Calculate the Percentage Of Fe^{2+} ions In a Sample Of Ferrous Sulphate. Prepare a Solution Of the Given Sample Having Strength Exactly Equal to 14.0 g/litre. Provided M/100 $KMnO_4$

Chemical Equations

Molecular Equation

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$
$$2FeSO_4 + H_2SO_4 + [O] \longrightarrow Fe_2(SO_4)_3 + H_2O\ ] \times 5$$

$$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + Fe_2(SO_4)_3$$

Ionic equation

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$
$$Fe^{2+} \longrightarrow Fe^{3+} + e^-\ ] \times 5$$

$$MnO_4^- + 8H^+ + 5Fe^{2+} \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

Theory

Since the given sample contains partially oxidized ferrous sulphate, it contains both ferrous ions, Fe^{2+}(unoxidised) and ferric ions Fe^{3+} (oxidised). The strength of partially oxidised sample is known. The solution of partially oxidised $FeSO_4$ of known strength is titrated against standard $KMnO_4$ solution to determine the molarity and strength of the unoxidised ferrous sulphate. From this the percentage oxidation of the sample can be calculated.

Indicator

$KMnO_4$ is a self-indicator.

End Point

Colourless to permanent pink ($KMnO_4$ in burette).

Procedure

1. Weigh exactly 3.50 g of the given sample of ferrous sulphate on a watch glass and dissolve in water to prepare exactly 250 ml of solution using a 250 ml measuring flask. Rinse and fill the pipette with prepared ferrous sulphate solution and pipette out 20.0 ml of it in a washed titration flask.
2. Rinse and fill the burette with the M/100 $KMnO_4$ solution.

3. Add one test-tube (~ 20 ml) full of dilute sulphuric acid (- 2 M) to the solution in titration flask.
4. Note the initial reading of the burette.
5. Now add $KMnO_4$ solution from the burette till a permanent light pink colour is imparted to the solution in the titration flask on addition of a last single drop of $KMnO_4$ solution.
6. Note the final reading of the burette.
7. Repeat the above steps 4—5 times to get three concordant reading.

Observations

Weight of watch glass =……. g
Weight of watch glass + Mohr's salt =……..g
Weight of mixture = 3.50 g
Volume of solution prepared = 250 ml
Molarity of $KMnO_4$ solution =M/100
Volume of oxalate solution taken for each titration = 20.0 ml.

S. No.	*Initial reading of the burette*	*Final reading of the burette*	*Volume of the $KMnO_4$ solution used*
1.	—	—	— ml
2.	—	—	— ml
3.	—	—	— ml
4.	—	—	— ml

Concordant volume = x ml (say).

Calculations

Volume of M/100 $KMnO_4$ solution required for the oxidation of 20.0 ml of the prepared ferrous sulphate solution = x ml.
From the equations it is clear that 2 moles of $KMnO_4$ react with 10 moles of ferrous sulphate.

$$\therefore \quad \frac{M_{KMnO_4} \times V_{KMnO_4}}{M_{FeSO_4} \times V_{FeSO_4}} = \frac{2}{10}$$

$$\frac{\frac{1}{100} \times x}{M_{FeSO_4} \times 20.2} = \frac{2}{10}$$

$$M_{FeSO_4} = \frac{1 \times x \times 10}{100 \times 20.0 \times 2} = \frac{x}{400}$$

Molarity of Fe^{2+} ions = Molarity of ferrous sulphate = $\frac{x}{400}$

Strength of Fe^{2+} ions = Molarity × Formula mass

$$= \frac{x}{400} \times 56 \text{ g/litre}$$

$$= y \text{ g/litre (say)}$$

Percentage of Fe^{2+} ions in the given sample of ferrous sulpha

$$= \frac{\text{Strength of } Fe^{2+} \text{ ions in g/litre}}{\text{Strength of ferrous sulphate in g/li}}$$

$$= \frac{y}{14} \times 100.$$

Instructions for the Preparation of Solutions

Provide the following :

1. $KMnO_4$ solution (1.58 g/litre)
2. $FeSO_4.7H_2O$ crystals
3. 4N H_2SO_4.

Exercises

1. Prepare a standard solution of M/50 $FeSO_4(NH_4)_2SO_4.6H_20$ (Mohr's salt). Using this solution find out the molarity of the given solution of KMn04.
2. Prepare M/50 solution of oxalic acid. Using this solution find out the molarity and strength of the given solution of $KMnO_4$.

3. Prepare a solution of ferrous ammonium sulphate containing exactly 4.9 g of the salt per 250 ml of solution. Using this solution determine the concentration of $KMnO_4$ in g/litre in the given solution.
4. Prepare M/20 solution of oxalic acid. Using this solution find out percentage purity of impure sample of $KMnO_4$, 3.5 g of which have been dissolved per litre.
5. Prepare M/50 ferrous ammonium sulphate solution. With its help, find out the percentage purity of impure sample of $KMnO_4$, 3.6 g of which have been dissolved per litre.
6. Prepare M/20 oxalic acid solution. You are provided two solutions of $KMnO_4$, A and B. Find out volumetrically which solution, (A or B) is more concentrated. Report the strength of more concentrated solution in g/litre.
7. You are provided with a solution of alkali metal permanganate, AMn04 containing 3.15 g of it per litre of the solution. Prepare M/20 oxalic acid solution and using this solution determine the atomic mass of the alkali metal ‘A’.
8. Determine volumetrically the percentage purity of a given sample of sodium oxalate. Provided M/50 $KMnO_4$ solution.