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![AQA logo]

Surname _____

Other Names _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

AS
CHEMISTRY

Paper 1: Inorganic and Physical Chemistry

7404/1

Friday 27 May 2016   **Morning**

Time allowed: 1 hour 30 minutes

For this paper you must have:

- **the Periodic Table/Data Sheet, provided as an insert (enclosed)**
- **a ruler with millimetre measurement**
- **a calculator, which you are expected to use where appropriate.**

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

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.**

0 2

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.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

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]

0 5

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

$\boxed{0}\boxed{2}$. $\boxed{1}$ **Deduce which of Na$^+$ and Mg^{2+} is the smaller ion.**
Explain your answer. [2 marks]

Smaller ion

Explanation

**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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[Turn over]

8

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]

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0 9
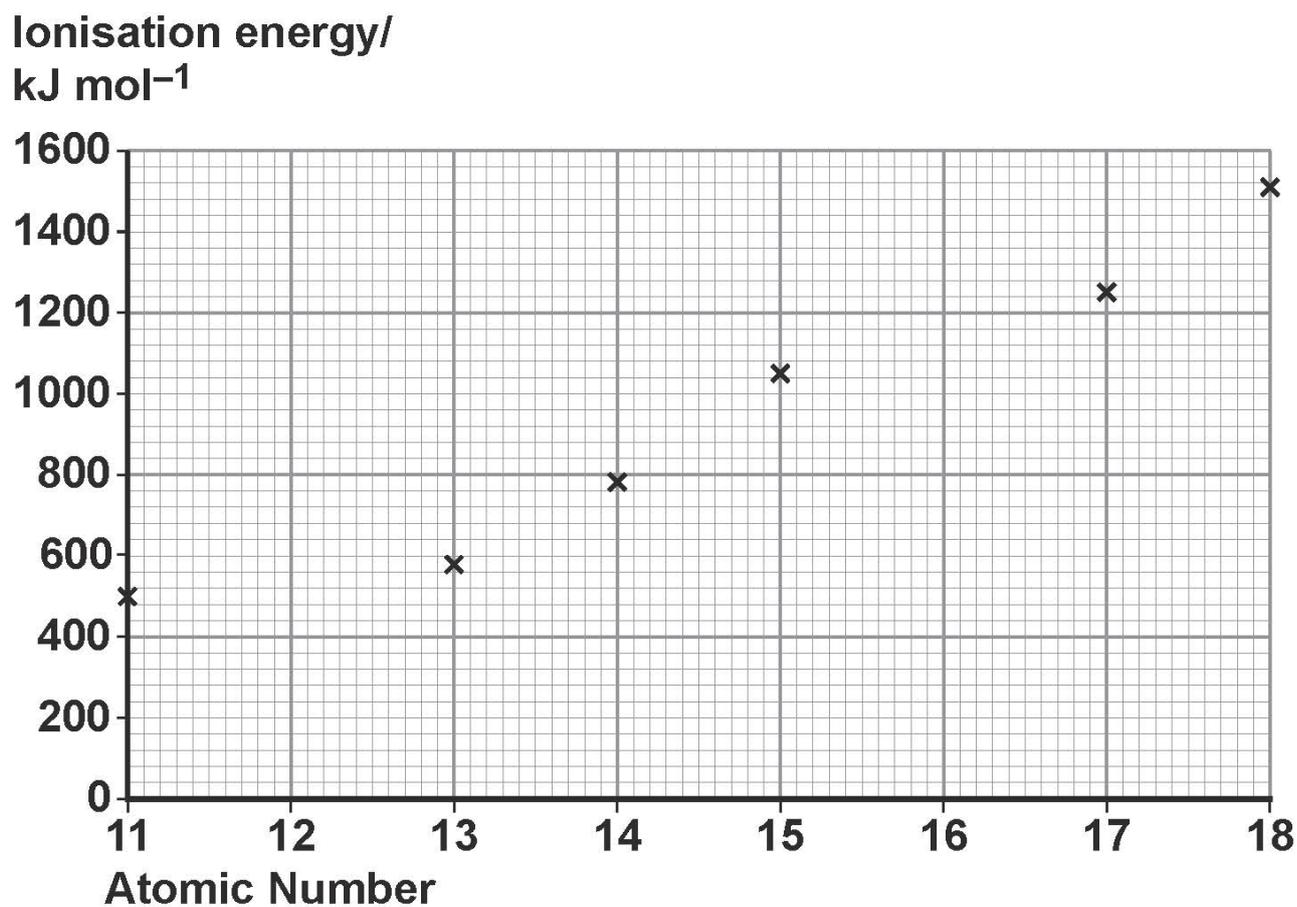
3   This question is about a white solid, $MHCO_3$, that dissolves in water and reacts with hydrochloric acid to give a salt.

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

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]

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[Turn over]

12

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]

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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 _____

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[Turn over]

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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15

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]

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1 6

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

Flask P   Tap   Flask Q
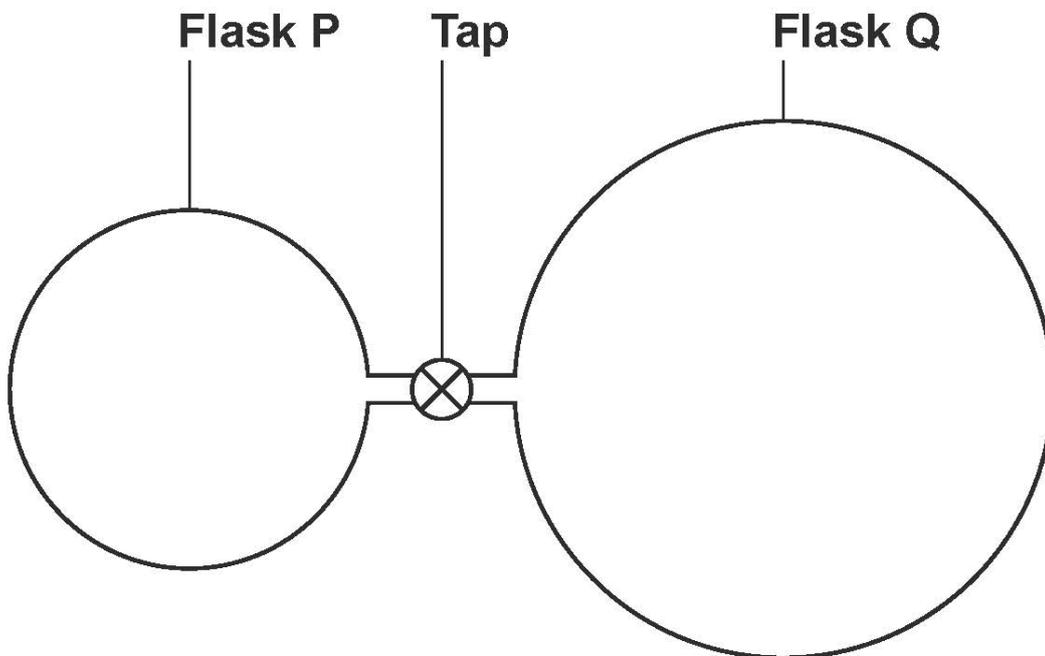
0 5 . 1 **Calculate the mass of ammonia in flask Q.**
Give your answer to the appropriate number
of significant figures. [3 marks]

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[Turn over]

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

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

[3 marks]

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[Turn over]

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 x 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 x 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]

_____

_____

$\boxed{0}\,\boxed{6}$. $\boxed{4}$ 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]
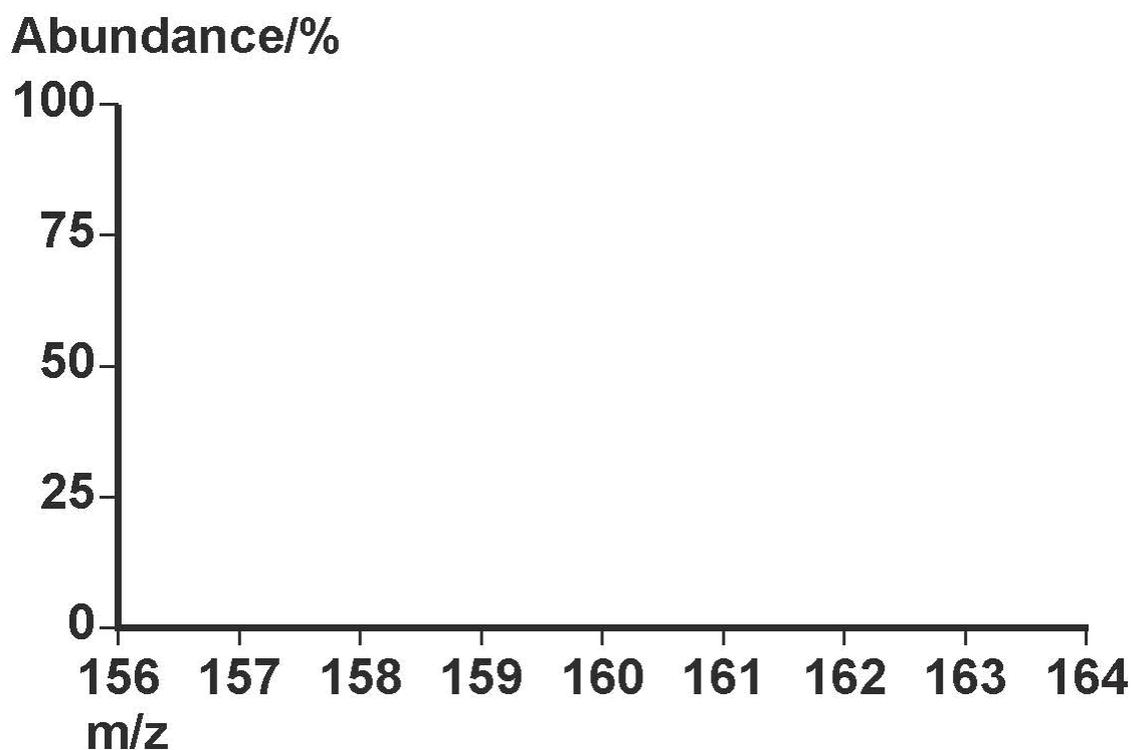
Abundance/%

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, ^mXe, is missing.

TABLE 3

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

Use the data to calculate the abundance of isotope ^mXe and calculate m, the mass number of ^mXe. Show your working. [4 marks]

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[Turn over]

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

$$NH_3 + AlCl_3 \rightarrow H_3NAlCl_3$$
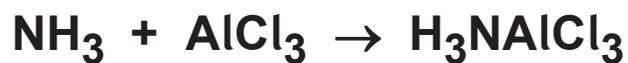
0 7 . 1 Draw diagrams to illustrate the shapes of NH_3 molecules and of $AlCl_3$ molecules.

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 _____

_____

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[Turn over]

2 7

07.3 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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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.

29

0 8 . 1 **Write a half-equation for the oxidation of chloride ions. [1mark]**

0 8 . 2 **Write a half-equation for the reduction of chlorate(l) ions to chlorine in acidic conditions. [1 mark]**

0 8 . 3 **Write an overall equation for the redox reaction of chlorate(l) ions with hydrochloric acid. [1 mark]**

2 9

0 8 . 4 A solution of sodium chlorate(l) 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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3 0

9

$\boxed{0}\ \boxed{9}$. $\boxed{1}$ 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]

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[Turn over]

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
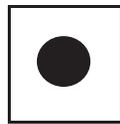
WRONG METHODS
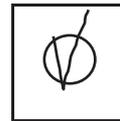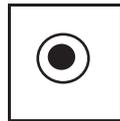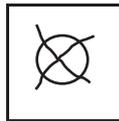
If you want to change your answer you must cross out your original answer as shown.
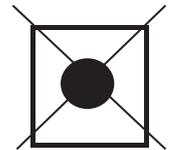
If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.
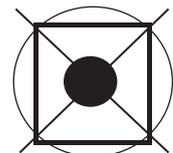
You may do your working out in the blank spaces around the questions but this will not be marked. Do NOT use additional sheets for this working.

[Turn over]

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

[Turn over]

36

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.

Ionisation energy/
kJ mol^{-1}

Number of ionisations
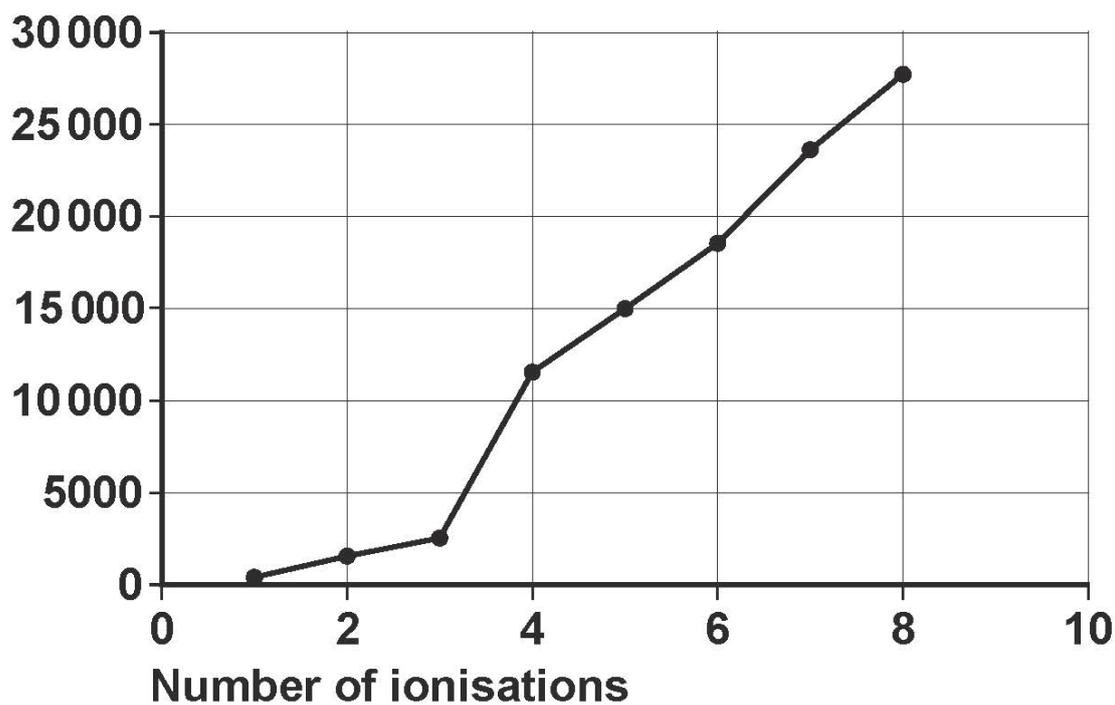
39

Which element in X? [1 mark]

A   **Nitrogen**

B   **Phosphorous**

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**

[Turn over]

3 9

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

$$K_2Cr_2O_7 + 3H_2C_2O_4 + \_H_2SO_4 \rightarrow Cr_2(SO_4)_3 + \_H_2O + 6CO_2 + K_2SO_4$$
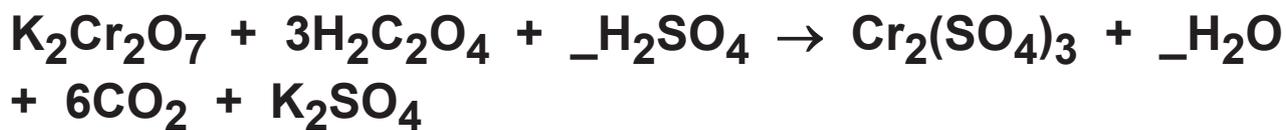
1 6   **In the balanced equation the mole ratio for sulfuric acid to water is**   **[1 mark]**

○   **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

[Turn over]

4 1

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.**

$2NO_2(g) \rightleftharpoons N_2O_4(g)$
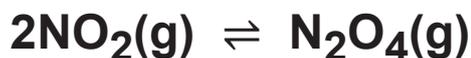
When the plunger is pushed further into the syringe the pressure increases and the mixture becomes paler in colour.

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]
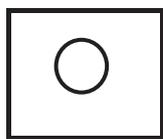
A ClF_3
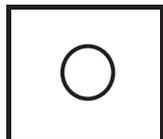
B BF_3
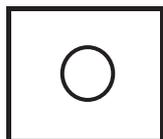
C SF_6
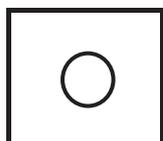
D CF_4

[Turn over]

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

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.

$$Xe(g) + F_2(g) \rightarrow XeF_2(g)$$
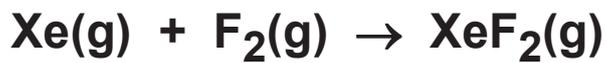
What is the final volume of gas after the reaction is complete?

A   50 cm^3

B   40 cm^3

C   30 cm^3

D   20 cm^3

[Turn over]

4 5

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)$_2$

4 6

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.

$$10Na(s) + 2KNO_3(s) \rightarrow N_2(g) + 5Na_2O(s) + K_2O(s)$$
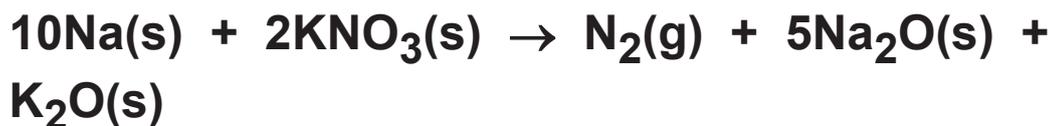
If 2.00 mol of sodium azide react in this way, how many molecules of N_2 will be formed?

(The Avogadro constant $L = 6.022 \times 10^{23}$ 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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There are no questions printed on this page

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