QUESTIONS on Oxidation Reduction Equations

Oxidation involves an increase in oxidation number (state)
Reduction involves a decrease in oxidation number (state)

Set 1:

Q1. Which of the following equations are oxidation–reduction reactions and which are not? Explain your decisions.

A. $Zn_{(s)} + 2\ MnO_{2(s)} + H_2O_{(l)} \rightarrow Zn(OH)_{2(s)} + Mn_2O_{3(s)}$
B. $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$
C. $CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$
D. $Na_{(s)} + Fe_2O_{3(s)} \rightarrow Na_2O_{(s)} + Fe_{(s)}$
E. $Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$
F. $HNO_{3(aq)} + H_3AsO_{3(aq)} \rightarrow NO_{(g)} + H_3AsO_{4(aq)} + H_2O_{(l)}$
G. $2Cu^{2+}_{(aq)} + 4\ I^-_{(aq)} \rightarrow 2\ CuI_{(s)} + I_{2(s)}$
H. $CaCO_{3(s)} + 2H^+_{(aq)} \rightarrow Ca^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$
I. $SO_{2(g)} + 2H_2S_{(g)} \rightarrow 2H_2O_{(l)} + 3S_{(s)}$
J. $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$
K. $Ca(OH)_{2(aq)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$
L. $3SO_{2(g)} + Cr_2O_7^{2-}{}_{(aq)} + 2H^+_{(aq)} \rightarrow 3SO_4^{2-}{}_{(aq)} + 2Cr^{3+}_{(aq)} + H_2O_{(l)}$
M. $BaO_{(s)} + SO_{2(g)} \rightarrow BaSO_{3(s)}$
N. $SO_{2(g)} + 2NO_3^-{}_{(aq)} \rightarrow SO_4^{2-}{}_{(aq)} + 2NO_{2(g)}$
O. $2NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$
P. $2Mg_{(s)} + SO_{2(g)} \rightarrow 2MgO_{(s)} + S_{(s)}$
Q. $MnO_4^-{}_{(aq)} + 5Fe^{2+}_{(aq)} + 8H^+_{(aq)} \rightarrow Mn^{2+}_{(aq)} + 5Fe^{3+}_{(aq)} + 4H_2O_{(l)}$

Q2. Which of these half-reactions represent oxidation and which reduction? Explain your reasoning.

A. $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2\ e^-$
B. $Ni^{4+}_{(aq)} + 2\ e^- \rightarrow Ni^{2+}_{(aq)}$
C. $2\ H_2O_{(l)} + 2\ e^- \rightarrow H_{2(g)} + 2\ OH^-_{(aq)}$
D. $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2\ e^-$
E. $Pb^{2+}_{(aq)} + 2e^- \rightarrow Pb_{(s)}$
F. $Cl_{2(g)} + 2\ e^- \rightarrow 2\ Cl^-_{(aq)}$
G. $Cr^{3+}_{(aq)} + 3e^- \rightarrow Cr_{(s)}$
H. $Cr_2O_7^{2-}{}_{(aq)} + 14\ H^+_{(aq)} + 6\ e^- \rightarrow 2\ Cr^{3+}_{(aq)} + 7\ H_2O_{(l)}$

Q3. How many electrons are in the following ½ equations

A. $Al \rightarrow Al^{3+} + ?\ e-$
B. $MnO_4^- + 8\ H^+ + ?\ e- \rightarrow Mn^{2+}_{(aq)} + 4\ H_2O_{(l)}$
C. $H_2O_2 \rightarrow 2\ H^+ + O_2 + ?\ e-$
D. $H_2O_2 + ?\ e- \rightarrow 2\ OH^-$
E. $S_8 + ?\ e- \rightarrow 8\ S^{2-}$
F. $NO_3^- + 2\ H^+ + ?\ e- \rightarrow NO_2 + H_2O$

Q4. Identify the reducing agent (reductant) in the following reactions.

A. $2\ Cr^{3+} + H_2O + 6\ ClO_3^- \rightarrow Cr_2O_7^{2-} + 6\ ClO_2 + 2\ H^+$
B. $Cr_2O_7^{2-} + HCHO \rightarrow HCOOH + Cr^{3+}$
C. $7\ CN^- + 2\ OH^- + 2\ Cu(NH_3)_4^{2+} \rightarrow 2\ Cu(CN)_3^{2-} + 8\ NH_3 + CNO^- + H_2O$
D. $2\ Li + 2\ H_2O \rightarrow 2\ LiOH + H_2$
E. $Cl_2 + 2\ KI \rightarrow 2\ KCl + I_2$
F. $SO_2 + 2H_2S \rightarrow 2H_2O + 3S$

Q5. Identify the oxidising agent (oxidant) in the following reactions.

A. $Ni + Pb(NO_3)_2 \rightarrow Ni(NO_3)_2(aq) + Pb(s)$
B. $2H_2O \rightarrow 2H_2 + O_2$
C. $Cr_2O_3 + Al \rightarrow Cr + Al_2O_3$
D. $FeO + H_2 \rightarrow Fe + H_2O$
E. $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$
F. $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$

Q6. Write the full oxidation-reduction equation from the following two half-reactions:

number of e⁻s lost = number of e⁻s gained

- Since charge is conserved, one or both ½ equations may need to be multiplied by an integer so that number of e⁻s lost = number of e⁻s gained.
- Like terms such as H^+ ions and H_2O molecules may need to be collected if they appear on both sides of the equation

A. $Cr_2O_7^{2-} + 14\ H^+ + 6\ e^- \rightarrow 2\ Cr^{3+} + 7\ H_2O$
$H_2C_2O_4 \rightarrow 2\ CO_2 + 2\ H^+ + 2\ e^-$

B. $Cd \rightarrow Cd^{2+} + 2\ e^-$
$4\ H^+ + NO_3^- + 3\ e^- \rightarrow NO + 2\ H_2O$

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

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

E. $C_2H_6O + H_2O \rightarrow C_2H_4O_2 + 4\ H^+ + 4\ e^-$
$Cr_2O_7^{2-} + 14\ H^+ + 6\ e^- \rightarrow 2\ Cr^{3+} + 7\ H_2O$

F. $Li + \rightarrow Li^+ + e^-$
$2\ H_2O + 2\ e^- \rightarrow 2OH^- + H_2$

G. $H_2O_2 + 2\ H^+ + 2\ e^- \rightarrow 2\ H_2O$
$H_2O_2 \rightarrow O_2 + 2\ H^+ + 2\ e^-$

H. $NO_3^- + 4\ H^+ + 3\ e^- \rightarrow NO + 2\ H_2O$
$AsO_3^{3-} + H_2O \rightarrow AsO_4^{3-} + 2\ H^+ + 2\ e^-$

I. $2\ MnO_2 + 2\ H^+ + 2\ e^- \rightarrow Mn_2O_3 + H_2O$
$Zn \rightarrow Zn^{2+} + 2\ e^-$

Q7. Balance each of the following ionic half-equations

A. $IO_3^-(aq) \rightarrow I_{2(aq)}$
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. $H_2O_{2(l)} \rightarrow H_2O_{(l)}$

Q8. Balance the following pairs of ionic equations and then write the overall 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. $SO_4^{2-}{}_{(aq)} \rightarrow H_2S_{(g)}$
$I_{2(aq)} \rightarrow IO_3^-{}_{(aq)}$

Q9. Balance the following equations

A. $Al + Cu^{2+} \rightarrow Cu + Al^{3+}$

B. $MnO_4^- + NO_2^- \rightarrow NO_3^- + Mn^{2+}$

C. $Ag + NO_3^- \rightarrow Ag^+ + NO$

D. $Zn + NO_3^- \rightarrow Zn^{2+} + NH_4^+$

E. $Cr_2O_7^{2-} + C_2H_4O \rightarrow C_2H_4O_2 + Cr^{3+}$

F. $H_2C_2O_4 + MnO_4^- \rightarrow CO_2 + Mn^{2+}$

G. $Au^{3+} + I^- \rightarrow Au + I_2$

H. $NO_2 + H_2 \rightarrow 2NH_3 + 4H_2O$

I. $Cr_2O_7^{2-} + NO_2^- \rightarrow Cr^{3+} + NO_3^-$

J. $I_3^- + S_2O_3^{2-} \rightarrow I^- + S_4O_6^{2-}$

K. $CH_3CH_2OH + Cr_2O_7^{2-} \rightarrow CH_3CO_2H + Cr^{3+}$

L. $SO_2 + Cr_2O_7^{2-} \rightarrow SO_4^{2-} + Cr^{3+}$

M. $MnO_4^- + H_2O_2 \rightarrow Mn^{2+} + O_2$

N. $I^- + OCl^- \rightarrow I_2 + Cl^-$

O. $P + Cu^{2+} \rightarrow Cu + H_2PO_4^-$

P. $SO_2 + 2H_2S \rightarrow 2H_2O + 3S$

Q. $Pb + PbO_2 + SO_4^{2-} \rightarrow PbSO_4$

R. $Cr^{3+} + Cl^- \rightarrow Cr + Cl_{2(g)}$

S. $Cu + NO_3^- \rightarrow Cu^{2+} + NO_2$

T. $Cr_2O_7^{2-} + Cl^- \rightarrow Cr^{3+} + Cl_2$

U. $MnO_4^- + I^- \rightarrow I_2 + Mn^{2+}$

V. $Cr^{3+} + ClO_3^- \rightarrow Cr_2O_7^{2-} + ClO_2$

W. $Mn^{2+} + BiO_3^- \rightarrow MnO_4^- + Bi^{3+}$

X. $ClO_3^- + Cl^- \rightarrow Cl_2 + ClO_2$

Y. $MnO_4^- + S_2O_3^{2-} \rightarrow S_4O_6^{2-} + Mn^{2+}$

Z. $PH_3 + I_2 \rightarrow H_3PO_2^- + I^-$

AA. $NO_2 \rightarrow NO_3^- + NO$

AB. $I^- + IO_3^- \rightarrow I_2$

Q10. For each of the following reactions, write the two ionic half-equations involved in the process, the overall equation, the oxidizing agent (oxidant) and the reducing agent (reductant).

A. Zinc reacting with hydrogen ions to produce zinc ions and hydrogen gas.
B. The sulfide ion reacting with iodine to produce sulfur and iodide ions.
C. Silver ions reacting with copper metal to produce silver metal and copper ions.
D. The silver ion oxidizing 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) ions and bromide ions.
G. Hydrogen ions reacting with magnesium metal.
H. Iodide ions reacting with iron(III) ions to give iodine and iron(II) ions.

Answers:

Q1.

A.	Yes, Zn and Mn change oxidation state	B.	No, no change in oxidation state
C.	Yes, C and O change oxidation state	D.	Yes, Na and Fe change oxidation state
E.	No, no change in oxidation state	F.	Yes, N and As change oxidation state
G.	Yes, Cu^{2+} and I^- change oxidation state	H.	No, no change in oxidation state
I.	Yes, S and S change oxidation state	J.	No, no change in oxidation state
K.	No, no change in oxidation state	L.	Yes, S and Cr change oxidation state
M.	No, no change in oxidation state	N.	Yes, S and N change oxidation state
O.	No, no change in oxidation state	P.	Yes, Mg and S change oxidation state
Q.	Yes, Mn and Fe^{2+} change oxidation state		

Q2. Oxidation: electrons on the right hand side Reduction: electrons on the left hand side

A.	Oxidation, increase in oxidation state	B.	Reduction, decrease in oxidation state
C.	Reduction, decrease in oxidation state	D.	Oxidation, increase in oxidation state
E.	Reduction, decrease in oxidation state	F.	Reduction, decrease in oxidation state
G.	Reduction, decrease in oxidation state	H.	Reduction, decrease in oxidation state

Q3. A. $3e^-$ B. $5e^-$ C. $2e^-$ D. 2 e^- E. $16e^-$ F. $1e^-$

Q4. A. Cr^{3+} B. HCHO C. CN^- D. Li E. I^- (KI) F. S(H_2S)

Q5. A. Pb^{2+} B. H(H_2O) C. Cr_2O_3 D. FeO E. MnO_4^- F. Cu^{2+}

Q6.

A. $Cr_2O_7^{2-} + 8H^+ + 3H_2C_2O_4 \rightarrow 2Cr^{3+} + 7H_2O + 6CO_2$
B. $3Cd + 8H^+ + 2NO_3^- \rightarrow 3Cd^{2+} + 2NO + 4H_2O$
C. $6H^+ + 5I^- + IO_3^- \rightarrow 3I_2 + 3H_2O$
D. $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$
E. $2Cr_2O_7^{2-} + 16H^+ + 3C_2H_6O \rightarrow 4Cr^{3+} + 3C_2H_4O_2 + 11H_2O$
F. $2Li + 2H_2O \rightarrow 2LiOH + H_2$
G. $2H_2O_2 \rightarrow 2H_2O + O_2$
H. $2NO_3^- + 2H^+ + 3AsO_3^{3-} \rightarrow 2NO + H_2O + 3AsO_4^{3-}$
I. $Zn + 2MnO_2 + 2H^+ \rightarrow Mn_2O_3 + H_2O + Zn^{2+}$

Q7.

A. $2IO_3^-{}_{(aq)} + 12H^+{}_{(aq)} + 10e^- \rightarrow I_{2(aq)} + 6H_2O_{(l)}$
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. $H_2O_{2(l)} + 2H^+{}_{(aq)} + 2e^- \rightarrow 2H_2O_{(l)}$

Q8.

A.
$Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+ + 5e^-$
$Fe^{3+} + e^- \rightarrow Fe^{2+}$] x5
$Mn^{2+} + 4H_2O + 5Fe^{3+} \rightarrow MnO_4^- + 8H^+ + 5Fe^{2+}$

B.
$NO_3^- + 2H^+ + e^- \rightarrow NO_2 + H_2O$] x 2
$Cu^{2+} + 2e^- \rightarrow Cu$
$2NO_3^- + 4H^+ + Cu^{2+} \rightarrow 2NO_2 + 2H_2O + Cu$

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

D.
$F_2 + 2e^- \rightarrow 2F^-$
$2Br^- \rightarrow Br_2 + 2e^-$
$F_2 + 2Br^- \rightarrow 2F^- + Br_2$

E.
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$] x 2
$C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$
$2Cr_2O_7^{2-} + 16H^+ + C_2H_5OH \rightarrow 4Cr^{3+} + 11H_2O + 2CO_2$ collect like terms (H_2O and H^+)

F.
$SO_4^{2-} + 10H^+ + 8e^- \rightarrow H_2S + 4H_2O$] x 5
$I_2 + 6H_2O \rightarrow 2IO_3^- + 12H^+ + 10e^-$] x 4
$5SO_4^{2-} + 4I_2 + 2H^+ + 4H_2O \rightarrow 5H_2S + 8IO_3^-$ collect like terms (H_2O and H^+)

Q9. A. $Al \rightarrow Al^{3+} + 3e^-$] x 2
$Cu^{2+} + 2e^- \rightarrow Cu$] x 3
$2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$ check that the charges are balanced

B. $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$] x 2
$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$] x 5
$2MnO_4^- + 6H^+ + 5NO_2^- \rightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$ collect like terms (H_2O and H^+)

C. $Ag \rightarrow Ag^+ + e^-$] x 3
$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$
$3Ag + NO_3^- + 4H^+ \rightarrow 3Ag^+ + NO + 2H_2O$ check that the charges are balanced

D. $Zn \rightarrow Zn^{2+} + 2e^-$] x 4
$NO_3^- + 10H^+ + 8e^- \rightarrow NH_4^+ + 3H_2O$
$4Zn + NO_3^- + 10H^+ \rightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$ check that the charges are balanced

E. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
$C_2H_4O + H_2O \rightarrow C_2H_4O_2 + 2H^+ + 2e^-$] x 3
$Cr_2O_7^{2-} + 8H^+ + 3C_2H_4O \rightarrow 2Cr^{3+} + 3C_2H_4O_2 + 4H_2O$ collect like terms (H_2O and H^+)

F. $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$] x 2
$H_2C_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e^-$] x 5
$2MnO_4^- + 6H^+ + 5H_2C_2O_4 \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$ collect like terms (H_2O and H^+)

G. $2I^- \rightarrow I_2 + 2e^-$] x 3
$Au^{3+} + 3e^- \rightarrow Au$] x 2
$2Au^{3+} + 6I^- \rightarrow 2Au + 3I_2$ check that the charges are balanced

H. $2NO_2 + 14H^+ + 14e^- \rightarrow 2NH_3 + 4H_2O$
$H_2O + H_2 \rightarrow H_2O + 2H^+ + 2e^-$] x7
$2NO_2 + 7H_2 \rightarrow 2NH_3 + 11H_2O$ collect like terms (H_2O and H^+)

I. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$] x 3
$Cr_2O_7^{2-} + 8H^+ + 3NO_2^- \rightarrow 2Cr^{3+} + 4H_2O + 3NO_3^-$ collect like terms (H_2O and H^+)

J. $I_3^- + 2e^- \rightarrow 3I^-$
$2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-$
$I_3^- + 2S_2O_3^{2-} \rightarrow 3I^- + S_4O_6^{2-}$ check that the charges are balanced

K. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$] x 2
$CH_3CH_2OH + H_2O \rightarrow CH_3CO_2H + 4H^+ + 4e^-$] x 3
$2Cr_2O_7^{2-} + 16H^+ + 3CH_3CH_2OH \rightarrow 4Cr^{3+} + 3CH_3CO_2H + 11H_2O$

L. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
$SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$] x3
$3SO_2 + Cr_2O_7^{2-} + 2H^+ \rightarrow 2Cr^{3+} + H_2O + 3SO_4^{2-}$ collect like terms (H_2O and H^+)

M. $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$] x 2
$H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$] x 5
$2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$ collect the H^+ ions

N. $2I^- \rightarrow I_2 + 2e^-$
$OCl^- + 2H^+ + 2e^- \rightarrow Cl^- + H_2O$
$OCl^- + 2H^+ + 2I^- \rightarrow Cl^- + H_2O + I_2$ check that the charges are balanced

O. $Cu^{2+} + 2e^- \rightarrow Cu$] x 5
$P + 4H_2O \rightarrow H_2PO_4^- + 6H^+ + 5e^-$] x 2
$2P + 8H_2O + 5Cu^{2+} \rightarrow 2H_2PO_4^- + 12H^+ + 5Cu$ check that the charges are balanced

P. $SO_2 + 4H^+ + 4e^- \rightarrow S + 2H_2O$
$H_2S \rightarrow S + 2H^+ + 2e^-$] x 2
$SO_2 + 2H_2S \rightarrow 2H_2O + 3S$ collect the H^+ ions and the S atoms

Q. $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$
$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$
$Pb + PbO_2 + 2SO_4^{2-} + 4H^+ \rightarrow 2PbSO_4 + 2H_2O$ collect the $PbSO_4$

R. $Cr^{3+} + 3e^- \rightarrow Cr$] x 2
$2Cl^- \rightarrow Cl_2 + 2e^-$] x 3
$2Cr^{3+} + 6Cl^- \rightarrow 2Cr + 3Cl_2$ check that the charges are balanced

S. $Cu \rightarrow Cu^{2+} + 2e^-$
$NO_3^- + 2H^+ + e^- \rightarrow NO_2 + H_2O$] x 2
$Cu + 2NO_3^- + 4H^+ \rightarrow Cu^{2+} + 2NO_2 + 2H_2O$ check that the charges are balanced

T. $2Cl^- \rightarrow Cl_2 + 2e^-$] x 3
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
$Cr_2O_7^{2-} + 14H^+ + 6Cl^- \rightarrow 2Cr^{3+} + 7H_2O + 3Cl_2$ check that the charges are balanced

U. $2I^- \rightarrow I_2 + 2e^-$] x 5
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$] x 2
$2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 8H_2O + 5I_2$ check that the charges are balanced

V. $2Cr^{3+} + 7H_2O \rightarrow Cr_2O_7^{2-} + 14H^+ + 6e^-$
$ClO_3^- + 2H^+ + e^- \rightarrow ClO_2 + H_2O$] x 6
$2Cr^{3+} + H_2O + 6ClO_3^- \rightarrow Cr_2O_7^{2-} + 6ClO_2 + 2H^+$ collect like terms (H_2O and H^+)

W. $BiO_3^- + 6H^+ + 2e^- \rightarrow Bi^{3+} + 3H_2O$
$Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+ + 5e^-$
$Mn^{2+} + H_2O + BiO_3^- \rightarrow MnO_4^- + 2H^+ + Bi^{3+}$ check that the charges are balanced

X. $ClO_3^- + 2H^+ + e^- \rightarrow ClO_2 + H_2O$] x 2
$2Cl^- \rightarrow Cl_2 + 2e^-$
$2ClO_3^- + 4H^+ + 2Cl^- \rightarrow 2ClO_2 + 2H_2O + Cl_2$ check that the charges are balanced

Y. $2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-$] x5
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$] x 2
$2MnO_4^- + 16H^+ + 10S_2O_3^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 5S_4O_6^{2-}$

Z. $PH_3 + 2H_2O \rightarrow H_3PO_2^- + 4H^+ + 3e^-$] x 2
$I_2 + 2e^- \rightarrow 2I^-$] x 3
$2PH_3 + 4H_2O + 3I_2 \rightarrow 2H_3PO_2^- + 8H^+ + 6I^-$ check that the charges are balanced

AA. $NO_2 + H_2O \rightarrow NO_3^- + 2H^+ + e^-$] x 2
$NO_2 + 2H^+ + 2e^- \rightarrow NO + H_2O$
$3NO_2 + H_2O \rightarrow 2NO_3^- + NO + 2H^+$ collect like terms (H_2O and H^+)

AB. $2I^- \rightarrow I_2 + 2e^-$] x 5
$2IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6H_2O$
$2IO_3^- + 12H^+ + 10I^- \rightarrow 5I_2 + I_2 + 6H_2O$ collect the I_2 molecules
$2IO_3^- + 12H^+ + 10I^- \rightarrow 6I_2 + 6H_2O$] ÷ 2 to get the smallest coefficients
$IO_3^- + 6H^+ + 5I^- \rightarrow 3I_2 + 3H_2O$ check that the charges are balanced

Q10.

A. $Zn \rightarrow Zn^{2+} + 2e^-$ oxidation ½ equation — Zn: reducing agent (reductant)
$2H^+ + 2e^- \rightarrow H_2$ reduction ½ equation — H^+: oxidizing agent (oxidant)
$Zn + 2H^+ \rightarrow Zn^{2+} + H_2$ overall equation

B. $S^{2-} \rightarrow S + 2e^-$ oxidation ½ equation — S^{2-}: reducing agent (reductant)
$I_2 + 2e^- \rightarrow 2I^-$ reduction ½ equation — I_2: oxidizing agent (oxidant)
$S^{2-} + I_2 \rightarrow S + 2I^-$ overall equation

C. $Cu \rightarrow Cu^{2+} + 2e^-$ oxidation ½ equation — Cu: reducing agent (reductant)
$2Ag^+ + 2e^- \rightarrow 2Ag$ reduction ½ equation — Ag^+: oxidizing agent (oxidant)
$Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$ overall equation

D. $Zn \rightarrow Zn^{2+} + 2e^-$ oxidation ½ equation — Zn: reducing agent (reductant)
$2Ag^+ + 2e^- \rightarrow 2Ag$ reduction ½ equation — Ag^+: oxidizing agent (oxidant)
$Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$ overall equation

E. $2Cl^- \rightarrow Cl_2 + 2e^-$ oxidation ½ equation — Cl^-: reducing agent (reductant)
$F_2 + 2e^- \rightarrow 2F^-$ reduction ½ equation — F_2: oxidizing agent (oxidant)
$2Cl^- + F_2 \rightarrow Cl_2 + 2F^-$ overall equation

F. $Fe \rightarrow Fe^{2+} + 2e^-$ oxidation ½ equation — Fe: reducing agent (reductant)
$Br_2 + 2e^- \rightarrow 2Br^-$ reduction ½ equation — Br_2: oxidizing agent (oxidant)
$Fe + Br_2 \rightarrow Fe^{2+} + 2Br^-$ overall equation

G. $Mg \rightarrow Mg^{2+} + 2e^-$ oxidation ½ equation — Mg: reducing agent (reductant)
$2H^+ + 2e^- \rightarrow H_2$ reduction ½ equation — H^+: oxidizing agent (oxidant)
$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ overall equation

H. $2I^- \rightarrow I_2 + 2e^-$ oxidation ½ equation — I^-: reducing agent (reductant)
$Fe^{3+} + 1e^- \rightarrow Fe^{2+}$ reduction ½ equation — Fe^{3+}: oxidising agent (oxidant)
$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ overall equation