Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CHEMISTRY **5070/02**

Paper 2 Theory

October/November 2006

1 hour 30 minutes

Candidates answer on the Question Paper.
Additional Materials: Answer Paper

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

Section A
Answer **all** questions.
Write your answers in the spaces provided on the Question Paper.

Section B
Answer any **three** questions.
Write your answers on any lined pages and/or separate answer paper.

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.
A copy of the Periodic Table is printed on page 20.

For Examiner's Use	
Section A	
B7	
B8	
B9	
B10	
Total	

This document consists of **17** printed pages and **3** lined pages.

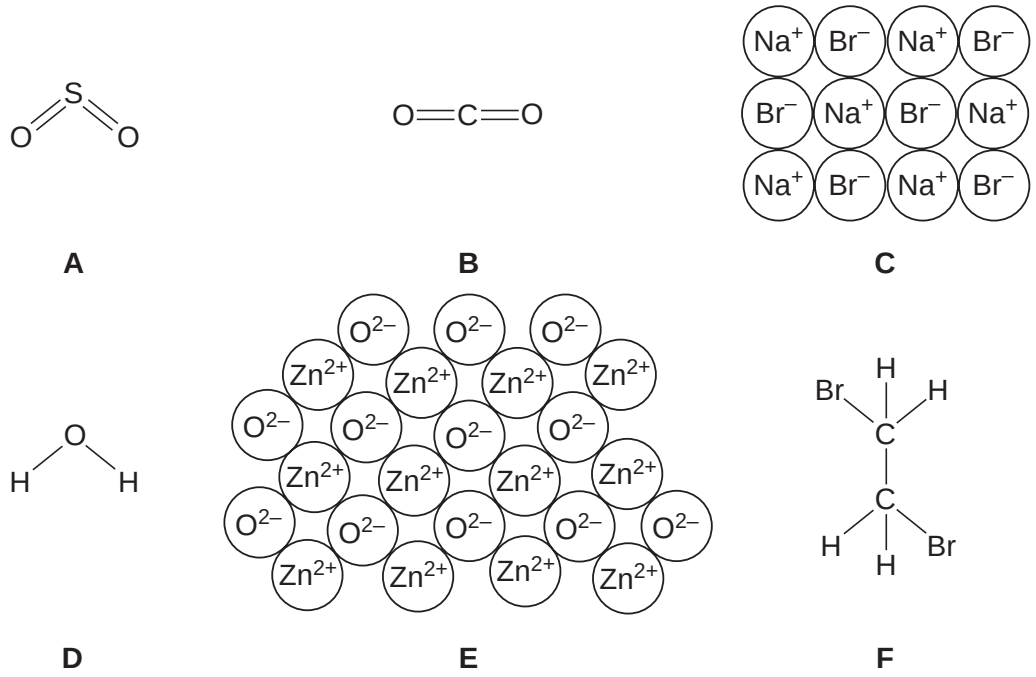
For Examiner's Use

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 The diagram shows the structures of various compounds.



(a) Use the letters **A** to **F** to answer the following.
Each compound may be used once, more than once or not at all.

(i) Which **one** of these compounds is most likely to contribute to acid rain?

..... [1]

(ii) Which **one** of these compounds is an amphoteric oxide?

..... [1]

(iii) Which **two** of these compounds have giant structures?

…… and …… [1]

(iv) Which **one** of these compounds when molten, releases a reddish brown gas at the anode on electrolysis?

..... [1]

(b) What is the empirical formula of compound **F**?

.....[1]

(c) Carbon monoxide is a poisonous atmospheric pollutant.
State how this gas gets into the air.

.....

.....[1]

A2 The table shows the decomposition temperatures of some metal carbonates.

metal carbonate	decomposition temperature / °C
magnesium carbonate	540
calcium carbonate	900
strontium carbonate	1280
barium carbonate	1360

(a) **(i)** Describe how the decomposition temperature depends on the position of the metal in the reactivity series.

.....

.....[1]

(ii) Write an equation for the thermal decomposition of magnesium carbonate.

.....[1]

(b) Petroleum fractions need to be cracked.

(i) Why do oil companies need to crack petroleum fractions?

.....

.....[1]

(ii) State the conditions needed for cracking.

.....[2]

(iii) Complete the following equation for the cracking of tetradecane.

$$C_{14}H_{30} \rightarrow C_{10}H_{22} + ...$$

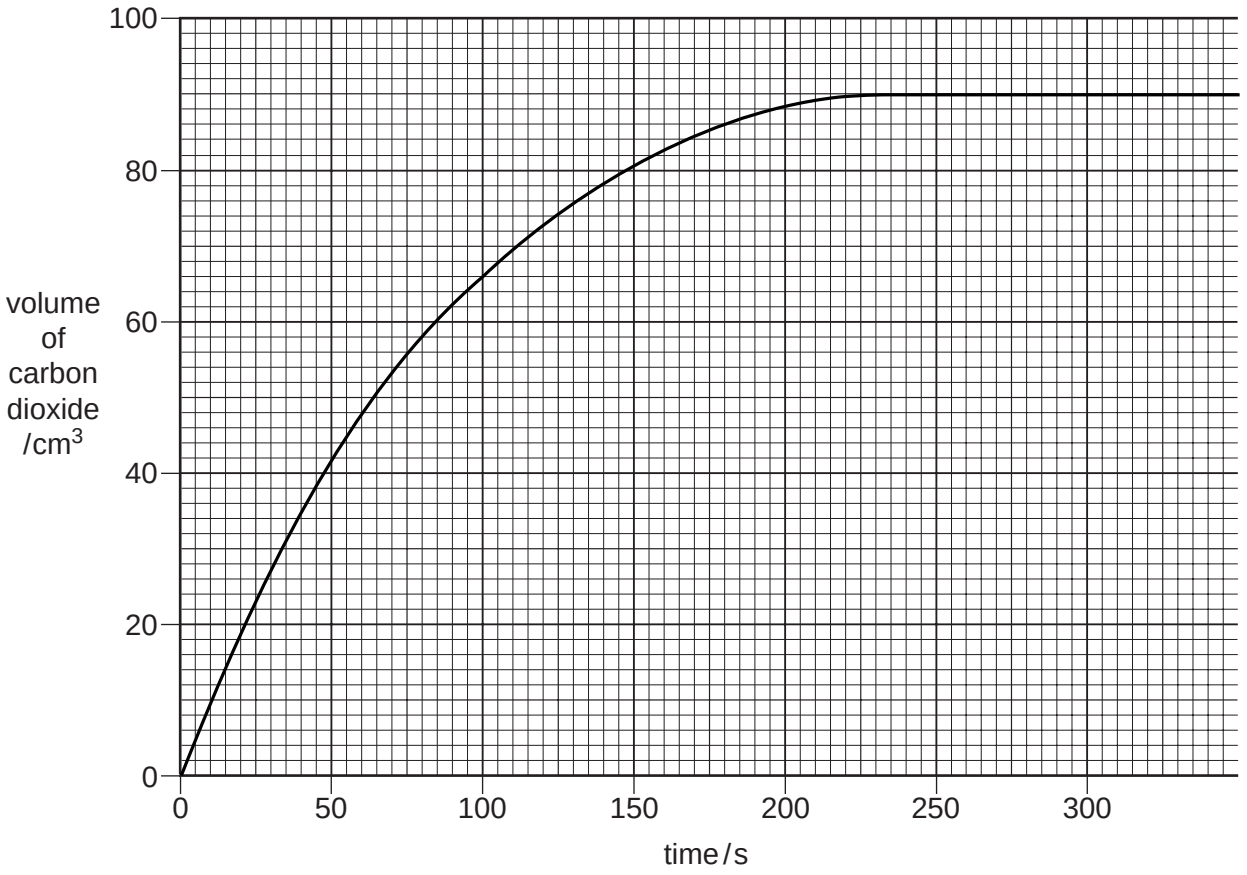
[1]

A3 A student investigated the reaction of calcium carbonate with hydrochloric acid.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

The student used large pieces of calcium carbonate and carried out the reaction at 20 °C. The concentration of hydrochloric acid was 1.0 mol/dm^3.

The results of the experiment were plotted as a graph which is shown below.



(a) After how many seconds did the reaction stop?

.....[1]

(b) Calculate the number of moles of carbon dioxide released during the reaction.
[The volume of one mole of any gas at r.t.p. is 24 dm^3]

[1]

(c) The student repeated the experiment using the same mass of calcium carbonate and the same concentration of acid at 20 °C.

This time the student used small pieces of calcium carbonate. On the grid opposite, sketch the graph for the reaction of small pieces of calcium carbonate with hydrochloric acid.

[2]

(d) When the student repeated the experiment using hydrochloric acid of concentration 2.0 mol/dm^3, the speed of reaction increased.

Use the kinetic particle theory to explain why the speed of this reaction increased.

.....

.....

.....[2]

A4 Helium, neon, argon, krypton and xenon are noble gases.

(a) State a use for argon.

.....[1]

(b) Use ideas about electronic structure to explain why the noble gases are unreactive.

.....

.....[1]

(c) Complete the table to show the number of particles in two isotopes of argon.

isotope	number of protons	number of electrons	number of neutrons
$^{36}_{18}Ar$			
$^{40}_{18}Ar$			

[2]

(d) Explain why potassium comes after argon in the Periodic Table even though it has a relative atomic mass which is lower than that of argon.

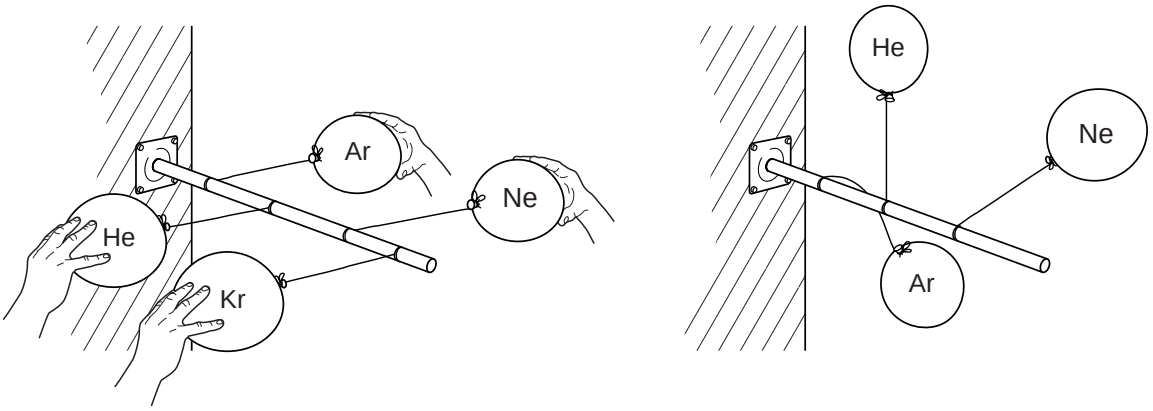
.....

.....[1]

(e) Compounds of xenon with fluorine were first made in the 1960s.
Xenon reacts with fluorine at 400 °C to form xenon tetrafluoride, XeF_4.
Write a symbol equation for this reaction.

[1]

(f) Balloons filled with helium, neon, argon and krypton were tied to a bar.
They were held horizontally at the same height and then released.
The position of three of the balloons 5 seconds after release is shown in the diagram.



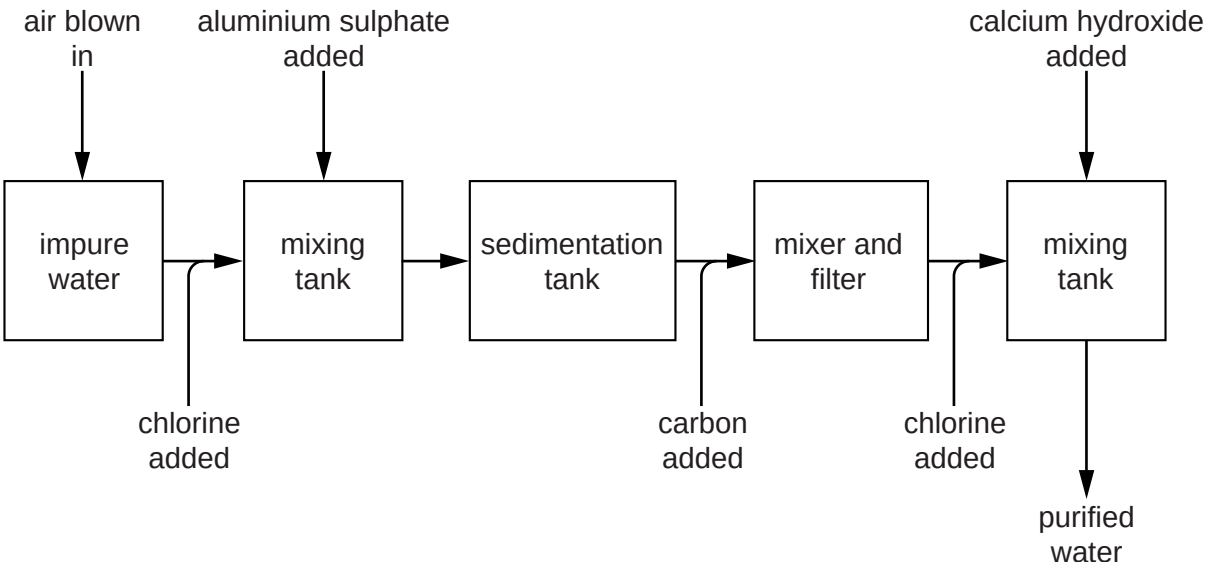
start after 5 seconds

Predict the position of the balloon filled with krypton.

.....

.....[1]

A5 The diagram shows the stages in water purification.



(a) After the air is blown in, the impure water contains iron(III) ions.

(i) What is the approximate percentage of oxygen in the air?

.....[1]

(ii) Describe a test for iron(III) ions.

test .....

result .....[2]

(b) Aluminium sulphate is added to clump tiny particles of clay together to form larger particles of solid.

(i) Suggest how the solids are separated from the water.

.....[1]

(ii) Aluminium sulphate contains Al^{3+} ions and SO_4^{2-} ions.
Deduce the formula of aluminium sulphate.

.....[1]

(c) Why are the following added during the water purification process?

(i) carbon

.....[1]

(ii) chlorine

.....[1]

(d) Calcium hydroxide is added to neutralise the acidic solution formed after chlorine has been added. This solution contains hydrochloric acid.

(i) Write an equation for the reaction of calcium hydroxide with hydrochloric acid.

.....[1]

(ii) Write the ionic equation for this reaction.

.....[1]

A6 Methane, CH_4, is the major constituent of natural gas.

(a) Draw a dot-and cross-diagram to show how the outer shell electrons are arranged in methane.

show hydrogen electrons as •
show carbon electrons as **x**

[1]

(b) At a temperature of –5 °C and a pressure of 26 atmospheres, methane combines with water and forms an ice-like structure called methane hydrate.
Large quantities of methane hydrate have been found underground.

(i) Describe the arrangement and motion of the particles in solid methane hydrate.

.....

.....[2]

(ii) The methane hydrate underground has not yet been extracted in large amounts. When it is extracted, large volumes of methane are released.

Suggest **two** reasons why methane hydrate decomposes when it is extracted.

.....

.....

.....[2]

(iii) Describe how the presence of methane in the atmosphere may affect the environment.

.....

.....[1]

(c) A very small quantity of methane is present in the atmosphere.

State another source of this gas.

.....[1]

(d) State a use of methane.

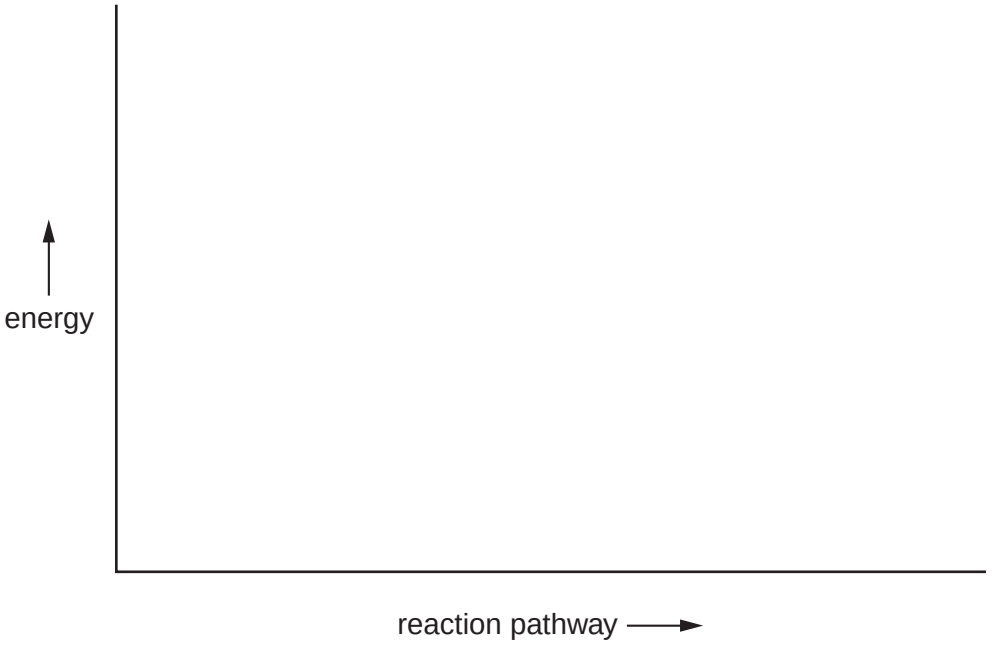
.....[1]

(e) In the presence of light methane reacts with chlorine.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl \qquad \Delta H = -99.5\,kJ$$

Draw an energy profile diagram for this reaction.

Show:
- the reactants and products,
- the activation energy,
- the enthalpy change.



[3]

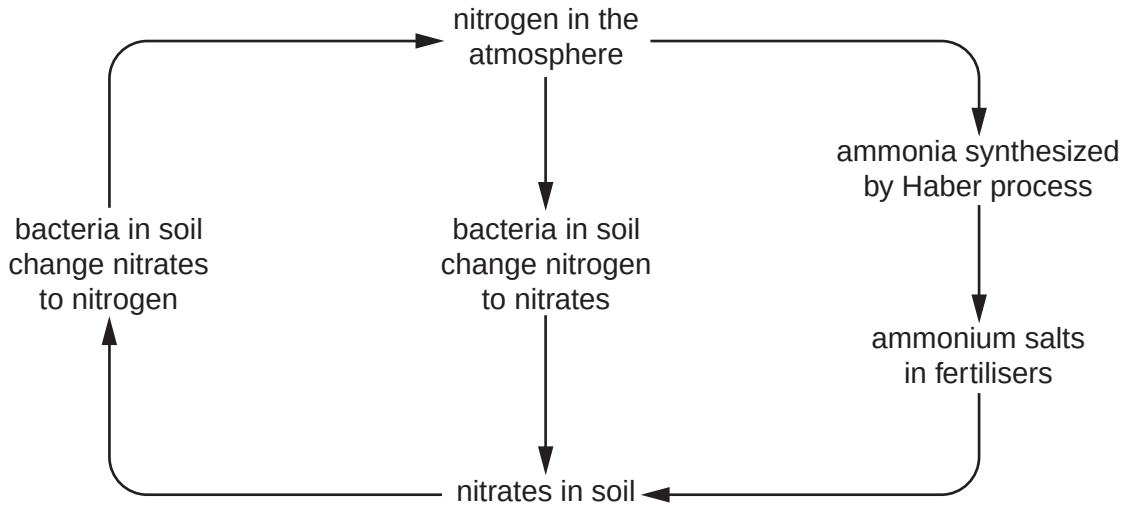
Section B

Answer **three** questions from this section on the lined pages at the end of this booklet.

Tie any extra sheets loosely to this booklet.

The total mark for this section is 30.

B7 A simplified diagram of the nitrogen cycle is shown below.



(a) Although certain bacteria in the soil convert nitrogen gas into nitrates, other bacteria convert nitrogen into ammonium salts. The ionic equation for this second reaction is

$$N_2 + 8H^+ + 6e^- \rightarrow 2NH_4^+$$

Explain why this is a reduction reaction. [1]

(b) In the presence of hydrogen ions, a different type of bacterium converts nitrate ions into nitrogen gas and water.
Give the ionic equation for this reaction. [1]

(c) Ammonia is synthesized by the Haber process.

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

(i) State the sources of both the nitrogen and hydrogen needed for the Haber process. [2]

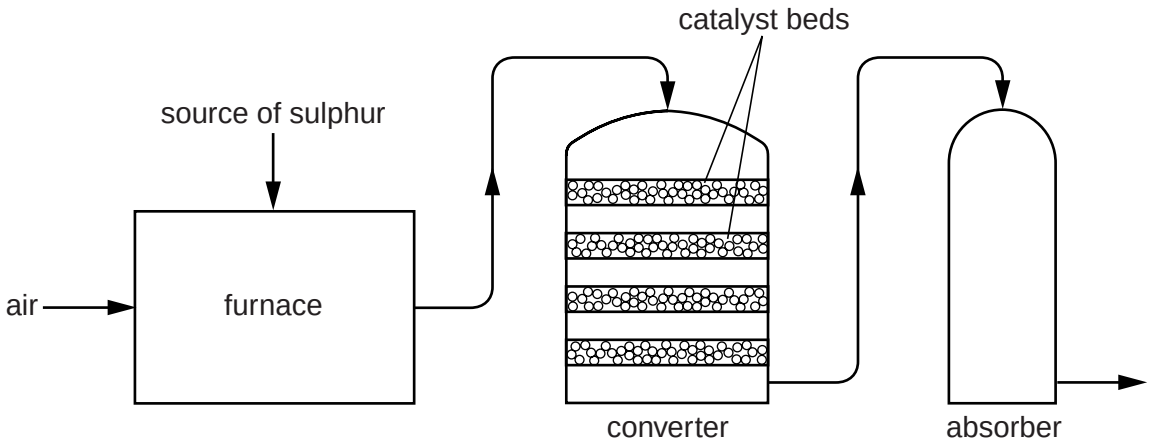
(ii) State the essential conditions for the Haber process. [2]

(d) Fertilisers are added to the soil to improve crop yields.
A farmer has the choice of two fertilisers, ammonium nitrate, NH_4NO_3, or diammonium hydrogen phosphate, $(NH_4)_2HPO_4$.

Show by calculation which of these fertilisers contains the greater percentage of nitrogen by mass.
You must show your working. [3]

(e) State one major problem caused when the nitrates from fertilisers leach from the soil into streams and rivers. [1]

B8 The diagram shows the stages in the manufacture of sulphuric acid.



(a) In the furnace, an ore containing zinc sulphide, ZnS, is heated in oxygen to make zinc oxide, ZnO, and sulphur dioxide.

Write an equation for this reaction. [1]

(b) In the converter, sulphur dioxide and oxygen are passed over a series of catalyst beds at a temperature of about 420 °C.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -196\,\text{kJ}$$

(i) An increase in pressure increases the yield of sulphur trioxide. Explain the reason for this effect. [1]

(ii) Even though an increase in pressure increases the yield of sulphur trioxide, the reaction in the converter is carried out at atmospheric pressure.
Suggest a reason for this. [1]

(iii) In some sulphuric acid plants, the gases are cooled when they pass from one catalyst bed to the next. Use the equation to explain why the gases need to be cooled. [2]

(c) When sulphuric acid is reacted with excess iron powder, iron(II) sulphate and hydrogen are produced.

Suggest how crystals of iron(II) sulphate could be prepared from this reaction mixture. [2]

(d) 12.0 cm^3 of an aqueous solution of sulphuric acid exactly neutralised 20.0 cm^3 of a solution of sodium hydroxide of concentration 0.150 mol/dm^3.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the concentration, in mol/dm^3 of the aqueous sulphuric acid. [3]

B9 Both ethanoic acid and butanoic acid are found in some plants and bacteria.

(a) Draw the structure of butanoic acid showing **all** atoms and bonds. [1]

(b) Explain:

(i) what is meant by a weak acid, [1]

(ii) how you could show that butanoic acid is a weak acid. [2]

(c) Butanoic acid can be converted into an ester by heating it with an alcohol and a few drops of concentrated sulphuric acid.

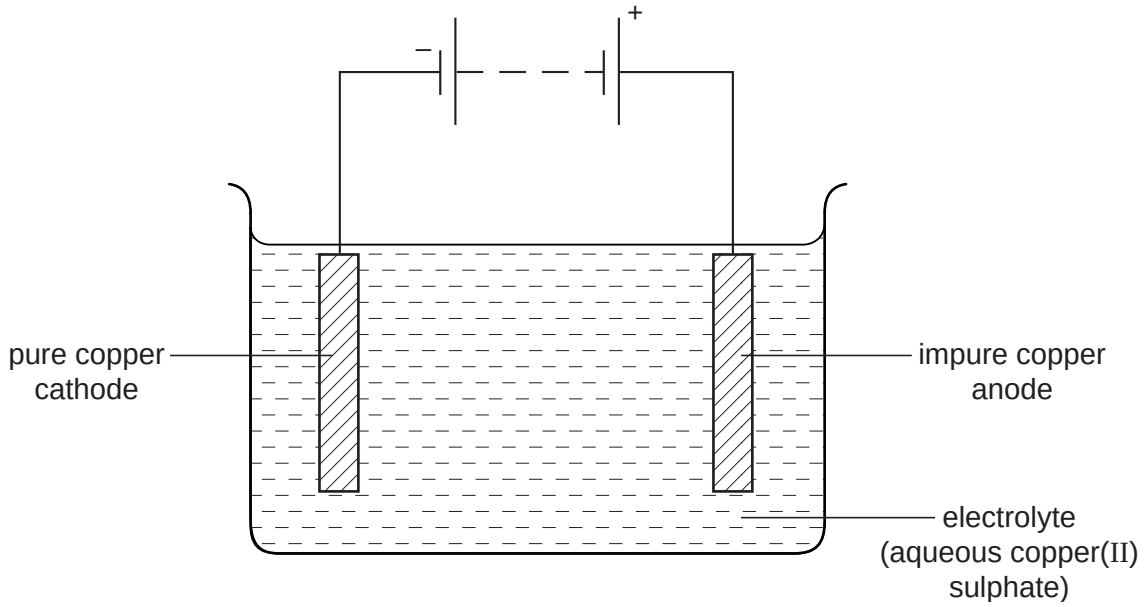
A sample of an ester contains 0.18 g of carbon, 0.03 g of hydrogen and 0.08 g of oxygen. The relative molecular mass of the ester is 116.
Calculate both the empirical and molecular formulae of this ester. [3]

(d) Ethanoic acid can be produced by the bacterial fermentation of glucose, $C_6H_{12}O_6$. During this process glucose is first oxidised to ethanol.

(i) Write an equation for the fermentation of glucose to form ethanol and carbon dioxide. [1]

(ii) State the reagents and conditions required for ethanol to be oxidised to ethanoic acid in the laboratory. [2]

B10 The diagram shows a cell for purifying copper.



(a) Describe what you would observe during this electrolysis and write the equations for the reactions at the electrodes. [3]

(b) The electrodes and the electrolyte conduct electricity.

(i) Explain how the structure of metals allows copper electrodes to conduct electricity. [1]

(ii) Explain why solid copper(II) sulphate does not conduct electricity but an aqueous solution of copper(II) sulphate does conduct. [2]

(c) Describe how the apparatus shown in the diagram could be modified in order to electroplate an iron object, such as a knife, with nickel. [2]

(d) Bronze is an alloy of copper and tin. Bronze is less malleable than pure copper. Use ideas about the structure of metals and alloys to explain why bronze is less malleable than pure copper. [2]

DATA SHEET
The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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 Sulphur 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.).