The Copperbelt University

School of Mathematics and Natural Sciences

Department of Chemistry

Course Name: General Chemistry (CH110)

Tutorial Sheet 4 **Date**: 27th February, 2023

THEORETICAL QUESTIONS

1. What is pressure and how is it measured?
2. State Boyle's law and give an example of a situation where it would apply.
3. Explain how the volume of a gas changes with temperature at constant pressure, according to Charles's law.
4. What is the relationship between the pressure and temperature of a gas at constant volume, according to Gay-Lussac's law?
5. What is the ideal gas law and how is it used to calculate the pressure, volume, temperature, or amount of gas in a system?
6. How is the gas constant, R, used in the ideal gas law and what are its units?
7. In gas stoichiometry, how is the ideal gas law used to calculate the amount of gas produced or consumed in a chemical reaction?
8. What is Dalton's law of partial pressures and how is it used to calculate the partial pressure of a gas in a mixture?
9. How do you calculate the mole fraction of a gas component in a mixture?
10. What is the van der Waals equation and how does it account for the behavior of real gases?

TUTORIAL 4

PRACTICAL QUESTIONS

Q1. (a) Gas Laws

(i) - Boyle's Law States that the pressure exerted by a gas of a given mass at constant temperature is inversely proportional to the volume occupied by it.

$$P \propto 1/V$$

- When pressure increases, volume decreases

Mathematical expression: $P_1V_1 = P_2V_2$ Where:

P_1 = Initial pressure

V_1 = Initial Volume

P_2 = Final pressure (pressure after change)

V_2 = Final volume.

(ii) - Charles Law States That the volume of a given mass of a gas is directly proportional to its temperature (in Kelvin) at constant pressure.

- When temperature increases the ~~pressure~~ volume also increases and vice versa (provided pressure is constant)

Mathematical expression: $\frac{V_1}{T_1} = V_2/T_2$

(b) This question is based on Dalton's Law Which states that for a mixture of non-interacting gases the total pressure exerted by the mixture is equal to the sum of the partial pressures of each gas present

$$P_{total} = P_1 + P_2 + P_3 + \ldots$$

b(i) When 'C' is added to the vessel the total moles of gas will increase which means the mole fraction and partial pressure of gas A will decrease

(ii) The total pressure will increase (provided volume and temperature are constant)

(iii) The mole fraction will decrease

(b) (i) The increase in volume of the bubbles as they rise is due to the decrease in pressure as the bubbles ascend, as bubbles rise towards the surface the pressure surrounding them decreases. According to Ideal gas Law ($PV = nRT$) when pressure decreases the volume of the bubbles decreases

(ii) - Following Boyle's Law:

$$P_1V_1 = P_2V_2$$

$$P_1 \times 4.0cm^3 = 1atm \times 10.0cm^3$$

$$P_1 = \frac{10.0\,cm^3\,atm}{4.0\,cm^3}$$

$$= 2.50\,atm$$

Data

$P_1 = ?$

$P_2 = 1\,atm$

$V_1 = 4.0cm^3$

$V_2 = 10.0cm^3$

iii) Boyle's Gas Law

NOTE: The deeper you go under water, the greater the pressure of the water pushing down on you.

(d) (i) Using the Idea Gas equation: $pV = nRT$

- We need to first calculate the number of moles in 2.30g of propane gas.

Step 1: $n = \frac{m}{M_r}$ C_3H_8 $\quad 8 \times 1 = 8$, $3 \times 12 = 36$, $44 g/mol$

$= \frac{2.30g}{44.00g/mol}$

$= 0.0523 mol$

Step 2: Rearranging the formula and inserting the actual values.

$P = \frac{nRT}{V}$

$= \frac{0.0523 mol \times 0.0821 \, atm/mol.K \times 296K}{0.25 dm^3}$

$= \frac{0.0523 \cancel{mol} \times 0.0821 atm/\cancel{mol}.\cancel{K} \times 296\cancel{K}}{0.25 dm^3}$

$= \underline{5.06 \, atm}$

T = temperature (Kelvin)
$= 23°C + 273 = 296K$

V = Volume in dm^3
$= \frac{250ml}{1000} = 0.25 dm^3$

n = number of mole
$= 0.0523 mol$

R = rate constant
$= 0.0821$

STP = 0°C, 1 atm

(ii) $pV = nRT$

$V = \frac{nRT}{P}$

$= \frac{0.0523 mol \times 0.0821 atm/mol.K \times 273K}{1 \, atm}$

$= 1.172 dm^3 \times 1000 \, ml/dm^3$

$= \underline{1172 mL}$

(iii)

(III) - First change the temperature to Kelvin

$$K = (F-32) \times \frac{5}{9} + 273$$

$$= (130-32) \times \frac{5}{9} + 273$$

$$= 327.59K$$

$$P = \frac{nRT}{V} \Rightarrow \frac{0.0523mol \times 0.0821 \frac{atm}{mol\,K} \times 327.59K}{0.25\,dm^3}$$

$$= \underline{5.626\,atm}$$

QUESTION 2

(a) $PV = nRT$

$$n = \frac{PV}{RT}$$

$$= \frac{0.668atm \times 1.5L}{0.0821 \frac{atm}{mol\,K} \times 290K}$$

$$= \frac{1.002\,atm\,L}{23.809\,\frac{atm}{mol}}$$

$$= \underline{0.042\,mol}$$

- To find the molar mass first find the # of moles

$P = 508\ torr = 0.668\ atm$

$T = 17°C + 273 = 290K$

$V = 1.500L$

$n = \frac{m}{M_r}$, $M_r = \frac{m}{n}$

$$M_r = \frac{1.77g}{0.042mol} = \underline{42g/mol}$$

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(b) (i) Partial pressure is the pressure each component gas would exert if it alone occupied the volume of the mixture at the same temperature.

(ii) — To calculate the partial pressure, you need to find the number of moles for each component gas i.e H_2 (2.02g) and Cl_2 (71g)

$H_{2(gas)}$ $\cancel{P} \cancel{=} \cancel{\frac{PV}{RT}}$

$$n = \frac{m}{M_r}$$

$$= \frac{2.02g}{2.02g/mol}$$

$$= 1.00 \text{ mol}$$

Partial pressure = $P = \frac{nRT}{V}$

$$= \frac{1.00 \text{ mol} \times 0.0821 \frac{dm^3 atm}{mol \cdot K} \times 298K}{5 \, dm^3}$$

$$= \underline{4.89 \text{ atm}}$$

$Cl_{2(gas)}$ $n = \frac{m}{M_r}$

$$= \frac{71g}{71g}$$

$$= 1.0 \text{ mol}$$

$$P = \frac{nRT}{V}$$

$$= 1.00 \text{ mol} \times 0.0821 \frac{dm^3 atm}{mol \, K} \times 298K$$

$$= 4.89 \text{ atm}$$

(iii) — According Dalton's Law of Partial Pressure:

$$P_{total} = P_1 + P_2$$

$$= 4.89 \text{ atm} + 4.89 \text{ atm}$$

$$= \underline{9.78 \text{ atm}}$$

(iv) mole Fractions: H_2 (gas) $= \frac{1 \text{ mol of } H_2}{2 \text{ moles (total)}}$

$= 1/2$

Formular $\boxed{X_1 = \frac{n_1}{n_{total}}}$ $\quad Cl_{2(g)} = \frac{1.0 \text{ moles } (Cl_2)}{2.0 \text{ moles (total)}}$

X_1 = molar fraction $\quad = 1/2$

n_1 = # of moles for the Component

n_{total} = Sum of the moles of all the compenents.

$(n_{total} = n_1 + n_2 + n_3 + \text{-----})$

Defination; Mole fraction is the ratio of the number of moles of a given Component in a ~~mixtu~~ mixture to the total number of moles in the mixture.

(C) — It is helium because of its small size. Ammonia will behave least like an ideal gas since it is a polar molecule that can exhibit strong hydrogen bonding interactions. The strong intermolecular forces results in greater deviation from ideal gas behaviour.

(d) Van der Waals equation is an equation that relates the temperature, pressure and Volume of a non-ideal gas and takes into account both the Intermolecular forces between the gas molecules and the volume of the gas molecules.

Van der waals equation: $RT = (P + aV^{-2})(V - b)$

Where: R = the Universal gas Constant

T = Temperature of the gas

P = pressure of the gas

V = volume of the gas

a = measure of the attraction of the molecules for each other due to Van der waals forces.

b = Volume occupied by a single molecule of a gas.

<u>NOTE</u>: The Values of 'a' and 'b' will be Unique to each gas because Van der waals equation accounts for the Unique properties of each gas

- Van der waals forces are weak Intermolecular forces that dependent on the distance between atoms or molecules. These forces arise from the Interactions between Uncharged atoms or molecules.