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 x 10^{23} atoms of carbon-12.

1 Mole = 6.022×10^{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

$$2.5 mg Fe\left(\frac{g\,Fe}{1000 mg}\right)\left(\frac{mol\,Fe}{55.85 g}\right) = 4.5x10^{-5} mol\,Fe$$

2. 2.5 g Fe = _____ atoms of Fe.

$$2.5 g Fe\left(\frac{mol\,Fe}{55.85 g}\right)\left(\frac{6.022x10^{23} atoms\,Fe}{mol\,Fe}\right) = 2.7x10^{22} atoms\,Fe$$

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

$$2.43x10^{18} atoms Pb\left(\frac{mol\,Pb}{6.022x10^{23} atoms\,Pb}\right)\left(\frac{207.2 g\,Pb}{mole Pb}\right)\left(\frac{10^6\,\mu g}{g}\right) = 836\mu g\,Pb$$

I.B: Calculate the Molar Mass of the following Compounds.
(in class)

1. Barium Chloride $BaCl_2$
137.33 + 2(35.45) = 208.23 g/mol

2. Glucose ($C_6H_{12}O_6$)
6(12.01) + 12(1.01) + 6(16.00) = 180.18 g/mol
(take home)

3. Aluminum Sulfate
$Al_2(SO_4)_3$ = 2(26.98) + 3(32.07) + 12(16.00) = 342.17 g/mol

4. Lysine (an amino acid, $C_6H_{14}N_2O_2$)
6(12.01) + 14(1.01) + 2(14.01) +2(16.00) = 146.22 g/mol

5. Vitamin C (Ascorbic acid, $C_6H_8O_6$)
6(12.01) + 8(1.01) + 6(16.00) = 176.14 g/mol

6. Barium hydroxide
$Ba(OH)_2$ 137.33 + 2(16.00) + 2(1.01) = 171.35 g/mol

7. Potassium phosphate
K_3PO_4 3(39.10) + 30.97 + 4(16) = 212.27 g/mol

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

1. How many moles are in 246.9 g of PCl_3

$$246.9g\ PCl_3\left(\frac{mol\ PCl_3}{137.32\,g}\right)=1.798mol$$

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

$$1.23x10^4\,g\ Mn(OH)_2\left(\frac{mol\ Mn(OH)_2}{88.96\,g}\right)=138\,mol\ Mn(OH)_2$$

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

$$1.23x10^4\,g\ Mn(OH)_2\left(\frac{mol\ Mn(OH)_2}{88.96\,g}\right)\left(\frac{5\,mol\ atoms}{mol\ Mn(OH)_2}\right)\left(\frac{6.022x10^{23}atoms}{mol\ atoms}\right)=4.16x10^{26}atoms$$

4. How many grams are in32.8 kmoles of SF_6

$$32.8kmol\ SF_6\left(\frac{1000\,mol\ SF_6}{kmol}\right)\left(\frac{146.07g}{mol\ SF_6}\right)=4.79x10^6\ mol\ SF_6$$

(take home)

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

$$7.67x10^{-4}\,g\ MnS\left(\frac{mol\ Mn(OH)_2}{87.01g}\right)=8.82x10^{-6}\ mol\ MnS$$

6. How many moles are in 246.9 kg of $Cu(NO_3)_2$

$$246.9kg\ Cu(NO_3)_2\left(\frac{1000g}{kg}\right)\left(\frac{mol\,Cu(NO_3)_2}{187.57\,g}\right)=1,316\,mol\,Cu(NO_3)_2$$

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

$$246.9mg\ P_4H_{10}\left(\frac{1g\ P_4H_{10}}{1000mg\ P_4H_{10}}\right)\left(\frac{mol\ P_4H_{10}}{133.88\,g}\right)=1.843\,x10^{-3}\ mol\ P_4H_{10}$$

8. How many grams are in 1.376 moles of $CuSO_4$

$$1.376 moles\, CuSO_4 \left(\frac{159.63 g\, CuSO}{1 mol} \right) = 219.6\, g\, CuSO$$

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

$$7.67 x10^{-4}\, moles\, CuSO_4 \left(\frac{159.63 g\, CuSO_4}{1 mol} \right) = 0.122\, g\, CuSO_4$$

10. How many grams are in1.67 x 10^4 moles of $CuSO_4$

$$1.67 x10^{4}\, moles\, CuSO_4 \left(\frac{159.63 g\, CuSO_4}{1 mol} \right) = 2.67\, Mg\, CuSO_4$$

11. How many molecules of Vitamin C (Ascorbic acid, $C_6H_8O_6$) are in a tablet which contains 500 mg of Vitamin C? Give answer in both the number of moles and the number of molecules

$$500 mg\, C_6H_8O_6 \left(\frac{g\, C_6H_8O_6}{1000 mg} \right) \left(\frac{mol\, C_6H_8O_6}{176.14 g} \right) = 3x10^{-3} moles$$

$$500 mg\, C_6H_8O_6 \left(\frac{g\, C_6H_8O_6}{1000 mg} \right) \left(\frac{mol\, C_6H_8O_6}{176.14 g} \right) \left(\frac{6.022 x10^{23}\, C_6H_8O_6}{mol\, C_6H_8O_6} \right) = 2x10^{21} molecules$$

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?

$$2.5 mol\, (NH_4)_3PO_4 \left(\frac{12\, mol\, H}{mol\, (NH_4)_3PO_4} \right) = 30 mol\, H$$

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

$$2.5 kg\, Al_2(SO_4)_3 \left(\frac{1000 g\, Al_2(SO_4)_3}{kg} \right) \left(\frac{mol\, Al_2(SO_4)_3}{342.17 g} \right) \left(\frac{2 mol\, Al}{mol\, Al_2(SO_4)_3} \right) \left(\frac{26.98 gAl}{mol} \right) = 394 g\, Al$$

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

$$12.0 gC \left(\frac{mol\, C}{12.01 g} \right) \left(\frac{mol\, H_2CO_3}{mol\, C} \right) \left(\frac{62.03 gH_2CO_3}{mol} \right) = 62.0 g\, H_2CO_3$$

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

$$1.45kg\ Cr(SO_4)_3\left(\frac{1000g}{kg}\right)\left(\frac{mol\ Cr(SO_4)_3}{340.21g}\right)\left(\frac{3mol\ S}{mol\ Cr(SO_4)_3}\right)=12.8mole\ S$$

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

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

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

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

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

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

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

$$52.0g\ Ag\left(\frac{mol\ Ag}{107.87g}\right)\left(\frac{mol\ Ag_2CO_3}{2mol\ Ag}\right)\left(\frac{g275.75\ Ag_2CO_3}{mol}\right)=66.5g\ Ag_2CO_3$$

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

$$52.0g\ C\left(\frac{mol\ C}{12.01g}\right)\left(\frac{mol\ Ag_2CO_3}{1mol\ C}\right)\left(\frac{g275.75\ Ag_2CO_3}{mol}\right)=1.19kg\ Ag_2CO_3$$

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

$$52.0g\ O\left(\frac{mol\ O}{16.00g}\right)\left(\frac{mol\ Ag_2CO_3}{3mol\ O}\right)\left(\frac{g275.75\ Ag_2CO_3}{mol}\right)=299g\ Ag_2CO_3$$

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
Hg =1/2= 0.5
S=1/2=0.5

2. IF_7
I= 1/8=0.125
F=7/8=0.875

3. copper(II) nitrate: $Cu(NO_3)_2$
Cu = 1/9=0.111
N=2/9=0.2222
O=6/9=6.667

4. ammonium phosphate: $(NH_4)_3PO_4$
N=3/20=0.15
H=12/20=0.6
P = 1/20=0.5
O=4/20=0.2

(take home)

5. titanium(II) hydroxide $Ti(OH)_2$
Ti=1/5=0.2
O = 2/5 = 0.4
H = 2/5 = 0.4

6. chromium(III) nitrite $Cr(NO_2)_3$
Cr = 1/10 = 0.10
N = 3/10 = 0.30
O = 6/10 = 0.60

7. vanadium(V) phosphate $V_3(PO_4)_5$
V = 3/28 = 0.107
P = 5/28 = 0.179
O = 20/28 = 0.714

8. molybdenum(V) sulfite $Mo_2(SO_3)_5$
Mo = 2/22 = 0.0909
S = 5/22 = 0.227
O = 15/22 = 0.682

9. iron(II) phosphite $Fe_3(PO_3)_2$
Fe = 3/11 = 0.2727
P = 2/11 = 0.1818
O = 6/11 = 0.54547

10. Iron(II) sulfate: $FeSO_4$
Fe = 1/6 = 0.167
S = 1/6 = 0.167
O = 0.6667

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

1. mercury(II)sulfide

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

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

2. IF_7

$$IF_7 \Rightarrow 1(126.90)+7(19.00)=126.90+133.0=259.99 g/mol$$

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

3. copper(II) nitrate

$$Cu(NO_3)_2 \Rightarrow 1(63.55)+2(14.01)+6(16.00)=63.55+28.02+96.00=187.57 g/mol$$

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

4. ammonium phosphate

$$(NH_4)_3PO_4 \Rightarrow 3(14.01)+12(1.01)+1(30.97)+4(16.00)$$
$$= 42.03+12.12+30.97+64.00 = 149.42\,g/mol$$
$$\%N = \frac{42.03}{149.42}(100) = 28.13\%, \quad \%H = \frac{12.12}{149.42}(100) = 8.111\%$$
$$\%P = \frac{30.97}{149.42}(100) = 20.73\% \quad \%O = \frac{64.00}{149.42}(100) = 42.83\%$$

(take home)

5. titanium(II) hydroxide

$$Ti(OH)_2 \Rightarrow 1(47.87)+2(16.00)+2(1.01)$$
$$= 47.87+32.00+2.02 = 81.89\,g/mol$$
$$\%Ti = \frac{47.87}{81.89}(100) = 58.46\%, \quad \%O = \frac{32.00}{81.89}(100) = 39.08\% \quad \%H = \frac{2.02}{81.89}(100) = 2.467\%$$

6. chromium(III) nitrite

$$Cr(NO_2)_3 \Rightarrow 1(52.00)+3(14.01)+6(16.00) = 52.00+42.03+96.00 = 190.03\,g/mol$$
$$\%Cr = \frac{52.00}{190.03}(100) = 27.36\%, \quad \%N = \frac{42.03}{190.03}(100) = 22.18\% \quad \%O = \frac{96.00}{190.03}(100) = 50.52\%$$

7. vanadium(V) phosphate

$$V_3(PO_4)_5 \Rightarrow 3(50.94)+5(30.97)+20(16.00) = 152.8+154.8+320.0 = 627.6\,g/mol$$
$$\%Cr = \frac{152.8}{627.6}(100) = 24.35\%, \quad \%N = \frac{154.8}{627.6}(100) = 24.67\% \quad \%O = \frac{320.0}{627.6}(100) = 50.99\%$$

8. molybdenum(V) sulfite

$$Mo_2(SO_3)_5 \Rightarrow 2(95.94)+5(32.07)+15(16.00) = 191.9+160.4+240.0 = 592.3\,g/mol$$
$$\%Mo = \frac{191.9}{592.3}(100) = 32.40\%, \quad \%S = \frac{160.4}{592.3}(100) = 27.08\% \quad \%O = \frac{240.0}{592.3}(100) = 40.52\%$$

9. iron(II) phosphite

$$Fe_3(PO_3)_2 \Rightarrow 3(55.85)+2(30.97)+6(16.00) = 167.55+61.94+96.00 = 325.49\,g/mol$$
$$\%Fe = \frac{167.55}{325.49}(100) = 51.48\%, \quad \%P = \frac{61.94}{325.49}(100) = 19.03\% \quad \%O = \frac{96.00}{325.49}(100) = 29.49\%$$

10. Iron(II) sulfate

$$FeSO_4 \Rightarrow 1(55.85)+1(32.07)+4(16.00) = 55.85+32.07+64.00 = 151.92\,g/mol$$
$$\%Fe = \frac{55.85}{151.92}(100) = 36.76\%, \quad \%P = \frac{32.07}{151.92}(100) = 21.10\% \quad \%O = \frac{64.00}{151.92}(100) = 42.13\%$$