1) A sample of element X weighing 156.0 mg combines completely with silicon, forming 268.3 mg of pure X_3Si_4. What is the identity of X?

Finding the identity of X can be done by finding the molar mass of X and then looking at the periodic table. So, we need to find moles of X and grams of X. We are given grams of X, so REALLY we are looking for moles of X! We also know the molar ration of X to Si, so if we can find out how much Si there is, we will know the number of moles of X.

$$268.3mg\ \mathrm{X_3Si_4} - 156.0mg\ \mathrm{X} = 112.3mg\ \mathrm{Si}$$

$$112.3mg\ \mathrm{Si} \times \frac{10^{-3} g\ \mathrm{Si}}{1mg\ \mathrm{Si}} \times \frac{1mol\ \mathrm{Si}}{28.0855g\ \mathrm{Si}} \times \frac{3mol\ \mathrm{X}}{4mol\ \mathrm{Si}} = 0.002999mol\ \mathrm{X}$$

$$\mathrm{M.M.} = \frac{g\ \mathrm{X}}{mol\ \mathrm{X}} = \frac{.1560g\ \mathrm{X}}{0.002999mol\ \mathrm{X}} = 52.02\, {}^{g}\!/_{mol} \Rightarrow \mathbf{Cr}$$

2) A 257.0 mg sample of a hydrocarbon C_xH_y gave, on complete combustion in oxygen, 880.2 mg of carbon dioxide and 151.1 mg if water. What is the empirical formula?

Empirical formulae are found by finding the whole number ratios of the elements in the compound. That means the number of moles of each element need to be found (in this case moles of carbon and moles of hydrogen). The only information we are given are masses of CO_2 and H_2O. Think about combustion reactions. Where does all of the carbon in CO_2 come from? What about all of the hydrogen in H_2O? Does this hold for oxygen?

$$880.2mg\ \mathrm{CO_2} \times \frac{10^{-3} g\ \mathrm{CO_2}}{1mg\ \mathrm{CO_2}} \times \frac{1mol\ \mathrm{CO_2}}{44.01g\ \mathrm{CO_2}} \times \frac{1mol\ \mathrm{C}}{1mol\ \mathrm{CO_2}} = 0.02000mol\ \mathrm{C}$$

$$151.1mg\ \mathrm{H_2O} \times \frac{10^{-3} g\ \mathrm{H_2O}}{1mg\ \mathrm{H_2O}} \times \frac{1mol\ \mathrm{H_2O}}{18.02g\ \mathrm{H_2O}} \times \frac{2mol\ \mathrm{H}}{1mol\ \mathrm{H_2O}} = 0.01677mol\ \mathrm{H}$$

$$\mathrm{C} = \frac{0.02000mol\ \mathrm{C}}{0.01677mol\ \mathrm{H}} \approx 1.2 \times 5 = 6$$

$$\mathrm{H} = \frac{0.01677mol\ \mathrm{H}}{0.01677mol\ \mathrm{H}} = 1 \times 5 = 5$$

E.F. = $\mathbf{C_6H_5}$

3) What mass of solid will result if 23.9 mL of a 0.324 M barium chloride solution is mixed with 45.3 mL of a 0.153 M potassium chromate solution?

Remember, when you see M, change it to $\frac{mol}{1L}$. You are going to need a balanced chemical equation because you are given information about one compound and asked for information about another. In addition, you are given information about 2 different starting materials, which makes this a limiting reagent problem!

$BaCl_{2(aq)} + K_2CrO_{4(aq)} \rightarrow 2KCl_{(aq)} + BaCrO_{4(s)}$

$$23.9mL\ \mathrm{BaCl_2} \times \frac{10^{-3} L\ \mathrm{BaCl_2}}{1mL\ \mathrm{BaCl_2}} \times \frac{0.324mol\ \mathrm{BaCl_2}}{1L\ \mathrm{BaCl_2}} \times \frac{1mol\ \mathrm{BaCrO_4}}{1mol\ \mathrm{BaCl_2}} \times \frac{253.32g\ \mathrm{BaCrO_4}}{1mol\ \mathrm{BaCrO_4}} = 1.96g\ \mathrm{BaCrO_4}$$

$$45.3mL\ \mathrm{K_2CrO_4} \times \frac{10^{-3} L\ \mathrm{K_2CrO_4}}{1mL\ \mathrm{K_2CrO_4}} \times \frac{0.153mol\ \mathrm{K_2CrO_4}}{1L\ \mathrm{K_2CrO_4}} \times \frac{1mol\ \mathrm{BaCrO_4}}{1mol\ \mathrm{K_2CrO_4}} \times \frac{253.32g\ \mathrm{BaCrO_4}}{1mol\ \mathrm{BaCrO_4}} = 1.76g\ \mathrm{BaCrO_4}$$

So, **1.76g $BaCrO_4$** can be made.

4) Lead (II) nitrate reacts with sodium iodide in a double replacement reaction to produce a precipitate. How many mL of 0.342 M lead (II) nitrate are necessary to precipitate all of the iodide in 34.5 mL of a 0.656 M sodium iodide solution?

This is another molarity question, so change the units! You are going to need a balanced chemical equation because you are given information about one compound and asked for information about another. You are given info about only one starting material, so this is NOT a L.R. problem.

$Pb(NO_3)_{2(aq)} + 2NaI_{(aq)} \rightarrow PbI_{2(s)} + 2NaNO_{3(aq)}$

$$34.5mL\ \mathrm{NaI} \times \frac{0.656mol\ \mathrm{NaI}}{1000mL\ \mathrm{NaI}} \times \frac{1mol\ \mathrm{Pb(NO_3)_2}}{1mol\ \mathrm{NaI}} \times \frac{1000mL\ \mathrm{Pb(NO_3)_2}}{0.342mol\ \mathrm{Pb(NO_3)_2}} = 33.1mL\ \mathrm{Pb(NO_3)_2}$$

5) A compound Y contains 2.98 g of carbon per gram of hydrogen, what is the empirical formula of Y?

E.F. is based on the molar ratio of the elements in the compound. The question gives the MASS ratio, which cannot be used to fin the E.F. How do we change mass to moles?

$$\frac{2.98g\ \mathrm{C}}{1.00g\ \mathrm{H}} \times \frac{1mol\ \mathrm{C}}{12.01g\ \mathrm{C}} \times \frac{1.01g\ \mathrm{H}}{1mol\ \mathrm{H}} = \frac{.251mol\ \mathrm{C}}{1mol\ \mathrm{H}} \Rightarrow \mathbf{CH_4}$$

6) A compound containing only a metal and oxygen, MO, can be decomposed to the elements (M and O_2) by heating. If 4.386 g of the compound forms 4.063 g M on heating, what is the atomic weight of M? What is the probable identity of M?

We are asked for atomic weight, which has units of $\frac{g\ \mathrm{M}}{mol\ \mathrm{M}}$. The question gives us the mass of M, so really we are simply looking for moles of M. We also know the molar ration of M to O, so if we can find out how much O there is, we will know the number of moles of M.

$$4.386g\ \mathrm{MO} - 4.063g\ \mathrm{M} = 0.323g\ \mathrm{O}$$

$$0.323g\ \mathrm{O} \times \frac{1mol\ \mathrm{O}}{16.00g\ \mathrm{O}} \times \frac{1mol\ \mathrm{M}}{1mol\ \mathrm{O}} = 0.02019mol\ \mathrm{M}$$

$$\mathrm{M.M.} = \frac{g\ \mathrm{M}}{mol\ \mathrm{M}} = \frac{4.063g\ \mathrm{M}}{0.02019mol\ \mathrm{M}} = 201.26\,{}^{g}\!/_{mol} \Rightarrow \mathbf{Hg}$$

7) A 0.00340 mol sample of a compound, X_2O_3, has a mass of 1584 mg. What is the atomic mass of X?

We are asked for atomic weight, which has units of $\frac{g\ \mathrm{X}}{mol\ \mathrm{X}}$. We are given mass AND moles of X_2O_3, so we know the molar mass of that:

$$\mathrm{M.M.} = \frac{g\ \mathrm{X_2O_3}}{mol\ \mathrm{X_2O_3}} = \frac{1.584g\ \mathrm{X_2O_3}}{0.00.00340mol\ \mathrm{X_2O_3}} = 465.88\,{}^{g}\!/_{mol}\ \mathrm{X_2O_3}$$

We also know that there are 3 mol O for every mole of X_2O_3, so:

$$1mol\ \mathrm{X_2O_3} \times \frac{465.88g\ \mathrm{X_2O_3}}{1mol\ \mathrm{X_2O_3}} - 3mol\ \mathrm{O} \times \frac{16.00g\ \mathrm{O}}{1mol\ \mathrm{O}} = 417.88g\ \mathrm{X}$$

$$\frac{417.88g\ \mathrm{X}}{2mol\ X} = 208.94\,{}^{g}\!/_{mol} \Rightarrow \mathbf{Bi}$$

8) Hemoglobin is 0.342 % Fe by mass, and each hemoglobin molecule contains four iron atoms. Calculate the molar mass of hemoglobin.

This is a mass percent question, so keep in mind the general equation for percent composition. Also remember that if there are 4 atoms of Fe per molecule of hemoglobin, then there are 4 moles of Fe per mole of hemoglobin.

$$\frac{\text{mass of Fe}}{\text{molar mass hemoglobin}} \times 100 = \%\mathrm{Fe}$$

$$\frac{4mol\ \mathrm{Fe} \times \frac{55.845g\ \mathrm{Fe}}{1mol\ \mathrm{Fe}}}{\text{molar mass hemoglobin}} \times 100 = 0.342\%$$

$$\text{molar mass hemoglobin} = 6.53 \times 10^4\ {}^{g}\!/_{mol}$$

9) **Oxygen masks for producing O_2 in emergency situations contain potassium superoxide (KO_2). It reacts according to this equation:**

$4KO_2 + 2H_2O + 4CO_2 \rightarrow 4KHCO_3 + 3O_2$

(A) If a person wearing such a mask exhales 0.85 g of CO_2 every minute, how many moles of KO_2 are consumed in 10.0 minutes?

$$10.0\,\text{min} \times \frac{0.85g\ \text{CO}_2}{1.00\ \text{min}} \times \frac{1mol\ \text{CO}_2}{44.01g\ \text{CO}_2} \times \frac{1mol\ \text{KO}_2}{1mol\ \text{CO}_2} = 0.193mol\ \text{KO}_2$$

(B) How many grams of oxygen are produced in 1.0 hour?

$$\frac{0.85g\ \text{CO}_2}{1\text{min}} \times \frac{1mol\ \text{CO}_2}{44.01g\ \text{CO}_2} \times \frac{3mol\ \text{O}_2}{4mol\ \text{CO}_2} \times \frac{32.00g\ \text{O}_2}{1mol\ \text{O}_2} \times \frac{60\,\text{min}}{1hr} = 28g\ \text{O}_2$$

10) **An unknown compound has the formula $C_xH_yO_z$. You burn 0.1523 g of the compound and isolate 0.3718 g of CO_2 and 0.1522 g of H_2O. What is the empirical formula? If the molar mass is 72.1 g/mol, what is the molecular formula?**
First thing to see is that the compound is made up of carbon, hydrogen, and oxygen. We can get the moles of the carbon and hydrogen from the CO_2 and H_2O respectively. How do we get the moles of oxygen? Think: you are given the mass of the compound, and if you know the mass of C and H, then you can find the mass of O by subtraction. After that, it is just an E.F. question!

$$0.3718g\ \text{CO}_2 \times \frac{1mol\ \text{CO}_2}{44.01g\ \text{CO}_2} \times \frac{1mol\ \text{C}}{1mol\ \text{CO}_2} = 0.008448mol\ \text{C} \times \frac{12.01g\ \text{C}}{1mol\ \text{C}} = 0.10146g\ \text{C}$$

$$0.1527g\ \text{H}_2\text{O} \times \frac{1mol\ \text{H}_2\text{O}}{18.02g\ \text{H}_2\text{O}} \times \frac{2mol\ \text{H}}{1mol\ \text{H}_2\text{O}} = 0.01699mol\ \text{H} \times \frac{1.01g\ \text{H}}{1mol\ \text{H}} = 0.01706g\ \text{H}$$

$$0.1523g\ \text{compound - } 0.1014g\ \text{C - } 0.01706g\ \text{H} = 0.0338g\ \text{O}$$

$$0.0338g\ \text{O} \times \frac{1mol\ \text{O}}{16.00g\ \text{O}} = 0.002111mol\ \text{O}$$

$$\text{C} = \frac{0.008448mol\ \text{C}}{0.002111mol\ \text{O}} = 4 \qquad \text{H} = \frac{0.01699mol\ \text{H}}{0.002111mol\ \text{O}} = 8 \qquad \text{O} = \frac{0.002111mol\ \text{O}}{0.002111mol\ \text{O}} = 1$$

E.F. = C_4H_8O The empirical formula mass is the same as the molar mass, this is also the molecular formula!

11) **Phosphoric acid can be synthesized from phosphorus, oxygen, and water according to these two reactions:**

$4P + 5O_2 \rightarrow P_4O_{10}$
$P_4O_{10} + 6H_2O \rightarrow 4\ H_3PO_4$

Starting with 20.0 g P, 30.0 g O_2, and 15.0 g H_2O, what is the mass of phosphoric acid that can be formed?
Not only is this a L.R. problem, but it is two successive ones. You are asked how much H_3PO_4 you can make, but you have to find out how much P_4O_{10} you have to work with, and to know that, you have to find out how much you can make from the first reaction.

$$20.0g\ \text{P} \times \frac{1mol\ \text{P}}{30.9738g\ \text{P}} \times \frac{1mol\ \text{P}_4\text{O}_{10}}{4mol\ \text{P}} = 0.1614mol\ \text{P}_4\text{O}_{10}$$

$$30.0g\ \text{O}_2 \times \frac{1mol\ \text{O}_2}{32.00g\ \text{O}_2} \times \frac{1mol\ \text{P}_4\text{O}_{10}}{5mol\ \text{O}_2} = 0.1875mol\ \text{P}_4\text{O}_{10}$$

Now use 0.1614 mol P_4O_{10} and 15.0 g H_2O to determine how much H_3PO_4 you can make.

$$0.1614mol\ \text{P}_4\text{O}_{10} \times \frac{4mol\ \text{H}_3\text{PO}_4}{1mol\ \text{P}_4\text{O}_{10}} \times \frac{98.004g\ \text{H}_3\text{PO}_4}{1mol\ \text{H}_3\text{PO}_4} = 63.28g\ \text{H}_3\text{PO}_4$$

$$15.0g\ \text{H}_2\text{O} \times \frac{1mol\ \text{H}_2\text{O}}{18.02g\ \text{H}_2\text{O}} \times \frac{2mol\ \text{H}_3\text{PO}_4}{3mol\ \text{H}_2\text{O}} \times \frac{98.004g\ \text{H}_3\text{PO}_4}{1mol\ \text{H}_3\text{PO}_4} = 54.4g\ \text{H}_3\text{PO}_4$$

So, 54.4g H_3PO_4 can be made.

12) Nickel forms a compound with carbon monoxide, $Ni_x(CO)_y$. To determine its formula, you carefully heat a 0.0973 g sample in air to convert the nickel to 0.0426 g of NiO and the CO to 0.100 g of CO_2. What is the empirical formula?

This is similar to previous problems. All of the nickel ends up as NiO, and all the CO ends up in CO_2. Use this information to find the moles of Ni and CO and then use that information to find the E.F.

$$0.0426g\ \mathrm{NiO}\times\frac{1mol\ \mathrm{NiO}}{74.6928g\ \mathrm{NiO}}\times\frac{1mol\ \mathrm{Ni}}{1mol\ \mathrm{NiO}}=5.70\times10^{-4}mol\ \mathrm{Ni}$$

$$0.100g\ \mathrm{CO_2}\times\frac{1mol\ \mathrm{CO_2}}{44.01g\ \mathrm{CO_2}}\times\frac{1mol\ \mathrm{C}}{1mol\ \mathrm{CO_2}}\times\frac{1mol\ \mathrm{CO}}{1mol\ \mathrm{C}}=2.27\times10^{-3}mol\ \mathrm{CO}$$

$$\mathrm{Ni}=\frac{5.70\times10^{-4}mol\ \mathrm{Ni}}{5.70\times10^{-4}mol\ \mathrm{Ni}}=1 \qquad \mathrm{Ni}=\frac{2.27\times10^{-3}mol\ \mathrm{CO}}{5.70\times10^{-4}mol\ \mathrm{Ni}}=4$$

E.F. = $Ni(CO)_4$

13) To find the formula of a compound composed of iron and carbon monoxide, $Fe_x(CO)_y$, the compound is burned in pure oxygen to give Fe_2O_3 and CO_2. If you burn 1.959 g of $Fe_x(CO)_y$ and obtain 0.799 g of Fe_2O_3 and 2.200 g of CO_2, what is the empirical formula of $Fe_x(CO)_y$?

Pretty much the same as the last problem…

$$0.799g\ \mathrm{Fe_2O_3}\times\frac{1mol\ \mathrm{Fe_2O_3}}{159.69g\ \mathrm{Fe_2O_3}}\times\frac{2mol\ \mathrm{Fe}}{1mol\ \mathrm{Fe_2O_3}}=0.01001mol\ \mathrm{Fe}$$

$$2.200g\ \mathrm{CO_2}\times\frac{1mol\ \mathrm{CO_2}}{44.01g\ \mathrm{CO_2}}\times\frac{1mol\ \mathrm{C}}{1mol\ \mathrm{CO_2}}\times\frac{1mol\ \mathrm{CO}}{1mol\ \mathrm{C}}=0.04999mol\ \mathrm{CO}$$

$$\mathrm{Fe}=\frac{0.01001mol\ \mathrm{Fe}}{0.01001mol\ \mathrm{Fe}}=1 \qquad \mathrm{Ni}=\frac{0.04999mol\ \mathrm{CO}}{0.01001mol\ \mathrm{Fe}}=5$$

E.F. = $Fe(CO)_5$

14) The compound $X_2(YZ_3)_3$ has a molar mass of 282.23 g and a percent composition (by mass) of 19.12% X, 29.86% Y, and 51.02% Z. What is the compound?

This looks like an E.F. problem, but really it is 3 "identify the element" problems rolled into one. You are given percentages of each element, but you aren't told what those elements are, so you can't to this like a standard E.F. problem. There are at least 2 ways of getting to the answer of this one. Here, I am going to assume that I have one mole of the compound. Why? Because then I can use the percentages to find the molar masses of each element.

$$\frac{282.23g\ \mathrm{X_2(YZ_3)_3}}{1mol\ \mathrm{X_2(YZ_3)_3}}\times\frac{19.12g\ \mathrm{X}}{100g\ \mathrm{X_2(YZ_3)_3}}\times\frac{1mol\ \mathrm{X_2(YZ_3)_3}}{2mol\ \mathrm{X}}=\frac{26.98g\ \mathrm{X}}{1mol\ \mathrm{X}}=\ \mathrm{Al}$$

$$\frac{282.23g\ \mathrm{X_2(YZ_3)_3}}{1mol\ \mathrm{X_2(YZ_3)_3}}\times\frac{29.86g\ \mathrm{X}}{100g\ \mathrm{X_2(YZ_3)_3}}\times\frac{1mol\ \mathrm{X_2(YZ_3)_3}}{3mol\ \mathrm{X}}=\frac{28.09g\ \mathrm{X}}{1mol\ \mathrm{X}}=\ \mathrm{Si}$$

$$\frac{282.23g\ \mathrm{X_2(YZ_3)_3}}{1mol\ \mathrm{X_2(YZ_3)_3}}\times\frac{51.02g\ \mathrm{X}}{100g\ \mathrm{X_2(YZ_3)_3}}\times\frac{1mol\ \mathrm{X_2(YZ_3)_3}}{9mol\ \mathrm{X}}=\frac{16.00g\ \mathrm{X}}{1mol\ \mathrm{X}}=\ \mathrm{O}$$

Compound = $Al_2(SiO_3)_3$

15) When 12.82 g of a mixture of $KClO_3$ and NaCl is heated strongly, the $KClO_3$ reacts according to this equation:

$$2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$$

The NaCl doesn't undergo any reaction. After the heating, the mass of the residue (KCl and NaCl) is 9.45 g. Assuming that all the loss of the mass represents loss of oxygen gas, calculate the percent of $KClO_3$ in the original mixture.

What?? What does NaCl have to do with anything? Actually, nothing other than it has mass. So, where to start? How about with the mass of oxygen lost. You are being asked for the mass percent of $KClO_3$ in the sample, and $KClO_3$ is the only source of oxygen. So, if you can find the moles of oxygen, you will know the mass of $KClO_3$.

$12.82g \text{ mixture} - 9.45g \text{ residue} = 3.37g \text{ O}$

$$3.3.7g \text{ O} \times \frac{1mol \text{ O}}{16.00g \text{ O}} \times \frac{1mol \text{ KClO}_3}{3mol \text{ O}} \times \frac{122.5483g \text{ KClO}_3}{1mol \text{ KClO}_3} = 8.064g \text{ KClO}_3$$

$$\frac{8.604g \text{ KClO}_3}{12.82g \text{ sample}} = 67.1\%$$

16) Gastric juice contains about 3.0 g HCl per liter. If a person produces about 2.5L of gastric juice per day, how many antacid tablets, each containing 400. mg of $Al(OH)_3$, are needed to neutralize all the HCl produced in 1 day?

$$Al(OH)_{3(s)} + 3HCl_{(aq)} \rightarrow AlCl_{3(aq)} + 3H_2O_{(l)}$$

Okay, here we have molarity and a neutralization reaction. This is a problem where, once you know were to start, you pretty much just need to follow the units.

$$1day \times \frac{2.5L \text{ juice}}{1day} \times \frac{3.0g \text{ HCl}}{1L \text{ juice}} \times \frac{1mol \text{ HCl}}{36.46g \text{ HCl}} \times \frac{1mol \text{ Al(OH)}_3}{3mol \text{ HCl}} \times \frac{75.46g \text{ Al(OH)}_3}{1mol \text{ Al(OH)}_3} \times \frac{1 \text{ tab}}{0.4g \text{ Al(OH)}_3} = 13 \text{ tablets}$$

17) Thioridazine, $C_{21}H_{26}N_2S_2$, is a pharmaceutical used to regulate dopamine. (Dopamine, a neurotransmitter, affects the brain processes that control movement, emotional response, and ability to experience pleasure and pain.) A chemist can analyze a sample of the pharmaceutical for the thioridazine content by decomposing it to convert the sulfur in the compound to sulfate ion. This is then "trapped" as water-insoluble barium sulfate.

$$SO_4^{2-}{}_{(aq,\ from\ thioridazine)} + BaCl_{2(aq)} \rightarrow BaSO_{4(s)} + 2Cl^-_{(aq)}$$

Suppose a 12-tablet sample of the drug yielded 0.301 g of $BaSO_4$. What was the thioridazine content, in milligrams, of each tablet?

Okay, where to start? Well, you know that your answer is eventually going to have mass units, so starting with a number that has a mass in it might be helpful. In addition, the only information outside of the chemical equation is that you get 0.301 g $BaSO_4$ from 12 tablets. Let's start there.

$$\frac{0.301g \text{ BaSO}_4}{12tab} \times \frac{1mol \text{ BaSO}_4}{235.3906g \text{ BaSO}_4} \times \frac{1mol \text{ S}}{1mol \text{ BaSO}_4} \times \frac{1mol \text{ C}_{21}\text{H}_{26}\text{N}_2\text{S}_2}{2mol \text{ S}} \times \frac{370.5756g \text{ C}_{21}\text{H}_{26}\text{N}_2\text{S}_2}{1mol \text{ C}_{21}\text{H}_{26}\text{N}_2\text{S}_2} \times \frac{1mg}{10^{-3}g} = \frac{19.74mg}{1tab}$$

18) A herbicide contains 2,4-D (2,4-dichlorophenoxyacetic acid), $C_8H_6Cl_2O_3$. A 1.236 g sample of the herbicide was decomposed to liberate chlorine as Cl^- ion. This was precipitated as AgCl, with a mass of 0.1840 g. what is the mass percent of 2,4-D in the sample?

Enough words, if you have questions, come ask…

$$0.1840g \text{ AgCl} \times \frac{1mol \text{ AgCl}}{143.3209g \text{ AgCl}} \times \frac{1mol \text{ Cl}}{1mol \text{ AgCl}} \times \frac{1\text{mol C}_8\text{H}_6\text{Cl}_2\text{O}_3}{2mol \text{ Cl}} \times \frac{221.036g \text{ C}_8\text{H}_6\text{Cl}_2\text{O}_3}{1\text{mol C}_8\text{H}_6\text{Cl}_2\text{O}_3} = 0.14189g \text{ C}_8\text{H}_6\text{Cl}_2\text{O}_3$$

$$\frac{0.14189g \text{ C}_8\text{H}_6\text{Cl}_2\text{O}_3}{1.236g \text{ sample}} = 11.48\%$$

19) Dilithium is the fuel of the ***Starship Enterprise***. **Because the density if quite low, however, you need space to store a large mass. To estimate the volume required, we shall use the element lithium.**
(A) If you need 256 mol for an interplanetary trip, what must the volume of a piece of lithium be?

$$256mol\ \text{Li} \times \frac{6.944g\ \text{Li}}{1mol\ \text{Li}} \times \frac{1cm^3\ \text{Li}}{0.534g\ \text{Li}} = 3.33\times10^3 cm^3\ \text{Li}$$

(B) If the piece of lithium is a cube, what is the dimension of an edge of the cube? (Density of lithium is 0.534 g/cm^3)

$$\sqrt[3]{3.33\times10^3 cm^3} = 14.9cm \text{ on a side}$$

20) **The accepted toxic does of mercury is 300 μg/day. Dental offices sometimes contain as much as 180 μg of mercury per cubic meter of air. If a nurse working in the office ingests 2x10^4 L of air per day, is he or she at risk for mercury poisoning?**

$$\frac{180\mu g\ \text{Hg}}{m^3} \times \left(\frac{10^{-2}m}{1cm}\right)^3 \times \frac{1cm^3}{1mL} \times \frac{1mL}{10^{-3}L} \times \frac{2\times10^4 L}{day} = \frac{3.6\times10^3 \mu g}{day}$$

21) **Cloth can be waterproofed by coating it with a silicone layer. This is done by exposing the cloth to $(CH_3)_2SiCl_2$ vapor. The silicon compound reacts with the OH groups of the cloth to form a waterproofing film of $[(CH_3)_2SiO]_n$, where n is a large integer number (density = 1.0 g/cm^3).**

$$n\ (CH_3)_2SiCl_2 + 2n\ OH^- \rightarrow 2n\ Cl^- + n\ H_2O + [(CH_3)_2SiO]_n$$

The coating layer is added layer by layer, each layer of $[(CH_3)_2SiO]_n$ being 0.60 nm thick. Suppose you want to waterproof a piece of cloth that is 3.00 m^2, and you want 250 layers of waterproofing compound on the cloth. What mass of $(CH_3)_2SiCl_2$ do you need?

$$250layer \times \frac{0.60nm}{1layer} \times \frac{10^{-9}m}{1nm} \times \frac{3.00m^2}{cloth} \times \left(\frac{1cm}{10^{-2}m}\right)^3 \times \frac{1g\ (\text{CH}_3)_2\text{SiCl}_2}{1cm^3\ (\text{CH}_3)_2\text{SiCl}_2} = \frac{0.45g\ (\text{CH}_3)_2\text{SiCl}_2}{cloth}$$

22) **A flask containing 100. mL of alcohol (density is 0.789 g/mL) is places on one pan of a two-pan balance. A larger container, with a mass of 11.0 g more than the empty flask, is placed on the other pan of the balance. What volume of turpentine (d = 0.87 g/mL) must be added to this container to bring the two pans into balance?**

$$100.mL \times \frac{0.789g}{1mL} = 11.0g + X \times \frac{0.87g}{1mL}$$

X = 78 mL

23) **The concentration of hydrogen peroxide in a solution is determined by reacting a 10.0 mL sample of the solution with permanganate ion:**

$$2MnO_4^-{}_{(aq)} + 5H_2O_{2(aq)} + 6H^+{}_{(aq)} \rightarrow 2Mn^{+2}{}_{(aq)} + 5O_{2(g)} + 8H_2O_{(l)}$$

If it requires 15.2 mL of a 0.103 M MnO_4^- solution to fully react, what is the molarity of the hydrogen peroxide solution?

$$15.2mL\ \text{MnO}_4^- \times \frac{0.103mol\ \text{MnO}_4^-}{1000mL\ \text{MnO}_4^-} \times \frac{5mol\ \text{H}_2\text{O}_2}{2mol\ \text{MnO}_4^-} = 3.91\times10^{-3} mol\ \text{H}_2\text{O}_2$$

since the volume of the H_2O_2 solution was 10 mL, or 0.010L:

$$\frac{3.91\times10^{-3} mol\ \text{H}_2\text{O}_2}{0.010L} = 0.391M\ \text{H}_2\text{O}_2$$

24) **An ancient gold coin is 2.2 cm in diameter and 3.0 mm think. It is a cylinder for which the** $V = \pi r^2(\text{thickness})$. **If the density of gold is 19.3 g/cm^3, what is the mass of the coin in grams?**

$$\pi(1.1cm)^2 \times 0.30cm \times \frac{19.3g\ \text{Au}}{cm^3} = 22g\ \text{Au}$$

25) **The largest nugget of gold on record was found in 1872 in New South Whales, Australia, and had a mass of 93.3 kg.**
(A) Assuming the nugget is pure gold, what is its volume in cubic centimeters?

$$93.3kg\ \text{Au} \times \frac{10^3 g\ \text{Au}}{1kg\ \text{Au}} \times \frac{1cm^3\ \text{Au}}{19.3g\ \text{Au}} = 4.83 \times 10^3 cm^3$$

(B) What is it worth by today's standards if gold is \$648.76 per troy ounce? (14.58 troy oz. = 1 lb, d = 19.3 g/cm^3)

$$93.3kg\ \text{Au} \times \frac{2.205lb\ \text{Au}}{1kg\ \text{Au}} \times \frac{14.58tr.oz.}{1lb\ \text{Au}} \times \frac{\$648.73}{1tr.oz.} = \$1.95 \times 10^6$$

26) **In July 1983, an Air Canada Boeing 767 ran out of fuel over central Canada on a trip from Montreal to Edmonton. (The plane glided safely to a landing at an abandoned airstrip.) The pilots knew that 22,300 kg of fuel were required for the trip, and knew that 7682 L of fuel were already in the tank. The ground crew added 4916 L of fuel, which was only about one fifth if what was required. The crew members used a factor of 1.77 for the fuel density -- the problem is that 1.77 has units of *pounds* per liter and NOT *kilograms* per liter!**
(A) What is the fuel density in units of kg/L?

$$\frac{1.77lb}{1L} \times \frac{0.4536kg}{1lb} = \frac{0.803kg}{1L}$$

(B) What mass of fuel should have been loaded? (1lb. = 453.6 g)

$$22300kg \ - \ 7682L \times \frac{0.803kg}{1L} = 1.61 \times 10^4 kg$$

total   onboard already   **needed**

27) **The fluoridation of city water supplies has been practiced in the U.S. for several decades. It is done by continuously adding sodium fluoride to water as it cines from a reservoir. Assume you live in a medium-sized city of 150,000 people and that 170 gallons of water are consumed per person per day. What mass of sodium fluoride (in kilograms) must be added to the water supply each year to have the required fluoride concentration of 1.00 kilogram of fluoride per 1.00x10^6 kilograms of water? (sodium fluoride is 45.2% fluoride and water weighs 1.00 grams per cm^3)**

$$150000\,people \times \frac{170gal\ \text{H}_2\text{O}}{people \times day} \times \frac{365day}{1yr} \times \frac{3.78L\ \text{H}_2\text{O}}{gal\ \text{H}_2\text{O}} \times \frac{1mL\ \text{H}_2\text{O}}{10^{-3}L\ \text{H}_2\text{O}} \times \frac{1cm^3\ \text{H}_2\text{O}}{1mL\ \text{H}_2\text{O}} \times \frac{1.00g\ \text{H}_2\text{O}}{1cm^3\ \text{H}_2\text{O}} \times \frac{1kg\ \text{H}_2\text{O}}{10^3 g\ \text{H}_2\text{O}} \times \frac{1.00kg\ \text{F}^-}{10^6 kg\ \text{H}_2\text{O}} \times \frac{100g\ \text{NaF}}{45.2g\ \text{F}^-} = \frac{7.78 \times 10^4 kg}{yr}$$

28) **About two centuries ago, Ben Franklin showed that 1 teaspoon of oil would cover about 0.5 acre of still water. If you know that 1.0x10^4 m^2 = 2.47 acre, and that there is approximately 5 cm^3 in a teaspoon, what is the thickness of the layer of oil?**

$$\frac{5cm^3}{1tsp} \times \frac{1tsp}{0.5acre} \times \frac{1acre}{1.0 \times 10^4 m^2} \times \left(\frac{10^{-2}m}{1cm}\right)^3 = 1.0 \times 10^{-9} m$$

29) **You have a 4.554 g sample that is a mixture of oxalic acid and another solid that does not react with sodium hydroxide. If 29.58 mL of 0.550 M sodium hydroxide is required to react with all of the oxalic acid in the 4.554 g ample, what is the weight percent of oxalic acid in the mixture?**

$H_2C_2O_{4(s)} + 2NaOH_{(aq)} \rightarrow Na_2C_2O_{4(aq)} + 2H_2O_{(l)}$

$$29.58mL\ \text{NaOH} \times \frac{0.550mol\ \text{NaOH}}{1000mL\ \text{NaOH}} \times \frac{1mol\ \text{H}_2\text{C}_2\text{O}_4}{2mol\ \text{NaOH}} \times \frac{90.04\text{g H}_2\text{C}_2\text{O}_4}{1mol\ \text{H}_2\text{C}_2\text{O}_4} = 0.732\text{g H}_2\text{C}_2\text{O}_4$$

30) **A 26 m tall statue of Buddha in Tibet is covered with 297 kg of gold. If the gold was applied to a thickness of 0.0015 mm, what surface area (in m^2) is covered? (density of Au is 19.3g/cm^3)**

$$297kg\ \text{Au} \times \frac{10^3 g\ \text{Au}}{1kg\ \text{Au}} \times \frac{1cm^3\ \text{Au}}{19.3g\ \text{Au}} \times \left(\frac{10^{-2}m}{1cm}\right)^3 \times \left(\frac{1mm}{10^{-3}m}\right)^3 \times \frac{1}{0.0015mm} \times \left(\frac{10^{-3}m}{1mm}\right)^2 = 1.0 \times 10^4 m^2$$

31) **Suppose your bedroom is 18 ft long, 15 ft wide, and the distance from floor to ceiling is 8 ft 6 in. You need to know the volume of the room in metric units for some reason.**
(A) What is the room's volume in cubic meters?

$$18\,ft \times 15\,ft \times 8.5\,ft \times \left(\frac{12in}{1\,ft}\right)^3 \times \left(\frac{2.54cm}{1in}\right)^3 = 6.5\times10^7\,cm^3$$

(B) What is the volume in liters?

$$6.5\times10^7\,cm^3 \times \frac{1mL}{1cm^3} \times \frac{10^{-3}L}{1mL} = 6.5\times10^4\,L$$

(C) What is the mass of the air in the room in kilograms? (Assume the density of air is 1.2 g/L and that the room is empty)

$$6.5\times10^4\,L \times \frac{1.2g}{L} \times \frac{1kg}{10^3 g} = 78kg$$

32) **500. mL of 2.50 M HCl is mixed with 250. mL of 3.75 M HCl. What is the concentration of HCl in the resulting solution?**

$$500.ml\ \mathrm{HCl} \times \frac{2.50mol\ \mathrm{HCl}}{1000mL} = 1.25mol\ \mathrm{HCl} \qquad 250.ml\ \mathrm{HCl} \times \frac{3.75mol\ \mathrm{HCl}}{1000mL} = 0.9375mol\ \mathrm{HCl}$$

1.25 mol HCl + 0.9375 mol HCl = 2.1815 mol HCl ***TOTAL***

$$\frac{2.1815mol\ \mathrm{HCl}}{0.750L} = 2.92M\ \mathrm{HCl}$$

33) **Suppose you place exactly 200. mL of vinegar in a beaker and add baking soda (sodium bicarbonate). How many spoonfuls of baking soda are required to consume all of the acetic acid in the 200. mL sample? (Assume there are 50.0 g of acetic acid per liter of vinegar and a spoonful of baking soda has a mass of 3.8 g)**

$HC_2H_3O_{2(aq)} + NaHCO_{3(s)} \rightarrow NaC_2H_3O_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

$$200.mL\ \mathrm{vinegar} \times \frac{50.0g\ \mathrm{HC_2H_3O_2}}{1000mL\ \mathrm{vinegar}} \times \frac{1mol\ \mathrm{HC_2H_3O_2}}{60.06g\ \mathrm{HC_2H_3O_2}} \times \frac{1mol\ \mathrm{NaHCO_3}}{1mol\ \mathrm{HC_2H_3O_2}} \times \frac{82.04g\ \mathrm{NaHCO_3}}{1mol\ \mathrm{NaHCO_3}} \times \frac{1spoon\ \mathrm{NaHCO_3}}{3.8g\ \mathrm{NaHCO_3}} = 3.6spoon\ \mathrm{NaHCO_3}$$

34) **HCN is a poisonous gas. The lethal does is approximately 300. mg HCN per kilogram of air when inhaled.**
(A) Calculate the amount of HCN that gives the lethal dose in a small laboratory room measuring 12 by 15 by 8.0 feet. The density of air at 26°C is 0.00118 g/cm³.

$$18\,ft \times 15\,ft \times 8.0\,ft \times \left(\frac{12in}{1\,ft}\right)^3 \times \left(\frac{2.54cm}{1in}\right)^3 \times \frac{0.00118g\ \mathrm{air}}{1cm^3} \times \frac{1kg\ \mathrm{air}}{10^3 g\ \mathrm{air}} \times \frac{0.300g\ \mathrm{HCN}}{1kg\ \mathrm{air}} = 14g\ \mathrm{HCN}$$

(B) If HCN is formed by the reaction of NaCN with an acid such as H_2SO_4, what mass of NaCN gives the lethal dose in the room?

$2NaCN + H_2SO_4 \rightarrow Na_2SO_4 + 2HCN$

$$14g\ \mathrm{HCN} \times \frac{1mol\ \mathrm{HCN}}{27.03g\ \mathrm{HCN}} \times \frac{1mol\ \mathrm{NaCN}}{1mol\ \mathrm{HCN}} \times \frac{49.01g\ \mathrm{NaCN}}{1mol\ \mathrm{NaCN}} = 26g\ \mathrm{NaCN}$$

(C) HCN forms when synthetic fibers containing Orlon® or Acrilan® burn. Acrilan has an empirical formula of CH_2CHCN, so HCN is 50.9% of the formula by mass. A rug measures 12 by 15 feet and contains 30. oz of Acrilan fibers per yd² of carpet. If the rug burns, will the lethal dose of HCN be generated in the room? Assume that only 20.% of the fibers release HCN and that only half of the carpet burns.

$$12\,ft \times 15\,ft \times \left(\frac{1yd\ \mathrm{car.}}{3\,ft}\right)^2 \times \frac{50.yd^2\ \mathrm{burn}}{100.yd^2\ \mathrm{car.}} \times \frac{30.oz\ \mathrm{CH_2CHCN}}{1yd^2\ \mathrm{burn}} \times \frac{28.35g\ \mathrm{CH_2CHCN}}{1oz\ \mathrm{CH_2CHCN}} \times \frac{20.g\ \mathrm{CH_2CHCN\ released}}{100.g\ \mathrm{CH_2CHCN}} \times \frac{50.9g\ \mathrm{HCN}}{100.g\ \mathrm{CH_2CHCN}} = 866g\ \mathrm{HCN}$$

35) **You need to know the volume of water in a small swimming pool, but, owing ot the pool's irregular shape, it is not a simple matter to determine and calculate the volume. To solve the problem, you stir in a solution of dye (1.0 g of methylene blue, $C_{16}H_{18}ClN_3S$, in 50.0 mL of water). After the dye has mixed with the water in the pool, you take a sample of the water. Using an instrument such as a spectrophotometer, you determine that the concentration of the dye in the pool is $4.1x10^{-8}$ M. What is the volume of the pool?**

$$1.0g\ \mathrm{C_{16}H_{18}ClN_3S} \times \frac{1mol\ \mathrm{C_{16}H_{18}ClN_3S}}{319.88g\ \mathrm{C_{16}H_{18}ClN_3S}} \times \frac{1L}{4.1\times10^{-8}\,mol\ \mathrm{C_{16}H_{18}ClN_3S}} = 7.6\times10^{4}\,L$$

36) **Uranium metal (0.169 g) is heated to between 800 and 900 °C in air to give 0.199 g of a dark green oxide, U_xO_y.**
(A) How many moles of uranium metal were used?

$$0.169g\ \mathrm{U}\times\frac{1mol\ \mathrm{U}}{238.0289g\ \mathrm{U}} = 7.10\times10^{-4}\,mol\ \mathrm{U}$$

(B) What is the empirical formula of the oxide, U_xO_y?

0.199 g oxide - 0.169 g U = 0.030 g oxygen

$$0.030g\ \mathrm{O}\times\frac{1mol\ \mathrm{O}}{16.00g\ \mathrm{O}} = 1.88\times10^{-3}\,mol\ \mathrm{O}$$

$$\mathrm{U} = \frac{7.10\times10^{-4}\,mol}{7.10\times10^{-4}\,mol} = 1 \qquad \mathrm{O} = \frac{1.88\times10^{-3}\,mol}{7.10\times10^{-4}\,mol} = 2.64$$

2.64 x 3 = 8 and 1 x 3 = 3, so **U_3O_8**

(C) How many moles of U_xO_y must have been obtained?

$$0.199g\ \mathrm{U_3O_8}\times\frac{1mol\ \mathrm{U_3O_8}}{842.0867g\ \mathrm{U_3O_8}} = 2.36\times10^{-4}\,mol\ \mathrm{U_3O_8}$$

(D) If the hydrated compound $UO_2(NO_3)_2 \bullet zH_2O$ is heated gently , the water of hydration is lost. If you have 0.865 g of the hydrated compound and obtain 0.679 g of $UO_2(NO_3)_2$ on heating, how many molecules of water of hydration are in each formula unit of the original compound?

0.865 g hydrate - 0.679 g $UO_2(NO_3)_2$ = 0.186 g H_2O

$$0.186g\ \mathrm{H_2O}\times\frac{1mol\ \mathrm{H_2O}}{16.00g\ \mathrm{H_2O}} = 0.0103mol\ \mathrm{H_2O}$$

$$0.679g\ \mathrm{UO_2(NO_3)_2}\times\frac{1mol\ \ \mathrm{UO_2(NO_3)_2}}{394.0489g\ \ \mathrm{UO_2(NO_3)_2}} = 0.001723mol\ \ \mathrm{UO_2(NO_3)_2}$$

$$\frac{0.0103mol\ \mathrm{H_2O}}{0.001723mol\ \ \mathrm{UO_2(NO_3)_2}} = \frac{6mol\ \mathrm{H_2O}}{1mol\ \ \mathrm{UO_2(NO_3)_2}}$$

37) **In some states, a person will receive a "driving while intoxicated" (DWI) ticket if the blood alcohol level (BAL) is 100. mg per deciliter of blood or higher. Suppose a person is found to have a BAL of .03 mol of ethanol (C_2H_5OH) per liter of blood. Will the person receive a DWI ticket?**

$$\frac{0.03mol\ \mathrm{C_2H_5OH}}{1L\ \text{blood}}\times\frac{46.08g\ \mathrm{C_2H_5OH}}{1mol\ \mathrm{C_2H_5OH}}\times\frac{1mg\ \mathrm{C_2H_5OH}}{10^{-3}\,g\ \mathrm{C_2H_5OH}}\times\frac{10^{-1}L\ \text{blood}}{1dL\ \text{blood}} = \frac{138mg\ \mathrm{C_2H_5OH}}{1dL\ \text{blood}}$$

DRUNK!!!!!

38) **If 0.0900 g of a metal (M) reacts with excess HCl to form $5.00x10^{-3}$ moles of hydrogen and a solution of $MCl_{3(aq)}$. What is the atomic mass of the metal?**

$2M_{(s)} + 6HCl_{(aq)} \rightarrow 3H_{2(g)} + 2MCl_{3(aq)}$

$$5.00\times10^{-3}\,mol\ \mathrm{H_2}\times\frac{2mol\ \mathrm{M}}{3mol\ \mathrm{H_2}} = 3.33\times10^{-3}\,mol\ \mathrm{M}$$

$$M.M = \frac{g\ \mathrm{M}}{mol\ \mathrm{M}} = \frac{.0900\mathrm{g\ M}}{3.33\times10^{-3}\,mol\ \mathrm{M}} = 27.03\,{}^{g}\!/_{mol} \Rightarrow Al$$