EMPIRICAL FORMULAE 1

1 Benzene has the molecular formula C_6H_6. Its empirical formula is CH. Explain what each of these formulas tells us about benzene.

molecular formula: 6C & 6H atoms in each molecule
empirical formula: ratio of C:H is 1:1

2 The empirical formula of sodium chloride is NaCl. It does not have a molecular formula. Explain why sodium chloride does not have a molecular formula.

It is an ionic substance and is not made of molecules

3 The following ratios are taken from experimental (i.e. not perfect) data. Write the simplest whole number ratio for each one.
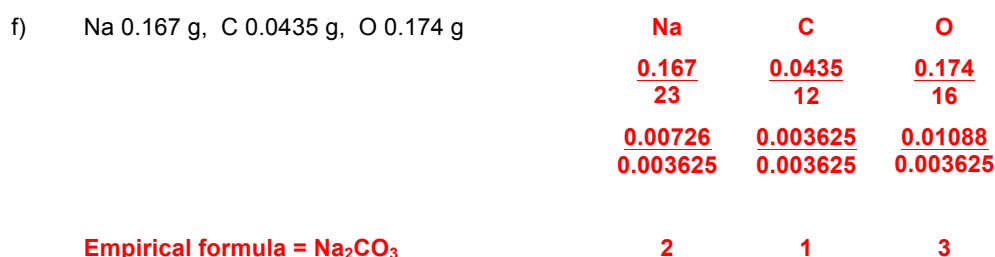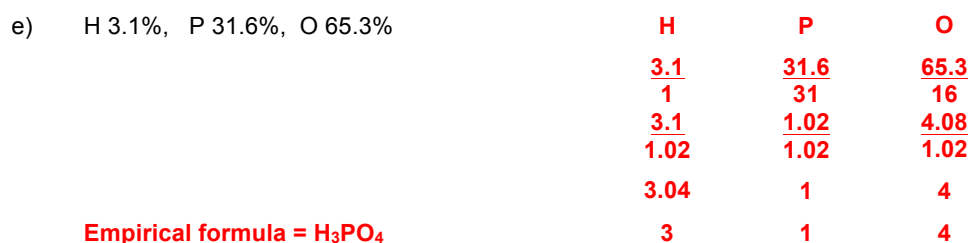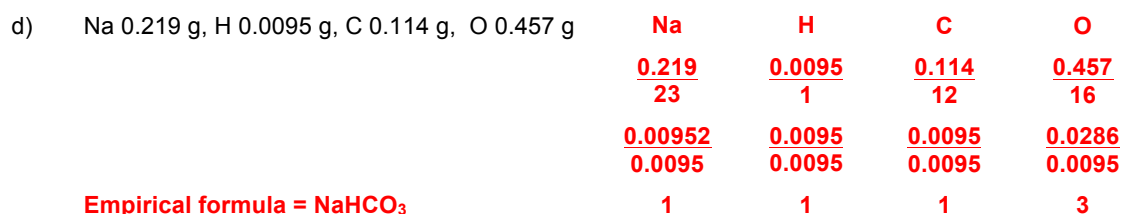
a) 2.5 : 1   **5 : 2**   e) 1.68 : 1   **5 : 3**

b) 1.33 : 1   **4 : 3**   f) 1 : 2.53   **2 : 5**

c) 1 : 2.67   **3 : 8**   g) 1.65 : 1   **5 : 3**

d) 1.48 : 1   **3 : 2**   h) 1.74 : 1   **7 : 4**

4 Find the empirical formula of each of the following substances.

a)   N 82.4%,   H 17.6%

	N	**H**
	$\frac{82.4}{14}$	$\frac{17.6}{1}$
	$\frac{5.89}{5.89}$	$\frac{17.6}{5.89}$
Empirical formula = NH$_3$	**1**	**3**

b)   C 1.24 g   H 0.26 g

	C	**H**
	$\frac{1.24}{12}$	$\frac{0.26}{1}$
	$\frac{0.103}{0.103}$	$\frac{0.26}{0.103}$
	1	**2.52**
Empirical formula = C$_2$H$_5$	**2**	**5**

c)   Al 52.9%,   O 47.1%

	Al	**O**
	$\frac{52.9}{27}$	$\frac{47.1}{16}$
	$\frac{1.96}{1.96}$	$\frac{2.94}{1.96}$
	1	**1.5**
Empirical formula = Al$_2$O$_3$	**2**	**3**

d) Na 0.219 g, H 0.0095 g, C 0.114 g, O 0.457 g

Na	H	C	O
$\dfrac{0.219}{23}$	$\dfrac{0.0095}{1}$	$\dfrac{0.114}{12}$	$\dfrac{0.457}{16}$
$\dfrac{0.00952}{0.0095}$	$\dfrac{0.0095}{0.0095}$	$\dfrac{0.0095}{0.0095}$	$\dfrac{0.0286}{0.0095}$
1	1	1	3

Empirical formula = $NaHCO_3$

e) H 3.1%, P 31.6%, O 65.3%

H	P	O
$\dfrac{3.1}{1}$	$\dfrac{31.6}{31}$	$\dfrac{65.3}{16}$
$\dfrac{3.1}{1.02}$	$\dfrac{1.02}{1.02}$	$\dfrac{4.08}{1.02}$
3.04	1	4
3	1	4

Empirical formula = H_3PO_4

f) Na 0.167 g, C 0.0435 g, O 0.174 g

Na	C	O
$\dfrac{0.167}{23}$	$\dfrac{0.0435}{12}$	$\dfrac{0.174}{16}$
$\dfrac{0.00726}{0.003625}$	$\dfrac{0.003625}{0.003625}$	$\dfrac{0.01088}{0.003625}$
2	1	3

Empirical formula = Na_2CO_3

5) 0.150 g of copper reacts with oxygen form 0.188 g of copper oxide. Find the empirical formula of copper oxide.

Mass Cu = 0.150 g

Mass O = 0.188 – 0.150 = 0.038 g

Cu	O
$\dfrac{0.150}{63.5}$	$\dfrac{0.038}{16}$
$\dfrac{0.00236}{0.00236}$	$\dfrac{0.002375}{0.00236}$
1	1

Empirical formula = CuO
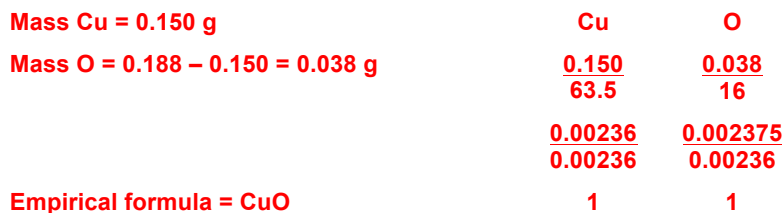
6) 1.00 g of phosphorus reacts with fluorine form 2.84 g of phosphorus fluoride. Find the empirical formula of phosphorus fluoride.

Mass P = 1.00 g

Mass O = 2.84 – 1.00 = 1.84 g

P	F
$\dfrac{1.00}{31}$	$\dfrac{1.84}{19}$
$\dfrac{0.0323}{0.0323}$	$\dfrac{0.0968}{0.0323}$
1	3

Empirical formula = PF_3
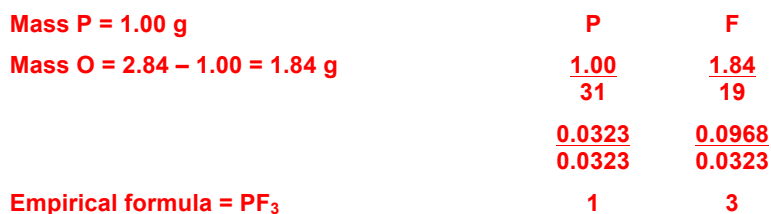
Area	Strength	To develop	Area	Strength	To develop
Done with care and thoroughness			Understands why NaCl does not have molecular formula		
Shows suitable working			Can convert ratios to whole number ratios		
Understands the difference between empirical & molecular formulae			Can use composition data to work out empirical formula		