1. The solubility of *melamine*, $C_3H_6N_6$, in water is 3.1 g/L at 20°C. How many mols of the element nitrogen are there in a liter of melamine solution that is saturated with that amount of melamine?

mol. wt. = $3(12.011) + 6(1.0079) + 6(14.007) = 126.1$ g/mol (3)

3.1 g melamine → $\frac{3.1\text{ g}}{126.1\text{ g/mol}} = 0.0246$ mol melamine (3)

6 N per melamine (6)

→ $6(0.0246)$ mol N = **0.148 mol N** (15)

How many g of nitrogen does this correspond to?

$(0.148\text{ mol N}) \rightarrow (0.148\text{ mol})\left(14.007\ \frac{\text{g}}{\text{mol}}\right)$

= **2.07 g N** (10)

2. *Melamine*, $C_3H_6N_6$, has been in the news the past several weeks as a toxic substance illegally used to raise the nitrogen content of milk and other products in China. It is prepared as a product from urea $(NH_2)_2CO$ as the only starting material. The other chemicals produced in the reaction besides melamine itself are ammonia, NH_3, and carbon dioxide, CO_2. If exactly 100.00 g of urea are allowed to react completely, how many g of what final substances remain when the reaction has ended? (Show all work.)

$(NH_2)_2CO \rightarrow C_3H_6N_6 + NH_3 + CO_2$ unbalanced

↑ note number of "C" must equal number of "O"

intermediate step $6(NH_2)_2CO \rightarrow C_3H_6N_6 + NH_3 + 3CO_2$

balance "N"

$6(NH_2)_2CO \rightarrow C_3H_6N_6 + 6NH_3 + 3CO_2$

check "H" balance $24 = 6+18$ ✓

$6(NH_2)_2CO \rightarrow C_3H_6N_6 + 6NH_3 + 3CO_2$ (10)

mol. wts	60.06	126.12	17.03	44.01	g/mol

$\frac{100.00\text{ g urea}}{60.06\text{ g urea/mol urea}} = 1.665$ mol urea

6 mol urea → 1 mole melamine, 6 mol NH_3, 3 mol CO_2

1.665 mole urea → 0.2775 mol $C_3H_6N_6$, 1.665 mol NH_3, 0.8325 mol CO_2

$0.2775\text{ mol } C_3H_6N_6 \rightarrow (0.2775\text{ mol})\left(126.12\ \frac{\text{g}}{\text{mol}}\right) = 35.00$ g $C_3H_6N_6$ (5)

$1.665\text{ mol } NH_3 \rightarrow (1.665)(17.03) = 28.36$ g NH_3 (5)

$0.8325\text{ mol } CO_2 \rightarrow (0.8325)(44.01) = 36.64$ g CO_2 (5)

check: start = 100.00 g

finish = 35.00 + 28.36 + 36.64 = 100.00 g ✓

3. You have 200.00 grams of a mixture of manganese ores *pyrolusite* (MnO_2) and *hausmannite* (Mn_3O_4). The mixture is converted to metallic manganese (Mn) by heating with carbon (C) to produce carbon dioxide as a waste product. When you are finished and isolate the pure manganese metal, it has a mass of 136.40 grams. What is the percent by mass of the original mixture that is *pyrolusite*? (You can verify your answer by working backwards.)

$MnO_2 + Mn_3O_4 + 3C \rightarrow 4Mn + 3CO_2$ is wrong! −2 pts

A mixture problem!

x = g of MnO_2 (mol. wt. = 86.94 g/mol)

$200.00 - x$ = g of Mn_3O_4 (mol. wt. = 228.81 g/mol)

$MnO_2 + C \rightarrow Mn + CO_2$ (5)

MnO_2 $\frac{x}{86.94}$ mol → $\frac{x}{86.94}$ mol Mn

$= \frac{x}{86.94}(54.94)$ g Mn = 0.6319x g Mn (10)

$Mn_3O_4 + 2C \rightarrow 3Mn + 2CO_2$

Mn_3O_4 $\frac{200-x}{228.81}$ mol → $3\left(\frac{200-x}{228.81}\right)$ mol Mn

→ $3\left(\frac{200-x}{228.81}\right)54.94$ g Mn = $(144.07 - 0.7203x)$ g Mn

Mn 136.40 g = $(0.6319x + 144.07 - 0.7203x)$ g (5)

$0.0884x = 7.67$

$x = 86.76$ (3)

MnO_2 is $\frac{86.76}{200.00}(100\%) =$ **43.4%** of total (25)

25 total

4. *Oil of wintergreen* is a natural product of many species of plants. Recent indications are that it is a defense against plant-eating insects functioning to attract other insects that feed on the harmful ones. Chemical analysis by mass shows it to be C 63.154%, H 5.300%, and O 31.546%. What is the empirical formula for this substance consistent with the precision of the analysis? (Show all steps.)

Assume you have 100.000 g of compound →

63.154 g C → $\frac{63.154\text{ g C}}{12.011\text{ g C/mol C}} = 5.258$ mol C (5)

5.300 g H → $\frac{5.300\text{ g}}{1.0079\text{ g/mol}} = 5.258$ mol H (5)

31.546 g O → $\frac{31.546\text{ g}}{15.999\text{ g/mol}} = 1.972$ mol O (5)

mol is a number — no rounding off!

C : H : O = 5.258 : 5.258 : 1.972

Divide by 1.972 (seeking integers)

C : H : O = 2.666 : 2.666 : 1 — no rounding off!

note 2.666 = 2 2/3

Multiply by 3

C : H : O → 7.998 : 7.998 : 3

= 8 : 8 : 3

$C_8H_8O_3$