Chapter 9: Gaseous State

Nov 23, 2022

Chemistry Department, Cypress College

Class Announcements

Lab

- Experiment 22 Titration
- Recall: Acid-Base Reaction
- Reminder - Need 70% of laborator points to pass the course

Lecture

- Finish up Ch 9 and lab practical review next Mon, Nov 28
- Post quiz based on lab experiments Fri, Nov 25th
- No Homework this week

Outline

Review: Boyle's Law, Charles' Law, and Avogadro's Hypothesis

Ideal Gas Law

Dalton's Law of Partial Pressures

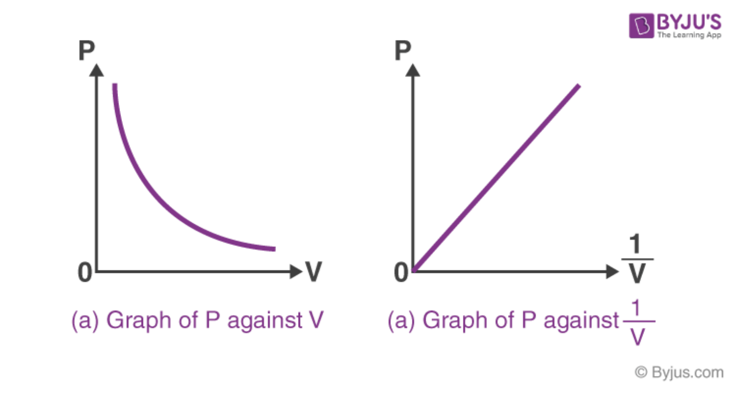
Boyle's Law

For a given mole of gas, the pressure and volume are inversely proportional.

$$PV = \text{constant} \tag{1}$$

$$P_1 V_1 = P_2 V_2 \tag{2}$$

Graphing Boyle's Law



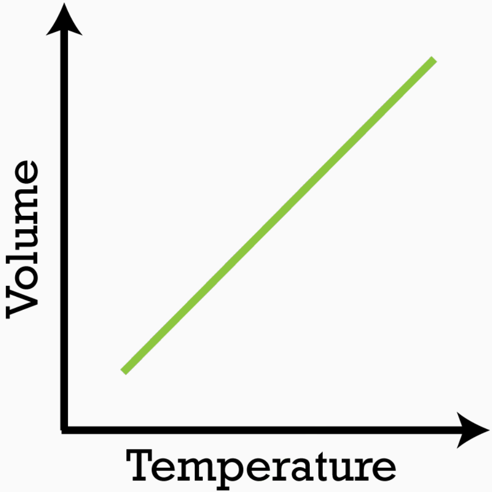
Charles' Law

For a given mole of gas, the volume and temperature are directly proportional

$$\frac{V}{T} = \text{constant} \tag{3}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \tag{4}$$

Graphing Charles' Law



Avogadro's Hypothesis

At constant temperature and pressure, the volume and moles of gas are directly proportional

$$\frac{V}{n} = \text{constant} \tag{5}$$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2} \tag{6}$$

Outline

Ideal Gas Model

Assumptions

- There is a large number of molecules that are in random motion
- Volume of the molecule is small relative to the volume occupied by the gas
- All molecules of a given gas are identical
- There no interactions between molecules (intermolecular forces)
- Collisions between gas molecules are perfectly elastic

Ideal Gas Formula

$$PV = nRT \tag{7}$$

where P is pressure (atm), V is volume (L), n moles of gas (mols), R is gas constant, and T is temperature (K)

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Gas Constants - Use the appropriate once based on the units in the problem

$$\begin{aligned} R =& 8,314.46 \, \frac{\text{L Pa}}{\text{K mol}} = 0.082057 \, \frac{\text{L atm}}{\text{K mol}} \\ =& 62.3636 \, \frac{\text{L Torr}}{\text{K mol}} \end{aligned}$$

Using Ideal Gas to Obtain Gas Laws

Boyle's Law - hold n and T constant

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Boyle's Law - hold n and T constant

$$
\begin{aligned}
PV &= nRT \\
PV &= \text{constant} \\
P_1 V_1 &= P_2 V_2
\end{aligned}
\tag{8}
$$

Using Ideal Gas to Obtain Gas Laws

Boyle's Law - hold n and T constant

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Boyle's Law - hold n and T constant

$$\begin{aligned} PV =& nRT \\ PV =& \text{constant} \\ P_1V_1 =& P_2V_2 \end{aligned} \tag{8}$$

Charles' Law - hold n and P constant

$$\begin{aligned} PV =& nRT \\ \frac{V}{T} =& \frac{nR}{P} = \text{constant} \\ \frac{V_1}{T_1} =& \frac{V_2}{T_2} \end{aligned} \tag{9}$$

Practice: Avogadro's Hypothesis

Obtain the Avogadro's hypothesis formula from the ideal gas law ($PV = nRT$).

Practice: Using Ideal Gas

Assuming ideal gas, what is the temperature for 2.10 moles of N_2 gas under 1.25 atm and in 25.0 L? ($R = 0.082057$ (L atm)/(K mol))

Practice: Using Ideal Gas

The volume of a propane cylinder is 0.960L. When filled, the cylinder contains liquid propane stored under pressure. When the cylinder is "empty," it contains propane gas molecules at atmospheric ppressure and temperature. How many moles of propane gas remain in a cylinder when it is empty if the surrounding atmospheric conditions are 298K and 0.980atm.

Finding Density from Ideal Gas Law

Q: What are the units for density?

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Given this ratio, the last step is to multiply by the molar mass of the given substance

Finding Density from Ideal Gas Law

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$$D = \frac{n\,MM}{RT}$$

where MM is the molar mass

Finding Molar Mass from Ideal Gas Law

Q: What are the units for molar mass?

Finding Molar Mass from Ideal Gas Law

Q: What are the units for molar mass?

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

Determine the moles and given the mass, divide by the moles

Practice: Determine Density from Ideal Gas

Calculate the density of butane at 298.15K and a pressure of 0.987atm. The gas constant is 0.08206 (L atm)/(K mol).

Practice: Determine Molar Mass from Ideal Gas

A sample of the gas at a pressure of 0.960atm and a temperature of 290K weighs 0.289g in a flask with a volume of 157.0mL. The gas constant is 0.08206 (L atm)/(K mol). Calculate the molar mass of the gas.

Outline

Review: Boyle's Law, Charles' Law, and Avogadro's Hypothesis

Ideal Gas Law

Dalton's Law of Partial Pressures

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Gases in a mixture behave independently and exert the same pressure they would exert if they were in a container alone

$$P_{\text{Total}} = P_A + P_B + P_C + \cdots \tag{10}$$

where P_{Total} is the total pressure and $P_A, P_B, \cdots$ are the pressures of the components

Practice: Dalton's Law of Partial Pressure

Suppose gaseous oxygen (O_2) is produced by:

$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

If 1.50L of O_2 is collected over water at 300.K and 0.970atm, how many moles of O_2 is produced? The vapor pressure of water is 0.0351atm.

Mole Fraction

Expressing the relative amounts of substances in a mixture

$$\chi_A = \frac{n_A}{n_{\text{Total}}} \tag{11}$$

where χ_A is the mole fraction of component A, n_A is the amount of moles for A, and n_{Total} is the total amount of moles in the mixture

Dalton's Law of Partial Pressure

Since each gas component exert its own pressure, the partial pressure of each component can be expressed by

$$P_A = \chi_A P_{\text{Total}} = \frac{n_A}{n_{\text{Total}}} P_{\text{Total}} \tag{12}$$

Practice: Dalton's Law of Partial Pressures

A flask contains a mixture of 1.25 mols of hydrogen gas and 2.90 moles of oxygen gas. If the total pressure is 104.kPa, what is the partial pressure of each gas?