| Surname | Centre Number | Candidate Number |
|---|---|---|
| Other Names | | 2 |

# GCE AS/A level

1092/01

# CHEMISTRY – CH2

A.M. WEDNESDAY, 16 January 2013

1½ hours

| FOR EXAMINER'S USE ONLY | | |
|---|---|---|
| Section | Question | Mark |
| A | 1-7 | |
| B | 8 | |
| | 9 | |
| | 10 | |
| | 11 | |
| | 12 | |
| TOTAL MARK | | |

## ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Sheet** containing a **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

## INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

**Section A** Answer **all** questions in the spaces provided.
**Section B** Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

## INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The *QWC* label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

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## SECTION A

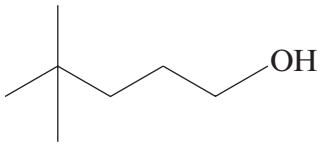
*Answer* **all** *questions in the spaces provided.*

**1.** Calcium and magnesium are essential elements in living things. Give **one** use of each element in biological systems. [1]

*Magnesium* .....

*Calcium* .....

**2.** Give the **systematic** name of the molecule shown below. [1]




.....

**3.** The electronegativity values of the halogens are listed below.

| Atom | F | Cl | Br | I | At |
|---|---|---|---|---|---|
| Electronegativity value | 4.0 | 3.0 | 2.9 | 2.6 | 2.2 |

*(a)* Define the term *electronegativity.* [1]

.....

.....

*(b)* Use the data in the table to identify any dipoles present in the following bonds, marking their polarity clearly. [1]

F — Cl At — Cl

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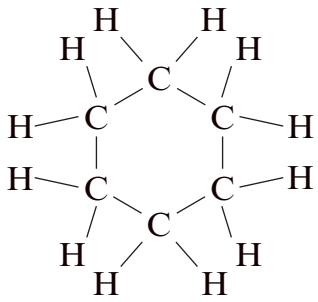
**4.** Cyclohexane is an example of a hydrocarbon containing a ring of carbon atoms. Its structure is shown below.



Give the **empirical** formula of this compound. [1]

.....

**5.** *(a)* Write the letter corresponding to the correct electronic structure of an atom that is a member of the *d*-block in the box below. [1]

**A** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^1$

**B** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

**C** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

**D** $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

*(b)* Write the letter corresponding to the electronic structure of the atom with the highest first ionisation energy in the box below. [1]

**A** $1s^2 2s^2 2p^6 3s^2 3p^6$

**B** $1s^2 2s^2 2p^6$

**C** $1s^2 2s^2 2p^6 3s^2$

**D** $1s^2 2s^2 2p^6 3s^2 3p^4$

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**6.** The gas oxygen, $O_2$, is converted into ozone, $O_3$, in the upper atmosphere. The equation for this process is:

$$3O_2 \longrightarrow 2O_3$$

Use oxidation states to explain why this is not a redox reaction. [2]

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**7.** Recent advances in chemistry have produced a range of smart materials.

Give the meaning of the term *smart material*. [1]

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**Total Section A [10]**

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## SECTION B

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

**8.** Barium chloride is a highly toxic compound that is frequently used in the laboratory.

*(a)* Aqueous barium chloride can be used to test for sulfate ions in solution.

(i) Write an **ionic** equation for the reaction that occurs when aqueous barium chloride is added to a solution containing sulfate ions. [1]

.....

(ii) Give the observation expected for a positive result in this chemical test. [1]

.....

*(b)* A solution of barium chloride can be identified using separate tests for barium ions and chloride ions.

(i) A flame test can be used to prove that the solution contains barium ions. State the flame colour that would be seen. [1]

.....

(ii) Give a chemical test to show that the solution contains chloride ions. Your answer should include the reagent(s) and expected observation(s). [2]

*Reagent(s)* .....

*Observation(s)* .....

*(c)* The solubility of barium chloride at two different temperatures is given in the table below.

| Temperature / °C | Solubility of $BaCl_2$ / g $dm^{-3}$ |
|---|---|
| 0 | 312 |
| 20 | 358 |

Calculate the mass of solid barium chloride that would be obtained by cooling 200 $cm^3$ of a saturated solution of barium chloride from 20 °C to 0 °C. [2]

*Mass* = ..... g

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*(d)* When solid barium chloride is crystallised from solution, it produces the hydrate $BaCl_2.xH_2O$. The relative molecular mass ($M_r$) of this hydrate was found to be 244. Calculate the value of $x$ in this formula. [2]

$x$ = .....

*(e)* Jack wishes to prepare a solution of barium chloride starting with the insoluble solid barium carbonate and dilute hydrochloric acid.

(i) Write the equation for this reaction. [1]

.....

(ii) Jack measured 50.0 $cm^3$ of hydrochloric acid of concentration 0.500 mol $dm^{-3}$.

I Calculate the number of moles of hydrochloric acid in this solution. [2]

*Moles of hydrochloric acid* = ..... mol

II He added an excess of solid barium carbonate to the dilute hydrochloric acid. Suggest how a pure solution of barium chloride could be obtained from the reaction mixture. [1]

.....

III Calculate the maximum mass of hydrated barium chloride ($M_r$ = 244) that could be produced in this reaction. [2]

*Maximum mass of hydrated barium chloride* = ..... g

Total [15]

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**Turn over.**

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**9.** Chloromethane can be produced by the chlorination of methane gas.

*(a)* During the initiation stage of this process, chlorine free radicals are produced.

(i) Give the condition(s) required for this initiation stage. [1]

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(ii) State what is meant by a *free radical.* [1]

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*(b)* Write the equation(s) for the propagation stage(s) to produce chloromethane starting with methane and chlorine free radicals. [2]

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*(c)* Apart from chloromethane, a range of other compounds are produced in small amounts during the reaction.

(i) One of the compounds produced in the reaction is ethane. Show how this compound is produced. [1]

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(ii) Another of the compounds produced contains 24.3% carbon, 4.1% hydrogen and 71.6% chlorine by mass. Calculate the **empirical** formula of this compound. [2]

*Empirical formula* .....

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*(d)* Chloromethane can be converted into methanol by reaction with hydroxide ions.

(i) Classify the mechanism of this reaction. [1]

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(ii) The boiling temperatures of chloromethane and methanol are given in the table below.

| Compound | Boiling temperature / K |
|---|---|
| chloromethane, $CH_3Cl$ | 249 |
| methanol, $CH_3OH$ | 338 |

Explain why the boiling temperature of methanol is higher than the boiling temperature of chloromethane. [3]

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(iii) Methanol can then be converted to methanoic acid. Give the reagent(s) and condition(s) required for this reaction. [2]

*Reagent(s)* .....

*Condition(s)* .....

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*(e)* CFCs are another class of organic compounds. They contain chlorine, fluorine and carbon. These compounds once had a range of uses, however their use is now avoided due to their effect on the ozone layer which is part of the **upper** atmosphere.

The table shows the lifetime of some compounds in the **lower** atmosphere and their relative ozone depletion potential (RODP), taking $CCl_3F$ as having a value of 1.0. The RODP is measured by mixing a compound with ozone in a laboratory experiment.

| Compound | Formula | Lifetime in the lower atmosphere | Relative ozone depletion potential (RODP) |
|---|---|---|---|
| **A** | $CHF_3$ | 243 years | 0.01 |
| **B** | $CCl_2F_2$ | 20 years | 0.86 |
| **C** | $CCl_3F$ | 75 years | 1.00 |
| **D** | $CBrClF_2$ | 120 days | 10.00 |

By referring to this table, explain why CFCs **B** and **C** are far more harmful than compounds **A** and **D**.
Your answer should explain how and why CFCs affect the ozone layer. [3]

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Total [16]

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**10.** Aluminium, boron and nitrogen all form chlorides containing three chlorine atoms, $XCl_3$.

*(a)* Molecules of boron chloride, $BCl_3$, and molecules of nitrogen chloride, $NCl_3$, have different shapes.

Use VSEPR (valence shell electron pair repulsion) theory to state and explain the shapes of these molecules. [6]

*QWC* [2]

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*(b)* The boron atom in boron chloride, $BCl_3$, is described as being electron deficient. Draw a dot and cross diagram for $BCl_3$ and use it to show what is meant by the term *electron deficient*. [2]

.....

.....

*(c)* Nitrogen chloride, $NCl_3$, is insoluble in cold water whilst the similar compound ammonia, $NH_3$, is very soluble. Explain this difference in behaviour. [2]

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*(d)* Aluminium chloride, $AlCl_3$, forms a dimer that contains both covalent bonds and coordinate bonds. Describe what is meant by the terms *covalent bond* and *coordinate bond*. [2]

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Total [14]

Examiner only

**11.** *(a)* Both sodium chloride and caesium chloride have giant ionic structures.

(i) Draw a labelled diagram to show the arrangement of ions in a crystal of caesium chloride. [2]

(ii) Give a reason why sodium chloride has a different structure from caesium chloride. [1]

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*(b)* Both diamond and graphite have giant covalent structures.

(i) Describe the structure and bonding in graphite. [3]
*QWC* [1]

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(ii) Explain why graphite can conduct electricity whilst diamond cannot. [2]

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(iii) Iodine, $I_2$, also contains covalent bonds. Explain why solid iodine can be converted into a vapour at a much lower temperature than diamond. [3]

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Total [12]







**Turn over.**

Examiner only

**12.** But-2-ene is a useful starting material for the production of synthetic rubber.

*(a)* But-2-ene can be produced from crude oil by fractional distillation and then cracking.

(i) Explain why fractional distillation can be used to separate molecules with different numbers of carbon atoms. [1]

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(ii) Write the equation for a cracking reaction that produces but-2-ene from decane, $C_{10}H_{22}$. [1]

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*(b)* Bromine solution can be used to distinguish between but-2-ene and butane.

(i) Give the colour **change** that would be expected when bromine solution is added to but-2-ene. [1]

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(ii) In a similar reaction hydrogen bromide reacts with propene.

Draw the mechanism of the reaction of propene with hydrogen bromide indicating clearly all charges and the movement of electrons. [3]

Examiner only

(iii) Propene can be produced from the product in part (ii) by using sodium hydroxide. Give the condition(s) required for this reaction. [1]

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.....

*(c)* But-2-ene can exist as *E*- and *Z*-isomers.

(i) Explain why but-2-ene can form *E*- and *Z*-isomers whilst propene and butane cannot. [2]

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(ii) Draw the **skeletal** formula for *Z*-but-2-ene. [1]

*(d)* In industry, butan-2-ol can be produced from but-2-ene. This uses the same reagent(s) and condition(s) as the production of ethanol from ethene.

(i) Give the reagent(s) and condition(s) used for this reaction. [2]

*Reagent(s)* .....

*Condition(s)* .....

(ii) Explain how infrared spectroscopy can be used to distinguish between butan-2-ol and but-2-ene. [1]

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Total [13]

**Total Section B [70]**

**END OF PAPER**

| Question number | **Additional page, if required. Write the question numbers in the left-hand margin.** |
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| Question number | **Additional page, if required. Write the question numbers in the left-hand margin.** |
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Examiner only

| Question number | **Additional page, if required. Write the question numbers in the left-hand margin.** |
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# GCE AS/A level

1092/01-A

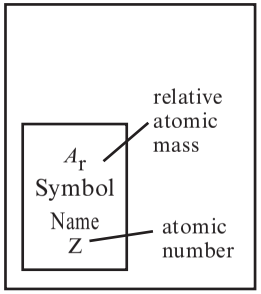
# CHEMISTRY – DATA SHEET
## FOR USE WITH CH2

A.M. WEDNESDAY, 16 January 2013

## Infrared Spectroscopy characteristic absorption values

| Bond | Wavenumber / $cm^{-1}$ |
|---|---|
| C—Br | 500 to 600 |
| C—Cl | 650 to 800 |
| C—O | 1000 to 1300 |
| C═C | 1620 to 1670 |
| C═O | 1650 to 1750 |
| C≡N | 2100 to 2250 |
| C—H | 2800 to 3100 |
| O—H | 2500 to 3550 |
| N—H | 3300 to 3500 |

# THE PERIODIC TABLE




| Period | Group 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 |
|---|---|---|---|---|---|---|---|---|
| | s Block | | | | | | | |
| 1 | 1.01 H Hydrogen 1 | | | | | | | 4.00 He Helium 2 |
| 2 | 6.94 Li Lithium 3 | 9.01 Be Beryllium 4 | | | | | p Block | 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 |
| 3 | 23.0 Na Sodium 11 | 24.3 Mg Magnesium 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 / 40.0 Ar Argon 18 |
| 4 | 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 |
| 5 | 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 | 98.9 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 ▸ | 179 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 | | | | | |

d Block

f Block

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ▸ Lanthanoid elements | 140 Ce Cerium 58 | 141 Pr Praseodymium 59 | 144 Nd Neodymium 60 | (147) Pm Promethium 61 | 150 Sm Samarium 62 | (153) 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 |
| ▸▸ Actinoid elements | 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 |