Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

1735313439

CO-ORDINATED SCIENCES **0654/42**

Paper 4 Theory (Extended) **May/June 2019**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 28.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **27** printed pages and **1** blank page.

1 **(a)** The graph in Fig. 1.1 shows the effect of temperature on enzyme activity.

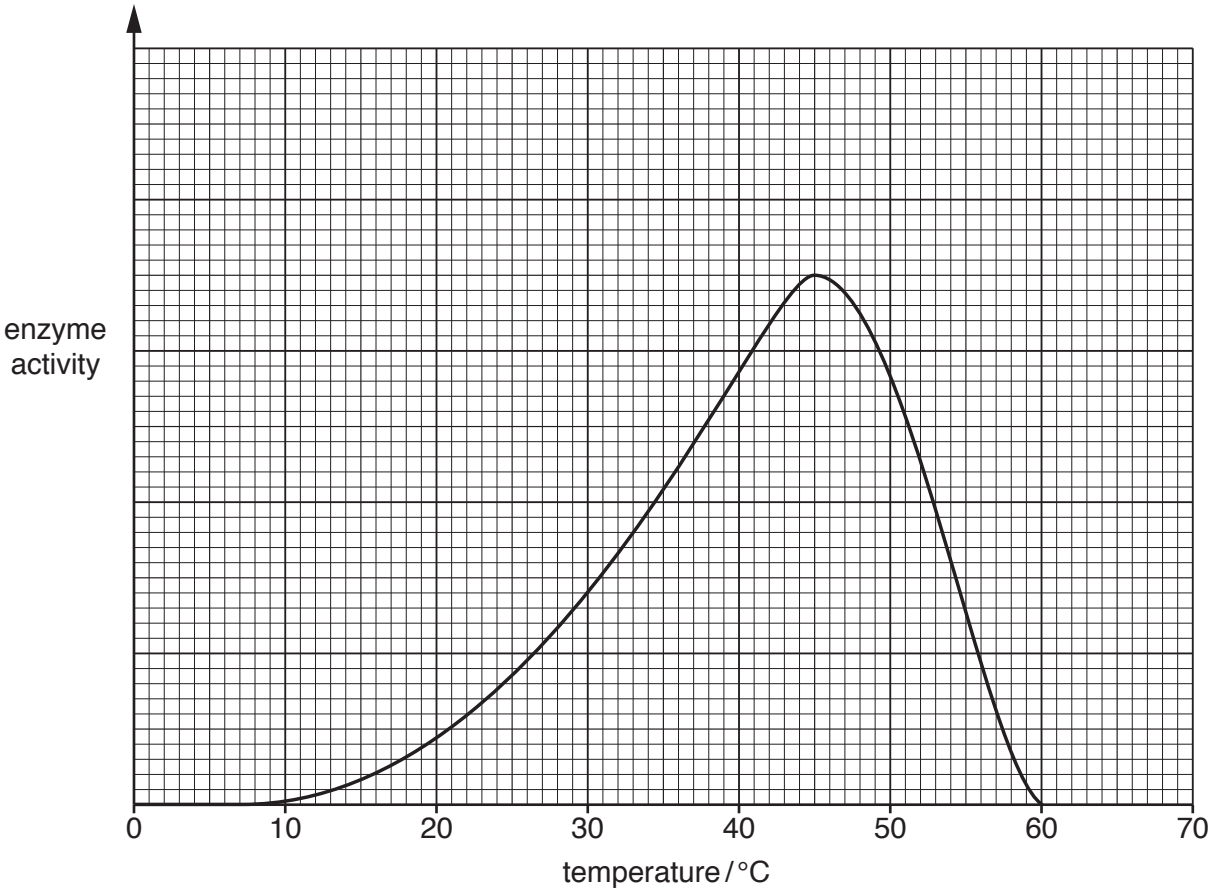


Fig. 1.1

(i) State the optimum temperature of the enzyme in Fig. 1.1.

..... °C [1]

(ii) Explain the results in Fig. 1.1 at **60 °C**.

.....

.....

.....

..... [2]

(b) Enzyme activity is also affected by pH.

Complete the graph in Fig. 1.2 to show how the activity of a protease enzyme in the stomach is affected by pH.

Include on your graph:

- labels for both axes
- a sketch of a suitable curve.

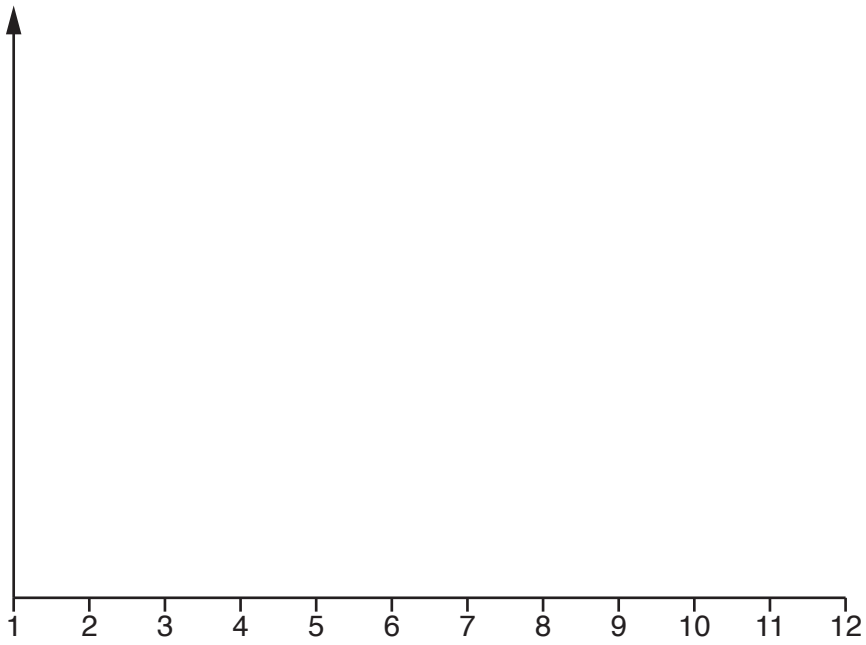


Fig. 1.2

[3]

(c) A solution containing an enzyme is tested with **biuret** solution.

State the colour change you would expect.

Give a reason for your answer.

the colour changes from ..... to .....

reason .....

.....

[2]

[Total: 8]

2 **(a)** Fig. 2.1 shows the composition of clean air and of natural gas.

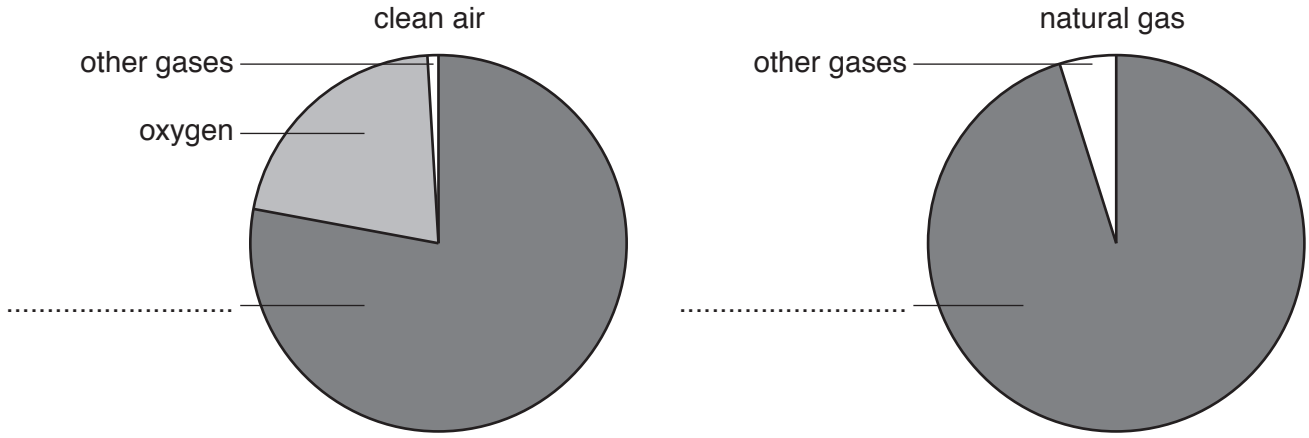


Fig. 2.1

(i) Complete the labels in Fig. 2.1 to show the main constituent of clean air and of natural gas. [2]

(ii) One of the other gases in natural gas is ethane.

Name two gases in clean air that are formed by the complete combustion of ethane.

1 .....

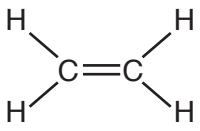
2 .....

[2]

(b) Name the process used to convert larger alkane molecules into ethene and hydrogen.

..... [1]

(c) The molecular structure of ethene is shown below.



The double bond in ethene allows it to undergo addition reactions.

(i) Complete the equation for the addition reaction between ethene and bromine.

$$C_2H_4 + Br_2 \rightarrow \text{.....}$$ [1]

(ii) Ethene is used to make ethanol in an addition reaction.

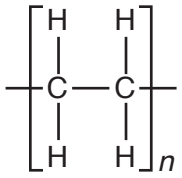
Name the other raw material required in the manufacture of ethanol.

..... [1]

(d) Ethene is used in the manufacture of poly(ethene).

Propene is used in the manufacture of poly(propene).

(i) The structure of poly(ethene) is shown by



(*n* is a large number)

Describe the formation of poly(ethene) using the terms *monomer* and *polymer*.

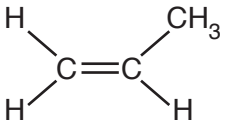
.....

.....

.....

..... [2]

(ii) The molecular structure of propene is shown below.



Suggest the structure of poly(propene). Draw your answer in the space below.

[1]

[Total: 10]

3 **(a)** In 1971, an astronaut hit a golf ball on the surface of the Moon.

The golf ball had a mass of 46 g and initially travelled at 50 m/s.

(i) Calculate the kinetic energy of the golf ball when travelling at 50 m/s.

Show your working.

kinetic energy = ... J [3]

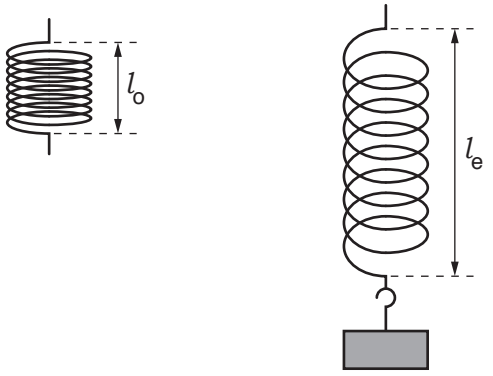
(ii) Describe the difference between the terms *speed* and *velocity*.

.....

.....

..... [1]

(b) On the Moon, an astronaut suspends masses on a spring and measures the extension of the spring in mm as shown in Fig. 3.1



extension = $l_e - l_o$

Fig. 3.1

Fig. 3.2 shows the results of the experiment.

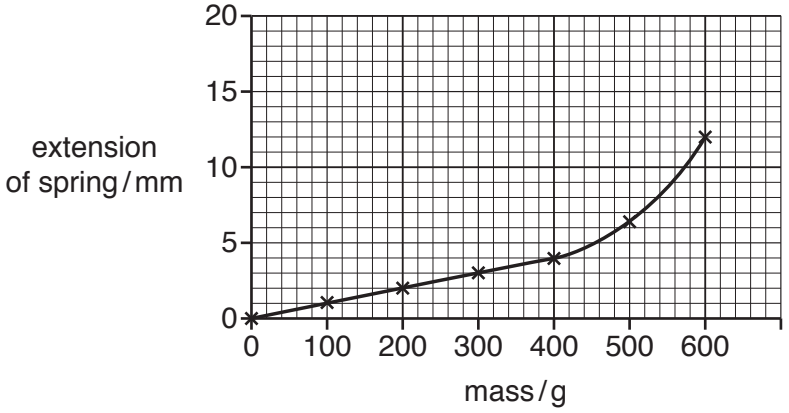


Fig. 3.2

(i) Use Fig. 3.2 to determine the range of masses where Hooke's Law is obeyed.

Explain your answer.

range of masses from ..... g to ..... g

explanation .....

[2]

(ii) The astronaut repeats the experiment with an identical spring on Earth.

Each 100 g mass produces a greater extension of the spring on Earth.

Calculate the mass that would need to be used on Earth to obtain the same extension as the addition of 300 g on the Moon.

The gravitational field strength on Earth is 10 N / kg and on the Moon is 1.6 N / kg.

Show your working.

mass = ... g [2]

(c) The astronaut is exposed to infra-red waves that travel from the Sun to the Moon.

(i) Name this method of energy transfer.

..... [1]

(ii) Name the type of nuclear reaction taking place in the Sun that releases energy.

..... [1]

[Total: 10]

4 **(a)** Fig. 4.1 shows a cross-section through a leaf.

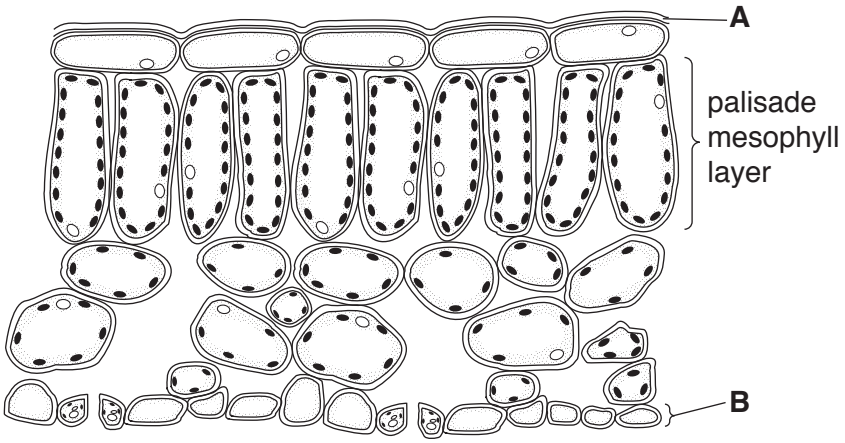


Fig. 4.1

(i) Name the parts **A** and **B**.

A .....

B .....

[2]

(ii) Draw **one** arrow on Fig. 4.1 to show where carbon dioxide enters the leaf. [1]

(b) Describe two features of the cells in the palisade mesophyll layer that allow efficient photosynthesis to occur.

1 .....

.....

2 .....

.....

[2]

(c) Describe the role of chlorophyll in photosynthesis.

.....

.....

.....

..... [2]

(d) Complete the balanced symbol equation for photosynthesis.

$$\text{.....} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{.....}$$

[2]

[Total: 9]

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5 A student investigates the colour in a leaf.

He crushes the leaf in a solvent to extract the coloured compounds.

Fig. 5.1 shows the apparatus he uses.

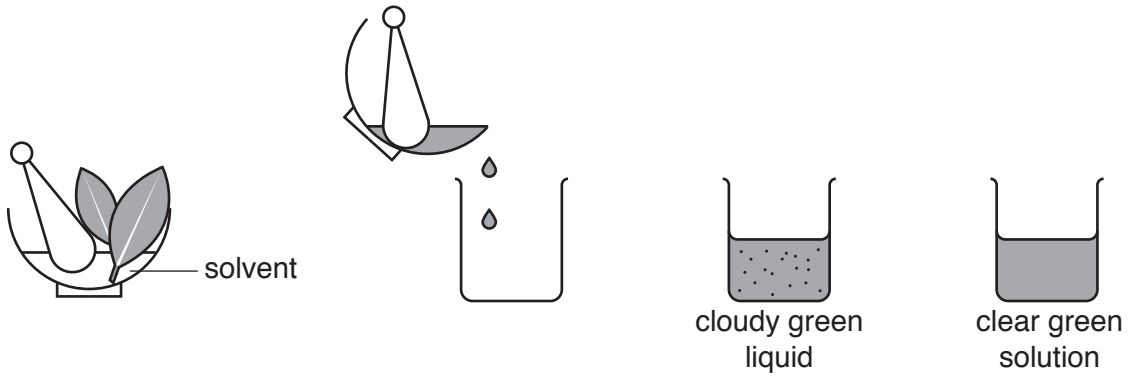

Fig. 5.1

(a) **(i)** Name the process he uses to remove the solids from the cloudy green liquid to obtain a clear green solution.

..... [1]

(ii) Describe how the process he uses produces a clear green solution.

.....

..... [1]

(b) The student uses paper chromatography to separate the compounds which give the solution its green colour.

He draws a pencil line on a strip of chromatography paper and places a drop of the green solution on the pencil line.

He dips the paper into a solvent.

Fig. 5.2 is an incomplete diagram of the apparatus he uses.

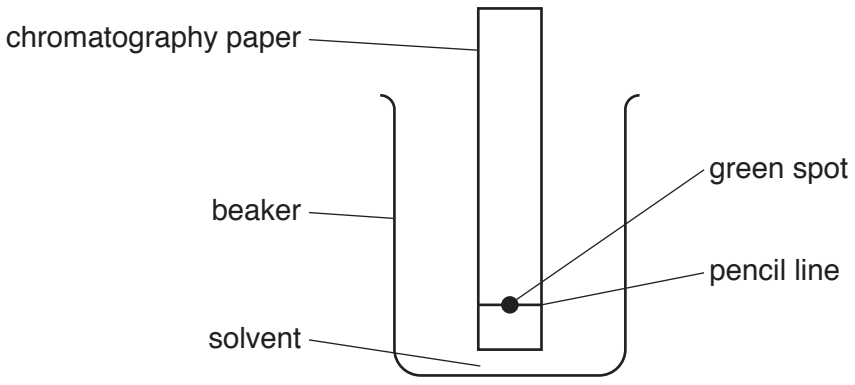

Fig. 5.2

(i) Draw a line on Fig. 5.2 to show the surface of the solvent in the beaker. [1]

(ii) Fig. 5.3 shows the chromatogram he obtains.

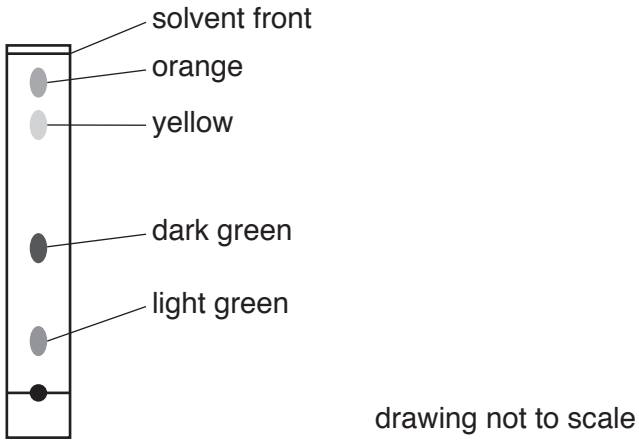

Fig. 5.3

Table 5.1 lists the R_f values of the coloured compounds on the chromatogram.

Table 5.1

coloured compound	R_f
carotene	0.91
chlorophyll A	0.42
chlorophyll B	0.16
xanthophyll	0.77

Use Table 5.1 to identify the yellow compound.

Explain how you obtained your answer.

yellow compound .....

explanation .....

.....

[2]

(iii) Describe how the student can obtain a pure, dry sample of the orange compound from the chromatogram.

.....

.....

.....

..... [3]

[Total: 8]

6 **(a)** Fig. 6.1 shows a car with two rear lamps, **L1** and **L2**.

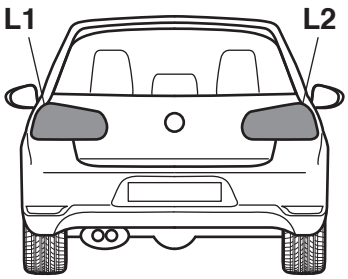

Fig. 6.1

The lamps are connected in parallel and powered by a 12 V battery.

The lamps each have a resistance of 33 Ω.

(i) Calculate the combined resistance of the two lamps connected in parallel in this circuit.

Show your working.

resistance = ... Ω [2]

(ii) Calculate the charge that passes through lamp **L2** in 30 minutes.

State any formula you use and show your working.

charge = ... C [4]

(b) The air in a car tyre exerts a pressure on the walls of the tyre.

(i) Use ideas about the motion of molecules to describe how the molecules exert a pressure on the walls of the tyre.

.....

.....

..... [2]

(ii) State what happens to the pressure of the air in the tyre if the temperature increases.

.....

..... [1]

(c) Hot exhaust gases from the car engine leave the engine through a steel exhaust pipe.

The steel exhaust pipe transfers thermal energy through the pipe wall by conduction.

(i) Describe the process of conduction in a solid, using ideas about particle vibration and transfer by electrons.

.....

.....

.....

.....

.....

..... [3]

(ii) When heated, the steel exhaust pipe expands.

Explain, in terms of the motion and arrangement of particles, why a solid expands less than a gas when heated.

.....

.....

.....

.....

..... [2]

[Total: 14]

[Turn over

7 Fig. 7.1 shows a cross-section through a human heart.

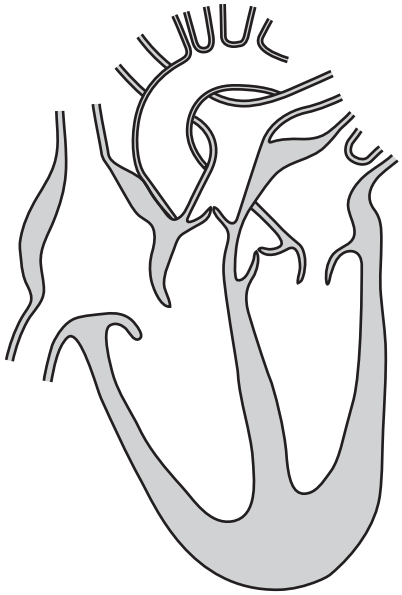

Fig. 7.1

(a) On Fig. 7.1, use a label line and the letter **X** to identify the septum. [1]

(b) The function of the heart is to pump blood around the body.

Describe how the heart pumps blood.

.....

.....

.....

..... [2]

(c) Name the two main **veins** of the heart.

1 .....

2 .....
[2]

(d) Fig. 7.2 shows a doctor's note about a patient. It contains information about the patient's lifestyle.

Patient notes:
Age: 23
Gender: Male

Has an office job.
Plays sport regularly.
Smokes 10 cigarettes a day.
Does not drink alcohol.
Eats large amounts of food high in fat.
Eats small amounts of fruit and vegetables.

Fig. 7.2

Use the information in Fig. 7.2 to answer these questions.

(i) Describe two ways in which this patient could reduce their risk of developing coronary heart disease.

1 .....

.....

2 .....

.....
[2]

(ii) State **one non-lifestyle** factor that increases this patient's risk of developing coronary heart disease.

..... [1]

[Total: 8]

8 **(a)** The thermite reaction is a redox reaction between aluminium and iron oxide, Fe_2O_3.

It produces molten iron and aluminium oxide, Al_2O_3.

(i) Write a balanced symbol equation for the thermite reaction.

..... [2]

(ii) During the reaction Fe^{3+} ions become Fe atoms and Al atoms become Al^{3+} ions.

Identify the oxidising agent and the reducing agent.

Explain your answer in terms of electron transfer.

oxidising agent .....

reducing agent .....

explanation .....

.....

[2]

(b) Fig. 8.1 shows the energy level diagram for the thermite reaction.

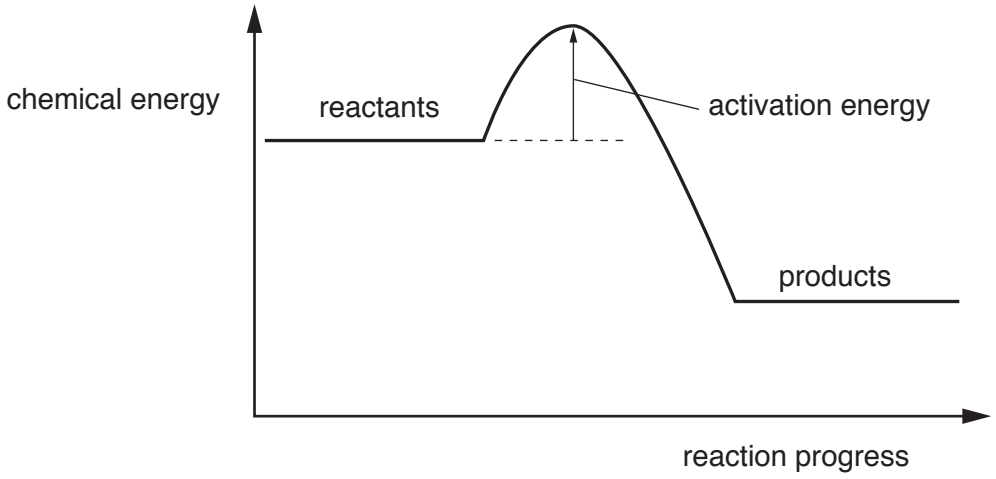

Fig. 8.1

(i) Use the diagram to explain why the reactant mixture must be heated before the reaction starts.

.....

..... [1]

(ii) Use the diagram to explain why the reaction is exothermic.

.....

..... [1]

(c) Steel is an alloy of iron.

(i) Describe the metallic bonding in iron.

You may include a labelled diagram in your answer.

.....

.....

..... [2]

(ii) State the meaning of the term *alloy*.

.....

..... [1]

(iii) Suggest two differences in the physical properties of steel and iron.

1 .....

2 .....

[2]

[Total: 11]

9 **(a)** Ultrasound waves are used in hospitals to scan unborn babies.

Ultrasound waves have a frequency that is too high for a human to hear.

(i) State, in terms of waves, what is meant by the term *frequency*.

.....

..... [1]

(ii) Using your knowledge of the range of audible frequencies for a healthy human ear, suggest a frequency for these ultrasound waves.

frequency = ... Hz [1]

(iii) Ultrasound waves are longitudinal waves.

Describe what is meant by a longitudinal wave.

.....

..... [1]

(b) Endoscopes are used by doctors in hospitals to observe the inside of a patient.

An endoscope uses optical fibres.

Complete Fig. 9.1 to show how a ray of light travels down an optical fibre by total internal reflection.

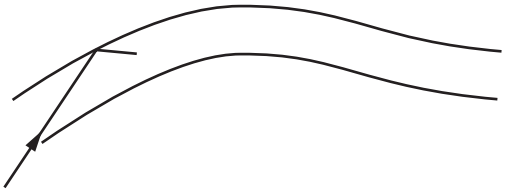

Fig. 9.1

[2]

(c) An isotope of strontium, strontium-89, is used in the treatment of bone cancer in hospitals.

Strontium-89 has a half-life of 50 days. A sample of this isotope contains 4×10^{14} atoms.

Some time later 3×10^{14} atoms have decayed.

Calculate the time needed for this number of atoms to decay.

Show your working.

time = ... days [3]

[Total: 8]

10 (a) The diagrams in Fig. 10.1 show two cells **C** and **D**.

The concentration of carbon dioxide inside and outside the cells is represented by the number of molecules drawn.

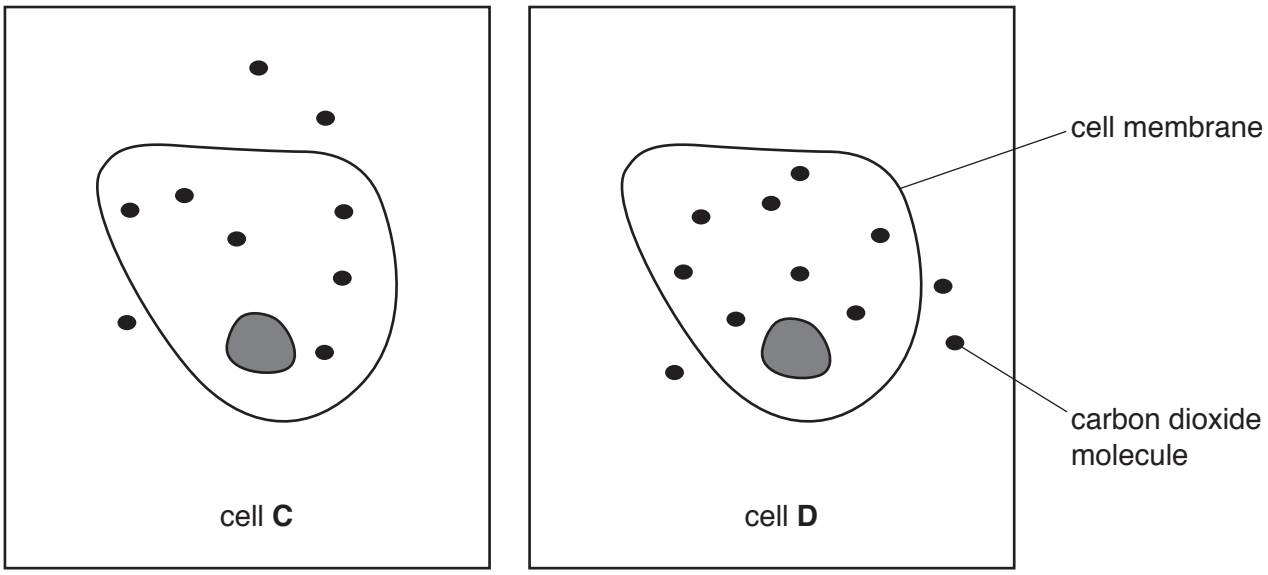

Fig. 10.1

(i) Add **one** arrow to **each** diagram to show the net movement of carbon dioxide molecules across the cell membrane by diffusion. [1]

(ii) State which cell has the greater rate of diffusion.

Give a reason for your answer.

cell .....

reason .....
[1]

(b) Humans excrete carbon dioxide.

(i) Define the term *excretion*.

.....

.....

..... [2]

(ii) Describe the pathway of carbon dioxide from the blood to the atmosphere.

.....

.....

.....

.....

..... [3]

[Total: 7]

11 The raw materials needed to make sulfuric acid in the Contact process are air, sulfur and water.

Fig. 11.1 shows the stages in the Contact process.

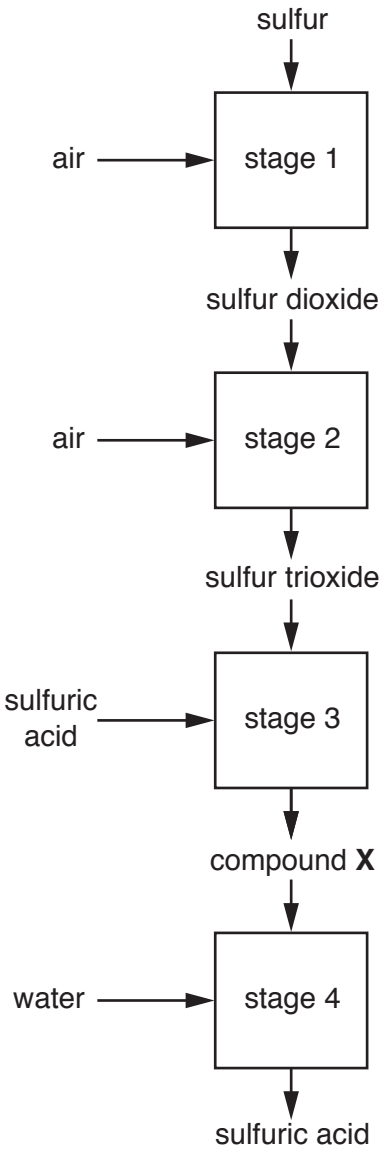

Fig. 11.1

(a) In stage 2, sulfur dioxide reacts with oxygen to make sulfur trioxide.

The equation for this reaction is

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

State the meaning of the $\rightleftharpoons$ symbol.

..... [1]

(b) Fig. 11.2 shows the relationship between the temperature of stage 2 and the percentage of sulfur dioxide converted to sulfur trioxide.

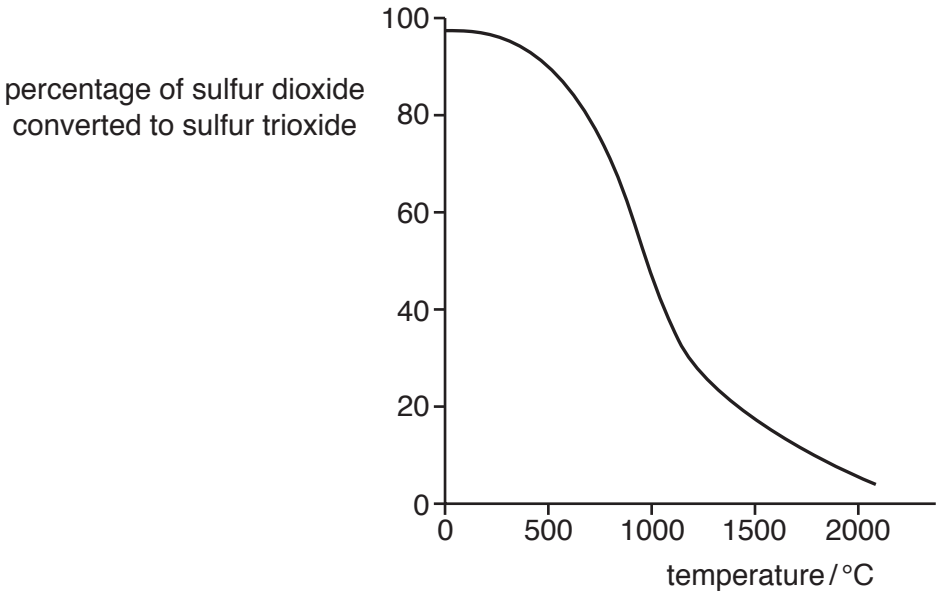

Fig. 11.2

(i) Suggest the temperature in stage 2 of the Contact process.

..... [1]

(ii) Use Fig. 11.2 to suggest **one** advantage, other than cost, of using a low temperature in stage 2.

..... [1]

(iii) State and explain why a low temperature is **not** used in stage 2.

Explain your answer in terms of particle movement in stage 2.

.....

.....

.....

..... [3]

(c) Compound **X**, $H_2S_2O_7$, is formed in stage 3.

Name compound **X**.

..... [1]

(d) The overall equation for the Contact process is

raw materials								product
$2S$	+	$3O_2$	+	$2H_2O$	$\rightarrow$	$2H_2SO_4$		

Complete steps 1 to 4 to calculate the mass of sulfuric acid made from 1000 g of sulfur.

Show your working.

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

Step 1

Calculate the number of moles in 1000 g of sulfur.

number of moles = ...

Step 2

Deduce the number of moles of sulfuric acid made from 1000 g of sulfur.

number of moles = ...

Step 3

Calculate the relative molecular mass, M_r , of sulfuric acid.

M_r = ...

Step 4

Calculate the mass of sulfuric acid made from 1000 g of sulfur.

mass = ... g

[4]

[Total: 11]

12 (a) Fig. 12.1 shows a large snow tractor used by scientists working in the Arctic region.

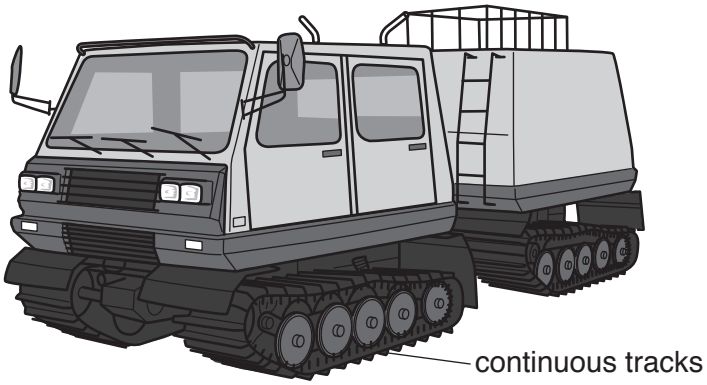

Fig. 12.1

The snow tractor has large continuous tracks (caterpillar tracks), driven by the wheels.

These tracks allow the snow tractor to travel across the soft snow without sinking.

A tractor with four ordinary wheels would sink into the soft snow.

Use ideas about pressure to explain this difference.

.....

.....

..... [2]

(b) The snow tractor has two headlamps.

The headlamps emit visible light of several different wavelengths. One of the wavelengths is 5.01×10^{-7} m. The frequency of this light is 5.98×10^{14} Hz.

Calculate the speed of this light.

Show your working.

speed of light = ... m/s [2]

(c) Visible light is part of the electromagnetic spectrum. All electromagnetic waves travel at the same speed in a vacuum.

State **one** other property that is the same for all electromagnetic waves.

.....

..... [1]

(d) Fig. 12.2 shows equipment for measuring wind speed used by Arctic scientists.

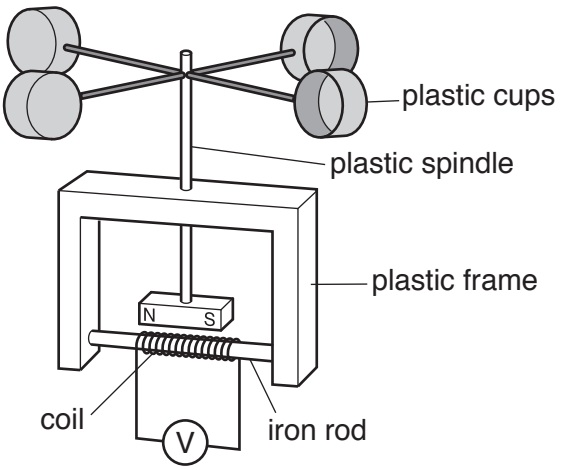

Fig. 12.2

The wind makes the plastic cups move and this causes the spindle and magnet to turn.

Suggest why an alternating voltage is measured on the voltmeter.

.....

.....

.....

..... [3]

[Total: 8]

13 (a) Excess use of fertilisers can cause eutrophication. Eutrophication eventually causes organisms in a lake to die.

(i) Explain why producers underneath the surface of the water die.

.....

.....

.....

.....

..... [3]

(ii) Explain why the death of producers eventually leads to the death of the fish in the lake.

.....

.....

.....

.....

..... [3]

(b) Table 13.1 shows some information about two mineral ions found in fertilisers.

Table 13.1

mineral ion	function of mineral ion	effect a deficiency in the mineral ion has on plant
magnesium		yellow leaves
	making amino acids	

Complete Table 13.1. [2]

[Total: 8]

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.).