VMC Vidyamandir Classes SINCE 1986

IIT JEE | MEDICAL | FOUNDATION

Stoichiometry-II (Redox reactions)

oxidation state ⟶ It is the total charge present on an atom of an element due to the difference in Electronegativity.

$A - A \Rightarrow A^0 \quad A^0$

$A = A \Rightarrow A^0 \quad A^0$

$A \equiv A \Rightarrow A^0 \quad A^0$

$A - B \Rightarrow (E.N.)_B > (E.N.)_A \Rightarrow A^{+1} \quad B^{-1}$

$(E.N.)_A > (E.N.)_B \Rightarrow A^{-1} \quad B^{+1}$

$A = B \Rightarrow (E.N.)_A < (E.N.)_B \Rightarrow A^{+2} \quad B^{-2}$

$(E.N.)_A > (E.N.)_B \Rightarrow A^{-2} \quad B^{+2}$

$A \equiv B \Rightarrow (E.N.)_A < (E.N.)_B \Rightarrow A^{+3} \quad B^{-3}$

$(E.N.)_A > (E.N.)_B \Rightarrow A^{-3} \quad B^{+3}$

$A \longrightarrow B \Rightarrow (E.N.)_A < (E.N.)_B \Rightarrow A^{+2} \quad B^{-2}$

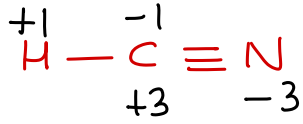
or

$^{+1}A - {}^{-1}B \quad (E.N.)_A > (E.N.)_B \Rightarrow A^0 \quad B^0$

$A \longrightarrow A \Rightarrow A^0 \quad A^0$

EN. ⇒ F > O > N > Cl > Br > I > S > C > H > P > B > Metals

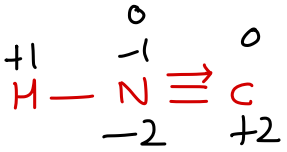
Ex.



H ⇒ +1

C ⇒ +2

N ⇒ −3



H ⇒ +1

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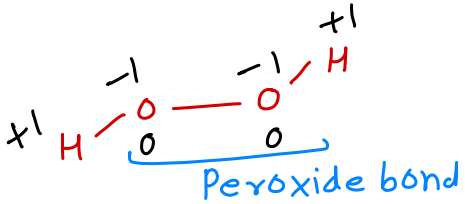
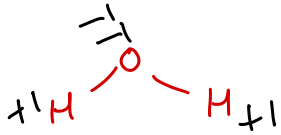


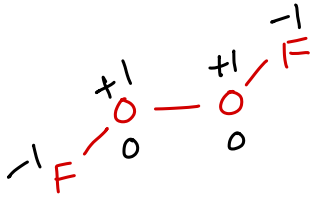
H ⇒ +1, +1

O ⇒ −1, −1



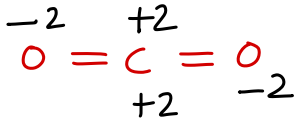
H ⇒ +1, +1

O ⇒ −2



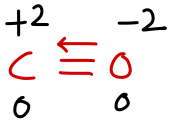
O ⇒ +1, +1

F ⇒ −1, −1



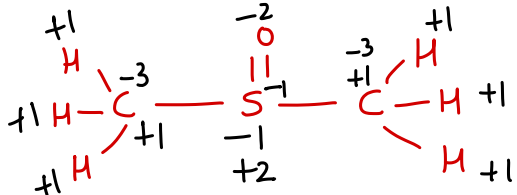
C ⇒ +4

O ⇒ −2, −2



C ⇒ +2

O ⇒ −2

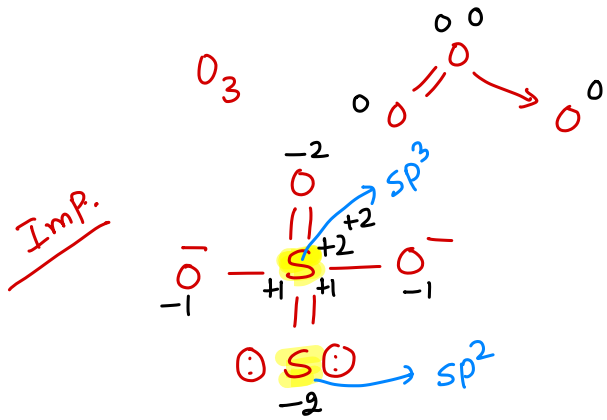


C ⇒ −2, −2

S ⇒ 0

O ⇒ −2

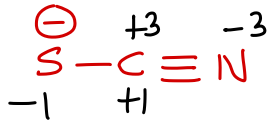
H ⇒ +1, +1, +1, +1, +1, +1



O ⇒ 0, 0, 0

S ⇒ +6, −2

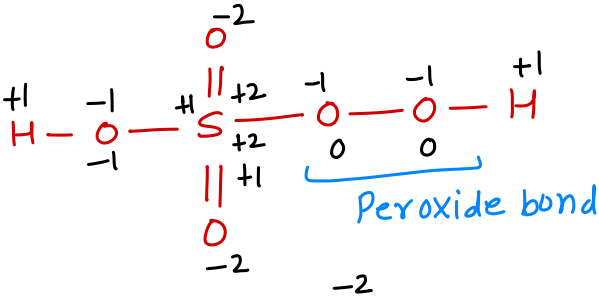
O ⇒ −2, −2, −2



S ⇒ −2

C ⇒ +4

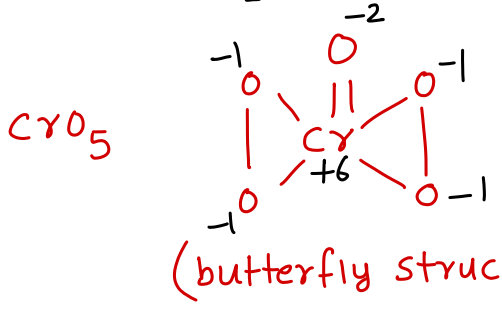
N ⇒ −3



S ⇒ +6

O ⇒ −1, −1, −2, −2, −2

H ⇒ +1, +1



Cr ⇒ +6

O ⇒ −1, −1, −1, −1, −2

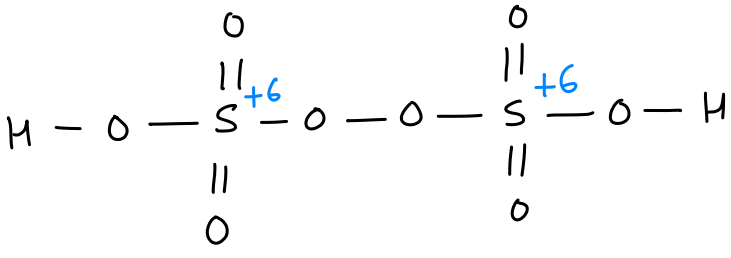
2 peroxide bond

$H_2S_2O_8$ (marshall's acid)

or

Peroxodisulphuric acid

$x = +7 \Rightarrow$ Peroxide bond is present.

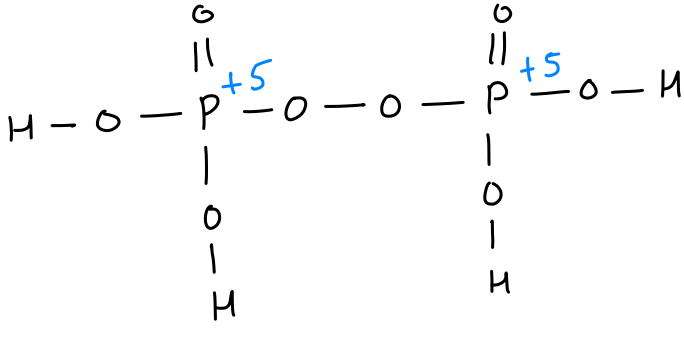


$S = +6, +6$

$H_4P_2O_8$

$4 + 2x - 16 = 0 \Rightarrow x = +6$ > max.

$\Rightarrow$ Peroxide bond is Present.



Rules for determination of oxidation state of an atom ⟶

* Oxidation state of an atom in elemental form is eaual to zero.

H in H_2 = 0

O in O_2, O_3 = 0

F in F_2 = 0

Na in $Na_{(s)}$ = 0

C in $C_{(Dia.)}$, $C_{(gr.)}$ = 0

P in white-P, black-P, red-P = 0

S in rhombic-S, Monoclinic-S = 0

Cl in Cl_2 = 0

N in N_2 = 0

* oxidation state of F = −1 (always in a comp.)

* O ⇒ −2 ⟶ oxides
  −1 ⟶ Peroxides
  −1/2 ⟶ Superoxides
  −1/3 ⟶ Ozonides
  +1, +2 ⟶ Fluorides.

* H ⇒ +1 (Generally)
  −1 (In case of metal hydrides)

* Alkali metals = +1 (Always)

* Alkaline earth metals = +2 (Always)

* Max. oxidation no. = Valence electrons

  Min. oxidation no. = Valence electrons − 8

Common oxidation state of group-13 ⇒ +1, +3

〃 group-14 ⇒ +2, +4
(C ⇒ −4 to +4)

〃 group-15 ⇒ +3, +5
(N = −3 to +5)

〃 group-16 ⇒ +2, +4, +6
(O = −2 to +2)

〃 group-17 ⇒ −1, +1, +3, +5, +7

〃 group-18 ⇒ 0, +2, +4, +6, +8

* Group oxidation state (In complex comp.) —

X, CN, OH, NH_2, ONO, NO_2, NCS, HSO_3, H,

$SCN, NOS, SH, N_3 \Rightarrow -1$

$C_2O_4(ox), SO_4, SO_3, S, NH, S_2O_3, CO_3 = -2$

$NO \longrightarrow +1, 0$

$NH_3, H_2O, en, CO, PH_3, PPh_3 = 0$

* Algebric sum of oxidation state of all the atoms present in a comp. is eaual to net charge present on that comp.

Q. Find the oxidation state of underlined atom in each of the following —

(i) $K\underline{Mn}O_4$

$+1 + x - 8 = 0$

$x = +7$

(ii) $K_2\underline{Mn}O_4$

$2 + x - 8 = 0$

$x = +6$

(iii) $K_2\underline{Cr}_2O_7$

$2 + 2x - 14 = 0$

$x = +6$

(iv) $\underline{Cr}O_4^{2-}$

$x - 8 = -2$

$x = +6$

(v) $K_4[\underline{Fe}(CN)_6]$

$+4 + x - 6 = 0$

$x = +2$

(vi) $Na_2[Fe(CN)_5(NO)]$

Sod. nitro prusside

$2 + x - 5 + 1 = 0$

$x = +2$

(vii) $[Fe(H_2O)_5(NO)]SO_4$

Brown ring complex

$x + 0 + 1 - 2 = 0$

$x = +1$

(viii) $C_{12}H_{22}O_{11}$

$12x + 22 - 22 = 0$

$x = 0$

(ix) $C_6H_{12}O_6$

$6x + 12 - 12 = 0$

$x = 0$

(x) $[Co(NH_3)_2(NO_2)_4]^-$

$x + 0 - 4 = -1$

$x = +3$

(xi) $[Ni(NH_3)_3(H_2O)_3]^{+4}$

$x + 0 + 0 = +4$

$x = +4$

(xii) $(NH_4)_2SO_4 \longrightarrow 2NH_4^+ + SO_4^{2-}$

$x = -3$ $\quad$ $x = +6$

(xiii) $KCrO_3Cl$

$1 + x - 6 - 1 = 0$

$x = +6$

(xiv) $(NH_4)_6Mo_7O_{24} \longrightarrow 6NH_4^+ + [Mo_7O_{24}]^{6-}$

$x = -3$ $\quad$ $7x - 48 = -6$

$x = +6$

(xv) Cs_2XeF_8

$2 + x - 8 = 0$

$x = +6$

(xvi) $[PtCl_6]^{2-}$ $\quad x - 6 = -2 \Rightarrow x = +4$

(xvii) $Ba(H_2P\underline{O}_2)_2$ $\quad 2 + 4 + 2x - 8 = 0$, $x = +1$

(xviii) $H_3P\underline{O}_4$ $\quad 3 + x - 8 = 0 \Rightarrow x = +5$

(xix) $[Fe(CN)_5(NOS)]^{4-}$ $\quad x - 5 - 1 = -4$, $x = +2$

(xx) $Be\underline{C}O_3$ $\quad 2 + x - 6 = 0 \Rightarrow x = +4$

Average oxidation no. $\longrightarrow$

Q. oxidation state of C-atoms in C_3O_2 is —

(A) $+\frac{4}{3}, +\frac{4}{3}, +\frac{4}{3}$

✓(B) $+2, 0, +2$

(C) $+3, 0, +1$

(D) $-1, +1, +4$

Soln $\rightarrow$

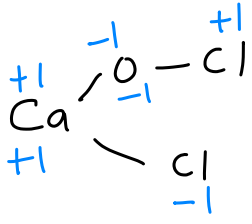
$$\overset{-2}{O} = \overset{+2}{C} = \overset{0}{C} = \overset{0}{C} = \overset{}{O}$$

$$\overset{}{} \quad \overset{0}{} \quad \overset{0}{} \quad \overset{+2}{} \quad \overset{-2}{}$$

C = +2, 0, +2 (Actual)

$\frac{+2+0+2}{3} = +\frac{4}{3}$ (Average o.s.)

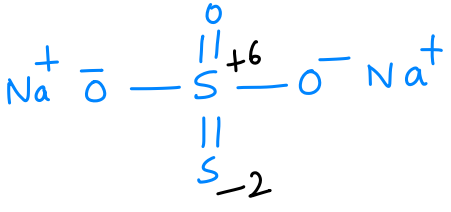
Q. $CaOCl_2$ (bleaching powder)



Cl ⇒ −1, +1 (Actual)

$\frac{-1+1}{2} = 0$ (Average O.S.)

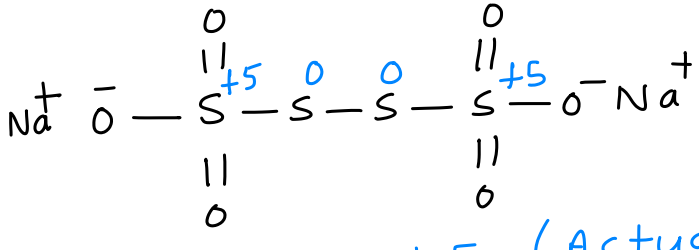
Q. $Na_2S_2O_3$ (sod. thio sulphate)



S = +6, −2 (Actual)

$\frac{+6-2}{2} = +2$ (Average)

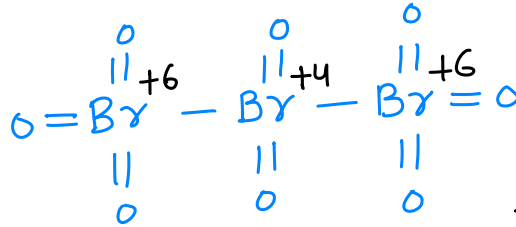
Q. $Na_2S_4O_6$ (sod. tetra thionate)



S = +5, 0, 0, +5 (Actual)

$\frac{5}{2}$ (Average)

Q. Br_3O_8



$Br = +6, +4, +6$ (Actual)

$+\frac{16}{3}$ (Average)

Q. Fe_3O_4 $\longrightarrow$ $FeO + Fe_2O_3$

$x = \frac{8}{3}$

$(+2)$ $(+3)$ → Actual

$\frac{+2+3+3}{3} = \frac{8}{3}$ (Average)

Q. Pb_3O_4 $\longrightarrow$ $2PbO + PbO_2$

$x = \frac{8}{3}$

$(+2)$ $(+4)$ → Actual

$\frac{+2+2+4}{3} = \frac{8}{3}$ (Average)

Q. KI_3 $\longrightarrow$ $KI + I_2$

$1 + 3x = 0$

$x = -\frac{1}{3}$

(-1) (0) → Actual

$\frac{-1+0+0}{3} = -\frac{1}{3}$ (Average)

Q. $NH_4NO_3 \longrightarrow NH_4^+ + NO_3^-$

$x = +1$ (Average)

NH_4^+: (−3) ; NO_3^-: (+5)

(Actual O.S.)

oxidation and Reduction ⟶

oxidation ⟶ Addition of oxygen

$$Zn + \frac{1}{2} O_2 \longrightarrow ZnO$$

Removal of hydrogen — $2HI \rightarrow H_2 + I_2$

Addition of more E.N element

$$FeCl_2 + \frac{1}{2} Cl_2 \longrightarrow FeCl_3$$

Removal of Electropositive element

$$Hg_2Cl_2 \longrightarrow Hg + HgCl_2$$

Loss of electrons ⟶ $Zn \longrightarrow Zn^{2+} + 2e^-$

$Na \longrightarrow Na^+ + e^-$

* Increase in oxidation state is oxidation

$$\underset{(0)}{Mg} \longrightarrow \underset{(+2)}{Mg^{2+}}$$

$$\underset{(+3)}{C_2O_4^{2-}} \longrightarrow \underset{(+4)}{CO_2}$$

Reduction ⟶ Removal of oxygen

$$2HgO \xrightarrow{\Delta} 2Hg + O_2$$

Removal of more E.N. element

$$SnCl_4 \longrightarrow SnCl_2 + Cl_2$$

Addition of hydrogen

$$CH_2 = CH_2 + H_2 \longrightarrow CH_3 - CH_3$$

Addition of Electropositive element

$$CuCl_2 + Cu \longrightarrow Cu_2Cl_2$$

gain of electrons $Cu^{2+} + 2e^- \longrightarrow Cu$

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

* Decrease in oxidation state is reduction.

$$\underset{(+3)}{Fe^{3+}} \longrightarrow \underset{(+2)}{Fe^{2+}}$$

$$\underset{(+7)}{MnO_4^-} \longrightarrow \underset{(+2)}{Mn^{2+}}$$

$$\underset{(+6)}{Cr_2O_7^{2-}} \longrightarrow \underset{(+3)}{Cr^{3+}}$$

Redox reactions → Rxⁿ in which oxidation and reduction take place simultaneously

Ex. $MnO_4^- + Fe^{2+} \longrightarrow Mn^{2+} + Fe^{3+}$

(+7) (+2) (+2) (+3)

R O

Ex. $Cr_2O_7^{2-} + C_2O_4^{2-} \longrightarrow Cr^{3+} + CO_2$

(+6) (+3) (+3) (+4)

R O

Ex. $Cr^{3+} + IO_3^- \longrightarrow CrO_4^{2-} + I^-$

(+3) (+5) (+6) (−1)

O R

Ex. $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$

+1 +5 −2 +1 −1 +1 −1 +1 +5 −2

It is not a redox Rxⁿ.

Ex. $I_2 + Na_2S_2O_3 \longrightarrow NaI + Na_2S_4O_6$

0 +2 −1 +2.5

R O

Reactant in redox Rx^n is called as

(i) oxidising agent (oxidant or oxidiser) ⟶
Oxidise other but reduce itself.

(ii) Reducing agent (Reductant or Reducer) ⟶
Reduce other but oxidise itself.

(iii) Redox substance ⟶
both e^- donor as well as e^- acceptor.

(iv) Spectator ⟶ Neither e^- donor nor e^- acceptor.

Ex. $\underset{(0)}{Zn} + \underset{+1\ +6\ -2}{H_2SO_4} \longrightarrow \underset{+2\ +6\ -2}{ZnSO_4} + \underset{0}{H_2}$

(RA) (OA)

$\underset{(0)}{Cl_2} + \underset{+1\ -2\ +1}{NaOH} \longrightarrow \underset{+1\ -1}{NaCl} + \underset{+1\ +5\ -2}{NaClO_3}$

(Redox subs.) (Spectator)

$\underset{+1\ +5\ -2}{KIO_3} + \underset{+1\ -1}{KI} + \underset{+1\ -1}{HCl} \longrightarrow \underset{0}{I_2} + \underset{+1\ -1}{KCl} + \underset{+1\ -2}{H_2O}$

(OA) (RA) (Spectator)

$\underset{(0)}{P_4} + \underset{+1\ -2\ +1}{NaOH} + \underset{+1\ -2}{H_2O} \longrightarrow \underset{-3\ +1}{PH_3} + \underset{+1\ +1\ +1\ -2}{NaH_2PO_2}$

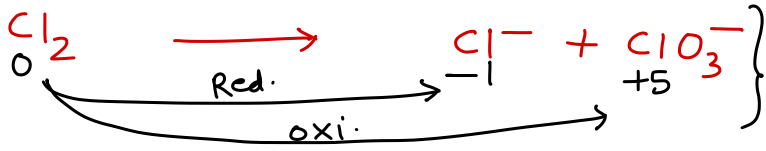
(Redox subs.) Spectator

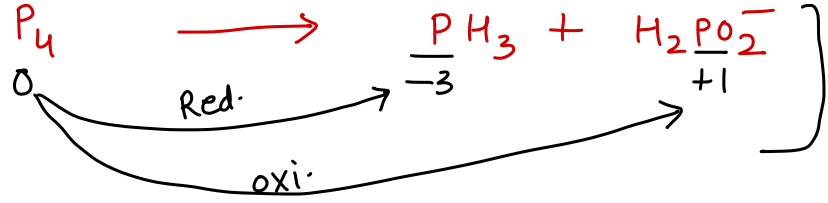
HSO_4^- + As_4 + Pb_3O_4 ⟶ $PbSO_4 + H_2AsO_4^- + H_2O$

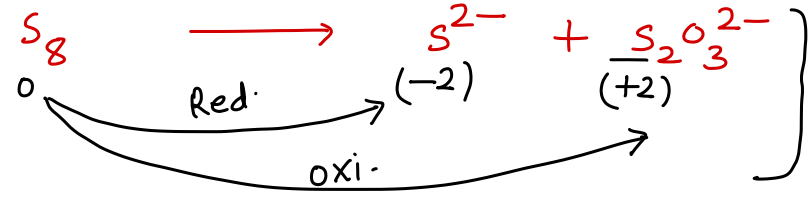
(Spectator) (RA) (OA)

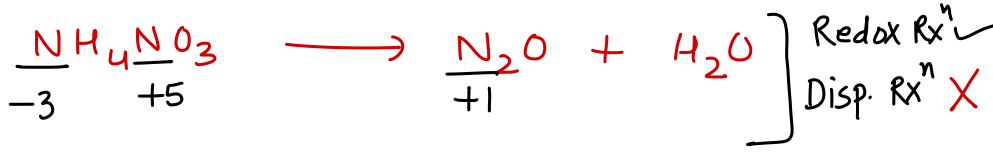
Disproportionation Rxn (Auto redox or self redox)

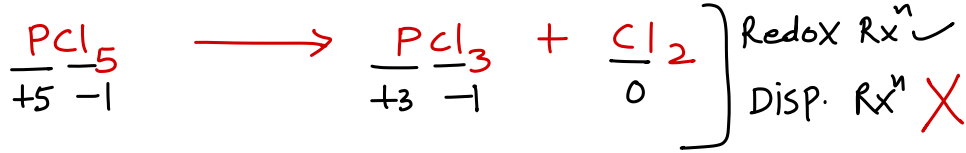
Redox Rxn in same comp., same element, with same O.S.











* Reverse Rxn of disproportionation Rxn is known as comproportionation Rxn.

Equivalent weight of reactants in redox Rxn →

$$\text{Ewt} = \frac{\text{Molar mass}}{\text{n-factor}}$$

n-factor for oxidant = No. of moles of e^- gained by 1 mole oxidiant

n-factor for reductant = No. of moles of e^- lost by 1 mol reductant

n-factor for redox substance = No. of moles of e^- exchanged by 1 mol redox substance

n-factor for spectator = $\frac{\text{No. of moles of } e^- \text{ exchanged in Rx}^n}{\text{No. of moles of spectator}}$

Ex. $\underset{+7}{KMnO_4} \longrightarrow \underset{+2}{Mn^{2+}}$

$nf = 5 \qquad 5$

$\underset{+7}{KMnO_4} \longrightarrow \underset{+4}{MnO_2}$

$nf = 3 \qquad 3$

$\underset{+5}{HNO_3} \longrightarrow \underset{+2}{NO}$

$nf = 3 \qquad 3$

$\underset{+2}{Na_2S_2O_3} \longrightarrow \underset{+2.5}{Na_2S_4O_6}$

$nf = 0.5 \times 2 = 1 \qquad 0.5 \times 4 = 2$

$\underset{+3}{C_2O_4} \longrightarrow \underset{+4}{CO_2}$

$nf = 2 \qquad 1$

$\underset{+5}{KIO_3} + 5\underset{-1}{KI} + 6HCl \longrightarrow \underset{0}{3I_2} + 6KCl + 3H_2O$

$nf = 5 \quad 1 \quad (5/6) \quad (5/3) \quad (5/6) \quad (5/3)$

$FeC_2O_4 \longrightarrow Fe^{3+} + CO_2$

Homework

Self study: Types of redox reactions (Combination reactions, decomposition reaction , displacement reactions) from NCERT.

DTS-1-11
Q.1-34,38,40,41,44,50,60-63,69,70,72,75-83,87,90,96, 98,110,135,136

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