MATTER & MINERALS

CHEMISTRY HOMEWORK - FALL - WEEK 6

Chapter 4

(30) (a) $FeSO_4(aq) + 2KCl(aq) \rightarrow FeCl_2(aq) + K_2SO_4(aq)$

both are soluble
no precipitate

(b) $2Al(NO_3)_3(aq) + 3Ba(OH)_2(aq) \rightarrow 2Al(OH)_3(s) + 3Ba(NO_3)_2(aq)$

precipitate $Al(OH)_3$

(c) $CaCl_2(aq) + Na_2SO_4(aq) \rightarrow CaSO_4(s) + 2NaCl(aq)$

$CaSO_4$: precipitate

(d) $K_2S(aq) + Ni(NO_3)_2(aq) \rightarrow 2KNO_3(aq) + NiS(s)$

NiS: precipitate

(32) all the molecular reactions (balanced) are given above.

(a) No reaction

(b) $2Al^{3+}(aq) + 6NO_3^-(aq) + 3Ba^{2+}(aq) + 6(OH)^-(aq) \rightarrow 2Al(OH)_3(s) + 3Ba^{2+}(aq) + 6NO_3^-(aq)$

$\cancel{2} Al^{3+}(aq) + \cancel{6}\,3\, OH^-(aq) \rightarrow \cancel{2} Al(OH)_3(s)$

net-ionic equation } $Al^{3+}(aq) + 3\,OH^-(aq) \rightarrow Al(OH)_3(s)$

(c) $Ca^{2+}(aq) + 2Cl^-(aq) + 2Na^+(aq) + SO_4^{2-}(aq) \rightarrow$

$CaSO_4(s) + 2Na^+(aq) + 2Cl^-(aq)$

net-ionic equation } $Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$

(d) $2K^+(aq) + S^{2-}(aq) + Ni^{2+}(aq) + 2NO_3^-(aq) \rightarrow$

$2K^+(aq) + 2NO_3^-(aq) + NiS(s)$

net-ionic equation } $Ni^{2+}(aq) + S^{2-}(aq) \rightarrow NiS(s)$

(34) (a) $Fe(NO_3)_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) +$

$3NaNO_3(aq)$

(b) $Hg_2(NO_3)_2(aq) + 2KCl(aq) \rightarrow Hg_2Cl_2(s) + 2KNO_3$

(c) $Pb(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow PbSO_4(s) +$

$2NaNO_3(aq)$

(d) $Ba(NO_3)_2(aq) + K_2CrO_4(aq) \rightarrow BaCrO_4(s) +$

$2KNO_3(aq)$

(36) (a) $CrCl_3(aq) + 3\,NaOH(aq) \rightarrow Cr(OH)_3(s) + 3\,NaCl(aq)$

$Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s)$

(b) $2\,AgNO_3(aq) + (NH_4)_2CO_3(aq) \rightarrow Ag_2CO_3(s) + 2\,NH_4NO_3(aq)$

$2\,Ag^+(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$

(c) $CuSO_4(aq) + Hg_2(NO_3)_2(aq) \rightarrow Cu(NO_3)_2(aq) + Hg_2SO_4(s)$

$Hg_2^{2+}(aq) + SO_4^{2-}(aq) \rightarrow Hg_2SO_4(s)$

(d) $Sr(NO_3)_2(aq) + 2\,KI(aq) \rightarrow SrI_2(aq) + 2\,KNO_3(aq)$

no reaction

(38) possible in original solution

$$\left.\begin{array}{l} Hg_2^{2+}(aq) \\ Ba^{2+}(aq) \\ Mn^{2+}(aq) \end{array}\right\} + \begin{array}{l} Na^+ \\ Cl^- \end{array} \longrightarrow \begin{array}{l} Hg_2Cl_2(s) \\ BaCl_2(aq) \\ MnCl_2(aq) \end{array}$$

Since no precipitate was formed, Hg_2^{2+} cannot be in the original solution.

$$\left.\begin{array}{l} ~~Hg_2~~ Ba^{2+}(aq) \\ Mn^{2+}(aq) \end{array}\right\} + \begin{array}{l} Na^+ \\ SO_4^{2-} \end{array} \longrightarrow \begin{array}{l} BaSO_4(s) \\ MnSO_4(aq) \end{array}$$

Since no precipitate was formed, Ba^{2+} ions cannot be in the original solution.

$$Mn^{2+}(aq) + \overset{Na^+}{OH^-} \longrightarrow Mn(OH)_2\ (s)$$

Therefore Mn^{2+} ions can be in the original solution.

(41) $Al(NO_3)_3\ (aq) + 3\,KOH(aq) \longrightarrow Al(OH)_3^{(s)} + 3\,KNO_3(aq)$

50.0 mL   200.0 mL
0.200 M   0.100 M

$$\#\text{ of moles of } Al(NO_3)_3 = \left(0.200\,\frac{mol}{L}\right) 50.0\,mL \times \left(\frac{L}{10^3\,mL}\right)$$
$$= 0.010\,mol$$

$$\#\text{ of moles of KOH} = \left(0.100\,\frac{mol}{L}\right)\left(200.0\,mL\right)\left(\frac{L}{10^3\,mL}\right)$$
$$= 0.020\,mol$$

$\#$ of mol $Al(NO_3)_3$ needed to react with 0.020 mol KOH $\Big\} = 0.020\,mol\ KOH \times \left(\frac{1\,mol\ Al(NO_3)_3}{3\,mol\ KOH}\right)$

$$= 0.00667\,mol\ Al(NO_3)_3$$

Since we have 0.010 mol $Al(NO_3)_3$, we have excess of it. KOH is the limiting reagent.

$$\text{moles of } Al(OH)_3 \text{ formed} = 0.020\,mol\ KOH \times \left(\frac{1\,mol\ Al(OH)_3}{3\,mol\ KOH}\right)$$
$$= 0.00667\,mol\ Al(OH)_3$$

$$\text{molar mass of } Al(OH)_3 = \left[26.98 + 3(16.00) + 3(1.008)\right]\ g/mol$$
$$= 78.004\ g/mol$$

mass of $Al(OH)_3$ formed $= 0.00667 \text{ mol} \times \left(\frac{78.004 \text{ g}}{\text{mol}}\right)$

$= \underline{\underline{0.520 \text{ g}}}$

(43) $2 AgNO_3 (aq) + CaCl_2 (aq) \rightarrow Ca(NO_3)_2 (aq) + 2 AgCl(s)$

100.0 mL   100.0 mL

0.20 M   0.15 M

# of moles of $AgNO_3$ $= \left(0.20 \frac{\text{mol}}{\text{L}}\right) 100 \text{ mL} \times \left(\frac{\text{L}}{10^3 \text{ mL}}\right)$

$= 0.020 \text{ mol}$

moles of $CaCl_2$ $= \left(0.15 \frac{\text{mol}}{\text{L}}\right)\left(100.0 \text{ mL}\right) \times \left(\frac{\text{L}}{10^{3} \text{ mL}}\right)$

$= 0.015 \text{ mol}$

moles of $AgNO_3$ required to react with 0.015 mol of $CaCl_2$ $= 0.015 \text{ mol } CaCl_2 \times \left(\frac{2 \text{ mol } AgNO_3}{1 \text{ mol } CaCl_2}\right)$

$= 0.030 \text{ mol } AgNO_3$

Since we have only 0.020 mol $AgNO_3$, $AgNO_3$ is the limiting reagent. $CaCl_2$ is in excess.

moles of AgCl formed $= 0.020 \text{ mol } AgNO_3 \times \left(\frac{2 \text{ mol } AgCl}{2 \text{ mol } AgNO_3}\right)$

$= 0.020 \text{ mol } AgCl$

molar mass of AgCl $= (107.9 + 35.5) \text{ g/mol}$

$= 143.4 \text{ g/mol}$

Mass of AgCl $= 0.020 \text{ mol AgCl} \times \left(\frac{143.4 g}{mol}\right)$

$= \underline{\underline{2.868 \text{ g AgCl}}}$

mol of $Ca(NO_3)_2$ produced $= \left(\begin{matrix}0.020 \text{ mol} \\ AgNO_3\end{matrix}\right) \times \left(\frac{1 \text{ mol } Ca(NO_3)_2}{2 \text{ mol } AgNO_3}\right)$

$= 0.010 \text{ mol } Ca(NO_3)_2$.

mol of $CaCl_2$ reacted $= \left(\begin{matrix}0.020 \text{ mol} \\ AgNO_3\end{matrix}\right) \times \left(\frac{1 \text{ mol } CaCl_2}{2 \text{ mol } AgNO_3}\right)$

$= 0.010 \text{ mol } CaCl_2$

mol of $CaCl_2$ left unreacted $= 0.015 \text{ mol} - 0.010 \text{ mol}$

$= 0.005 \text{ mol } CaCl_2$

What is left in the reaction vessel after the reaction is complete =

$0.005 \text{ mol } CaCl_2 (aq) \rightarrow Ca^{2+} (aq) + 2Cl^- (aq)$

0.005 mol   0.010 mol

$0.020 \text{ mol } AgCl (s)$

$0.010 \text{ mol } Ca(NO_3)_2 (aq) \rightarrow Ca^{2+} (aq) + 2NO_3^- (aq)$

0.010 mol   0.020 mol

0.020 mol NO_3^- 0.015 mol Ca^{2+} 0.010 mol Cl^-

Total volume of solution = 100.0 mL + 100.0 mL

= 200.0 mL

= 200.0×10^{-3} L

Concentration of the ions left

NO_3^-	Ca^{2+}	Cl^-
$\frac{0.020 \text{ mol}}{200.0 \times 10^{-3} \text{ L}}$	$\frac{0.015 \text{ mol}}{200.0 \times 10^{-3} \text{ L}}$	$\frac{0.010 \text{ mol}}{200.0 \times 10^{-3} \text{ L}}$
= 0.10 M	0.075 M	0.050 M

(45) (a) $2HClO_4(aq) + Mg(OH)_2(s) \rightarrow Mg(ClO_4)_2(aq) + 2H_2O(l)$

$2H^+(aq) + 2ClO_4^-(aq) + Mg(OH)_2(s) \rightarrow Mg^{2+}(aq) + 2ClO_4^-(aq) + 2H_2O(l)$

$2H^+(aq) + Mg(OH)_2(s) \rightarrow Mg^{2+}(aq) + 2H_2O(l)$

(b) $HCN(aq) + NaOH(aq) \rightarrow NaCN(aq) + H_2O(l)$

$H^+(aq) + CN^-(aq) + Na^+(aq) + OH^-(aq) \rightarrow Na^+(aq) + CN^-(aq) + H_2O(l)$

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

(c) $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

$H^+(aq) + Cl^-(aq) + Na^+(aq) + OH^-(aq) \rightarrow Na^+(aq) + Cl^-(aq) + H_2O(l)$

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

(47) (a) $KOH(aq) + HNO_3(aq) \rightarrow KNO_3(aq) + H_2O(l)$

$K^+(aq) + OH^-(aq) + H^+(aq) + NO_3^-(aq) \rightarrow K^+(aq) + NO_3^-(aq) + H_2O(l)$

$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

(b) $Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$

$Ba^{2+}(aq) + 2OH^-(aq) + 2H^+(aq) + 2Cl^-(aq) \rightarrow Ba^{2+}(aq) + 2Cl^-(aq) + 2H_2O(l)$

$2OH^-(aq) + 2H^+(aq) \rightarrow 2H_2O(l)$

$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

(c) $3HClO_4(aq) + Fe(OH)_3(s) \rightarrow Fe(ClO_4)_3(aq) + 3H_2O(l)$

$3H^+(aq) + 3ClO_4^-(aq) + Fe(OH)_3(s) \rightarrow Fe^{3+}(aq) + 3ClO_4^-(aq) + 3H_2O(l)$

$3H^+(aq) + Fe(OH)_3(s) \rightarrow Fe^{3+}(aq) + 3H_2O(l)$

(50) 25.00 mL of 0.200 M HCl

$\#$ of mol of HCl $= \left(\frac{0.200\ mol}{L}\right)\left(25.00\ mL\right) \times \left(\frac{L}{10^3\ mL}\right)$

$= 5.00 \times 10^{-3}\ mol$

(a) $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

$1 : 1$

mol of NaOH required for complete reaction $= 5.00 \times 10^{-3}$ mol NaOH

$\therefore$ volume of NaOH $= \frac{5.00 \times 10^{-3}\ mol}{0.100\ mol\ L^{-1}} \cdot \left(\frac{10^3\ mL}{L}\right)$

$= \underline{\underline{50.0\ mL}}$

(b) $Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$

mol of $Ba(OH)_2$ required for complete reaction $= 5.00 \times 10^{-3}$ mol HCl $\times \frac{1\ mol\ Ba(OH)_2}{2\ mol\ HCl}$

$= 0.0025$ mol

volume of $Ba(OH)_2 = \dfrac{0.0025\ mol}{0.0500\ mol\ L^{-1}}\left(\dfrac{10^3\ mL}{L}\right)$

$= \underline{\underline{50.0\ mL}}$

(c) $KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(l)$

1 : 1

mol of KOH required for complete reaction $= 5.00 \times 10^{-3}$ mol

volume of KOH $= \dfrac{5.00 \times 10^{-3}\ mol}{0.250\ mol\ L^{-1}}\left(\dfrac{10^3\ mL}{L}\right)$

$= \underline{\underline{20.0\ mL}}$

(52) $2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$

75.0 mL   225.0 mL

0.250 M   0.0550 M

mol of HCl $= (0.250\ M)(75.0\ mL) \times \left(\dfrac{L}{10^3\ mL}\right)$

$= 1.875 \times 10^{-2}$ mol

mol of $Ba(OH)_2$ $= (0.0550\ M)(225.0\ mL) \times \left(\dfrac{L}{10^3\ mL}\right)$

$= 1.2375 \times 10^{-2}$ mol

mol of HCl needed to react with all of $Ba(OH)_2$ $= 1.2375 \times 10^{-2}$ mol $Ba(OH)_2 \times \left(\dfrac{2\ mol\ HCl}{1\ mol\ Ba(OH)_2}\right)$

$$= 2.475 \times 10^{-2} \text{ mol HCl}$$

$\therefore$ We do not have enough HCl. HCl is the limiting reagent.

Amount of $Ba(OH)_2$ that reacts $= \left(1.875 \times 10^{-2} \text{ mol HCl}\right)\left[\dfrac{1 \text{ mol } Ba(OH)_2}{2 \text{ mol HCl}}\right]$

$$= 9.375 \times 10^{-3} \text{ mol } Ba(OH)_2$$

$\therefore$ Amount of $Ba(OH)_2$ left $= \left(1.2375 \times 10^{-2} - 9.375 \times 10^{-3}\right)$ mol

$$= 3.000 \times 10^{-3} \text{ mol}$$

$$Ba(OH)_2(aq) \longrightarrow Ba^{2+}(aq) + 2OH^-(aq)$$

$Ba(OH)_2(aq)$	$Ba^{2+}(aq)$	$2OH^-(aq)$
3.000×10^{-3} mol	3.000×10^{-3} mol	$2 \times 3.000 \times 10^{-3}$ mol $= 6.000 \times 10^{-3}$ mol

Excess OH^- left after reaction $= 6.000 \times 10^{-3}$ mol

$$= 6.00 \times 10^{-3} \text{ mol}$$

Volume of solution after reaction $= (75.0 + 225.0)$ mL

$$= 300 \text{ mL}$$

Concentration of OH^- after reaction $= \dfrac{6.00 \times 10^{-3} \text{ mol}}{300 \text{ mL}} \times \dfrac{10^3 \text{ mL}}{L}$

$$= \underline{\underline{0.0200 \text{ M}}}$$

(53) $HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$

25.00 mL   24.16 mL

M_1 0.106 M

M_1 = Concentration of HCl

$$\#\text{ moles of HCl} = (M_1 \times 25.00 \times 10^{-3} L)$$

$$\#\text{ moles of NaOH} = (0.106 M \times 24.16 \times 10^{-3} L)$$

$$= 2.561 \times 10^{-3} \text{ mol}$$

$$\#\text{ mol HCl} = \#\text{ of NaOH}$$

$$M_1 \times 25.00 \times 10^{-3} L = 2.561 \times 10^{-3} \text{ mol}$$

$$M_1 = \frac{2.561 \times 10^{-3} \text{ mol}}{25.00 \times 10^{-3} L} = \underline{0.102 M}$$