Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CHEMISTRY **0620/03**

Paper 3

May/June 2004

1 hour 15 minutes

Candidates answer on the Question Paper.
No Additional Materials 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 in the spaces provided on the Question Paper.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
You may use a calculator.

Answer **all** questions.
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 12.

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

For Examiner's Use	
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Total	

This document consists of **12** printed pages.

UNIVERSITY of CAMBRIDGE
International Examinations

[Turn over

1 It was reported from America that a turbine engine, the size of a button, might replace batteries. The engine would be built from silicon which has suitable properties for this purpose.

(a) (i) Why are batteries a convenient source of energy?

.....

[1]

(ii) The engine will run on a small pack of jet fuel. What other chemical is needed to burn this fuel?

.....

[1]

(b) Silicon has the same type of macromolecular structure as diamond.

(i) Explain why one atom of either element can form four covalent bonds.

.....

.....

[2]

(ii) Predict **two** physical properties of silicon.

.....

.....

[2]

(iii) Name a different element that has a similar structure and properties to silicon.

.....

[1]

(c) Silicon is made by the carbon reduction of the macromolecular compound, silicon(IV) oxide.

(i) Balance the equation for the reduction of silicon(IV) oxide.

SiO_2 + ... C $\rightarrow$ Si + ... CO [1]

(ii) Explain why the silicon(IV) oxide is said to be reduced.

.....

[1]

(iii) Describe the structure of silicon(IV) oxide. You may use a diagram.

.....

[2]

2 Sulphur is used to make sulphuric acid. In the UK, the annual production of the acid is about 2.5 million tonnes.

(a) The reactions in the manufacture of sulphuric acid by the Contact Process are shown below.

Sulphur	⟶	Sulphur dioxide
S	**reaction 1**	SO_2
Sulphur dioxide + oxygen	⟶	Sulphur trioxide
$2SO_2 + O_2$	**reaction 2**	$2SO_3$
Sulphur trioxide	⟶	Oleum
SO_3	**reaction 3**	$H_2S_2O_7$
Oleum + water	⟶	Sulphuric acid
$H_2S_2O_7$	**reaction 4**	H_2SO_4

(i) Give a large scale source of the element sulphur.

..... [1]

(ii) State another use of sulphur dioxide.

..... [1]

(iii) How is sulphur changed into sulphur dioxide?

..... [1]

(iv) Name the catalyst used in reaction **2**.

..... [1]

(v) Reaction **2** is exothermic. Why is a catalyst, rather than a higher temperature, used to increase the rate of this reversible reaction?

.....

..... [2]

(vi) Write a word equation for reaction **3**.

..... [1]

(vii) Write a symbol equation for reaction **4**.

..... [1]

[Turn over

(b) About one third of this production of acid is used to make nitrogen and phosphorus-containing fertilisers.

(i) Name the third element that is essential for plant growth and is present in most fertilisers.

..... [1]

(ii) Name a nitrogen-containing fertiliser that is manufactured from sulphuric acid.

..... [1]

(iii) Rock phosphate (calcium phosphate) is obtained by mining. It reacts with concentrated sulphuric acid to form the fertiliser, superphosphate. Predict the formula of each of these phosphates.

fertiliser	ions	formula
calcium phosphate	Ca^{2+} and PO_4^{3-}	.....
calcium superphosphate	Ca^{2+} and $H_2PO_4^-$	..... [2]

(iv) The ionic equation for the reaction between the phosphate ion and sulphuric acid is shown below.

$$PO_4^{3-} + 2H_2SO_4 \rightarrow H_2PO_4^- + 2HSO_4^-$$

Explain why the phosphate ion is described as acting as a base in this reaction.

..... [2]

3 An organic compound decomposes to form nitrogen.

$$C_6H_5N_2C\ell(aq) \rightarrow C_6H_5C\ell(l) + N_2(g)$$

(a) Explain the state symbols.

aq .....

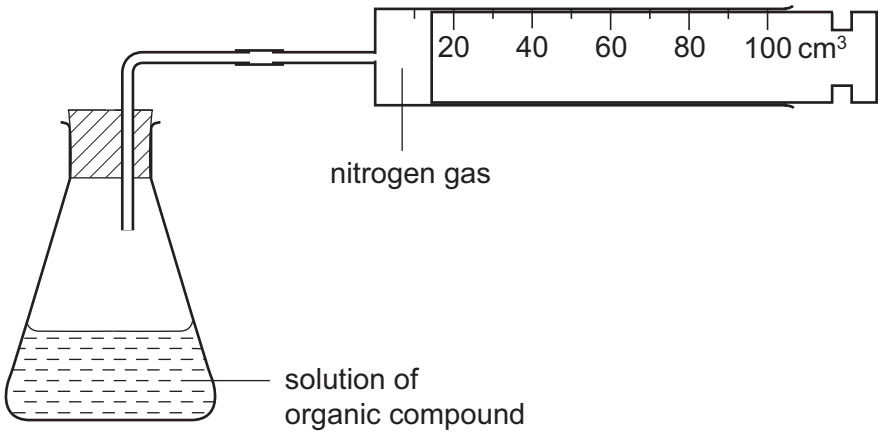
l .....

g ..... [2]

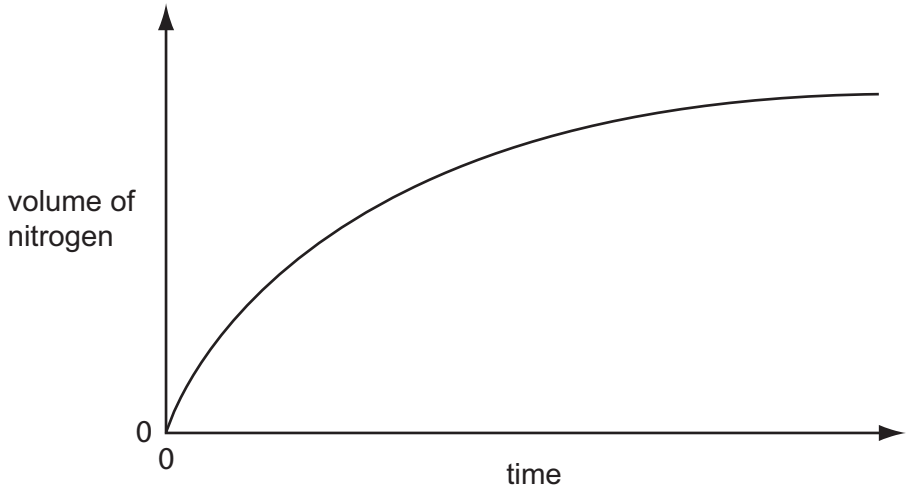
(b) Draw a diagram to show the arrangement of the valency electrons in **one** molecule of nitrogen.

[2]

(c) The rate of this reaction can be measured using the following apparatus.



The results of this experiment are shown on the graph below.



(i) How does the rate of this reaction vary with time?

.....

..... [1]

(ii) Why does the rate vary?

.....

..... [2]

(iii) The reaction is catalysed by copper powder. Sketch the graph for the catalysed reaction on the same grid. [2]

(iv) Why is copper powder more effective as a catalyst than a single piece of copper?

..... [1]

4 **(a)** Insoluble compounds are made by precipitation.

(i) Complete the word equation for the preparation of zinc carbonate.

..... + sodium carbonate → zinc carbonate + ...

..... [2]

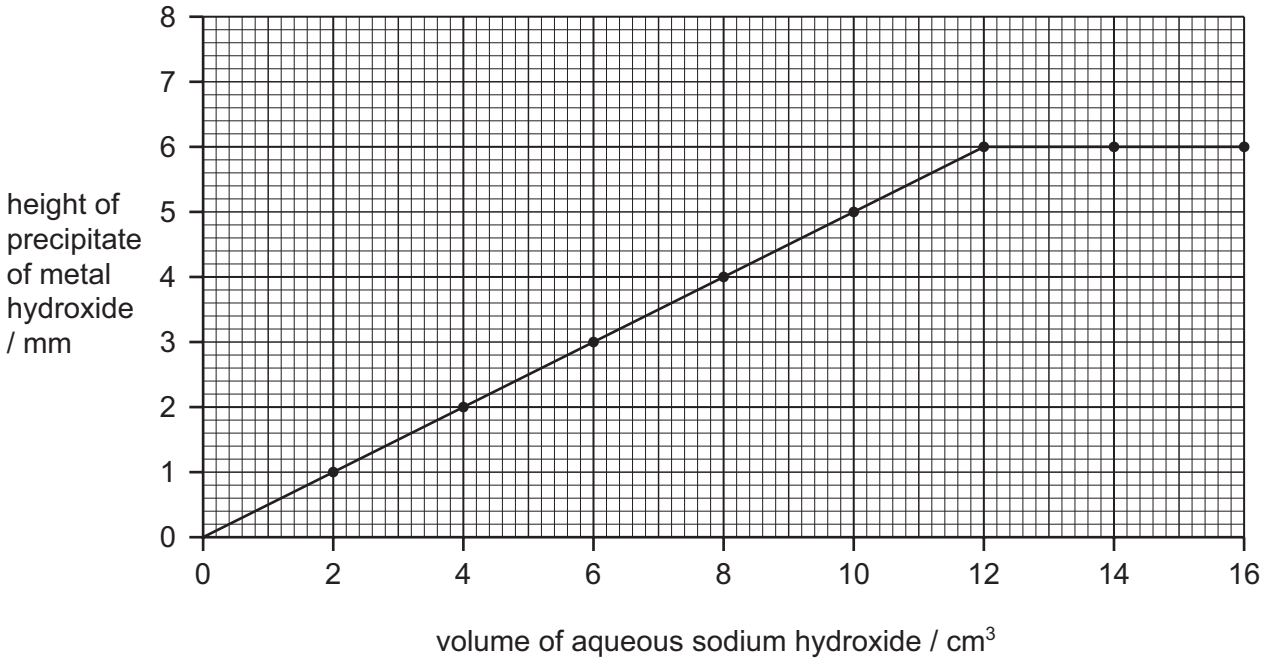
(ii) Complete the following symbol equation.

$Pb(NO_3)_2$ + ... $NaCl$ → ..... + ... [2]

(iii) Write an ionic equation for the precipitation of the insoluble salt, silver(I) chloride.

..... [2]

(b) 2.0 cm^3 portions of aqueous sodium hydroxide were added to 4.0 cm^3 of aqueous iron(III) chloride. Both solutions had a concentration of 1.0 mol/dm^3. After each addition, the mixture was stirred, centrifuged and the height of the precipitate of iron(III) hydroxide was measured. The results are shown on the following graph.



(i) Complete the ionic equation for the reaction.

Fe^{3+} + ...OH^- → ..... [1]

(ii) On the same grid, sketch the graph that would have been obtained if iron(II) chloride had been used instead of iron(III) chloride? [2]

(iii) If aluminium chloride had been used instead of iron(III) chloride, the shape of the graph would be different. How are the shapes of these two graphs different and why?

difference in shape .....

.....

reason for difference .....

..... [2]

5 **(a)** Copper has the structure of a typical metal. It has a lattice of positive ions and a "sea" of mobile electrons. The lattice can accommodate ions of a different metal.

Give a **different** use of copper that depends on each of the following.

(i) the ability of the ions in the lattice to move past each other

..... [1]

(ii) the presence of mobile electrons

..... [1]

(iii) the ability to accommodate ions of a different metal in the lattice

..... [1]

(b) Aqueous copper(II) sulphate solution can be electrolysed using carbon electrodes. The ions present in the solution are as follows.

$Cu^{2+}(aq)$, $SO_4^{2-}(aq)$, $H^+(aq)$, $OH^-(aq)$

(i) Write an ionic equation for the reaction at the negative electrode (cathode).

..... [1]

(ii) A colourless gas was given off at the positive electrode (anode) and the solution changes from blue to colourless.

Explain these observations.

.....

..... [2]

(c) Aqueous copper(II) sulphate can be electrolysed using copper electrodes. The reaction at the negative electrode is the same but the positive electrode becomes smaller and the solution remains blue.

(i) Write a word equation for the reaction at the positive electrode.

.....

[1]

(ii) Explain why the colour of the solution does not change.

.....

.....

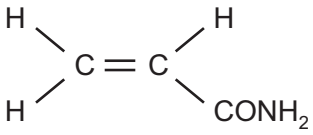
[2]

(iii) What is the large scale use of this electrolysis?

.....

[1]

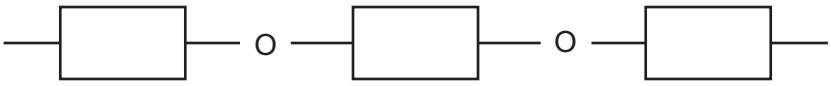
6 In 2002, Swedish scientists found high levels of acrylamide in starchy foods that had been cooked above 120 °C. Acrylamide, which is thought to be a risk to human health, has the following structure.



(a) (i) It readily polymerises to polyacrylamide. Draw the structure of this polymer.

[2]

(ii) Starch is formed by polymerisation. It has a structure of the type shown below. Name the monomer.



..... [1]

(iii) What are the differences between these two polymerisation reactions, one forming polyacrylamide and the other starch?

.....

..... [2]

(b) Acrylamide hydrolyses to form acrylic acid and ammonium ions.

(i) Describe the test for the ammonium ion.

test .....

.....

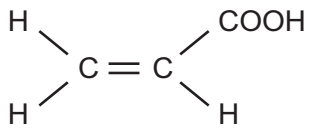
result ..... [2]

(ii) Given an aqueous solution, concentration 0.1 mol / dm^3, how could you show that acrylic acid is a weak acid.

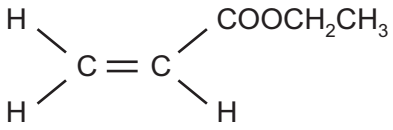
.....

..... [2]

(c) The structural formula of acrylic acid is shown below. It forms compounds called acrylates.



(i) Acrylic acid reacts with ethanol to form the following compound.



Deduce the name of this compound. What type of organic compound is it?

name .....

type of compound ..... [2]

(ii) Acrylic acid is an unsaturated compound. It will react with bromine. Describe the colour change and draw the structural formula of the product of this addition reaction.

colour change .....

structural formula of product

[2]

7 Chemists use the concept of the mole to calculate the amounts of chemicals involved in a reaction.

(a) Define *mole*.

.....

[1]

(b) 3.0 g of magnesium was added to 12.0 g of ethanoic acid.

$Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$

The mass of one mole of Mg is 24 g.

The mass of one mole of CH_3COOH is 60 g.

(i) Which one, magnesium or ethanoic acid, is in excess? You must show your reasoning.

.....

[3]

(ii) How many moles of hydrogen were formed?

.....

[1]

(iii) Calculate the volume of hydrogen formed, measured at r.t.p.

.....

[2]

(c) In an experiment, 25.0 cm^3 of aqueous sodium hydroxide, 0.4 mol/dm^3, was neutralised by 20.0 cm^3 of aqueous oxalic acid, $H_2C_2O_4$.

$$2NaOH + H_2C_2O_4 \rightarrow Na_2C_2O_4 + 2H_2O$$

Calculate the concentration of the oxalic acid in mol/dm^3.

(i) Calculate the number of moles of NaOH in 25.0 cm^3 of 0.4 mol/dm^3 solution.

.....

[1]

(ii) Use your answer to **(i)** and the mole ratio in the equation to find out the number of moles of $H_2C_2O_4$ in 20 cm^3 of solution.

.....

[1]

(iii) Calculate the concentration, mol/dm^3, of the aqueous oxalic acid.

.....

[2]

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 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.).