Empirical Formula Notes

Shows the smallest whole number ratio of atoms of each element in a compound. Also called the simplest formula. Empirical formula can be calculated from percentage composition data.

Textbook Empirical formula is explained on pages 87-94 in your textbook (McGraw-Hill Ryerson Chemistry).

Question 8 on the mole calculations worksheet deals with empirical formula.

Questions 8a) 80.0% carbon, 20.0% hydrogen

Step 1 Assume a 100 g sample and calculate the mass of each element in the sample. A 100 g s ample is chosen for convenience – it makes converting from percentage to mass simple.

80.0 g carbon 20.0 g hydrogen

Step 2 Calculate moles of each element. Chemical formulas are written in terms of atoms of each element or moles of atoms of each element.

$$\frac{80.0\ \text{g carbon}}{12.011\ \text{g/mol}} \qquad \frac{20.0\ \text{g hydrogen}}{1.00794\ \text{g/mol}}$$

6.66056 mol C 19.84245 mol H

Step 3 Now you have a mole ratio, but it is not whole numbers. Divide all results by the smallest answer – this will give you at least one whole number.

$$\frac{6.66056\ \text{mol C}}{6.66056} \qquad \frac{19.84245\ \text{mol H}}{6.66056}$$

1.00 2.979

Because the data is experimental, the results are often not exact. If the number, when rounded to one decimal place is a whole number, that is close enough. 2.979 – if you round this to one decimal place, the nine would round up as it is followed by a 7, giving you 3.0, which is a whole number. Therefore the ratio of C:H is 1:3 and the empirical formula is

CH_3

Step 4 If you do not get a whole number from step 3, multiply by a whole number in order to produce a whole number ratio.

8b) 35.0% nitrogen 5.0% hydrogen 60.0% oxygen

Step 1 Convert percentages to mass based on a 100 g sample
Step 2 Convert mass to moles

$\frac{35.0\ g\ N}{14.0067\ g/mol}$	$\frac{5.0\ g\ H}{1.00794\ g/mol}$	$\frac{60.0\ g\ O}{15.9994\ g/mol}$
2.4988 mol N	4.9606 mol H	3.7501 mol O

Step 3 Divide by the smallest

$\frac{2.4988\ mol\ N}{2.4988}$	$\frac{4.9606\ mol\ H}{2.4988}$	$\frac{3.7501\ mol\ O}{2.4988}$
1.00	1.985	1.500

The nitrogen is a whole number (1.00) and the hydrogen will round to a whole number (2.00), but the oxygen is not a whole number

1	2	1.500

Step 4 Multiply to get a whole number. In order to turn 1.5 into a whole number, we need to multiply by 2 – therefore all results must be multiplied by 2.

2	4	3

Final Answer: 2:4:3, therefore the empirical formula is $N_2H_4O_3$