Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level
CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

Tuesday 5 June 2018 Afternoon Time allowed: 2 hours

Materials

For this paper you must have:
- the Periodic Table/Data Booklet, 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 the 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 marks for questions are shown in brackets.
- The maximum mark for this paper is 105.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

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

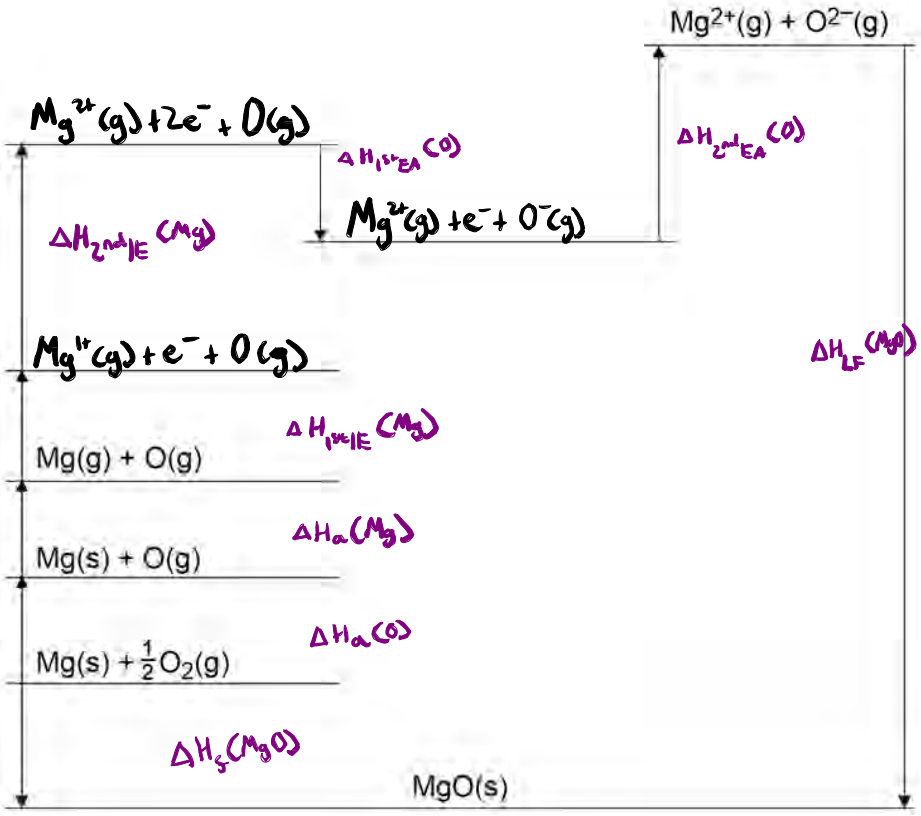
0 1 This question is about lattice enthalpies.

0 1 . 1 **Figure 1** shows a Born–Haber cycle for the formation of magnesium oxide.

Complete **Figure 1** by writing the missing symbols on the appropriate energy levels.

[redacted]]

Figure 1



0 1 . 2 **Table 1** contains some thermodynamic data.

Table 1

	Enthalpy change / kJ mol^{-1}
Enthalpy of formation for magnesium oxide	–602
Enthalpy of atomisation for magnesium	+150
First ionisation energy for magnesium	+736
Second ionisation energy for magnesium	+1450
Bond dissociation enthalpy for oxygen	+496
First electron affinity for oxygen	–142
Second electron affinity for oxygen	+844

Calculate a value for the enthalpy of lattice formation for magnesium oxide.

A → B
↘ ↗
C

$\Delta H_f(MgO) = \Delta H_a(Mg) + \frac{1}{2}\Delta H_{BD}(O_2) + \Delta H_{1^{st}IE}(Mg)$ ①

$+ \Delta H_{2^{nd}IE}(Mg) + \Delta H_{1^{st}EA}(O) + \Delta H_{2^{nd}EA}(O) + \Delta H_{LF}(MgO)$

$-602 = 150 + \frac{1}{2}(496) + 736 + 1450 - 142 + 844 + \Delta H_{LF}(MgO)$

$-602 = 3286 + \Delta H_{LF}(MgO)$ ①

$\Delta H_{LF}(MgO) = -602 - 3286 = -3888\ kJ\ mol^{-1}$ ①

Enthalpy of lattice formation −3888 kJ mol^{-1}

6

Turn over for the next question

0 2 Nitrogen and hydrogen were mixed in a 1:3 mole ratio and left to reach equilibrium in a flask at a temperature of 550 K. The equation for the reaction between nitrogen and hydrogen is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

0 2 . 1 When equilibrium was reached, the total pressure in the flask was 150 kPa and the mole fraction of $NH_3(g)$ in the mixture was 0.80

Calculate the partial pressure of each gas in this equilibrium mixture.

Partial pressure = total pressure × mole fraction

$pp\ NH_3 = 150 \times 0.8 = 120\ kPa$

$1 - 0.8 = 0.2$ 1:3

$0.2 \div 4 = 0.05$ 0.05 : 0.15

$pp\ N_2 = 150 \times 0.05 = 7.5\ kPa$

$pp\ H_2 = 150 \times 0.15 = 22.5\ kPa$

Partial pressure of nitrogen 7.5 kPa

Partial pressure of hydrogen 22.5 kPa

Partial pressure of ammonia 120 kPa

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

$$K_p = \frac{(pp\ NH_3)^2}{(pp\ N_2)(pp\ H_2)^3}$$

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

$K_p = \frac{pp\ \text{Products}^{\text{molar ratio}}}{pp\ \text{reactants}^{\text{molar ratio}}}$

0 2 . 3 In a different equilibrium mixture, under different conditions, the partial pressures of the gases are shown in **Table 2**.

Table 2

Gas	Partial pressure / kPa
N_2	1.20×10^2
H_2	1.50×10^2
NH_3	1.10×10^3

Calculate the value of the equilibrium constant (K_p) for this reaction and give its units.

$$K_p = \frac{(pp\,NH_3)^2}{(pp\,N_2)(pp\,H_2)^3} = \frac{(1.1\times10^3)^2}{1.2\times10^2 \times (1.5\times10^2)^3} = 2.99\times10^{-3}$$

$$= \frac{kPa^2}{kPa \times kPa^3} = \frac{kPa^2}{kPa^4} = kPa^{-2}$$

K_p 2.99×10^{-3} Units kPa^{-2}

0 2 . 4 The enthalpy change for the reaction is –92 kJ mol^{-1}

State the effect, if any, of an increase in temperature on the value of K_p for this reaction.
Justify your answer.

$K_p = \frac{\text{Products}}{\text{reactants}}$]

Effect on K_p Lower

Justification The forward reaction is exothermic
the equilibrium will move left
This is to reduce the temperature (opposing the change)

9

0 3 The equation for the reaction between ammonia and oxygen is shown.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -905 \text{ kJ mol}^{-1}$$

Some standard entropies are given in **Table 3**.

Table 3

Gas	$S^{\ominus}$ / J K^{-1} mol^{-1}
$NH_3(g)$	193
$O_2(g)$	205
$NO(g)$	211
$H_2O(g)$	189

0 3 . 1 Calculate the entropy change for the reaction between ammonia and oxygen.

$\Delta S = \sum S_{products} - \sum S_{reactants}$

$= (6(189) + 4(211)) - (5(205) + 4(193))$

$= 181 \text{ J K}^{-1}\text{mol}^{-1}$

Entropy change 181 J K^{-1} mol^{-1}

0 3 . 2 Calculate a value for the Gibbs free-energy change (Δ*G*), in kJ mol^{-1}, for the reaction between ammonia and oxygen at 600 °C

(If you were unable to obtain an answer to Question **03.1**, you should assume that the entropy change is 211 J K^{-1} mol^{-1}. This is **not** the correct answer.)

$\Delta G = \Delta H - T\Delta S$

$\Delta H = -905\ kJ mol^{-1}$

$T = 600°C = 600 + 273\ K = 873\ K$

$\Delta S = 181\ J K^{-1} mol^{-1} = 181 \div 1000\ kJ K^{-1} mol^{-1}$

$= 0.181\ kJ K^{-1} mol^{-1}$

$\Delta G = -905 - (873 \times 0.181)$

$= -1063\ kJ mol^{-1}$

Δ*G* −1063 kJ mol^{-1}

0 3 . 3 The reaction between ammonia and oxygen was carried out at a higher temperature.

Explain how this change affects the value of Δ*G* for the reaction.

$\Delta G = \Delta H - T\Delta S$ (↓ ΔG, ↑ TΔS)

ΔG becomes more negative

As ΔS is positive for this reaction

Question 3 continues on the next page

0 3 . 4 Platinum acts as a heterogeneous catalyst in the reaction between ammonia and oxygen. It provides an alternative reaction route with a lower activation energy.

Describe the stages of this alternative route.

The reactants are adsorped to the platinum
Reactions weaken the bonds in the reactants, allowing products to form
The products are released from the catalyst (desorption)

0 3 . 5 Deduce the change in oxidation state of nitrogen, when NH_3 is oxidised to NO

N H_3
−3 +1x3
+3

NO
+2 −2

−3 to +2 (+5)

0 3 . 6 When ammonia reacts with oxygen, nitrous oxide (N_2O) can be produced instead of NO

Give an equation for this reaction.

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

$2NH_3 + 2O_2 \rightarrow N_2O + 3H_2O$

11

0 4 This question is about s-block metals.

0 4 . 1 Give the full electron configuration for the calcium ion, Ca^{2+}

Ca = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

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

0 4 . 2 Explain why the second ionisation energy of calcium is lower than the second ionisation energy of potassium.

Ca, K Ca^+, K^+

In Ca^+, the Valence electron is in a higher energy orbital

In Ca^+, there is more electron shielding on the Valence electron

0 4 . 3 Identify the s-block metal that has the highest first ionisation energy.

electron shielding Li, Be

nuclear charge

Beryllium (Be)

0 4 . 4 Give the formula of the hydroxide of the element in Group 2, from Mg to Ba, that is least soluble in water.

Magnesium hydroxide

Mg^{2+} OH^-

$Mg(OH)_2$

Question 4 continues on the next page

0 4 . 5 A student added [redacted] of [redacted] dm^3 barium chloride solution to [redacted] of [redacted] sodium sulfate solution.
The student filtered off the precipitate and collected the filtrate.

Give an ionic equation for the formation of the precipitate.
Show by calculation which reagent is in excess.
Calculate the total volume of the other reagent which should be used by the student so that the filtrate contains only one solute.

$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$

Ionic equation $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

$n = c \times v$

moles of $BaCl_2 = 0.25 \times \frac{6}{1000} = 1.5 \times 10^{-3}$ moles

moles of $Na_2SO_4 = 0.15 \times \frac{8}{1000} = 1.2 \times 10^{-3}$ moles

Reagent in excess Barium chloride

Total volume of other reagent $(1.5 \times 10^{-3}) - (1.2 \times 10^{-3}) = 0.3 \times 10^{-3}$ moles

$V = \frac{n}{c}$ $V = \frac{0.3 \times 10^{-3}}{0.15} = 0.01\ dm^3 = 10\ cm^3$

0 4 . 6 A sample of strontium has a relative atomic mass of [redacted] and consists of three isotopes, [redacted], [redacted] and [redacted]
In this sample, the ratio of abundances of the isotopes ^{86}Sr : ^{87}Sr is [redacted]

State why the isotopes of strontium have identical chemical properties.
Calculate the percentage abundance of the ^{88}Sr isotope in this sample.

[redacted]

Why isotopes of strontium have identical chemical properties

They have the same number of electrons and protons

1:1 ^{86}Sr : ^{87}Sr x

$A_r = 87.7$

$$\frac{86x + 87x + 88(100-2x)}{100} = 87.7$$

$$86x + 87x + 88(100-2x) = 8770$$

$$86x + 87x + 8800 - 176x = 8770$$

$$-3x + 8800 = 8770$$

$$8800 - 8770 = 3x$$

$$30 = 3x$$

$$x = 10$$

$$\text{abundance} = 100 - 2x = 100 - 2(10)$$

$$= 100 - 20$$

$$= 80\%$$

Percentage abundance of ^{88}Sr 80% %

0 4 . 7 A time of flight (TOF) mass spectrum was obtained for a sample of barium that contains the isotopes ^{136}Ba, ^{137}Ba and ^{138}Ba
The sample of barium was ionised by electron impact.

Identify the ion with the longest time of flight.

[redacted]

$^{138}Ba^+$

Turn over ►

0 4 . 8 A [redacted] ion travels through the flight tube of a TOF mass spectrometer with a kinetic energy of [redacted]
This ion takes [redacted] s to reach the detector.

[redacted] where m = mass (kg) and v = speed (m s^{-1})

The Avogadro constant, [redacted] mol^{-1}

Calculate the length of the flight tube in metres.
Give your answer to the appropriate number of significant figures.

[redacted]

$m = \frac{0.137}{6.022 \times 10^{23}} = 2.275 \times 10^{-25}$ kg (1)

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

$v^2 = \frac{2KE}{m} = \frac{2 \times 3.65 \times 10^{-16}}{2.275 \times 10^{-25}} = 3.2088 \times 10^9$ (1)

$v = \sqrt{3.2088 \times 10^9} = 5.6696 \times 10^4$ (1)

$d = vxt = 5.6696 \times 10^4 \times 2.71 \times 10^{-5} = 1.536$ m (1)

≈ 1.54 m (1)

Length of flight tube 1.54 m

18

0 5 Hydrochloric acid is a strong acid and ethanoic acid is a weak acid.

0 5 . 1 State the meaning of the term [redacted].

[1 mark]

An acid which completely dissociates in solution

0 5 . 2 In an experiment, [redacted] of [redacted] hydrochloric acid are added to [redacted] of [redacted] barium hydroxide solution.

Calculate the pH of the solution that forms at 30 °C

K_w = [redacted] at 30 °C

Give your answer to 2 decimal places.

[redacted]

$n = C \times V \quad C = \frac{n}{V}$

$n HCl = 0.1 \times 0.01035 = 1.035 \times 10^{-3}\ mol = n H^+$

$n Ba(OH)_2 = 0.15 \times 0.025 = 3.75 \times 10^{-3}\ mol$ (1)

$3.75 \times 10^{-3} \times 2 = n OH^- = 7.5 \times 10^{-3}\ mol$ (1)

$7.5 \times 10^{-3} - 1.035 \times 10^{-3} = 6.465 \times 10^{-3}\ mol$ (1)

$[OH^-] = \frac{6.465 \times 10^{-3}}{0.03535} = 0.182885\ mol\,dm^{-3}$ (1)

total volume

$K_w = [H^+][OH^-]$

$[H^+] = \frac{K_w}{[OH^-]} = \frac{1.47 \times 10^{-14}}{0.182885} = 8.0378 \times 10^{-14}$ (1)

$pH = -\log_{10}[H^+] = -\log_{10}(8.0378 \times 10^{-14})$

$= 13.09$ (1)

pH 13.09

0 5 . 3 The pH of water at 30 °C is 6.92

Give the reason why water is neutral at this temperature.

$H_2O \rightleftharpoons H^+ + OH^-$

$[H^+] = [OH^-]$

0 5 . 4 Identify the oxide that could react with water to form a solution with pH = 2

Tick (✓) **one** box.

Al_2O_3 ☐

Na_2O ☐

Metal oxide + Water → basic solution

SiO_2 ☐ Semi metal, unreactive with water

SO_2 ☑ Non-metal oxide + Water → acidic solution

0 5 . 5 Give the expression for the acid dissociation constant (K_a) for ethanoic acid (CH_3COOH).

$K_a = \dfrac{[H^+][CH_3COO^-]}{[CH_3COOH]}$

$K_a = \dfrac{[H^+][X^-]}{[HX]}$

0 5 . 6 A buffer solution contains [redacted] mol of sodium ethanoate dissolved in [redacted] of [redacted] mol dm^{-3} ethanoic acid at 25 °C
A sample of [redacted] of [redacted] dm^{-3} hydrochloric acid is added to this buffer solution.

Calculate the pH of the solution formed.

For ethanoic acid, K_a = [redacted] at 25 °C

$n = c \times V$

$n CH_3COOH = 0.07 \times 0.5 = 0.035 mol$

$n HCl = 2 \times 0.005 = 0.01 mol$ (1)

$n CH_3COO^- = 0.025 - 0.01 = 0.015$ (1)

$n CH_3COOH = 0.035 + 0.01 = 0.045$ (1)

$K_a = \dfrac{[H^+][CH_3COO^-]}{[CH_3COOH]}$

$[H^+] = \dfrac{K_a [CH_3COOH]}{[CH_3COO^-]} = \dfrac{1.76 \times 10^{-5} \times \frac{0.045}{0.505}}{\frac{0.015}{0.505}} = 5.28 \times 10^{-5}$ (1)

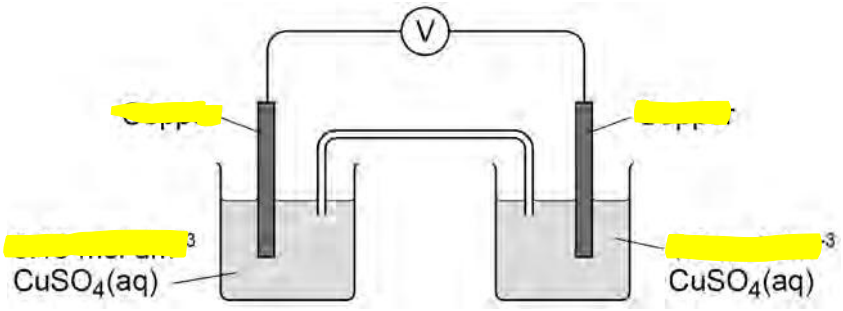
$pH = -\log_{10}[H^+] = -\log_{10} 5.28 \times 10^{-5} = 4.28$ (1)

pH 4.28

15

0 6 A student set up the cell shown in **Figure 2**.

Figure 2



The student recorded an initial voltage of [redacted] at 25 °C

0 6 . 1 Explain how the salt bridge provides an electrical connection between the two solutions.

It allows for the movement of ions through it

0 6 . 2 The standard electrode potential for the Cu^{2+}/Cu electrode is

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$ [redacted]

Calculate the electrode potential of the left-hand electrode in **Figure 2**.

$0.16 = 0.34 - E_L$ $E_L = 0.34 - 0.16 = +0.18V$

potential of left electrode

Electrode potential +0.18 V

0 6 . 3 Both electrodes contain a strip of copper metal in a solution of aqueous Cu^{2+} ions.

State why the left-hand electrode does **not** have an electrode potential of [redacted]

temperature, pressure, concentration

The left hand electrode does not have a concentration of 1.0 mol dm^{-3}

0 6 . 4 Give the conventional representation for the cell in **Figure 2**.
Include all state symbols.

$Cu(s), Cu^{2+}(aq)$

R1011O1R

$Cu(s) | Cu^{2+}(aq) || Cu^{2+}(aq) | Cu(s)$

0 6 . 5 When the voltmeter is replaced by a bulb, the EMF of the cell in **Figure 2** decreases over time to 0 V

Suggest how the concentration of copper(II) ions in the left-hand electrode changes when the bulb is alight.
Give **one** reason why the EMF of the cell decreases to 0 V

Change in concentration of copper(II) ions in the left-hand electrode

Increases

Reason why the EMF decreases to 0 V The Concentrations of Cu^{2+} become equal in both of the half cells

6

Turn over for the next question

0 7 . 1 When anhydrous aluminium chloride reacts with water, solution **Y** is formed that contains a complex aluminium ion, **Z**, and chloride ions.

Give an equation for this reaction.

$AlCl_3 + 6H_2O \rightarrow [Al(H_2O)_6]^{3+} + 3Cl^-$

0 7 . 2 Give an equation to show how the complex ion **Z** can act as a Brønsted–Lowry acid with water.

$[Al(H_2O)_6]^{3+} + H_2O \rightarrow [Al(H_2O)_5(OH)]^{2+} + H_3O^+$

0 7 . 3 Describe **two** observations you would make when an excess of sodium carbonate solution is added to solution **Y**.
Give an equation for the reaction. In your equation, include the formula of each complex aluminium species.

Observation 1 White precipitate

Observation 2 Effervescence

Equation

$2[Al(H_2O)_6]^{3+} + 3CO_3^{2-} \rightarrow 2[Al(H_2O)_3(OH)_3] + 3CO_2 + 3H_2O$

0 7 . 4 Aqueous potassium hydroxide is added, until in excess, to solution **Y**.

Describe **two** observations you would make.
For each observation give an equation for the reaction that occurs.
In your equations, include the formula of each complex aluminium species.

Observation 1 White precipitate

Equation 1

$[Al(H_2O)_6]^{3+} + 3OH^- \rightarrow [Al(H_2O)_3(OH)_3] + 3H_2O$

Observation 2 Precipitate redissolves

Equation 2

$[Al(H_2O)_3(OH)_3] + OH^- \rightarrow [Al(H_2O)_2(OH)_4]^- + H_2O$

9

Turn over for the next question

0 8 This question is about sodium and some of its compounds.

0 8 . 1 Use your knowledge of structure and bonding to explain why sodium bromide has a melting point that is higher than that of sodium, and higher than that of sodium iodide.

[redacted]

3 stages:

1. Describe the bonding in Na
2. Describe the bonding in NaI and NaBr
3. Comparison and conclusion

Na has metallic bonding. It has a giant lattice structure in which the metal ions are attracted to delocalised electrons.

NaI and NaBr have ionic bonding. They have a giant lattice structure in which there is electrostatic attraction between oppositely charged ions.

Ionic bonding is stronger than metallic bonding. The Br^- ion is smaller than the I^- ion, so the ionic bonding in NaBr is stronger than in NaI. Therefore NaBr has a higher melting point than both NaI and Na.

0 8 . 2 When [redacted] of sodium were added to [redacted] of water at [redacted] a gas was produced.

Give an equation for the reaction that occurs.
Calculate the volume, in cm^3, of the gas formed at [redacted]

The gas constant, R = [redacted] K^{-1}

[redacted]

Equation $Na + H_2O \rightarrow NaOH + \frac{1}{2}H_2$ (1)

$n Na = \frac{m}{Ar} = \frac{0.25}{23.0} = 0.0109\ mol$ (1)

$n H_2 = 0.0109 \div 2 = 5.45 \times 10^{-3}\ mol$ (1)

$pV = nRT$ (1)

$p = 101\ kPa = 101000\ Pa \quad T = 25°C = 25 + 273\ K = 298\ K$

$V = \frac{nRT}{p} = \frac{5.45 \times 10^{-3} \times 8.31 \times 298}{101000}$ (1)

$= 1.34 \times 10^{-4}\ m^3$

$= 1.34 \times 10^{-4} \times 100^3\ cm^3$

$= 134\ cm^3$ (1)

Volume 134 cm^3

0 8 . 3 Calculate the concentration, in mol dm^{-3}, of sodium ions in the solution produced in the reaction in Question **08.2**.

$Na + H_2O \rightarrow NaOH + \frac{1}{2}H_2$

[redacted]

$C = \frac{n}{V} = \frac{0.0109}{0.5} = 0.0218\ mol\ dm^{-3}$

$500\ cm^3 = \frac{500}{1000}\ dm^3 = 0.5\ dm^3$

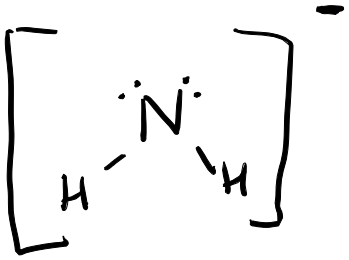
Concentration 0.0218 mol dm^{-3}

0 8 . 4 Sodium reacts with ammonia to form the compound $NaNH_2$ that contains the NH_2^- ion.

Draw the shape of the NH_2^- ion.
Include any lone pairs of electrons that influence the shape.

Predict the bond angle.
Justify your prediction.

Shape



Bond angle 104.5°

Justification Lone pair / lone pair repulsion is the strongest electron repulsion and bonding pair / bonding pair is the weakest. Electron pairs repel each other as much as possible, pushing the bonding pairs closer together, reducing the bond angle.

[17]

Turn over for the next question

0 9 This question is about vanadium compounds and ions.

0 9 . 1 Use data from **Table 4** to identify the species that can be used to reduce VO_2^+ ions to VO^{2+} in aqueous solution and no further.
Explain your answer.

Table 4

Electrode half-equation	$E^\ominus$ / V
$VO_2^+(aq) + 2H^+(aq) + e^- \rightarrow VO^{2+}(aq) + H_2O(l)$	+1.00
$VO^{2+}(aq) + 2H^+(aq) + e^- \rightarrow V^{3+}(aq) + H_2O(l)$	+0.34
$Cl_2(aq) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76

Reagent Fe^{2+}

Explanation $E^\ominus VO_2^+ > E^\ominus Fe^{2+} > E^\ominus VO^{2+}$

0 9 . 2 Give the oxidation state of vanadium in $[VO(H_2O)_5]^{2+}$

$+2 = V - 2$

$-2 \quad 0$

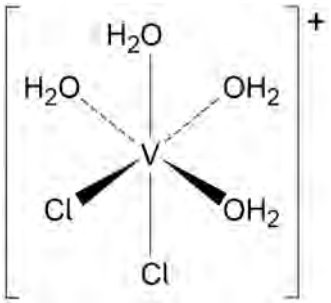
$2+2 = V$

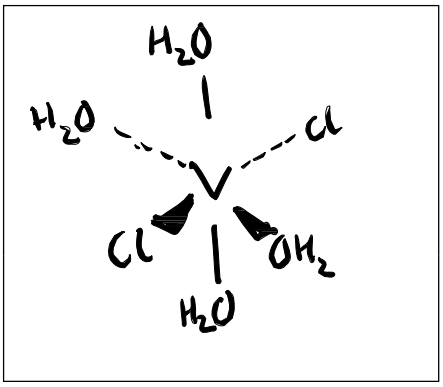
$= 4$

$+4$

0 9 . 3 The $[V(H_2O)_4Cl_2]^+$ ion exists as two isomers. One isomer is shown.

Draw the structure of the other isomer and state the type of isomerism.





Type of isomerism E-Z Cis-trans

0 9 . 4 Heating NH_4VO_3 produces vanadium(V) oxide, water and one other product.

Give an equation for the reaction. Thermal decomposition

$2NH_4VO_3 \rightarrow V_2O_5 + H_2O + 2NH_3$

0 9 . 5 Vanadium(V) oxide is the catalyst used in the manufacture of sulfur trioxide.

Give **two** equations to show how the catalyst is used and regenerated.

$V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$

$V_2O_4 + \frac{1}{2}O_2 \rightarrow V_2O_5$

7

10.1 A student added [redacted] of hydrated sodium carbonate ($Na_2CO_3.xH_2O$) to [redacted] of [redacted] dm^3 hydrochloric acid in a beaker and stirred the mixture.
After the reaction was complete, the resulting solution was transferred to a volumetric flask, made up to [redacted] dm^3 with deionised water and mixed thoroughly.
Several [redacted] portions of the resulting solution were titrated with [redacted] aqueous sodium hydroxide. The mean titre was [redacted] dm^3 of aqueous sodium hydroxide.

Calculate the value of x in $Na_2CO_3.xH_2O$
Show your working.
Give your answer as an integer.

[redacted]

$n = c \times V$

$n HCl = 0.25 \times 0.2 = 0.05 \text{ mol}$ — (1)

$n NaOH = 0.15 \times 0.0266 = 3.99 \times 10^{-3} \text{ mol}$ – in $25 cm^3$

$\frac{250}{25} = 10$ $\quad 3.99 \times 10^{-3} \times 10 = 3.99 \times 10^{-2} \text{ mol}$ – in $250 cm^3$

excess $n HCl = 3.99 \times 10^{-2} \text{ mol}$ – (1) in $250 cm^3$ as $HCl : NaOH = 1:1$

reaction $n HCl = 0.05 - 3.99 \times 10^{-2} = 0.0101 \text{ mol}$ (1)

$HCl : Na_2CO_3 = 2:1$

$n Na_2CO_3.xH_2O = 0.0101 \div 2 = 5.05 \times 10^{-3} \text{ mol}$ (1)

$M_r = \frac{m}{n} = \frac{0.627}{5.05 \times 10^{-3}} = 124.16$ (1) — $M_r Na_2CO_3 + x M_r H_2O$

$M_r Na_2CO_3 = (2 \times 23) + 12 + (3 \times 16) = 106$

$x M_r H_2O = 124.16 - 106 = 18.16$ (1)

$x = \frac{18.16}{M_r H_2O} = \frac{18.16}{18} \approx 1$ (1)

Value of x 1

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END OF QUESTIONS

There are no questions printed on this page

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