1) **a)** $5.94\ g\ \mathbf{H} \times \frac{1\ mol\ \mathbf{H}}{1.00797\ g\ \mathbf{H}} = 5.89\ mol\ \mathbf{H}$ $\quad$ $94.06\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 5.88\ mol\ \mathbf{O}$

$\mathbf{H} = \frac{5.89}{5.88} \approx 1$ $\quad$ $\mathbf{O} = \frac{5.88}{5.88} = 1$

Empirical Formula = HO

Empirical mass HO = 17.0074 g/mol, molar mass of compound = 34.02 g/mol (given in problem)

$\frac{34.02}{17.0074} \approx 2$ $\quad$ **Molecular Formula = H_2O_2**

b) $80.34\ g\ \mathbf{Zn} \times \frac{1\ mol\ \mathbf{Zn}}{65.37\ g\ \mathbf{Zn}} = 1.229\ mol\ \mathbf{Zn}$ $\quad$ $19.66\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 1.229\ mol\ \mathbf{O}$

$\mathbf{Zn} = \frac{1.229}{1.229} = 1$ $\quad$ $\mathbf{O} = \frac{1.229}{1.229} = 1$

Empirical Formula = ZnO

Empirical mass ZnO = 81.37 g/mol, molar mass of compound = 81.39 g/mol (given in problem)

$\frac{81.39}{81.37} \approx 1$ $\quad$ **Molecular Formula = ZnO**

c) $35.18\ g\ \mathbf{Fe} \times \frac{1\ mol\ \mathbf{Fe}}{55.847\ g\ \mathbf{Fe}} = 0.6299\ mol\ \mathbf{Fe}$ $\quad$ $44.66\ g\ \mathbf{Cl} \times \frac{1\ mol\ \mathbf{Cl}}{35.453\ g\ \mathbf{Cl}} = 1.260\ mol\ \mathbf{Cl}$

$20.16\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 1.260\ mol\ \mathbf{O}$

$\mathbf{Fe} = \frac{0.6299}{0.6299} = 1$ $\quad$ $\mathbf{Cl} = \frac{1.260}{0.6299} \approx 2$ $\quad$ $\mathbf{O} = \frac{1.260}{0.6299} \approx 2$

Empirical Formula = $FeCl_2O_2$

$FeCl_2O_2$ = 158.752 g/mol $\quad$ $\frac{158.75}{158.752} \approx 1$ $\quad$ **Molecular Formula = $FeCl_2O_2$**

d) $26.19\ g\ \mathbf{N} \times \frac{1\ mol\ \mathbf{N}}{14.0067\ g\ \mathbf{N}} = 1.870\ mol\ \mathbf{N}$ $\quad$ $7.55\ g\ \mathbf{H} \times \frac{1\ mol\ \mathbf{H}}{1.00797\ g\ \mathbf{H}} = 7.49\ mol\ \mathbf{H}$

$66.26\ g\ \mathbf{Cl} \times \frac{1\ mol\ \mathbf{Cl}}{35.453\ g\ \mathbf{Cl}} = 1.870\ mol\ \mathbf{Cl}$

$\mathbf{N} = \frac{1.870}{1.870} = 1$ $\quad$ $\mathbf{H} = \frac{7.49}{1.870} \approx 4$ $\quad$ $\mathbf{Cl} = \frac{1.870}{1.870} = 1$

Empirical Formula = NH_4Cl

NH_4Cl = 53.492 g/mol $\quad$ $\frac{53.50}{53.492} \approx 1$ $\quad$ **Molecular Formula = NH_4Cl**

2) **a)** EF = KBr **c)** EF = $Ca(OH)_2$

b) EF = $AgNO_3$ **d)** EF = H_2SO_4

3) **a)** $63.6\ g\ \mathbf{N} \times \frac{1\ mol\ \mathbf{N}}{14.0067\ g\ \mathbf{N}} = 4.54\ mol\ \mathbf{N}$ $36.4\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 2.28\ mol\ \mathbf{O}$

$\mathbf{N} = \frac{4.54}{2.28} \approx 2$ $\mathbf{O} = \frac{2.28}{2.28} = 1$

Empirical Formula = N_2O

b) $46.7\ g\ \mathbf{N} \times \frac{1\ mol\ \mathbf{N}}{14.0067\ g\ \mathbf{N}} = 3.33\ mol\ \mathbf{N}$ $53.3\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 3.33\ mol\ \mathbf{O}$

$\mathbf{N} = \frac{3.33}{3.33} = 1$ $\mathbf{O} = \frac{3.33}{3.33} = 1$

Empirical Formula = NO

c) $25.9\ g\ \mathbf{N} \times \frac{1\ mol\ \mathbf{N}}{14.0067\ g\ \mathbf{N}} = 1.85\ mol\ \mathbf{N}$ $74.1\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 4.63\ mol\ \mathbf{O}$

$\mathbf{N} = \frac{1.85}{1.85} = 1 \times 2 = 2$ $\mathbf{O} = \frac{4.63}{1.85} = 2.50 \times 2 = 5$

Empirical Formula = N_2O_5

d) $43.4\ g\ \mathbf{Na} \times \frac{1\ mol\ \mathbf{Na}}{22.9898\ g\ \mathbf{Na}} = 1.89\ mol\ \mathbf{Na}$ $11.3\ g\ \mathbf{C} \times \frac{1\ mol\ \mathbf{C}}{12.0112\ g\ \mathbf{C}} = 0.941\ mol\ \mathbf{C}$

$45.3\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 2.83\ mol\ \mathbf{O}$

$\mathbf{Na} = \frac{1.89}{0.941} = 2$ $\mathbf{C} = \frac{0.941}{0.941} = 1$ $\mathbf{O} = \frac{2.83}{0.941} = 3$

Empirical Formula = Na_2CO_3

e) $18.8\ g\ \mathbf{Na} \times \frac{1\ mol\ \mathbf{Na}}{22.9898\ g\ \mathbf{Na}} = 0.818\ mol\ \mathbf{Na}$ $29.0\ g\ \mathbf{Cl} \times \frac{1\ mol\ \mathbf{Cl}}{35.453\ g\ \mathbf{Cl}} = 0.818\ mol\ \mathbf{Cl}$

$52.3\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 3.27\ mol\ \mathbf{O}$

$\mathbf{Na} = \frac{0.818}{0.818} = 1$ $\mathbf{Cl} = \frac{0.818}{0.818} = 1$ $\mathbf{O} = \frac{3.27}{0.818} = 4$

Empirical Formula = $NaClO_4$

f) $72.02\ g\ \mathbf{Mn} \times \frac{1\ mol\ \mathbf{Mn}}{54.938\ g\ \mathbf{Mn}} = 1.311\ mol\ \mathbf{Mn}$ $27.98\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 1.749\ mol\ \mathbf{O}$

$\mathbf{Mn} = \frac{1.311}{1.311} = 1 \times 3 = 3$ $\mathbf{O} = \frac{1.749}{1.311} = 1.334 \times 3 = 4$

Empirical Formula = Mn_3O_4

4) **a)** EF = $CuCl$ **d)** EF = K_3PO_4

b) EF = $CuCl_2$ **e)** EF = $BaCr_2O_7$

c) EF = Cr_2S_3 **f)** EF = PBr_8Cl_3

5) $3.996\ g\ \mathbf{Sn} \times \frac{1\ mol\ \mathbf{Sn}}{118.69\ g\ \mathbf{Sn}} = 0.03367\ mol\ \mathbf{Sn}$ $1.077\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 0.06732\ mol\ \mathbf{O}$

$\mathbf{Sn} = \frac{0.03367}{0.03367} = 1$ $\mathbf{O} = \frac{0.06732}{0.03367} = 2$

Empirical Formula = SnO_2

6) $65.45\ g\ \mathbf{C} \times \frac{1\ mol\ \mathbf{C}}{12.0112\ g\ \mathbf{C}} = 5.449\ mol\ \mathbf{C}$ $5.45\ g\ \mathbf{H} \times \frac{1\ mol\ \mathbf{H}}{1.00797\ g\ \mathbf{H}} = 5.41\ mol\ \mathbf{H}$

$29.09\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 1.818\ mol\ \mathbf{O}$

$\mathbf{C} = \frac{5.449}{1.818} = 3$ $\mathbf{H} = \frac{5.45}{1.818} = 3$ $\mathbf{O} = \frac{1.818}{1.818} = 1$

Empirical Formula = C_3H_3O

C_3H_3O = 55.0569 g/mo $1\frac{110.1}{55.0659} \approx 2$

Molecular Formula = $C_6H_6O_2$

7) The only elements in the compound are nitrogen and oxygen. If you know the mass of the compound sample and you know the mass of nitrogen, then you can find the mass of oxygen. Once you know the masses of both oxygen and nitrogen, this becomes a straight forward percent composition and molecular formula problem.

39.54 g compound – 12.04 g N = 27.50 g O

percent composition N $= \frac{12.04}{39.54} \times 100 = 30.45\%$ **percent composition O** $= \frac{27.50}{39.54} \times 100 = 69.55\%$

You can do the molecular formula part of the question by starting with either the given masses OR the percents calculated in the first part of the question. I am going to do it with the given masses.

$12.04\ g\ \mathbf{N} \times \frac{1\ mol\ \mathbf{N}}{14.0067\ g\ \mathbf{N}} = 0.8596\ mol\ \mathbf{N}$ $27.50\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 1.719\ mol\ \mathbf{O}$

$\mathbf{N} = \frac{0.8596}{0.8596} = 1$ $\mathbf{O} = \frac{1.719}{0.8593} = 2$

Empirical Formula = NO_2

NO_2 = 46.0055 g/mol $\frac{92.02}{46.0055} \approx 2$

Molecular Formula = N_2O_4

8) $90.3\ g\ \mathbf{C} \times \frac{1\ mol\ \mathbf{C}}{12.0112\ g\ \mathbf{C}} = 7.52\ mol\ \mathbf{C}$ $\quad$ $15.2\ g\ \mathbf{H} \times \frac{1\ mol\ \mathbf{H}}{1.00797\ g\ \mathbf{H}} = 15.1\ mol\ \mathbf{H}$

$60.1\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 3.76\ mol\ \mathbf{O}$

$\mathbf{C} = \frac{7.52}{3.76} = 2$ $\quad$ $\mathbf{H} = \frac{15.1}{3.76} = 4.02 \approx 4$ $\quad$ $\mathbf{O} = \frac{3.76}{3.76} = 1$

Empirical Formula = C_2H_4O

C_2H_4O = 44.0537 g/mol $\quad$ $\frac{396.2}{44.0537} \approx 9$

Molecular Formula = $C_{18}H_{36}O_9$

9) $0.4806\ g\ \mathbf{C} \times \frac{1\ mol\ \mathbf{C}}{12.0112\ g\ \mathbf{C}} = 0.04001\ mol\ \mathbf{C}$ $\quad$ $0.0759\ g\ \mathbf{H} \times \frac{1\ mol\ \mathbf{H}}{1.00797\ g\ \mathbf{H}} = 0.0753\ mol\ \mathbf{H}$

$0.2134\ g\ \mathbf{O} \times \frac{1\ mol\ \mathbf{O}}{15.9994\ g\ \mathbf{O}} = 0.01334\ mol\ \mathbf{O}$ $\quad$ $0.0935\ g\ \mathbf{N} \times \frac{1\ mol\ \mathbf{N}}{14.0067\ g\ \mathbf{N}} = 0.00668\ mol\ \mathbf{N}$

$\mathbf{C} = \frac{0.04001}{0.00668} \approx 6 \times 4 = 24$ $\quad$ $\mathbf{H} = \frac{0.0753}{0.00668} \approx 11.25 \times 4 = 45$

$\mathbf{O} = \frac{0.01334}{0.00668} \approx 2 \times 4 = 8$ $\quad$ $\mathbf{N} = \frac{0.00668}{0.00668} = 1 \times 4 = 4$

Empirical Formula = $C_{24}H_{45}O_8N_4$

10) $0.7722\ g\ \mathbf{C} \times \frac{1\ mol\ \mathbf{C}}{12.01\ g\ \mathbf{C}} = 0.0643\ mol\ \mathbf{C}$ $\quad$ $0.0867\ g\ \mathbf{H} \times \frac{1\ mol\ \mathbf{H}}{1.01\ g\ \mathbf{H}} = 0.0858\ mol\ \mathbf{H}$

$2.282\ g\ \mathbf{Br} \times \frac{1\ mol\ \mathbf{Br}}{79.91\ g\ \mathbf{Br}} = 0.0287\ mol\ \mathbf{Br}$

$\mathbf{C} = \frac{0.0643}{0.0287} \approx 2.24 \times 4 = 9$ $\quad$ $\mathbf{H} = \frac{0.0858}{0.0287} \approx 3 \times 4 = 12$ $\quad$ $\mathbf{Br} = \frac{0.0287}{0.0287} = 1 \times 4 = 4$

Empirical Formula = $C_9H_{12}Br_4$

$C_9H_{12}Br_4$ = 439.832 g/mol $\quad$ $\frac{1773.05}{439.832} \approx 4$

Molecular Formula = $C_{36}H_{48}Br_{16}$

11) $\mathbf{X} = \frac{1 \times [\text{molar mass of element}]}{100.09} \times 100 = 40.04\% \Rightarrow [\text{molar mass of element}] = 40.07\ g/mol = Ca$

$\mathbf{Y} = \frac{1 \times [\text{molar mass of element}]}{100.09} \times 100 = 12.00\% \Rightarrow [\text{molar mass of element}] = 12.01\ g/mol = C$

$\mathbf{Z} = \frac{3 \times [\text{molar mass of element}]}{100.09} \times 100 = 47.96\% \Rightarrow [\text{molar mass of element}] = 16.00\ g/mol = O$

Compound = $CaCO_3$

12) There are SEVERAL ways of doing this problem. I think that the easiest way is to use the following equation, which I gave in class: $$\frac{\textbf{[\# of moles of element]} \times \textbf{[molar mass of element]}}{\textbf{molar mass of compound}} \times \textbf{100} = \textbf{\% composition}$$

The question gives you the **molar mass of compound**, the **% composition**, and the **# of moles of element** (the subscripts in the formula). This becomes plug and chug with algebra. To find the identity of the elements, you need to compare the molar mass of the element to the periodic table.

$$\textbf{X} = \frac{\textbf{2} \times \textbf{[molar mass of element]}}{\textbf{282.23}} \times \textbf{100} = \textbf{19.12\%} \Rightarrow \textbf{[molar mass of element]} = \textbf{26.98 g/mol} = \textbf{Al}$$

$$\textbf{Y} = \frac{\textbf{3} \times \textbf{[molar mass of element]}}{\textbf{282.23}} \times \textbf{100} = \textbf{29.86\%} \Rightarrow \textbf{[molar mass of element]} = \textbf{28.09 g/mol} = \textbf{Si}$$

$$\textbf{Z} = \frac{\textbf{9} \times \textbf{[molar mass of element]}}{\textbf{282.23}} \times \textbf{100} = \textbf{51.02\%} \Rightarrow \textbf{[molar mass of element]} = \textbf{16.00 g/mol} = \textbf{O}$$

Compound = $Al_2(SiO_3)_3$