UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE
NAME

CENTRE
NUMBER

CANDIDATE
NUMBER

CO-ORDINATED SCIENCES **0654/31**

Paper 3 (Extended) **May/June 2012**

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 a soft pencil for any diagrams, graphs, tables or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

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.

For Examiner's Use	
1	
2	
3	
4	
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6	
7	
8	
9	
10	
11	
12	
Total	

This document consists of **28** printed pages.

For
iner's

1   Sugar cane is a food crop grown in Australia. It is harvested and then transported o
     trains to the processing plant.

   Fig. 1.1 shows one of the trains carrying sugar cane.
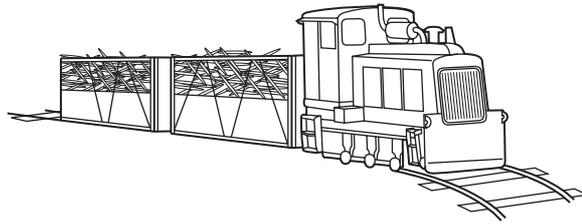
     Fig. 1.1

(a) The mass of the engine and empty trucks is 20 000 kg and the mass of the sugar cane
     transported is 10 000 kg.

     The train travels at a speed of 0.5 m / s.

     (i) Calculate the kinetic energy of the loaded train.

          State the formula that you use and show your working.

             formula used

             working

                                                                    .... [2]

     (ii) To travel at this speed, a driving force of 1 000 000 N is needed.

          Calculate the work done by the engine when the train travels 1 km.

          State the formula that you use and show your working.

             formula used

             working

                                                                  .... [2]
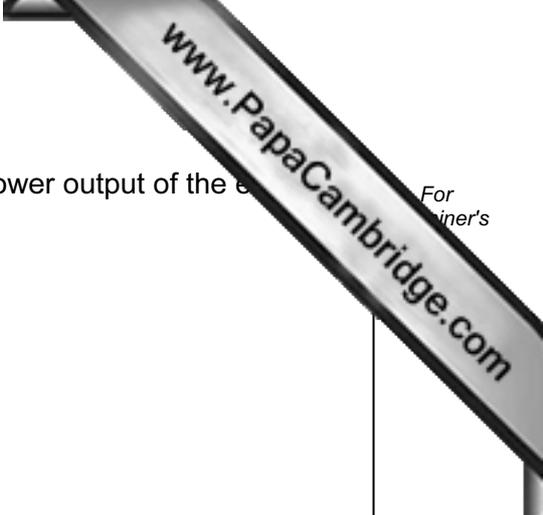
(iii) It takes the train 5 minutes to travel 1 km. Calculate the power output of the e

State the formula that you use and show your working.

formula used

working

.... [2]

(b) The water used to irrigate one sugar cane farm comes from a waterfall. The farmer attempts to reconstruct an experiment which may have been carried out by James Joule in 1847.

Joule attempted to show that the water at the bottom of a waterfall was hotter than water at the top of the waterfall. His reasoning was that the water had gravitational potential energy at the top of the waterfall, which would be converted to kinetic energy as it fell. This kinetic energy would be changed to heat energy when the water fell into the pool at the bottom of the waterfall.

(i) 1 kg of water has 300 J of gravitational potential energy at the top of the waterfall.

State the maximum kinetic energy that 1 kg of water will have when it reaches the bottom of the waterfall. Explain your answer.

maximum kinetic energy ....

explanation ....

.... [1]

(ii) Assuming that all the kinetic energy of the water is converted to thermal (heat) energy, calculate the temperature rise in the 1 kg of water. The specific heat capacity of water is 4200 J/kg °C.

State the formula that you use and show your working.

formula used

working

.... [3]

2 Magnesium is a reactive metal that combines with both oxygen and nitrogen when burnt in air. The white solid that remains after this combustion reaction contains mainly magnesium oxide mixed with a little magnesium nitride.

Nitrogen exists in the air in the form of diatomic molecules, N_2.

(a) A diagram of a nitrogen atom is shown below.
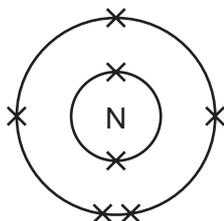
(i) Complete the bonding diagram below to show how all the **outer** electrons are arranged in a nitrogen molecule.
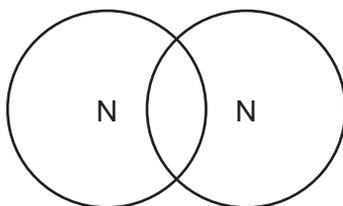
[2]

(ii) When magnesium reacts with nitrogen, the bonds in the nitrogen molecules are broken. Nitrogen atoms then combine with magnesium atoms to form the **ionic** compound magnesium nitride.

Draw a diagram of a nitride **ion**, N^{3-}, showing how **all** of the electrons are arranged.

[1]

(iii) Explain, in terms of protons and electrons, why the nitride ion carries an electrical charge of 3^-.

....

....

.... [2]

(iv) Magnesium ions have the formula Mg^{2+}.

Deduce the chemical formula of magnesium nitride.

Explain your answer briefly. .... [2]

(b) Metallic magnesium may be obtained by the electrolysis of an electrolyte which contains molten magnesium chloride.

Fig. 2.1 shows a simplified diagram of this process.
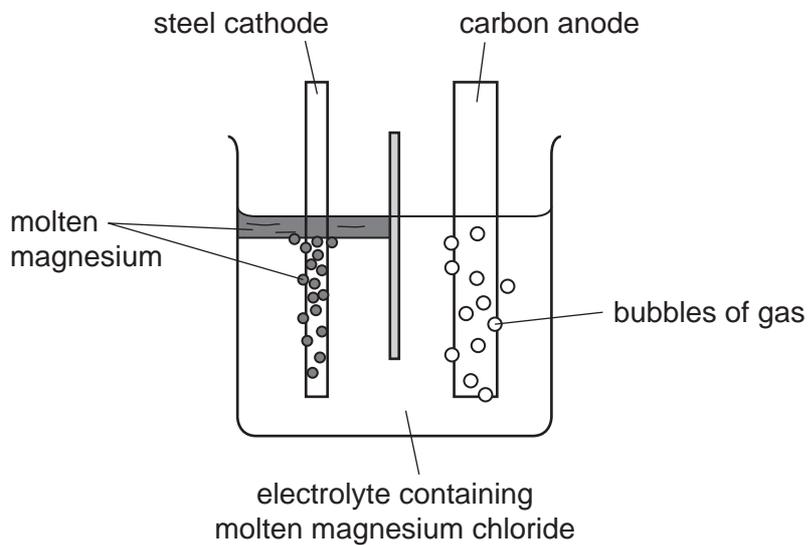
Fig. 2.1

(i) Suggest the name of the gaseous element which forms on the surface of the anode in Fig. 2.1.

.... [1]

(ii) If an aqueous solution of magnesium chloride is used as the electrolyte instead of the molten salt, a colourless gas forms on the cathode instead of magnesium.

Suggest the name of this gas and describe a simple test which would confirm its identity.

gas ....

test ....

.... [2]

3   Fig. 3.1 shows part of a section across a root from a radish plant, photographed through a microscope.
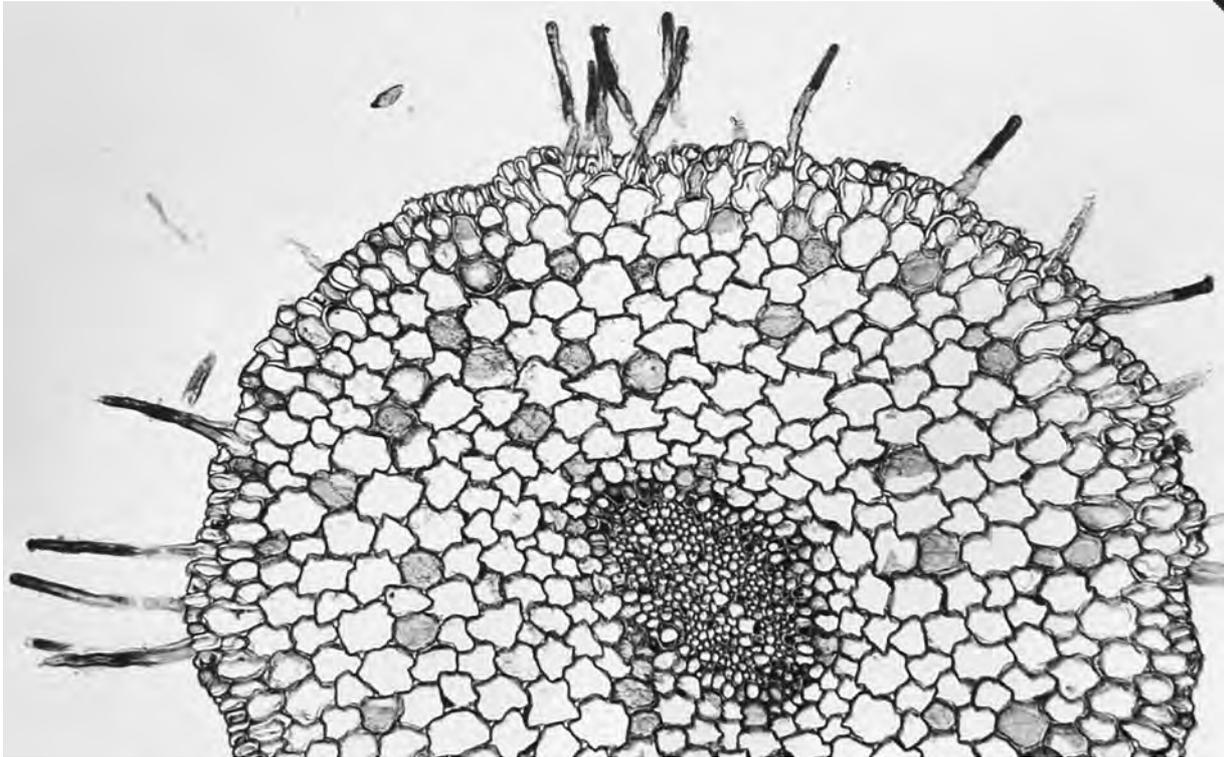
Fig. 3.1

(a) **On Fig. 3.1**, use a label line to label a root hair cell.   [1]

(b) Root hair cells absorb water from the soil.

   (i) Explain how root hair cells absorb water.

      ....

      ....

      .... [2]

  (ii) State **one** other function of root hair cells.

      .... [1]

 (iii) Explain how root hair cells are adapted for their functions.

      ....

      ....

      .... [2]
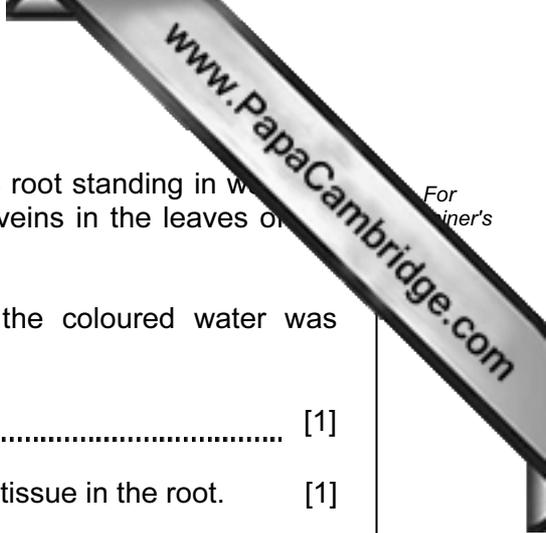
(c) A complete radish plant was placed with the lower part of its root standing in w̶ soluble red dye was added to the water. After a while, the veins in the leaves o̶ radish plant became red.

   (i) Name the tissue in the radish plant through which the coloured water was transported from the roots to the leaves.

.... [1]

   (ii) **On Fig. 3.1**, write the letter **A** to show the position of this tissue in the root.   [1]

  (iii) Water was drawn up through the radish plant because water vapour was constantly escaping from its leaves. A plastic bag was placed over the leaves of the radish plant and the water vapour formed colourless droplets of liquid water on the bag as it condensed.

Explain why these water droplets were not red.

....

....

.... [2]

4   (a)   A bat produces a sound wave with a frequency of 212 kHz and a wavelength of 0.0

(i)   State the meaning of the terms *frequency* and *wavelength*, when describing
wave. You may use a diagram if it helps your explanation.

frequency

....

....

....

wavelength

....

....

.... [2]

(ii)   Calculate the speed of the sound wave produced by the bat.

State the formula that you use and show your working.

formula used

working

.... [2]

For
iner's

(iii) Sound travels through the air by a series of compressions and rarefactions.

Describe what this means in terms of air particles.

....

....

.... [2]

(b) The two incomplete diagrams below show rays of light travelling through a rectangular glass block.

(i) Fig. 4.1 shows a ray of light passing out of a glass block.
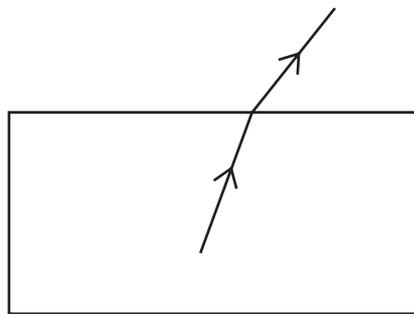
Fig. 4.1

On Fig. 4.1, label the angle of incidence, *i*, and the angle of refraction, *r*.   [2]

(ii) Fig. 4.2 shows a ray of light that does not pass out of the glass block. This is called total internal reflection.
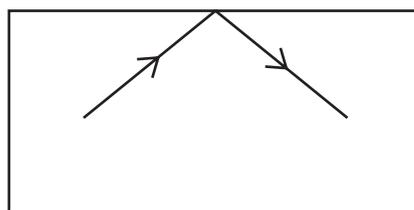
Fig. 4.2

On Fig. 4.2, label the angle of reflection.   [1]

(iii) Describe **one** way in which total internal reflection of light is used.

....

....

.... [2]

5   Marmots are herbivorous mammals. Fig. 5.1 shows a marmot.
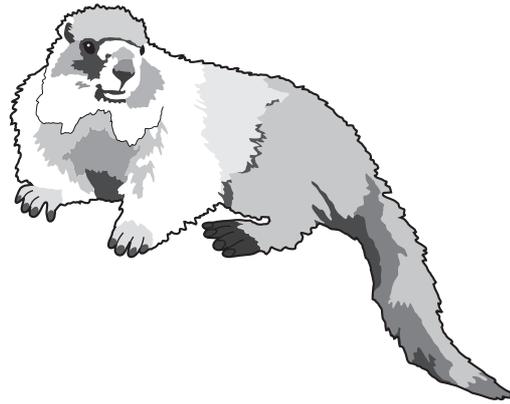
Fig. 5.1

(a) Explain how mammals, such as marmots, use food to help to keep their body temperature constant.

....

....

....

....

.... [3]

(b) A study has been carried out on the marmots living in Colorado, USA.

The winters in this part of Colorado are so cold that the marmots would not be able to find enough food to eat. Instead, they allow their body temperature to drop much lower than normal and stay inactive for many months. This is called hibernation. They do not eat while they are hibernating. They emerge from hibernation in spring.

Before they hibernate, marmots build up large fat stores beneath their skin.

(i) Suggest and explain what marmots must do in order to build up large fat stores in their bodies.

....

....

.... [2]

Fig. 5.2 shows the percentage of marmots with different body masses that ~~s~~ through the winter.
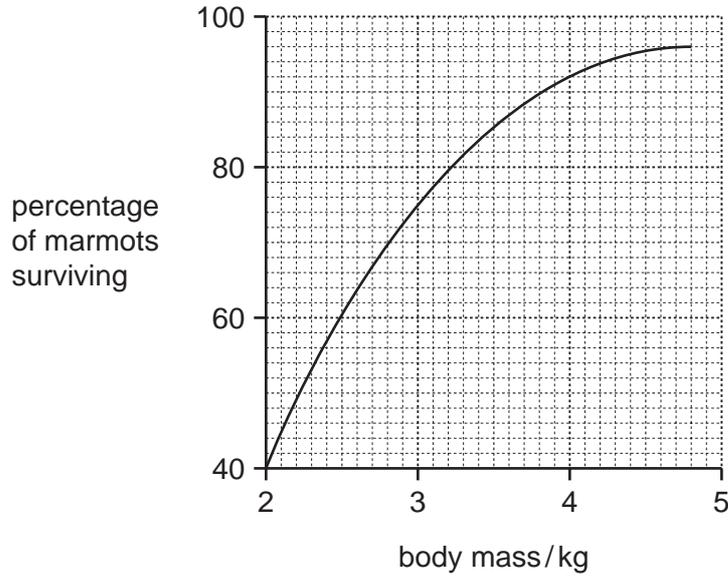
Fig. 5.2

(ii) Describe the relationship between a marmot's body mass and its chance of surviving the winter.

....

....

.... [2]

(iii) Suggest how a layer of fat beneath the skin can reduce heat transfer from a hibernating marmot's body to its surroundings.

....

.... [1]
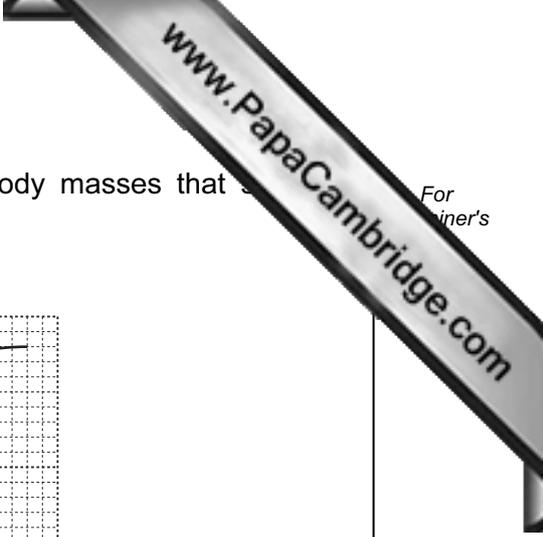
(c) In the last twenty years in Colorado, spring has been arriving earlier in the year. a result of global warming.

Explain how human activities, other than the combustion of fossil fuels, are thought to be contributing to global warming.

....

....

..

....

.... [3]

(d) Fig. 5.3 shows the mean body mass of the marmots on the first day of August (during summer) between 1976 and 2006.
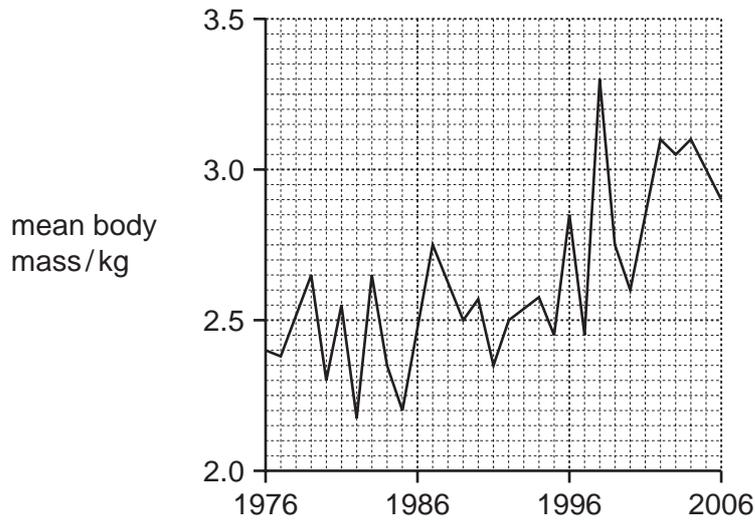
Fig. 5.3

   (i) Describe the general trend shown in Fig. 5.3.

....

.... [1]

   (ii) Suggest how the earlier arrival of spring could be responsible for this trend.

....

.... [1]

6 Fig. 6.1 shows the apparatus a student used to investigate the effect of changing the concentration on the rate of reaction between dilute hydrochloric acid and magnesium. At the start of the experiment the measuring cylinder contained no gas and was full of water.
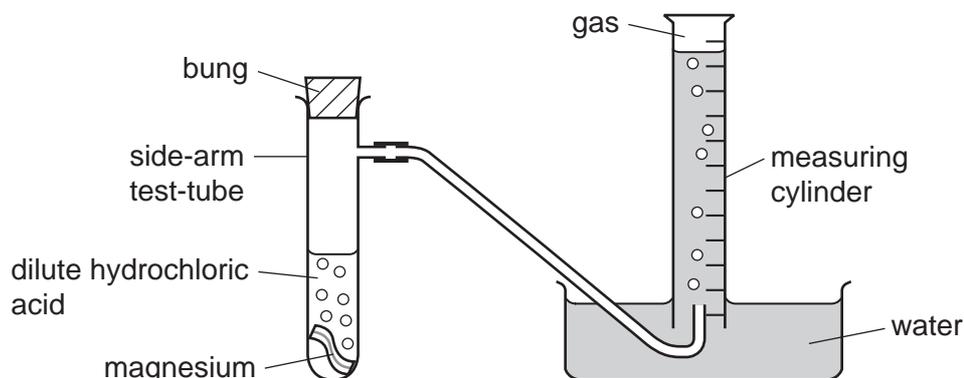
Fig. 6.1

To carry out his investigation the student used the following method.

- He dropped the magnesium into the dilute acid.

- He immediately placed the bung into the side-arm test-tube and started a stopclock.

- He measured the volume of gas in the measuring cylinder every half minute for eight minutes.

He carried out two experiments, **A** and **B**, in which the only variable that he changed was the concentration of the hydrochloric acid.

(a) State **two** other variables (factors) that the student needed to keep the same in experiments **A** and **B**.

1 ....

2 .... [1]

(b) Fig. 6.2 shows the results the student obtained for experiments **A** and **B**.
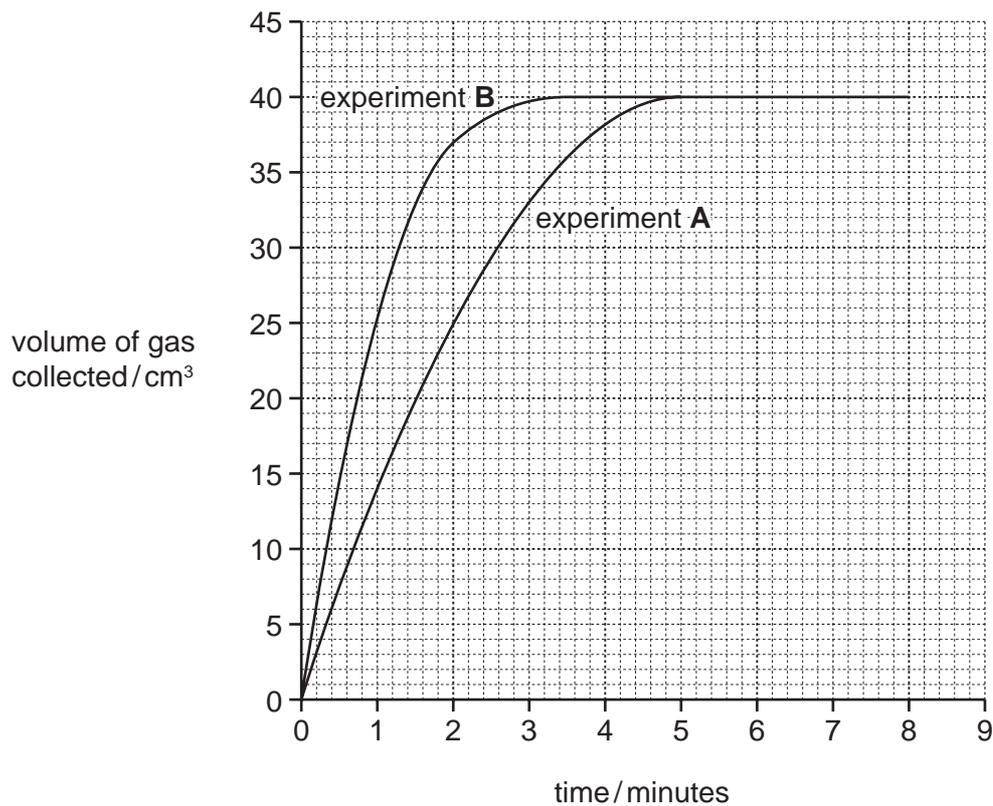
Fig. 6.2

(i) In which experiment, **A** or **B**, did the student use hydrochloric acid which had the higher concentration?

Explain your answer.

experiment ....

explanation ....

....

.... [1]

(ii) The student was told that he could calculate the average rate of reaction us~

$$\text{average rate of reaction} \ = \ \frac{\text{maximum volume of gas collected}}{\text{minimum time taken to collect maximum volume}}$$

Use the information in Fig. 6.2 to calculate the average rate of reaction for experiment **A**.

Show your working and state the units.

.... [3]

(c) The balanced symbol equation for the reaction between hydrochloric acid and magnesium is shown below.

$$Mg \ (s) \ + \ 2HCl \ (aq) \ \rightarrow \ MgCl_2 \ (aq) \ + \ H_2 \ (g)$$
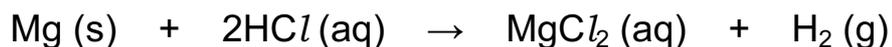
(i) What is meant by the state symbol (aq) in this equation?

.... [1]

(ii) Calculate the number of moles of magnesium atoms contained in 6.0 g of magnesium metal.

Show your working.

.... [2]

7 Nuclear power can be used to generate electricity.

(a) Energy is released from atoms during nuclear fission.

Describe what happens to the nuclei of atoms during nuclear fission.

.... [1]

(b) When an unstable strontium-90 nucleus changes into an yttrium nucleus, a beta particle is emitted.

| strontium | yttrium | beta |
| nucleus | nucleus | particle |
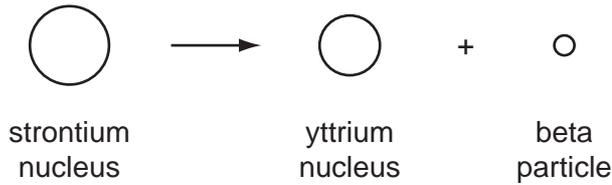
(i) What is a beta particle?

.... [1]

(ii) The nucleus of the strontium-90 atom contains 38 protons and 52 neutrons.

How many protons and neutrons are there in the yttrium nucleus that is produced?

number of neutrons   ....

number of protons   .... [2]

(iii) Explain how a neutral atom may be changed by a collision with a beta particle.

....

....

.... [2]

(c) The graphs in Fig. 7.1 show how the count rate for three different radioactive s... **X**, **Y** and **Z**, changes with time.
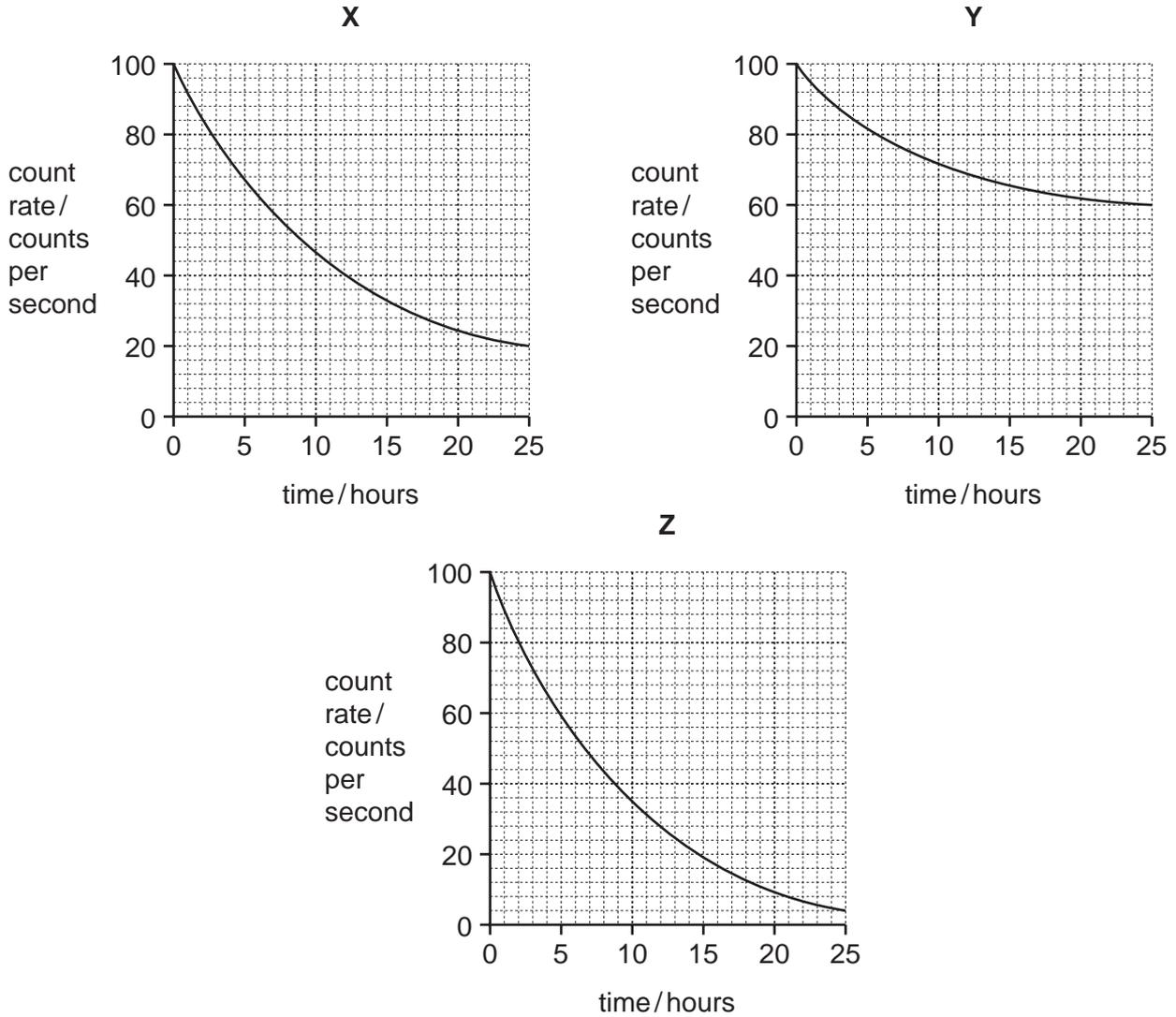
Fig. 7.1

(i) For source **X**, what is the count rate after 10 hours?

.... [1]

(ii) Which source, **X**, **Y** or **Z** has the shortest half-life?

.... [1]

8 An element is a substance that is made of atoms which have the same proton n̲u̲m̲b̲e̲r̲. Most atoms contain protons, neutrons and electrons.

(a) The electronic structures (configurations) of atoms of three elements, **P**, **Q** and **R** are shown below. **P**, **Q** and **R** are **not** the chemical symbols of these elements.

P 2,8,1   **Q** 2,8   **R** 2,7

(i) Use the electronic structures to state and explain the group numbers in the Periodic Table that contain elements **P**, **Q** and **R**.

P Group ....

Q Group ....

R Group ....

explanation ....

.... [2]

(ii) State and explain which of the elements, **P**, **Q** or **R**, is the least reactive.

element ....

explanation ....

.... [1]

(iii) State and explain which **one** of the elements, **P**, **Q** or **R**, is a good conductor of electricity.

element ....

explanation ....

.... [1]

(b) Most metallic elements occur combined with non-metals in the Earth's cru~~st~~. ~~For~~ thousands of years, humans have carried out chemical reactions to extract metals~~ ~~ ~~their ores.~~

Fig. 8.1 shows a cross-section through a shaft furnace which was a simple reaction vessel used by ancient civilisations to extract iron.

waste gases escape
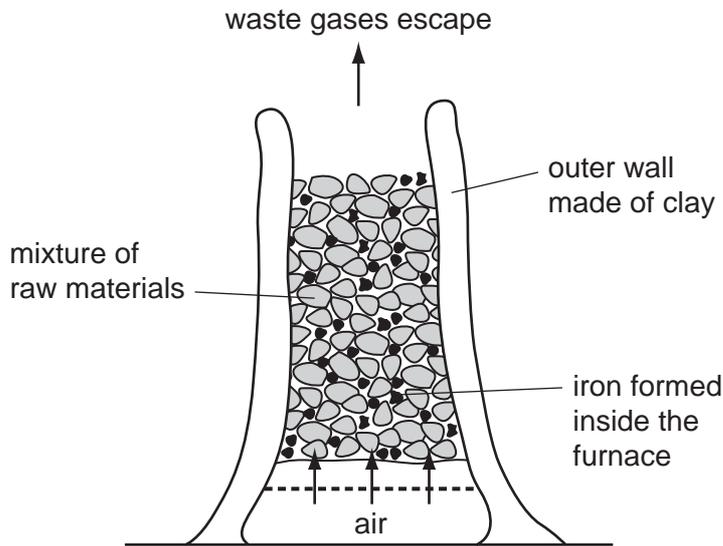
Fig. 8.1

In this shaft furnace the mixture of raw materials consisted of charcoal and iron ore. Charcoal contains mainly carbon, and iron ore contains iron oxide.

Nowadays iron is extracted from iron ore in a blast furnace.

(i) Name another raw material, which is added to a modern blast furnace but which is **not** present in the shaft furnace in Fig. 8.1.

Explain briefly why this material is used.

name of material ....

reason this material is used ....

.... [2]

(ii) Iron is extracted from iron ore when a gaseous oxide of carbon reacts with iron oxide.

Write a **word** chemical equation for this reaction.

.... [2]
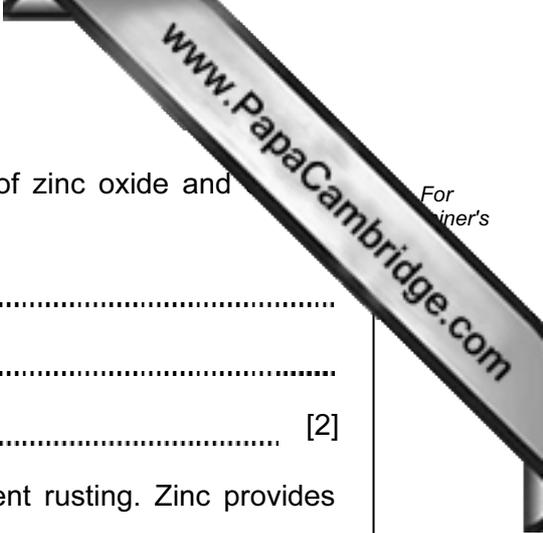
(c) (i) Suggest, in terms of relative reactivity, why a mixture of zinc oxide and .... does **not** produce any metallic zinc in a blast furnace.

....

....

.... [2]

(ii) A thin coating of zinc is often applied to steel to prevent rusting. Zinc provides sacrificial protection for the steel.

Explain briefly the meaning of the term *sacrificial protection*.

....

....

.... [2]

For
iner's

9 **(a)** Define the term *hormone*.

....

....

....

....

.... [3]

(b) Insulin and glucagon are hormones that help to keep the blood glucose concentration constant.

(i) Name the gland that produces insulin and glucagon.

.... [1]

(ii) Describe how the production of insulin helps to lower the concentration of glucose in the blood.

....

....

....

.... [2]

(c) Adrenaline is sometimes called the 'fright, flight or fight' hormone. It is produced when a person is frightened.

Describe **two** effects of adrenaline on the body.

For each effect, explain how it helps the person to respond to the event that has frightened them.

effect 1 ....

how it helps ....

....

effect 1 ....

how it helps ....

....

[4]
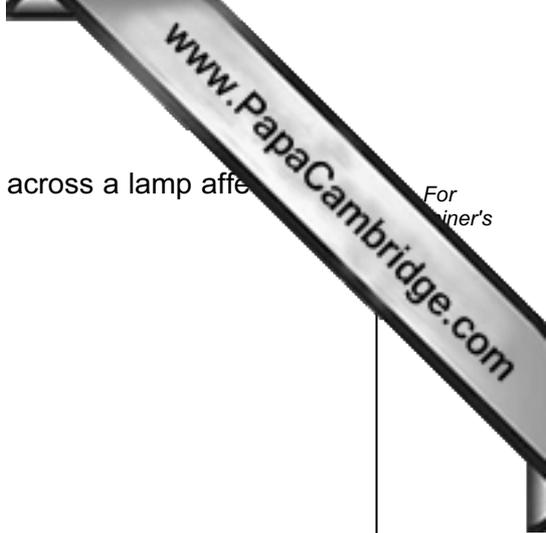
10 (a) A student investigates how the change in potential difference across a lamp affe
current flowing through it.

(i) Draw the circuit diagram that the student uses.

[3]

(ii) During his investigations the student measures the voltage across the lamp as 3.0 V
and the current passing through the lamp as 0.3 A.

Calculate the resistance of the lamp.

State the formula that you use and show your working.

formula used

working

.... [2]

(b) Table 10.1 shows some information about six pieces of wire, all at room temp (20 °C).

Table 10.1

wire	metal composition	length/cm	cross-sectional area/mm²
A	copper	10	0.5
B	nichrome	10	0.5
C	copper	20	0.5
D	nichrome	20	0.5
E	copper	10	1.0
F	copper	20	1.0

(i) Which wire, **B** or **D**, will have the greater resistance?

Explain your answer.

wire ....

.... [1]

(ii) Which wire, **A** or **E**, will have the greater resistance?

Explain your answer.

wire ....

.... [1]

**(iii)** If the resistance of wire **A** is 10 Ω, state the resistance of wires **C** and **E**.

wire **C** resistance = ...

wire **E** resistance = ...

Explain your answers.

....

....

.... [2]

11 Human gametes are produced by a type of nuclear division called meiosis.

(a) State **two** ways in which meiosis differs from mitosis.

1 ....

....

2 ....

.... [2]

(b) Cystic fibrosis is an inherited condition caused by a recessive allele **f**. The normal allele, **F**, is dominant.

A couple who were both heterozygous for cystic fibrosis wanted to have children.

(i) State the probability that their first child would have cystic fibrosis.

.... [1]

(ii) Explain your answer to **(i)**. You may use a genetic diagram as part of your explanation.

[4]

(c) A person with cystic fibrosis makes very thick mucus. This can form a thick c̶ [For] over the inner surfaces of the alveoli in the lungs.

Explain how this would make gas exchange difficult.

....

....

....

.... [2]

12 The element carbon is combined with other elements in millions of different compounds.

Chemists have organised carbon compounds into families which have similar chemical properties to one another.

(a) (i) The structures of three molecules together with the names of three families of carbon compounds are shown below.

Draw straight lines to connect the molecules with the family to which they belong.
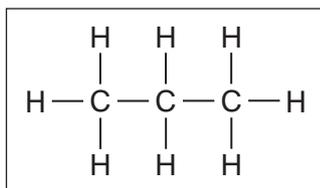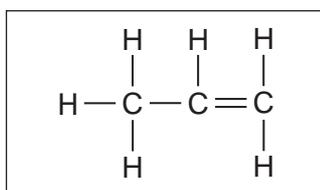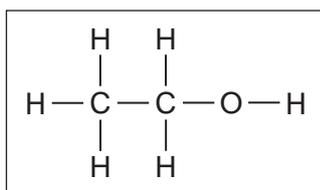
[2]

(ii) Complete the molecular structure below to show a hydrocarbon molecule which contains four carbon atoms and eight hydrogen atoms combined together.
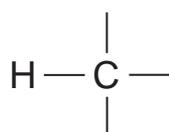
[2]

(b) The combustion of hydrocarbons is believed to be increasing the level of CO_2 dioxide in the atmosphere.

Electric vehicles are powered by batteries which are recharged from the mains electricity supply.

Some people have suggested that the build-up of carbon dioxide in the atmosphere would be greatly reduced if all gasoline and diesel vehicles were replaced by electric vehicles.

Suggest why this might **not** achieve the predicted reduction in carbon dioxide build-up.

....

....

.... [2]

(c) In many countries, ethanol, C_2H_6O , is added to hydrocarbon fuels such as gasoline.

  (i) Describe briefly how the compound ethene, C_2H_4, is converted into ethanol.

....

....

....

.... [3]

  (ii) State **one** use of ethanol other than as a fuel.

.... [1]

DATA SHEET
The Periodic Table of the Elements

Group

I	II											III	IV	V	VI	VII	0
						1 **H** Hydrogen 1											4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †															

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	**Pa** Protactinium 91	238 **U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58-71 Lanthanoid series
†90-103 Actinoid series

Key

a	
	X
b	

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).