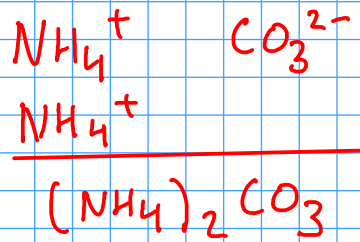Example: How many grams of ammonium carbonate do we need to weigh out to get 3.65 moles of ammonium carbonate?

$NH_4^+ \quad CO_3^{2-}$

$\dfrac{NH_4^+}{(NH_4)_2 CO_3}$

$N : 2 \times 14.01$

$H : 8 \times 1.008$

$C : 1 \times 12.01$

$O : 3 \times 16.00$

$\overline{96.094}$

$96.094 \text{ g } (NH_4)_2 CO_3 = 1 \text{ mol } (NH_4)_2 CO_3$

$3.65 \text{ mol } (NH_4)_2 CO_3 \times \dfrac{96.094 \text{ g } (NH_4)_2 CO_3}{1 \text{ mol } (NH_4)_2 CO_3} = \boxed{351 \text{ g } (NH_4)_2 CO_3}$

PERCENTAGE COMPOSITION

- sometimes called "percent composition" or "percent composition by mass"

- the percentage of each element in a compound, expressed in terms of mass

Example: Find the percentage composition of ammonium nitrate.
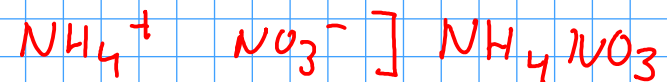
$$NH_4^+ \quad NO_3^- \,] \; NH_4NO_3$$

NH_4NO_3 : $N: 2 \times 14.01 = 28.02$

$\qquad\qquad H: 4 \times 1.008 = \quad 4.032$

$\qquad\qquad O: 3 \times 16.00 = \underline{48.00}$

$\qquad\qquad\qquad\qquad\qquad 80.052 \, g \; NH_4NO_3 = 1 \, mol \; NH_4NO_3$

$\%N: \dfrac{28.02 \, g \, N}{80.052 g \; total} \times 100\% = \boxed{35.0\% \, N}$

$\%H: \dfrac{4.032 \, g \, H}{80.052 g \; total} \times 100\% = \boxed{5.0\% \, H}$

$\%O: \dfrac{48.00 \, g \, O}{80.052 g \; total} \times 100\% = \boxed{60.0\% \, O}$

So far, we have

      - looked at how to determine the composition by mass of a compound from a formula

      - converted from MASS to MOLES (related to the number of atoms/molecules)

      - converted from MOLES to MASS

Are we missing anything?

      - What about SOLUTIONS, where the desired chemical is not PURE, but
       found DISSOLVED IN WATER?

      - How do we deal with finding the moles of a desired chemical when it's in
       solution?

MOLAR CONCENTRATION

- unit: MOLARITY (M): moles of dissolved substance per LITER of solution

$$M = MOLARITY = \frac{moles\ of\ solute}{L\ solution}$$

6.0 M HCl solution: $\frac{6.0\ mol\ HCl}{L}$

There are 6.0 moles of hydrochloric acid in each liter of this solution, so you can write this relationship another way:

$$6.0\ mol\ HCl = 1\ L$$

If you have 0.250 L (250 mL) of 6.0 M HCl, how many moles of HCl do you have?

$$6.0\ mol\ HCl = 1\ L$$

$$0.250\ L \times \frac{6.0\ mol\ HCl}{1\ L} = \boxed{1.5\ mol\ HCl}$$

If you need 0.657 moles of hydrochloric acid, how many liters of 0.0555 M HCl do you need to measure out? $0.0555 \text{ mol } HCl = 1 L$

$0.657 \text{ mol } HCl \times \dfrac{1 L}{0.0555 \text{ mol } HCl} = \boxed{11.8 L}$

$11,800 \text{ mL.}$ ✓

What if we used 6.00 M HCl?

$6.00 \text{ mol } HCl = 1 L$

$0.657 \text{ mol } HCl \times \dfrac{1 L}{6.00 \text{ mol } HCl} = \boxed{0.110 L}$

$110. \text{ mL.}$ ✓

CHEMICAL CALCULATIONS CONTINUED: REACTIONS

- Chemical reactions proceed on an ATOMIC basis, NOT a mass basis!

- To calculate with chemical reactions (i.e. use chemical equations), we need everything in terms of ATOMS ... which means MOLES of atoms

$$2\,Al\,(s) + 3\,Br_2\,(l) \longrightarrow 2\,AlBr_3\,(s)$$
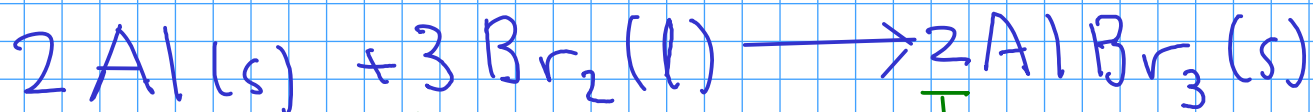
coefficients are in terms of atoms and molecules!

$$2\ atoms\ Al = 3\ molecules\ Br_2 = 2\ formula\ units\ AlBr_3$$

$$2\ mol\ Al = 3\ mol\ Br_2 = 2\ mol\ AlBr_3$$

- To do chemical calculations, we need to:

- Relate the amount of substance we know (mass or volume) to a number of moles

- Relate the moles of one substance to the moles of another using the equation

- Convert the moles of the new substance to mass or volume as desired