78.114 g/mol 123.111 g/mol <- Formula weights

22.4 g 31.6 g ACTUAL

$$C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$$

benzene nitric acid nitrobenzene

22.4 grams of benzene are reacted with excess nitric acid. If 31.6 grams of nitrobenzene are collected from the reaction, what is the percent yield?

To find the percent yield, we need to know both the ACTUAL YIELD (31.6g of nitrobenzene) and the THEORETICAL YIELD. We CALCULATE the theoretical yield based on the starting amount of benzene (22.4g).

78.114 g C_6H_6 = mol C_6H_6 | 1 mol C_6H_6 = 1 mol $C_6H_5NO_2$ | 123.11g $C_6H_5NO_2$ = mol $C_6H_5NO_2$

$$22.4\,g\ C_6H_6 \times \frac{mol\ C_6H_6}{78.114g\ C_6H_6} \times \frac{1\ mol\ C_6H_5NO_2}{1\ mol\ C_6H_6} \times \frac{123.11g\ C_6H_5NO_2}{mol\ C_6H_5NO_2} = 35.3\,g\ C_6H_5NO_2$$

<- THEORETICAL YIELD

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

$$\frac{31.6g}{35.3g} \times 100\% = \boxed{89.5\%}$$

25.0 mL of acetic acid solution requires 37.3 mL of 0.150 M sodium hydroxide for complete reaction. The equation for this reaction is:

$$NaOH + HC_2H_3O_2 \rightarrow NaC_2H_3O_2 + H_2O$$

What is the molar concentration of the acetic acid?

$$\hookrightarrow \frac{\text{mol } HC_2H_3O_2}{\text{L solution}} \leftarrow 25.0\text{ mL } (0.0250\text{ L})$$

Since we know the volume of the acetic acid solution, we merely need to calculate the number of moles of acetic acid reacted.

$0.150\text{ mol } NaOH = \text{L NaOH solution}$ | $1\text{ mol } NaOH = 1\text{ mol } HC_2H_3O_2$

units: 37.3 mL → 0.0373 L

$$0.0373\text{ L NaOH solution} \times \frac{0.150\text{ mol } NaOH}{\text{L NaOH solution}} \times \frac{1\text{ mol } HC_2H_3O_2}{1\text{ mol } NaOH} = 0.005595\text{ mol } HC_2H_3O_2$$

$$M = \frac{\text{moles } HC_2H_3O_2}{\text{L acid}} = \frac{0.005595\text{ mol } HC_2H_3O_2}{0.0250\text{ L}} = \boxed{0.224\text{ M } HC_2H_3O_2}$$

Shortcut: Use millimoles!

$$37.3\text{ mL} \times \frac{0.150\text{ mol } NaOH}{\text{L}} \times \frac{1\text{ mol } HC_2H_3O_2}{1\text{ mol } NaOH} = 5.595\text{ mmol } HC_2H_3O_2$$

$$M = \frac{\text{mol}}{\text{L}} = \frac{\text{mmol}}{\text{mL}} = \frac{5.595\text{ mmol } HC_2H_3O_2}{25.0\text{ mL}} = 0.224\text{ M } HC_2H_3O_2$$

$$\underset{\text{propylene}}{\overset{42.081\text{ g/mol}}{4\,C_3H_6}} + 6\,NO \longrightarrow \underset{\text{acrylonitrile}}{\overset{53.064\text{ g/mol}}{4\,C_3H_3N}} + 6\,H_2O + N_2$$

Calculate how many grams of acrylonitrile could be obtained from 651 kg of propylene, assuming there is excess NO present.

(651000 g)

1 - Convert mass propylene to moles using formula weight of propylene
2 - Convert moles propylene to moles acrylonitrile using chemical equation
3 - Convert moles acrylonitrile to grams using formula weight of acrylonitrile

$42.081\text{ g } C_3H_6 = \text{mol } C_3H_6$ | $4\text{ mol } C_3H_6 = 4\text{ mol } C_3H_3N$ | $53.064\text{ g } C_3H_3N = \text{mol } C_3H_3N$

$$651000\text{ g } C_3H_6 \times \underset{①}{\frac{\text{mol } C_3H_6}{42.081\text{ g } C_3H_6}} \times \underset{②}{\frac{4\text{ mol } C_3H_3N}{4\text{ mol } C_3H_6}} \times \underset{③}{\frac{53.064\text{ g } C_3H_3N}{\text{mol } C_3H_3N}} =$$

$$= \boxed{821000\text{ g } C_3H_3N} \quad (821\text{ kg})$$

151.90 g/mol

$$\underline{10FeSO_4} + \underline{2KMnO_4} + 8H_2SO_4 \rightarrow 5Fe_2(SO_4)_3 + 2MnSO_4 + K_2SO_4 + 8H_2O$$

How many mL of 0.250M potassium permangenate are needed to react with 3.36 g of iron(II) sulfate?

---

1 - Change the mass of iron(II) sulfate to moles using its formula weight
2 - Change the moles of iron(II) sulfate to moles potassium permangenate using chemical equation
3 - Change moles of potassium permangenate to volume using concentration

$151.90\ g\ FeSO_4 = mol\ FeSO_4$ | $10\ mol\ FeSO_4 = 2\ mol\ KMnO_4$ | $0.250\ mol\ KMnO_4 = L$

$$3.36\ g\ FeSO_4 \times \underset{①}{\frac{mol\ FeSO_4}{151.90\ g\ FeSO_4}} \times \underset{②}{\frac{2\ mol\ KMnO_4}{10\ mol\ FeSO_4}} \times \underset{③}{\frac{L}{0.250\ mol\ KMnO_4}} = 0.0177\ L$$

$mL = 10^{-3}\ L$ Problem asked for mL of solution, so convert!

$$0.0177\ L \times \frac{mL}{10^{-3}\ L} = \boxed{17.7\ mL\ of\ 0.250\ M\ KMnO_4}$$

Electrolytes and Ionic Theory

- electrolytes: substances that dissolve in water to form charge-carrying solutions

* Electrolytes form ions in solution - (ions that are mobile are able to carry charge!). These IONS can undergo certain kinds of chemistry!

IONIC THEORY

- the idea that certain compounds DISSOCIATE in water to form free IONS

What kind of compounds?

- Soluble ionic compounds
- Acids (strong AND weak)
- Bases (strong AND weak)

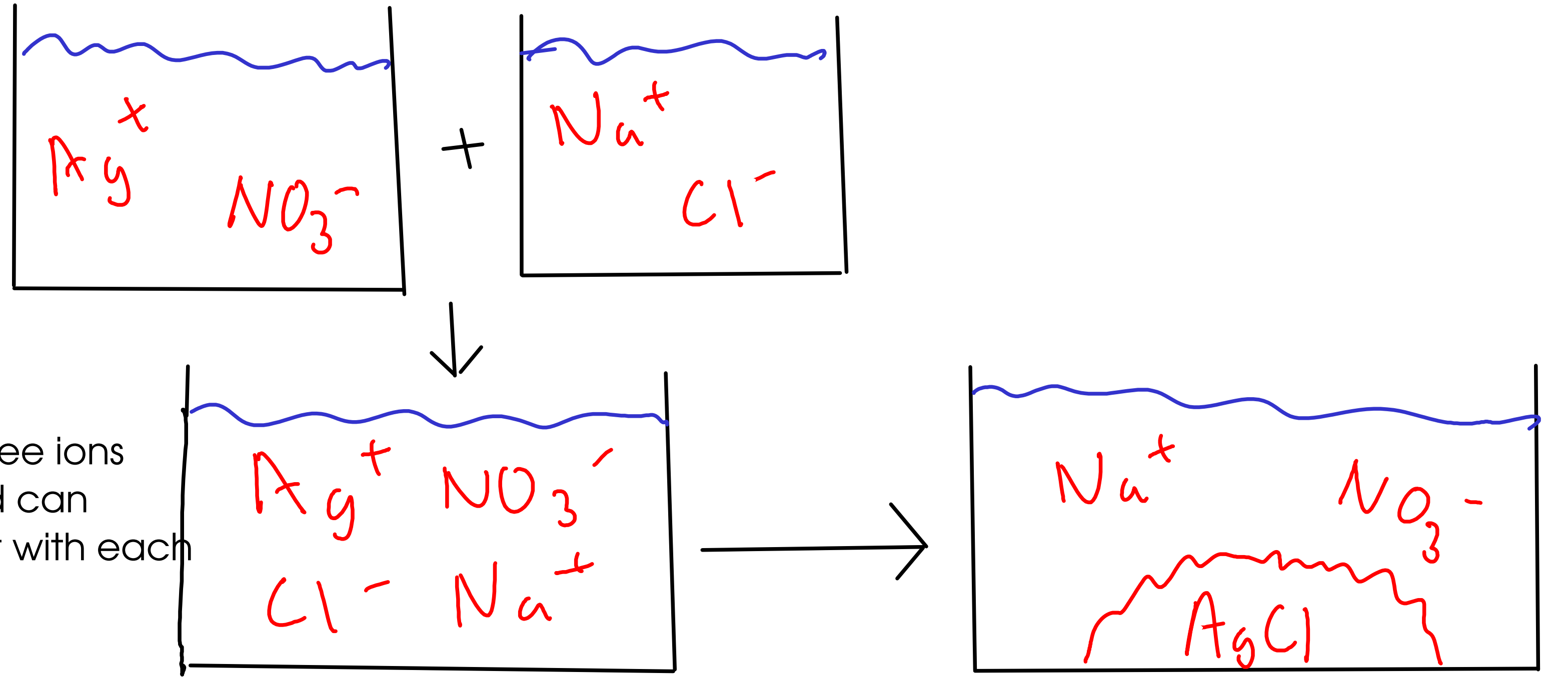
The ions formed may interact with each other to form NEW compounds!

Strong vs weak?

- If an electrolyte COMPLETELY IONIZES in water, it's said to be STRONG
- If an electrolyte only PARTIALLY IONIZES in water, it's said to be WEAK
- Both kinds of electrolyte undergo similar kinds of chemistry.

- What good is ionic theory?
  - provides an easy-to-understand MECHANISM for certain kinds of chemical reactions.
    - "Exchange" reactions. (a.k.a "double replacement" reactions)

$$AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$$

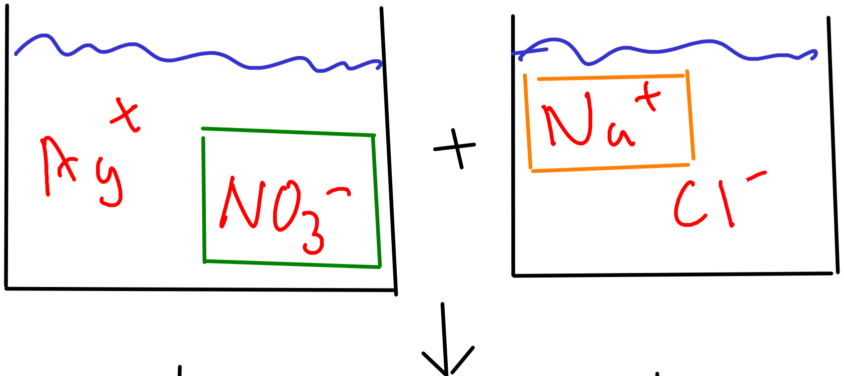


These free ions mix and can interact with each other!

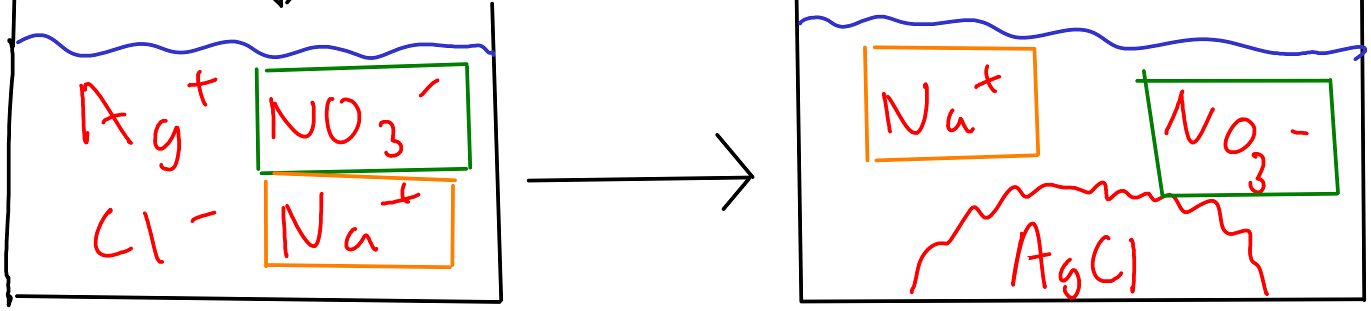
"ion soup"!

Insoluble AgCl falls out of solution as it is formed - "precipitation"

Looking a bit more closely...



The nitrate and sodium ions do not really participate in this reaction. They start and end in exactly the same state. We call them "SPECTATOR IONS".



$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$ "Molecular equation"

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$ "Net ionic equation"

(The net ionic equation shows only ions and substances that change during the course of the reaction!)

- The net ionic equation tells us that any source of aqueous silver and chloride ions will exhibit this same chemistry, not just silver nitrate and sodium chloride!