Unit 3B: The Mole: Mole-Particles Relationship

- Just like a pair or a dozen, the mole is an amount of things.

1 pair of shoes = 2 shoes
1 dozen doughnuts = 12 doughnuts

1 mole of atoms = 602 000 000 000 000 000 000 000 atoms
or
6.02×10^{23} atoms → called Avogadro's Number

- You can have one mole of anything, really, but for this class, we will mean:

particles:
- 1 mole atoms → if you are working w/ elements
- 1 mole molecules → if you are working w/ covalent compounds
- 1 mole formula units → if you are working w/ ionic compounds or acids
- 1 mole ions → if you are working w/ ions

- If you were asked: How many doughnuts are in 5 dozen?, I bet you could easily come up with the answer:

$$5 \text{ dozen} \times \frac{12 \text{ doughnuts}}{1 \text{ dozen}} = 60 \text{ doughnuts}$$

We do similar calculations using the mole because it is easier than counting individual atoms or molecules. (They are super tiny & there are a lot of atoms or molecules in substances.)

- We will use a method called dimensional analysis to solve these problems. It is based on cancelling out units we don't want (through division) for units we do want (through multiplication.). We will use a ratio to do this:

$$\frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ particles}} \quad \text{or} \quad \frac{6.02 \times 10^{23} \text{ particles}}{1 \text{ mol}}$$

* FYI - the abbreviation for mole is mol

Examples

* significant figures are still needed for all work!

1. How many atoms (unknown) are in 3.30 mols of silver (Given)?

- Always write the given 1st. Then draw a T-chart (—|—).

$$3.30\ \text{mol Ag} \mid$$

- Write down the unit of the unknown you need. In this case, it's atoms Ag:

$$3.30\ \text{mol Ag} \mid \qquad \text{atoms Ag}$$

- Now we need to determine how to write the ratio. Remember, we need to remove the unit of moles & replace it with atoms. Therefore the value 1 mol needs to be in the denominator & 6.02×10^{23} atoms needs to be on top. Why? So that the unit mol will divide out and the unit atoms remains. Write the ratio like I have done below:

$$3.30\ \text{mol Ag} \left| \frac{6.02 \times 10^{23}\ \text{atoms}}{1\ \text{mol}} \right. = \qquad \text{atoms Ag}$$

- In dimensional analysis, any units (& their corresponding numbers) on top & below the horizontal line get divided and the units cancel each other out. Any numbers and units on top of the horizontal line get multiplied.

$$3.30\ \text{mol Ag} \left| \frac{6.02 \times 10^{23}\ \text{atoms}}{1\ \text{mol}} \right. = \qquad \text{atoms Ag}$$

(× on top, ÷ on bottom)

In your calculator, you would type:

$$3.30 \times 6.02 \times 10^{23} \div 1 =$$

don't forget how to use scientific notation, use the EE, EXP, or $\times 10^{\square}$ button!

- This is what I would like to see on your paper:

$$3.30\ \text{mol Ag} \left| \frac{6.02 \times 10^{23}\ \text{atoms}}{1\ \text{mol}} \right. = 1.9866 \times 10^{24} = 1.99 \times 10^{24}\ \text{atoms Ag}$$

2. How many (moles) are in 7.50×10^{22} molecules of H_2O?
unknown — given

$$7.50 \times 10^{22} \text{ molecules } H_2O \left| \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ molecules}} \right. = .124584717 \text{ mol } H_2O$$

$= .125 \text{ mol } H_2O$

3. How many (ions) are in .63 moles of Fe^{3+} ions?
unknown — given

$$.63 \text{ mol } Fe^{3+} \left| \frac{6.02 \times 10^{23} \text{ ions}}{1 \text{ mol}} \right. = 3.7926 \times 10^{23} = 3.8 \times 10^{23} Fe^{3+} \text{ ions}$$

4. How many (moles) are in 1.420×10^{24} formula units of Na_2CO_3?
unknown — given

I usually shorten formula units to f.u.

$$1.420 \times 10^{24} \text{ f.u. } Na_2CO_3 \left| \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ f.u.}} \right. = 2.358803987 = 2.359 \text{ mol } Na_2CO_3$$