Combustion Analysis problem

What's it look like

You are given: ***mass of sample*** with unknown formula, list of elements in the compound, ***masses of CO_2 and H_2O*** produced after ***combustion analysis***, possibly additional types of analysis.

Ex: A 0.1156 g sample of an unknown compound (composed of carbon, hydrogen, and nitrogen) combusts to form 0.1638 g of carbon dioxide and 0.1676 g of water. What is the empirical formula of this substance?

Concept behind it

This is basically an empirical formula problem starting with masses instead of percentages. However, you have to find the mass of each element in the compound from the products of the analysis.

How to tackle it

Some assumptions: ALL the C in the unknown compound is converted to CO_2 in the products, ALL the H is converted to H_2O, and if there are additional analyses performed, all of those additional elements are converted to the product they list (ex: S to $BaSO_4$ in a barium sulfate analysis). Find the amount of each element by multiplying its percent in the given product by the amount of that product produced. There is often one last element with no analysis. The mass for this element is found by subtracting the masses of the other elements from the initial sample. Then proceed with finding an empirical formula: convert grams to moles, divide by smallest mole amount, assign subscripts.

Detailed steps (steps 2-6 below appear on "Emipirical Formula How To" sheet in greater detail)

1) Find grams of each element in unknown compound by multiplying the grams of the product which includes that element by that element's percent in that product. Ex: Since ALL of the C in the reactant goes to CO_2 in the products, if you find the amt. of C in the CO_2 in the products, you also know how much C you started with.
2) Convert grams of each element to moles (divide the grams of each element by its atomic mass)
3) Find the smallest number of moles and divide all the mole amounts by this number.
4) ***If*** any numbers are common fractions, multiply all numbers by factor to make numbers integers.
5) Use these integers as your subscripts in your empirical formula.
6) If a molecular formula is required, divide molar mass by empirical mass and multiply subscripts by this factor.

Example (continued from above):

Finding grams of reactants in products (and therefore also in original compound):

$$C: 0.1638\ g\ CO_2 \cdot \frac{12.011\ g\ C}{44.011\ g\ CO_2} = 0.0447025\ g\ C$$

$$H: 0.1676\ g\ H_2O \cdot \frac{2.0158\ g\ H}{18.0158\ g\ H_2O} = 0.0187529\ g\ H$$

$$N: 0.1156\ g\ (unk.\ compound) - 0.0447025\ g\ C - 0.0187529\ g\ H = 0.0521446\ g\ N$$

Converting grams to moles and dividing by smallest mol amount:

$$C: 0.0447025\ g\ C \cdot \frac{1\ mol\ C}{12.011\ g\ C} = 0.0037217967\ mol\ C \quad /0.0037217967 = 1$$

$$H: 0.0187529\ g\ H \cdot \frac{1\ mol\ H}{1.0079\ g\ H} = 0.0186059133\ mol\ H \quad /0.0037217967 = 5$$

$$N: 0.0521446\ g\ N \cdot \frac{1\ mol\ N}{14.007\ g\ N} = 0.0037227529\ mol\ N \quad /0.0037217967 = 1$$

Empirical formula: CH_5N or CH_3NH_2