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| Centre Number       |  |  |  |  |  | Candidate Number |  |  |  |  |
| Surname             |  |  |  |  |  |                  |  |  |  |  |
| Other Names         |  |  |  |  |  |                  |  |  |  |  |
| Candidate Signature |  |  |  |  |  |                  |  |  |  |  |

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|---------------------|------|
| For Examiner's Use  |      |
| Examiner's Initials |      |
| Question            | Mark |
| 1                   |      |
| 2                   |      |
| 3                   |      |
| 4                   |      |
| 5                   |      |
| 6                   |      |
| TOTAL               |      |



General Certificate of Education  
Advanced Subsidiary Examination  
January 2009

# Chemistry

# CHEM1

## Unit 1 Foundation Chemistry

Friday 9 January 2009 1.30 pm to 2.45 pm

**For this paper you must have:**

- a calculator.

### Time allowed

- 1 hour 15 minutes

### Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. **Answers written in margins or on blank pages will not be marked.**
- All working must be shown.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The Periodic Table/Data Sheet is provided as an insert.

### Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  - use good English
  - organise information clearly
  - use specialist vocabulary where appropriate.

### Advice

- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.



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APW/Jan09/CHEM1

# CHEM1

**SECTION A**

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

**1** In 1913 Niels Bohr proposed a model of the atom with a central nucleus, made up of protons and neutrons, around which electrons moved in orbits. After further research, the model was refined when the existence of energy levels and sub-levels was recognised.

**1** (a) Complete the following table for the particles in the nucleus.

| Particle | Relative charge | Relative mass |
|----------|-----------------|---------------|
| proton   |                 |               |
| neutron  |                 |               |

(2 marks)

**1** (b) State the block in the Periodic Table to which the element tungsten, W, belongs.

.....  
(1 mark)

**1** (c) Isotopes of tungsten include  $^{182}\text{W}$  and  $^{186}\text{W}$

**1** (c) (i) Deduce the number of protons in  $^{182}\text{W}$

.....  
(1 mark)

**1** (c) (ii) Deduce the number of neutrons in  $^{186}\text{W}$

.....  
(1 mark)



1 (d) In order to detect the isotopes of tungsten using a mass spectrometer, a sample containing the isotopes must be vaporised and then ionised.

1 (d) (i) Give **two** reasons why the sample must be ionised.

1 .....

2 .....

(2 marks)

1 (d) (ii) State what can be adjusted in the mass spectrometer to enable ions formed by the different isotopes to be directed onto the detector.

.....  
(1 mark)

1 (e) State and explain the difference, if any, between the chemical properties of the isotopes  $^{182}\text{W}$  and  $^{186}\text{W}$

Difference .....

Explanation .....

.....  
(2 marks)

1 (f) The table below gives the relative abundance of each isotope in the mass spectrum of a sample of tungsten.

|                        |      |      |      |      |
|------------------------|------|------|------|------|
| $m/z$                  | 182  | 183  | 184  | 186  |
| Relative abundance / % | 26.4 | 14.3 | 30.7 | 28.6 |

Use the data above to calculate a value for the relative atomic mass of this sample of tungsten. Give your answer to 2 decimal places.

.....

.....

.....  
(2 marks)



2 The table below shows the electronegativity values of some elements.

|                   |     |     |     |     |
|-------------------|-----|-----|-----|-----|
|                   | H   | C   | N   | O   |
| Electronegativity | 2.1 | 2.5 | 3.0 | 3.5 |

2 (a) State the meaning of the term *electronegativity*.

.....

.....

.....

(2 marks)

2 (b) State the strongest type of intermolecular force in the following compounds.

Methane (CH<sub>4</sub>) .....

Ammonia (NH<sub>3</sub>) .....

(2 marks)

2 (c) Use the values in the table to explain how the strongest type of intermolecular force arises between two molecules of ammonia.

.....

.....

.....

.....

.....

(3 marks)

2 (d) Phosphorus is in the same group of the Periodic Table as nitrogen.

A molecule of PH<sub>3</sub> reacts with an H<sup>+</sup> ion to form a PH<sub>4</sub><sup>+</sup> ion.

Name the type of bond formed when PH<sub>3</sub> reacts with H<sup>+</sup> and explain how this bond is formed.

Type of bond .....

Explanation .....

.....

.....

(3 marks)



- 2 (e) Arsenic is in the same group as nitrogen. It forms the compound  $\text{AsH}_3$ . Draw the shape of an  $\text{AsH}_3$  molecule, including any lone pairs of electrons. Name the shape made by its atoms.

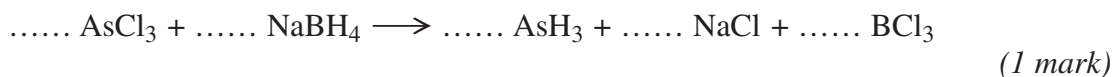
Shape

Name of shape .....  
(2 marks)

- 2 (f) The boiling point of  $\text{AsH}_3$  is  $-62.5^\circ\text{C}$  and the boiling point of  $\text{NH}_3$  is  $-33.0^\circ\text{C}$ . Suggest why the boiling point of  $\text{AsH}_3$  is lower than that of  $\text{NH}_3$ .

.....  
.....  
.....  
(1 mark)

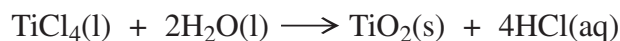
- 2 (g) Balance the following equation which shows how  $\text{AsH}_3$  can be made.



**Turn over for the next question**



- 3 Titanium(IV) oxide ( $\text{TiO}_2$ ,  $M_r = 79.9$ ) is used as a white pigment in some paints. The pigment can be made as shown in the following equation.



- 3 (a) (i) Calculate the percentage atom economy for the formation of  $\text{TiO}_2$

.....  
.....  
.....

(2 marks)

- 3 (a) (ii) In view of the low atom economy of this reaction, suggest how a company can maximise its profits without changing the reaction conditions or the production costs.

.....  
.....

(1 mark)

- 3 (b) In an experiment 165 g of  $\text{TiCl}_4$  were added to an excess of water.

- 3 (b) (i) Calculate the amount, in moles, of  $\text{TiCl}_4$  in 165 g.

.....  
.....  
.....

(2 marks)

- 3 (b) (ii) Calculate the maximum amount, in moles, of  $\text{TiO}_2$  which can be formed in this experiment.

.....  
.....

(1 mark)

- 3 (b) (iii) Calculate the maximum mass of  $\text{TiO}_2$  formed in this experiment.

.....  
.....

(1 mark)



- 3 (b) (iv) In this experiment only 63.0 g of  $\text{TiO}_2$  were produced. Calculate the percentage yield of  $\text{TiO}_2$

.....  
.....  
.....

(1 mark)

8

**Turn over for the next question**

**Turn over ►**



4 This question is about the elements in Period 3 from Na to P

4 (a) (i) Explain the meaning of the term *first ionisation energy*.

.....  
.....  
.....  
(2 marks)

4 (a) (ii) State and explain the general trend in first ionisation energies for the elements Na to P

Trend .....

Explanation .....

.....  
.....  
(3 marks)

4 (a) (iii) State which one of the elements from Na to P deviates from this general trend and explain why this occurs.

Element .....

Explanation .....

.....  
.....  
(3 marks)

4 (b) State which one of the elements from Na to P has the highest melting point and explain your answer.

Element .....

Explanation .....

.....  
.....  
(3 marks)





- 5 A metal carbonate  $\text{MCO}_3$  reacts with hydrochloric acid as shown in the following equation.



A 0.548 g sample of  $\text{MCO}_3$  reacted completely with  $30.7 \text{ cm}^3$  of  $0.424 \text{ mol dm}^{-3}$  hydrochloric acid.

- 5 (a) (i) Calculate the amount, in moles, of HCl which reacted with 0.548 g  $\text{MCO}_3$

.....  
 .....  
 (1 mark)

- 5 (a) (ii) Calculate the amount, in moles, of  $\text{MCO}_3$  in 0.548 g.

.....  
 .....  
 (1 mark)

- 5 (a) (iii) Calculate the relative formula mass of  $\text{MCO}_3$

.....  
 .....  
 (1 mark)

- 5 (b) Use your answer from part (a) (iii) to deduce the relative atomic mass of metal M and suggest its identity.  
 (If you have been unable to calculate a value for the relative formula mass of  $\text{MCO}_3$  you should assume it to be 147.6 but this is not the correct answer.)

Relative atomic mass .....

.....

.....

Identity of M .....

(2 marks)

|   |
|---|
| 5 |
|---|

Turn over ►



**SECTION B**

Answer Question 6 in the spaces provided on pages 10 to 15.

- 6** Petrol contains saturated hydrocarbons. Some of the molecules in petrol have the molecular formula  $C_8H_{18}$  and are referred to as octanes. These octanes can be obtained from crude oil by fractional distillation and by cracking suitable heavier fractions.

Petrol burns completely in a plentiful supply of air but can undergo incomplete combustion in a car engine.

- 6** (a) State the meaning of both the words *saturated* and *hydrocarbon* as applied to the term *saturated hydrocarbon*.

Name the homologous series to which  $C_8H_{18}$  belongs.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
*(3 marks)*



**6** (b) Outline the essential features of the fractional distillation of crude oil that enable the crude oil to be separated into fractions.

.....

.....

.....

.....

.....

.....

.....

.....

.....

*(4 marks)*

**Question 6 continues on the next page**

**Turn over ►**







- 6 (e) When some petrol was accidentally contaminated in 2007, the sensors in the affected cars caused a decrease in the supply of petrol to the engine.

Suggest the effect that the contaminated fuel would have on the performance of the cars.

State how the oil company might have recognised the problem before the petrol was sold.

.....

.....

.....

.....

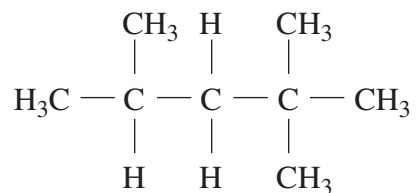
(2 marks)



- 6 (f) The molecular formula  $C_8H_{18}$  represents several structural isomers.

State what is meant by the term *structural isomers*.

Name the following structural isomer of  $C_8H_{18}$



(3 marks)

20

**END OF QUESTIONS**



**There are no questions printed on this page**

**DO NOT WRITE ON THIS PAGE  
ANSWER IN THE SPACES PROVIDED**





## GCE Chemistry Data Sheet

**Table 1**

Infrared absorption data

| Bond           | Wavenumber /cm <sup>-1</sup> |
|----------------|------------------------------|
| N-H (amines)   | 3300 – 3500                  |
| O-H (alcohols) | 3230 – 3550                  |
| C-H            | 2850 – 3300                  |
| O-H (acids)    | 2500 – 3000                  |
| C≡N            | 2220 – 2260                  |
| C=O            | 1680 – 1750                  |
| C=C            | 1620 – 1680                  |
| C-O            | 1000 – 1300                  |
| C-C            | 750 – 1100                   |


**Table 2**

<sup>1</sup>H n.m.r. chemical shift data

| Type of proton  | δ/ppm       |
|---|-------------|
| ROH   | 0.5 – 5.0   |
| RCH <sub>3</sub>  | 0.7 – 1.2   |
| RNH <sub>2</sub>  | 1.0 – 4.5   |
| R <sub>2</sub> CH <sub>2</sub>  | 1.2 – 1.4   |
| R <sub>3</sub> CH   | 1.4 – 1.6   |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{C}- \\    \quad   \\ \text{O} \quad \text{H} \end{array}$          | 2.1 – 2.6   |
| $\begin{array}{c}   \\ \text{R}-\text{O}-\text{C}- \\   \\ \text{H} \end{array}$                                  | 3.1 – 3.9   |
| RCH <sub>2</sub> Cl or Br   | 3.1 – 4.2   |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{O}-\text{C}- \\    \quad   \\ \text{O} \quad \text{H} \end{array}$ | 3.7 – 4.1   |
| $\begin{array}{c} \text{H} \\   \\ \text{R}-\text{C}=\text{C}- \\   \\ \text{H} \end{array}$                      | 4.5 – 6.0   |
| $\begin{array}{c} \text{O} \\    \\ \text{R}-\text{C}-\text{H} \end{array}$                                       | 9.0 – 10.0  |
| $\begin{array}{c} \text{O} \\    \\ \text{R}-\text{C}-\text{O}-\text{H} \end{array}$                              | 10.0 – 12.0 |

**Table 3**

<sup>13</sup>C n.m.r. chemical shift data

| Type of carbon   | δ/ppm                                 |
|--|---------------------------------------|
| $\begin{array}{c}   \\ -\text{C}- \\   \end{array}$  | 5 – 40                                |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{Cl} \text{ or } \text{Br} \\   \end{array}$ | 10 – 70                               |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{C}- \\    \quad   \\ \text{O} \end{array}$  | 20 – 50                               |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{N}- \\   \end{array}$                       | 25 – 60                               |
| $\begin{array}{c}   \\ -\text{C}-\text{O}- \\   \end{array}$                               | alcohols, ethers or esters<br>50 – 90 |
| $\begin{array}{c} \diagup \\ \text{C}=\text{C} \\ \diagdown \end{array}$                   | 90 – 150                              |
| R-C≡N  | 110 – 125                             |
|         | 110 – 160                             |
| $\begin{array}{c} \text{O} \\    \\ \text{R}-\text{C}- \end{array}$                        | esters or acids<br>160 – 185          |
| $\begin{array}{c} \text{O} \\    \\ \text{R}-\text{C}- \end{array}$                        | aldehydes or ketones<br>190 – 220     |

**ACQA** 

