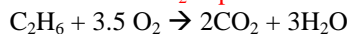


1. What volume of CO₂ is produced when 32g of ethane is burned in excess O₂? 100kPa, 120°C



For every mole C₂H₆ of you get 2 moles CO₂.

$$\begin{array}{llll} \text{Moles C}_2\text{H}_6 & 2 \text{ C} \rightarrow 24\text{g} & 1 \text{ mol} \rightarrow 30\text{g} & x = \frac{32}{30} = 1.07 \text{ moles C}_2\text{H}_6 \\ & 6 \text{ H} \rightarrow \underline{6\text{g}} & x \text{ mol} \rightarrow 32\text{g} & \\ & & & 30\text{g} \end{array}$$

There fore 2.14 moles CO₂.

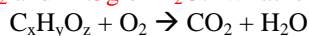
Volume CO₂

$$PV=nRT$$

$$V = \frac{nRT}{P} = \frac{(2.14 \text{ mole})(8.314 \frac{\text{kPa}\cdot\text{L}}{\text{mol}\cdot\text{K}})(393\text{K})}{100 \text{ kPa}}$$

$$V = 69.92 \text{ L}$$

2. A compound is made of C, H, O. When 39.6g of the sample is burned in excess O₂ we obtain 84.4g of CO₂ and 11.5g of H₂O. What is the empirical formula?



CO₂

$$\begin{array}{ll} 1 \text{ mole CO}_2 \rightarrow 1 \text{ C} \rightarrow 12\text{g} & \frac{84.4\text{g}}{44\text{g}} = 1.92 \text{ moles CO}_2 \\ & 2 \text{ O} \rightarrow \underline{32\text{g}} \\ & 44\text{g/mol} \end{array}$$

Therefore 1.92 moles C originally

H₂O

$$\begin{array}{ll} 1 \text{ mole H}_2\text{O} \rightarrow 2 \text{ H} \rightarrow 2\text{g} & \frac{11.5\text{g}}{18\text{g}} = 0.64 \text{ moles H}_2\text{O} \\ & 1 \text{ O} \rightarrow \underline{16\text{g}} \\ & 18\text{g/mol} \end{array}$$

Therefore 1.28 moles of H originally (not H₂)

O

$$\begin{aligned} \text{Mass O} &= \text{total mass} - \text{mass C} - \text{mass H} \\ &= 39.6 - 12(1.92) - 1(1.28) \\ &= 39.6 - 23 - 1.28 \\ &= 15.32\text{g} \end{aligned}$$

$$\frac{15.32\text{g}}{16 \text{ g/mol}} = 0.958 \text{ moles O}$$

$$\text{EF} = \text{C}_6\text{H}_4\text{O}_3$$

C		H		O	
<u>1.92</u>		<u>1.28</u>		<u>0.958</u>	percent to mass
0.958		0.958		0.958	mass to moles
2	:	1.337	:	1	divide by small
6	:	4	:	3	mult 'til whole

b) It was found that at STP the sample was a gas and occupied a volume of 3.575L. What is the molecular formula?

$$\begin{array}{ll}\text{STP} & T=273 \text{ K} \\ & P=101.3 \text{ kPa}\end{array}$$

$$n = \frac{PV}{RT} = \frac{101.3 * 3.575}{8.314 * 273} = 0.1595 \text{ moles}$$

$$\begin{array}{ll}39.6\text{g} & \rightarrow 0.1595 \text{ moles} \\ x \text{ g} & \rightarrow 1 \text{ mole}\end{array}$$

$$x = \frac{39.6}{0.1595} = 248.3 \text{ g/mol}$$

$$\begin{array}{l}1 \text{ mol C}_6\text{H}_4\text{O}_3 \rightarrow 6 \text{ C} \rightarrow 72\text{g} \\ \quad \quad \quad 4 \text{ H} \rightarrow 4\text{g} \\ \quad \quad \quad 3 \text{ O} \rightarrow \underline{48\text{g}} \\ \quad \quad \quad 124 \text{ g/mol for EF}\end{array}$$

$$MF = \frac{MF_M}{EF_M} (\text{EF})$$

$$MF = \frac{248.3}{124} (\text{C}_6\text{H}_4\text{O}_3)$$

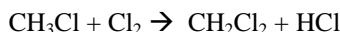
$$MF = \text{C}_{12}\text{H}_8\text{O}_6$$

Extra Questions

1. What is the percentage composition by mass of a) ammonia (NH₃) b) glucose C₆H₁₂O₆?

2. Given $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 + \text{Br}_2 \rightarrow \text{CH}_3\text{CHBrCH}_2\text{CH}_3 + \text{HBr}$

- a) What is the theoretical yield of 2-bromobutane if one mole of butane reacts with one mole of bromine? What if only 0.65 moles of 2-bromobutane is produced then what is the percentage yield of 2-bromobutane?
- b) What is the theoretical yield of 2-bromobutane in grams if one mole of butane reacts with 0.5 moles of bromine? What if only 0.2 moles of 2-bromobutane is produced then what is the percentage yield of 2-bromobutane?
3. Adrenaline is 56.8% C, 6.5% H, 28.4% O and 8.28% N by mass. Find the empirical formula.
4. A chemist new to the behaviour of chlorine with hydrocarbons tried to make dichloromethane (CH₂Cl₂) by mixing 0.25 moles of chloromethane (CH₃Cl) and 0.25 moles of chlorine (Cl₂) expecting the following reaction:



Inevitably some chloroform (CHCl₃) and carbon tetrachloride (CCl₄) formed along with CH₂Cl₂. Also some CH₃Cl remained unchanged. When the mixture of products was separated a yield of 12.8g of dichloromethane was obtained. Calculate the percentage yield of dichloromethane. (Ans = 60.4%)

5. It was found that 500 mL of an unknown gas had a mass of 3.00g at 20°C and 95kPa. Further analysis showed the gas was 86% C and 14% H by mass. Find the molecular formula. (Ans = C₁₁H₂₂)
6. A solution of Br₂ in CCl₄ is 0.08 mol/L. If the reaction is a 1 to 1 ratio then what volume of this solution will react with 0.196g of 3-methyl-2-hexene? (Ans = 25 mL)
7. Analysis revealed 40.7% C, 8.5% H, 23.7% N and the remainder oxygen for an organic compound. When vapourized 0.25 g of the compound gave 52.3 mL of gas at 98.6 kPa and 20°C. Find the molar mass of the compound. (Ans = 118.1 g/mol)
8. When a hydrocarbon is burned the carbon dioxide's mass is 1.83 times as much as the water formed. Assuming complete combustion find the molecular formula of the hydrocarbon. (Ans = C₃H₈)
9. When 32.0 mL of benzene is reacted with 79.9g of liquid bromine 30.0g of bromobenzene is formed.
- a) Find theoretical yield of bromobenzene. (Ans = 56.6g)
- b) What is the percentage yield? (Ans = 52.2%)
- Note: the density of liquid benzene is 879 kg/m³
10. When 0.601 g of an organic compound with the empirical formula CH₂O is vapourized at 200°C and 101.3 kPa the gas volume is 388 mL. This same volume is occupied by ethane under the same conditions.
- a) What is the molecular formula of the compound? (Ans = C₂H₄O₂)
- b) If 1 mol of the same compound reacts slowly with Zn to yield 0.5 mol H_{2(g)} what is the compound's name and structural formula? (ethanoic acid CH₃COOH)
11. A 100 mg sample of a compound containing C, H, and O was found to give 149 mg of CO₂ and 45.5 mg of H₂O when burned completely. Find the empirical formula. (Ans = C₂H₃O₂)
12. What mass of ethanol can be made by reacting NaOH (aq) with 50 g of bromoethane? What assumption is made in this calculation? (Ans = 21.12g)

Organic Problems Assignment

- 1) Write chemical equations for the following:
 - a) 2,2-dimethyl-1-propanol reacting with butanoic acid
 - b) 2,2,3-trimethylpentane (the "octane" in gasoline) burning completely in air
 - c) hydroiodic acid reacting with 1-butene
 - d) show the formation of N-ethyl ethanamide from ethanol and any inorganic reagents (not just one reaction)
- 2) A sample of liquid consisting of only C, H and O has a mass of 0.5438g. This sample was burned in pure oxygen with the release of 1.039g of CO₂ and 0.6369g of H₂O. What is the empirical formula of the compound?
- 3) When 1 mole of a hydrocarbon is burned, the carbon dioxide released has a mass equal to 2.09524 times the mass of the water released. Assuming complete combustion, what is the molecular formula for the hydrocarbon?
- 4) One mole of NaCN reacts with one mole of bromoethane to form 45g of cyanoethane.
 - a) What is the theoretical yield of cyanoethane in grams?
 - b) What is the percentage yield of cyanoethane?
 - c) Given 8.53g of NaCN and 10.98g of bromoethane and taking into account the percentage yield, find the volume of liquid cyanoethane (C₂H₅CN) (d=0.783g/mL)?
- 5) When 1.202g of an organic compound with empirical formula C₃H₆O₂ is vapourized at 673°C and 2 atm pressure, the gas volume is 630.5mL.
 - a) What is the molecular formula of the compound?
 - b) If one mole of the same compound reacts slowly with Zn to yield 0.5 mol of H_{2(g)}, what is the compound's name and structural formula?

$R=0.08206 \text{ L}\cdot\text{atm}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$
- 6) Sodium hydroxide reacts with bromoethane to give ethanol. If the percentage yield for this reaction is 72%, what mass of ethanol can be made by reacting NaOH_(aq) with 85g of bromoethane? (bromoethane is the limiting reagent)
- 7) 20 mL of a Br₂ (solute) solution in CCl₄ (solvent) react with 0.23g of 4-methyl-2-heptene. What is the concentration of the Br₂ solution?
- 8) The motor of an airplane is equipped with a condenser so that all of the steam formed during the complete combustion of fuel can be used on board while the CO₂ is released (into the atmosphere, increasing the CO₂ concentration there, thus increasing the greenhouse effect, inevitably destroying all life on earth). Will the plane gain or lose mass? Calculate the gain or loss per 50kg of 2,2,4-trimethylpentane fuel burned.
- 9) Analysis of an organic compound revealed %O=36.36, %C=27.27%, %N=31.82 and the rest hydrogen. When vapourized a 0.4g sample of the compound gave 139.13mL at 100°C and 1 atm pressure. Find the molecular formula of the compound.
- 10) Write equations using structural formula for:
 - i) 2-hexyne + 1 mole of H_{2(g)}
 - ii) benzoic acid + ethanol
 - iii) oxidation of butanal
 - iv) 2-pentane + HCl