SENIOR CHEMISTRY ELECTIVE

"OXIDATION-REDUCTION"

Introductory Problems - Set Number 1

1. Identify each of the following as either oxidation or reduction :

(a) $Na(s) \rightarrow Na^{+} + e$
(b) $F(g) + e \rightarrow F^{-}$
(c) $Mg^{2+}(aq) + 2e \rightarrow Mg(s)$
(d) $2Cl^{-}(aq) \rightarrow Cl_2(aq) + 2e$
(e) $H_2(g) + 2e \rightarrow 2H^{-}(g)$
(f) $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$
(g) $Fe(s) \rightarrow Fe^{2+}(aq) + 2e$
(h) $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e$

2. The equations listed in question 1. can be described as being of what type?

3. Why must oxidation and reduction occur together (as paired processes)?

4. In each of the following oxidation-reduction equations, state :

(i) what is being oxidised
(ii) what is being reduced
(iii) the oxidising agent (oxidant)
(iv) the reducing agent (reductant)

(a) $C(s) + O_2(g) \rightarrow CO_2(g)$
(b) $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$
(c) $Pb(s) + Cu^{2+}(aq) \rightarrow Pb^{2+}(aq) + Cu(s)$
(d) $Fe(s) + 2Ag^{+}(aq) \rightarrow Fe^{2+}(aq) + 2Ag(s)$
(e) $2Fe^{2+}(aq) + I_2(aq) \rightarrow 2Fe^{3+}(aq) + 2I^{-}(aq)$
(f) $Ce^{3+}(aq) + Fe^{3+}(aq) \rightarrow Ce^{4+}(aq) + Fe^{2+}(aq)$
(g) $F_2(g) + 2I^{-}(aq) \rightarrow 2F^{-}(aq) + I_2(aq)$
(h) $Mg(s) + 2H^{+}(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$

5. For each of the following reactions, write the two ionic half-equations involved in the process, the overall equation, and the oxidising and reducing agents :

(a) Zinc reacting with hydrogen ions to produce zinc(II) ions and hydrogen gas.

(b) The sulfide ion reacting with iodine (I_2) to produce sulfur and iodide ions.

(c) Silver ions reacting with copper metal to produce silver metal and copper(II) ions.

(d) The silver ion oxidising zinc metal.

(e) Fluorine gas reacting with chloride ions to produce chlorine gas and fluoride ions.

(f) Iron metal reacting with bromine to produce iron(II) bromide (containing iron(II) ions and bromide ions)

Oxidation - Reduction Problems #1.

1.

a) Oxidation
b) Reduction
c) Reduction
d) Oxidation
e) Reduction
f) Reduction
g) Oxidation
h) Oxidation

2. Half - Equations

3.

4.

a) C oxidised (Reductant) O_2 is Reduced (Oxidant)
b) Na oxidised (Reductant) Cl_2 is Reduced (Oxidant)
c) Pb oxidised (Reductant) Cu^{2+} is Reduced (Oxidant)
d) Fe oxidised (Reductant) Ag^+ is Reduced (Oxidant)
e) Fe^{2+} oxidised (Reductant) I_2 is Reduced (Oxidant)
f) Ce^{3+} oxidised (Reductant) Fe^{3+} is Reduced (Oxidant)
g) F_2 Reduced (Oxidant) I^- is oxidised (Reductant)
h) Mg oxidised (Reductant) H^+ is Reduced (Oxidant)

5. a) $Zn \rightarrow Zn^{2+} + 2e^-$
$2H^+ + 2e \rightarrow H_2$

$Zn_{(s)} + 2H^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + H_{2(g)}$

H^+ Oxidising Agent
Zn Reducing Agent

b) $S^{2-} \rightarrow S + 2e^-$
$I_2 + 2e^- \rightarrow 2I^-$

$S^{2-} + I_2 \rightarrow S + 2I^-$

I_2 Oxidising Agent
S^{2-} Reducing Agent.

c) $Ag^+ + e^- \rightarrow Ag$
$Cu \rightarrow Cu^{2+} + 2e^-$

$Cu + 2Ag^+ \rightarrow 2Ag + Cu^{2}$

Ag^+ Oxidising Agent
Cu Reducing Agent.

P.T.O.

d) $Zn \rightarrow Zn^{2+} + 2e$
$Ag^+ + e^- \rightarrow Ag$

$2Ag^+ + Zn \rightarrow Zn^{2+} + 2Ag$

Ag^+ Oxidising Agent
Zn Reducing Agent.

e) $F_2 + 2e^- \rightarrow 2F^-$
$2Cl^- \rightarrow Cl_2 + 2e^-$

$F_2 + 2Cl^- \rightarrow 2F^- + Cl_2$

F_2 Oxidising Agent
Cl^- Reducing Agent

f) $Fe \rightarrow Fe^{2+} + 2e^-$
$Br_2 + 2e^- \rightarrow 2Br^-$

$Fe + Br_2 \rightarrow Fe^{2+} + 2Br^-$

Br_2 Oxidising Agent
Fe Reducing Agent.

SENIOR CHEMISTRY ELECTIVE

"OXIDATION-REDUCTION"

Problems in Balancing Redox Equations - Set Number 2

SET (A)

1. Balance each of the following ionic half-equations :

(a) $IO_3^-(aq) \rightarrow I^-(aq)$

(b) $NO_3^-(aq) \rightarrow NO_2(g)$

(c) $I_2(aq) \rightarrow IO_3^-(aq)$

(d) $Cl_2(g) \rightarrow Cl^-(aq)$

(e) $H_2S(g) \rightarrow S(s)$

(f) $C_2O_4^{2-}(aq) \rightarrow CO_2(g)$

(g) $CH_4(g) \rightarrow CO_2(g)$

(h) $F^-(aq) \rightarrow F_2(g)$

(i) $S(s) \rightarrow SO_2(g)$

(j) $H_2O_2(l) \rightarrow H_2O(l)$

SET (B)

1. Balance the following PAIRS of ionic equations, then write the OVERAL NET IONIC EQUATION.

(a) $Mn^{2+}(aq) \rightarrow MnO_4^-(aq)$

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

(b) $NO_3^-(aq) \rightarrow NO_2(g)$

$Cu(s) \rightarrow Cu^{2+}(aq)$

(c) $Pb^{2+}(aq) \rightarrow Pb(s)$

$SO_2(g) \rightarrow SO_4^{2-}(aq)$

(d) $F_2(g) \rightarrow F^-(aq)$

$Br^-(aq) \rightarrow Br_2(aq)$

(e) $Cr_2O_7^{2-}(aq) \rightarrow Cr^{3+}(aq)$

$C_2H_5OH(l) \rightarrow CO_2(g)$

(f) $SO_2(g) \rightarrow SO_4^{2-}(aq)$

$IO_3^-(aq) \rightarrow I_2(aq)$

Answers to Problems in Balancing Redox Equations - Set 2

SET (A)

1. (a) $IO_3^-(aq) + 6H^+(aq) + 6e \rightarrow I^-(aq) + 3H_2O(l)$

(b) $NO_3^-(aq) + 2H^+(aq) + e \rightarrow NO_2(g) + H_2O(l)$

(c) $I_2(aq) + 6H_2O(l) \rightarrow 2IO_3^-(aq) + 12H^+(aq) + 10e$

(d) $Cl_2(g) + 2e \rightarrow 2Cl^-(aq)$

(e) $H_2S(g) \rightarrow S(s) + 2H^+(aq) + 2e$

(f) $C_2O_4^{2-}(aq) \rightarrow 2CO_2(g) + 2e$

(g) $CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+(aq) + 8e$

(h) $2F^-(aq) \rightarrow F_2(g) + 2e$

(i) $S(s) + 2H_2O(l) \rightarrow SO_2(g) + 4H^+(aq) + 4e$

(j) $H_2O_2(l) + 2H^+(aq) + 2e \rightarrow H_2O(l) + H_2O(l)$

SET (B) :

(a) $Mn^{2+}(aq) + 4H_2O(l) \rightarrow MnO_4^-(aq) + 8H^+(aq) + 5e$

$(Fe^{3+}(aq) + e \rightarrow Fe^{2+}(aq)) \times 5$

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

(b) $(NO_3^- + 2H^+ + e \rightarrow NO_2(g) + H_2O) \times 2$

$Cu \rightarrow Cu^{2+} + 2e$

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

(c) $Pb^{2+} + 2e \rightarrow Pb$

$SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e$

$Pb^{2+} + SO_2 + 2H_2O \rightarrow Pb + SO_4^{2-} + 4H^+$

(d) $F_2 + 2e \rightarrow 2F^-$

$2Br^- \rightarrow Br_2 + 2e$

$F_2 + 2Br^- \rightarrow 2F^- + Br_2$

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

$C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e$

$2Cr_2O_7^{2-} + 16H^+ + C_2H_5OH \rightarrow 2CO_2 + 4Cr^{3+} + 11H_2O$

(f) $(SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e) \times 5$

$2IO_3^- + 12H^+ + 10e \rightarrow I_2 + 6H_2O$

$5SO_2 + 4H_2O + 2IO_3^- \rightarrow 5SO_4^{2-} + I_2 + 8H^+$

REDOX EQUATIONS

1. Determine the unit oxidation numbers (oxidation states) of the elements mentioned in the following:

N in NO_3^-, NH_3, NH_4^+, NO, N_2O, NO_2, N_2O_4, N_2O_5 NO_3^-, NO_2^-, N_2.

S in H_2S, SO_2, H_2SO_3, SO_3^{--}, HSO_3^-, H_2SO_4, SO_4^{--}, SO_3, $S_2O_3^{--}$, $S_4O_6^{--}$.

C in CO_2, CaC_2, CH_4, $HCHO$, C_2H_5OH, $CHCl_3$, CS_2, SiC, CO_3^{--}, HCO_3^-, C_2O_4

C in $HC_2O_4^-$, CO, *Diamond*, $C_{12}H_{22}O_{11}$, CG_3CGO, C_2H_4, C_2H_2.

Fe in Metallic iron, ferrous oxide, ferric oxide, Fe_3O_4, $Fe_2(SO_4)_3$.

Mn in $KMnO_4$, MnO_4^-, MnO_2, $MnSO_4$, $Mn(OH)_2$, K_2MnO_4, Mn^{++}

Boron in $B_4O_7^{--}$, H_3BO_3, B_2H_6.

Cl in HCl, Cl_2, Cl^-, $KClO_3$, ClO_2, $HClO$, ClO^-, ClO_2^-.

O in O_2, O_3, H_2O, ClO_3^-, Na_2O_2.

Cr in $Cr_2O_7^{--}$, CrO_4^{--}, Cr_2O_3, *Chromite anions*

2. State whether the following reactions involve redox or not and, if so, which substance is oxidized and which reduced.

(a) $Zn + Fe^{++} \rightarrow Zn^{++} + Fe$

(b) $2Na + 2H_2O \rightarrow 2Na^+ + 2OH^- + H_2$

(c) $NH_4Cl\ (Solid) \rightleftharpoons NH_3\ (Gas) + HCl\ (Gas)$

(d) $NH_4NO_3\ (Solid) \rightleftharpoons N_2O\ (Gas) + 2H_2O\ (Gas)$

Now have another look at it!!

(e) $CuO + H_2 \rightarrow Cu + H_2O$

(f) $2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{++} + 5O_2 + 8H_2O$

(g) $2H_2O_2 \rightarrow 2H_2O + O_2$

(h) $OCl^- + 2H^+ + Cl^- \rightarrow H_2O + Cl_2$

(i) $2OH^- + Cl_2 \rightarrow OCl^- + H_2O$

(j) $2CrO_4^{--} + 2H^+ \rightleftharpoons Cr_2O_7^{--} + H_2O$

(k) $2KmnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 10\,CO_2 + 8\,H_2O$

(l) $Na_2CO_3 + 2H^+ \rightarrow 2Na^+ + H_2O + CO_2$

(m) $HC_2O_4^- + OH^- \rightarrow H_2O + C_2O_4^{--}$

(n) $2HCl + Zn \rightarrow ZnCl_2 + H_2$

(o) $(NH_4)_2\,Cr_2O_7 \rightarrow Cr_2O_3 + N_2\nearrow + 4H_2O$

(p) $Cr_2O_7^{--} + 3SO_2 + 2H^+ \rightarrow 2Cr^{+++} + 3SO_4^{--} + H_2O$

(q) $2H_2S + SO_2 \rightarrow 2H_2O + 3S$

Give ionic half equations (partial equations) for:

(a) the oxidation of ferrous ions to ferric ions,

(b) the reduction of nitric acid to nitric oxide,

(c) the oxidation of hydrogen peroxide to oxygen,

(d) the reduction of hydrogen peroxide to water,

(e) the oxidation of oxalic acid $H_2C_2O_4$ to carbon dioxide,

(f) the reduction of potassium permanganate to manganous sulphate,

(g) the reduction of potassium permanganate to manganese dioxide.

Redox Equations (Answers)

Q1.

NO_3^-	$+5\ 3(-2) = -1$	∴ N	is +5
NH_3	$-3\ 3(+1) = 0$	∴ N	is −3
NH_4^+	$-3\ 4(+1) = +1$	∴ N	is −3
NO	$+2\ -2 = 0$	∴ N	is +2
N_2O	$2(+1)\ -2 = 0$	∴ N	is +1
NO_2	$+4\ 2(-2) = 0$	∴ N	is +4
N_2O_4	$2(+4)\ 4(-2) = 0$	∴ N	is +4
N_2O_5	$2(+5)\ 5(-2) = 0$	∴ N	is +5
NO_3^-	$+5\ 3(-2) = -1$	∴ N	is +5
NO_2^-	$+3\ 2(-2) = -1$	∴ N	is +3
N_2	ELEMENT	N	is 0

H_2S	$2(+1)\ -2 = 0$	∴ S	is −2
SO_2	$+4\ 2(-2) = 0$	∴ S	is +4
H_2SO_3	$2(+1) + 4\ 3(-2) = 0$	∴ S	is +4
SO_3^{2-}	$+4\ 3(-2) = -2$	∴ S	is +4
HSO_3^-	$+1\ +4\ 3(-2) = -1$	∴ S	is +4
H_2SO_4	$2(+1) + 6\ 4(-2) = 0$	∴ S	is +6
SO_4^{2-}	$+6\ 4(-2) = -2$	∴ S	is +6
SO_3	$+6\ 3(-2) = 0$	∴ S	is +6
$S_2O_3^{2-}$	$2(+2)\ 3(-2) = -2$	∴ S	is +2
$S_4O_6^{2-}$	$4(\ )\ 6(-2) = -2$	S	will have

A number of oxidation states here

3 (+2) And 1 (+4)

CO_2	$+4\ 2(-2) = 0$	$\therefore$ C is $+4$
CaC_2	$+2\ 2(-1) = 0$	$\therefore$ C is -1
CH_4	$-4\ 4(+1) = 0$	$\therefore$ C is -4
$HCHO$	$+1\ 0\ +1\ -2 = 0$	$\therefore$ C is 0
C_2H_5OH	$2(-2)\ 5(+1)\ -2\ +1 = 0$	$\therefore$ C is -2
$CHCl_3$	$+2\ +1\ 3(-1) = 0$	$\therefore$ C is $+2$
CS_2	$+4\ 2(-2) = 0$	$\therefore$ C is $+4$
SiC	$+4\ -4 = 0$	$\therefore$ C is -4
CO_3^{2-}	$+4\ 3(-2) = -2$	$\therefore$ C is $+4$
HCO_3^-	$+1\ +4\ 3(-2) = -1$	$\therefore$ C is $+4$
$C_2O_4^{2-}$	$2(+3)\ 4(-2) = -2$	$\therefore$ C is $+3$
$HC_2O_4^-$	$+1\ 2(+3)\ 4(-2) = -1$	$\therefore$ C is $+3$
CO	$+2\ -2 = 0$	$\therefore$ C is $+2$
DIAMOND	ELEMENTAL C	$\therefore$ C is 0
$C_{12}H_{22}O_{11}$	$12(0)\ 22(+1)\ 11(-2) = 0$	$\therefore$ C is 0
CH_3CHO	$-1\ 3(+1)\ -1\ +1\ -2 = 0$	$\therefore$ C is -1
C_2H_4	$2(-2)\ 4(+1) = 0$	$\therefore$ C is -2
C_2H_2	$2(-1)\ 2(+1) = 0$	$\therefore$ C is -1

METALLIC IRON	ELEMENT	$\therefore$ Fe is 0
Fe^{2+}		$\therefore$ Fe is $+2$
Fe^{3+}		$\therefore$ Fe is $+3$
Fe_3O_4	$3(\ )\ 4(-2) = 0$	Fe will have a number of oxidation states here 1 (+2) and 2 (+3)
$Fe_2(SO_4)_3$	$2(+3)\ 3(-2) = 0$	$\therefore$ Fe is $+3$

$KMnO_4$	$+1\ +7\ 4(-2) = 0$	$\therefore$ Mn is $+7$
MnO_4^-	$+7\ 4(-2) = -1$	$\therefore$ Mn is $+7$
MnO_2	$+4\ 2(-2) = 0$	$\therefore$ Mn is $+4$
$MnSO_4$	$+2\ -2 = 0$	$\therefore$ Mn is $+2$
$Mn(OH)_2$	$+2\ 2(-1) = 0$	$\therefore$ Mn is $+2$
K_2MnO_4	$2(+1)\ +6\ 4(-2) = 0$	$\therefore$ Mn is $+6$
Mn^{2+}		$\therefore$ Mn is $+2$

HCl	$+1 \ -1 = 0$	$\therefore$ Cl is -1
Cl_2	ELEMENT	$\therefore$ Cl is 0
Cl^-		$\therefore$ Cl is -1
$KClO_3$	$+1 \ +5 \ 3(-2) = 0$	$\therefore$ Cl is $+5$
ClO_2	$+4 \ 2(-2) = 0$	$\therefore$ Cl is $+4$
$HClO$	$+1 \ +1 \ -2 = 0$	$\therefore$ Cl is $+1$
ClO^-	$+1 \ -2 = -1$	$\therefore$ Cl is $+1$
ClO_2^-	$+3 \ 2(-2) = -1$	$\therefore$ Cl is $+3$

O_2	ELEMENT	$\therefore$ O is 0
O_3	ELEMENT	$\therefore$ O is 0
H_2O	$2(+1) - 2 = 0$	$\therefore$ O is -2
ClO_3^-	$+5 \ 3(-2) = -1$	$\therefore$ O is -2
Na_2O_2	$2(+1) \ 2(-1) = 0$	$\therefore$ O is -1

$Cr_2O_7^{2-}$	$2(+6) \ 7(-2) = -2$	$\therefore$ Cr is $+6$
CrO_4^{2-}	$+6 \ 4(-2) = -2$	$\therefore$ Cr is $+6$
Cr_2O_3	$2(+3) \ 3(-2) = 0$	$\therefore$ Cr is $+3$
$Cr_2O_4^{2-}$	$2(+3) \ 4(-2) = 0$	$\therefore$ Cr is $+3$

Q2 a) YES ; Zn is oxidised Fe^{2+} is Reduced

b) YES ; Na is oxidised $H(H_2O)$ is Reduced

c) NO

d) YES ; $N(NH_4^+)$ is oxidised $N(NO_3^-)$ is Reduced

THIS IS CALLED DISPROPORTIONATION

e) YES ; H_2 is oxidised Cu is Reduced

f) YES ; O is oxidised Mn is Reduced

g) YES ; O is oxidised O is Reduced

THIS IS CALLED DISPROPORTIONATION

h) YES ; Cl^- is oxidised $Cl(OCl^-)$ is Reduced

i) YES ; Cl_2 is oxidised SPECIES Reduced IS MISSING FROM EQUATION OR OTHER PRODUCT NOT SHOWN

j) NO

(k) YES $C(H_2C_2O_4)$ is oxidised $Mn(KMnO_4)$ is Reduced

(l) No

(m) NO

(n) YES Zn is oxidised H(HCl) is Reduced

(o) YES N is oxidised Cr is Reduced

(p) YES S is oxidised Cr is Reduced

(q) YES S(H_2S) is oxidised S(SO_2) is Reduced

Q3 (a) $Fe^{2+} \rightarrow Fe^{3+} + 1e^-$

(b) $NO_3^- + 4H^+ + 3e^- \rightarrow NO + H_2O$

(c) $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$

(d) $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$

(e) $H_2C_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e^-$

(f) $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

(g) $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$