Chemistry 20 – Lesson 21
Solution Stoichiometry

/80

1. $Cu_{(s)} + 2\,AgNO_{3\,(aq)} \longrightarrow Cu(NO_3)_{2\,(aq)} + 2\,Ag_{\,(s)}$

/6 $m_{Cu} = ?$ $c_{AgNO_3} = 0.100\,{}^{mol}/_{L}$

$v_{AgNO_3} = 0.250L$

A. calculate moles

$n_{AgNO_3} = 0.100\,{}^{mol}/_{L}(0.250L)$

$n_{AgNO_3} = 0.0250mol$

B. mole ratio

$$\frac{n_{AgNO_3}}{2} = \frac{n_{Cu}}{1}$$

$$\frac{0.0250mol}{2} = \frac{n_{Cu}}{1}$$

$$n_{Cu} = 0.0125mol$$

C. calculate mass

$m_{Cu} = 0.0125mol(63.55\,{}^{g}/_{mol})$

$\boxed{m_{Cu} = 0.794\,g}$

OR

$$m_{Cu} = \frac{0.100\ mol\ AgNO_3}{1\ L} \times 0.250\ L \times \frac{1\ mol\ Cu}{2\ mol\ AgNO_3} \times \frac{63.55\,g\,Cu}{1\ mol\ Cu}$$

$\boxed{m_{Cu} = 0.794\,g}$

2. $2\,Al_{(s)} + 3\,H_2SO_{4\,(aq)} \longrightarrow 3\,H_{2\,(g)} + Al_2(SO_4)_{3\,(aq)}$

/7 $m_{Al\,reacted} = m_{Al\,initial} - m_{Al\,after}$ $c_{H_2SO_4} = ?$

$m_{Al} = 15.14g - 9.74g$

$m_{Al} = 5.40g$

A. Calculate moles

$$n_{Al} = \frac{5.40g}{26.98\,{}^{g}/_{mol}}$$

$$n_{Al} = 0.200\,mol$$

B. Mole ratio

$$\frac{n_{H_2SO_4}}{3} = \frac{n_{Al}}{2}$$

$$\frac{n_{H_2SO_4}}{3} = \frac{0.200\,mol}{2}$$

$$n_{H_2SO_4} = 0.300\,mol$$

C. Calculate concentration

$$c_{H_2SO_4} = \frac{0.300\,mol}{0.500\,L}$$

$\boxed{c_{H_2SO_4} = 0.600\,{}^{mol}/_{L}}$

OR

$$c_{H_2SO_4} = 3.40\,g\,Al \times \frac{1\,mol\,Al}{26.98\,g\,Al} \times \frac{3\,mol\,H_2SO_4}{2\,mol\,Al} \times \frac{1}{0.500\,L}$$

$\boxed{c_{H_2SO_4} = 0.600\,{}^{mol}/_{L}}$

3. $Mg_{(s)} + 2\,HCl_{(aq)} \longrightarrow H_{2\,(g)} + MgCl_{2\,(aq)}$

/8

First calculate the mass of magnesium that reacted.

$m_{Mg} = ?$

$c_{HCl} = 6.00\,{}^{mol}/_{L}$

$v_{HCl} = 2.40L$

A. calculate moles

$n_{HCl} = 6.00\,{}^{mol}/_{L}\,(2.40L)$

$n_{HCl} = 14.4mol$

B. mole ratio

$$\frac{n_{Mg}}{1} = \frac{n_{HCl}}{2}$$

$$\frac{n_{Mg}}{1} = \frac{14.4\,mol}{2}$$

$n_{Mg} = 7.20\,mol$

C. calculate mass

$m_{Mg} = 7.20\,mol(24.31\,{}^{g}/_{mol})$

$m_{Mg\,reacted} = 175\,g$

OR

$$m_{Mg} = \frac{6.00\,mol\,HCl}{1L} \times 2.40L \times \frac{1\,mol\,Mg}{2\,mol\,HCl} \times \frac{24.32\,g\,Mg}{1\,mol\,Mg} = 175\,g$$

$m_{Mg\ remaining} = m_{Mg\ initial} - m_{Mg\ reacted}$

$m_{Mg\ remaining} = 200\,g - 175\,g$

$\boxed{m_{Mg\ remaining} = 25\,g}$

4. $2\,NaBr_{(aq)} + Cl_{2\,(g)} \longrightarrow 2\,NaCl_{(aq)} + Br_{2\,(l)}$

/5

$c_{NaBr} = 0.300\,{}^{mol}/_{L}$

$v_{NaBr} = 0.120L$

$n_{Cl_2} = ?$

A. calculate moles

$n_{NaBr} = 0.300\,{}^{mol}/_{L}\,(0.120L)$

$n_{NaBr} = 0.0360mol$

B. mole ratio

$$\frac{n_{Cl_2}}{1} = \frac{n_{NaBr}}{2}$$

$$\frac{n_{Cl_2}}{1} = \frac{0.0360mol}{2}$$

$\boxed{n_{Cl_2} = 0.0180mol}$

OR

$$n_{Cl_2} = \frac{0.300\,mol\,NaBr}{1L} \times 0.120L \times \frac{1\,mol\,Cl_2}{2\,mol\,NaBr}$$

$\boxed{n_{Cl_2} = 0.0180\,mol}$

5. $3\ NH_4OH_{(aq)} + FeCl_{3\ (aq)} \longrightarrow 3\ NH_4Cl_{(aq)} + Fe(OH)_{3\ (s)}$

/8 $c_{NH_4OH} = 0.670\ ^{mol}/_{L}$ $\quad m_{Cu} = ?$

$v_{NH_4OH} = 0.050L$

A. calculate moles

$n_{NH_4OH} = 0.670\ ^{mol}/_{L}(0.050L)$

$n_{NH_4OH} = 0.0335mol$

B. mole ratio

$$\frac{n_{Fe(OH)_3}}{1} = \frac{n_{NH_4OH}}{3}$$

$$\frac{n_{Fe(OH)_3}}{1} = \frac{0.0335mol}{3}$$

$n_{Fe(OH)_3} = 0.0112mol$

C. calculate mass

$m_{Fe(OH)_3} = 0.0112mol(106.88\ ^{g}/_{mol})$

$m_{Fe(OH)_3} = 1.193g$

D. calculate % error

$$\%\,error = \frac{m_{exp\,yield} - m_{theo\,yield}}{m_{theo\,yield}} \times 100\%$$

$$\%\,error = \frac{1.135g - 1.193g}{1.193g} \times 100\%$$

$\boxed{\%\,error = -4.90\%}$

6. $Mg_{(s)} + 2\ HBr_{(aq)} \longrightarrow MgBr_{2\ (aq)} + H_{2\ (g)}$

/8 $c_{HBr} = 1.35\ ^{mol}/_{L}$ $\quad m_{H_2} = ?$

$v_{HBr} = 0.0461L$

A. calculate moles

$n_{HBr} = 1.35\ ^{mol}/_{L}(0.0461L)$

$n_{HBr} = 0.0622mol$

B. mole ratio

$$\frac{n_{H_2}}{1} = \frac{n_{HBr}}{3}$$

$$\frac{n_{H_2}}{1} = \frac{0.0622mol}{2}$$

$n_{Fe(OH)_3} = 0.0311mol$

C. calculate mass

$m_{H_2} = 0.0311mol(2.02\ ^{g}/_{mol})$

$m_{H_2} = 0.0629g$

D. calculate % error

$$\%\,error = \frac{m_{exp\,yield} - m_{theo\,yield}}{m_{theo\,yield}} \times 100\%$$

$$\%\,error = \frac{0.0556g - 0.0629g}{0.0629g} \times 100\%$$

$\boxed{\%\,error = -11.5\%}$

7. $Na_2SO_{4\,(aq)} + Ba(OH)_{2\,(aq)} \longrightarrow 2\,NaOH_{(aq)} + BaSO_{4(s)}$

/8 $c_{Na_2SO_4} = 1.75\,{}^{mol}/_{L}$ $\quad m_{H_2} = ?$

$v_{Na_2SO_4} = 0.0200L$

A. calculate moles

$n_{Na_2SO_4} = 1.75\,{}^{mol}/_{L}(0.0200L)$

$n_{Na_2SO_4} = 0.0350mol$

B. mole ratio

$$\frac{n_{BaSO_4}}{1} = \frac{n_{Na_2SO_4}}{1}$$

$$\frac{n_{BaSO_4}}{1} = \frac{0.0350mol}{1}$$

$n_{BaSO_4} = 0.0350mol$

C. calculate mass

$m_{BaSO_4} = 0.0350mol(233.40\,{}^{g}/_{mol})$

$m_{BaSO_4} = 8.17\,g$

D. calculate % yield

$$\%\,yield = \frac{m_{exp\,yield}}{m_{theo\,yield}} \times 100\%$$

$$\%\,yield = \frac{6.17\,g}{8.17\,g} \times 100\%$$

$\boxed{\%\,yield = 75.5\%}$

8. $HNO_{3\,(aq)} + NaOH_{(aq)} \longrightarrow NaNO_{3\,(aq)} + HOH_{(l)}$

/6 $c_{HNO_3} = 3.00\,{}^{mol}/_{L}$ $\quad c_{NaOH} = 0.10\,{}^{mol}/_{L}$ $\quad m_{H_2} = ?$

$v_{HNO_3} = ?$ $\quad v_{NaOH} = 0.0600L$

A. calculate moles

$n_{NaOH} = 0.10\,{}^{mol}/_{L}(0.0600L)$

$n_{NaOH} = 0.00600mol$

B. mole ratio

$$\frac{n_{HNO_3}}{1} = \frac{n_{NaOH}}{1}$$

$$\frac{n_{HNO_3}}{1} = \frac{0.00600mol}{1}$$

$n_{HNO_3} = 0.00600mol$

C. calculate volume

$$v_{HNO_3} = \frac{0.00600mol}{3.00\,{}^{mol}/_{L}}$$

$\boxed{v_{HNO_3} = 2.00\,mL}$

9. $3\ Ba(OH)_{2\ (aq)} + Al_2(SO_4)_{3\ (aq)} \longrightarrow 3\ BaSO_{4\ (s)} + 2\ Al(OH)_{3\ (s)}$

/8 $c_{Ba(OH)_2} = 0.0450\ ^{mol}/_{L}$ $\quad m_{BaSO_4} = ?$ $\quad m_{Al(OH)_3} = ?$

$v_{Ba(OH)_2} = 0.0250L$

A. calculate moles

$n_{Ba(OH)_2} = 0.0450\ ^{mol}/_{L}(0.0250L)$

$n_{Ba(OH)_2} = 0.001125mol$

B. mole ratios

for $BaSO_4$

$$\frac{n_{BaSO_4}}{3} = \frac{n_{Ba(OH)_2}}{3}$$

$$\frac{n_{BaSO_4}}{3} = \frac{0.001125mol}{3}$$

$n_{BaSO_4} = 0.001125mol$

for $Al(OH)_3$

$$\frac{n_{Al(OH)_3}}{2} = \frac{n_{Ba(OH)_2}}{3}$$

$$\frac{n_{Al(OH)_3}}{2} = \frac{0.001125mol}{3}$$

$n_{Al(OH)_3} = 0.000750mol$

C. calculate masses

$m_{BaSO_4} = 0.001125mol(233.40\ ^{g}/_{mol})$

$m_{BaSO_4} = 0.2626g$

$m_{Al(OH)_3} = 0.00075mol(78.01\ ^{g}/_{mol})$

$m_{Al(OH)_3} = 0.0585g$

D. calculate % error

$$\%\,error = \frac{m_{exp\ yield} - m_{theo\ yield}}{m_{theo\ yield}} \times 100\%$$

$$\%\,error = \frac{0.31g - (0.2626g + 0.0585g)}{(0.2626g + 0.0585g)} \times 100\%$$

$$\boxed{\%\,error = -3.46\%}$$

10. $Pb(NO_3)_{2\ (aq)} + 2\ RbBr_{(aq)} \longrightarrow 2\ RbNO_{3\ (aq)} + PbBr_{2(s)}$

/6 $m_{RbBr} = ?$

$m_{PbBr_2} = m_{product+filter\ paper} - m_{filter\ paper}$

$m_{PbBr_2} = 6.83g - 0.21g$

$m_{PbBr_2} = 6.62g$

A. calculate moles

$$n_{PbBr_2} = \frac{6.62g}{378.13\ ^{g}/_{mol}}$$

$n_{PbBr_2} = 0.0175mol$

B. mole ratio

$$\frac{n_{RbBr}}{2} = \frac{n_{PbBr_2}}{1}$$

$$\frac{n_{RbBr}}{2} = \frac{0.0175mol}{1}$$

$n_{RbBr} = 0.0350mol$

C. calculate mass

$m_{RbBr} = 0.0350mol(165.37\ ^{g}/_{mol})$

$\boxed{m_{RbBr} = 5.79g}$

11. $Ba(OH)_{2\,(aq)} + Mg(NO_3)_{2\,(aq)} \longrightarrow Ba(NO_3)_{2\,(aq)} + Mg(OH)_{2\,(s)}$

/10 $m_{Mg(NO_3)_2} = 17.86g$ $m_{Mg(OH)_2} = ?$

A. calculate moles

$$n_{Mg(NO_3)_2} = \frac{17.86\,g}{148.33\,{}^{g}\!/_{mol}}$$

$$n_{Mg(NO_3)_2} = 0.1204mol$$

B. mole ratio

$$\frac{n_{Mg(OH)_2}}{1} = \frac{n_{Mg(NO_3)_2}}{1}$$

$$\frac{n_{Mg(OH)_2}}{1} = \frac{0.1204\,mol}{1}$$

$$n_{Mg(OH)_2} = 0.1204\,mol$$

C. calculate mass

$$m_{Mg(OH)_2} = 0.1204mol(58.33\,{}^{g}\!/_{mol})$$

$$\boxed{m_{Mg(OH)_2} = 7.023\,g}$$

$Ba(OH)_{2\,(aq)} + Na_2SO_{4\,(aq)} \longrightarrow BaSO_{4\,(s)} + 2\,NaOH_{\,(aq)}$

$n_{Na_2SO_4} = 0.035\,mol$ $m_{BaSO_4} = ?$

A. mole ratio

$$\frac{n_{BaSO_4}}{1} = \frac{n_{Na_2SO_4}}{1}$$

$$\frac{n_{BaSO_4}}{1} = \frac{0.035\,mol}{1}$$

$$n_{BaSO_4} = 0.035\,mol$$

B. calculate mass

$$m_{BaSO_4} = 0.035\,mol(233.40\,{}^{g}\!/_{mol})$$

$$\boxed{m_{BaSO_4} = 8.2\,g}$$