

I. The Mole:

The mole is one of the seven SI base units and represents a unit of measurement for "quantity". The mole represents the number of carbon-12 atoms in 12 grams of carbon-12. One mole of carbon-12 contains 6.022×10^{23} atoms of carbon-12.

$$\mathbf{1 \text{ Mole} = 6.022 \times 10^{23}}$$

I.A: Counting by weight. In this exercise we will calculate the number of atoms in a mass of an element, or the mass of an element which will provide a desired number of atoms.

(in class)

1. 2.5 mg Fe = _____ mole Fe

$$2.5 \text{ mg Fe} \left(\frac{g \text{ Fe}}{1000 \text{ mg}} \right) \left(\frac{\text{mol Fe}}{55.85 \text{ g}} \right) = 4.5 \times 10^{-5} \text{ mol Fe}$$

2. 2.5 g Fe = _____ atoms of Fe.

$$2.5 \text{ g Fe} \left(\frac{\text{mol Fe}}{55.85 \text{ g}} \right) \left(\frac{6.022 \times 10^{23} \text{ atoms Fe}}{\text{mol Fe}} \right) = 2.7 \times 10^{22} \text{ atoms Fe}$$

3. What mass of lead has 2.43×10^{18} atoms?

$$2.43 \times 10^{18} \text{ atoms Pb} \left(\frac{\text{mol Pb}}{6.022 \times 10^{23} \text{ atoms Pb}} \right) \left(\frac{207.2 \text{ g Pb}}{\text{mole Pb}} \right) \left(\frac{10^6 \mu\text{g}}{\text{g}} \right) = 836 \mu\text{g Pb}$$

I.B: Calculate the Molar Mass of the following Compounds.

(in class)

1. Barium Chloride BaCl_2

$$137.33 + 2(35.45) = 208.23 \text{ g/mol}$$

2. Glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)

$$6(12.01) + 12(1.01) + 6(16.00) = 180.18 \text{ g/mol}$$

(take home)

3. Aluminum Sulfate

$$\text{Al}_2(\text{SO}_4)_3 = 2(26.98) + 3(32.07) + 12(16.00) = 342.17 \text{ g/mol}$$

4. Lysine (an amino acid, $\text{C}_6\text{H}_{14}\text{N}_2\text{O}_2$)

$$6(12.01) + 14(1.01) + 2(14.01) + 2(16.00) = 146.22 \text{ g/mol}$$

5. Vitamin C (Ascorbic acid, $\text{C}_6\text{H}_8\text{O}_6$)

$$6(12.01) + 8(1.01) + 6(16.00) = 176.14 \text{ g/mol}$$

6. Barium hydroxide

$$\text{Ba(OH)}_2 \quad 137.33 + 2(16.00) + 2(1.01) = 171.35 \text{ g/mol}$$

7. Potassium phosphate

$$\text{K}_3\text{PO}_4 \quad 3(39.10) + 30.97 + 4(16) = 212.27 \text{ g/mol}$$

I.C: Molar Mass Calculations,
(in class)

1. How many moles are in 246.9 g of PCl_3

$$246.9 \text{ g PCl}_3 \left(\frac{\text{mol PCl}_3}{137.32 \text{ g}} \right) = 1.798 \text{ mol}$$

2. How many moles of Mn(OH)_2 are in 1.23×10^4 g of Mn(OH)_2

$$1.23 \times 10^4 \text{ g Mn(OH)}_2 \left(\frac{\text{mol Mn(OH)}_2}{88.96 \text{ g}} \right) = 138 \text{ mol Mn(OH)}_2$$

3. How many atoms (all types) are in 1.23×10^4 g of Mn(OH)_2

$$1.23 \times 10^4 \text{ g Mn(OH)}_2 \left(\frac{\text{mol Mn(OH)}_2}{88.96 \text{ g}} \right) \left(\frac{5 \text{ mol atoms}}{\text{mol Mn(OH)}_2} \right) \left(\frac{6.022 \times 10^{23} \text{ atoms}}{\text{mol atoms}} \right) = 4.16 \times 10^{26} \text{ atoms}$$

4. How many grams are in 32.8 kmol of SF_6

$$32.8 \text{ kmol SF}_6 \left(\frac{1000 \text{ mol SF}_6}{\text{kmol}} \right) \left(\frac{146.07 \text{ g}}{\text{mol SF}_6} \right) = 4.79 \times 10^6 \text{ mol SF}_6$$

(take home)

5. How many moles are in 7.67×10^{-4} g of MnS

$$7.67 \times 10^{-4} \text{ g MnS} \left(\frac{\text{mol Mn(OH)}_2}{87.01 \text{ g}} \right) = 8.82 \times 10^{-6} \text{ mol MnS}$$

6. How many moles are in 246.9 kg of $\text{Cu(NO}_3)_2$

$$246.9 \text{ kg Cu(NO}_3)_2 \left(\frac{1000 \text{ g}}{\text{kg}} \right) \left(\frac{\text{mol Cu(NO}_3)_2}{187.57 \text{ g}} \right) = 1,316 \text{ mol Cu(NO}_3)_2$$

7. How many moles are in 246.9 mg of P_4H_{10}

$$246.9 \text{ mg P}_4\text{H}_{10} \left(\frac{1 \text{ g P}_4\text{H}_{10}}{1000 \text{ mg P}_4\text{H}_{10}} \right) \left(\frac{\text{mol P}_4\text{H}_{10}}{133.88 \text{ g}} \right) = 1.843 \times 10^{-3} \text{ mol P}_4\text{H}_{10}$$

8. How many grams are in 1.376 moles of CuSO_4

$$1.376 \text{ moles CuSO}_4 \left(\frac{159.63 \text{ g CuSO}_4}{1 \text{ mol}} \right) = 219.6 \text{ g CuSO}_4$$

9. How many grams are in 7.67×10^{-4} moles of CuSO_4

$$7.67 \times 10^{-4} \text{ moles CuSO}_4 \left(\frac{159.63 \text{ g CuSO}_4}{1 \text{ mol}} \right) = 0.122 \text{ g CuSO}_4$$

10. How many grams are in 1.67×10^4 moles of CuSO_4

$$1.67 \times 10^4 \text{ moles CuSO}_4 \left(\frac{159.63 \text{ g CuSO}_4}{1 \text{ mol}} \right) = 2.67 \text{ Mg CuSO}_4$$

11. How many molecules of Vitamin C (Ascorbic acid, $\text{C}_6\text{H}_8\text{O}_6$) are in a tablet which contains 500 mg of Vitamin C? Give answer in both the number of moles and the number of molecules

$$500 \text{ mg C}_6\text{H}_8\text{O}_6 \left(\frac{1 \text{ g C}_6\text{H}_8\text{O}_6}{1000 \text{ mg}} \right) \left(\frac{1 \text{ mol C}_6\text{H}_8\text{O}_6}{176.14 \text{ g}} \right) = 3 \times 10^{-3} \text{ moles}$$

$$500 \text{ mg C}_6\text{H}_8\text{O}_6 \left(\frac{1 \text{ g C}_6\text{H}_8\text{O}_6}{1000 \text{ mg}} \right) \left(\frac{1 \text{ mol C}_6\text{H}_8\text{O}_6}{176.14 \text{ g}} \right) \left(\frac{6.022 \times 10^{23} \text{ molecules C}_6\text{H}_8\text{O}_6}{1 \text{ mol C}_6\text{H}_8\text{O}_6} \right) = 2 \times 10^{21} \text{ molecules}$$

II. Determination of the moles of elements in a compound

II.A: (in class)

1. How many moles of hydrogen are in 2.5 moles of ammonium phosphate?

$$2.5 \text{ mol (NH}_4)_3\text{PO}_4 \left(\frac{12 \text{ mol H}}{1 \text{ mol (NH}_4)_3\text{PO}_4} \right) = 30 \text{ mol H}$$

2. How many grams of aluminum are in 2.50 kg of aluminum sulfate?

$$2.5 \text{ kg Al}_2(\text{SO}_4)_3 \left(\frac{1000 \text{ g Al}_2(\text{SO}_4)_3}{1 \text{ kg}} \right) \left(\frac{2 \text{ mol Al}}{1 \text{ mol Al}_2(\text{SO}_4)_3} \right) \left(\frac{26.98 \text{ g Al}}{1 \text{ mol}} \right) = 394 \text{ g Al}$$

3. What mass of carbonic acid has 12.0 g of carbon?

$$12.0 \text{ g C} \left(\frac{1 \text{ mol C}}{12.01 \text{ g}} \right) \left(\frac{1 \text{ mol H}_2\text{CO}_3}{1 \text{ mol C}} \right) \left(\frac{62.03 \text{ g H}_2\text{CO}_3}{1 \text{ mol}} \right) = 62.0 \text{ g H}_2\text{CO}_3$$

4. How many moles of sulfur are in 1.45kg of chromium(VI)sulfate?

$$1.45\text{kg Cr}(\text{SO}_4)_3 \left(\frac{1000\text{g}}{\text{kg}} \right) \left(\frac{\text{mol Cr}(\text{SO}_4)_3}{340.21\text{g}} \right) \left(\frac{3\text{mol S}}{\text{mol Cr}(\text{SO}_4)_3} \right) = 12.8\text{mole S}$$

5. How many grams of barium are in 2.50 kg of barium hydroxide?

$$2.50\text{kg Ba}(\text{OH})_2 \left(\frac{1000\text{g}}{\text{kg}} \right) \left(\frac{\text{mol Ba}(\text{OH})_2}{171.35\text{g}} \right) \left(\frac{1\text{mol Ba}}{\text{mol Ba}(\text{OH})_2} \right) \left(\frac{137\text{gBa}}{\text{mol}} \right) = 2.00\text{kg Ba}$$

6. How many grams of oxygen are in 2.50 kg of barium hydroxide?

$$2.50\text{kg Ba}(\text{OH})_2 \left(\frac{1000\text{g}}{\text{kg}} \right) \left(\frac{\text{mol Ba}(\text{OH})_2}{171.35\text{g}} \right) \left(\frac{2\text{mol O}}{\text{mol Ba}(\text{OH})_2} \right) \left(\frac{16.00\text{gO}}{\text{mol}} \right) = 467\text{g O}$$

7. How many grams of hydrogen are in 2.50 kg of barium hydroxide?

$$2.50\text{kg Ba}(\text{OH})_2 \left(\frac{1000\text{g}}{\text{kg}} \right) \left(\frac{\text{mol Ba}(\text{OH})_2}{171.35\text{g}} \right) \left(\frac{2\text{mol H}}{\text{mol Ba}(\text{OH})_2} \right) \left(\frac{1.01\text{gH}}{\text{mol}} \right) = 29.5\text{g H}$$

8. What mass of silver carbonate has 52.0 g of silver?

$$52.0\text{g Ag} \left(\frac{\text{mol Ag}}{107.87\text{g}} \right) \left(\frac{\text{mol Ag}_2\text{CO}_3}{2\text{mol Ag}} \right) \left(\frac{\text{g } 275.75\text{ Ag}_2\text{CO}_3}{\text{mol}} \right) = 66.5\text{g Ag}_2\text{CO}_3$$

9. What mass of silver carbonate has 52.0 g of carbon?

$$52.0\text{g C} \left(\frac{\text{mol C}}{12.01\text{g}} \right) \left(\frac{\text{mol Ag}_2\text{CO}_3}{1\text{mol C}} \right) \left(\frac{\text{g } 275.75\text{ Ag}_2\text{CO}_3}{\text{mol}} \right) = 1.19\text{kg Ag}_2\text{CO}_3$$

10. What mass of silver carbonate has 52.0 g of oxygen?

$$52.0\text{g O} \left(\frac{\text{mol O}}{16.00\text{g}} \right) \left(\frac{\text{mol Ag}_2\text{CO}_3}{3\text{mol O}} \right) \left(\frac{\text{g } 275.75\text{ Ag}_2\text{CO}_3}{\text{mol}} \right) = 299\text{g Ag}_2\text{CO}_3$$

Fractions and Percentages:

The fraction of one part in a system with more than one part is that part divided by the whole. When we look at compound formula we can express the fraction of one element in one of two ways, either the number of particles or the masses of those particles. Chemists typically use mole fractions to describe the former and mass percentages to describe the later.

Note: Neither the mass percent or the mole fraction depend on the quantity of matter you have. If you are not given a quantity, choose one mole (as the math is easiest)

IIB: Give the mole fraction of each element in the following compounds.1. mercury(II)sulfide: HgS

$$\text{Hg} = 1/2 = 0.5$$

$$\text{S} = 1/2 = 0.5$$

2. IF_7

$$\text{I} = 1/8 = 0.125$$

$$\text{F} = 7/8 = 0.875$$

3. copper(II) nitrate: $\text{Cu}(\text{NO}_3)_2$

$$\text{Cu} = 1/9 = 0.111$$

$$\text{N} = 2/9 = 0.2222$$

$$\text{O} = 6/9 = 6.667$$

4. ammonium phosphate: $(\text{NH}_4)_3\text{PO}_4$

$$\text{N} = 3/20 = 0.15$$

$$\text{H} = 12/20 = 0.6$$

$$\text{P} = 1/20 = 0.05$$

$$\text{O} = 4/20 = 0.2$$

(take home)

5. titanium(II) hydroxide $\text{Ti}(\text{OH})_2$

$$\text{Ti} = 1/5 = 0.2$$

$$\text{O} = 2/5 = 0.4$$

$$\text{H} = 2/5 = 0.4$$

6. chromium(III) nitrite $\text{Cr}(\text{NO}_2)_3$

$$\text{Cr} = 1/10 = 0.10$$

$$\text{N} = 3/10 = 0.30$$

$$\text{O} = 6/10 = 0.60$$

7. vanadium(V) phosphate $\text{V}_3(\text{PO}_4)_5$

$$\text{V} = 3/28 = 0.107$$

$$\text{P} = 5/28 = 0.179$$

$$\text{O} = 20/28 = 0.714$$

8. molybdenum(V) sulfite $\text{Mo}_2(\text{SO}_3)_5$

$$\text{Mo} = 2/22 = 0.0909$$

$$\text{S} = 5/22 = 0.227$$

$$\text{O} = 15/22 = 0.682$$

9. iron(II) phosphite $\text{Fe}_3(\text{PO}_3)_2$

$$\text{Fe} = 3/11 = 0.2727$$

$$\text{P} = 2/11 = 0.1818$$

$$\text{O} = 6/11 = 0.54547$$

10. Iron(II) sulfate: FeSO_4

$$\text{Fe} = 1/6 = 0.167$$

$$\text{S} = 1/6 = 0.167$$

$$\text{O} = 0.6667$$

IIC: Give the mass percent of each element in the following compounds.

(in class)

1. mercury(II)sulfide

$$\text{HgS} \Rightarrow 1(200.59) + 1(32.07) = 232.66 \text{ g/mol}$$

$$\% \text{H} = \frac{200.59}{232.66}(100) = 86.22\%, \quad \% \text{S} = \frac{32.07}{232.66}(100) = 13.78\%$$

2. IF_7

$$\text{IF}_7 \Rightarrow 1(126.90) + 7(19.00) = 126.90 + 133.0 = 259.99 \text{ g/mol}$$

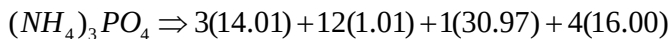
$$\% \text{I} = \frac{126.90}{259.99}(100) = 48.81\%, \quad \% \text{F} = \frac{133.0}{259.99}(100) = 51.16\%$$

3. copper(II) nitrate

$$\text{Cu}(\text{NO}_3)_2 \Rightarrow 1(63.55) + 2(14.01) + 6(16.00) = 63.55 + 28.02 + 96.00 = 187.57 \text{ g/mol}$$

$$\% \text{Cu} = \frac{63.55}{187.57}(100) = 33.88\%, \quad \% \text{N} = \frac{28.02}{187.57}(100) = 14.94\% \quad \% \text{O} = \frac{96.00}{187.57}(100) = 51.18\%$$

4. ammonium phosphate



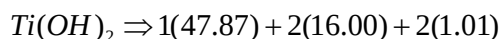
$$= 42.03 + 12.12 + 30.97 + 64.00 = 149.42 \text{ g/mol}$$

$$\%N = \frac{42.03}{149.42}(100) = 28.13\%, \quad \%H = \frac{12.12}{149.42}(100) = 8.111\%$$

$$\%P = \frac{30.97}{149.42}(100) = 20.73\% \quad \%O = \frac{64.00}{149.42}(100) = 42.83\%$$

(take home)

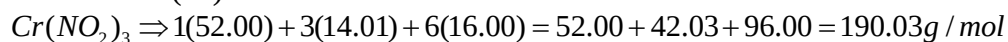
5. titanium(II) hydroxide



$$= 47.87 + 32.00 + 2.02 = 81.89 \text{ g/mol}$$

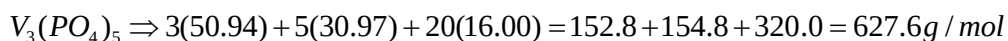
$$\%Ti = \frac{47.87}{81.89}(100) = 58.46\%, \quad \%O = \frac{32.00}{81.89}(100) = 39.08\% \quad \%H = \frac{2.02}{81.89}(100) = 2.467\%$$

6. chromium(III) nitrite



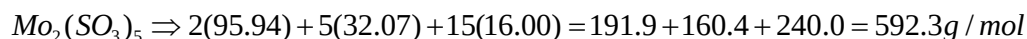
$$\%Cr = \frac{52.00}{190.03}(100) = 27.36\%, \quad \%N = \frac{42.03}{190.03}(100) = 22.18\% \quad \%O = \frac{96.00}{190.03}(100) = 50.52\%$$

7. vanadium(V) phosphate



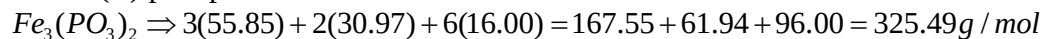
$$\%Cr = \frac{152.8}{627.6}(100) = 24.35\%, \quad \%N = \frac{154.8}{627.6}(100) = 24.67\% \quad \%O = \frac{320.0}{627.6}(100) = 50.99\%$$

8. molybdenum(V) sulfite



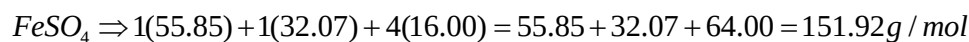
$$\%Mo = \frac{191.9}{592.3}(100) = 32.40\%, \quad \%S = \frac{160.4}{592.3}(100) = 27.08\% \quad \%O = \frac{240.0}{592.3}(100) = 40.52\%$$

9. iron(II) phosphite



$$\%Fe = \frac{167.55}{325.49}(100) = 51.48\%, \quad \%P = \frac{61.94}{325.49}(100) = 19.03\% \quad \%O = \frac{96.00}{325.49}(100) = 29.49\%$$

10. Iron(II) sulfate



$$\%Fe = \frac{55.85}{151.92}(100) = 36.76\%, \quad \%P = \frac{32.07}{151.92}(100) = 21.10\% \quad \%O = \frac{64.00}{151.92}(100) = 42.13\%$$