Applications of Stoichiometry

1. How many grams of calcium chloride can be prepared from 60.4 g of calcium oxide and 69.0 g of hydrochloric acid in a double displacement reaction?

$$\underset{60.4\,g}{CaO} + \underset{69.0\,g}{2\,HCl} \rightarrow \underset{?}{CaCl_2} + H_2O$$

$$\left(\frac{60.4\ g\ CaO}{56.0774\ g/mol}\right)\left(\frac{1\ mol\ CaCl_2}{1\ mol\ CaO}\right)\left(110.984\ \frac{g}{mol}\right) = 120.\ g$$

$$\left(\frac{69.0\ g\ HCl}{36.46094\ g/mol}\right)\left(\frac{1\ mol\ CaCl_2}{2\ mol\ HCl}\right)\left(110.984\ \frac{g}{mol}\right) = 105\ g$$

$\therefore$ 105 g of $CaCl_2$ can be prepared

2. How many grams of aluminum sulfate form when 6.71 g of aluminum reacts with 12.95 g of sulfuric acid?

$$\underset{6.71\,g}{2\,Al} + \underset{12.95\,g}{3\,H_2SO_4} \rightarrow \underset{?\ mass}{Al_2(SO_4)_3} + 3\,H_2$$

$$\left(\frac{6.71\ g\ Al}{26.98154\ g/mol}\right)\left(\frac{1\ mol\ Al_2(SO_4)_3}{2\ mol\ Al}\right)\left(342.15388\ \frac{g}{mol}\right) = 42.5\ g$$

$$\left(\frac{12.95\ g\ H_2SO_4}{98.07948\ g/mol}\right)\left(\frac{1\ mol\ Al_2(SO_4)_3}{3\ mol\ H_2SO_4}\right)\left(342.15388\ \frac{g}{mol}\right) = 15.06\ g$$

$\therefore$ 15.06 g $Al_2(SO_4)_3$ form

3. Aspirin, $C_9H_8O_4$, is prepared by heating salicylic acid, $C_7H_6O_3$, with acetic anhydride, $C_4H_6O_3$:

$$C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2$$

If 4.00 g of salicylic acid are heated with 8.00 g of acetic anhydride, what is the theoretical yield? If the actual yield of aspirin is 4.36 g, what is the percent yield?

$$\left(\frac{4.00\ g\ C_7H_6O_3}{138.12284\ g/mol}\right)\left(\frac{1\ mol\ C_9H_8O_4}{1\ mol\ C_7H_6O_3}\right)\left(180.16012\ \frac{g}{mol}\right) = 5.22\ g$$

$$\left(\frac{8.00\ g\ C_4H_6O_3}{102.08984\ g/mol}\right)\left(\frac{1\ mol\ C_9H_8O_4}{1\ mol\ C_4H_6O_3}\right)\left(180.16012\ \frac{g}{mol}\right) = 14.1\ g$$

$\therefore$ 5.22 g Aspirin produced = theoretical yield

$$\%\ yield = \frac{4.36}{5.22} \times 100 = 83.6\ \%\ yield$$

4. Oil of wintergreen (methyl salicylate) is prepared by heating salicylic acid, $C_7H_6O_3$, with methanol, CH_3OH:

$$C_7H_6O_3 + CH_3OH \rightarrow C_8H_8O_3 + H_2O$$

If 4.50 g of salicylic acid is reacted with excess methanol and the yield of oil of wintergreen is 3.73 g, what is the percent yield?

$$\left(\frac{4.50\text{ g } C_7H_6O_3}{138.122\,84\text{ g/mol}}\right)\left(\frac{1\text{ mol } C_8H_8O_3}{1\text{ mol } C_7H_6O_3}\right)\left(152.149\,72\frac{\text{g}}{\text{mol}}\right) = 4.96\text{ g}$$

$$\%\text{ yield} = \frac{3.73\text{ g}}{4.96\text{ g}} \times 100 = 75.2\%\text{ yield}$$

5. In an experiment 10.80 g of butanoic acid, $C_4H_8O_2$, was heated with 3.40 g of ethanol, C_2H_5OH, to produce ethyl butanoate, $C_6H_{12}O_2$, and water. What is the theoretical yield of the ethyl butanoate? If the actual yield was 5.57 g, what is the percent yield?

$$C_4H_8O_2 + C_2H_5OH \rightarrow C_6H_{12}O_2 + H_2O$$

10.80 g   3.40 g   ? mass

$$\left(\frac{10.80\text{ g } C_4H_8O_2}{88.106\,32\text{ g/mol}}\right)\left(\frac{1\text{ mol } C_6H_{12}O_2}{1\text{ mol } C_4H_8O_2}\right)\left(116.160\,08\frac{\text{g}}{\text{mol}}\right) = 14.24\text{ g}$$

$$\left(\frac{3.40\text{ g } C_2H_5OH}{46.069\,04\text{ g/mol}}\right)\left(\frac{1\text{ mol } C_6H_{12}O_2}{1\text{ mol } C_2H_5OH}\right)\left(116.160\,08\frac{\text{g}}{\text{mol}}\right) = 8.57\text{ g}$$

theoretical yield = 8.57 g $\%\text{ yield} = \frac{5.57}{8.57} \times 100 = 65.0\%\text{ yield}$

6. Phosphorus oxide is extracted from phosphate-containing rocks by reaction with silicon dioxide found in sand:

$$2Ca_3(PO_4)_2 + 6SiO_2 \rightarrow 6CaSiO_3 + P_4O_{10}$$

If 1.00 t of sand that is 60.0 silicon dioxide is used, how many kilograms of tetraphosphorus decoxide could be produced?

$$(1.00\text{ t})(0.600) = 0.600\text{ t } SiO_2 = 600.\text{ kg} = 6.00\times10^5\text{ g } SiO_2$$

$$\left(\frac{6.00\times10^5\text{ g } SiO_2}{60.0843\text{ g/mol}}\right)\left(\frac{1\text{ mol } P_4O_{10}}{6\text{ mol } SiO_2}\right)\left(283.889\,04\frac{\text{g}}{\text{mol}}\right) = 472\,000\text{ g}$$

$$= 472\text{ kg } P_4O_{10}$$

7. A tank of impure carbon monoxide contains 6.8 g of oxygen impurity per 100.0 kg of gas. The oxygen is removed by reacting it with cobalt(II) oxide:

$$4CoO + O_2 \rightarrow 2Co_2O_3$$

How many grams of impure gas can be purified by passing it through a column containing 47.9 g of cobalt(II) oxide?

$$\left(\frac{47.9 \text{ g CoO}}{74.9326 \text{ g/mol}}\right)\left(\frac{1 \text{ mol } O_2}{4 \text{ mol CoO}}\right)\left(31.9988 \frac{\text{g}}{\text{mol}}\right) = 5.11 \text{ g } O_2$$

$$\frac{5.11 \text{ g } O_2}{x \text{ kg gas}} = \frac{6.8 \text{ g } O_2}{100.0 \text{ kg gas}} \qquad x = 75.2 \text{ kg gas can be purified}$$

8. Titanium is produced from the mineral rutile, TiO_2, by a two-step process:

$$TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$$

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

How many kilograms of titanium can be obtained from 1.00 t of rutile?

$$1 \text{ t rutile} = 1000 \text{ kg} = 1.00 \times 10^6 \text{ g rutile}$$

$$\left(\frac{1.00 \times 10^6 \text{ g}}{79.8788 \text{ g/mol}}\right)\left(\frac{1 \text{ mol } TiCl_4}{1 \text{ mol } TiO_2}\right)\left(\frac{1 \text{ mol Ti}}{1 \text{ mol } TiCl_4}\right)\left(47.88 \frac{\text{g}}{\text{mol}}\right)$$

$$= 599\,408.1033 \text{ g}$$

$$\doteq 599 \text{ kg Ti}$$

9. Antimony is usually found as the mineral stibnite, Sb_2S_3. Pure antimony can be obtained by a two-step process:

$$2Sb_2S_3 + 9O_2 \rightarrow Sb_4O_6 + 6SO_2$$

$$Sb_4O_6 + 6C \rightarrow 4Sb + 6Co$$

How many grams of antimony can be obtained from 1.00 kg of stibnite?

$$\left(\frac{1.00 \times 10^3 \text{ g } Sb_2S_3}{339.698 \text{ g/mol}}\right)\left(\frac{1 \text{ mol } Sb_4O_6}{2 \text{ mol } Sb_2S_3}\right)\left(\frac{4 \text{ mol Sb}}{1 \text{ mol } Sb_4O_6}\right)\left(121.75 \frac{\text{g}}{\text{mol}}\right)$$

$$= 717 \text{ g Sb}$$

10. Coal from a certain mine contains 2.80% sulfur. When the coal is burned at a power generating station, the sulfur is converted to calcium sulfite. If 1200.0 t of coal is burned at the power plant each day, what is the daily output of calcium sulfite?

$$S + O_2 \rightarrow SO_2$$
$$SO_2 + CaO \rightarrow CaSO_3$$

$$(1200.0\,t)(0.0280) = 33.6\,t\ S = 3.36 \times 10^7\,g\ S$$

$$\left(\frac{3.36 \times 10^7\,g\ S}{32.066\,g/mol}\right)\left(\frac{1\ mol\ SO_2}{1\ mol\ S}\right)\left(\frac{1\ mol\ CaSO_3}{1\ mol\ SO_2}\right)\left(120.1422\,\frac{g}{mol}\right)$$
$$= 125\ 889\ 662.6\ g$$
$$= 126\ t\ CaSO_3 \text{ per day}$$

11. The mass percentage of chloride ion in a 25.00 mL sample of seawater was determined by titrating the sample with silver nitrate, causing the precipitation of silver chloride. It required 42.58 mL of 0.2997 M silver nitrate solution to reach the equivalence point in the titration. What is the mass percentage of chloride ion in the seawater if its density is 1.025 g/mL?

$$Cl^- + AgNO_3 \rightarrow AgCl + NO_3^-$$

? mass — 42.58 mL, 0.2997 M

$$mol = C \cdot V = \left(0.2997\,\frac{mol}{L}\right)(0.04258\,L) = 0.01276\ mol\ AgNO_3$$

$$(0.1276\ mol\ AgNO_3)\left(\frac{1\ mol\ Cl^-}{1\ mol\ AgNO_3}\right)\left(35.453\,\frac{g}{mol}\right) = \sout{4.52}\ 0.4525\ g\ Cl^-$$

$$\text{mass of seawater} = (25.00\,mL)\left(1.025\,\frac{g}{mL}\right) = 25.625\,g$$

$$\%\ Cl^- = \frac{\text{mass } Cl^-}{\text{total mass}} \times 100 = \frac{\sout{4.52\,g}\ 0.452}{25.625\,g} \times 100 = \sout{17.7}\ 1.77\ \%\ Cl^-$$

12. Aspirin ($C_9H_8O_4$) is produced commercially from salicylic acid ($C_7H_6O_3$) and acetic anhydride ($C_4H_6O_3$) according to the equation:

$$C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2$$

a) If all of the salicylic acid is converted to aspirin, how much salicylic acid is required to prepare 175 kg of aspirin?

$$\left(\frac{1.75\times10^5\text{ g } C_9H_8O_4}{180.16012\text{ g/mol}}\right)\left(\frac{1\text{ mol } C_7H_6O_3}{1\text{ mol } C_9H_8O_4}\right)\left(138.12284\ \frac{\text{g}}{\text{mol}}\right) = 134\,166.745\text{ g}$$

$$= 134\text{ kg}$$

b) If only 75.0% of the salicylic acid is converted to aspirin, how much salicylic acid would be required to prepare 175 kg of aspirin?

$$\frac{134\text{ kg}}{x} = \frac{75.0}{100.0} \qquad x = 179\text{ kg salicylic acid needed}$$

c) If salicylic acid costs \$10.00/kg and acetic anhydride costs \$13.00/kg, which compound would you choose as the limiting reactant in order to have the most economical process? Justify your answer.

The acetic anhydride costs more, therefore you should use as little as possible, and it should be the limiting reactant.

d) What is the theoretical yield of aspirin if 205 kg of salicylic acid are allowed to react with 140.0 kg of acetic anhydride?

$$\left(\frac{2.05\times10^5\text{ g } C_7H_6O_3}{138.12284\text{ g/mol}}\right)\left(\frac{1\text{ mol } C_9H_8O_4}{1\text{ mol } C_7H_6O_3}\right)\left(180.16012\ \frac{\text{g}}{\text{mol}}\right) = 267\,391.1\text{ g}$$

$$\left(\frac{1.400\times10^5\text{ g } C_4H_6O_3}{102.08984\text{ g/mol}}\right)\left(\frac{1\text{ mol } C_9H_8O_4}{1\text{ mol } C_4H_6O_3}\right)\left(180.16012\ \frac{\text{g}}{\text{mol}}\right) = 247\,060.99\text{ g}$$

theoretical yield = 247 kg aspirin

e) If the actual yield of aspirin from part (d) is 202 kg, what is the percent yield?

$$\%\text{ yield} = \frac{202\text{ kg}}{247\text{ kg}}\times 100 = 81.8\ \%\text{ yield}$$

f) What would you have to charge for a kilogram of aspirin to cover the cost of the raw materials? (Ignore the cost of labour, electricity, machinery, taxes, etc.)

$$\left(\frac{1000\text{ g } C_9H_8O_4}{180.16012\text{ g/mol}}\right)\left(\frac{1\text{ mol } C_7H_6O_3}{1\text{ mol } C_9H_8O_4}\right)\left(138.12284\ \frac{\text{g}}{\text{mol}}\right) = 767\text{ g } C_7H_6O_3\text{ needed}$$

$$\left(\frac{1000\text{ g } C_9H_8O_4}{180.16012\text{ g/mol}}\right)\left(\frac{1\text{ mol } C_4H_6O_3}{1\text{ mol } C_9H_8O_4}\right)\left(102.08984\ \frac{\text{g}}{\text{mol}}\right) = 567\text{ g } C_4H_6O_3\text{ needed}$$

$$(0.767\text{ kg } C_7H_6O_3)(\$10.00/\text{kg}) + (0.567\text{ kg } C_4H_6O_3)(\$13.00/\text{kg}) = \$15.0/\text{kg aspirin}$$

13. The Solvay process is an important commercial method of preparing sodium carbonate. In the first step of this process, ammonia, water and carbon dioxide react to produce ammonium bicarbonate. This product is then treated in the second step with sodium chloride to allow conversion to sodium bicarbonate. Finally, the sodium bicarbonate is heated, and sodium carbonate, carbon dioxide, and water are produced. If this process is initiated with a stream of ammonia flowing at the rate of 40.0 L/s, at what rate must carbon dioxide be supplied in the first step? How much sodium chloride (in grams per second) is required to permit the second step to occur as required? Finally, how much sodium carbonate (in grams), and how much carbon dioxide (in litres), are formed every second under these conditions?

$$NH_3 + H_2O + CO_2 \rightarrow NH_4HCO_3$$

$$NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl$$

$$2\,NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$$

$$\left(\frac{40.0\text{ L }NH_3}{22.4\text{ L/mol}}\right)\left(\frac{1\text{ mol }CO_2}{1\text{ mol }NH_3}\right)\left(22.4\frac{\text{L}}{\text{mol}}\right) = 40.0\text{ L }CO_2$$

1st step → CO_2 must be supplied at 40.0 L/s.

$$\left(\frac{40.0\text{ L }NH_3}{22.4\text{ L/mol}}\right)\left(\frac{1\text{ mol }NH_4HCO_3}{1\text{ mol }NH_3}\right)\left(\frac{1\text{ mol }NaCl}{1\text{ mol }NH_4HCO_3}\right)\left(58.442\,77\frac{\text{g}}{\text{mol}}\right) = 104\text{ g}$$

2nd step → 104 g/s of NaCl is required

$$\left(\frac{40.0\text{ L }NH_3}{22.4\text{ L/mol}}\right)\left(\frac{1\text{ mol }NH_4HCO_3}{1\text{ mol }NH_3}\right)\left(\frac{1\text{ mol }NaHCO_3}{1\text{ mol }NH_4HCO_3}\right)\left(\frac{1\text{ mol }Na_2CO_3}{2\text{ mol }NaHCO_3}\right)\left(105.988\,74\frac{\text{g}}{\text{mol}}\right) = 94.6\text{ g}$$

Final step → 94.6 g/s Na_2CO_3 produced

$$\left(\frac{40.0\text{ L }NH_3}{22.4\text{ L/mol}}\right)\left(\frac{1\text{ mol }NH_4HCO_3}{1\text{ mol }NH_3}\right)\left(\frac{1\text{ mol }NaHCO_3}{1\text{ mol }NH_4HCO_3}\right)\left(\frac{1\text{ mol }CO_2}{2\text{ mol }NaHCO_3}\right)\left(22.4\frac{\text{L}}{\text{mol}}\right) = 20.0\text{ L}$$

Final Step → 20.0 L/s CO_2 produced

14. HCN is a poisonous gas. The lethal dose is approximately 300.0 mg HCN per kilogram of air when inhaled.

a) Calculate the amount of HCN that gives the lethal dose in a small laboratory room measuring 12 by 15 by 8.0 ft. The density of air at 26°C is 0.00118 g/cm³.

$(12\ ft)\left(\frac{12\ in}{1\ ft}\right)\left(\frac{1\ cm}{0.39370\ in}\right) = 365.7607\ cm$

$(15\ ft)\left(\frac{12\ in}{1\ ft}\right)\left(\frac{1\ cm}{0.39370\ in}\right) = 457.2009\ cm$

$(8\ ft)\left(\frac{12\ in}{1\ ft}\right)\left(\frac{1\ cm}{0.39370\ in}\right) = 243.8405\ cm$

volume of room

$= (365.7607\ cm)(457.2009\ cm)(243.8405\ cm)$

$= 40\ 776\ 503.75\ cm^3$

mass of air in room

$= (0.00118\ g/cm^3)(40\ 776\ 504\ cm^3)$

$= 48\ 116\ g$

$= 48\ kg$

Lethal dose

$= (300.0\ mg/kg\ air) \times 48\ kg\ air$

$= 14\ 434\ mg = 14\ g$

b) If the HCN is formed by the reaction of NaCN with an acid such as H_2SO_4, what mass of NaCN gives the lethal dose in the room?

$$2NaCN(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2HCN(g)$$

$$\left(\frac{14\ g\ HCN}{27.02564\ g/mol}\right)\left(\frac{2\ mol\ NaCN}{2\ mol\ HCN}\right)\left(49.00747\ \frac{g}{mol}\right) = 26\ g\ NaCN$$

c) HCN forms when synthetic fibres containing Orlon® or Acrilan® burn. Acrilan® has an empirical formula of CH_2CHCN, and so HCN is 50.9% of the formula by mass. A rug measures 12 by 15 ft and contains 30 oz of Acrilan® fibres per square yard of carpet. If the rug burns, will a lethal dose of HCN be generated in the room? Assume that the yield of HCN from the fibres is 20% and the carpet is 50% consumed.

Conversions: 1 cm = 0.39370 in, 1 ft = 12 in, 1 kg = 2.2046 lb, 1 lb = 16 oz

12 ft = 4.0 yards, 15 feet = ~~3.0 yards~~ 5.0 yards

rug = (4.0 yard)(~~3.0~~ 5.0 yards) = ~~12~~ 20 square yards

Amount of Acrilan in rug = (30 oz per sq yard)(~~12~~ 20 sq yards)

= ~~360 oz~~ 600 oz

$(\text{~~360~~ } 600\ oz)\left(\frac{1\ lb}{16\ oz}\right)\left(\frac{1\ kg}{2.2046\ lb}\right) = \text{~~10.2~~ } 17.0\ kg$

(~~10.2~~ 17.0 kg)(0.50) = ~~5.1~~ 8.5 kg Acrilan (50 % consumed)

Amount HCN

= (~~5.1~~ 8.5 kg)(0.509) = ~~2.6~~ 4.3 kg HCN - theoretical

Actual yield of HCN

= (~~2.6~~ 4.3 kg)(0.20) = ~~0.52~~ 0.87 kg or ~~520~~ 870 g ⇒ Yes this will generate a lethal dose

15. Vinyl chloride is the raw material for the production of commercial plastic called PVC. Vinyl chloride contains only carbon, hydrogen, and chlorine, and it burns in air (oxygen) to form carbon dioxide, water vapour, and hydrogen chloride. If the combustion of 2.152 g of vinyl chloride produces 3.029 g of carbon dioxide and 1.257 g of hydrogen chloride, what is the empirical formula of vinyl chloride?

$$\_\,C_xH_yCl_z + \_\,O_2 \rightarrow \_\,CO_2 + \_\,H_2O + \_\,HCl$$

2.152g   3.029 g   1.257g

CO_2 mol = $\frac{3.029\text{ g}}{44.0098\text{ g/mol}}$ = 0.068 825 579 mol CO_2

= 0.068 825 579 mol C

× 12.011 g/mol

= 0.826 640 38 g C in compound

HCl mol = $\frac{1.257\text{ g}}{36.46094\text{ g/mol}}$ = 0.034 475 249 mol HCl

= 0.034 475 249 mol Cl

× 35.453 g/mol

= 1.222 251 017 g Cl in compound

Total mass − mass C − mass Cl = mass H

2.152g − 0.8266g − 1.222g = 0.1031g

C	H	Cl
$\frac{0.8266\text{ g}}{12.011\text{ g/mol}}$	$\frac{0.1031\text{ g}}{1.00794\text{ g/mol}}$	$\frac{1.222\text{ g}}{35.453\text{ g/mol}}$
$\frac{0.06883\text{ mol}}{0.03448}$	$\frac{0.1023\text{ mol}}{0.03448}$	$\frac{0.03448\text{ mol}}{0.03448}$
2	3	1

∴ C_2H_3Cl

16. Menthol, the substance we can smell in mentholated cough drops, is composed of carbon, hydrogen, and oxygen. A 0.1005 g sample of menthol is combusted, producing 0.2829 g of carbon dioxide and 0.1159 g of water. What is the empirical formula for menthol?

$$\_C_xH_yO_z + \_O_2 \rightarrow \_CO_2 + \_H_2O$$

$C_xH_yO_z$: 0.1005 g; CO_2: 0.2829 g; H_2O: 0.1159 g

$$CO_2 \text{ mol} = \frac{0.2829 \text{ g}}{44.0098 \text{ g/mol}} = 0.006428 \text{ mol } CO_2$$

$= 0.006428$ mol C

$\times$ 12.011 g/mol $= 0.07721$ g C

$$H_2O \text{ mol} = \frac{0.1159 \text{ g}}{18.01528 \text{ g/mol}} = 0.006433 \text{ mol } H_2O$$

$\times 2 = 0.01287$ mol H

$\times$ 1.00794 $= 0.01297$ g H

Total mass − mass C − mass H = mass O

0.1005 g − 0.07721 g − 0.01297 g = 0.01032 g O

Empirical Formula

$$\frac{0.07721 \text{ g C}}{12.011 \text{ g/mol}} \quad \frac{0.01297 \text{ g H}}{1.00794 \text{ g/mol}} \quad \frac{0.01032 \text{ g O}}{15.9994 \text{ g/mol}}$$

$$\frac{0.006428 \text{ mol C}}{0.0006452} \quad \frac{0.01287 \text{ mol H}}{0.0006452} \quad \frac{0.0006452 \text{ mol O}}{0.0006452}$$

9.96   19.94   1

$C_{10}H_{20}O$

17. The characteristic odour of pineapple is due to ethyl butyrate, a compound containing carbon, hydrogen, and oxygen. Combustion of 2.78 mg of ethyl butyrate produces 6.32 mg of carbon dioxide and 2.58 mg of water. What is the empirical formula of the compound.

$$\_C_xH_yO_z + \_O_2 \rightarrow \_CO_2 + \_H_2O$$

2.78 mg → 6.32 mg, 2.58 mg

$$CO_2 \text{ mol} = \frac{0.00632\text{ g}}{44.0098\text{ g/mol}} = 1.436\times10^{-4}\text{ mol } CO_2$$

$$= 1.436\times10^{-4}\text{ mol C}$$

$$\times 12.011\text{ g/mol} = 0.001725\text{ g C}$$

$$H_2O \text{ mol} = \frac{0.00258\text{ g}}{18.01528\text{ g/mol}} = 1.432\times10^{-4}\text{ mol } H_2O$$

$$\times 2 = 2.864\times10^{-4}\text{ mol H}$$

$$\times 1.00794\text{ g/mol} = 2.887\times10^{-4}\text{ g H}$$

Total mass − mass C − mass H = mass O

$$0.00278\text{ g} - 0.001725\text{ g} - 0.0002887\text{ g} = 0.0007665\text{ g O}$$

Empirical Formula

$$\frac{0.001725\text{ g C}}{12.011\text{ g/mol}} \quad \frac{0.0002887\text{ g H}}{1.00794\text{ g/mol}} \quad \frac{0.0007665\text{ g O}}{15.9994\text{ g/mol}}$$

$$\frac{1.436\times10^{-4}\text{ mol C}}{4.791\times10^{-5}} \quad \frac{2.864\times10^{-4}\text{ mol H}}{4.791\times10^{-5}} \quad \frac{4.791\times10^{-5}\text{ mol O}}{4.791\times10^{-5}}$$

2.998   5.979   1

$$C_3H_6O$$

5.250 mg

18. Nicotine, a component of tobacco, is composed of carbon, hydrogen, and nitrogen. A ~~5.250~~ mg sample of nicotine was combusted, producing 14.242 mg of carbon dioxide and 4.083 mg of water. What is the empirical formula for nicotine?

CO_2 mol = $\frac{0.014242\ g}{44.0098\ g/mol}$ = 3.236×10^{-4} mol CO_2

= 3.236×10^{-4} mol C

$\times$ 12.011 g/mol = 0.003887 g C

H_2O mol = $\frac{0.004083\ g}{18.01528\ g/mol}$ = 2.2664×10^{-4} mol H_2O

$\times$ 2 = 4.5328×10^{-4} mol H

$\times$ 1.00794 g/mol = 4.5688×10^{-4} g H

Total mass − mass C − mass H = mass N

0.005250 g − 0.003887 g − 0.00045688 g = 0.0009062 g N

Empirical Formula

$\frac{0.003887\ g\ C}{12.011\ g/mol}$ $\frac{0.00045688\ g\ H}{1.00794\ g/mol}$ $\frac{0.00090626\ N\ \text{(~~0.001036 g O~~)}}{14.0067\ \text{(~~15.9994~~)}\ g/mol}$

$\frac{3.236 \times 10^{-4}\ mol\ C}{6.477 \times 10^{-5}}$ $\frac{4.533 \times 10^{-4}\ mol\ H}{6.477 \times 10^{-5}}$ $\frac{6.477 \times 10^{-5}\ mol\ O}{6.477 \times 10^{-5}}$

5.002   7.006   1

C_5H_7N