AQA

Please write clearly in block capitals.

Centre number | | | | | |

Candidate number | | | | |

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________

AS
CHEMISTRY

Paper 1: Inorganic and Physical Chemistry

Friday 27 May 2016 Morning Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a calculator, which you are expected to use where appropriate.

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. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The maximum mark for this paper is 80.
- The Periodic Table/Data Sheet is provided as in insert.

Advice
- You are advised to spend about 65 minutes on **Section A** and 25 minutes on **Section B**.

Section A

Answer **all** questions in this section.

1 This question is about electron configuration.

0 1 . 1 Give the full electron configuration of an Al atom and of a Cr^{3+} ion.

[2 marks]

Al atom ____________________

Cr^{3+} ion ____________________

0 1 . 2 Deduce the formula of the ion that has a charge of 2+ with the same electron configuration as krypton.

[1 mark]

____

0 1 . 3 Deduce the formula of the compound that contains 2+ ions and 3− ions that both have the same electron configuration as argon.

[1 mark]

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

2 This question is about Period 3 of the Periodic Table.

0 2 . 1 Deduce which of Na^+ and Mg^{2+} is the smaller ion.
Explain your answer.

[2 marks]

Smaller ion ____________________

Explanation ____________________

____

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0 2 . 2 Write an equation to represent the process that occurs when the first ionisation energy for sodium is measured.

[1 mark]

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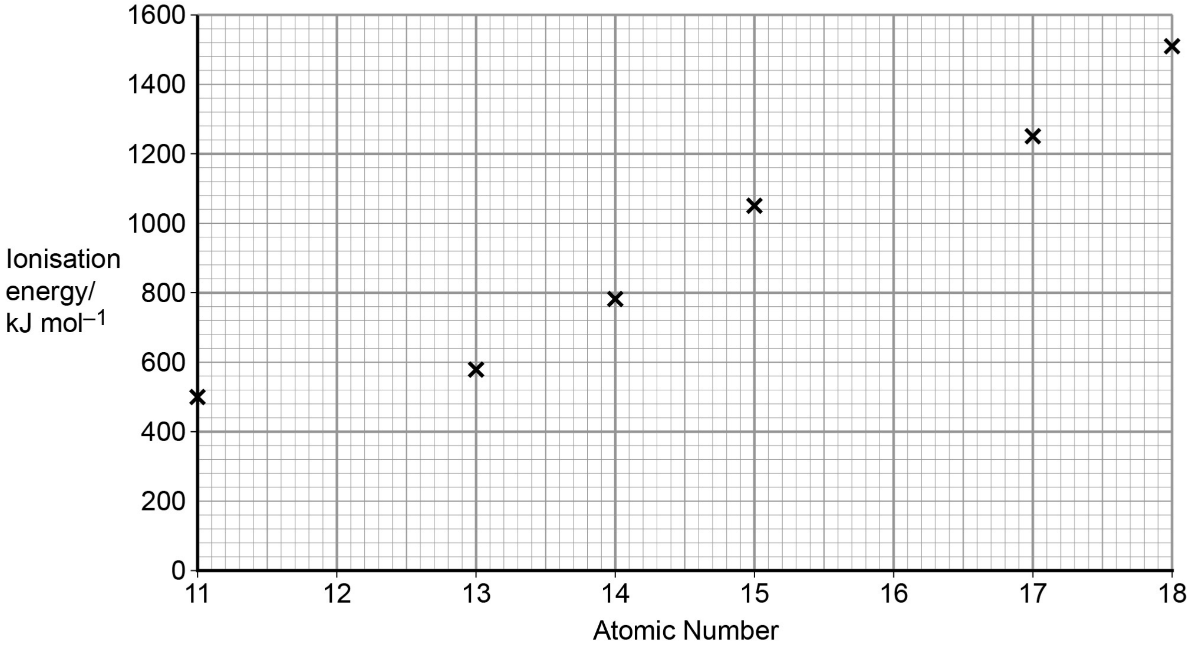
0 2 . 3 The first ionisation energies of some Period 3 elements are shown in **Figure 1**.

Figure 1



Complete **Figure 1** by plotting the approximate first ionisation energy values for magnesium and sulfur.

Explain why the first ionisation energy of sulfur is different from that of phosphorus.

[4 marks]

3 This question is about a white solid, $MHCO_3$, that dissolves in water and reacts with hydrochloric acid to give a salt.

$$MHCO_3 + HCl \rightarrow MCl + H_2O + CO_2$$

A student was asked to design an experiment to determine a value for the M_r of $MHCO_3$. The student dissolved 1464 mg of $MHCO_3$ in water and made the solution up to 250 cm^3.
25.0 cm^3 samples of the solution were titrated with 0.102 mol dm^{-3} hydrochloric acid. The results are shown in **Table 1**.

Table 1

	Rough	**1**	**2**	**3**
Initial burette reading / cm^3	0.00	10.00	19.50	29.25
Final burette reading / cm^3	10.00	19.50	29.25	38.90
Titre / cm^3	10.00	9.50	9.75	9.65

0 3 . 1 Calculate the mean titre and use this to determine the amount, in moles, of HCl that reacted with 25.0 cm^3 of the $MHCO_3$ solution.

[3 marks]

0 3 . 2 Calculate the amount, in moles, of $MHCO_3$ in 250 cm^3 of the solution.
Then calculate the experimental value for the M_r of $MHCO_3$.
Give your answer to the appropriate number of significant figures.

[3 marks]

0 3 . 3 The student identified use of the burette as the largest source of uncertainty in the experiment.

Using the same apparatus, suggest how the procedure could be improved to reduce the percentage uncertainty in using the burette.

Justify your suggested improvement.

[2 marks]

Suggestion ____

____

Justification ____

____

____

0 3 . 4 Another student is required to make up 250 cm^3 of an aqueous solution that contains a known mass of $MHCO_3$. The student is provided with a sample bottle containing the $MHCO_3$.

Describe the method, including apparatus and practical details, that the student should use to prepare the solution.

[6 marks]

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More answer space is available on page 8

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4 **Table 2** shows some data about the elements bromine and magnesium.

Table 2

Element	Melting point / K	Boiling point / K
Bromine	266	332
Magnesium	923	1383

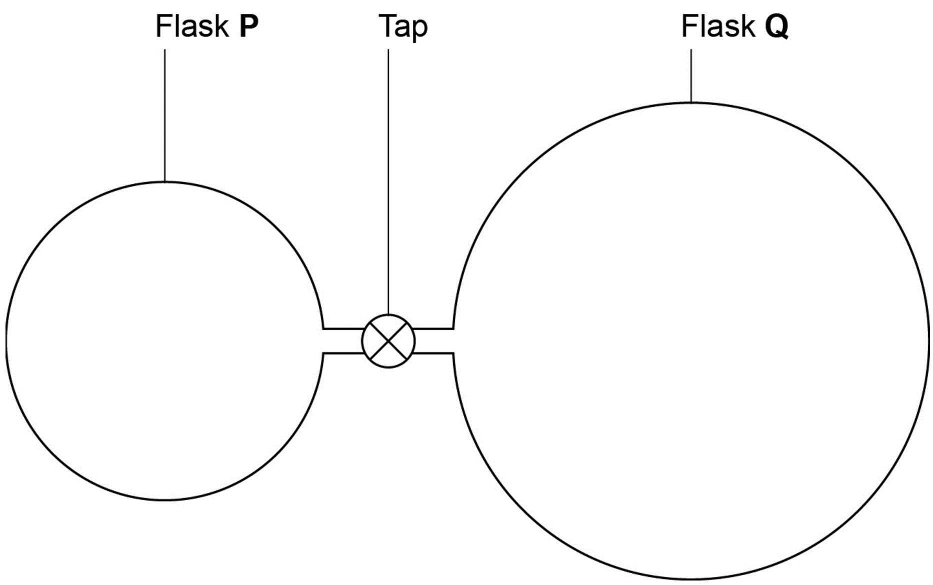
0 4 . 1 In terms of structure and bonding explain why the boiling point of bromine is different from that of magnesium. Suggest why magnesium is a liquid over a much greater temperature range compared to bromine.

[5 marks]

5 **Figure 2** represents two glass flasks, **P** and **Q**, connected via a tap.

Flask **Q** (volume = 1.00 x 10^3 cm^3) is filled with ammonia (NH_3) at 102 kPa and 300 K. The tap is closed and there is a vacuum in flask **P**.
(Gas constant R = 8.31 J K^{-1} mol^{-1})

Figure 2



0 5 . 1 Calculate the mass of ammonia in flask **Q**.
Give your answer to the appropriate number of significant figures.

[3 marks]

0 5 . 2 When the tap is opened, ammonia passes into flask **P**. The temperature decreases by 5 °C. The final pressure in both flasks is 75.0 kPa.
Calculate the volume, in cm^3, of flask **P**.

[3 marks]

Turn over for the next question

6

0 6 . 1 Explain how ions are accelerated, detected and have their abundance determined in a time of flight (TOF) mass spectrometer.

[3 marks]

0 6 . 2 Calculate the mass, in kg, of a single $^{52}Cr^{+}$ ion.
Assume that the mass of a $^{52}Cr^{+}$ ion is the same as that of a ^{52}Cr atom.

(The Avogadro constant L = 6.022×10^{23} mol^{-1})

[1 mark]

0 6 . 3 In a TOF mass spectrometer the kinetic energy (KE) of a $^{52}Cr^{+}$ ion was 1.269×10^{-13} J

Calculate the velocity of the ion using the equation.

$$KE = \frac{1}{2}mv^2$$

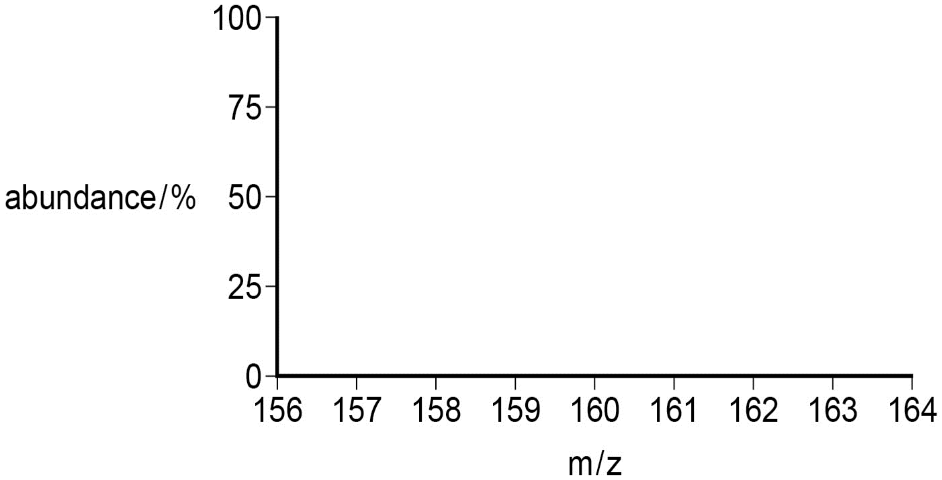
(m = mass/kg and v = velocity/ms^{-1})

[2 marks]

0 6 . 4 Bromine has two isotopes, ^{79}Br and ^{81}Br, in approximately equal abundance. In a TOF mass spectrometer bromine forms ions with formula $[Br_2]^+$

Sketch the pattern of peaks you would expect to see in the mass spectrum of a sample of bromine.

[2 marks]



0 6 . 5 A sample of xenon has A_r = 131.31. The sample consists of four isotopes. The abundances of three of the isotopes are shown in **Table 3**. The data for one of the isotopes, ^{m}Xe, is missing.

Table 3

Isotope	^{129}**Xe**	^{131}**Xe**	^{132}**Xe**	^{m}**Xe**
% abundance	28.0	25.0	27.0	To be calculated

Use the data to calculate the abundance of isotope ^{m}Xe and calculate m, the mass number of ^{m}Xe. Show your working.

[4 marks]

7 Ammonia reacts with aluminium chloride as shown by the equation:

$$NH_3 + AlCl_3 \rightarrow H_3NAlCl_3$$

0 7 . 1 Draw diagrams to illustrate the shapes of NH_3 molecules and of $AlCl_3$ molecules.

Include in your diagrams any lone pairs of electrons that influence the shape.

Indicate the values of the bond angles.

[3 marks]

0 7 . 2 Name the type of bond formed between N and Al in H_3NAlCl_3 and explain how this bond is formed.

[2 marks]

Type of bond ______________________________

Explanation ______________________________

____

____

____

0 7 . 3 Explain how the value of the Cl-Al-Cl bond angle in $AlCl_3$ changes, if at all, on formation of the compound H_3NAlCl_3

[2 marks]

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Turn over for the next question

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8 A student oxidised a solution of hydrochloric acid with a few drops of sodium chlorate(I) solution. The reaction mixture effervesced and turned pale green. The gas formed bleached universal indicator paper.

0 8 . 1 Write a half-equation for the oxidation of chloride ions.

[1 mark]

____

0 8 . 2 Write a half-equation for the reduction of chlorate(I) ions to chlorine in acidic conditions.

[1 mark]

____

0 8 . 3 Write an overall equation for the redox reaction of chlorate(I) ions with hydrochloric acid.

[1 mark]

____

0 8 . 4 A solution of sodium chlorate(I) was added to a colourless solution of potassium iodide.
Suggest what is observed.

Explain the reaction that leads to this observation.

[3 marks]

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9

0 9 . 1 A student was given a powder made from a mixture of anhydrous barium chloride and anhydrous magnesium chloride. The student dissolved 1.056 g of the powder in water in a conical flask and added an excess of sulfuric acid. A white precipitate formed and was filtered off, washed and dried. The mass of this solid was 0.764 g.

Identify the white precipitate and calculate the percentage, by mass, of magnesium chloride in the powder.

[4 marks]

Turn over for the next question

Section B

Answer **all** questions in the spaces provided

Only **one** answer per question is allowed.
For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

You may do your working out in the blank spaces around the questions but this will not be marked.
Do **not** use additional sheets for this working.

1 0 Which element is in the d-block of the Periodic Table?

[1 mark]

A Selenium

B Antimony

C Tantalum

D Lead

1 1 Which species contains an element with an oxidation state of +4?

[1 mark]

A NO_2^+

B ClO_3^-

C H_2SO_3

D PCl_5

1 2 There are 392 mol of pure gold in a bar measuring 10 cm by 10 cm by 40 cm.
What is the density of gold in kg dm^{-3}?

[1 mark]

A 193 ⬭

B 19.3 ⬭

C 1.93 ⬭

D 0.193 ⬭

1 3 Ions of two isotopes of iron are

$^{53}Fe^{2+}$ $^{56}Fe^{2+}$

Which statement is correct?

[1 mark]

A The ions of both the isotopes have the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$ ⬭

B The ions of both the isotopes contains 26 neutrons ⬭

C $^{53}Fe^{2+}$ has fewer protons than $^{56}Fe^{2+}$ ⬭

D After acceleration to the same kinetic energy $^{56}Fe^{2+}$ will move more slowly than $^{53}Fe^{2+}$ ⬭

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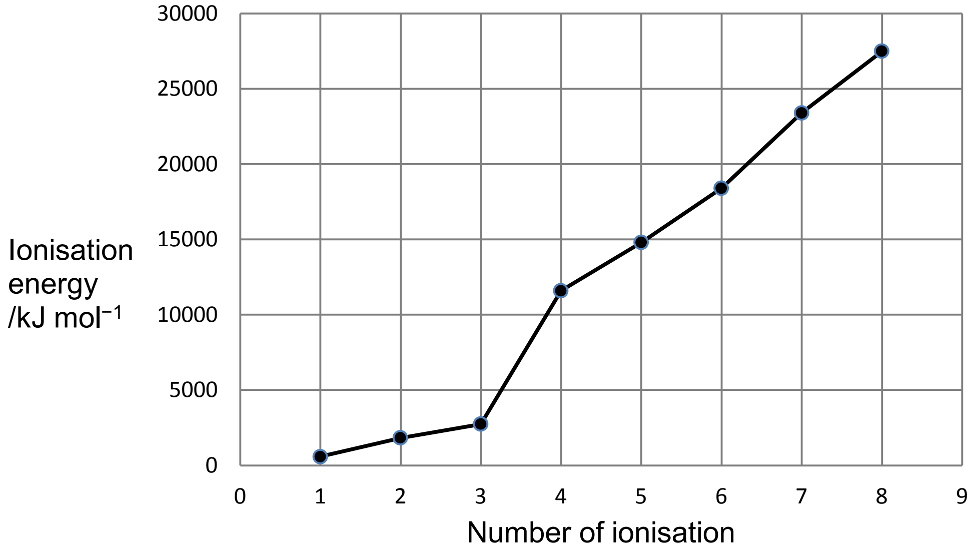
1 4 The successive ionisation energies for element X are shown in **Figure 3**.

Figure 3



Which element is X?

[1 mark]

A Nitrogen

B Phosphorus

C Aluminium

D Boron

1 5 Which of these decreases down Group 2?

[1 mark]

A First ionisation energy

B Atomic radius

C Number of protons

D Reactivity with water

Refer to the unbalanced equation below when answering questions **16** and **17**.

$$K_2Cr_2O_7 + 3H_2C_2O_4 + \_H_2SO_4 \rightarrow Cr_2(SO_4)_3 + \_H_2O + 6CO_2 + K_2SO_4$$

1 6 In the balanced equation the mole ratio for sulfuric acid to water is

[1 mark]

A 1 : 4

B 1 : 2

C 4 : 7

D 4 : 9

1 7 What is the reducing agent in this reaction?

[1 mark]

A H^+

B $C_2O_4^{2-}$

C K^+

D $Cr_2O_7^{2-}$

1 8 Which substance exists as a macromolecule?

[1 mark]

A Cu

B SiO_2

C P_4O_{10}

D MgO

1 9 A pale brown mixture of NO_2 and N_2O_4 is allowed to reach equilibrium in a sealed gas syringe according to the following equation.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

When the plunger is pushed further into the syringe the pressure increases and the mixture becomes paler in colour.

When the syringe is placed in a hot oven the mixture becomes darker in colour.

Which of the following statements is correct?

[1 mark]

A NO_2 is brown and the forward reaction is exothermic.

B NO_2 is brown and the forward reaction is endothermic.

C NO_2 is colourless and the forward reaction is exothermic.

D NO_2 is colourless and the forward reaction is endothermic.

2 0 Which molecule has the largest dipole?

[1 mark]

A ClF_3 ⬭

B BF_3 ⬭

C SF_6 ⬭

D CF_4 ⬭

2 1 In a molecule of a hydrocarbon, the fraction by mass of carbon is $\frac{9}{11}$

What is the empirical formula of the hydrocarbon?

[1 mark]

A CH ⬭

B CH_3 ⬭

C C_3H_8 ⬭

D C_5H_{12} ⬭

2 2 30 cm^3 of xenon are mixed with 20 cm^3 of fluorine. The gases react according to the following equation. Assume that the temperature and pressure remain constant.

$$Xe(g) + F_2(g) \rightarrow XeF_2(g)$$

What is the final volume of gas after the reaction is complete?

[1 mark]

A 50 cm^3

B 40 cm^3

C 30 cm^3

D 20 cm^3

2 3 Which of the following solutions would react exactly with a solution containing 0.0500 mol sulfuric acid?

[1 mark]

A 50.0 cm^3 of 1.00 mol dm^{-3} KOH

B 100.0 cm^3 of 2.00 mol dm^{-3} KOH

C 100.0 cm^3 of 2.00 mol dm^{-3} $Ba(OH)_2$

D 50.0 cm^3 of 1.00 mol dm^{-3} $Ba(OH)_2$

2 4 In a car airbag, sodium azide (NaN_3) decomposes to form sodium metal and nitrogen gas.

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

The sodium metal then reacts with potassium nitrate to produce more nitrogen gas.

$$10Na(s) + 2KNO_3(s) \rightarrow N_2(g) + 5Na_2O(s) + K_2O(s)$$

If 2.00 mol of sodium azide react in this way, how many molecules of N_2 will be formed?
(The Avogadro constant L = 6.022×10^{23} mol^{-1})

[1 mark]

A 2.41×10^{24} ⬭

B 1.93×10^{24} ⬭

C 1.81×10^{24} ⬭

D 9.63×10^{23} ⬭

END OF QUESTIONS

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