| Centre No. | | | | | | Paper Reference | | | | | | | Surname | Initial(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Candidate No. | | | | | | 6 | 2 | 4 | 4 | / | 0 | 1 | Signature | |

Paper Reference(s)

**6244/01**

# Edexcel GCE

## Chemistry

## Advanced

Unit Test 4

Tuesday 23 January 2007 – Morning

Time: 1 hour 30 minutes

Examiner's use only

| | | |
|---|---|---|
| | | |

Team Leader's use only

| | | |
|---|---|---|
| | | |

| Question Number | Leave Blank |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| Total | |

**Materials required for examination**
Nil

**Items included with question papers**
Nil

**A calculator may be used.**

### Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Answer **ALL** the questions. Write your answers in the spaces provided in this question paper.
**Show all the steps in any calculations and state the units.**

### Information for Candidates

The total mark for this paper is 75. The marks for individual questions and parts of questions are shown in round brackets: e.g. **(2)**. There are 20 pages in this question paper. Any blank pages are indicated.
A Periodic Table is printed on the back cover of this booklet.

### Advice to Candidates

You are reminded of the importance of clear English and careful presentation in your answers.

This publication may be reproduced only in accordance with Edexcel Limited copyright policy.
©2007 Edexcel Limited.

Printer's Log. No.
N24700A
W850/R6244/57570 7/7/7/7100

N 2 4 7 0 0 A 0 1 2 0

***Turn over***

edexcel
advancing learning, changing lives

Leave blank

**Answer ALL questions. Write your answers in the spaces provided.**

**1.** (a) Methanoic acid, HCOOH, is a weak acid. Explain what is meant by the terms **weak** and **acid**.

.....

.....

.....

**(2)**

(b) Write a balanced equation, including state symbols, for the reaction between aqueous solutions of methanoic acid and sodium carbonate.

.....

**(2)**

(c) The following equilibrium is set up when methanoic acid dissociates in water:

$$HCOOH(aq) + H_2O(1) \rightleftharpoons HCOO^-(aq) + H_3O^+(aq)$$

(i) There are two conjugate acid-base pairs in the above equation.

Identify them by completing the sentences below:

Formula of one acid is ..... .

The formula of its conjugate base is ..... .

**(1)**

Formula of the other acid is ..... .

The formula of its conjugate base is ..... .

**(1)**

Leave blank

(ii) Write the expression for the acid dissociation constant, $K_a$, for methanoic acid.

**(1)**

(iii) Calculate the pH of a 0.100 mol $dm^{-3}$ solution of methanoic acid at 298 K.
[$K_a$ for methanoic acid is $1.60 \times 10^{-4}$ mol $dm^{-3}$ at 298 K]

**(3)**

(d) A buffer solution is made up by mixing equal volumes of 0.100 mol $dm^{-3}$ methanoic acid and 0.400 mol $dm^{-3}$ sodium methanoate.

(i) Calculate the pH of the buffer solution obtained.

**(3)**

Leave blank

(ii) Explain why the pH of this mixture of methanoic acid and sodium methanoate remains almost constant when a small quantity of an acidic solution, containing hydrogen ions, or a small quantity of an alkaline solution, containing hydroxide ions, is added.

In your explanation include equations to show the effect of adding hydrogen ions and of adding hydroxide ions.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**(3)**

**Q1**

**(Total 16 marks)**

Leave blank

**2.** One stage in the manufacture of sulphuric acid is

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The equilibrium constant $K_p = \dfrac{p^2_{SO_3}}{p^2_{SO_2} \times p_{O_2}}$

(a) 10.0 mol of $SO_2$ and 5.00 mol of $O_2$ were allowed to react. At equilibrium, 90.0% of the $SO_2$ was converted into $SO_3$.

(i) Calculate the number of moles of $SO_2$, $O_2$ and $SO_3$ present in the equilibrium mixture.

**(2)**

(ii) Calculate the mole fractions of $SO_2$, $O_2$ and $SO_3$ at equilibrium.

**(1)**

Leave blank

(iii) Assuming that the total pressure of the equilibrium mixture was 2.00 atm, calculate the partial pressures of $SO_2$, $O_2$ and $SO_3$ at equilibrium.

**(1)**

(iv) Calculate the value of $K_p$.

**(2)**

Leave blank

(b) The reaction between sulphur dioxide and oxygen is exothermic.

(i) State the effect, if any, on $K_p$ of increasing the temperature at constant pressure.

.....

**(1)**

(ii) Use your answer to (i), **and** the expression $K_p = \frac{p^2_{SO_3}}{p^2_{SO_2} \times p_{O_2}}$ to explain the effect on the position of equilibrium of increasing the temperature at constant pressure.

.....

.....

.....

.....

.....

.....

.....

**(2)**

(c) The reaction was repeated at a higher pressure whilst maintaining a constant temperature.

(i) State the effect, if any, of an increase in the total pressure on the value of $K_p$.

.....

**(1)**

(ii) State the effect, if any, of this increase in pressure on the amount of sulphur trioxide in the equilibrium mixture.

.....

**(1)**

(d) State the effect, if any, of a catalyst on:

(i) $K_p$

.....

**(1)**

(ii) the equilibrium position.

.....

**(1)**

**Q2**

**(Total 13 marks)**

Leave blank

**3.** Two compounds, **A** and **B**, are isomers with molecular formula $C_4H_8O$.

- Both compounds produce an orange-yellow precipitate with 2,4-dinitrophenylhydrazine.
- Both compounds react with sodium borohydride (sodium tetrahydridoborate(III)).
- When the compounds are warmed separately with Fehling's solution, **A** forms a red-brown precipitate but **B** does not.
- Compound **B** forms yellow crystals when warmed with aqueous iodine and sodium hydroxide, whereas **A** does not.

(a) Draw **full** structural formulae for **A** and **B**, showing all bonds.

| | Full structural formula |
|---|---|
| Compound **A** | |
| Compound **B** | |

**(2)**

(b) Draw the structural formula of the product from the reaction of compound **A** with 2,4-dinitrophenylhydrazine.

**(2)**

Leave blank

(c) Give the name and formula of:

(i) the yellow solid formed when compound **B** reacts with aqueous iodine and sodium hydroxide:

name .....

formula

**(2)**

(ii) the organic product of the reaction between compound **B** and sodium borohydride (sodium tetrahydridoborate(III)) in water:

name .....

formula

**(2)**

(d) Molecules of the organic product formed in (c)(ii) are chiral and exist as optical isomers.

(i) What is meant by the term **chiral molecule**?

.....

.....

.....

**(1)**

(ii) How could the optical isomers of the compound formed in (c)(ii) be distinguished from each other?

.....

.....

**(1)**

Leave blank

(e) Compound **C** has the molecular formula $C_4H_8O$.

- When phosphorus pentachloride, $PCl_5$, was added to a dry sample of **C**, steamy fumes were observed.
- When bromine water was shaken with a sample of **C**, the bromine water turned colourless.
- Compound **C** can be oxidised to a carboxylic acid which has a geometric isomer.

Use the information above to draw the formulae of the two isomers which could be compound **C**.

**(2)**

**Q3**

**(Total 12 marks)**

Leave blank

**4.** (a) (i) Write the equation which represents the change occurring when the standard enthalpy of atomisation of bromine is measured.

.....

**(2)**

(ii) Define **lattice energy**.

.....

.....

.....

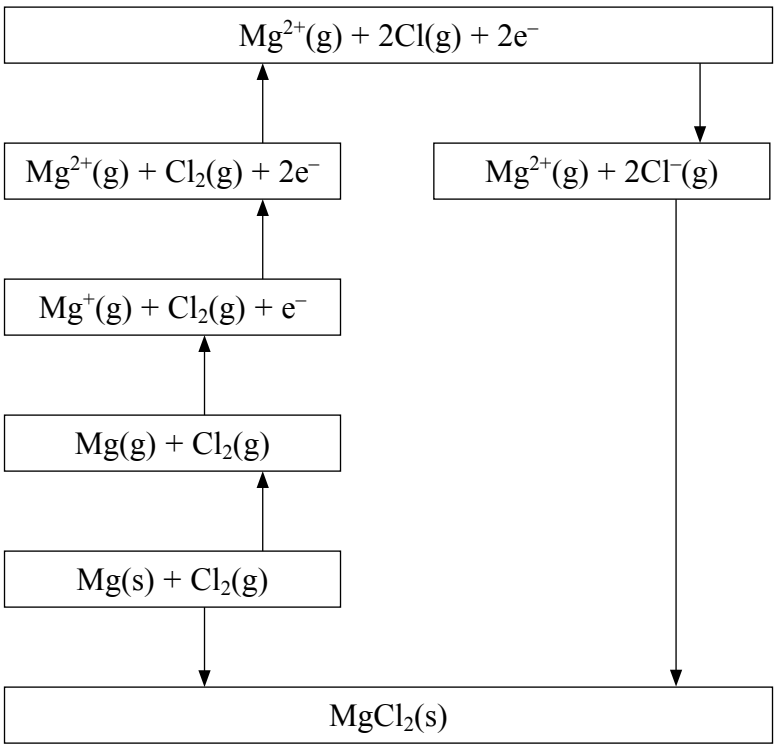
.....

**(3)**

**QUESTION 4 CONTINUES ON THE NEXT PAGE**

Leave blank

(b) A Born-Haber cycle for the formation of magnesium chloride is shown below.




| | Value / kJ mol$^{-1}$ |
|---|---|
| Enthalpy of atomisation of magnesium | +150 |
| 1st ionisation energy of magnesium | +736 |
| 2nd ionisation energy of magnesium | +1450 |
| Enthalpy of atomisation of chlorine | +122 |
| Enthalpy of formation of magnesium chloride | –642 |
| Lattice energy of magnesium chloride | –2526 |

(i) Use the data to calculate the first electron affinity of chlorine.

**(3)**

Leave blank

(ii) The theoretically calculated value for the lattice energy of magnesium chloride is $-2326\ kJ\ mol^{-1}$.

Explain, in terms of the bonding in magnesium chloride, why the experimentally determined value of $-2526\ kJ\ mol^{-1}$ is significantly different from the theoretical value.

.....

.....

.....

.....

.....

.....

.....

.....

**(2)**

(c) The table shows values for the lattice energies of the metal chlorides of some Group 2 metals.

| Group 2 metal chloride | $MgCl_2$ | $CaCl_2$ | $SrCl_2$ | $BaCl_2$ |
|---|---|---|---|---|
| Lattice energy/ $kJ\ mol^{-1}$ | –2526 | –2237 | –2112 | –2018 |

Explain why these lattice energies become less exothermic from $MgCl_2$ to $BaCl_2$.

**(3)**

**Q4**

**(Total 13 marks)**

Leave blank

**5.** (a) Complete the table below by writing down the formula of one anhydrous chloride of each of the Period 3 elements shown, other than silicon.

| Element | Na | Mg | Al | Si | P |
|---|---|---|---|---|---|
| Formula of a chloride | | | | $SiCl_4$ | |

**(2)**

(b) (i) Write equations to represent the changes occurring when the following chlorides are added to excess water.

sodium chloride (state symbols are required)

.....

**(1)**

a chloride of phosphorus (state symbols are **not** required).

.....

**(1)**

(ii) Account for the difference in the changes by comparing the bonding in these two chlorides.

.....

.....

.....

.....

.....

**(2)**

Leave blank

(c) Carbon tetrachloride and silicon tetrachloride behave in different ways when added to water. State how each chloride behaves and explain the difference.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**(5)**

(d) Lead(IV) oxide, $PbO_2$, is a powerful oxidising agent.

(i) Write the balanced equation for the reaction between lead(IV) oxide and warm concentrated hydrochloric acid, given that lead(II) chloride is one of the products.

.....

**(1)**

(ii) State why lead(IV) compounds such as lead(IV) oxide can be reduced to the +2 oxidation state, whereas silicon(IV) compounds such as silicon(IV) oxide cannot.

.....

.....

.....

**(1)**

**Q5**

**(Total 13 marks)**

Leave blank

**6.** (a) Consider the following reaction scheme which shows how compound **X** is converted into compound **Y**.

$$\underset{\textbf{X}}{CH_3CN} \xrightarrow{\textbf{Step 1}} CH_3COOH \xrightarrow{\textbf{Step 2}} CH_3COCl \xrightarrow{\textbf{Step 3}} \underset{\textbf{Y}}{CH_3CONHCH_3}$$

(i) Name compound **X**.

.....

**(1)**

(ii) State the type of reaction occurring in **Step 1**.

.....

**(1)**

(iii) Identify the reagents used for each of **Steps 1** and **2**.

Reagent for Step 1 .....

Reagent for Step 2 .....

**(2)**

(iv) Write an equation for the reaction taking place in **Step 3**.

.....

**(1)**



N 2 4 7 0 0 A 0 1 6 2 0

Leave blank

(b) The halogenoalkane 1-bromopropane reacts with magnesium to form the Grignard reagent, $CH_3CH_2CH_2MgBr$.

This Grignard reagent reacts with

- water to form compound **L**
- ethanal, followed by dilute hydrochloric acid, to form compound **M**
- carbon dioxide, followed by dilute hydrochloric acid, to form compound **N**

Write the **full** structural formulae of compounds **L**, **M** and **N**, showing all bonds.

Compound **L**

Compound **M**

Compound **N**

**(3)** **Q6**

**(Total 8 marks)**

**TOTAL FOR PAPER: 75 MARKS**

**END**

**BLANK PAGE**



N24700A01820

**BLANK PAGE**



N2470 0A01920

# THE PERIODIC TABLE

| Period | 1 | 2 | Group | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 H Hydrogen 1 | | | | | | | | | | | | | | | | | 4 He Helium 2 |
| 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 |
| 3 | 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 |
| 4 | 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 | 63.5 Cu Copper 29 | 65.4 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 |
| 5 | 85 Rb Rubidium 37 | 88 Sr Strontium 38 | 89 Y Yttrium 39 | 91 Zr Zirconium 40 | 93 Nb Niobium 41 | 96 Mo Molybdenum 42 | 99 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 |
| 6 | 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 | 210 Po Polonium 84 | 210 At Astatine 85 | 222 Rn Radon 86 |
| 7 | 223 Fr Francium 87 | 226 Ra Radium 88 | 227 Ac Actinium 89 | | | | | | | | | | | | | | | |

**Key**

Molar mass g mol$^{-1}$

Symbol

Name

Atomic number

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 163 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 | (242) Pu Plutonium 94 | (243) Am Americium 95 | (247) Cm Curium 96 | (245) Bk Berkelium 97 | (251) Cf Californium 98 | (254) Es Einsteinium 99 | (253) Fm Fermium 100 | (256) Md Mendelevium 101 | (254) No Nobelium 102 | (257) Lr Lawrencium 103 |