Balancing Chemical Equations - EXERCISES

EXERCISES

1) $KMnO_4 + H_2SO_4 + KI \rightarrow MnSO_4 + I_2 + K_2SO_4 + H_2O$

2) $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO + H_2O$

3) $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$

4) $I_2 + HNO_3 \rightarrow NO + HIO_3 + H_2O$

5) $K_2Cr_2O_7 + HI + HClO_4 \rightarrow Cr(ClO_4)_3 + KClO_4 + I_2 + H_2O$

6) $K_2Cr_2O_7 + H_2SO_3 \rightarrow Cr_2(SO_4)_3 + H_2O + K_2SO_3$

7) $KMnO_4 + Fe + HCl \rightarrow FeCl_2 + MnCl_2 + KCl + H_2O$

8) $KMnO_4 + H_2SO_4 + H_2O_2 \rightarrow MnSO_4 + H_2O + O_2 + K_2SO_4$

9) $MnCl_2 + KCl + H_2O_2 \rightarrow KMnO_4 + HCl + H_2O$

10) $KIO_3 + Al + HCl \rightarrow I_2 + AlCl_3 + KCl + H_2O$

① $KMnO_4 + H_2SO_4 + KI \rightarrow MnSO_4 + I_2 + K_2SO_4 + H_2O$

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

oxidant — reduced

$5\times$ ($2I^-$ $\rightarrow$ I_2 + $2e^-$) oxidation

reductant — oxidized

↓

$2\ MnO_4^- + 10\ I^- + 16\ H^+ \rightarrow 2\ Mn^{2+} + 5\ I_2 + 8\ H_2O$ IONIC EQUATION

↓ $16\ H^+ \rightarrow 8\ H_2SO_4$

$2\ KMnO_4 + 8\ H_2SO_4 + 10\ KI \rightarrow 2\ MnSO_4 + 5\ I_2 + 6\ K_2SO_4 + 8\ H_2O$

MOLECULAR EQUATION

(2)

$\overset{0}{Cu} + \overset{+1}{H}\overset{+5}{N}O_3\overset{-2}{} \rightarrow \overset{+2}{Cu}(\overset{+5}{N}O_3\overset{-2}{})_2 + \overset{+2}{N}\overset{-2}{O} + \overset{+1}{H_2}\overset{-2}{O}$

Cu $\quad H^+$ $\quad NO_3^-$ $\quad Cu^{2+}$ $\quad 2\ NO_3^-$ $\quad NO$

$3\times (Cu \rightarrow Cu^{2+} + 2e^-)$ oxidation

reductant $\quad$ oxidized

$2\times (NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O)$ reduction

oxidant $\quad$ reduced

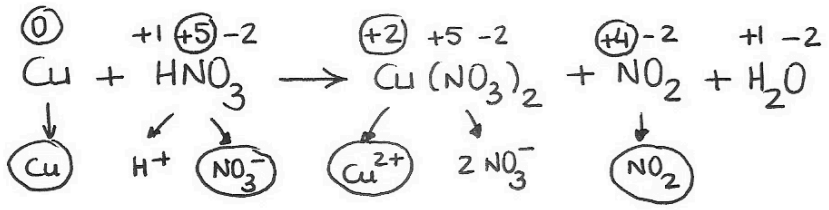
$3\ Cu + 2\ NO_3^- + 8H^+ \rightarrow 3\ Cu^{2+} + 2NO + 4\ H_2O$ IONIC EQUATION

$2\ NO_3^-$
$8\ H^+$ $\rightarrow 8\ HNO_3$

$3\ Cu + 8\ HNO_3 \rightarrow 3\ Cu(NO_3)_2 + 2\ NO + 4\ H_2O$

MOLECULAR EQUATION

(3)



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

reductant → oxidized

$2\times (NO_3^- + 2H^+ + e^- \longrightarrow NO_2 + H_2O)$ reduction

oxidant → reduced

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

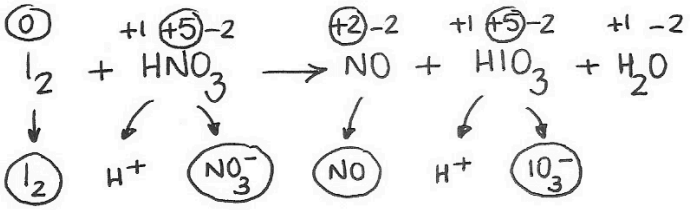
IONIC EQUATION

$2\,NO_3^-$, $4\,H^+ \longrightarrow 4\,HNO_3$

$Cu + 4\,HNO_3 \longrightarrow Cu(NO_3)_2 + 2\,NO_2 + 2\,H_2O$

MOLECULAR EQUATION

(4)



$3\times\ (\ I_2 + 6H_2O \longrightarrow 2\ IO_3^- + 12\,H^+ + 10\,e^-\ )$ oxidation

reductant → oxidized

$10\times\ (\ NO_3^- + 4H^+ + 3\,e^- \longrightarrow NO + 2\,H_2O\ )$ reduction

oxidant → reduced

$$3\ I_2 + 10\ NO_3^- + 18\ H_2O + 40\ H^+ \rightarrow 10\ NO + 6\ IO_3^- + 36\ H^+ + 20\ H_2O$$

$$3\ I_2 + 10\ NO_3^- + 4\ H^+ \rightarrow 10\ NO + 6\ IO_3^- + 2\ H_2O$$

IONIC EQUATION

$10\ NO_3^-$
$4\ H^+ \rightarrow 10\ HNO_3$

$$3\ I_2 + 10\ HNO_3 \rightarrow 10\ NO + 6\ HIO_3 + 2\ H_2O$$

MOLECULAR EQUATION

(5) $\overset{+1}{K_2}\overset{(+6)}{Cr_2}\overset{-2}{O_7} + \overset{+1}{H}\overset{(-1)}{I} + \overset{+1}{H}\overset{+7}{Cl}\overset{-2}{O_4} \rightarrow \overset{(+3)}{Cr}(\overset{+7}{Cl}\overset{-2}{O_4})_3 + \overset{+1}{K}\overset{+7}{Cl}\overset{-2}{O_4} + \overset{(0)}{I_2} + \overset{+1}{H_2}\overset{-2}{O}$

$Cr_2O_7^{=}$ I^- Cr^{3+} I_2

$Cr_2O_7^{=} + 14H^+ + 6e^- \rightarrow 2\,Cr^{3+} + 7\,H_2O$ reduction

oxidant — reduced

$3\times (\quad 2I^- \rightarrow I_2 + 2e^-)$ oxidation

reductant — oxidized

$Cr_2O_7^{=} + 6I^- + 14H^+ \rightarrow 2\,Cr^{3+} + 3\,I_2 + 7\,H_2O$ IONIC EQUATION

$6I^-, 14H^+ \rightarrow \begin{cases} 6\,HI \\ 8\,HClO_4 \end{cases}$

$\ldots \rightarrow \ldots 2\,KClO_4 \ldots$

$K_2Cr_2O_7 + 6\,HI + 8\,HClO_4 \rightarrow 2\,Cr(ClO_4)_3 + 2\,KClO_4 + 3\,I_2 + 7\,H_2O$

MOLECULAR EQUATION

(6)

$$\overset{+1}{K_2}\overset{(+6)}{Cr_2}\overset{-2}{O_7} + \overset{+1}{H_2}\overset{(+4)}{S}\overset{-2}{O_3} \rightarrow \overset{(+3)}{Cr_2}(\overset{(+6)}{S}\overset{-2}{O_4})_3 + \overset{+1}{K_2}\overset{+4}{S}\overset{-2}{O_3} + \overset{+1}{H_2}\overset{-2}{O}$$

$Cr_2O_7^{=}$ $SO_3^{=}$ $2\,Cr^{3+}$ $SO_4^{=}$

$$Cr_2O_7^{=} + 14H^+ + 6e^- \longrightarrow 2\,Cr^{3+} + 7\,H_2O \quad \text{reduction}$$

oxidant reduced

$$3\times\,(SO_3^{=} + H_2O \longrightarrow SO_4^{=} + 2H^+ + 2e^-) \quad \text{oxidation}$$

reductant oxidized

$$Cr_2O_7^{=} + 3\,SO_3^{=} + 14\,H^+ + 3\,H_2O \rightarrow 2\,Cr^{3+} + 3\,SO_4^{=} + 6H^+ + 7H_2O$$

$$Cr_2O_7^{=} + 3\,SO_3^{=} + 8\,H^+ \rightarrow 2\,Cr^{3+} + 3\,SO_4^{=} + 4\,H_2O$$ IONIC EQUATION

$3\,SO_3^{=}$
$8\,H^+$ $\longrightarrow 4\,H_2SO_3$

$\dots \longrightarrow 1\ K_2SO_3 \dots$

$$\boxed{K_2Cr_2O_7 + 4\,H_2SO_3 \rightarrow Cr_2(SO_4)_3 + K_2SO_3 + 4H_2O}$$

MOLECULAR EQUATION

(7) $\overset{+1}{K}\overset{+7}{Mn}\overset{-2}{O_4} + \overset{0}{Fe} + \overset{+1}{H}\overset{-1}{Cl} \rightarrow \overset{+2}{Fe}\overset{-1}{Cl_2} + \overset{+2}{Mn}\overset{-1}{Cl_2} + \overset{+1}{K}\overset{-1}{Cl} + \overset{+1}{H_2}\overset{-2}{O}$

MnO_4^- (reduction) $\quad$ Fe (oxidation) $\quad$ Fe^{2+} $\quad$ Mn^{2+}

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

oxidant $\quad$ reduced

$5\times (Fe \rightarrow Fe^{2+} + 2e^-)$ oxidation

reductant $\quad$ oxidized

$\downarrow$

$2\,MnO_4^- + 5\,Fe + 16\,H^+ \rightarrow 2\,Mn^{2+} + 5\,Fe^{2+} + 8\,H_2O$

IONIC EQUATION

$\downarrow$

$16\,H^+ \rightarrow 16\,HCl$

$\ldots \rightarrow 2\,KCl \ldots$

$\downarrow$

$2\,KMnO_4 + 5\,Fe + 16\,HCl \rightarrow 5\,FeCl_2 + 2\,MnCl_2 + 2\,KCl + 8\,H_2O$

MOLECULAR EQUATION

(8) $\overset{+1}{K}\overset{(+7)}{Mn}\overset{-2}{O_4} + \overset{+1}{H_2}\overset{+6}{S}\overset{-2}{O_4} + \overset{+1}{H_2}\overset{(-1)}{O_2} \rightarrow \overset{(+2)}{Mn}\overset{+6}{S}\overset{-2}{O_4} + \overset{+1}{H_2}\overset{-2}{O} + \overset{(0)}{O_2} + \overset{+1}{K_2}\overset{+6}{S}\overset{-2}{O_4}$

MnO_4^- H_2O_2 Mn^{2+} O_2

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

oxidant — reduced

$5x\,(\,H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-)$ oxidation

reductant — oxidized

$2\,MnO_4^- + 16H^+ + 5\,H_2O_2 \rightarrow 2\,Mn^{2+} + 5\,O_2 + 10H^+ + 8H_2O$

$2\,MnO_4^- + 6H^+ + 5\,H_2O_2 \rightarrow 2\,Mn^{2+} + 5\,O_2 + 8\,H_2O$ IONIC EQUATION

$6H^+ \rightarrow 3\,H_2SO_4$

$\ldots \rightarrow 1\,K_2SO_4\ldots$

$2\,KMnO_4 + 3\,H_2SO_4 + 5\,H_2O_2 \rightarrow 2\,MnSO_4 + 5\,O_2 + K_2SO_4 + 8\,H_2O$

MOLECULAR EQUATION

(9)

$\overset{+2}{Mn}\overset{-1}{Cl_2} + \overset{+1}{K}\overset{-1}{Cl} + \overset{+1}{H_2}\overset{-1}{O_2} \longrightarrow \overset{+1}{K}\overset{+7}{Mn}\overset{-2}{O_4} + \overset{+1}{H}\overset{-1}{Cl} + \overset{+1}{H_2}\overset{-2}{O}$

Mn^{2+} $\quad H_2O_2$ $\quad MnO_4^-$ $\quad H_2O$

$2\times (\underset{\text{reductant}}{Mn^{2+}} + 4H_2O \longrightarrow \underset{\text{oxidized}}{MnO_4^-} + 8H^+ + 5e^-)$ oxidation

$5\times (\underset{\text{oxidant}}{H_2O_2} + 2H^+ + 2e^- \longrightarrow \underset{\text{reduced}}{2H_2O})$ reduction

$2\,Mn^{2+} + 5H_2O_2 + 8H_2O + 10H^+ \longrightarrow 2\,MnO_4^- + 10H_2O + 16H^+$

$2\,Mn^{2+} + 5\,H_2O_2 \longrightarrow 2\,MnO_4^- + 2\,H_2O + 6\,H^+$ IONIC EQUATION

$\ldots\ 2\,KCl\ \ldots \longrightarrow \ldots$

$6H^+ \longrightarrow 6\,HCl$

$2\,MnCl_2 + 2\,KCl + 5\,H_2O_2 \longrightarrow 2\,KMnO_4 + 6HCl + 2H_2O$

MOLECULAR EQUATION

(10) $\overset{+1}{K}\overset{+5}{I}\overset{-2}{O_3} + \overset{0}{Al} + \overset{+1}{H}\overset{-1}{Cl} \rightarrow \overset{0}{I_2} + \overset{+3}{Al}\overset{-1}{Cl_3} + \overset{+1}{K}\overset{-1}{Cl} + \overset{+1}{H_2}\overset{-2}{O}$

IO_3^- Al I_2 Al^{3+}

$3\times (2\, IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6\, H_2O)$ reduction

oxidant — reduced

$10\times (Al \rightarrow Al^{3+} + 3e^-)$ oxidation

reductant — oxidized

$6\, IO_3^- + 10\, Al + 36\, H^+ \rightarrow 3\, I_2 + 10\, Al^{3+} + 18\, H_2O$

IONIC EQUATION

$36\, H^+ \rightarrow 36\, HCl$

$\ldots \rightarrow 6\, KCl \ldots$

$$6\, KIO_3 + 10\, Al + 36\, HCl \rightarrow 3\, I_2 + 10\, AlCl_3 + 6\, KCl + 18\, H_2O$$

MOLECULAR EQUATION