GASES

Characteristics of Gases

Pressure

Barometers and Atmospheric Pressure

Manometers and Pressures of Enclosed Gases
Gas Laws

Boyle’s Law

![Boyle's Law Graphs]

Ex 1 Some nitrogen gas is in a 2.00-L tank at a pressure of 3.00 atm. The tank is connected to a 5.00-L tank that is completely empty (evacuated), and a valve connects the two tanks. If the valve is opened, determine the total pressure in this two-tank system after the nitrogen stops flowing. No temperature change occurs in the process.

Charles’s Law

![Charles’s Law Graph]

Avogadro’s Law
Ex 2 A certain mass of C₃H₆ reacts completely with an excess of ammonia and oxygen to give 38.2 L of C₃H₃N at 75°C and P = 1 atm. If the same mass of C₃H₆ reacts completely at 350°C and P = 1 atm, what volume of C₃H₃N can be collected at the higher temperature?

\[
2 \text{C}_3\text{H}_6(g) + 2 \text{NH}_3(g) + 3 \text{O}_2(g) \rightarrow 2 \text{C}_3\text{H}_3\text{N}(g) + 6 \text{H}_2\text{O}(g)
\]

The Ideal-Gas Equation

Ex 3 A gas is in a container with a movable piston under a pressure of 6.4 atm. The volume of the container is increased by a factor of 4.5 by moving the piston. The absolute temperature is simultaneously doubled. Calculate the pressure of the gas after these changes.
**Applications of the Ideal-Gas Equation**

**Gas Density and Molar Mass**

**Ex 4** At what temperature (in K) does 29.8 g of O$_2$ gas have a pressure of 2.00 atm in a 10.0-liter tank?

**Ex 5** Calculate the density of gaseous SF$_6$ at a temperature of 27°C and a pressure of 0.873 atm.
Ex 6  The empirical formula of a gaseous fluorocarbon is CF$_2$. If 1.55 g of this compound occupies 0.174 L at STP determine the molecular formula of this compound.

Ex 7  An important process for the production of acrylonitrile (C$_3$H$_3$N) is given by the reaction: 2 C$_3$H$_6$(g) + 2 NH$_3$(g) + 3 O$_2$(g) → 2 C$_3$H$_3$N(g) + 6 H$_2$O(g)

A 150.0-L reactor is charged to the following partial pressures at 25°C:
P$_{C3H6}$ = 4.93 atm, P$_{NH3}$ = 7.90 atm, P$_{O2}$ = 14.8 atm
What mass of acrylonitrile can be produced from this mixture?

Ex 8  A 0.326-g sample of XH$_2$ reacts with water according to the equation

XH$_2$(s) + 2 H$_2$O(l) → X(OH)$_2$(s) + 2 H$_2$(g)

The hydrogen evolved is found to have a volume when dry of 375 cm$^3$ at 21°C and 1.00 atm. What is the atomic mass of X?
Acetylene (C$_2$H$_2$) can be made by allowing calcium carbide to react with water.

\[ \text{CaC}_2(s) + 2 \text{H}_2\text{O}(l) \rightarrow \text{C}_2\text{H}_2(g) + \text{Ca}($\text{OH}$)$_2$(aq) \]

You place 2.65 g of CaC$_2$ in excess water and collect the acetylene over water.

(a) Calculate the theoretical yield of acetylene (in grams).

(b) After reaction, the volume of the acetylene and water vapor is 795 mL at 25.0°C and a pressure of 0.967 atm. Calculate the percent yield of acetylene. The vapor pressure of water at 25.0°C is 0.0313 atm.

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**Gas Mixtures and Partial Pressures**

**Partial Pressure**

**Mole Fraction**
Ex 10  The partial pressure of $O_2(g)$ in a mixture of $O_2(g)$ and $H_2(g)$ is 2.54 atm. The total pressure of the mixture is 3.92 atm. Determine the partial pressure of $H_2(g)$, and the mole fraction of each gas in the mixture.

Ex 11  A gas mixture at room temperature contains 4.3 mol of $H_2$ and 8.2 mol of $N_2$.

(a) Compute the mole fraction of $N_2$ in the mixture.

(b) The mixture is then heated, and the $N_2$ starts to react with the $H_2$ to give $NH_3$:

$$N_2(g) + 3\, H_2(g) \rightarrow 2\, NH_3(g)$$

The reaction is stopped when 2.8 mol of $NH_3$ is present. Determine the mole fraction of $N_2$ in this new mixture.

Collecting Gases over Water
Ex 12  Hydrogen gas is produced when zinc reacts with sulfuric acid:

\[ \text{Zn}(s) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{ZnSO}_4(aq) + \text{H}_2(g) \]

If 159 mL of wet \( \text{H}_2 \) is collected over water at 24°C and a barometric pressure of 738 torr, how many grams of Zn have been consumed? \((P_{\text{H}_2\text{O}, 24^\circ C}) = 22.38 \) torr.