"Problem Set" 3.5 - Stoichiometry

① $4\,Al(s) + 3O_2(g) \rightarrow 2\,Al_2O_3(s)$

$6.0\ mol\ Al\left(\frac{3\ mol\ O_2}{4\ mol\ Al}\right) = \boxed{4.5\ mol\ O_2\ needed}$

$6.0\ mol\ Al\left(\frac{2\ mol\ Al_2O_3}{4\ mol\ Al}\right)\left(\frac{101.9612\ g}{1\ mol\ Al_2O_3}\right) = \boxed{3.1 \times 10^2\ g\ Al_2O_3}$

② a. $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

b. $2.68\ g\ Fe\left(\frac{1\ mol\ Fe}{55.847\ g}\right)\left(\frac{2\ mol\ Fe_2O_3}{4\ mol\ Fe}\right)\left(\frac{159.6922\ g}{1\ mol\ Fe_2O_3}\right) = \boxed{3.83\ g\ Fe_2O_3}$

c. $2.68\ g\ Fe\left(\frac{1\ mol\ Fe}{55.847\ g}\right)\left(\frac{3\ mol\ O_2}{4\ mol\ Fe}\right)\left(\frac{31.9988\ g}{1\ mol\ O_2}\right) = \boxed{1.15\ g\ O_2}$

③ a. $2C_6H_{14}(\ell) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(g \text{ or } \ell)$

b. Find the limiting reactant:

max. mass CO_2 from C_6H_{14} $= 215\ g\ C_6H_{14}\left(\frac{1\ mol\ C_6H_{14}}{86.178\ g}\right)\left(\frac{12\ mol\ CO_2}{2\ mol\ C_6H_{14}}\right)\left(\frac{44.010\ g}{1\ mol\ CO_2}\right) = 658.8\ g\ CO_2$

max mass CO_2 from O_2 $= 215\ g\ O_2\left(\frac{1\ mol\ O_2}{31.9988\ g}\right)\left(\frac{12\ mol\ CO_2}{19\ mol\ O_2}\right)\left(\frac{44.010\ g}{1\ mol\ CO_2}\right) = 186.8\ g\ CO_2$

O_2 is limiting. 187 g of CO_2 can be formed.

max mass H_2O $= 215\ g\ O_2\left(\frac{1\ mol\ O_2}{31.9988\ g}\right)\left(\frac{14\ mol\ H_2O}{19\ mol\ O_2}\right)\left(\frac{18.015\ g}{1\ mol\ H_2O}\right) = 89.2\ g\ H_2O$

③ cont.

c) C_6H_{14} is in excess. Amount left over = Initial mass − Mass used

$$\text{mass } C_6H_{14} \text{ used} = 215\text{ g } O_2 \left(\frac{1\text{ mol } O_2}{31.9988\text{ g}}\right)\left(\frac{2\text{ mol } C_6H_{14}}{19\text{ mol } O_2}\right)\left(\frac{86.178\text{ g}}{1\text{ mol } C_6H_{14}}\right) = 60.95\text{ g}$$

215 g initially − 60.95 g used = **154 g C_6H_{14} left over**

④ $CuSO_4(aq) + 4NH_3(aq) \rightarrow Cu(NH_3)_4SO_4(aq)$

a) Note: You are told that $CuSO_4$ is the limiting reactant.

$$10.0\text{ g } CuSO_4 \left(\frac{1\text{ mol } CuSO_4}{159.6096\text{ g}}\right)\left(\frac{1\text{ mol } Cu(NH_3)_4SO_4}{1\text{ mol } CuSO_4}\right)\left(\frac{227.734\text{ g}}{1\text{ mol}}\right)$$

= 14.3 g $Cu(NH_3)_4SO_4$

b) % Yield = $\frac{12.6\text{ g actually made}}{14.3\text{ g theoretically}} * 100\% =$ **88.1 %**

⑤ $TiCl_4(l) + 2H_2O(l) \rightarrow TiO_2(s) + 4HCl(g)$

a) titanium (IV) chloride; water; titanium (IV) oxide; hydrogen chloride or hydrochloric acid

b) $$14.0\text{ mL } TiCl_4 \left(\frac{1.73\text{ g}}{1\text{ mL } TiCl_4}\right)\left(\frac{1\text{ mol } TiCl_4}{189.692\text{ g}}\right)\left(\frac{2\text{ mol } H_2O}{1\text{ mol } TiCl_4}\right)\left(\frac{18.015\text{ g}}{1\text{ mol } H_2O}\right)$$

From 1st 2 steps in (b) → **= 4.60 g H_2O**

c) $$0.12768\text{ mol } TiCl_4 \left(\frac{1\text{ mol } TiO_2}{1\text{ mol } TiCl_4}\right)\left(\frac{79.8788\text{ g}}{1\text{ mol } TiO_2}\right) =$$ **10.2 g TiO_2**

$$0.12768\text{ mol } TiCl_4 \left(\frac{4\text{ mol } HCl}{1\text{ mol } TiCl_4}\right)\left(\frac{36.461\text{ g}}{1\text{ mol } HCl}\right) =$$ **18.6 g HCl**

(6) $2HNO_{3(aq)} + Ba(OH)_{2(s)} \rightarrow 2H_2O_{(l)} + Ba(NO_3)_{2(aq)}$

1. Find moles of HNO_3 required; 2. then, use concentration to find volume of HNO_3.

$$\text{moles } HNO_3 = 2.50\text{ g } Ba(OH)_2 \left(\frac{1\text{ mol } Ba(OH)_2}{171.3448\text{ g}}\right)\left(\frac{2\text{ mol } HNO_3}{1\text{ mol } Ba(OH)_2}\right) = 0.02918 \text{ mol } HNO_3$$

$$\text{Molarity} = \frac{\text{moles } HNO_3}{V \text{ in liters}}$$

$$V = \frac{\text{moles}}{\text{molarity}} = \frac{0.02918\text{ mol}}{0.109\text{ mol/L}} = 0.268\text{L}$$

$$0.268\text{L}\left(\frac{1000\text{ mL}}{1\text{ L}}\right) = \boxed{268\text{ mL of } HNO_3}$$