**Chapter 1**

**Solutions to review problems**

1 Caproic acid, responsible for the distinctive smell of old socks, contains C, H and O. On combustion in an excess of oxygen, 0.45 g caproic acid gives 0.418 g water, and 1.023 g carbon dioxide. What is the empirical formula of caproic acid? The relative molecular mass is 116.2; what is the molecular formula?

0.418 g water contains 2/18 x 0.418 g H

= 0.04644 g

So % H in caproic acid is

(0.04644/0.45) x 100 = 10.3 %

1.023 g carbon dioxide contains

12/44 x 1.023 g C = 0.279 g

So % C in caproic acid = 62%

Remainder must be oxygen = 27.7 %

Relative number of atoms of

C = 62/12 = 5.167

H = 10.3/1 = 10.3

O = 27.7/16 = 1.73

Dividing through by the lowest number

C 2.99

H 5.95

O 1

Empirical formula is C3H6O

Mass of C3H6O is 36+6+16 = 58

Molecular mass is 116, so molecular formula is C6H12O2

2 One form of Vitamin A, retinol, has the following percentage composition. Derive its empirical formula

83.9 % C

10.5 % H

5.6 % O

Relative # atoms C = 83.9/12 = 6.99

Relative # atoms H = 10.5

Relative # atoms O = 5.6/16 = 0.35

Dividing through by 0.35

C 19.97

H 30

O 1

So empirical formula is C20H30O

Retinol has the structure:



3 The alkaloid morphine has been shown to contain only C, H, N and O. Morphine contains, according to elemental analysis, 71.6 % C, 6.7 % H and 4.9 % N by weight. What is the empirical formula of morphine?

To do this problem we first need to divide the percentages by the appropriate atomic weights to get the relative numbers of atoms of each type.

Relative # C = 71.6/12 = 5.97

Relative # H = 6.7/1 = 6.7

Relative # N = 4.9/14 = 0.35

Relative # O = 16.8/16 = 1.05

Now divide through by the smallest number (0.35)

Relative # C = 5.97/0.35 = 17

Relative # H = 6.7/0.35 = 19

Relative # N = 0.35/0.35 = 1

Relative # O = 1.05/0.35 = 3

So empirical formula of morphine is C17H19NO3

4 Write the electronic configuration for the ground state of each of the following species (show the contents of px, py and pz orbitals where appropriate):

 (a) Li+ (b) N (c) S (d) Ga (b) F- (c) Cl (d) K (e) Br

Li+ 1s2

N 1s22s22px12py12pz1

S [Ne] 3s23px23py13pz1 or 1s22s22p63s23px23py13pz1

Ga [Ar] 3d104s24p1 or 1s12s22p63p63d104s24p1

F- 1s22s22px22py22pz2

Cl[Ne] 3s23px23py23pz1 or 1s22s22p63s23px23py23pz1

K [Ne] 4s1 or 1s22s22p63s23p64s1

Br [Ar] 3d104s24px24py24pz1  or 1s22s22p63s23p63d104s24px24py24pz1

5 Which element corresponds with each of the following electronic configurations?

 (a) 1s22s2

 (b) 1s22s22p6

(a) 1s22s2 Be

(b) 1s22s22p6 Ne

6 The density of oak wood is 0.72 g cm-3. Assume oak wood has the formula C6H12O6 and calculate the mass of water produced when a dry log 12 cm x 14 cm x 25 cm is burned.

1.8 kg

7 What are the principal and orbital angular momentum quantum numbers for each of the following orbitals?

(a) 2s

(b) 6f

(a) 2s n = 2, l = 0

(b) 6f n = 6, l = 3

8 Why does N have a less favourable electron affinity than its neighbors on either side in the Periodic Table, carbon and oxygen?

Half-filled p-shell has additional stability

9 Cytochrome-c is an iron-containing enzyme found in the cells of all aerobic organisms. If cytochrome-c is 0.43 % Fe by weight, what is the minimum molecular weight of cytochrome‑c?

There must be at least one iron atom in the cytochrome. 0.43 % iron, which has an atomic weight of 55.845

Thus 55.845/Mol wt = 4.3 x 10-3

Thus molecular weight = 55.845 x 103/4.3 = 12987

10 Calculate the % composition of Tylenol, C8H9NO2

C 63.6 %; H 6.0 %; N 9.3 %; O 21.2 %

11 Explain clearly, in terms of molecular orbitals, why the molecule He2 does not exist, but [He2]+ does.

He2 σ1s2 σ\*1s2, therefore no net bonding

[He2]+ σ1s2 σ\*1s1 , therefore half a net bond