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Subject: Chemistry

Class: Semester-2

Paper: C3T:Inorganic Chemistry

Topic: Redox and Precipitation Reaction

Part 2

... to the balanced equ^n.

vi) The given equ^n is $BiO_3^- + Mn^{2+} + H^+ \rightarrow Bi^{3+} + MnO_4^- + H_2O$

a) This equ^n is in the ionic form. Since H^+ ions are involved in this equ^n, hence this rxn occurs in acid medium. In this equ^n BiO_3^- is reduced to Bi^{3+} and Mn^{2+} is oxidised to MnO_4^- ion. Thus the given equ^n can be broken into two partial equations are

$BiO_3^- \rightarrow Bi^{3+}$ (Reduction) — ①

$Mn^{2+} \rightarrow MnO_4^-$ (oxidation) — ②

b) The equ^n ① can be balanced by using the following steps.

A. $BiO_3^- \rightarrow Bi^{3+} + 3H_2O$ (to balance O atoms)

B. $BiO_3^- + 6H^+ \rightarrow Bi^{3+} + 3H_2O$ (to balance H atoms)

C. $BiO_3^- + 6H^+ + 2e \rightarrow Bi^{3+} + 3H_2O$ (to balance electrical charge) ..... ③

c) The equation ② can be balanced by using following steps.

A. $Mn^{2+} + 4H_2O \rightarrow MnO_4^-$ (to balance O atom)

B. $Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+$ (to balance H atoms)

C. $Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+ + 5e$ (to balance electrical charges) ..... ④

d) Multiplying equⁿ ③ by 5 and eqⁿ ④ by 2 and adding them we get,

$$5BiO_3^- + 30H^+ + 10e \rightarrow 5Bi^{3+} + 15H_2O$$
$$2Mn^{2+} + 8H_2O \rightarrow 2MnO_4^- + 16H^+ + 10e$$
$$\overline{5BiO_3^- + 30H^+ + 2Mn^{2+} + 8H_2O = 5Bi^{3+} + 15H_2O + 2MnO_4^- + 16H^+}$$

or $5BiO_3^- + 2Mn^{2+} + 14H^+ = 5Bi^{3+} + 7H_2O + 2MnO_4^-$

This is the balanced equation.

vii) The given equⁿ is $Cr_2O_7^= + Fe^{2+} + H^+ \rightarrow Cr^{3+} + Fe^{3+} + H_2O$

a) This eqⁿ is in the ionic form. Since H^+ ions are involved in this equation, hence this rxn occurs in acid medium. In this equation $Cr_2O_7^=$ is reduced to Cr^{3+} and Fe^{2+} is oxidised to Fe^{3+}. Thus the given equation can be broken into two partial equations

$Cr_2O_7^= \rightarrow Cr^{3+}$ (Reduction) — ①

$Fe^{2+} \rightarrow Fe^{3+}$ (oxidation) — ②

b) The eqⁿ ① can be balanced and finally we get $Cr_2O_7^= + 14H^+ + 16e \rightarrow 2Cr^{3+} + 7H_2O$ — ③

c) The equⁿ ② can be balanced and finally we get $Fe^{2+} \rightarrow Fe^{3+} + e$ — ④

d) Multiplying equⁿ ③ by 1 and equⁿ ④ by 6 and adding them we get

$$Cr_2O_7^= + 14H^+ + 6e + 6Fe^{2+} = 2Cr^{3+} + 7H_2O + 6Fe^{3+} + 6e$$

or $Cr_2O_7^= + 14H^+ + 6Fe^{2+} = 2Cr^{3+} + 7H_2O + 6Fe^{3+}$

This is the balanced equation.

viii) The given equⁿ is $MnO_4^- + Fe^{2+} + H^+ \rightarrow Mn^{2+} + Fe^{3+} + H_2O$

a) This equation is in the ionic form. Since H^+ ions are involved in this equation, hence this rxn occurs in acid medium. In this equation MnO_4^- is reduced to Mn^{2+} and Fe^{2+} is oxidised to Fe^{3+} ion. thus the equation can be broken into two partial equation.

$$MnO_4^- \rightarrow Mn^{2+} \text{ (Reduction)} \text{ — } (1)$$
$$Fe^{2+} \rightarrow Fe^{3+} \text{ (oxidation)} \text{ — } (2)$$

b) To balance all the atoms and electrical charge in equation (1) the following steps are required.

A. $MnO_4^- \rightarrow Mn^{2+} + 4H_2O$ (to balance O atom)

B. $MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$ (to balance H atoms)

C. $MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$ (to balance electrical Charge) .... (3)

c) The eqn (2) can also be balanced as follows.

$$Fe^{2+} \rightarrow Fe^{3+} + e \quad \text{...} \ (4)$$

d) Multiplying eqn (3) by 1 and eqn (4) by 5 and adding them we get

$$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$$
$$5Fe^{2+} \rightarrow 5Fe^{3+} + 5e$$
$$\overline{MnO_4^- + 8H^+ + 5Fe^{2+} = Mn^{2+} + 5Fe^{3+} + 4H_2O}$$

This is the balanced equation.

- Some example for balancing of Redox Rxn by ion electron method

i) Rxn between sodium sulphite and Potassium dichromate in acid medium.

As the medium is acidic, Na_2SO_3 is oxidised to Na_2SO_4 and the partial equation is

$$SO_3^{2-} + H_2O \rightarrow SO_4^{=} + 2H^+ + 2e \text{ — } (1)$$

The oxidant $K_2Cr_2O_7$ is reduced to chromic salt and the partial equation is

$$Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O \text{ — } (2)$$

Multiplying eqn (1) by 3 and eqn (2) by 1 and adding them we get

$$3SO_3^{=} + 3H_2O + Cr_2O_7^{2-} + 14H^+ + 6e = 3SO_4^{=} + 6H^+ + 2Cr^{3+} + 7H_2O$$

or $3SO_3^{=} + Cr_2O_7^{=} + 8H^+ = 3SO_4^{=} + 2Cr^{3+} + 4H_2O$

This is the balanced equation.

...sulphide dissolves in hot dil HNO_3 aq.

In This rxn dil HNO_3 is reduced to NO and ...us oxidised to 'S'. the partial equations are.

$$NO_3^- + 4H^+ + 3e \rightarrow NO + 2H_2O \quad \dots (1)$$

$$S^{2-} \rightarrow S + 2e \quad \dots\dots (2)$$

Multiplying equation ① by 2 and equation ② by 3 and adding Them we get,

$$2NO_3^- + 8H^+ + 3S^{2-} = 2NO + 4H_2O + 3S$$

iii) Rxn between sodium Nitrate and metallic Al in Presence of NaOH

In This rxn nitrate is reduced to NH_3 and Al is oxidised to Aluminate. Since the medium is alkaline the partial equations are,

$$NO_3^- + 6H_2O + 8e \rightarrow NH_3 + 9OH^- \quad \dots ①$$

$$Al + 4OH^- \rightarrow AlO_2^- + 2H_2O + 3e \quad \dots ②$$

Multiplying equation ① by 3 and equ^n ② by 8 and adding Them we get,

$$3NO_3^- + 2H_2O + 8Al + 5OH^- = 3NH_3 + AlO_2^-$$

iv) Rxn between $KMnO_4$ and H_2O_2 in acid medium.

In This rxn $KMnO_4$ is reduced to manganous salt and H_2O_2 oxidised to O_2. The partial equations are -

$$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O \quad \dots ①$$

$$H_2O_2 \rightarrow O_2 + 2H^+ + 2e \quad \dots ②$$

multiplying equ^n ① by 2 and equ^n ② by 5 and adding Them we get,

$$2MnO_4 + 16H^+ + 10e + 5H_2O_2 = 2Mn^{2+} + 8H_2O + 5O_2 + 10H^+ + 10e$$

or, $$2MnO_4 + 6H^+ + 5H_2O_2 = 2Mn^{2+} + 8H_2O + 5O_2$$

v) Rxn between $K_3[Fe(CN)_6]$ and hydrazene in alkaline sol^n

In This rxn N_2H_4 is oxidised to N_2 and ferricianide is reduced to ferocianide and The partial equations are,

$$N_2H_4 + 4OH^- \rightarrow N_2 + 4H_2O + 4e \quad \dots ①$$

$$[Fe(CN)_6]^{3-} + e \rightarrow [Fe(CN)_6]^{4-} \text{ ---- } ②$$

Multiplying equation ① by 1 and equation ② by 4 and adding them we get,

$$N_2H_4 + 4OH^- + 4[Fe(CN)_6]^{3-} + 4e = N_2 + 4H_2O + 4e + 4[Fe(CN)_6]^{4-}$$

vi) Rxn between sodium Chromite ($NaCrO_2$) and sodium hypochlorite in alkaline soln

As the medium is alkaline, hypochlorite is reduced to chloride and chromite is oxidised to chromate and the partial equations are,

$$OCl^- + H_2O + 2e \rightarrow Cl^- + 2OH^- \text{ ---- } ①$$

and $CrO_2^- + 4OH^- \rightarrow CrO_4^{=} + 2H_2O + 3e$ ---- ②

Multiplying equn ① by 3 and equn ② by 2 and adding them we get,

$$3OCl^- + 2CrO_2^- + 2OH^- = 3Cl^- + 2CrO_4^{=} + H_2O.$$

vii) Rxn between Barium peroxide and ozone(O_3)

In this rxn one atom of 'O' in ozone is reduced to oxide ion and BaO_2 is oxidised to oxygen. The partial equations are,

$$O_3 + 2e \longrightarrow O^{2-} + O_2 \text{ ---- } ①$$

and $BaO_2 \longrightarrow O_2 + Ba^{2+} + 2e$ --- ②

Adding them weget,

$$O_3 + BaO_2 = O^{2-} + 2O_2 + Ba^{2+}$$

viii) Rxn between mangarous salt and PbO_2 in acid medium.

As the medium is acidic, Mn^{2+} is oxidised to MnO_4^- and PbO_2 is reduced to lead salt (Pb^{2+}) and the partial equations are,

$$Mn^{2+} + 4H_2O \longrightarrow MnO_4^- + 8H^+ + 5e \text{ ---- } ①$$

$$PbO_2 + 4H^+ + 2e \longrightarrow Pb^{2+} + 2H_2O \text{ --- } ②$$

Multiplying equn ① by 2 and equn ② by 5 and adding them we get,

$$5PbO_2 + 2Mn^{2+} + 4H^+ = 2MnO_4^- + 5Pb^{2+} + 2H_2O$$

ix) The action of Conc. HNO_3 on Cu-turnings.

In this rxn. Conc HNO_3 is reduced to NO_2 and Cu is oxidised to Cupric salt (Cu^{2+}). The

...ial equations are,

$$NO_3^- + 2H^+ + e \longrightarrow NO_2 + H_2O \quad ---- ①$$

$$Cu \longrightarrow Cu^{2+} + 2e \quad ---- ②$$

Multiplying equ^n ① by 2 and equ^n ② by 1 and adding them we get,

$$2NO_3^- + 4H^+ + Cu = 2NO_2 + 2H_2O + Cu^{2+}$$

x) the action of I_2 on sodium Thio-sulphate sol^n.

In This rxn Thio-sulphate is oxidised to Tetra Thionate and I is reduced to iodide ion (I^-). The partial equations are,

$$2S_2O_3^{=} \longrightarrow S_4O_6^{=} + 2e \quad --- ①$$

$$I_2 + 2e \longrightarrow 2I^- \quad --- ②$$

Adding equ^n ① and ② we get,

$$2S_2O_3^{=} + I_2 = S_4O_6^{=} + 2I^-$$

xi) Rxn between $NaNO_3$ and Zn dust in alkaline med.

In This rxn $NaNO_3$ is reduced to NH_3 and Zn dust is oxidised to sodium zincate. The partial equations are,

$$NO_3^- + 6H_2O + 8e \longrightarrow NH_3 + 9OH^- \quad ---- ①$$

$$Zn + 4OH^- \longrightarrow ZnO_2^{2-} + 2H_2O + 2e \quad --- ②$$

Multiplying equ^n ① by 1 and equ^n ② by 4 and adding them we get,

$$NO_3^- + 4Zn + 7OH^- = NH_3 + 4ZnO_2^{=} + 2H_2O$$

xii) Rxn between HI and Conc. H_2SO_4

In This rxn Conc. H_2SO_4 is reduced to SO_2 and I^- is oxidised to I_2. The partial equations are,

$$SO_4^{=} + 4H^+ + 2e \longrightarrow SO_2 + 2H_2O \quad ---- ①$$

$$\text{and} \quad 2I^- \longrightarrow I_2 + 2e \quad ---- ②$$

Adding Them we get,

$$SO_4^{=} + 2I^- + 4H^+ = SO_2 + 2H_2O + I_2$$

xiii) Rxn between MnO_2 and conc. HCl in acid med.

In This rxn MnO_2 is reduced to Mn^{2+} and HCl is oxidised to Cl_2. The partial equations are

$$MnO_2 + 4H^+ + 2e \longrightarrow Mn^{2+} + 2H_2O \quad --- ①$$

$$\text{and} \quad Cl^- \longrightarrow Cl_2 + 2e \quad --- ②$$

Adding equ^n ① and equ^n ② we get,

$$MnO_2 + 4H^+ + 2e + 2Cl^- = Mn^{2+} + 2H_2O + Cl_2$$

or, $$MnO_2 + 4H^+ + 2Cl^- = Mn^{2+} + 2H_2O + Cl_2$$

xiv) Rxn between H_2O_2 and O_3 in acid medium

In This rxn H_2O_2 is oxidised to O_2 and O_3 is also reduced to O_2. The partial equations are,

$$H_2O_2 \rightarrow O_2 + 2H^+ + 2e \quad \text{---} \quad (1)$$

$$O_3 + 2H^+ + 2e \rightarrow H_2O + O_2 \quad \text{---} \quad (2)$$

Adding Them we get,

$$H_2O_2 + O_3 = 2O_2 + H_2O$$

Disproportionation Or Dismutation Reaction.

There are some chemical changes in which an element is converted into two oxidation states. One higher and another is lower, Than it's oxidation state in the reactants. Such reactions are called disproportionation or dismutation reaction.

Disproportionation rxn is That redox rxn in which some part of a substance undergoes oxidation while the remaining part of That same substance undergoes reduction i.e The same substance is oxidised as well as reduced. Hence This substance acts both as oxidising as well as reducing agent.

Some examples are given below,

i) The soluble cuprous compounds disproportionate in soln, with the formation of metallic copper and corresponding cupric salt.

$$\overset{+1}{Cu_2}SO_4\,(aq) \longrightarrow \overset{0}{Cu}\,(s) + \overset{+2}{Cu}SO_4\,(aq)$$

reduction

oxidation

ii) When white P is boiled with Caustic soda, in an inert atmosphere PH_3 is evolved and sodium hypophosphite is also produced.

$$\overset{0}{P_4} + 3NaOH + 3H_2O = \overset{-3}{P}H_3 + 3NaH_2\overset{+1}{P}O_2$$

reduction.

oxidation.

iii) Manganate ion is stable in highly alkaline medium. But on adding large quantity of water or on acidifying the soln, it readily undergoes disproportionation to produce MnO_2 and MnO_4^- ion.

$$3K_2MnO_4 + 2H_2O = 2KMnO_4 + MnO_2 + 4KOH$$

Comproportionation Rxn.

Comproportionation rxn is the reverse of the disproportionation rxn.

In this rxn two different oxidation states of the same element give a product with intermediate oxidation state.

The examples of the spontaneous comproportionation rxns are given below,

i) $Ag^{2+}(aq) + Ag = 2Ag^{+}(aq)$

ii) $\overset{-3}{N}H_4\overset{+3}{N}O_2 = \overset{0}{N}_2 + H_2O$

Complementary and Non-Complementary Redox rxn.

The redox rxn in which oxidants gain the same no. of electrons as the reductant losses, are called complementary redox rxns.

When the no. of electrons gained and lost are different, the redox rxns are called non-complementary redox rxn.

The complementary redox rxns are generally faster than the non complementary rxns.

The examples are given below,

i) $Sn^{2+} + Ti^{3+} = Sn^{4+} + Ti^{+}$

ii) $Sn^{2+} + Hg^{2+} = Sn^{4+} + Hg^{0}$

iii) $Ce^{4+} + Fe^{2+} = Ce^{3+} + Fe^{3+}$

(i)–(iii): Complementary redox rxn.

iv) $Sn^{2+} + 2Fe^{3+} = Sn^{4+} + 2Fe^{2+}$

v) $2Fe^{3+} + Ti^{+} = 2Fe^{2+} + Ti^{3+}$

(iv)–(v): Non Complementary redox rxn

[N.B.-Acknowledgement of indebtedness to Mr. Sibshankar Das, my respected Teacher regarding collection of study materials in Inorganic Chemistry**]**