| Centre Number | Candidate Number | Name |
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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

**CHEMISTRY** **0620/03**

Paper 3

May/June 2006

**1 hour 15 minutes**

Candidates answer on the Question Paper.
No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
A copy of the Periodic Table is printed on page 16.

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 | |
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| 4 | |
| 5 | |
| 6 | |
| 7 | |
| Total | |

This document consists of **16** printed pages.




UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

**1** Iron is a transition element.

**(a)** Which of the following statements about transition elements are correct?

Tick **three** boxes.

The metals are highly coloured e.g. yellow, green, blue. ☐

The metals have low melting points. ☐

Their compounds are highly coloured. ☐

Their compounds are colourless. ☐

The elements and their compounds are often used as catalysts. ☐

They have more than one oxidation state. ☐

[3]

**(b) (i)** In which Period in the Periodic Table is iron to be found?

..... [1]

**(ii)** Use the Periodic Table to work out the number of protons and the number of neutrons in one atom of iron.

number of protons = ..... number of neutrons = ..... [1]

**(c)** Iron is extracted in a blast furnace. The list below gives some of the substances used or formed in the extraction.

**carbon monoxide** **coke** **iron ore** **limestone** **slag**

**(i)** Which substance is a mineral containing largely calcium carbonate?

..... [1]

**(ii)** Which substance is formed when impurities in the ore react with calcium oxide?

..... [1]

**(iii)** Which substance is also called hematite?

..... [1]

**(d)** State **two** functions of the coke used in the blast furnace.

.....

..... [2]

**(e)** Most of the iron is converted into mild steel or stainless steel. Give **one** use for each.

mild steel .....

stainless steel ..... [2]





[Turn over

**2** Some reactions of metals **W**, **X**, **Y** and **Z** are given below.

| metal | reaction with water | reaction with dilute hydrochloric acid |
|---|---|---|
| **W** | A few bubbles form slowly in cold water. | Vigorous reaction. Gas given off. |
| **X** | Vigorous reaction. Metal melts. Gas given off. | Explosive reaction. Should not be attempted. |
| **Y** | No reaction. | No reaction. |
| **Z** | Does not react with cold water. Hot metal reacts with steam. | Steady fizzing. |

**(a)** Arrange these metals in order of reactivity.

most reactive .....

.....

.....

least reactive ..... [2]

**(b)** Which of these metals could be

**(i)** magnesium,

..... [1]

**(ii)** copper?

..... [1]

**(c)** The equation for the reaction of **X** with cold water is given below.

$$2\mathbf{X}(s) + 2H_2O(l) \longrightarrow 2\mathbf{X}OH(aq) + H_2(g)$$

**(i)** Describe the test you would use to show that the gas evolved is hydrogen.

.....

..... [1]

**(ii)** How could you show that the water contained a compound of the type **X**OH?

.....

..... [2]

**(iii)** In which group of the Periodic Table does metal **X** belong?

..... [1]

**(iv)** The ore of **X** is its chloride. Suggest how metal **X** could be extracted from its chloride.

..... [2]





**[Turn over**

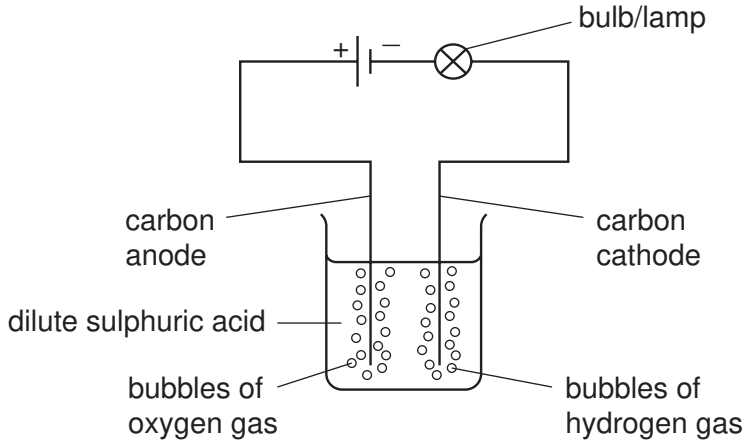
**3** **(a)** Four bottles were known to contain aqueous ammonia, dilute hydrochloric acid, sodium hydroxide solution and vinegar, which is dilute ethanoic acid. The bottles had lost their labels. The pH values of the four solutions were 1, 4, 10 and 13.

Complete the table.

| solution | pH |
|---|---|
| aqueous ammonia | |
| dilute hydrochloric acid | |
| sodium hydroxide solution | |
| vinegar | |

[2]

**(b)** The following apparatus was set up to investigate the electrical conductivity of dilute acids.




Dilute sulphuric acid is a strong acid. If it was replaced by a weak acid, what **two** differences in the observations would you expect to make?

.....

.....

..... [2]

**(c)** When nitric acid is added to water the following reaction occurs.

$$HNO_3 + H_2O \longrightarrow NO_3^- + H_3O^+$$

Give the name and the formula of the particle which is transferred from nitric acid to water.

name .....

formula ..... [2]

**(d)** This question is concerned with the following oxides.

| | |
|---|---|
| aluminium oxide | $Al_2O_3$ |
| calcium oxide | CaO |
| carbon dioxide | $CO_2$ |
| carbon monoxide | CO |
| magnesium oxide | MgO |
| sulphur dioxide | $SO_2$ |

**(i)** Which of the above oxides will react with hydrochloric acid but not with aqueous sodium hydroxide?

..... [1]

**(ii)** Which of the above oxides will react with aqueous sodium hydroxide but not with hydrochloric acid?

..... [1]

**(iii)** Which of the above oxides will react both with hydrochloric acid and with aqueous sodium hydroxide?

..... [1]

**(iv)** Which of the above oxides will react neither with hydrochloric acid nor with aqueous sodium hydroxide?

..... [1]

**4** The first three elements in Group IV are
carbon,
silicon,
germanium.

**(a)** The element germanium has a diamond-type structure. Describe the structure of germanium. A diagram is acceptable.

[2]

**(b)** Unlike diamond, graphite is soft and is a good conductor of electricity.

**(i)** Explain why graphite has these properties.

.....

.....

..... [3]

**(ii)** Give a use of graphite that depends on one of these properties.

property .....

use ..... [1]

**(c)** Carbon dioxide and silicon(IV) oxide have similar formulae but different types of structure.

**(i)** Give the formulae of these oxides.

..... [1]

**(ii)** How are their structures different?

.....

..... [2]

**(d)** All these elements form compounds with hydrogen called hydrides. The saturated hydrides of carbon are the alkanes. Predict the formula of the hydride of germanium which contains two germanium atoms.

..... [1]

**5** Sulphuric acid is made by the Contact process in the following sequence of reactions.

**sulphur → sulphur dioxide → sulphur trioxide → sulphuric acid**

**(a) (i)** How is sulphur dioxide made from sulphur?

..... [1]

**(ii)** Sulphur dioxide has other uses.
Why is it used in the manufacture of paper?

..... [1]

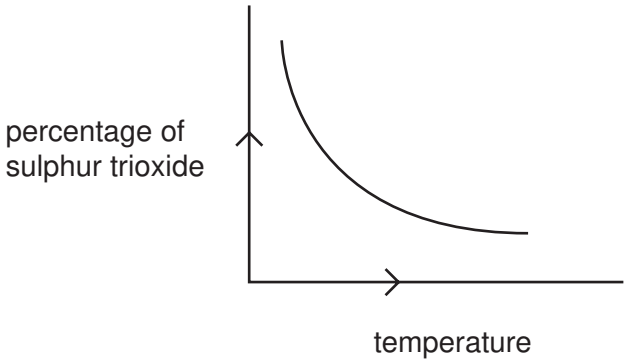
**(iii)** How does it preserve food?

..... [1]

**(b)** The equation for a stage of the Contact process is

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

The percentage of sulphur trioxide in the equilibrium mixture varies with temperature.




**(i)** How does the percentage of sulphur trioxide in the equilibrium mixture vary as the temperature increases? Circle the correct answer.

**increases** **stays the same** **decreases** [1]

**(ii)** Is the forward reaction in the equilibrium $2SO_2 + O_2 \rightleftharpoons 2SO_3$ exothermic or endothermic? Give a reason for your choice.

.....

..... [2]

**(iii)** Explain, mentioning both rate and percentage yield, why the temperature used in the Contact process is 450°C.

.....

..... [2]

**(iv)** Describe how the sulphur trioxide is changed into concentrated sulphuric acid.

.....

..... [2]

**6** **(a)** Exothermic reactions produce heat energy.

An important fuel is methane, natural gas. The equation for its combustion is as follows.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

**(i)** In chemical reactions bonds are broken and new bonds are formed.
Using this reaction give an example of

a bond that is broken, .....

a bond that is formed. ..... [2]

**(ii)** Explain, using the idea of bonds forming and breaking, why this reaction is exothermic, that is it produces heat energy.

.....

..... [2]

**(b)** Some radioactive isotopes are used as nuclear fuels.

**(i)** Give the symbol and the nucleon number of an isotope that is used as a nuclear fuel.

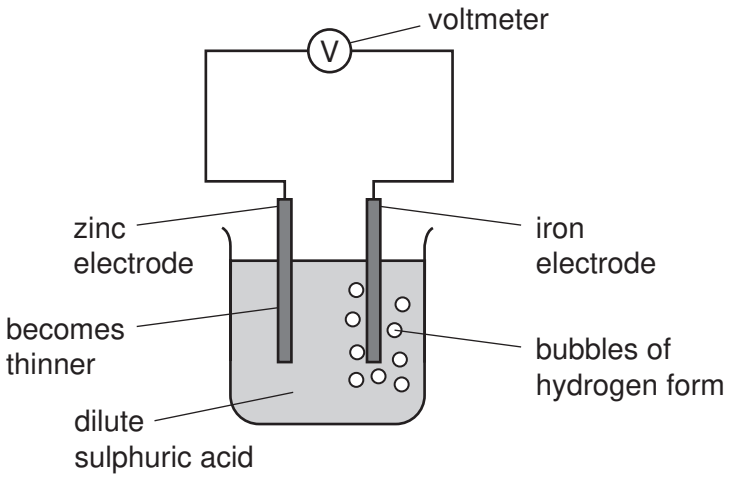
..... [2]

**(ii)** Give another use of radioactive isotopes.

..... [1]

**(c)** Cell reactions are both exothermic and redox. They produce electrical energy as well as heat energy.

**(i)** The diagram shows a simple cell.




Which substance in this cell is the reductant and which ion is the oxidant?

reductant .....

oxidant ..... [2]

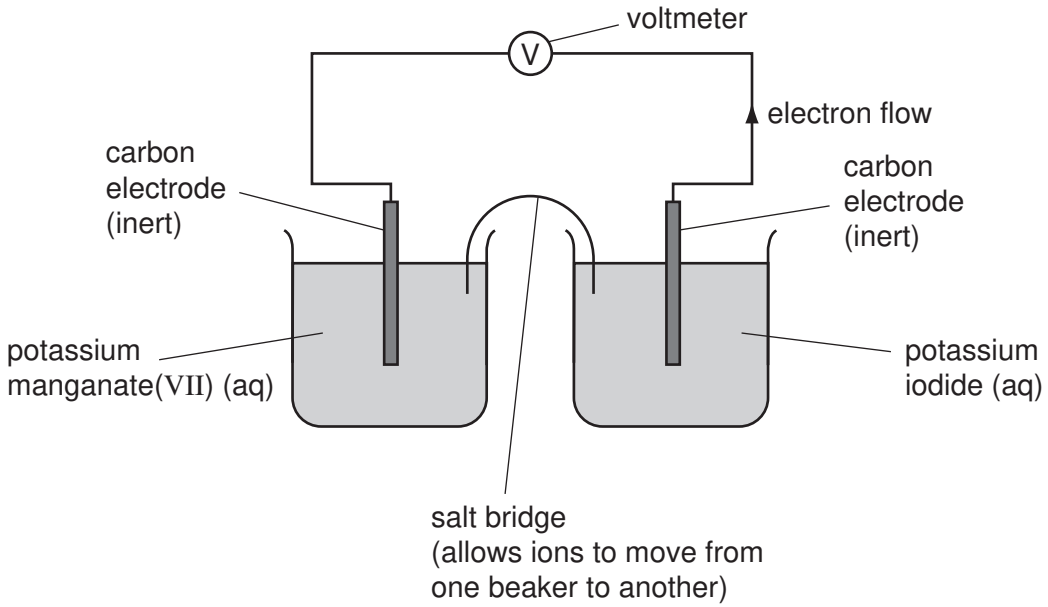
**(ii)** How could the voltage of this cell be increased?

..... [1]

**(iii)** What is the important large scale use, relating to iron and steel, of this type of cell reaction?

..... [1]

**(d)** Cells can be set up with inert electrodes and the electrolytes as oxidant and reductant.




The potassium manganate(VII) is the oxidant and the potassium iodide is the reductant.

**(i)** Describe the colour change that would be observed in the left hand beaker.

..... [2]

**(ii)** Write an ionic equation for the reaction in the right hand beaker.

..... [2]

**7** The fractional distillation of crude oil usually produces large quantities of the heavier fractions. The market demand is for the lighter fractions and for the more reactive alkenes. The heavier fractions are cracked to form smaller alkanes and alkenes as in the following example.

$$\underset{\text{octane}}{C_8H_{18}} \longrightarrow \underset{\text{butane}}{C_4H_{10}} + \underset{\text{butenes}}{C_4H_8}$$

**(a) (i)** Write a different equation for the cracking of octane.

$C_8H_{18} \longrightarrow$ ..... + ..... [1]

**(ii)** The cracking of octane can produce isomers with the molecular formula $C_4H_8$. Draw the structural formulae of two of these isomers.

[2]

**(b) (i)** Give the essential condition for the reaction between chlorine and butane.

..... [1]

**(ii)** What type of reaction is this?

..... [1]

**(iii)** This reaction produces a mixture of products. Give the names of **two** products that contain four carbon atoms per molecule.

..... and ..... [2]

**(c)** Alkenes are more reactive than alkanes and are used to make a range of organic chemicals. Propene, $CH_3–CH=CH_2$, is made by cracking. Give the structural formula of the addition product when propene reacts with the following.

**(i)** water

[1]

**(ii)** bromine

[1]

**(d)** Propene reacts with hydrogen iodide to form 2-iodopropane.

$$CH_3–CH=CH_2 + HI \longrightarrow CH_3–CHI–CH_3$$

1.4 g of propene produced 4.0 g of 2-iodopropane.

Calculate the percentage yield.

moles of $CH_3–CH=CH_2$ reacted = .....

maximum moles of $CH_3–CHI–CH_3$ that could be formed = .....

mass of one mole of $CH_3–CHI–CH_3$ = 170 g

maximum mass of 2-iodopropane that could be formed = .....

percentage yield .....% [4]

# 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 | a = relative atomic mass |
| X | X = atomic symbol |
| b | b = proton (atomic) number |

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