KEY

pirical and Molecular Formula Problems Name KEY

1. The insecticide DDT has the following composition by mass: 47.5 % C, 2.54 % H, and 50.0 % Cl. Determine the empirical formula of DDT.

Multiply all by 2 – not better, then 3
Need to be closer than 0.1, if possible – lab data
Give good lab data on test

$\frac{47.5\,g\,C}{1}\Big|\frac{1\,mole\,C}{12.01\,g\,C} = \frac{3.96\,mol\,C}{1.41} = 2.81 \times 5 = 14.1$

$\frac{2.54\,g\,H}{1}\Big|\frac{1\,mole\,H}{1.01\,g\,H} = \frac{2.51\,mol\,H}{1.41} = 1.78 \times 5 = 8.90$

$\frac{50.0\,g\,Cl}{1}\Big|\frac{1\,mole\,Cl}{35.45\,g\,Cl} = \frac{1.41\,mol\,Cl}{1.41} = 1 \times 5 = 5$

$C_{14}H_9Cl_5$

$C_{14}H_9Cl_5$

2. A compound gave on analysis the following percent composition: K = 26.57 %, Cr = 35.36 %, O = 38.07 %. Derive the empirical formula of the compound.

$\frac{26.57\,g\,K}{1}\Big|\frac{1\,mole\,K}{39.10\,g\,K} = \frac{.6795\,mol\,K}{.6795} = 1 \times 2 = 2$

$\frac{35.36\,g\,Cr}{1}\Big|\frac{1\,mole\,Cr}{52.00\,g\,Cr} = \frac{.6800\,mol\,Cr}{.6795} = 1.001 \times 2 = 2$

$\frac{38.07\,g\,O}{1}\Big|\frac{1\,mole\,O}{16.00\,g\,O} = \frac{2.379\,mol\,O}{.6795} = 3.501 \times 2 = 7.$

$K_2Cr_2O_7$

3. A compound has the following percent composition: C = 40.0 %, H = 6.67 %, O = 53.3 %. Its molar mass is 60.0 g/mole. Derive its empirical and molecular formulas.

Empirical: CH_2O
Molecular: $C_2H_4O_2$

$\frac{40.0\,g\,C}{1}\Big|\frac{1\,mole\,C}{12.01\,g\,C} = \frac{3.33\,mol\,C}{3.33} = 1\,mol\,C$

$\frac{6.67\,g\,H}{1}\Big|\frac{1\,mole\,H}{1.01\,g\,H} = \frac{6.60\,mol\,H}{3.33} = 1.98\,mol\,H$

$\frac{53.3\,g\,O}{1}\Big|\frac{1\,mole\,O}{16.00\,g\,O} = \frac{3.33\,mol\,O}{3.33} = 1\,mol\,O$

CH_2O

$1\,C \times 12.01 = 12.01\,g$
$2\,H \times 1.01 = 2.02\,g$
$1\,O \times 16.00 = \underline{16.00\,g}$
$30.03\,g/mol \times \underline{2} = 60.0\,g/mol$

4. Determine the empirical formula and the molecular formula of a hydrocarbon which has a molar mass of 84.0 grams and contains 85.7 % carbon. (A hydrocarbon is a compound that contains only carbon and hydrogen.)

$\frac{85.7\,g\,C}{1}\Big|\frac{1\,mol\,C}{12.01\,g\,C} = \frac{7.14\,mol\,C}{7.14} = 1\,mol\,C$

Empirical CH_2
Molecular C_6H_{12}

$\frac{14.3\,g\,H}{1}\Big|\frac{1\,mol\,H}{1.01\,g\,H} = \frac{14.2\,mol\,H}{7.14} = 1.99\,mol\,H \approx 2\,mol\,H$

CH_2

$1\,C \times 12.01 = 12.01\,g$
$2\,H \times 1.01 = \underline{2.02\,g}$
$14.03\,g \times \underline{\sim 6} = 84.0\,g$

– Multiply empirical formula by $\underline{6}$

5. **A sample of a pure compound contains 2.04 g of sodium, 2.65×10^{22} atoms of carbon, and 0.132 mole of oxygen atoms. Find the empirical formula. (Think in terms of moles.)**

$\frac{2.04\,g\,Na}{1} \times \frac{1\,mol}{22.99\,g} = \frac{.0887\,mol\,Na}{.0440} = 2.02$

$\frac{2.65 \times 10^{22}\,atoms\,C}{1} \times \frac{1\,mol\,C}{6.02 \times 10^{23}\,atoms} = \frac{.0440\,mol\,C}{.0440} = 1$ $\quad Na_2CO_3$

$\frac{.132\,mol\,O}{.0440} = 3$

6. **A 2.500 g sample of uranium was heated in the air. The resulting oxide weighed 2.949 g. Determine the empirical formula of the compound.**

$2.949\,g - 2.500 = .449\,g$ Oxygen

$\frac{.449\,g\,O}{1} \times \frac{1\,mol\,O}{16.00\,g} = \frac{.0281\,mol\,O}{.01050} = 2.68 \times 3 = 8.04$

$\frac{2.500\,g\,U}{1} \times \frac{1\,mol\,U}{238.03\,g} = \frac{.01050}{.01050} = 1 \times 3 = 3$ $\quad U_3O_8$

7. **Determine the simplest formula of a compound that has the following composition:**

Cr = 26.52 %, S = 24.52 %, O = 48.96 %

$\frac{26.52\,g\,Cr}{1} \Big| \frac{1\,mol\,Cr}{52.00\,g\,Cr} = \frac{0.5100\,mol\,Cr}{0.5100} = 1\,mol\,Cr \times 2 = 2\,mol\,Cr$

$\frac{24.52\,g\,S}{1} \Big| \frac{1\,mol\,S}{32.07\,g\,S} = \frac{0.7646\,mol\,S}{0.5100} = 1.499\,mol\,S \times 2 = \sim 3\,mol\,S$ $\quad Cr_2S_3O_{12}$

$\frac{48.96\,g\,O}{1} \Big| \frac{1\,mol\,O}{16.00\,g\,O} = \frac{3.060\,mol\,O}{0.5100} = 6\,mol\,O \times 2 = 12\,mol\,O$

8. **A compound contains 63.1 % carbon, 11.92 % hydrogen, and 24.97 % fluorine. Derive its empirical formula.**

$\frac{63.1\,g\,C}{1} \Big| \frac{1\,mol\,C}{12.01\,g\,C} = \frac{5.25\,mol\,C}{1.314} = \sim 4\,mol\,C$

$\frac{11.92\,g\,H}{1} \Big| \frac{1\,mol\,H}{1.01\,g\,H} = \frac{11.8\,mol\,H}{1.314} = \sim 9\,mol\,H$ $\quad C_4H_9F$

$\frac{24.97\,g\,F}{1} \Big| \frac{1\,mol\,F}{19.00\,g\,F} = \frac{1.314\,mol\,F}{1.314} = 1\,mol\,F$

9. **A compound with a molar mass of about 175 grams/mole consists of 40.0 % carbon, 6.7 % hydrogen, and 53.3 % oxygen. What is the empirical and molecular formula of the compound?**

$\frac{40.0\,g\,C}{1} \Big| \frac{1\,mole\,C}{12.01\,g\,C} = \frac{3.33\,mol\,C}{3.33} = 1\,mol\,C$

$\frac{6.7\,g\,H}{1} \Big| \frac{1\,mole\,H}{1.01\,g\,H} = \frac{6.6\,mol\,H}{3.33} = 2.0\,mol\,H$

$\frac{53.3\,g\,O}{1} \Big| \frac{1\,mol\,O}{16.00\,g\,O} = \frac{3.33\,mol\,O}{3.33} = 1\,mol\,O$

CH_2O

$C = 12.01 \times 1 = 12.01\,g$

$H = 1.01 \times 2 = 2.02\,g$

$O = 16.00 \times 1 = 16.00\,g$

$\sim 6 \quad \frac{30.03\,g/mol}{175}$ ×

Empirical CH_2O

Molecular $C_6H_{12}O_6$