Write your name here

| Surname | Other names |
|---|---|
| | |

Centre Number | Candidate Number

# Edexcel GCE

# Chemistry

## Advanced Subsidiary

## Unit 2: Application of Core Principles of Chemistry

Friday 27 May 2011 – Afternoon
**Time: 1 hour 30 minutes**

Paper Reference
**6CH02/01**

**Candidates may use a calculator.**

Total Marks

## Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

## Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

## Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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7/7/5/5/3/

P 3 8 4 7 9 A 0 1 2 0

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## SECTION A

**Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.**

**1** The correct balanced equation for the reaction between heated magnesium and steam, including state symbols, is

☒ **A** $Mg(s) + H_2O(l) \rightarrow MgO(s) + H_2(g)$

☒ **B** $Mg(s) + 2H_2O(g) \rightarrow Mg(OH)_2(aq) + H_2(g)$

☒ **C** $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

☒ **D** $Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$

**(Total for Question 1 = 1 mark)**

**2** This question concerns the trends in properties on descending Group 2 of the Periodic Table.

(a) What are the trends in solubility of sulfates and hydroxides down Group 2?

**(1)**

☒ **A** Sulfates increase, hydroxides decrease.

☒ **B** Sulfates decrease, hydroxides increase.

☒ **C** Sulfates increase, hydroxides increase.

☒ **D** Sulfates decrease, hydroxides decrease.

(b) What are the trends in thermal stability of carbonates and nitrates down Group 2?

**(1)**

☒ **A** Carbonates increase, nitrates decrease.

☒ **B** Carbonates decrease, nitrates increase.

☒ **C** Carbonates increase, nitrates increase.

☒ **D** Carbonates decrease, nitrates decrease.

(c) What are the trends in first ionization energy and electronegativity of the elements down Group 2?

**(1)**

☒ **A** Ionization energy increases, electronegativity decreases.

☒ **B** Ionization energy decreases, electronegativity increases.

☒ **C** Ionization energy increases, electronegativity increases.

☒ **D** Ionization energy decreases, electronegativity decreases.

**(Total for Question 2 = 3 marks)**

**3** Which silver halide is a cream coloured solid which darkens in sunlight and dissolves in concentrated ammonia solution?

- ☒ **A** AgF
- ☒ **B** AgCl
- ☒ **C** AgBr
- ☒ **D** AgI

**(Total for Question 3 = 1 mark)**

**4** What is the FBF bond angle in boron trifluoride, $BF_3$?

- ☒ **A** 180°
- ☒ **B** 120°
- ☒ **C** 109.5°
- ☒ **D** 90°

**(Total for Question 4 = 1 mark)**

**5** What is the total number of electrons in the covalent bonds in a beryllium chloride molecule, $BeCl_2$?

- ☒ **A** 2
- ☒ **B** 4
- ☒ **C** 6
- ☒ **D** 8

**(Total for Question 5 = 1 mark)**

**6** Which of the following molecules is linear?

- ☒ **A** $CO_2$
- ☒ **B** $C_2H_4$
- ☒ **C** $H_2O$
- ☒ **D** $NH_3$

**(Total for Question 6 = 1 mark)**

**7** Which of the following molecules is **non-polar**?

☒ **A** $CH_3Cl$

☒ **B** $CH_2Cl_2$

☒ **C** $CHCl_3$

☒ **D** $CCl_4$

**(Total for Question 7 = 1 mark)**

**8** Methanol dissolves in water mainly due to the formation of new

☒ **A** hydrogen bonds.

☒ **B** dipole-dipole forces.

☒ **C** London forces.

☒ **D** covalent bonds.

**(Total for Question 8 = 1 mark)**

**9** Which of the following molecules does **not** absorb infrared radiation?

☒ **A** $N_2$

☒ **B** $NO_2$

☒ **C** CO

☒ **D** $CO_2$

**(Total for Question 9 = 1 mark)**

**10** There would be a major peak in the mass spectrum for butan-1-ol, $CH_3CH_2CH_2CH_2OH$, but **not** for butan-2-ol, $CH_3CH_2CH(OH)CH_3$, at *m/e* value

☒ **A** 15

☒ **B** 17

☒ **C** 29

☒ **D** 43

**(Total for Question 10 = 1 mark)**

**Use this space for any rough working. Anything you write in this space will gain no credit.**

**11** How many molecular ion peaks (parent ion peaks) occur in the mass spectrum of 1,2-dibromoethane, $CH_2BrCH_2Br$?

Assume the only isotopes present are $^{1}H$, $^{12}C$, $^{79}Br$ and $^{81}Br$.

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

**(Total for Question 11 = 1 mark)**

**12** The following reactions have been used in the chemical industry to make liquid and solid products, allowing any gaseous products to escape into the atmosphere:

**A** $CH_3OH(g) + CO(g) \rightarrow CH_3COOH(l)$

**B** $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

**C** $CH_4(g) + 3Cl_2(g) \rightarrow CHCl_3(l) + 3HCl(g)$

**D** $CH_2CH_2(g) + Cl_2(g) \rightarrow CH_2ClCH_2Cl(l)$

(a) Which reaction has an atom economy by mass of 56%?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which reaction causes the most immediate damage to the environment?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which reaction is an electrophilic addition?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 12 = 3 marks)**

**13** Propan-1-ol and propan-2-ol are separately oxidized under mild conditions by acidified sodium dichromate(VI) and the product immediately distilled off. What is the oxidation product in each case?

| | | Propan-1-ol | Propan-2-ol |
|---|---|---|---|
| ☒ | **A** | propanal | propanone |
| ☒ | **B** | propanoic acid | propanone |
| ☒ | **C** | propanal | propanoic acid |
| ☒ | **D** | propanone | propanal |

**(Total for Question 13 = 1 mark)**

**14** Unsaturated vegetable oils are hardened to make margarine by reaction with hydrogen and a nickel catalyst. Which terms could both be used to describe this type of reaction?

☒ **A** Substitution and oxidation

☒ **B** Substitution and reduction

☒ **C** Addition and oxidation

☒ **D** Addition and reduction

**(Total for Question 14 = 1 mark)**

**15** When iodomethane, $CH_3I$, is heated in a sealed tube with an excess of alcoholic ammonia, which of the following **cannot** be formed?

☒ **A** Methylamine, $CH_3NH_2$

☒ **B** Ethylamine, $CH_3CH_2NH_2$

☒ **C** Dimethylamine, $(CH_3)_2NH$

☒ **D** Ammonium iodide, $NH_4I$

**(Total for Question 15 = 1 mark)**

**Use this space for any rough working. Anything you write in this space will gain no credit.**

**16** The enthalpy change of neutralization of an acid by an alkali is measured by adding 10.0 $cm^3$ of hydrochloric acid to 10.0 $cm^3$ of sodium hydroxide. 10.0 $cm^3$ pipettes with an accuracy of ±0.04 $cm^3$ are used to measure out both solutions.

The overall percentage error in measuring the total volume of the reaction mixture is

☒ **A** ±0.04%

☒ **B** ±0.08%

☒ **C** ±0.4%

☒ **D** ±4.0%

**(Total for Question 16 = 1 mark)**

**TOTAL FOR SECTION A = 20 MARKS**

## SECTION B

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

**17** This question is about the element chlorine and its compounds.

(a) When chlorine is bubbled through water, a solution of chlorine water forms. What is the colour of chlorine water?

**(1)**

.....

(b) Chlorine water is added to potassium iodide solution.

(i) State the colour of the solution produced.

**(1)**

.....

(ii) Write the **ionic** equation for the reaction, including state symbols.

**(2)**

(c) The concentration of chlorine water was found by taking 10.0 $cm^3$ of solution, adding an excess of potassium iodide solution, and titrating with 0.0100 mol $dm^{-3}$ of sodium thiosulfate solution. The experiment was repeated.

The following results were obtained.

| Titration number | 1 | 2 |
|---|---|---|
| Final burette reading / $cm^3$ | 38.60 | 47.60 |
| Initial burette reading / $cm^3$ | 29.50 | 38.60 |
| Volume added / $cm^3$ | 9.10 | 9.00 |

(i) Name a suitable indicator for the titration. State the colour change you would expect to see at the end point.

**(2)**

Indicator .....

Colour change from ..... to .....

(ii) Calculate the mean titre and use this value to calculate the number of moles of sodium thiosulfate used in the titration.

**(1)**

Mean titre = ..... $cm^3$

Moles of sodium thiosulfate

(iii) Complete the ionic equation for the reaction between iodine and thiosulfate ions.

**(2)**

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow$

(iv) Calculate the number of moles of iodine which reacted with the sodium thiosulfate solution.

**(1)**

(v) Hence state the number of moles of chlorine present in 10.0 $cm^3$ of the chlorine water.

**(1)**

(vi) Calculate the concentration of the chlorine water, in mol $dm^{-3}$.

**(1)**

(d) Potassium burns in chlorine to form potassium chloride.

(i) Give the colour of the flame when potassium burns in chlorine.

**(1)**

(ii) Write the equation for the reaction between potassium and chlorine. State symbols are **not** required.

**(1)**

(e) Concentrated sulfuric acid is added to potassium chloride in a test tube. Steamy fumes are given off which react with ammonia to give dense white smoke.

(i) Name the gas given off in this reaction.

**(1)**

(ii) Steamy fumes are observed at the mouth of the test tube. Explain how these fumes are formed.

**(1)**

(iii) The steamy fumes react with ammonia to give a dense white smoke. Identify the white smoke by name or formula.

**(1)**

(f) 2-chlorobutane can be made from butan-2-ol.

(i) Name the chemical you would add to butan-2-ol in the laboratory to make 2-chlorobutane.

**(1)**

(ii) 2-chlorobutane reacts with alcoholic potassium hydroxide at a high temperature to form a mixture of gaseous alkenes.

Draw a fully labelled diagram of the apparatus you would use to prepare and collect this mixture.

**(3)**

**(Total for Question 17 = 21 marks)**

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**18** This question is about ethanethiol, $CH_3CH_2SH$. Thiols are like alcohols, but the oxygen atom has been replaced by a sulfur atom. They react in a similar way to alcohols.

(a) (i) Draw a dot and cross diagram for ethanethiol, showing outer electrons only.

**(2)**

(ii) Give the value for the CSH bond angle in ethanethiol. Justify your answer.

**(3)**

CSH angle .....

Justification .....

.....

.....

.....

(b) There are hydrogen bonds between ethanol molecules but not between ethanethiol molecules.

(i) Explain why the bond angle around the hydrogen atom involved in a hydrogen bond is 180°.

**(2)**

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(ii) Explain why there are no hydrogen bonds between ethanethiol molecules.

**(1)**

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(c) (i) Describe the formation of London forces.

**(2)**

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(ii) Explain why the London forces in ethanethiol are stronger than those in ethanol.

**(1)**

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(d) The reaction of sodium with ethanethiol, $CH_3CH_2SH$, is similar to its reaction with ethanol.

(i) Suggest one observation you would make when sodium is added to ethanethiol.

**(1)**

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.....

(ii) Suggest a balanced equation for this reaction. State symbols are **not** required.

**(1)**

(e) Ethanol can be made from bromoethane by reaction with aqueous potassium hydroxide, KOH(aq), under suitable conditions.

(i) Write the equation for this reaction. State symbols are **not** required.

**(1)**

(ii) State the type and mechanism of this reaction.

**(2)**

Type .....

Mechanism .....

(iii) Suggest the formula of a suitable chemical to make ethanethiol from bromoethane.

**(1)**

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(f) When ethanethiol undergoes complete combustion in air, a gas is produced which is not formed on the complete combustion of ethanol. Identify the gas and suggest why it is damaging to the environment.

**(2)**

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**(Total for Question 18 = 19 marks)**

**TOTAL FOR SECTION B = 40 MARKS**

## SECTION C

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

**19** This question is about nitrogen monoxide, NO, which can be described both as a friend and a foe.

Chemists have discovered that nitrogen monoxide plays an important role in the body by dilating blood vessels. If someone is suffering from blood circulatory or heart problems, a chemical may be given which will quickly break down to give nitrogen monoxide. Years ago, nitroglycerine was used for this purpose. Interestingly, the same chemical Nobel had used to make dynamite was used to treat him in old age.

In the laboratory, nitrogen monoxide can be prepared by adding concentrated nitric acid to powdered silver. Nitrogen monoxide is a colourless gas which is partially soluble in water. It is difficult to detect its smell, because it reacts with oxygen in the air to form pungent-smelling nitrogen dioxide.

Nitrogen monoxide is formed when a mixture of air and oxygen is heated to a high temperature. This reaction occurs in the engines of cars and aeroplanes. Nitrogen monoxide has a disastrous effect on the ozone layer because it is a free radical. Nitrogen monoxide is also a greenhouse gas.

(a) (i) What is meant by the term **free radical**?

**(1)**

.....

.....

(ii) Suggest a dot and cross diagram for nitrogen monoxide, showing outer shell electrons only, remembering that it is a free radical.

**(2)**

(b) (i) **Part** of the **unbalanced** equation for the preparation of nitrogen monoxide from nitric acid is shown below.

$$Ag(s) + HNO_3(aq) \rightarrow NO(g) + AgNO_3(aq)$$

Identify the elements which are oxidized and reduced and give their oxidation numbers.

**(3)**

Element oxidized .....

Oxidation number initial ..... final .....

Element reduced .....

Oxidation number initial ..... final .....

(ii) Complete and balance the equation for the reaction between silver and nitric acid.

**(2)**

.....$Ag(s)$ + .....$HNO_3(aq) \rightarrow NO(g)$ + .....$AgNO_3(aq)$ + .....

(c) The reaction between nitrogen and oxygen to form nitrogen monoxide reaches equilibrium.

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \qquad \Delta H^{\ominus} = +180.4 \text{ kJ mol}^{-1}$$

(i) Explain why the yield of nitrogen monoxide is increased when the temperature is increased.

**(1)**

.....

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*(ii) State and explain the effect, if any, on the yield of nitrogen monoxide when the pressure is increased.

**(2)**

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(iii) State and explain how the rate of the reaction is affected by an increase in pressure.

**(2)**

*(d) (i) Explain why a jet aeroplane in flight causes much more damage to the ozone layer than cars carrying the same number of passengers at sea level. You should assume that the nitrogen monoxide outputs for both methods of conveying the passengers are the same.

**(2)**

(ii) The reactions of chlorine free radicals with ozone may be represented by the following equations.

$$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$$

$$ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$$

Write corresponding equations for the reactions of the free radical nitrogen monoxide with ozone. Combine your two equations to show the overall reaction.

Use these equations to explain why a small quantity of nitrogen monoxide can have a continuing effect on the ozone layer.

**(5)**

Equations

Explanation .....

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**(Total for Question 19 = 20 marks)**

**TOTAL FOR SECTION C = 20 MARKS**
**TOTAL FOR PAPER = 80 MARKS**

# The Periodic Table of Elements

| 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 (8) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | (18) |
| | | | | | | | 1.0 H hydrogen 1 | | | | | | | | | | 4.0 He helium 2 |
| (1) | (2) | | | | | | | | | | | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | | | | | | | | | | 10.8 B boron 5 | 12.0 C carbon 6 | 14.0 N nitrogen 7 | 16.0 O oxygen 8 | 19.0 F fluorine 9 | 20.2 Ne neon 10 |
| 23.0 Na sodium 11 | 24.3 Mg magnesium 12 | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | 27.0 Al aluminium 13 | 28.1 Si silicon 14 | 31.0 P phosphorus 15 | 32.1 S sulfur 16 | 35.5 Cl chlorine 17 | 39.9 Ar argon 18 |
| 39.1 K potassium 19 | 40.1 Ca calcium 20 | 45.0 Sc scandium 21 | 47.9 Ti titanium 22 | 50.9 V vanadium 23 | 52.0 Cr chromium 24 | 54.9 Mn manganese 25 | 55.8 Fe iron 26 | 58.9 Co cobalt 27 | 58.7 Ni nickel 28 | 63.5 Cu copper 29 | 65.4 Zn zinc 30 | 69.7 Ga gallium 31 | 72.6 Ge germanium 32 | 74.9 As arsenic 33 | 79.0 Se selenium 34 | 79.9 Br bromine 35 | 83.8 Kr krypton 36 |
| 85.5 Rb rubidium 37 | 87.6 Sr strontium 38 | 88.9 Y yttrium 39 | 91.2 Zr zirconium 40 | 92.9 Nb niobium 41 | 95.9 Mo molybdenum 42 | [98] Tc technetium 43 | 101.1 Ru ruthenium 44 | 102.9 Rh rhodium 45 | 106.4 Pd palladium 46 | 107.9 Ag silver 47 | 112.4 Cd cadmium 48 | 114.8 In indium 49 | 118.7 Sn tin 50 | 121.8 Sb antimony 51 | 127.6 Te tellurium 52 | 126.9 I iodine 53 | 131.3 Xe xenon 54 |
| 132.9 Cs caesium 55 | 137.3 Ba barium 56 | 138.9 La* lanthanum 57 | 178.5 Hf hafnium 72 | 180.9 Ta tantalum 73 | 183.8 W tungsten 74 | 186.2 Re rhenium 75 | 190.2 Os osmium 76 | 192.2 Ir iridium 77 | 195.1 Pt platinum 78 | 197.0 Au gold 79 | 200.6 Hg mercury 80 | 204.4 Tl thallium 81 | 207.2 Pb lead 82 | 209.0 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 | [261] Rf rutherfordium 104 | [262] Db dubnium 105 | [266] Sg seaborgium 106 | [264] Bh bohrium 107 | [277] Hs hassium 108 | [268] Mt meitnerium 109 | [271] Ds darmstadtium 110 | [272] Rg roentgenium 111 | | | | | | | |

Key

relative atomic mass
**atomic symbol**
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

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