1. (3 points) Hydrazine is compound made up of molecules built of nitrogen and hydrogen atoms as follows:

(a) Fill the blanks.
   Molecular formula of hydrazine \( \text{N}_2\text{H}_4 \)
   Empirical formula hydrazine \( \text{NH}_2 \)

(b) Fill the blanks.
   Numeric Value: Unit:
   Molecular weight of hydrazine \( 32.05 \text{ amu} \)
   Molar mass of hydrazine \( 32.05 \text{ g} \)
   Average mass of hydrazine molecules in grams \( 5.32\times10^{-23} \text{ g} \)

2. (3 points) Fill the blanks in the following table.

<table>
<thead>
<tr>
<th></th>
<th>Bromine</th>
<th>Diamond</th>
<th>Sodium chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of molecules in 1.00 mole</td>
<td>(6.02\times10^{23})</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>The number of atoms in 1.00 mole</td>
<td>(1.20\times10^{24})</td>
<td>(6.02\times10^{23})</td>
<td>(1.20\times10^{24})</td>
</tr>
<tr>
<td>The number of elements in 1.00 mole</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>The number of substances in 1.00 mole</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>The number of compounds in 1.00 mole</td>
<td>none</td>
<td>none</td>
<td>1</td>
</tr>
<tr>
<td>The mass in grams of 1.00 mole</td>
<td>159.8</td>
<td>12.01</td>
<td>58.44</td>
</tr>
<tr>
<td>The volume in cm(^3) of 1.00 mole</td>
<td>51.5</td>
<td>3.41</td>
<td>26.9</td>
</tr>
</tbody>
</table>
3. (3 points) Briefly (in general terms) describe how one can distinguish between Na$_2$CO$_3$ and K$_2$CO$_3$ samples using the method employed in Experiment 3 “Identification of a Metal Carbonate”. Outline the measurements that should be taken and calculations that should be performed based on those measurements to tell the two samples apart.

**Measurements:**
1. masses of a small portions of each sample;
2. masses of CO$_2$ produced in the reactions of the portions of each carbonate with hydrochloric acid.

**Calculations:**
1. moles of CO$_2$ which are equal to moles of each carbonate reacted;
2. molar mass of each carbonate (grams of carbonate / moles of carbonate).

If the molar mass is close 105.99 g/mol, the sample is Na$_2$CO$_3$; if the molar mass is close 138.21 g/mol, the sample is K$_2$CO$_3$.

4. (6 points) 0.487 grams of an organic compound (molar mass is approximately 320 g/mol) is combusted and found to produce 1.321 g CO$_2$, 0.325 g H$_2$O and 0.0421 g N$_2$. Determine the empirical and molecular formulas of the compound.

\[
\begin{align*}
1.321 \text{ g CO}_2 & \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ mol C}}{1 \text{ mol CO}_2} \times \frac{12.01 \text{ g C}}{1 \text{ mol C}} = 0.360 \text{ g C} \\
0.325 \text{ g H}_2\text{O} & \times \frac{1 \text{ mol H}_2\text{O}}{18.01 \text{ g H}_2\text{O}} \times \frac{2 \text{ mol H}}{1 \text{ mol H}_2\text{O}} \times \frac{1.008 \text{ g H}}{1 \text{ mol H}} = 0.03638 \text{ g H} \\
0.0421 \text{ g N}_2 & = 0.0421 \text{ g N}
\end{align*}
\]

\[
\begin{align*}
\text{mass of O} & = 0.487 \text{ g} - 0.360 \text{ g} - 0.03638 \text{ g} - 0.0421 \text{ g} = 0.04852 \text{ g} \\
C & = 0.360 \text{ g} \times \frac{1 \text{ mol}}{12.01 \text{ g}} = 0.02998 \text{ mol} \text{ CO}_2 \approx 10 \text{ mol} \\
H & = 0.03638 \text{ g} \times \frac{1 \text{ mol}}{1.008 \text{ g}} = 0.03609 \text{ mol} \text{ H}_2\text{O} \approx 12 \text{ mol} \\
O & = 0.04852 \text{ g} \times \frac{1 \text{ mol}}{16.00 \text{ g}} = 0.003033 \text{ mol} \text{ CO}_2 \approx 1 \text{ mol} \\
N & = 0.0421 \text{ g} \times \frac{1 \text{ mol}}{14.01 \text{ g}} = 0.003005 \text{ mol} \text{ N}_2 \approx 1 \text{ mol}
\end{align*}
\]

Molar Mass from Empirical Formula = 162 g/mol

**Molecular Formula:** $(C_{10}H_{12}NO)_n$ \quad n = (320 g/mol) / (162 g/mol) \approx 2 \quad C_{20}H_{24}N_2O_2