Sheet #7

1. $CaCO_3 \Rightarrow CaO + CO_2$

b) $225g\ CaCO_3 \times \frac{1\ mol\ CaCO_3}{100.086g\ CaCO_3} \times \frac{1\ mol\ CO_2}{1\ mol\ CaCO_3} \times \frac{22.414L\ CO_2}{1\ mol\ CO_2} = 50.388\ L\ CO_2$

c) $\%\ yield = \frac{actual\ yield}{theoretical\ yield} \times 100\%$

$= \frac{28.2\ L\ CO_2}{50.388L} \times 100\%$

$= 55.97\%$

2. $\overset{50g}{Fe} + \overset{150g}{CuSO_4} \Rightarrow FeSO_4 + Cu$

consider Fe:

$50g\ Fe \times \frac{1\ mol\ Fe}{55.845g\ Fe} = 0.8953\ mol\ Fe$ (available)

$0.8953\ mol\ Fe \times \frac{1\ mol\ CuSO_4}{1\ mol\ Fe} = 0.8953\ mol\ CuSO_4$ (required)

consider $CuSO_4$:

$150g\ CuSO_4 \times \frac{1\ mol\ CuSO_4}{159.608g\ CuSO_4} = 0.9398\ mol\ CuSO_4$ (available)

$0.9398\ mol\ CuSO_4 \times \frac{1\ mol\ Fe}{1\ mol\ CuSO_4} = 0.9398\ mol\ Fe$ (required)

∴ Fe is the limiting reagent.

b) $0.8953\ mol\ Fe \times \frac{1\ mol\ Cu}{1\ mol\ Fe} \times \frac{63.546g\ Cu}{1\ mol\ Cu} = 56.893g\ Cu$

c) $\%\ yield = \frac{43g\ Cu}{56.893g\ Cu} \times 100\%$

$= 75.58\%$

3. $2C_2H_6 + 7O_2 \Rightarrow 6H_2O + 4CO_2$

$40g\ C_2H_6 \times \frac{1\ mol\ C_2H_6}{30.070g\ C_2H_6} \times \frac{6\ mol\ H_2O}{2\ mol\ C_2H_6} \times \frac{18.015g\ H_2O}{1\ mol\ H_2O} = 71.892g\ H_2O$

$\%\ yield = \frac{60g\ H_2O}{71.892g\ H_2O} \times 100\%$

$= 83.46\%$

4. $Mg_3N_2 + 6H_2O \Rightarrow 2NH_3 + 3Mg(OH)_2$

consider Mg_3N_2:

$50.0g\ Mg_3N_2 \times \frac{1\ mol\ Mg_3N_2}{100.929g\ Mg_3N_2} = 0.4954\ mol\ Mg_3N_2$ (available)

$0.4954\ mol\ Mg_3N_2 \times \frac{6\ mol\ H_2O}{1\ mol\ Mg_3N_2} = 2.9724\ mol\ H_2O$ (required)

consider H_2O:

$30.0g\ H_2O \times \frac{1\ mol\ H_2O}{18.015g\ H_2O} = 1.6653\ mol\ H_2O$ (available)

$1.6653\ mol\ H_2O \times \frac{1\ mol\ Mg_3N_2}{6\ mol\ H_2O} = 0.2776\ mol\ Mg_3N_2$ (required)

∴ H_2O is the limiting reagent.

$1.6653\ mol\ H_2O \times \frac{3\ mol\ Mg(OH)_2}{6\ mol\ H_2O} \times \frac{58.319g\ Mg(OH)_2}{1\ mol\ Mg(OH)_2} = 48.559g\ Mg(OH)_2$

$\%\ yield = \frac{40g\ Mg(OH)_2}{48.559g\ Mg(OH)_2} \times 100\%$

$= 82.37\%$

(continued on next page)

$P = 98\ kPa$

$V = ?\ L$

$n = 1.6653\ mol\ H_2O \times \frac{2\ mol\ NH_3}{6\ mol\ H_2O} = 0.5551\ mol\ NH_3$

$R = 8.314\ \frac{kPa \cdot L}{mol \cdot K}$

$T = 25°C + 273.15 = 298.15\ K$

- - - - - - -

$V = \frac{nRT}{P}$

$= \frac{0.5551\ mol \times 8.314\ \frac{kPa \cdot L}{mol \cdot K} \times 298.15\ K}{98\ kPa}$

$= 14.04\ L$

(of NH_3)

if % yield was the same,

$14.04\ L\ NH_3 \times 82.37\%$

$= 11.563\ L\ NH_3$

5. $N_2 + 3H_2 \Rightarrow 2NH_3$

consider N_2:

$10\ L\ N_2 \times \frac{1\ mol\ N_2}{22.414\ L\ N_2} = 0.4461\ mol\ N_2$ (available)

$0.4461\ mol\ N_2 \times \frac{3\ mol\ H_2}{1\ mol\ N_2} = 1.3383\ mol\ H_2$ (required)

consider H_2:

$25\ L\ H_2 \times \frac{1\ mol\ H_2}{22.414\ L\ H_2} = 1.1154\ mol\ H_2$ (available)

$1.1154\ mol\ H_2 \times \frac{1\ mol\ N_2}{3\ mol\ H_2} = 0.3718\ mol\ N_2$ (required)

∴ H_2 is the limiting reagent

$1.1154\ mol\ H_2 \times \frac{2\ mol\ NH_3}{3\ mol\ H_2} \times \frac{22.414\ L\ NH_3}{1\ mol\ NH_3} = 16.667\ L\ NH_3$

% yield $= \frac{15\ L\ NH_3}{16.667\ L\ NH_3} \times 100\%$

$= 89.998\%$

6. $3O_2 + 4Al \Rightarrow 2Al_2O_3$

Consider O_2:

$5\ L\ O_2 \times \frac{1\ mol\ O_2}{22.414\ L\ O_2} = 0.2231\ mol\ O_2$ (available)

$0.2231\ mol\ O_2 \times \frac{4\ mol\ Al}{3\ mol\ O_2} = 0.2975\ mol\ Al$ (required)

Consider Al

$2\ g\ Al \times \frac{1\ mol\ Al}{26.982\ g\ Al} = 0.0741\ mol\ Al$ (available)

$0.0741\ mol\ Al \times \frac{3\ mol\ O_2}{4\ mol\ Al} = 0.0556\ mol\ O_2$ (required)

∴ Al is the limiting reagent

$0.0741\ mol\ Al \times \frac{2\ mol\ Al_2O_3}{4\ mol\ Al} \times \frac{101.961\ g\ Al_2O_3}{1\ mol\ Al_2O_3} = 3.778\ g\ Al_2O_3$

% yield $= \frac{2.95\ g\ Al_2O_3}{3.778\ g\ Al_2O_3} \times 100\%$

$= 78.08\%$

7. a) $2Hg_2O \Rightarrow 4Hg + O_2$

$P = 1\ atm. \times \frac{101.325\ kPa}{1\ atm.} = 101.325\ kPa$

$V = ?\ L$

$n = 500g\ Hg_2O \times \frac{1\ mol\ Hg_2O}{417.179g\ Hg_2O} \times \frac{1\ mol\ O_2}{2\ mol\ Hg_2O} = 0.5993\ mol\ O_2$

$R = 8.314\ \frac{kPa \cdot L}{mol \cdot K}$

$T = 185°C + 273.15 = 458.15\ K$

$V = \frac{0.5993\ mol\ O_2 \times 8.314 \frac{kPa \cdot L}{mol \cdot K} \times 458.15K}{101.325kPa}$

$= 22.529\ L\ O_2$

$\%\ yield = \frac{6.95L\ O_2}{22.529L\ O_2} \times 100\%$

$= 30.849\ \%$

b) $500g\ Hg_2O \times \frac{1\ mol\ Hg_2O}{417.179g\ Hg_2O} \times \frac{4\ mol\ Hg}{2\ mol\ Hg_2O} \times \frac{200.59g\ Hg}{1\ mol\ Hg} = 480.825g\ Hg$

c) if % yield was the same,

$480.825g\ Hg \times 30.849\%$

$= 148.3297g\ Hg$

d) The mass in b) would be closer to the experimental observations because gas is harder to recover than liquids or solids in a reaction.

8. $2Fe_2O_3 \Rightarrow 4Fe + 3O_2$

$12200t\ iron\ ore \times \frac{56.1t\ Fe_2O_3}{100t\ iron\ ore} \times \frac{85.5t\ Fe_2O_3}{100t\ Fe_2O_3} \times \frac{1000000g\ Fe_2O_3}{1t\ Fe_2O_3} \times \frac{1\ mol\ Fe_2O_3}{159.687g\ Fe_2O_3} \times \frac{4mol\ Fe}{2mol\ Fe_2O_3} \times \frac{55.845g\ Fe}{1mol\ Fe}$

$\times \frac{1t\ Fe}{1000000g\ Fe} = 4092.923t\ Fe$