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Gas Laws – Supplemental Worksheet

1 atm = 760 mm Hg = 760 torr = 101,325 Pa Molar volume of an ideal gas is 22.42 L at STP.

1. Given *h* = 5.24 cm in a sealed-tube manometer, calculate the pressure in the flask in torr, pascals, and atmospheres.

$$5.24cm \times \frac{10mm}{cm} = 52.4mm\ Hg = 52.4\ torr$$

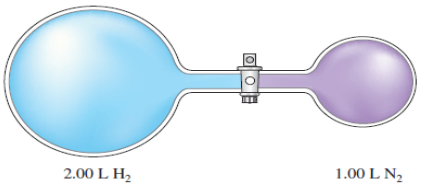
$$52.4\ torr \times \frac{1\ atm}{760\ torr} = 0.069\ atm$$

2. Several volume measurements were made at various pressures using 1.0 mol of NH_3 gas at a temperature of 0°C. Which law is being observed? Calculate the law constant for NH_3 at various pressures.

Experiment	Pressure (atm)	Volume (L)
1	0.1300	172.1
2	0.2500	89.28
3	0.3000	74.35
4	0.5000	44.49
5	0.7500	29.55
6	1.000	22.08

Since n and T are constant, we are observing Boyle's law. k = PV
Looking at data indicates P & V are inversely proportional.
Exp 1 k = 0.1300atm x 172.1L = 22.37 L atm
Exp 2 k = 22.32 L atm
Exp 3 k = 22.31 L atm
Exp 4 k = 22.25 L atm
Exp 5 k = 22.16 L atm
Exp 6 k = 22.06 L atm

3. Consider the flask diagramed below with the following pressures 492 torr for H_2 and 0.376 atm for N_2. What are the final partial pressures of H_2 and N_2 after the stopcock between the 2 flask is opened? (Assume the final volume is 3.00L) What is the total pressure in torr?



Treat each gas separately $P_1V_1 = P_2V_2$ (Boyle's Law)

$$For\ H_2{:}\ P_2 = \frac{p_1V_1}{V_2} = 492\ torr \times \frac{2L}{3L} = 328\ torr$$

$$For\ N_2{:}\ P_2 = 0.376\ atm \times \frac{1L}{3L} = 0.125\ atm \times \frac{760\ torr}{1\ atm} = 95.3\ torr$$

$$P_{Total} = P_1 + P_2 = 328\ torr + 95.3\ torr = 423.3\ torr$$

4. Explain absolute zero.

Absolute zero is 0 Kelvin. When extrapolating the volume below this temperature, the volume would be negative, which gases cannot have.

5. If 32.1 mL of NO_2 gas is completely converted to N_2O_4 gas under the same conditions, what volume will the N_2O_4 occupy? $2NO_2\,(g) \rightarrow N_2O_4\,(g)$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}\,, \qquad V_2 = V_1 \times \frac{n_2}{n_1} = 32.1\ mL \times \frac{1}{2} = 16.1\ mL$$

6. A sample of H_2 has a volume of 9.37 L at a temperature of 0°C and pressure of 2.1 atm. Calculate the moles of H_2 present in the sample.

$$PV = nRT\,,\ n = \frac{PV}{RT} = \frac{(2.1\ atm)(9.37L)}{\left(0.08206\frac{L\ atm}{K\ mol}\right)(273K)} = 0.878\ moles$$

7. A 3.4 L sample of methane gas is heated from 9°C to 74°C at constant pressure. Calculate the new volume. R, n, & P are constants.

$$\frac{V_1}{T_1} = \frac{nR}{P} = \frac{V_2}{T_2}\,, \quad V_2 = \frac{T_2 V_1}{T_1} = \frac{347\ K \times 3.4L}{282\ K} = 4.18\ L$$

8. CaO is produced by thermal decomposition of $CaCO_3$. Calculate the volume of CO_2 produced at STP from the decomposition of 129g of $CaCO_3$.

$CaCO_3\,(s) \rightarrow CaO\,(s) + CO_2\,(g)$

$$129\ g\ CaCO_3 \times \frac{1\ mol\ CaCO_3}{100.1\ g\ CaCO_3} = 1.29\ mol\ CaCO_3$$

1.29 mol CO_2 formed because there is a 1:1:1 mole ratio. Molar volume of an ideal gas is 22.42 L at STP.

$$1.29\ mol\ CO_2 \times \frac{22.42\ L\ CO_2}{1\ mol\ CO_2} = 28.9\ L\ CO_2$$

OR

The ideal gas law can be used. At STP, T = 273K and P = 1 atm

$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{1.29mol\ CO_2 \times 0.08206\frac{L\ atm}{K\ mol} \times 273K}{1atm} = 28.9\ L\ CO_2$$

9. A 3.598 g sample of manganese metal is reacted with excess HCl gas to produce 2.37 L of H_2(g) at 100°C and 0.834 atm and a manganese chloride compound ($MnCl_x$). What is the formula of the manganese chloride compound produced in the reaction?

Mn (s) + x HCl (g) → $MnCl_x$ (s) + $\frac{x}{2}\ H_2\ (g)$

$$n_{H2} = \frac{PV}{RT} = \frac{0.8341\ atm \times 2.37\ L}{\frac{0.08206\ L\ atm}{K\ mol} \times 373K} = 0.0646\ mol\ H_2$$

mol Cl in MnCl = mol HCl = $0.0646\ mol\ H_2 \times \frac{x\ mol\ Cl}{\frac{x}{2} mol\ H_2} = 0..129\ mol\ Cl$

$$\frac{mol\ Cl}{mol\ Mn} = \frac{0.129\ mol\ Cl}{3.598\ g \times \frac{1\ mol\ Mn}{54.94\ g\ Mn}} = 1.97\ \approx 2$$

Formula compound $MnCl_2$

10. A compound contains only nitrogen and hydrogen and is 87.4% nitrogen by mass. A gaseous sample of the compound has a density of 0.977 g/L at 710 torr and 373K. What is the molecular formula of the compound?

Assume 100g $87.4\ g\ N \times \frac{1\ mol\ N}{14.01\ g\ N} = 6.24\ mol\ N$ $Ratio\ \frac{6.24}{6.24} = 1$

$12.6\ g\ H \times \frac{1 mol\ H}{1.08\ g\ H} = 12.5\ mol\ H$ $Ratio\ \frac{12.5}{6.24} = 2$

2 H for every 1 N $MWt = \frac{density \times RT}{P} = \frac{\frac{0.977g}{L} \times \frac{0.08206\ L\ atm}{K\ mol} \times 373K}{710\ torr \times \frac{1\ atm}{760\ torr}} = 32.0g/mol$

NH_2 = 16.0g molecular formula is N_2H_4