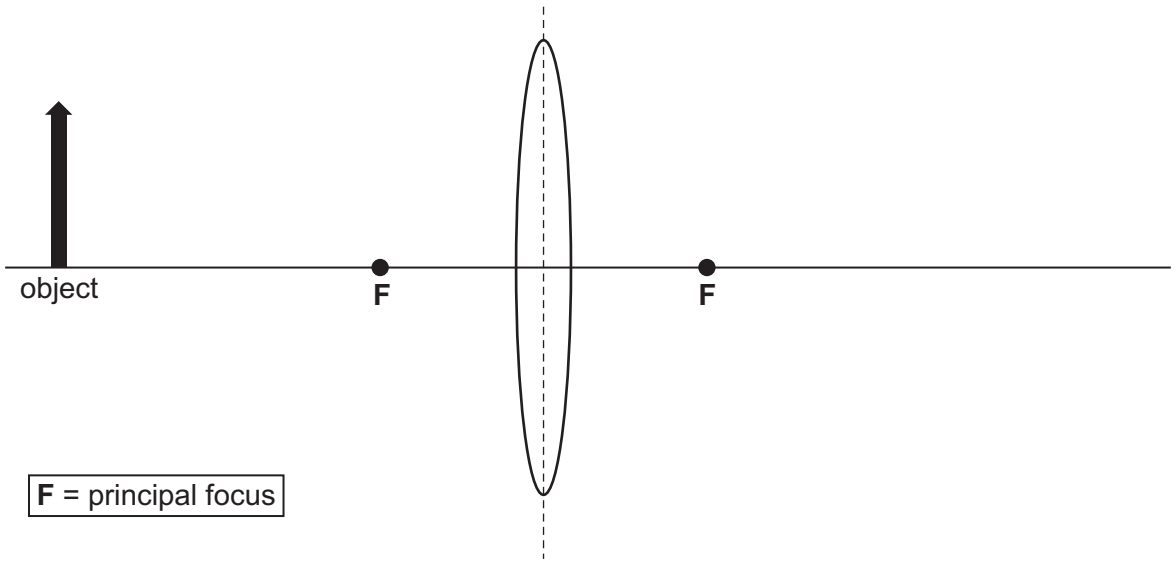

Fig. 9.2

(i) Draw a ray diagram on Fig. 9.2 to show the formation of a real image.

Label the image with the word image. [3]

(ii) The image formed is a real image.

Describe **one** difference between a *real image* and a *virtual image*.

.....

..... [1]

(c) The visible light that passes through the lens is part of the electromagnetic spectrum.

(i) State the speed of visible light in a vacuum.

..... [1]

(ii) γ-rays and radio waves are also part of the electromagnetic spectrum.

Place ticks (✓) in the boxes in Table 9.1 to show which statements are true for γ-rays and radio waves.

Table 9.1

	γ-rays	radio waves
is used in communication		
is used in medicine		
can cause cancer		
is higher frequency than visible light		
has a longer wavelength than visible light		

[3]

[Total: 11]

10 The percentage of the population of males and females in different age groups with chronic obstructive pulmonary disease (COPD) in one country is recorded.

Fig. 10.1 shows a graph of the results.

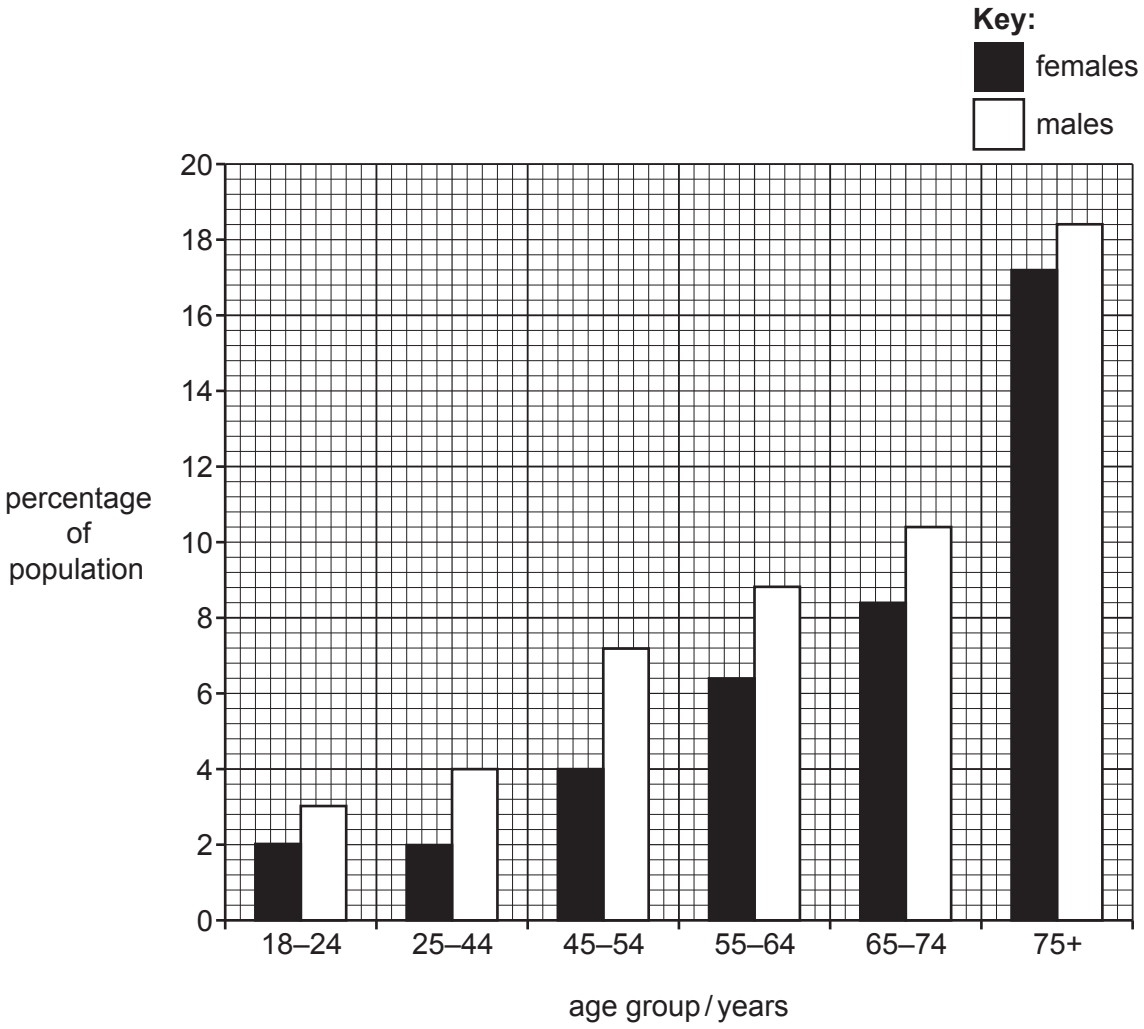

Fig. 10.1

(a) Use evidence from Fig. 10.1 to suggest two risk factors associated with COPD in this country.

1 .....

2 .....

[2]

(b) The percentage of the population of males and females in different age groups with COPD in one other country is recorded.

The country has a higher percentage of tobacco smokers across all age groups.

Describe **and** explain the difference you would expect to see in the results.

.....

.....

..... [2]

(c) Table 10.1 shows some components of tobacco smoke and their effects.

Complete Table 10.1.

Table 10.1

component of tobacco smoke	effect
.....	causes addiction
carbon monoxide	.....
.....	causes cancer

[3]

(d) Smoking also causes an increased concentration of carbon dioxide in the blood.

State the effect of an increased concentration of carbon dioxide in the blood on the gas exchange system.

.....

..... [1]

(e) State the name of the specialised cells that protect the gas exchange system by removing mucus.

..... [1]

[Total: 9]

11 Fractional distillation of petroleum makes useful fractions.

Three of these fractions are gasoline, gas oil and refinery gas.

(a) Refinery gas contains butane, C_4H_{10}.

Draw a diagram to show the structure of butane.

[2]

(b) Fractional distillation makes too much gas oil and not enough gasoline.

Cracking breaks large hydrocarbon molecules into smaller molecules.

State two conditions needed for cracking.

1 .....

2 .....

[2]

(c) Cracking involves the breaking of covalent bonds within molecules.

Fig. 11.1 shows the structure of dodecane.

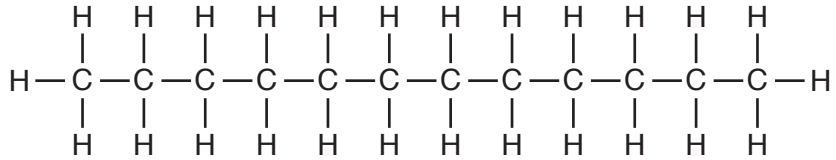

Fig. 11.1

The cracking of dodecane makes a mixture of products.

Explain why.

.....

..... [1]

(d) Dodecane has the formula $C_{12}H_{26}$.

During cracking, dodecane can make octane, C_8H_{18}, and ethene, C_2H_4.

Ethene is an alkene. Alkenes have the general formula C_nH_{2n}.

Dodecane and octane are alkanes.

State the general formula of the **alkanes**.

general formula = ... [1]

(e) In an experiment, 114 g of octane react with oxygen.

The mass of carbon dioxide gas made is 352 g.

Calculate the volume occupied by 352 g of carbon dioxide gas.

Show your working.

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

[A_r : C, 12; O, 16]

volume = ... dm^3 [3]

[Total: 9]

12 **(a)** Fig. 12.1 shows a transformer.

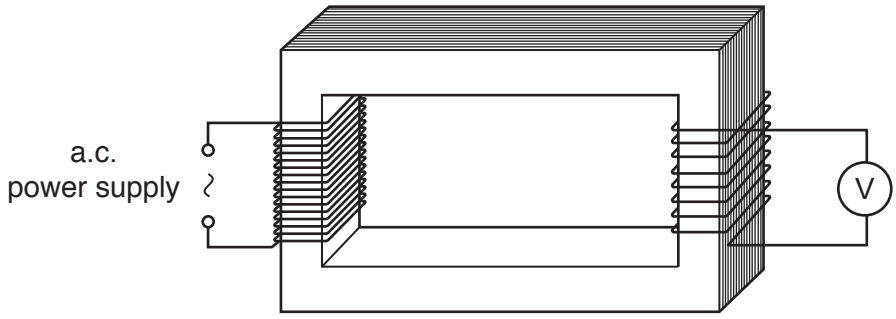

Fig. 12.1

(i) On Fig. 12.1, label the soft-iron core with an **X**. [1]

(ii) The transformer has 17 turns on the primary coil and 8 turns on the secondary coil.

Calculate the output voltage when the a.c. power supply has an e.m.f. of 34 000 V.

Assume the transformer has an efficiency of 100%.

output voltage = ... V [2]

(b) Fig. 12.2 shows a current-carrying solenoid.

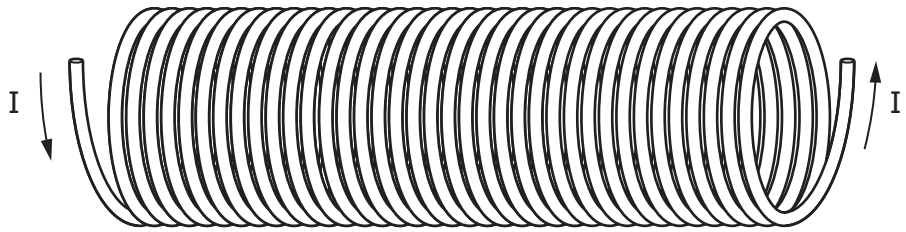

Fig. 12.2

On Fig. 12.2, draw the magnetic field pattern, including direction, around the solenoid. [2]

(c) The radioactive isotope uranium-238 decays into an isotope of thorium by emitting an α-particle.

(i) Use the correct nuclide notation to complete the decay equation for uranium-238.

$$^{238}_{92}U \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}Th + {}^{\cdots\cdots}_{\cdots\cdots}\alpha$$

[2]

(ii) Suggest why an α-particle is deflected when moving through a magnetic field.

.....

.....

.....

..... [2]

[Total: 9]

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.).