UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

9669161496

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	
5	
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7	
8	
9	
10	
11	
12	
Total	

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

For Examiner's Use

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

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

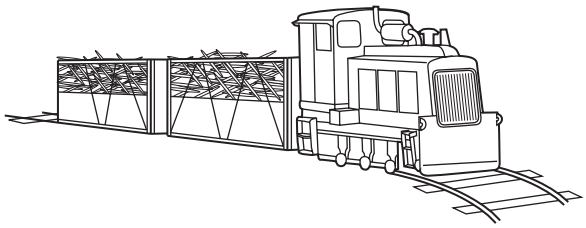


Fig. 1.1

(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]

For Examiner's Use

(iii) It takes the train 5 minutes to travel 1 km. Calculate the power output of the engine.

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

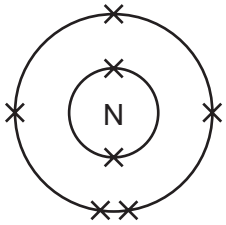
..... [3]

For Examiner's Use

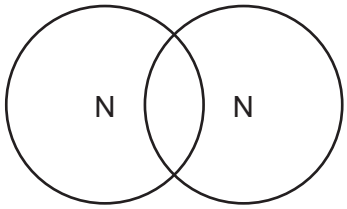
2 Magnesium is a reactive metal that combines with both oxygen and nitrogen when burnt in air. The white solid that remains after this combustion reaction contains mainly magnesium oxide mixed with a little magnesium nitride.

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.

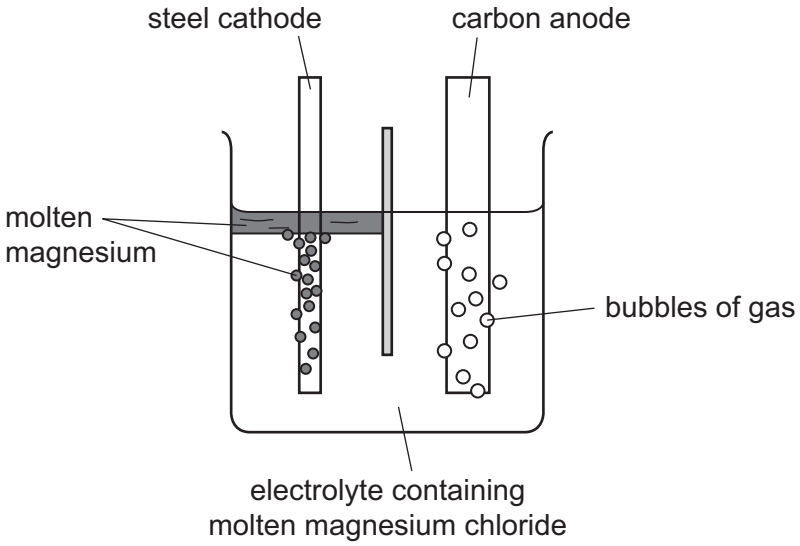


Fig. 2.1

(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.

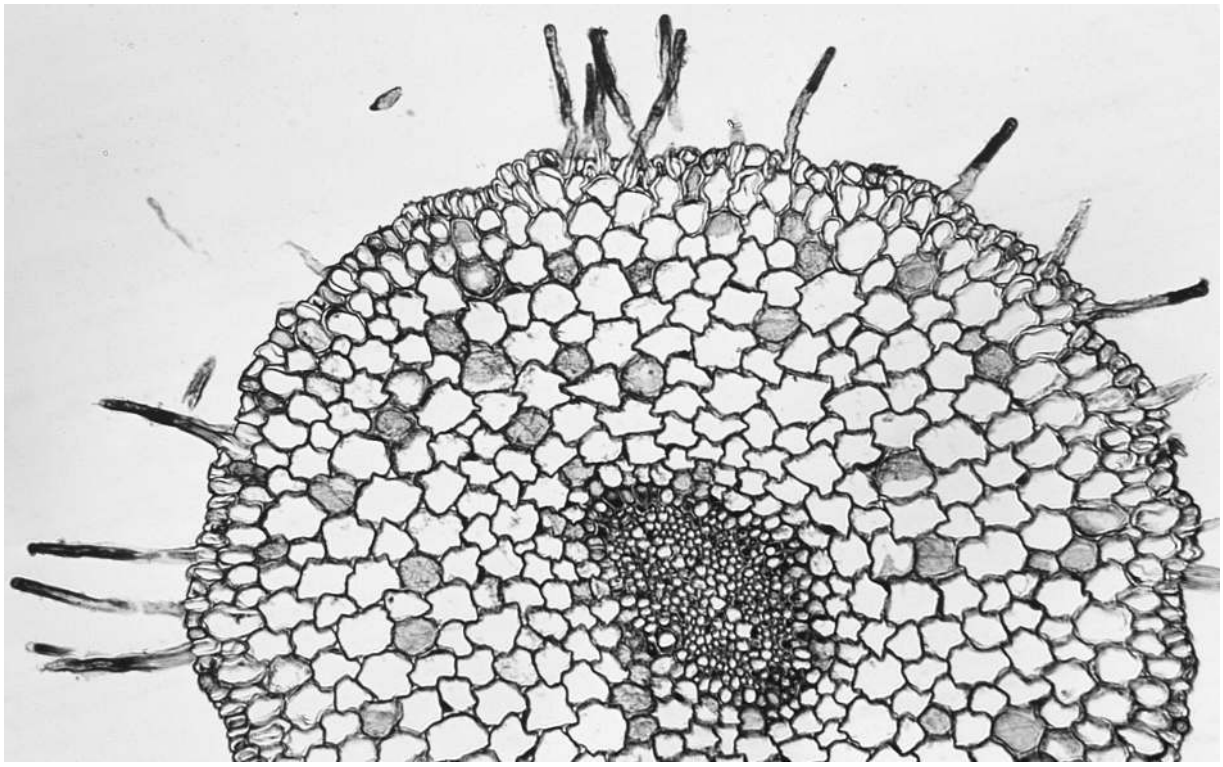


Fig. 3.1

(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]

For Examiner's Use

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

For Examiner's Use

4 **(a)** A bat produces a sound wave with a frequency of 212 kHz and a wavelength of 0.0016 m.

(i) State the meaning of the terms *frequency* and *wavelength*, when describing a 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]

(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.

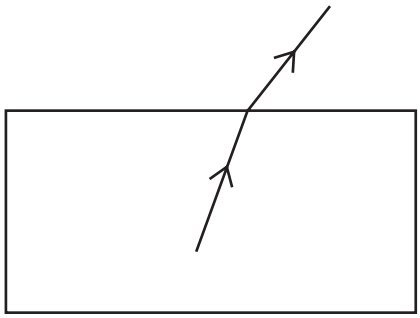


Fig. 4.1

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.

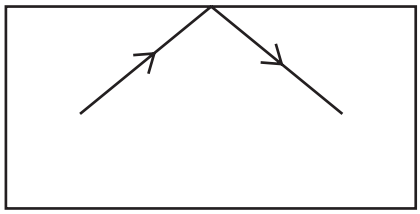


Fig. 4.2

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

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

.....

.....

..... [2]

For Examiner's Use

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 survive through the winter.

For Examiner's Use

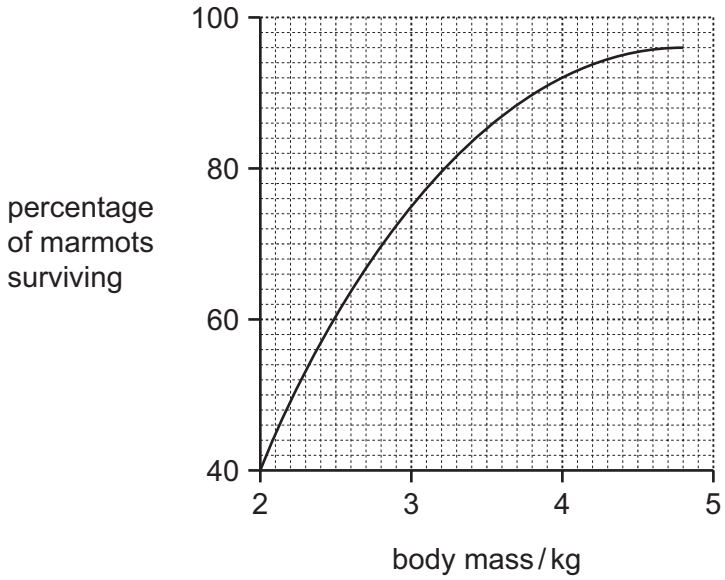


Fig. 5.2

(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. This is 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.

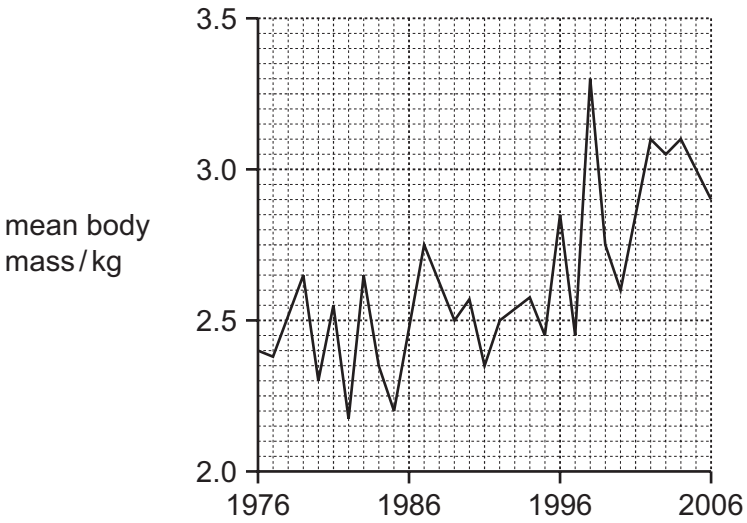


Fig. 5.3

(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 acid 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.

For Examiner's Use

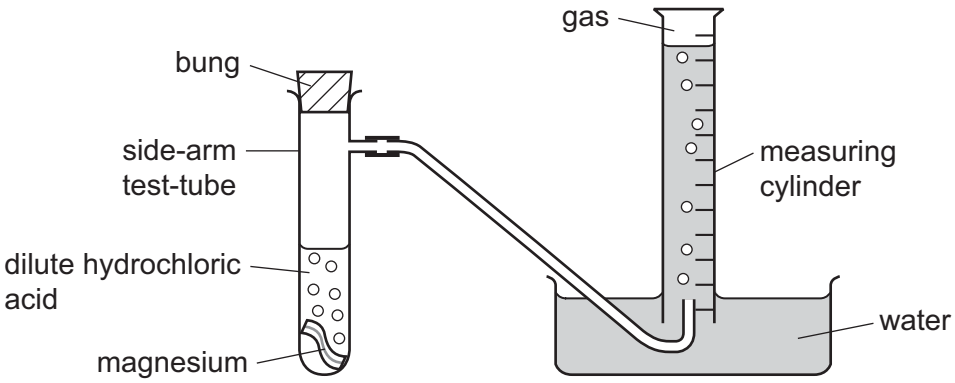


Fig. 6.1

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**.

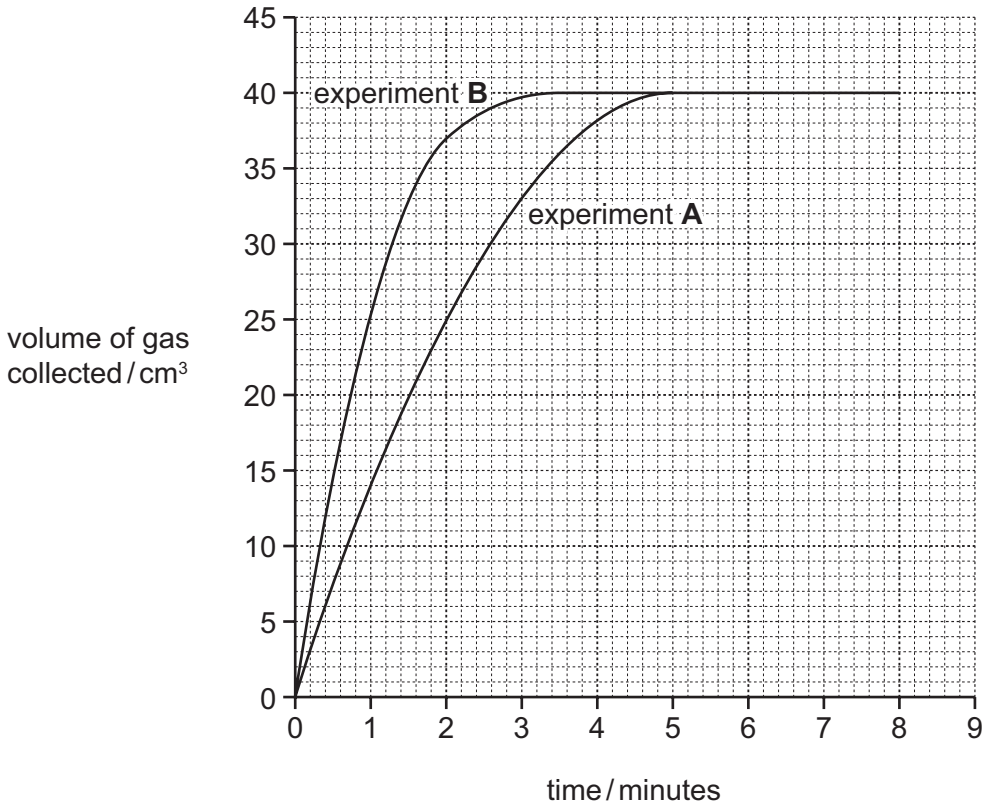


Fig. 6.2

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

Explain your answer.

experiment .....

explanation .....

.....

..... [1]

For Examiner's Use

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

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

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]

For Examiner's Use

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 nucleus | yttrium nucleus | beta 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 sources, **X**, **Y** and **Z**, changes with time.

For Examiner's Use

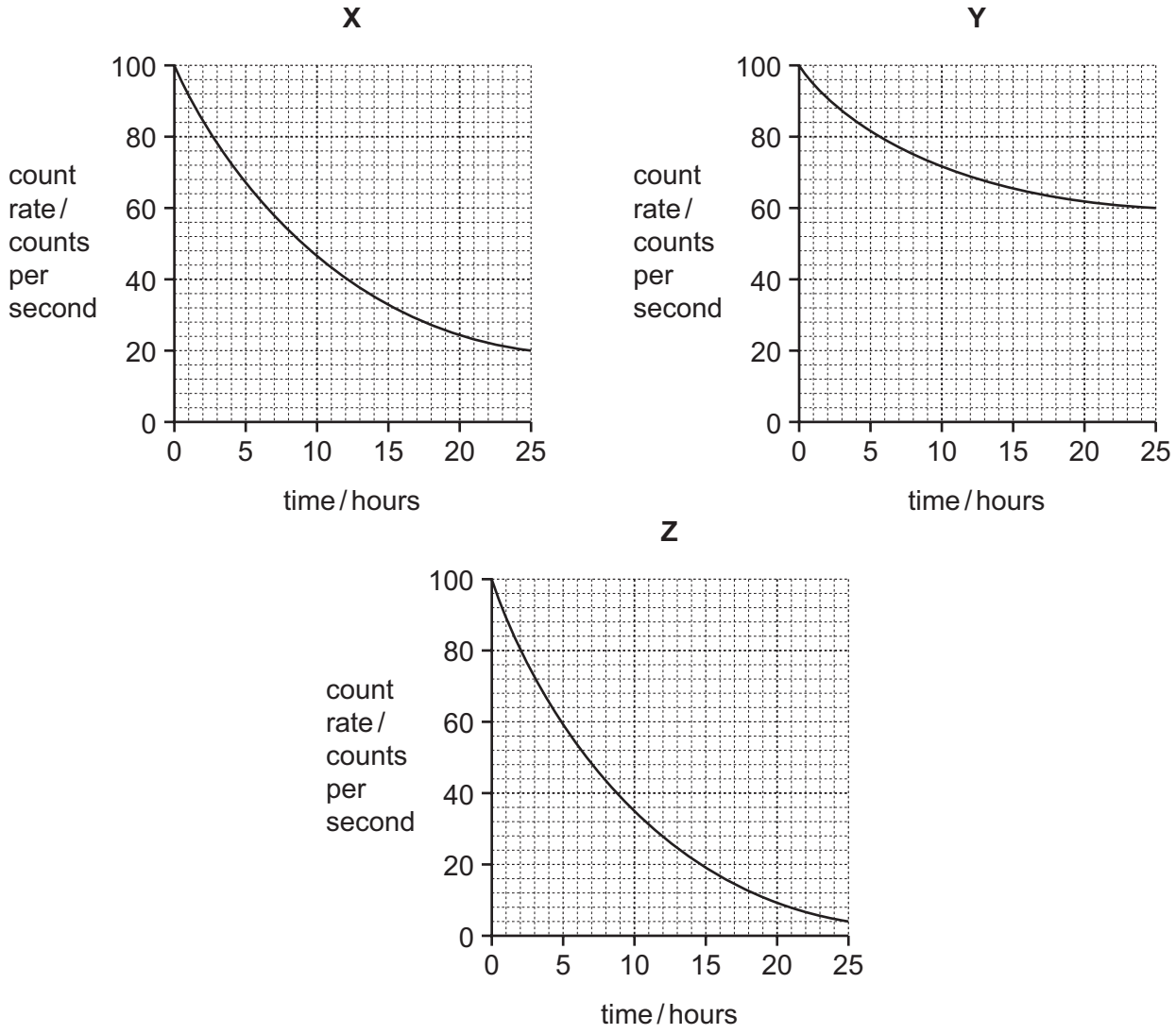


Fig. 7.1

(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]

[Turn over

For Examiner's Use

8 An element is a substance that is made of atoms which have the same proton number. 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 crust. For thousands of years, humans have carried out chemical reactions to extract metals from 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.

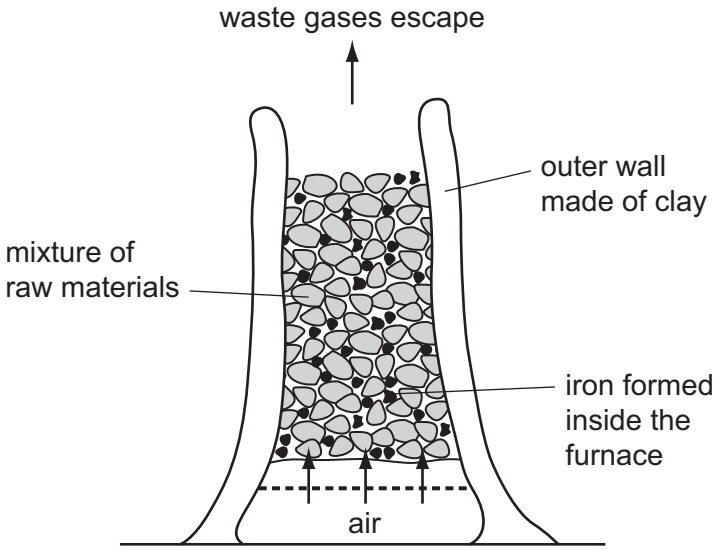


Fig. 8.1

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]

[Turn over

For Examiner's Use

(c) (i) Suggest, in terms of relative reactivity, why a mixture of zinc oxide and carbon 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 Examiner's Use

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]

For Examiner's Use

10 (a) A student investigates how the change in potential difference across a lamp affects the 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]

For Examiner's Use

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

Table 10.1

wire	metal composition	length / cm	cross-sectional area / mm^2
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]

For Examiner's Use

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 covering over the inner surfaces of the alveoli in the lungs.

For Examiner's Use

Explain how this would make gas exchange difficult.

.....

.....

.....

..... [2]

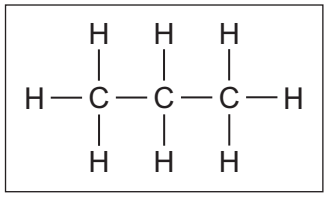
12 The element carbon is combined with other elements in millions of different compounds.

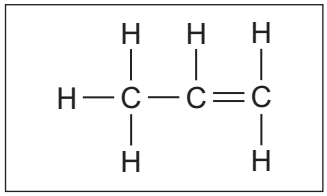
For Examiner's Use

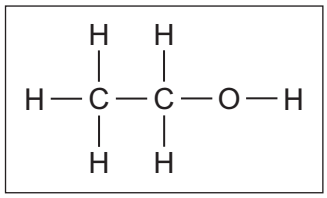
Chemists have organised carbon compounds into families which have similar chemical properties to one another.

(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.







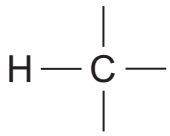
alkene

alcohol

alkane

[2]

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



[2]

For Examiner's Use

(b) The combustion of hydrocarbons is believed to be increasing the level of carbon 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 = relative atomic mass; X = atomic symbol; b = proton (atomic) number

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