Determine the Equivalent Mass & Number of Molecules of Water of Crystallisation in a Sample of Mohr's salt, $FeSO_4(NH_4)_2 SO_4 . nH_20$. Provided $KMnO_4$

Chemical Equations

Molecular equations

$$FeSO_4(NH_4)_2SO_4 . nH_2O \longrightarrow FeSO_4 + (NH_4)_2SO_4 + nH_2O$$

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

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

Ionic equations

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

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-] \times 5$$

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

Theory

Prepare a solution of Mohr's salt with known strength (g/litre). Molarity of ferrous ammonium sulphate can be determined by directly titrating it against standard (M/100) $KMnO_4$ solution.
Molecular mass = strength/molarity.
Substituting the value of strength and value of molarity as calculated above, the molecular mass of Mohr's salt can be calculated. Suppose it comes out to be M.
Theoretical molecular mass of Mohr's salt, $FeSO_4.(NH_4)_2SO_4. nH_20$
= 284 + 18n
∴ 284 + 18n = M
whence, n can be calculated.
In case of Mohr's salt equivalent mass is equal to its molecular mass. Therefore, Equivalent mass of Mohr's salt = M.

Indicator

$KMnO_4$ is a self-indicator.

End Point

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

Procedure

1. Weigh exactly 4.90 g of Mohr's salt and dissolve in water to prepare exactly 250 ml of solution, using a 250 ml measuring flask. Rinse the pipette with the prepared

Mohr's
salt solution and pipette out 20.0 ml of it in a washed titration flask.

2. Rinse and fill the burette with M/100 $KMnO_4$ solution.
3. Add one test-tube (~ 20 ml) full of dilute sulphuric acid (~ 4 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 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 a set of three concordant readings.

Observations

Weight of watch glass =……. g
Weight of watch glass + Mohr's salt =…………..g
Weight of Mohr's salt = 4.90 g
Volume of Mohr's salt solution prepared = 250 ml
Volume of Mohr's salt solution taken for each titration = 20.0 ml
Molarity of $KMnO_4$ solution =M/100

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

Molarity of the standard $KMnO_4$ solution = $\frac{M}{100}$

x ml of $\frac{M}{100}$ $KMnO_4$ react with 20.0 ml of the given Mohr's salt solution.

From the chemical equations, it is clear that one mole of $KMnO_4$ reacts with 5 moles Mohr's salt.

$$\therefore \quad \frac{M_{\text{Mohr's salt}} \times V_{\text{Mohr's salt}}}{M_{KMnO_4} \times V_{KMnO_4}} = \frac{5}{1}$$

$$\frac{M_{\text{Mohr's salt}} \times 20.0}{1/100 \times x} = \frac{5}{1}$$

$$M_{\text{Mohr's salt}} = \frac{5 \times x \times 1}{20 \times 100} = \frac{x}{400}$$

$$\text{Molecular mass of Mohr's salt} = \frac{\text{Strength in g/litre}}{\text{Molarity}}$$

$$= \frac{19.6}{x/400} = \text{M (say)}$$

(*a*) *Calculation of no. of molecules of water of crystallisation*

Theoretically, molecular mass of Mohr's salt, $FeSO_4.(NH_4)_2SO_4.nH_2O$

$$= 284 + 18n$$

Equating this with the experimentally determined molecular mass, we get

$$M = 284 + 18n$$

$$n = \frac{M - 284}{18}$$

(*b*) *Calculation of equivalent mass of Mohr's salt*

Since oxidation of Mohr's salt involves one electron per molecule, therefore, equivalent mass of Mohr's salt is equal to its molecular mass.

$$\text{Equivalent mass} = \frac{\text{Molecular mass}}{1} = \frac{M}{1} = M$$

Instructions for the Preparation of Solutions

Provide the following:

1. Mohr's salt
2. $KMnO_4$ solution (1.58 g/litre)
3. 4N H_2SO_4.