| Centre Number | Candidate Number | Name |
|---|---|---|
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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

**CHEMISTRY** **5070/02**

Paper 2 Theory

May/June 2004

**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 blue or black pen.
Do not use staples, paper clips, highlighters, glue or correction fluid.
You may use a calculator.

**Sections 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 16.

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 | |
|---|---|
| Section A | |
| B7 | |
| B8 | |
| B9 | |
| B10 | |
| Total | |

This document consists of **15** printed pages and **1** lined page.

## Section A

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

**A1** Choose from the following substances to answer the questions below.

**argon**

**calcium phosphate**

**ethene**

**lead(II) nitrate**

**methane**

**phosphorus oxide**

**potassium nitrate**

**sulphur dioxide**

Each substance can be used once, more than once, or not at all.

Name a substance which,

**(a)** is a greenhouse gas produced by the decay of vegetable matter,

.....[1]

**(b)** contains **two** of the essential elements needed by plants,

.....[1]

**(c)** reacts with warm aqueous sodium hydroxide and aluminium powder to form a gas that turns moist red litmus blue,

.....[1]

**(d)** dissolves in water to form a solution which neutralises sodium hydroxide.

.....[1]

**A2** Two isotopes of potassium are $^{39}_{19}K$ and $^{40}_{19}K$.

**(a)** Complete the table about the number of particles found in one atom of each of these isotopes.

| | protons | number of electrons | neutrons |
|---|---|---|---|
| $^{39}_{19}K$ | | | |
| $^{40}_{19}K$ | | | |

[2]

**(b)** Potassium reacts with water as shown in the equation.

$$2K(s) + 2H_2O(l) \longrightarrow 2K^+(aq) + 2OH^-(aq) + H_2(g)$$

Describe what you would see when potassium reacts with water.

.....

.....

.....[2]

**(c)** A sample of 0.195 g of potassium was added to 500 $cm^3$ of cold water. When the reaction was finished, 100 $cm^3$ of 0.100 $mol/dm^3$ hydrochloric acid was added to form solution **X**.

**(i)** Calculate the number of moles of hydroxide ions formed when the potassium was added to water.

**(ii)** Calculate the number of moles of hydrogen ions in 100 $cm^3$ of 0.100 $mol/dm^3$ hydrochloric acid.

**(iii)** Give an ionic equation to represent the neutralisation reaction.

.....

**(iv)** Suggest a pH value for solution **X**.
Explain your answer.

.....

.....
[4]

**(d)** Potassium oxide is an ionic solid.

Draw the electronic structure of both a potassium ion and an oxide ion.
Include the charge on each ion.

Potassium ion

Oxide ion

[2]

**A3** More than 60 000 plastic materials, or polymers, are in use.

The table gives some information about five important polymers.

| polymer | density in kg/m$^3$ | maximum useable temperature / °C | solubility in organic solvents |
|---|---|---|---|
| low density poly(ethene) | 920 | 85 | soluble above 80 °C |
| high density poly(ethene) | 960 | 120 | soluble above 80 °C |
| poly(phenylethene) | 1050 | 65 | soluble |
| poly(chloroethene) | 1390 | 60 | soluble |
| poly(propene) | 900 | 150 | insoluble |

**(a)** Which polymer would be most suited for making a pipe to carry lubricating oil at 100 °C? Give **two** reasons for your answer.

answer .....

reasons .....

.....

.....[2]

**(b)** State **one** use for poly(ethene).

.....[1]

**(c)** Describe some of the problems of the disposal of waste polymers.

.....

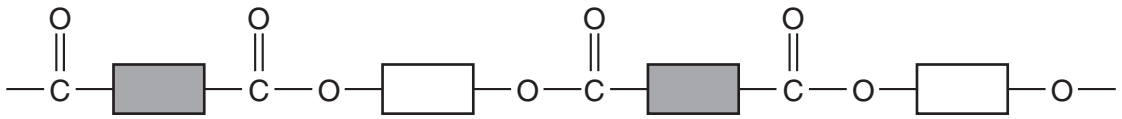
.....

.....[2]

**(d)** Poly(propene) is made from the monomer propene.
Draw the structure of poly(propene).

[2]

**(e)** *Terylene* is a condensation polymer.
The structure of *Terylene* is shown below.



**(i)** What is the name of the linkage shown in the structure of *Terylene*?

.....

**(ii)** Name a natural macromolecule that contains the same linkage as *Terylene*.

.....

[2]

**(f)** Draw the structure of a polyamide such as nylon.

[1]

**A4** The exhaust fumes from the internal combustion engines of motor vehicles contribute to the poor quality of air in many cities. The exhaust fumes contain atmospheric pollutants such as nitric oxide, NO, and carbon monoxide, CO.

**(a)** Nitric oxide, NO, is formed when oxygen and nitrogen from the air react in an internal combustion engine.

**(i)** Construct a balanced equation for this reaction.

.....

**(ii)** Explain why, in terms of collisions between particles, the rate of this reaction increases as the concentration of oxygen increases.

.....

.....

**(iii)** Explain why the rate of this reaction increases as the engine temperature increases.

.....

.....

[4]

**(b)** Explain how carbon monoxide is formed in an internal combustion engine.

.....

.....[1]

**(c)** Nitric oxide and carbon monoxide in the exhaust gases react together in the catalytic converter of a motor vehicle.

**(i)** Write a balanced equation for this reaction.

.....

**(ii)** Explain why the catalyst should be in the form of a powder supported on a mesh.

.....

.....

.....

[3]

**A5** Electrolysis is the decomposition of a liquid by the passage of an electrical current.

**(a)** Aqueous copper(II) sulphate contains the following ions, $Cu^{2+}$, $H^+$, $OH^-$ and $SO_4^{2-}$.
Aqueous copper(II) sulphate can be electrolysed using inert electrodes.

The electrode reactions are represented below.

cathode $Cu^{2+} + 2e^- \longrightarrow Cu$
anode $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$

**(i)** Explain why copper, **not** hydrogen, is formed at the cathode.

.....

.....

**(ii)** Explain why the formation of oxygen at the anode is an example of oxidation.

.....

.....

**(iii)** The electrolysis of aqueous copper(II) sulphate using copper electrodes has a different anode reaction.
Give the equation for the electrode reaction at the anode.

.....
[3]

**(b)** Molten lead(II) bromide decomposes when an electric current is passed through it.

**(i)** Explain why solid lead(II) bromide will not conduct electricity but molten lead(II) bromide will.

.....

.....

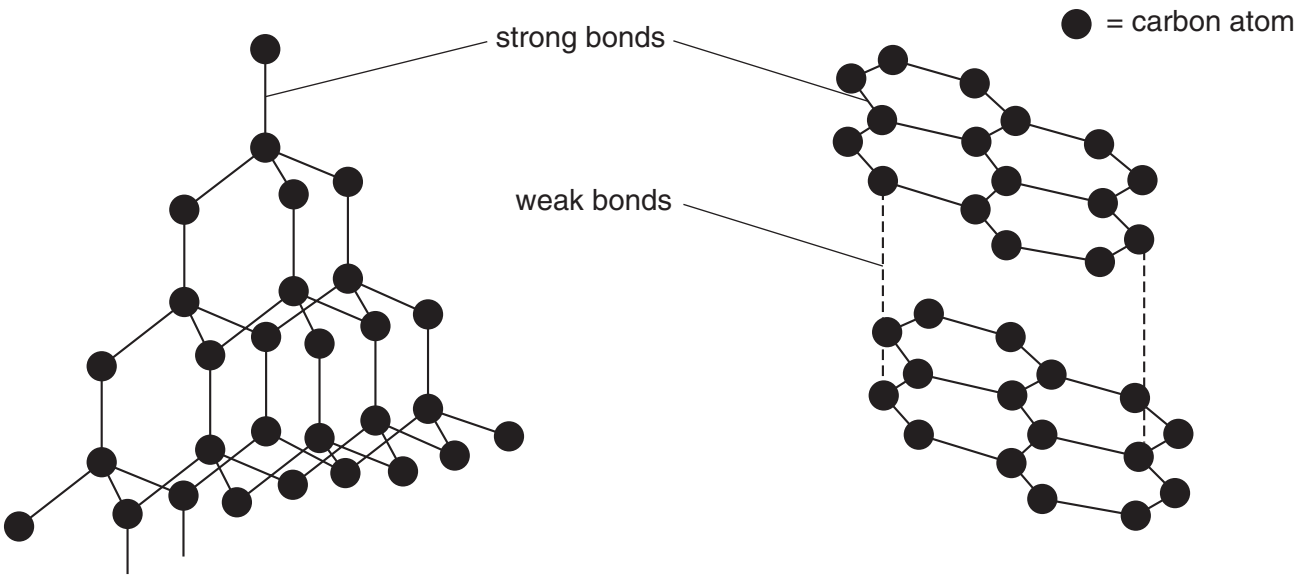
.....

**(ii)** Construct the equations for the two electrode reactions.

cathode .....

anode .....
[4]

**A6** The structures of diamond and graphite are drawn below.




**(a)** Name the type of strong bond shown on the diagram.

.....[1]

**(b)** Diamond has a melting point of about 3700 °C and graphite has a melting point of about 3300 °C.

**(i)** Explain why both diamond and graphite have very high melting points.

.....

.....

.....

**(ii)** Suggest why the melting point of graphite is lower than that of diamond.

.....

.....
[3]

**(c)** Compare the electrical conductivity of diamond and graphite.
Explain your answer.

.....

.....

.....[2]

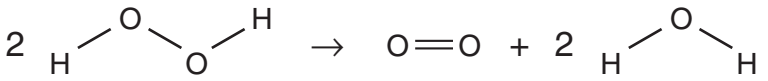
## Section B

Answer **three** questions from this section.

**B7** Aqueous hydrogen peroxide is used to sterilise contact lenses.

At room temperature aqueous hydrogen peroxide decomposes very slowly to form water and oxygen.

The decomposition can be represented by the equation below.



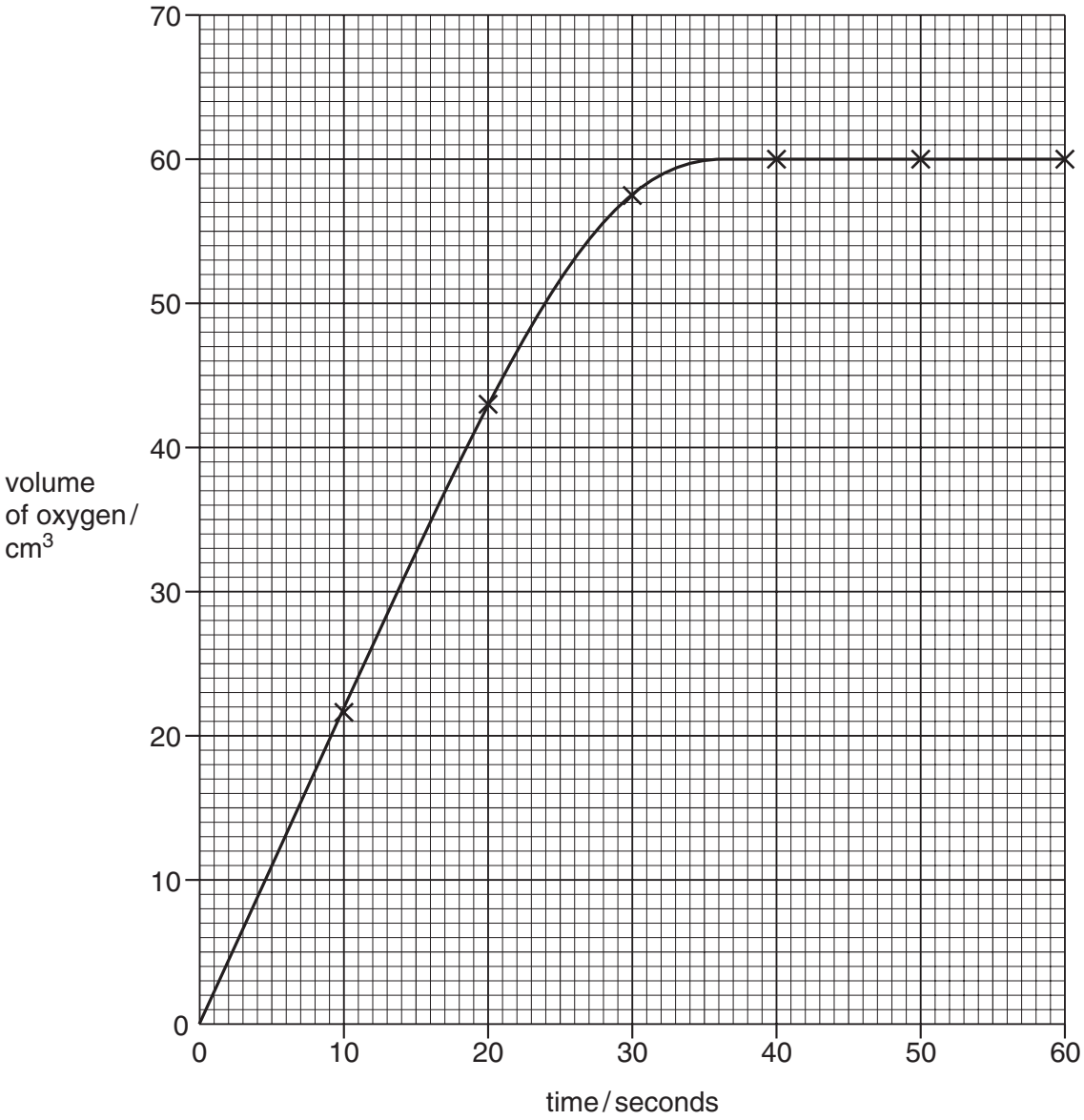
$\Delta H = -206\ \text{kJ/mol}$

**(a)** Explain why this reaction is exothermic in terms of the energy changes that take place during bond breaking and bond making. [2]

**(b)** Draw the energy profile diagram for the decomposition of hydrogen peroxide.
Label on the diagram the activation energy and the enthalpy change. [3]

**(c)** Manganese(IV) oxide catalyses the decomposition of aqueous hydrogen peroxide. In an experiment 50.0 $cm^3$ of aqueous hydrogen peroxide was mixed with 0.50 g of manganese(IV) oxide. The total volume of oxygen formed was measured every 10 seconds.

The results of the experiment are shown in the graph.




**(i)** After how many seconds did the decomposition of hydrogen peroxide finish?

**(ii)** How many moles of oxygen were produced at the end of the decomposition? [At room temperature and pressure one mole of oxygen occupies 24000 $cm^3$.]

**(iii)** Use your answer to **(ii)** to calculate the concentration, in $mol/dm^3$, of the 50.0 $cm^3$ of aqueous hydrogen peroxide used in the experiment.

[5]

**B8** Nickel is a transition element. It is manufactured in a four-stage process from nickel(II) sulphide, NiS.

- Stage 1 – nickel(II) sulphide is heated in air to form nickel(II) oxide and sulphur dioxide.
- Stage 2 – nickel(II) oxide is heated with carbon to give impure nickel.
- Stage 3 – impure nickel is reacted with carbon monoxide to make nickel tetracarbonyl, $Ni(CO)_4$.
- Stage 4 – nickel tetracarbonyl is decomposed to give pure nickel.

**(a)** **(i)** Construct the balanced equation for the reaction in stage 1.

**(ii)** Calculate the mass of sulphur dioxide that is formed when 182 kg of nickel sulphide is heated in air. [3]

**(b)** Nickel tetracarbonyl is a liquid with a boiling point of 43 °C.
Suggest, with a reason, the type of bonding in nickel tetracarbonyl. [2]

**(c)** Suggest **one** possible environmental consequence of the manufacture of nickel. [1]

**(d)** Give an example of the use of nickel as a catalyst. [1]

**(e)** In an experiment, small amounts of three metals were added to three aqueous metal nitrate solutions.
The results are shown in the table.

| | aqueous zinc nitrate $Zn(NO_3)_2$ | aqueous nickel(II) nitrate, $Ni(NO_3)_2$ | aqueous copper(II) nitrate, $Cu(NO_3)_2$ |
|---|---|---|---|
| zinc | no reaction | green solution went colourless and zinc coated with a silver solid | blue solution went colourless and zinc coated with a pink solid |
| nickel | | no reaction | |
| copper | no reaction | no reaction | no reaction |

Predict the observations when nickel is added to separate solutions of zinc nitrate and copper(II) nitrate.
Write an ionic equation for **one** of the reactions that takes place. [3]

**B9** Ethene is an important starting material for the production of chemicals such as ethanol, ethanoic acid and ethane-1,2-diol. Ethene, $C_2H_4$, is manufactured by the cracking of long chain hydrocarbons such as dodecane, $C_{12}H_{26}$.

**(a)** Construct an equation to show the cracking of dodecane to make ethene. [1]

**(b)** Draw a 'dot and cross' diagram for ethene. You only need to draw the valence (outer shell) electrons. [1]

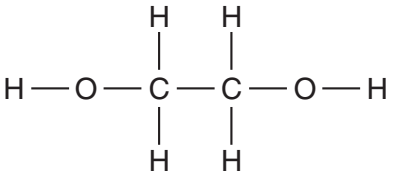
**(c)** Ethene can also be converted into a compound that contains carbon, hydrogen and oxygen. A sample of the compound was analysed and found to contain 0.72 g of carbon, 0.18 g of hydrogen and 0.96 g of oxygen.
Show that the empirical formula of the compound is $CH_3O$. [3]

**(d)** Describe how ethene can be converted industrially into ethanol. [2]

**(e)** Ethanol reacts with hot acidified potassium dichromate(VI) to form ethanoic acid.

**(i)** Describe the colour change that occurs during this reaction and draw the structure of ethanoic acid.

**(ii)** Ethane-1,2-diol has the structure drawn below.



Suggest the structure of the product of the reaction between ethane-1,2-diol and hot acidified potassium dichromate(VI).

[3]

**B10** The table below shows some of the ores of iron.

| ore | formula |
|---|---|
| haematite | $Fe_2O_3$ |
| magnetite | $Fe_3O_4$ |
| siderite | $FeCO_3$ |

**(a)** Which ore in the table contains the greatest percentage by mass of iron? Explain your answer. [2]

**(b)** Give the equations for the **redox** reactions taking place in the extraction of iron from haematite.
In each case state which substance is oxidised and which is reduced. [4]

**(c)** Iron is malleable. Describe how this property can be explained in terms of its structure. [2]

**(d)** State and explain how the properties of iron can be changed by the addition of carbon. [2]

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# 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 Radius 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.).