UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

*4178971357*

**CHEMISTRY** **5070/22**

Paper 2 Theory **October/November 2013**

**1 hour 30 minutes**

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 or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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

**Section B**
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

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.

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

## Section A

For Examiner's Use

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

The total mark for this section is 45.

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

**chlorine**
**hydrogen**
**iron**
**lithium**
**nickel**
**nitrogen**
**oxygen**
**potassium**
**silver**
**sulfur**
**vanadium**
**zinc**

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

Which element

**(a)** is liberated at the anode when an aqueous solution of potassium sulfate is electrolysed,

.....[1]

**(b)** is used as a catalyst in the manufacture of margarine,

.....[1]

**(c)** is a non-metallic solid, an atom of which contains only six valency electrons,

.....[1]

**(d)** is higher than sodium in the reactivity series,

.....[1]

**(e)** is in Period 5 of the Periodic Table,

.....[1]

**(f)** forms a white oxide which is amphoteric?

.....[1]

[Total: 6]

**A2** Carboxylic acids are a homologous series containing the $–CO_2H$ group.
The table shows some properties of the first four carboxylic acids in the series.

*For Examiner's Use*

| carboxylic acid | molecular formula | density in g/cm$^3$ | boiling point in °C |
|---|---|---|---|
| methanoic acid | $CH_2O_2$ | 1.220 | 101 |
| | $C_2H_4O_2$ | 1.049 | 118 |
| propanoic acid | $C_3H_6O_2$ | 0.993 | 141 |
| butanoic acid | $C_4H_8O_2$ | 0.958 | 165 |

**(a) (i)** Describe how the density of these carboxylic acids varies with the number of carbon atoms in the molecule.

.....[1]

**(ii)** Name the carboxylic acid with the molecular formula $C_2H_4O_2$.

.....[1]

**(iii)** Draw the structure of propanoic acid, showing all atoms and bonds.

[1]

**(b)** The next carboxylic acid in this homologous series is pentanoic acid.
Pentanoic acid has five carbon atoms.

**(i)** Deduce the molecular formula for pentanoic acid.

.....[1]

**(ii)** Suggest a value for the boiling point of pentanoic acid.

.....°C [1]

**(c)** Butanoic acid, $C_3H_7CO_2H$, reacts with sodium to form a salt and a gas.

**(i)** Name the gas.

.....[1]

**(ii)** Give the formula of the salt.

.....[1]

**(d)** Esters are formed when carboxylic acids react with alcohols.
The reaction is catalysed by hydrogen ions.

**(i)** Describe and explain the effect of a catalyst on reaction rate.

.....

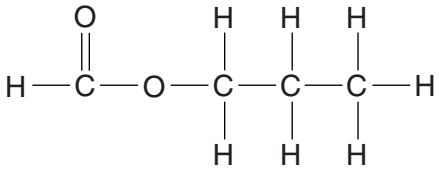
.....

.....[2]

**(ii)** State one commercial use of esters.

.....[1]

**(iii)** The structure of an ester is shown below.



Name this ester.

.....[1]

[Total: 11]

**A3** Silicon is an element in Group IV of the Periodic Table.

*For Examiner's Use*

**(a)** Give the electronic configuration for a silicon atom.

.....[1]

**(b)** Silicon has three naturally occurring isotopes.

Complete the following table for two of these isotopes.

| isotope | $^{28}$Si | $^{30}$Si |
|---|---|---|
| number of protons | | |
| number of electrons | | |
| number of neutrons | | |

[3]

**(c)** Silicon reacts with chlorine on heating to form silicon(IV) chloride, $SiCl_4$.

Construct an equation for this reaction.

[1]

**(d)** Silicon(IV) chloride is a simple molecular compound.

**(i)** Suggest **two** physical properties of silicon(IV) chloride other than solubility.

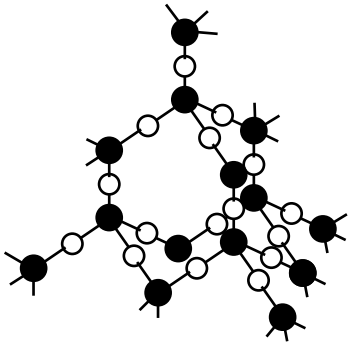
1 .....

2 .....[2]

**(ii)** Draw a 'dot-and-cross' diagram for silicon(IV) chloride.
You only need to show the outer shell electrons for each atom.

[2]

**(e)** Silicon(IV) chloride reacts with water to form silicon(IV) oxide.
Part of the structure of silicon(IV) oxide is shown below.



**Key**
● silicon atom
○ oxygen atom

Explain, in terms of structure and bonding, why silicon(IV) oxide has a very high melting point.

.....

.....

.....

.....[2]

[Total: 11]

**A4** The carbon cycle regulates the amount of carbon dioxide in the atmosphere.

*For Examiner's Use*

**(a) (i)** State **two** processes which release carbon dioxide into the atmosphere.

1 .....

2 .....[2]

**(ii)** Name one process which removes carbon dioxide from the atmosphere.

.....[1]

**(b)** Carbon dioxide is a greenhouse gas.

**(i)** What is the meaning of the term *greenhouse gas*?

.....

.....[1]

**(ii)** Name another greenhouse gas and give a natural source of this gas.

name .....

source .....[2]

**(c)** Carbon dioxide dissolves in water to form a weakly acidic solution.

$$CO_2(g) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$$

**(i)** What is the meaning of the term *weak acid*?

.....

.....[1]

**(ii)** Describe how you could measure the pH of this solution other than by using a pH meter.

.....

.....

.....[2]

**(d)** Sodium hydrogencarbonate, $NaHCO_3$, decomposes on heating to form a carbonate, water and a gas which turns limewater milky.
Construct an equation for this reaction.

[2]
[Total: 11]

**A5** A student reacts magnesium ribbon with excess hydrochloric acid.
She follows the course of the reaction by measuring the volume of gas produced against time.

*For Examiner's Use*

**(a)** Write the equation for the reaction of magnesium with hydrochloric acid.

.....[1]

**(b)** **(i)** On the axes below draw a sketch graph to show how the volume of gas produced during the reaction varies with time and label this line 'A'.
Label the axes with the appropriate units.

[2]

**(ii)** The student then carries out the experiment at a **lower** temperature. All the other conditions remain the same.

On the axes above draw another line to show how the volume of gas produced varies with time and label this line 'B'. [1]

**(c)** Magnesium reacts with carbon to form the compound magnesium carbide.

Calculate the percentage by mass of magnesium in magnesium carbide, $MgC_2$.

[2]

[Total: 6]

## Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

**B6** Aluminium is extracted from purified bauxite by electrolysis.

**(a)** Describe how this electrolysis is carried out and construct equations for the reactions occurring at both the anode and cathode.

.....

.....

.....

.....

.....

.....

.....[4]

**(b)** What properties of aluminium make it useful for

**(i)** making aircraft, .....

**(ii)** making electricity cables. .....[2]

**(c)** Aluminium is high in the reactivity series.

**(i)** Explain why aluminium does not react with aqueous copper(II) sulfate.

.....

.....[2]

**(ii)** When a few drops of aqueous sodium chloride are added to a mixture of aluminium and aqueous copper(II) sulfate, a vigorous reaction occurs.

$$\text{copper(II) sulfate} + \text{aluminium} \longrightarrow \text{aluminium sulfate} + \text{copper}$$

What type of reaction is this?

.....[1]

**(iii)** State the formula of aluminium sulfate.

.....[1]

[Total: 10]

**B7** Ethene is an unsaturated hydrocarbon.

*For Examiner's Use*

**(a)** What is the meaning of each of these terms?

*unsaturated* .....

*hydrocarbon* .....[2]

**(b)** Ethene can be manufactured by cracking.

**(i)** State the conditions used for cracking.

.....

.....[2]

**(ii)** Construct an equation for the cracking of tetradecane, $C_{14}H_{30}$, to form ethene and one other hydrocarbon.

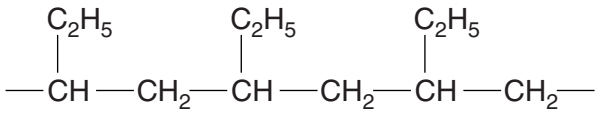
.....[1]

**(c)** Alkenes such as ethene can undergo addition polymerisation.

**(i)** State one use of poly(ethene).

.....[1]

**(ii)** The diagram below shows a section of a polymer chain.




Deduce the structure of the monomer which is used to make this polymer.

[1]

**(d)** Ethanol can be manufactured by the catalytic addition of steam to ethene.

*For Examiner's Use*

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

If the reactants are not recycled, only 5% of the ethene is converted to ethanol.

Calculate the mass of ethanol formed from 0.4 tonnes of ethene when only 5% of the ethene is converted to ethanol.
[1 tonne is 1 000 000 grams]

mass of ethanol ..... tonnes [3]

[Total: 10]

**B8** When hydrogen iodide, HI, is heated in a closed tube, the following dynamic equilibrium is established.

For Examiner's Use

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad \Delta H = +9.6\ kJ/mol$$

**(a)** What is meant by the term *dynamic equilibrium*?

.....

.....

.....[2]

**(b)** The table shows the concentrations of HI(g), $H_2(g)$ and $I_2(g)$ in the equilibrium mixture at 25 °C and 450 °C.

| substance | concentration at 25 °C / mol/dm$^3$ | concentration at 450 °C / mol/dm$^3$ |
|---|---|---|
| HI(g) | 0.94 | 0.79 |
| $H_2(g)$ | 0.033 | 0.11 |
| $I_2(g)$ | 0.033 | 0.11 |

**(i)** The tube has a volume of 50 cm$^3$.

Calculate the mass of hydrogen iodide in the equilibrium mixture at 25 °C.

[2]

**(ii)** Describe and explain the differences in the concentrations of reactant and products at 25 °C and 450 °C.

.....

.....

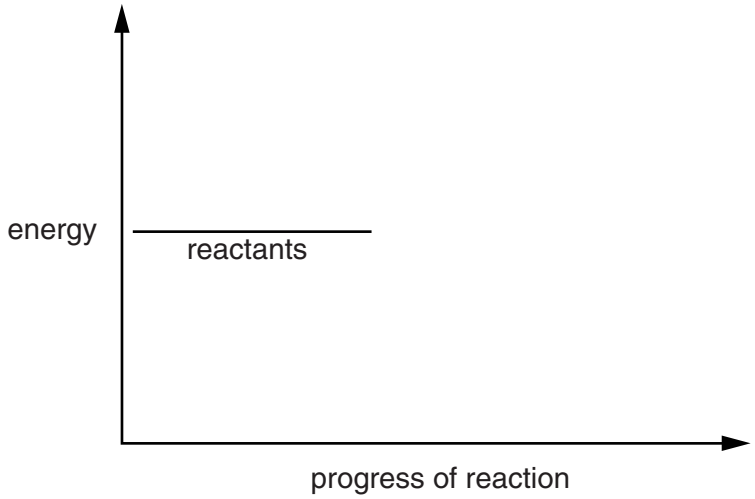
.....

.....[2]

**(c)** Complete the energy profile diagram for the decomposition of hydrogen iodide.
On your diagram label

- the products,
- the enthalpy change of the reaction, $\Delta H$.






[2]

**(d)** An aqueous solution of hydrogen iodide contains iodide ions.

Describe a test for iodide ions.

.....

.....[2]

[Total: 10]

**B9** The compounds ammonium nitrate and ammonium sulfate are both fertilisers.

*For Examiner's Use*

**(a)** Explain why farmers add these fertilisers to soils.

.....

.....[1]

**(b)** Ammonium sulfate can be prepared by adding sulfuric acid to aqueous ammonia.

Construct the equation for this reaction.

.....[1]

**(c)** Excess acidity in soils can be treated by adding calcium hydroxide.

**(i)** Give the formula of the ion present in calcium hydroxide which causes it to be alkaline.

.....[1]

**(ii)** Explain why adding calcium hydroxide causes loss of nitrogen from fertilisers such as ammonium nitrate, which have been previously added to the soil.

.....

.....

.....[2]

**(d)** A student titrated 10.0 $cm^3$ of aqueous calcium hydroxide with hydrochloric acid.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

It required 4.00 $cm^3$ of 0.0100 $mol/dm^3$ hydrochloric acid to neutralise 10.0 $cm^3$ of aqueous calcium hydroxide.

Calculate the concentration of the calcium hydroxide.

..... mol/ $dm^3$ [3]

**(e)** Describe how to obtain pure dry crystals of calcium chloride from an aqueous solution of calcium chloride.

*For Examiner's Use*

.....

.....

.....

.....

.....[2]

[Total: 10]

# 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 | 209 Po Polonium 84 | 210 At Astatine 85 | 222 Rn Radon 86 |
| 223 Fr Francium 87 | 226 Ra Radium 88 | 227 Ac Actinium 89 † | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 Ce Cerium 58 | 141 Pr Praseodymium 59 | 144 Nd Neodymium 60 | 147 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 | 231 Pa Protactinium 91 | 238 U Uranium 92 | 237 Np Neptunium 93 | 244 Pu Plutonium 94 | 243 Am Americium 95 | 247 Cm Curium 96 | 247 Bk Berkelium 97 | 251 Cf Californium 98 | 252 Es Einsteinium 99 | 257 Fm Fermium 100 | 258 Md Mendelevium 101 | 259 No Nobelium 102 | 260 Lr Lawrencium 103 |

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key: a = relative atomic mass; X = atomic symbol; b = atomic (proton) number

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