AQA

AS
CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

Tuesday 16 May 2023   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 scientific 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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
Section B	
TOTAL	

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

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.

0 1 This question is about the elements in Period 3.

0 1 . 1 Give the full electron configuration of the element in Period 3 with the highest first ionisation energy.

[1 mark]

_____

0 1 . 2 Give an equation, including state symbols, to represent the process that occurs when the second ionisation energy of sodium is measured.

[1 mark]

_____

_____

0 1 . 3 **Table 1** shows some successive ionisation energies for an element in Period 3.

Table 1

Ionisation number	1	2	3	4	5	6	7	8
Ionisation energy / kJ mol^{-1}	1000	2260	3390	4540	6990	8490	27 100	31 700

Identify the Period 3 element.

Explain your answer.

[3 marks]

Element _____

Explanation _____

_____

_____

5

0 2 This question is about the elements in Group 2.

0 2 . 1 Describe the structure and bonding in magnesium.

[2 marks]

0 2 . 2 State the trend in the atomic radius of the elements down Group 2 from Mg to Ba

Give a reason for this trend.

[2 marks]

Trend

Reason

0 2 . 3 Give an equation, including state symbols, for the reaction of magnesium with steam.

State **two** observations for this reaction.

[3 marks]

Equation

Observation 1

Observation 2

Question 2 continues on the next page

Turn over ▶

0 2 . 4 The sulfates of the elements in Group 2 from Mg to Ba have different solubilities.

State the formula of the least soluble of these sulfates.

Give a use for this sulfate.

[2 marks]

Formula _____

Use _____

0 2 . 5 A sample of strontium is made up of only three isotopes: ^{86}Sr, ^{87}Sr and ^{88}Sr
This sample contains 83.00% by mass of ^{88}Sr
This sample of strontium has A_r = 87.73

Calculate the percentage abundance of each of the other two isotopes in this sample.

[4 marks]

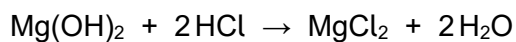% abundance ^{87}Sr = _____

% abundance ^{86}Sr = _____

0 2 . 6 $Mg(OH)_2$ is used as an antacid to treat indigestion.
A student does an experiment to determine the percentage by mass of $Mg(OH)_2$ in an indigestion tablet.

40.0 cm³ of 0.200 mol dm⁻³ HCl (an excess) is added to 0.200 g of a powdered tablet.
The mixture is swirled thoroughly.
All of the $Mg(OH)_2$ reacts with HCl as shown.

$$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$$

The amount of HCl remaining after this reaction is determined by titration with 0.100 mol dm⁻³ $NaOH$

29.25 cm³ of 0.100 mol dm⁻³ $NaOH$ are needed.

Calculate the percentage by mass of $Mg(OH)_2$ in the indigestion tablet.

[6 marks]

Percentage by mass _____

19

Turn over ▶

0 3   A student uses this method to prepare a standard solution of sodium carbonate.

1. Weigh a clean, dry, empty container on a balance that reads to 2 decimal places.
2. Add about 2.5 g of solid sodium carbonate to the container.
3. Tip the solid into a beaker.
4. Add approximately 100 cm^3 of distilled water to the beaker and stir until all the solid has dissolved.
5. Pour the solution into a 250 cm^3 volumetric flask.
6. Add distilled water until the top of the meniscus is level with the graduation mark.

0 3 . 1   Suggest **three** improvements to this method.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

0 3 . 2   A different student uses the correct method to prepare
250 cm^3 of sodium carbonate solution in a volumetric flask.
The uncertainty for the volumetric flask is ±0.20 cm^3

Calculate the percentage uncertainty in the volume of this sodium carbonate solution.
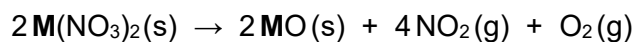
[1 mark]

Percentage uncertainty _____

4

0 4   **M** is a Group 2 metal that forms the nitrate $M(NO_3)_2$
0.320 g of **M**$(NO_3)_2$ is heated strongly and decomposes completely.

$$2\,M(NO_3)_2(s) \rightarrow 2\,MO(s) + 4\,NO_2(g) + O_2(g)$$

The mixture of gases formed has a volume of 225 cm³ at 450 °C and 101 000 Pa

Determine the M_r of **M**$(NO_3)_2$

Identify **M**.

The gas constant, $R = 8.31$ J K⁻¹ mol⁻¹

[5 marks]

M_r of **M**$(NO_3)_2$ _____

Identity of **M** _____

5

Turn over ▶

0 5 This question is about the shapes of molecules.

Discuss the difference between the shapes of CF_4 and XeF_4
In your answer you should:
- name the shape of each molecule
- explain the shape of each molecule
- explain the bond angle(s) in each molecule.

[6 marks]

_____

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6

Turn over ▶

0 6 This question is about halogens and halide ions.

0 6 . 1 Explain why the electronegativity of the halogens decreases down the group.

[2 marks]

Concentrated sulfuric acid reacts with solid sodium chloride and with solid sodium bromide.

0 6 . 2 State **one** similarity in, and **one** difference between, these reactions.

[2 marks]

Similarity

Difference

0 6 . 3 Solid sodium iodide reacts with concentrated sulfuric acid to form hydrogen sulfide.

Give a half-equation to show the oxidation of iodide ions.

Give a half-equation to show the reduction of concentrated sulfuric acid to hydrogen sulfide.

Use your half-equations to deduce an overall equation for this reaction.

[3 marks]

Half-equation 1

Half-equation 2

Overall equation

7

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED**

Turn over ▶

0 7 This question is about time of flight (TOF) mass spectrometry.

0 7 . 1 Compound **X** is dissolved in a polar, volatile solvent and is ionised by electrospray ionisation.
Each ion is accelerated so that it has a kinetic energy of 1.36×10^{-16} J

The kinetic energy of an ion is given by the equation $KE = \frac{1}{2}mv^2$
where:

KE = kinetic energy / J
m = mass / kg
v = speed / m s^{-1}

The time of flight along the 0.750 m flight tube is 2.48×10^{-5} s

Determine the mass, in g, of one mole of **X**.

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

[5 marks]

Mass of one mole of **X** _____ g

A mixture of gases is analysed using TOF mass spectrometry.
The mixture contains argon, carbon dioxide, nitrogen and oxygen.
The mixture is ionised by electron impact.

0 7 . 2 State the meaning of the term electron impact ionisation.

[1 mark]

0 7 . 3 Identify the ion formed from this mixture that reaches the detector last.

Justify your answer.

[2 marks]

Ion that reaches detector last _____

Justification _____

0 7 . 4 State how the ions are detected, and how the abundance of each ion is measured, in a TOF mass spectrometer.

[2 marks]

How ions are detected _____

How abundance is measured _____

10

Turn over for the next question

Turn over ▶

0 8 This question is about the equilibrium mixture formed when **A** and **B** react.

$$A(aq) + 2B(aq) \rightleftharpoons C(aq) \qquad \Delta H = -32 \text{ kJ mol}^{-1}$$
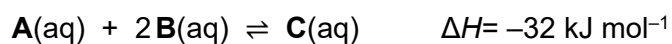
0 8 . 1 A solution containing 0.60 mol of **A** is added to a solution containing 0.60 mol of **B**. The amount of **C** formed at equilibrium is 0.28 mol

Deduce the amounts, in moles, of **A** and **B** in this mixture at equilibrium.

[2 marks]

Amount of **A** _____ mol

Amount of **B** _____ mol

0 8 . 2 Give an expression for the equilibrium constant (K_c) for this reaction.

[1 mark]

K_c

0 8 . 3 The temperature of the equilibrium mixture is decreased.

Predict the effect, if any, on the value of K_c
Give a reason for your prediction.

[3 marks]

Prediction _____

Reason _____

_____

_____

0 8 . 4 In another mixture at equilibrium

$[A]$ = 0.48 mol dm^{-3}
$[C]$ = 0.62 mol dm^{-3}

For this reaction, the equilibrium constant K_c = 7.8 mol^{-2} dm^6

Calculate $[B]$ at equilibrium.
Give your answer to the appropriate number of significant figures.

[3 marks]

$[B]$ _____ mol dm^{-3}

9

Turn over ▶

Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.
For each question 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 in the blank space around each question but this will not be marked.
Do **not** use additional sheets for this working.

| 0 | 9 | Which atom contains the most neutrons? |

[1 mark]

A ^{54}Cr ⬭

B ^{55}Mn ⬭

C ^{57}Fe ⬭

D ^{58}Ni ⬭

Use this information for Questions **10** and **11**.

A student completes a titration to determine the concentration of ethanoic acid in vinegar.

25.0 cm^3 of vinegar are transferred to a conical flask using a pipette.
A few drops of phenolphthalein are added to the conical flask.
Sodium hydroxide solution is added from a burette to the conical flask.
The titration is repeated until concordant results are obtained.

1 0 Which suggestion improves the accuracy of the titres?

[1 mark]

A Rinsing the conical flask with vinegar between each titration. ⬭

B Rinsing the conical flask with sodium hydroxide solution between each titration. ⬭

C Rinsing the conical flask with water between each titration. ⬭

D Not rinsing the conical flask between each titration. ⬭

1 1 Which suggestion decreases the percentage uncertainty in the mean titre?

[1 mark]

A Use a more dilute solution of sodium hydroxide in the burette. ⬭

B Use a more dilute solution of vinegar. ⬭

C Rinse the inside of the conical flask with distilled water during each titration. ⬭

D Rinse the tip of the burette with distilled water near the end point in each titration. ⬭

1 2 Which reaction has the highest percentage atom economy for the production of hydrogen?

[1 mark]

A $LiH + H_2O \rightarrow LiOH + H_2$ ⬭

B $CO + H_2O \rightarrow CO_2 + H_2$ ⬭

C $2 Al + 3 H_2O \rightarrow Al_2O_3 + 3 H_2$ ⬭
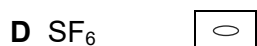
D $CH_4 + H_2O \rightarrow CO + 3 H_2$ ⬭

Turn over for the next question

Turn over ▶

1 3 Which molecule has a permanent dipole?

[1 mark]

A NCl_3 ⬭

B CCl_4 ⬭

C PF_5 ⬭

D SF_6 ⬭

1 4 Which molecule can accept an electron pair during the formation of a coordinate bond?

[1 mark]

A NH_3 ⬭

B $AlCl_3$ ⬭

C SiH_4 ⬭

D PCl_3 ⬭
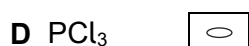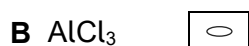
1 5 Which reaction has an enthalpy change equal to the standard enthalpy of formation of potassium oxide?

[1 mark]

A $4K(s) + O_2(g) \rightarrow 2K_2O(s)$ ⬭

B $2K(s) + O(g) \rightarrow K_2O(s)$ ⬭

C $2K^+(g) + O^{2-}(g) \rightarrow K_2O(s)$ ⬭
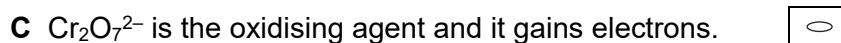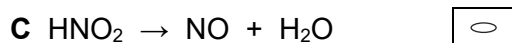
D $2K(s) + \frac{1}{2}O_2(g) \rightarrow K_2O(s)$ ⬭
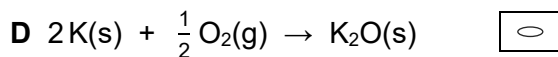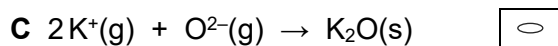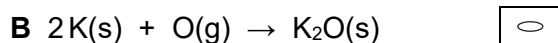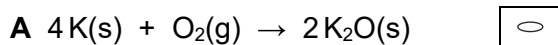
1 6 In which species is chlorine in its highest oxidation state?

[1 mark]

A ClF_2^- ☐

B ClO_4^- ☐

C ClO_2 ☐

D ClF_3 ☐

1 7 Which statement about this redox reaction is correct?

$$3\,Sn^{2+}(aq)\ +\ Cr_2O_7^{2-}(aq)\ +\ 2\,H^+(aq)\ \rightarrow\ 2\,Cr^{3+}(aq)\ +\ 3\,SnO_2(s)\ +\ H_2O(l)$$

[1 mark]

A Sn^{2+} is the oxidising agent and it gains electrons. ☐

B Sn^{2+} is the reducing agent and it gains electrons. ☐

C $Cr_2O_7^{2-}$ is the oxidising agent and it gains electrons. ☐

D $Cr_2O_7^{2-}$ is the reducing agent and it gains electrons. ☐
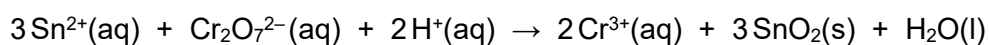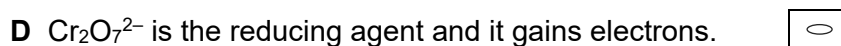
1 8 Which incomplete half-equation is balanced by adding two H^+ ions and one electron to the left-hand side?

[1 mark]

A $CH_3CHO\ \rightarrow\ CH_3CH_2OH$ ☐

B $VO^{2+}\ \rightarrow\ V^{3+}\ +\ H_2O$ ☐

C $HNO_2\ \rightarrow\ NO\ +\ H_2O$ ☐

D $O_2\ \rightarrow\ H_2O_2$ ☐
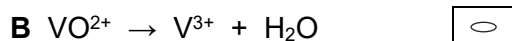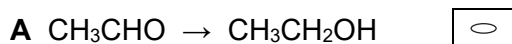
Turn over for the next question

Turn over ▶

Use this information for Questions **19** to **23**.

A student completes some test-tube reactions on five solutions, **P**, **Q**, **R**, **S** and **T**.
The student completes each test on separate samples of each solution.
Observations are shown in the table.

Solution	Test 1 Add a few drops of $H_2SO_4(aq)$	Test 2 Add $HNO_3(aq)$ then a few drops of $AgNO_3(aq)$	Test 3 Add a few drops of $NaOH(aq)$	Test 4 Add a few drops of $Cl_2(aq)$
P	White precipitate	Cream precipitate	No visible change	Orange solution
Q	Effervescence	Effervescence and white precipitate	No visible change	No visible change
R	No visible change	No visible change	White precipitate	No visible change
S	White precipitate		No visible change	Dark brown solution
T	No visible change	White precipitate	White precipitate	No visible change

Use the information in the table to answer Questions **19** to **23**.

1 9 Which solution contains carbonate ions?

[1 mark]

A Solution **P** ⬭

B Solution **Q** ⬭

C Solution **R** ⬭

D Solution **S** ⬭

2 0 What could be the identity of the compound in solution **P**?

[1 mark]

A $MgBr_2$ ⬭

B $BaBr_2$ ⬭

C $MgCl_2$ ⬭

D $BaCl_2$ ⬭

2 1 What observation is expected in **Test 2** for solution **S**?

[1 mark]

A No visible change ⬯

B Effervescence ⬯

C White precipitate ⬯

D Pale yellow precipitate ⬯

2 2 In **Test 2**, the mixture formed by solution **S** is filtered.

Which substance is present in the filtrate?

[1 mark]

A $AgBr$ ⬯

B AgI ⬯

C $Ba(NO_3)_2$ ⬯

D $Mg(NO_3)_2$ ⬯

2 3 What could be the identity of the compound in solution **T**?

[1 mark]

A $MgCl_2$ ⬯

B $BaCl_2$ ⬯

C $MgBr_2$ ⬯

D $BaBr_2$ ⬯

15

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED**

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

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