UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4665247311

CO-ORDINATED SCIENCES **0654/03**

Paper 3 (Extended) **October/November 2009**

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 24.

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	
6	
7	
8	
9	
Total	

This document consists of **22** printed pages and **2** blank pages.

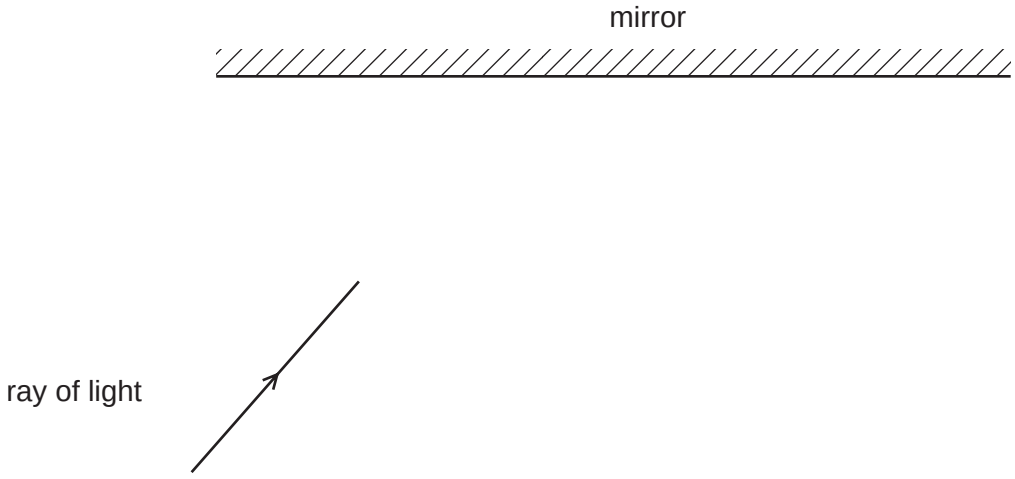
UNIVERSITY of CAMBRIDGE International Examinations

BLANK PAGE

For Examiner's Use

1 **(a)** The Law of Reflection states that when a ray of light is reflected at a surface, the angle of incidence equals the angle of reflection.

Complete the diagram to show how a ray of light is reflected by a plane (flat) mirror. Label the angle of incidence and angle of reflection.



[3]

(b) When white light passes through a prism, it is split into its component colours.

(i) Which colour is refracted most by the prism?

.....

[1]

(ii) Why are some colours refracted more than others?

.....

.....

[1]

For Examiner's Use

2 Soy beans (soyabeans) are grown for their seeds. The seeds are an excellent source of protein and starch, and are used in the production of a wide variety of foods.

(a) Soy beans have nodules on their roots that contain nitrogen-fixing bacteria called *Rhizobium*.

Suggest how this helps soy bean plants to produce seeds containing a lot of protein.

.....

.....

..... [2]

(b) Soy beans have been cultivated for hundreds of years, and artificial selection has produced many different varieties. The soy bean plants have been selected to possess a particular set of characteristics, such as providing high yields of seeds.

Outline how artificial selection would be carried out to produce a variety of soy beans that produced high yields of seeds.

.....

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.....

..... [4]

(c) An investigation was carried out to find out how four different varieties of soy beans would be affected if the concentration of carbon dioxide in the atmosphere increased.

Four varieties were used, called Arksoy, Dunfield, Mukden and Mandarin.

Several plants of each variety were grown in normal concentrations of carbon dioxide. Another set of plants of each variety was grown in a high concentration of carbon dioxide.

The mean masses of leaves and seeds produced per plant were measured at each carbon dioxide concentration. The results are shown in Table 2.1.

For Examiner's Use

Table 2.1

variety	feature	at normal carbon dioxide concentration	at high carbon dioxide concentration
Arksoy	mass of leaves per plant / g	6.54	7.75
	mass of seeds per plant / g	30.8	42.4
Dunfield	mass of leaves per plant / g	7.20	11.19
	mass of seeds per plant / g	46.1	55.9
Mukden	mass of leaves per plant / g	6.08	8.93
	mass of seeds per plant / g	41.4	56.5
Mandarin	mass of leaves per plant / g	5.43	7.30
	mass of seeds per plant / g	31.3	58.4

(i) State which variety of soy bean would be best to grow at normal carbon dioxide concentration.

.....[1]

(ii) State which variety of soy bean showed the greatest increase in seed production at high carbon dioxide concentration compared with normal carbon dioxide concentration.

.....[1]

(iii) Explain why the mass of leaves and seeds per plant was greater at high carbon dioxide concentration than at normal carbon dioxide concentration.

.....

.....

.....[2]

(iv) Suggest and explain why it is important to find out how crops grow in carbon dioxide concentrations that are greater than in our present atmosphere.

.....

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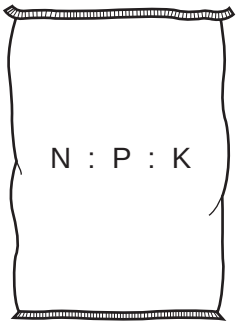
.....[2]

[Turn over

For Examiner's Use

3 Some types of fertiliser have the letters NPK on the package label, indicating the chemical symbols of three elements contained in the fertiliser.



(a) State and explain which of the elements shown in the name NPK contains atoms that have their electrons arranged as shown in Fig. 3.1.

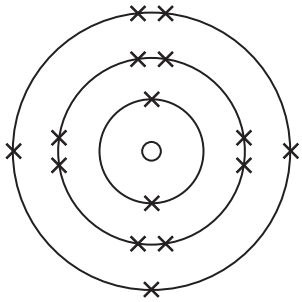


Fig. 3.1

element .....

explanation .....

.....

..... [2]

(b) Plants need nitrogen in order to produce amino acids.

Name the **three** elements, other than nitrogen, which are present in all amino acid molecules.

.....

.....

..... [1]

(c) Ammonia is an important compound that is used in the manufacture of fertilisers.

Fig. 3.2 shows a simplified diagram of the type of reaction vessel that is used in the production of ammonia.

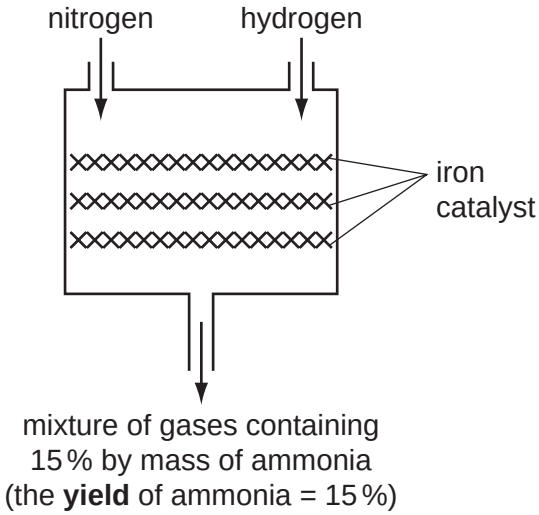


Fig. 3.2

(i) The equation below shows what happens on the surface of the iron catalyst.

The equation is not balanced.

Balance the equation.

$$N_2 + H_2 \rightleftharpoons NH_3$$

[1]

(ii) The yield of ammonia in this reaction vessel is 15%. This means that the mixture of gases coming out of the reaction vessel contains 15% by mass of ammonia.

State and explain which gases account for most of the remaining 85% of the gas mixture.

.....

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..... [2]

(iii) Research chemists and engineers have investigated the effects of temperature and pressure on the yield of ammonia.

Fig 3.3 shows the results of their investigations.

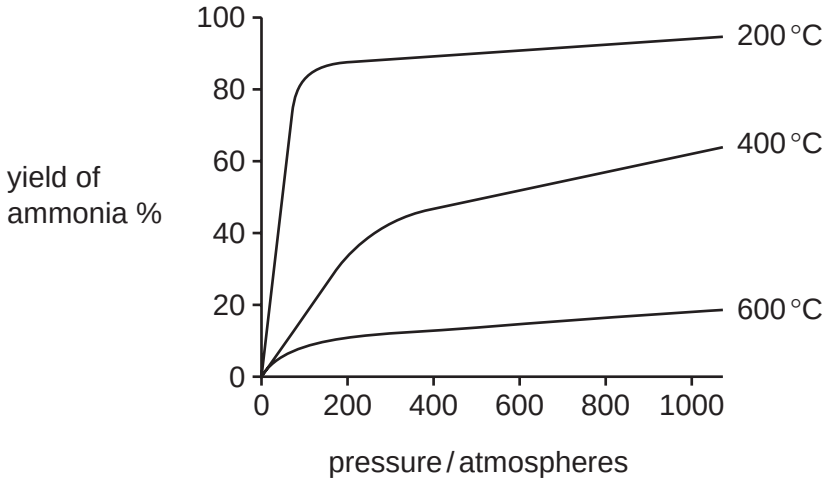

Fig. 3.3

The engineers running the factory want to increase the yield of ammonia.

Use the information in Fig. 3.3 to suggest two ways in which this could be done.

1 .....

2 ..... [2]

(d) In an ammonia factory, 1000 kg of gas mixture leave the reaction vessel every minute. In this factory the yield of ammonia is 17 %.

Calculate the number of moles of ammonia which leave the reaction vessel every minute.

Show your working.

[relative atomic masses, A_r : N=14; H=1]
1 kg = 1000 g

.....

.....

.....

.....

.....

..... [4]

For Examiner's Use

4 **(a)** Humans, like all mammals, keep their body temperature fairly constant.

(i) Explain how a body temperature that is much higher than normal could affect the chemical reactions that take place in the body.

.....

.....

.....

..... [3]

(ii) Explain how sweating helps to cool the body.

.....

.....

..... [2]

(b) A gene has recently been discovered which affects the ability to smell a particular component of male sweat.

The gene has two alleles. Allele **A** is dominant and causes the ability to smell this substance. Allele **a** is recessive, and causes inability to smell it.

Construct a complete genetic diagram to show the expected genotypes and phenotypes in the offspring of two parents who are both heterozygous for these alleles.

[4]

5 **(a)** Fig. 5.1 shows some apparatus set up to measure the specific heat capacity of aluminium.

For Examiner's Use

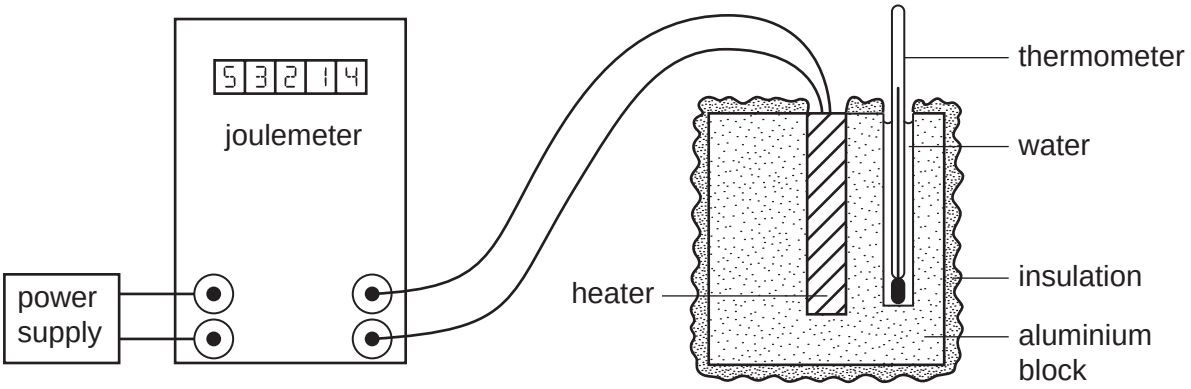

Fig. 5.1

The block is heated electrically and the electrical energy input is measured using a joulemeter. The temperature of the block and the total electrical energy supplied are measured at intervals.

The results are shown on Fig. 5.2.

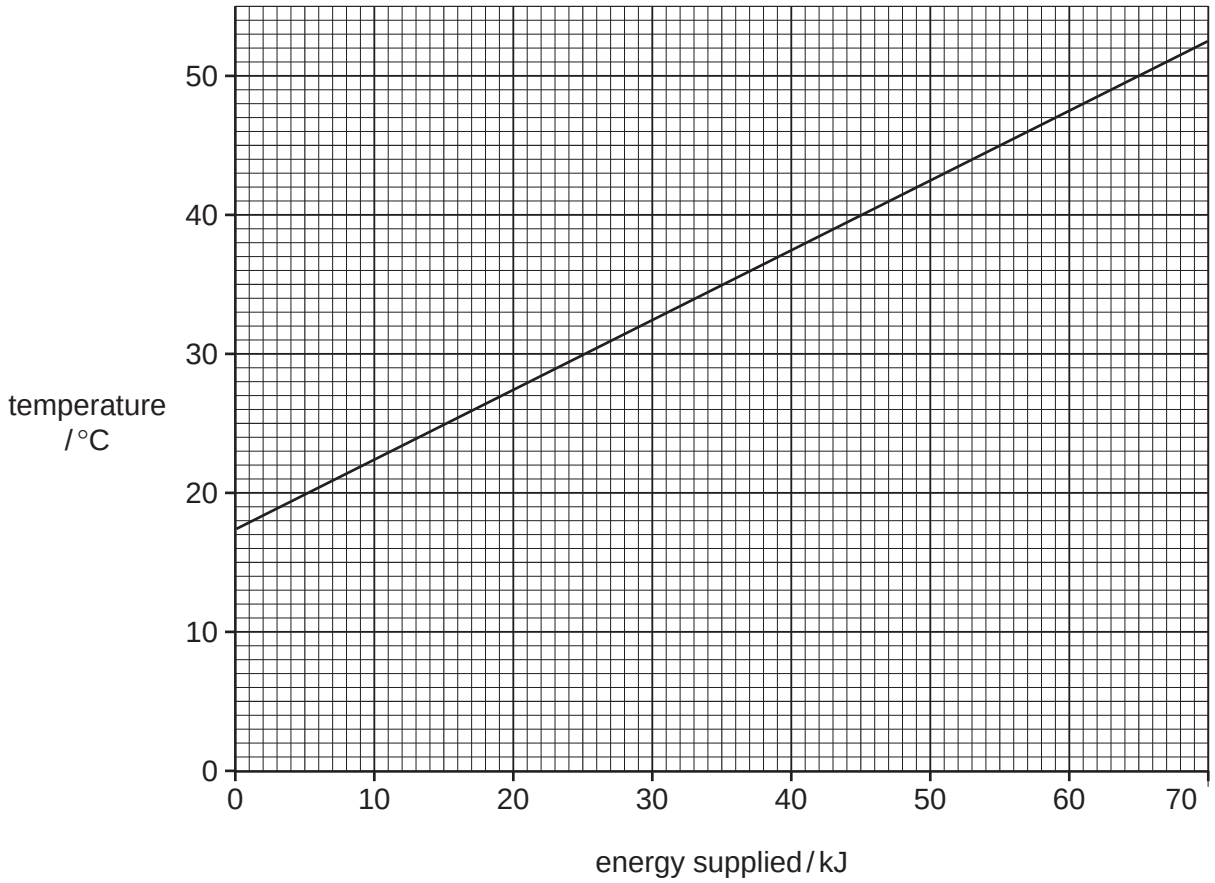

Fig. 5.2

(i) State the relationship between the temperature and the energy supplied.

.....

..... [1]

(ii) Use the graph to calculate the energy needed to raise the temperature of the block from 25 °C to 45 °C.

Show your working on the graph.

..... [2]

(iii) The mass of the aluminium block is 2 kg.

Use the formula

energy = mass x specific heat capacity x temperature change

to calculate the specific heat capacity of aluminium.

Show your working.

..... [3]

(iv) The temperature of the block rose from 25 °C to 45 °C in 600 seconds.

Use your answer from **(ii)** to calculate the electrical power during this time.

State the formula that you use and show your working.

formula

working

..... [2]

For Examiner's Use

(v) The voltage of the power supply in Fig. 5.1 is 12 V. It is fitted with a 10 amp fuse.

Use the formula

power = voltage x current

to explain why this fuse is adequate for this experiment.

.....

.....

..... [2]

(b) A thin sheet of aluminium is placed between a radioactive source and a radiation detector. The source emits one type of radiation only.

The radiation detected is reduced but not completely stopped.

(i) Suggest which type of radiation is being emitted and explain your answer.

.....

.....

..... [2]

(ii) A thin sheet of another metal will completely stop this type of radiation. Suggest what this metal could be.

..... [1]

6 The Earth's crust contains very large amounts of the elements silicon and aluminium.

These elements are found combined in compounds such as silicon dioxide and aluminium oxide.

(a) Pure silicon is used in the manufacture of many types of electronic devices.

Silicon can be obtained by heating a mixture of silicon dioxide and carbon.

A symbolic equation for this reaction is shown below.

$$SiO_2 + C \rightarrow Si + CO_2$$

State the type of chemical reaction shown above.

Explain your answer briefly.

.....

.....

..... [2]

(b) Fig. 6.1 shows a diagram of the process used to extract aluminium from aluminium compounds.

A simplified equation for what happens in this electrolysis reaction is shown below.

$$\text{aluminium oxide} \rightarrow \text{aluminium} + \text{oxygen}$$

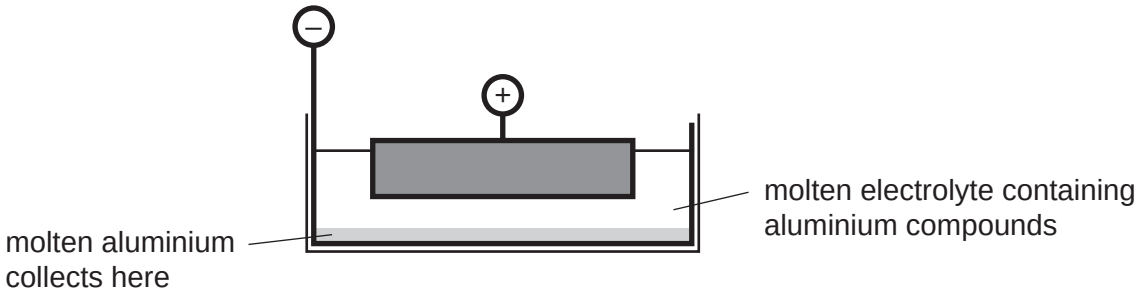

Fig. 6.1

(i) Explain why aluminium atoms are formed at the cathode and **not** at the anode.

.....

..... [2]

(ii) Describe what happens to convert aluminium ions into aluminium atoms on the surface of the cathode.

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..... [2]

(c) Silicon dioxide and aluminium oxide are found together in clay.

When some types of clay are shaken with water, a colloid is produced. Fig. 6.2 shows a diagram of how such a mixture might look when magnified.

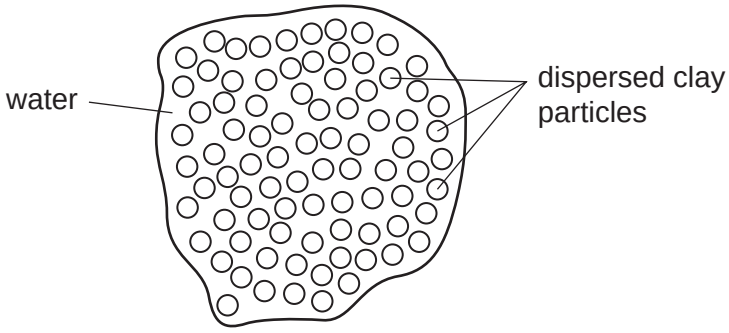

Fig. 6.2

Explain, in terms of rays of light, why a colloid is **not** transparent, but an aqueous solution of sodium chloride is transparent.

.....

.....

.....

..... [2]

(d) Table 6.1 shows some information about carbon dioxide and silicon dioxide.

Table 6.1

	carbon dioxide	**silicon dioxide**
chemical formula	CO_2	SiO_2
type of bonding	covalent	covalent
melting point / °C	– 57	1710

Explain, in terms of their internal structures, why much more energy is needed to melt silicon dioxide than to melt carbon dioxide.

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..... [2]

7 Fig. 7.1 shows the main bones, muscles and tendons in the human arm.

For Examiner's Use

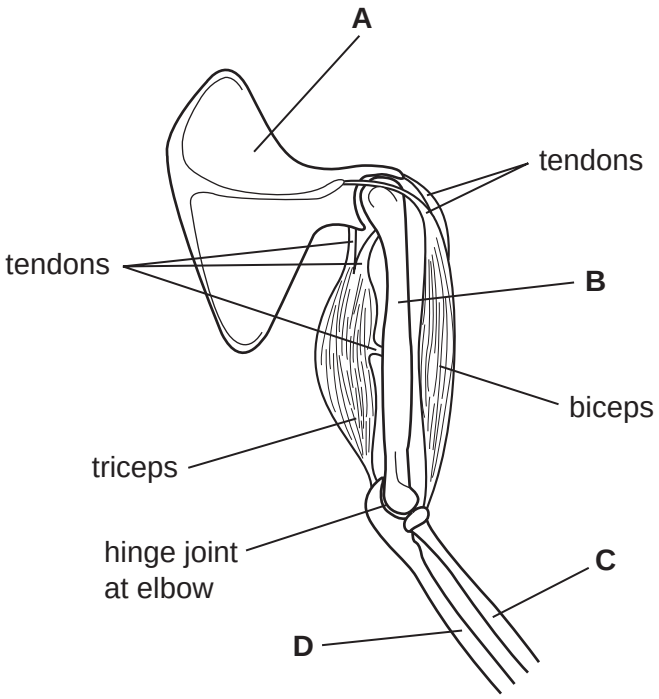

Fig. 7.1

(a) Name bones **A**, **B**, **C** and **D**.

A .....

B .....

C .....

D ..... [2]

(b) Describe the roles of each of the following structures in helping to make the arm bend at the elbow.

(i) biceps muscle

.....

.....

..... [2]

(ii) tendons

.....

..... [1]

For Examiner's Use

(c) Muscles are able to produce quite large forces, but they cannot change their length by very much.

Use this information, and the principle of levers, to explain why the biceps muscle is attached to bone **C** close to the elbow joint, and not further away from it.

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..... [3]

(d) Blood is supplied to muscles in capillaries.

(i) Explain why a muscle such as the biceps needs a good supply of blood.

.....

.....

.....

..... [3]

(ii) Describe **one** way in which the structure of a capillary is related to its function.

structure .....

how this relates to its function .....

..... [2]

For Examiner's Use

8 **(a)** **(i)** An elephant of mass 4000 kg is moving at 0.5 m / s.

Calculate the momentum of the elephant.

State the formula that you use and show your working.

formula

working

..... [2]

(ii) Two elephants, both of mass 4000 kg and both travelling at a speed of 0.5 m / s, collide head on. Explain what happens to their momentum, energy and speed.

momentum .....

.....

energy .....

.....

speed .....

..... [3]

(b) An elephant lifts a mass of 300 kg through a vertical distance of 2 m.

Calculate the work done by the elephant.

State the formula that you use and show your working.

formula

working

..... [2]

For Examiner's Use

(c) **(i)** To determine the density of an elephant, its volume must be measured.

Describe a method for measuring the volume of an irregularly shaped object.

.....

.....

.....

..... [2]

(ii) The volume of an elephant is 4 m^3. Its mass is 4000 kg.

Calculate the density of this elephant.

State the formula that you use and show your working.

formula

working

..... [2]

(d) Elephants can communicate using infra-sound. These sound waves have frequencies as low as 5 Hz. The audible range for an elephant is 5 Hz – 10 000 Hz.

(i) What is meant by the term *frequency*?

.....

..... [1]

(ii) State the audible range for humans.

..... [1]

(iii) Sound waves are longitudinal waves. Explain how these differ from transverse waves.

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..... [2]

9 Fig. 9.1 shows a process carried out at an oil refinery.

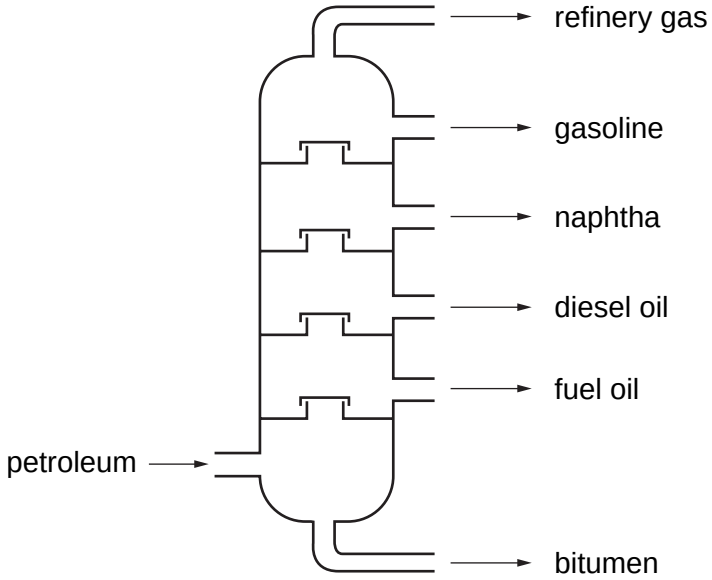


Fig. 9.1

(a) State **one** way in which the properties of gasoline are different from those of diesel oil.

.....

..... [1]

(b) Gasoline (petrol) is used as car fuel.

(i) Name a poisonous carbon compound which is found in the exhaust gases from cars.

..... [1]

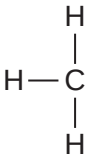
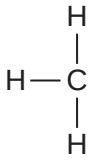
(ii) Describe briefly how the amount of this gas entering the air is reduced in modern cars.

.....

..... [1]

(c) Alkenes are unsaturated hydrocarbons produced by the catalytic cracking of alkanes from petroleum (crude oil).

(i) Complete the graphic (displayed) formulae for the alkane and the alkene which have three carbon atoms per molecule.

ALKANE	ALKENE
	

[2]

(ii) The apparatus in Fig. 9.2 can be used to test a gaseous hydrocarbon to discover whether it is an alkane or an alkene.

Name solution **X** and describe what would be observed if the gaseous hydrocarbon is an alkene.

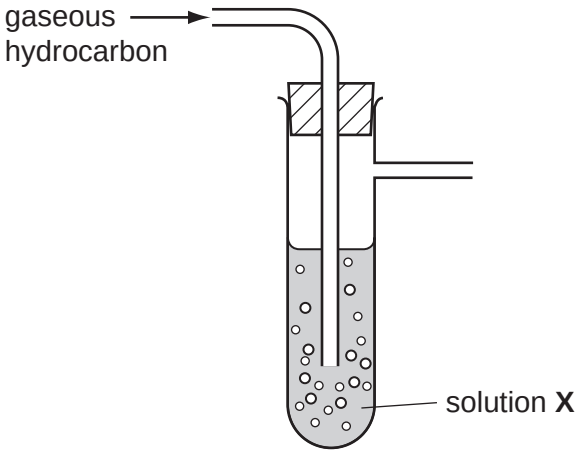


Fig. 9.2

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..... [2]

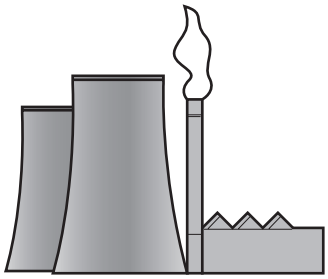
For Examiner's Use

(d) Ethanol, C_2H_6O, is an important chemical which is made from ethene, C_2H_4, in the presence of a catalyst.

Write a balanced symbolic equation for the conversion of ethene to ethanol.

..... [1]

(e) Fuel oil is used as an energy source in some power stations. Fuel oil which is obtained from petroleum contains sulfur compounds.



In some power stations, the combustion products from the burning of fuel oil are treated with calcium hydroxide, an alkali, before release into the atmosphere.

Suggest and explain why this is done.

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.....

..... [3]

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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 dm^3 at room temperature and pressure (r.t.p.).