

Name of the Student: _____

Max. Marks : 27 Marks

Time : 27 Minutes

Q1.

This question is about vanadium ions.

The table below shows some standard electrode potential values.

	E° / V
$\text{O}_2(\text{g}) + 4 \text{H}^+(\text{aq}) + 4 \text{e}^- \rightarrow 2 \text{H}_2\text{O}(\text{l})$	+1.23
$\text{VO}_2^+(\text{aq}) + 2 \text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{VO}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+1.00
$\text{VO}^{2+}(\text{aq}) + 2 \text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+0.34
$\text{V}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{V}^{2+}(\text{aq})$	-0.26
$\text{Fe}^{2+}(\text{aq}) + 2 \text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
$\text{Zn}^{2+}(\text{aq}) + 2 \text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
$\text{V}^{2+}(\text{aq}) + 2 \text{e}^- \rightarrow \text{V}(\text{s})$	-1.20
$\text{Mg}^{2+}(\text{aq}) + 2 \text{e}^- \rightarrow \text{Mg}(\text{s})$	-2.38

- (a) Use the data in the table above to explain why Zn reduces an aqueous solution of VO_2^+ ions to V^{2+} ions, but does not reduce it any further.

(2)

- (b) Identify the species in the table above that can reduce an aqueous solution of VO_2^+ to V

(1)

- (c) Two half-cells $\text{Fe}^{2+}(\text{aq}) / \text{Fe}(\text{s})$ and $\text{VO}^{2+}(\text{aq}) / \text{V}^{3+}(\text{aq})$ are connected.

Calculate the EMF of this cell.

Give the conventional representation for this cell.

Give a half-equation for the reaction that occurs at the negative electrode.

EMF _____

Cell representation

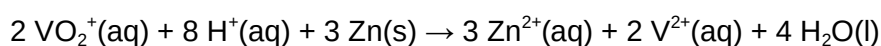
Half-equation

(3)

- (d) 0.151 g of impure NH_4VO_3 is added to dilute sulfuric acid to form a solution containing aqueous VO_2^+ ions.

All the VO_3^- ions are converted to VO_2^+ ions.

These VO_2^+ ions are reduced to aqueous V^{2+} ions by reaction with an excess of zinc.

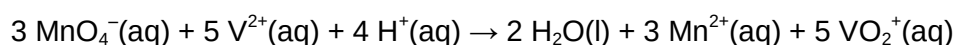


The excess of zinc is removed by filtration and washed.

The filtrate, containing the V^{2+} ions, is titrated with a $0.0200 \text{ mol dm}^{-3}$ solution of acidified KMnO_4

29.43 cm^3 of KMnO_4 solution are needed to oxidise all the V^{2+} ions to VO_2^+ ions.

The ionic equation for the reaction of MnO_4^- ions with V^{2+} ions is



Calculate the percentage purity of the NH_4VO_3
Give your answer to 3 significant figures.

Percentage purity _____

(4)

(Total 10 marks)

Q2.

This question is about metals and their compounds.

- (a) State why the atomic radius of calcium is greater than the atomic radius of magnesium.

(1)

- (b) Magnesium reacts with steam.

Give an equation, including state symbols, for this reaction.

(1)

- (c) Similar-sized pieces of barium and magnesium are added to separate 100 cm³ samples of dilute sulfuric acid. In each case the sulfuric acid is in excess.

The barium reacts quickly at first. After a few minutes the reaction stops, even though there is still some unreacted barium in the flask.

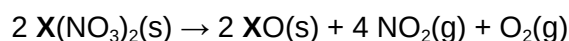
The magnesium reacts more slowly than the barium, but the reaction continues until all the magnesium has reacted.

Explain why

- the barium initially reacts more quickly than the magnesium
- the barium reaction stops before all the barium has reacted.

(3)

- (d) A metal nitrate $\text{X}(\text{NO}_3)_2$ completely decomposes when heated.



A 0.832 g sample of $\text{X}(\text{NO}_3)_2$ decomposes on heating to produce a total of 348 cm³ of gas at 298 K and 100 kPa

Deduce the identity of metal X.

The ideal gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Identity of metal X _____

(6)

- (e) Sodium reacts with aluminium and hydrogen to form solid NaAlH_4

Give an equation for this reaction.

Suggest why NaAlH_4 has a high melting point.

Equation

Suggestion _____

(3)

- (f) Give the equation for the reaction between H_3PO_4 and an excess of NaOH

(1)

Lithium is an important metal used in cells to power mobile phones.

- (g) In a lithium cell, a lithium cobalt oxide electrode and a lithium electrode are used.

Give the equation for the reaction that occurs at the positive electrode.

(1)

- (h) Commercial electrochemical cells can be rechargeable or non-rechargeable.

State why lithium cells can be recharged.

(1)

(Total 17 marks)