Determine the equivalent mass and number of molecules of water of crystallisation in a sample of Mohr's salt $FeSO_4 (NH_4)_2 SO_4.nH_20$. Provided N/20 $KMnO_4$

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

Normality of ferrous ammonium sulphate can be determined by directly titrating it against standard (N/20) $KMnO_4$ solution.

Eq. mass = Strength/normality

Substituting the value of strength and value of normality as calculated above, the equivalent mass of Mohr's salt can be calculated. Suppose it comes out to be E.

Since Eq. mass of mohr's salt is equal to its molecular mass, therefore molecular mass of Mohr's salt is also equal to E.

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

$$= 284 + 18n$$

$$\therefore \quad 284 + 18n = E$$

whence n can be calculated.

Indicator

$KMnO_4$ is a self-indicator.

Endpoint

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

Procedure

1. Rinse and fill the burette with N/20 $KMnO_4$. solution.
2. 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.
3. Add one test tube (~ 20 ml) full of dilute sulphuric acid (~ 4 N) to the solution in titration flask.
4. Note the initial reading of the burette.
5. Add $KMnO_4$ solution into the titration flask 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 readings.

Observations

Normality of $KMnO_4$ solution = $\frac{1}{20}$

Volume of Mohr's salt 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

(*a*) *Equivalent mass of Mohr's salt*

x ml of $\frac{1}{20}$ $KMnO_4$ solution are equivalent to 20 ml of prepared Mohr's salt solution.

Applying normality equation,

$$\underset{\text{Mohr's salt}}{N_1V_1} = \underset{KMnO_4}{N_2V_2}$$

$$N_1 \times 20 = \frac{1}{20} \times x$$

$\therefore$ Normality of Mohr's salt solution, $N_1 = \frac{x}{400}$

Equivalent mass of Mohr's salt = $\frac{\text{Strength}}{\text{Normality}} = \frac{19.6}{x/400}$ = E (say).

(*b*) *No. of molecules of water of crystallisation, n*

Equivalent mass of Mohr's salt is equal to its molecular mass. Theoretical mol. mass of Mohr's salt, $FeSO_4.(NH_4)_2SO_4.nH_2O$

$$= 284 + 18n$$

$$\therefore \quad E = 284 + 18n$$

No. of molecules of water of crystallisation, $n = \frac{E - 284}{18}$.