Chemical equations - gives proportions or ratios in moles

$$Fe_2O_{3(s)} + C_{(s)} \rightarrow CO_{2(g)} + Fe_{(s)}$$

* Balance!

$$Fe_2O_{3(s)} + \frac{3}{2}C_{(s)} \rightarrow \frac{3}{2}CO_{2(g)} + 2Fe_{(s)}$$

or

$$2\,Fe_2O_{3(s)} + 3\,C_{(s)} \rightarrow 3\,CO_{2(g)} + 4\,Fe_{(s)}$$

If we want 10 moles Fe, how much Fe_2O_3 and C do we need?

$$10 \text{ moles Fe} \times \frac{2 \text{ moles } Fe_2O_3}{4 \text{ moles Fe}} = 5 \text{ moles } Fe_2O_3$$

$$10 \text{ moles Fe} \times \frac{3 \text{ moles C}}{4 \text{ moles Fe}} = 7.5 \text{ moles C}$$

If we want 100 kg Fe, how much Fe_2O_3, C?

$$100 \text{ kg Fe} \times \frac{1000\text{g}}{1 \text{ kg}} \times \frac{1 \text{mol Fe}}{55.8\text{g}} = 1792 \text{ moles Fe}$$

$$1792 \text{ moles Fe} \times \frac{2 \text{ moles } Fe_2O_3}{4 \text{ moles Fe}} = 896 \text{ moles } Fe_2O_3 \times \frac{159.69 \; Fe_2O_3}{\text{moles } Fe_2O_3}$$

$$= 143000\text{g or } 143 \text{ kg } Fe_2O_3$$

$$1792 \text{ moles Fe} \times \frac{3 \text{ moles C}}{4 \text{ moles Fe}} \times \frac{12\text{ g}}{1 \text{ mole C}} = 16100\text{g or } 16.1 \text{ kg C}$$

Limiting reactant - the thing you run out of first
-once you run out you can't make any more product

If we have 47 kg Fe_2O_3 and 4.3 kg C
how much Fe can we make

1. which is limiting reactant
2. How much Fe
3. How much reactant left over

$47\ kg\ Fe_2O_3 \times \frac{1000g}{1kg} \times \frac{1 mole}{159.6g} = 294.5\ mol\ Fe_2O_3$

$4300g\ C \times \frac{1 mol}{12g} = 358\ moles\ C$

How much C needed to react w/ 294.5 mol Fe_2O_3?

$294.5\ Fe_2O_3 \times \frac{3\ moles\ C}{2\ moles\ Fe_2O_3} = 441.8$ moles C are needed to react w/ 294.5 moles Fe_2O_3
but we only have 358 moles C
so we run out of C before Fe_2O_3 → C is limiting reactant

Use moles of LR to determine moles of prod

$358\ moles\ C \times \frac{4\ moles\ Fe}{3\ moles\ C} = 477\ moles\ Fe \times \frac{55.8g}{1 mol} \rightarrow 27\ kg\ Fe$

How much Fe_2O_3 left over?

294.5 mole Fe_2O_3 init

$477\ mol\ Fe\ made \times \frac{1\ mole\ Fe_2O_3}{2\ mol\ Fe} = 238.5$ moles Fe_2O_3 used

$294.5 - 238.5 = 56$ moles Fe_2O_3 left over → 8.9 kg Fe_2O_3

$$\text{Percent yield} = \frac{\text{actual amount of prod}}{\text{theoretical amount}} \times 100$$

If we only got 24 kg instead of 27 kg that was expected

$$\frac{24\,kg}{27\,kg} \times 100 = 89\%$$

For solutions we use "molarity"

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liter of solution}}$$

liter of solution is NOT liter of solvent

$[C_6H_{12}O_6]$ = "molarity of $C_6H_{12}O_6$"

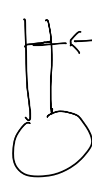
2 moles of sugar in enough water to make 1L of solution $[\text{sugar}] = \frac{2\text{ moles}}{1\,L} = 2M$

"molar"

5 mL = 0.005 L = 1 teaspoon

$$0.005\,L \times \frac{2\text{ mol sugar}}{1\,L} = 0.01\text{ moles sugar}$$

Ex: 25.3 g NaCl dissolved in enough water to make 0.5 L of solution



exactly 0.5L

$$25.3\,g\text{ NaCl} \times \frac{1\text{ mol}}{58.4\,g} = 0.433\text{ moles NaCl}$$

$$[NaCl] = \frac{0.433\text{ mol}}{0.5\,L} = 0.866\,M$$

Ex: 11.1 g $Mg(NO_3)_2$ dissolved in enough water to make 250 mL of solution

$$11.1\text{ g } Mg(NO_3)_2 \times \frac{1\text{ mol}}{148.3\text{ g}} = \frac{0.075\text{ mol } Mg(NO_3)_2}{0.25\text{ L}} = 0.3\text{ M}$$

$$Mg(NO_3)_{2\,(s)} \rightarrow Mg^{2+}_{(aq)} + 2\,NO^-_{3\,(aq)}$$

0.075 mol $Mg(NO_3)_2 \rightarrow 0.075$ moles Mg^{2+}

$\rightarrow 0.15$ moles NO_3^-

$$[Mg^{2+}] = \frac{0.075\text{ mol}}{0.25\text{ L}} = 0.3\text{ M}$$

$$[NO_3^-] = \frac{0.15\text{ mol}}{0.25\text{ L}} = 0.6\text{ M}$$

Have 0.3 M $Mg(NO_3)_2$, want 0.05 mol of $Mg(NO_3)_2$

$$0.05\text{ mol } Mg(NO_3)_2 \times \frac{1\text{ L sol'n}}{0.3\text{ mol } Mg(NO_3)_2} = 0.167\text{ L}$$

$$\underline{3\,Co^{2+}_{(aq)}} + 6\,Cl^-_{(aq)} + 6\,Na^+_{(aq)} + \underline{2\,PO_4^{3-}{}_{(aq)}} \rightarrow \underline{Co_3(PO_4)_{2\,(s)}} + 6\,Na^+_{(aq)} + 6\,Cl^-_{(aq)}$$

20 mL of 0.2 M $CoCl_2$ solution
15 mL of 0.25 M Na_3PO_4 solution } mix → how many grams of precip

$$0.02\text{ L } CoCl_2 \times \frac{0.2\text{ mol}}{1\text{ L}} \times \frac{1\text{ mol } Co^{2+}}{1\text{ mol } CoCl_2} = 0.004\text{ mol } Co^{2+}$$

$$0.015\text{ L } Na_3PO_4 \times \frac{0.25\text{ mol}}{1\text{ L}} \times \frac{1\text{ mol } PO_4^{-3}}{1\text{ mol } Na_3PO_4} = 0.00375\text{ mol } PO_4^{-3}$$

If we want to react all 0.004 mol Co^{2+}, how much PO_4^{-3} needed?

$$0.004\text{ mol } Co^{2+} \times \frac{2\text{ mol } PO_4^{-3}}{3\text{ mol } Co^{2+}} = 0.0027\text{ mol } PO_4^{-3}$$

So Co^{2+} is limiting reactant

If we want to react all 0.00375 mol PO_4^{-3}, how much Co^{2+} needed?

$$0.00375 \text{ mol } PO_4^{-3} \times \frac{3 \text{ mol } Co^{2+}}{2 \text{ mol } PO_4^{-3}} = 0.0056 \text{ mol } Co^{2+}$$ - but we only have 0.004 moles so Co^{2+} is limiting

$$0.004 \text{ mol } Co^{2+} \times \frac{1 \text{ mol } Co_3(PO_4)_2}{3 \text{ mol } Co^{2+}} \times \frac{367 \text{ g}}{1 \text{ mol } Co_3(PO_4)_2} = 0.49 \text{ g } Co_3(PO_4)_2$$