Chemistry 20 – Lesson 6
Gravimetric stoichiometry

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Practice problems

1. $3H_2 + N_2 \longrightarrow 2NH_3$

$m_{H_2} = 5.40\,g$ $\quad$ $m_{NH_3} = ?$

$M_{H_2} = 2.02\,{}^{g}/_{mol}$ $\quad$ $M_{NH_3} = 17.04\,{}^{g}/_{mol}$

I. calculate moles

$$n_{H_2} = \frac{5.40\,g}{2.02\,{}^{g}/_{mol}}$$

$$n_{H_2} = 2.673\,mol$$

II. mole ratio

$$\frac{n_{NH_3}}{2} = \frac{n_{H_2}}{3}$$

$$\frac{n_{NH_3}}{2} = \frac{2.673\,mol}{3}$$

$$n_{NH_3} = 1.782\,mol$$

III. calculate mass

$$m_{NH_3} = 1.782\,mol \times 17.04\,{}^{g}/_{mol}$$

$$\boxed{m_{NH_3} = 30.4\,g}$$

OR

$$m_{NH_3} = 5.40\,\cancel{g\,H_2} \times \frac{1\,mol\,H_2}{2.02\,\cancel{g\,H_2}} \times \frac{2\,\cancel{mol\,NH_3}}{3\,\cancel{mol\,H_2}} \times \frac{17.04\,g\,NH_3}{1\,\cancel{mol\,NH_3}}$$

$$\boxed{m_{NH_3} = 30.4\,g}$$

2. $S_8 + 8O_2 \longrightarrow 8SO_2$

$m_{O_2} = 160\,g$ $\quad$ $n_{SO_2} = ?$

$M_{O_2} = 32.00\,{}^{g}/_{mol}$

I. calculate moles

$$n_{O_2} = \frac{160\,g}{32.00\,{}^{g}/_{mol}}$$

$$n_{O_2} = 5.00\,mol$$

II. mole ratio

$$\frac{n_{SO_2}}{8} = \frac{n_{O_2}}{8}$$

$$\frac{n_{SO_2}}{8} = \frac{5.00\,mol}{8}$$

$$\boxed{n_{SO_2} = 5.00\,mol}$$

OR

$$n_{O_2} = 160\,\cancel{g\,O_2} \times \frac{1\,\cancel{mol\,O_2}}{32.00\,\cancel{g\,O_2}} \times \frac{8\,mol\,SO_2}{8\,\cancel{mol\,O_2}}$$

$$\boxed{n_{O_2} = 5.00\,mol}$$

3. $2H_2O \longrightarrow 2H_2 + O_2$

$n_{H_2} = 500\,mol$ $\quad m_{O_2} = ?$

$M_{O_2} = 32.00\,{}^{g}/_{mol}$

I. mole ratio

$$\frac{n_{O_2}}{1} = \frac{n_{H_2}}{2}$$

$$\frac{n_{O_2}}{1} = \frac{500\,mol}{2}$$

$$n_{O_2} = 250\,mol$$

II. calculate mass

$$m_{O_2} = 250\,mol \times 32.00\,{}^{g}/_{mol}$$

$$\boxed{m_{O_2} = 8.00\,kg}$$

OR

$$m_{O_2} = 500\ \cancel{mol\,H_2} \times \frac{1\ \cancel{mol\,O_2}}{2\ \cancel{mol\,H_2}} \times \frac{32.00\,g\,O_2}{1\ \cancel{mol\,O_2}}$$

$$\boxed{m_{O_2} = 8.00\,kg}$$

4. $3H_2 + N_2 \longrightarrow 2NH_3$

$n_{N_2} = 0.60\,mol$ $\quad n_{NH_3} = ?$

I. mole ratio

$$\frac{n_{NH_3}}{2} = \frac{n_{N_2}}{1}$$

$$\frac{n_{NH_3}}{2} = \frac{0.60\,mol}{1}$$

$$\boxed{n_{NH_3} = 1.20\,mol}$$

OR

$$n_{NH_3} = 0.60\ \cancel{mol\,N_2} \times \frac{2\,mol\,NH_3}{1\ \cancel{mol\,N_2}}$$

$$\boxed{n_{NH_3} = 1.20\,mol}$$

Assignment

1. $8\,Zn + S_8 \longrightarrow 8\,ZnS$

$m_{Zn} = 25\,g$ $\quad m_{S_8} = ?$

$M_{Zn} = 65.38\,{}^{g}/_{mol}$ $\quad M_{S_8} = 256.56\,{}^{g}/_{mol}$

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I. calculate moles

$$n_{Zn} = \frac{25\,g}{65.38\,{}^{g}/_{mol}}$$

$$n_{Zn} = 0.38\,mol$$

II. mole ratio

$$\frac{n_{S_8}}{1} = \frac{n_{Zn}}{8}$$

$$\frac{n_{S_8}}{1} = \frac{0.38\,mol}{8}$$

$$n_{S_8} = 0.048\,mol$$

III. calculate mass

$$m_{S_8} = 0.048\,mol \times 256.56\,{}^{g}/_{mol}$$

$$\boxed{m_{S_8} = 12\,g}$$

2. $2\,Al_2O_3 \longrightarrow 4\,Al + 3\,O_2$

$m_{Al_2O_3} = 100\,g$ $\quad m_{Al} = ?$

$M_{Al_2O_3} = 101.96\,{}^{g}/_{mol}$ $\quad M_{Al} = 26.98\,{}^{g}/_{mol}$

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I. calculate moles

$$n_{Al_2O_3} = \frac{100\,g}{101.96\,{}^{g}/_{mol}}$$

$$n_{Al_2O_3} = 0.981\,mol$$

II. mole ratio

$$\frac{n_{Al}}{4} = \frac{n_{Al_2O_3}}{2}$$

$$\frac{n_{Al}}{4} = \frac{0.981\,mol}{2}$$

$$n_{Al} = 1.96\,mol$$

III. calculate mass

$$m_{Al} = 1.96\,mol \times 26.98\,{}^{g}/_{mol}$$

$$\boxed{m_{Al} = 52.9\,g}$$

3. $C_3H_8 + 5\,O_2 \longrightarrow 3\,CO_2 + 4\,H_2O$

$m_{C_3H_8} = 10.0\,g$ $\quad m_{O_2} = ?$

$M_{C_3H_8} = 44.11\,{}^{g}/_{mol}$ $\quad M_{O_2} = 32.00\,{}^{g}/_{mol}$

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I. calculate moles

$$n_{C_3H_8} = \frac{10.0\,g}{44.11\,{}^{g}/_{mol}}$$

$$n_{C_3H_8} = 0.227\,mol$$

II. mole ratio

$$\frac{n_{O_2}}{5} = \frac{n_{C_3H_8}}{1}$$

$$\frac{n_{O_2}}{5} = \frac{0.227\,mol}{1}$$

$$n_{O_2} = 1.13\,mol$$

III. calculate mass

$$m_{O_2} = 1.13\,mol \times 32.00\,{}^{g}/_{mol}$$

$$\boxed{m_{O_2} = 36.3\,g}$$

4. $Pb(NO_3)_2 + 2\,NaCl \longrightarrow 2\,NaNO_3 + PbCl_2$

$m_{NaCl} = 2.57\,g$ $\qquad$ $m_{PbCl_2} = ?$

$M_{NaCl} = 58.44\,g/mol$ $\qquad$ $M_{PbCl_2} = 278.1\,g/mol$

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I. calculate moles

$$n_{NaCl} = \frac{2.57\,g}{58.44\,g/mol}$$

$$n_{NaCl} = 0.0440\,mol$$

II. mole ratio

$$\frac{n_{PbCl_2}}{1} = \frac{n_{NaCl}}{2}$$

$$\frac{n_{PbCl_2}}{1} = \frac{0.0440\,mol}{2}$$

$$n_{PbCl_2} = 0.0220\,mol$$

III. calculate mass

$$m_{PbCl_2} = 0.0220\,mol \times 278.1\,g/mol$$

$$\boxed{m_{PbCl_2} = 6.11\,g}$$

5. $2\,Al + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2$

$m_{Al} = 2.73\,g$ $\qquad$ $m_{H_2} = ?$

$M_{Al} = 26.98\,g/mol$ $\qquad$ $M_{H_2} = 2.02\,g/mol$

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I. calculate moles

$$n_{Al} = \frac{2.73\,g}{26.98\,g/mol}$$

$$n_{Al} = 0.101\,mol$$

II. mole ratio

$$\frac{n_{H_2}}{3} = \frac{n_{Al}}{2}$$

$$\frac{n_{H_2}}{3} = \frac{0.101\,mol}{2}$$

$$n_{H_2} = 0.152\,mol$$

III. calculate mass

$$m_{H_2} = 0.152\,mol \times 2.02\,g/mol$$

$$\boxed{m_{H_2} = 0.307\,g}$$

6. $2\,KOH + Cu(NO_3)_2 \longrightarrow 2\,KNO_3 + Cu(OH)_2$

$m_{KOH} = 2.67\,g$ $\qquad$ $m_{Cu(OH)_2} = ?$

$M_{KOH} = 56.11\,g/mol$ $\qquad$ $M_{Cu(OH)_2} = 97.57\,g/mol$

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I. calculate moles

$$n_{KOH} = \frac{2.67\,g}{56.11\,g/mol}$$

$$n_{KOH} = 0.0476\,mol$$

II. mole ratio

$$\frac{n_{Cu(OH)_2}}{1} = \frac{n_{KOH}}{2}$$

$$\frac{n_{Cu(OH)_2}}{1} = \frac{0.0476\,mol}{2}$$

$$n_{Cu(OH)_2} = 0.0238\,mol$$

III. calculate mass

$$m_{Cu(OH)_2} = 0.0238\,mol \times 97.57\,g/mol$$

$$\boxed{m_{Cu(OH)_2} = 2.32\,g}$$

7. $LiOH + HCl \longrightarrow LiCl + HOH$

$m_{LiOH} = ?$ $m_{HCl} = ?$ $m_{LiCl} = 34.0\,g$

$M_{LiOH} = 23.95\,{}^{g}/_{mol}$ $M_{HCl} = 36.46\,{}^{g}/_{mol}$ $M_{LiCl} = 42.39\,{}^{g}/_{mol}$

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I. calculate moles

$$n_{LiCl} = \frac{34.0\,g}{42.39\,{}^{g}/_{mol}}$$

$$n_{LiCl} = 0.802\,mol$$

II. mole ratios

$$\frac{n_{LiOH}}{1} = \frac{n_{LiCl}}{1}$$

$$\frac{n_{LiOH}}{1} = \frac{0.802\,mol}{1}$$

$$n_{LiOH} = 0.802\,mol$$

III. calculate masses

$$m_{LiOH} = 0.802\,mol \times 23.95\,{}^{g}/_{mol}$$

$$\boxed{m_{LiOH} = 19.2\,g}$$

$$\frac{n_{HCl}}{1} = \frac{n_{LiCl}}{1}$$

$$\frac{n_{HCl}}{1} = \frac{0.802\,mol}{1}$$

$$n_{HCl} = 0.802\,mol$$

$$m_{HCl} = 0.802\,mol \times 36.46\,{}^{g}/_{mol}$$

$$\boxed{m_{HCl} = 29.2\,g}$$

8. $4K + O_2 \longrightarrow 2K_2O$

$m_{K} = 4.57\,g$ $m_{K_2O} = ?$

$M_{K} = 39.10\,{}^{g}/_{mol}$ $M_{K_2O} = 94.20\,{}^{g}/_{mol}$

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I. calculate moles

$$n_{KOH} = \frac{4.57\,g}{39.10\,{}^{g}/_{mol}}$$

$$n_{KOH} = 0.117\,mol$$

II. mole ratio

$$\frac{n_{K_2O}}{2} = \frac{n_{KOH}}{4}$$

$$\frac{n_{K_2O}}{2} = \frac{0.117\,mol}{4}$$

$$n_{K_2O} = 0.058\,mol$$

III. calculate mass

$$m_{K_2O} = 0.058\,mol \times 94.20\,{}^{g}/_{mol}$$

$$\boxed{m_{K_2O} = 5.51\,g}$$

9. $3H_2 + N_2 \longrightarrow 2NH_3$

$m_{N_2} = 5.40\,g$ $m_{NH_3} = ?$

$M_{N_2} = 28.02\,{}^{g}/_{mol}$ $M_{NH_3} = 17.04\,{}^{g}/_{mol}$

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I. calculate moles

$$n_{N_2} = \frac{5.40\,g}{28.02\,{}^{g}/_{mol}}$$

$$n_{N_2} = 0.193\,mol$$

II. mole ratio

$$\frac{n_{NH_3}}{2} = \frac{n_{N_2}}{1}$$

$$\frac{n_{NH_3}}{2} = \frac{0.193\,mol}{1}$$

$$n_{NH_3} = 0.385\,mol$$

III. calculate mass

$$m_{NH_3} = 0.385\,mol \times 17.04\,{}^{g}/_{mol}$$

$$\boxed{m_{NH_3} = 6.57\,g}$$

10A. $CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$

$m_{CaC_2} = 5.00\,g$ $\quad m_{C_2H_2} = ?$

$M_{CaC_2} = 64.10\,{}^{g}/_{mol}$ $\quad M_{C_2H_2} = 26.04\,{}^{g}/_{mol}$

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I. calculate moles	II. mole ratio	III. calculate mass
$n_{CaC_2} = \frac{5.00\,g}{64.10\,{}^{g}/_{mol}}$	$\frac{n_{C_2H_2}}{1} = \frac{n_{CaC_2}}{1}$	
$n_{CaC_2} = 0.0780\,mol$	$\frac{n_{C_2H_2}}{1} = \frac{0.0780\,mol}{1}$	$m_{C_2H_2} = 0.0780\,mol \times 26.04\,{}^{g}/_{mol}$
	$n_{C_2H_2} = 0.0780\,mol$	$\boxed{m_{C_2H_2} = 2.03\,g}$

10B. $CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$

$m_{CaC_2} = ?$ $\quad m_{H_2O} = 98.0$

$M_{CaC_2} = 64.10\,{}^{g}/_{mol}$ $\quad M_{H_2O} = 18.02\,{}^{g}/_{mol}$

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I. calculate moles	II. mole ratio	III. calculate mass
$n_{H_2O} = \frac{98.0\,g}{18.02\,{}^{g}/_{mol}}$	$\frac{n_{CaC_2}}{1} = \frac{n_{H_2O}}{2}$	
$n_{H_2O} = 5.44\,mol$	$\frac{n_{CaC_2}}{1} = \frac{5.44\,mol}{2}$	$m_{CaC_2} = 2.72\,mol \times 64.10\,{}^{g}/_{mol}$
	$n_{CaC_2} = 2.72\,mol$	$\boxed{m_{CaC_2} = 174\,g}$

11. $Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$

$m_{Zn\,reacted} = 15.42\,g - 14.15\,g$

$m_{Zn\,reacted} = 1.27\,g$

$M_{Zn} = 65.38\,{}^{g}/_{mol}$

$m_{Cu} = ?$

$M_{Cu} = 63.55\,{}^{g}/_{mol}$

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I. calculate moles	II. mole ratio	III. calculate mass
$n_{Zn} = \frac{1.27\,g}{65.38\,{}^{g}/_{mol}}$	$\frac{n_{Cu}}{1} = \frac{n_{Zn}}{1}$	
$n_{Zn} = 0.0194\,mol$	$\frac{n_{Cu}}{1} = \frac{0.0194\,mol}{1}$	$m_{Cu} = 0.0194\,mol \times 63.55\,{}^{g}/_{mol}$
	$n_{Cu} = 0.0194\,mol$	$\boxed{m_{Cu} = 1.23\,g}$

12. $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

$m_{C_6H_{12}O_6} = ?$ $\quad n_{O_2} = 0.450\,mol$

$M_{C_6H_{12}O_6} = 180.18\,{}^{g}/_{mol}$

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I. mole ratio $\quad$ II. calculate mass

$$\frac{n_{C_6H_{12}O_6}}{1} = \frac{n_{O_2}}{6}$$

$$\frac{n_{C_6H_{12}O_6}}{1} = \frac{0.450\,mol}{6} \qquad m_{C_6H_{12}O_6} = 0.0750\,mol \times 180.18\,{}^{g}/_{mol}$$

$$n_{C_6H_{12}O_6} = 0.0750\,mol \qquad \boxed{m_{C_6H_{12}O_6} = 13.5\,g}$$