Chapter 9 Part 2

Dr. Turner

Ideal Gas Law

$$PV = nRT$$

$$\frac{PV}{nT} = R$$

$$\frac{PV}{nT} = 0.0821 \frac{L\ atm}{mol\ K}$$

This is true regardless of what P, V, n, and T are

Ideal Gas Law

So if $\frac{P_1 V_1}{n_1 T_1} = 0.0821 \frac{\text{L atm}}{\text{mol K}}$ and $\frac{P_2 V_2}{n_2 T_2} = 0.0821 \frac{\text{L atm}}{\text{mol K}}$

then

$$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$$

From this we see several relations

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

If n and T are constant

$$P_1V_1 = P_2V_2$$

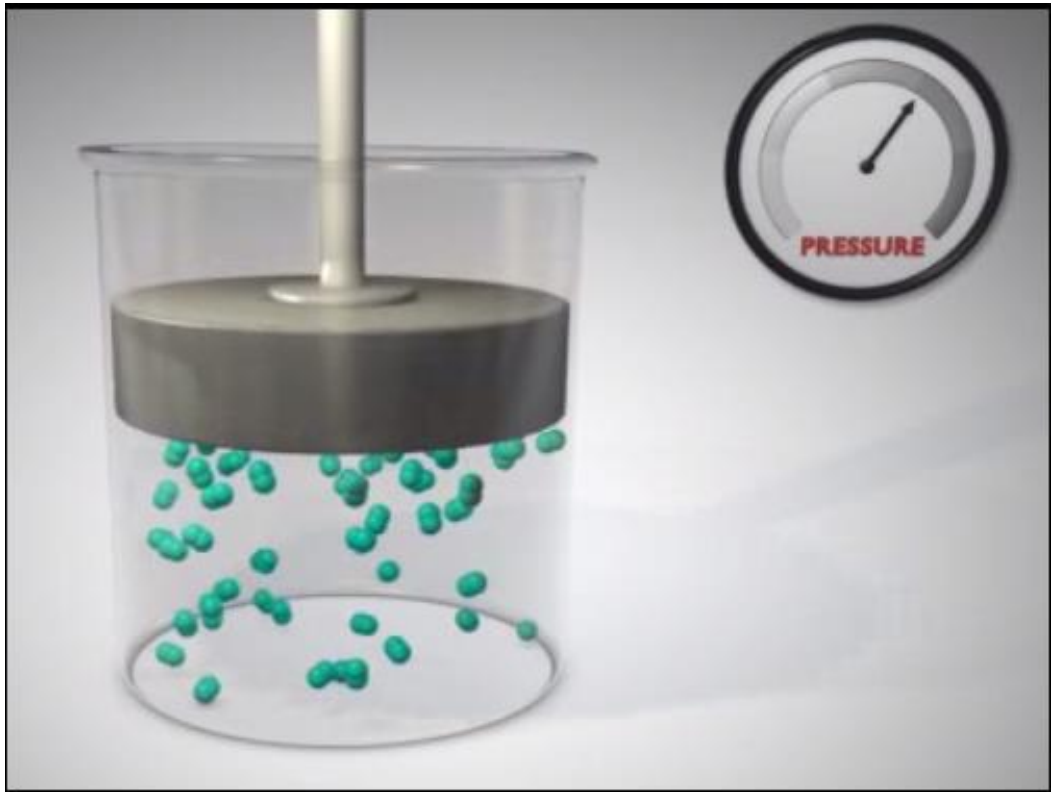
V and P may be in any units but T must be in Kelvin

Relating Pressure and Volume: Boyle's Law

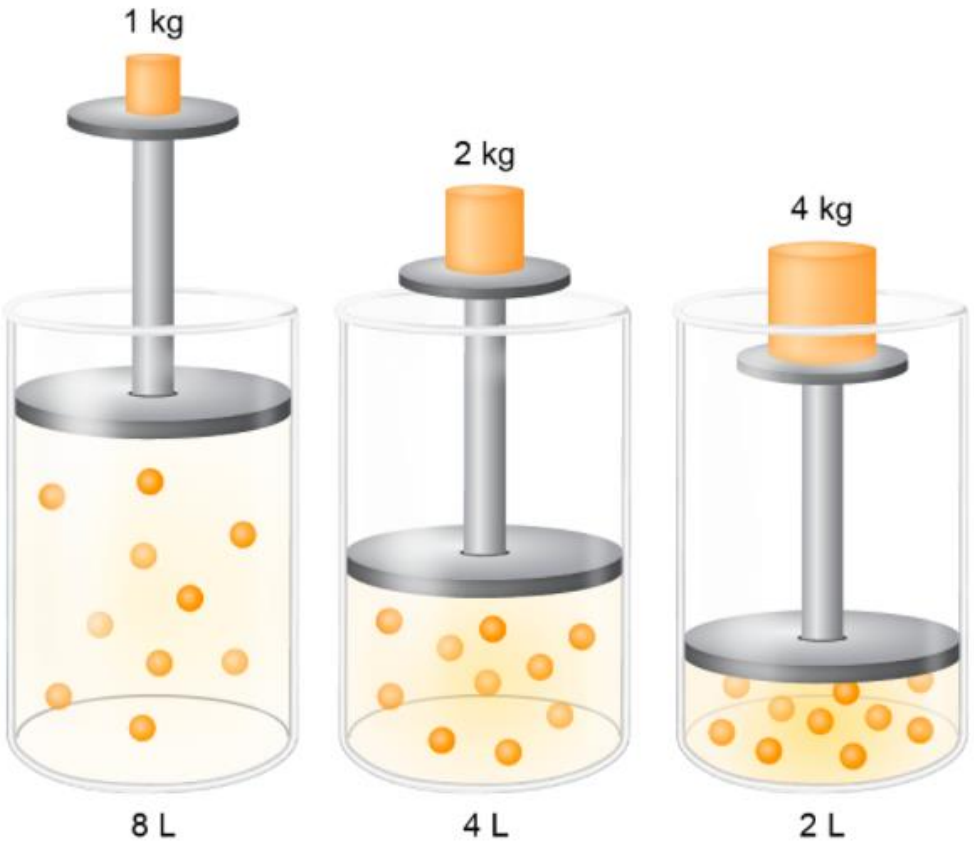
$$P_1 V_1 = P_2 V_2$$

- Pressure and volume are inversely proportional
- Pressure and Volume may be in any units as long as P_1 and P_2 are in the same units, and V_1 and V_2 are in the same units

Boyle's Law



Boyle's Law



Boyle's Law

A volume of air occupying 12.0 cm^3 at 98.9 kPa is compressed to a pressure of 119.0 kPa. The temperature remains constant. What is the new volume in cm^3?

From this we see several relations

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

If n and T are constant

$$P_1V_1 = P_2V_2$$

If n and P are constant

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

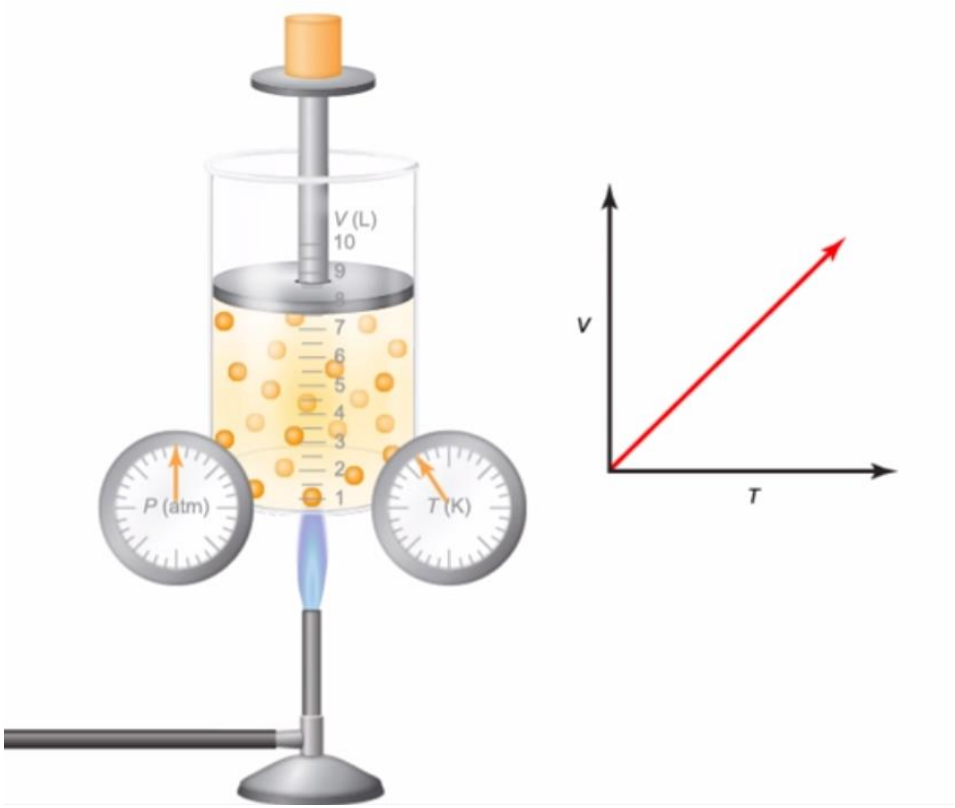
V and P may be in any units but T must be in Kelvin

Relating Volume and Temperature: Charles's Law

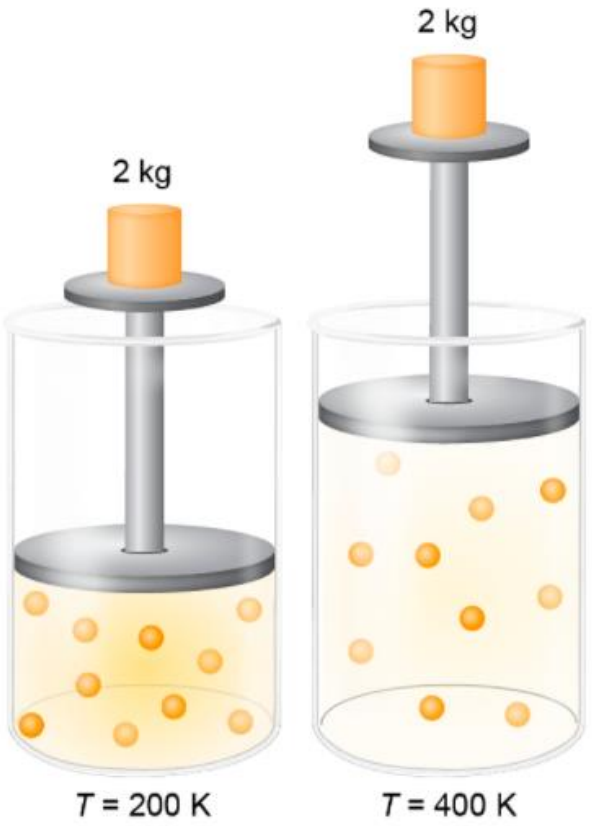
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

- Volume and temperature are directly proportional
- Volume may be in any units as long as V_1 and V_2 are in the same units
- Temperature must be in Kelvin

Charles's Law



Charles's Law



Charles's Law

A 3.75 L sample of nitrogen gas at 25.00 °C is heated at constant pressure to a final volume of 8.33 L. What is the final temperature in °C?

From this we see several relations

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

If n and T are constant

$$P_1V_1 = P_2V_2$$

If n and P are constant

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

If n is constant

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

V and P may be in any units but T must be in Kelvin

Relating Pressure, Volume, and Temperature: The Combined Gas Law

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

- Pressure and Volume may be in any units as long as P_1 and P_2 are in the same units, and V_1 and V_2 are in the same units
- Temperature must be in Kelvin

The Combined Gas Law

If 10.1 L of nitrogen gas at 23.00 °C has a pressure of 746 mmHg, what is the volume in L of nitrogen gas at 0.00 °C and 760 mmHg?

From this we see several relations

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

If n and T are constant

$$P_1V_1 = P_2V_2$$

If P and T are constant

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

If n and P are constant

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

If n is constant

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

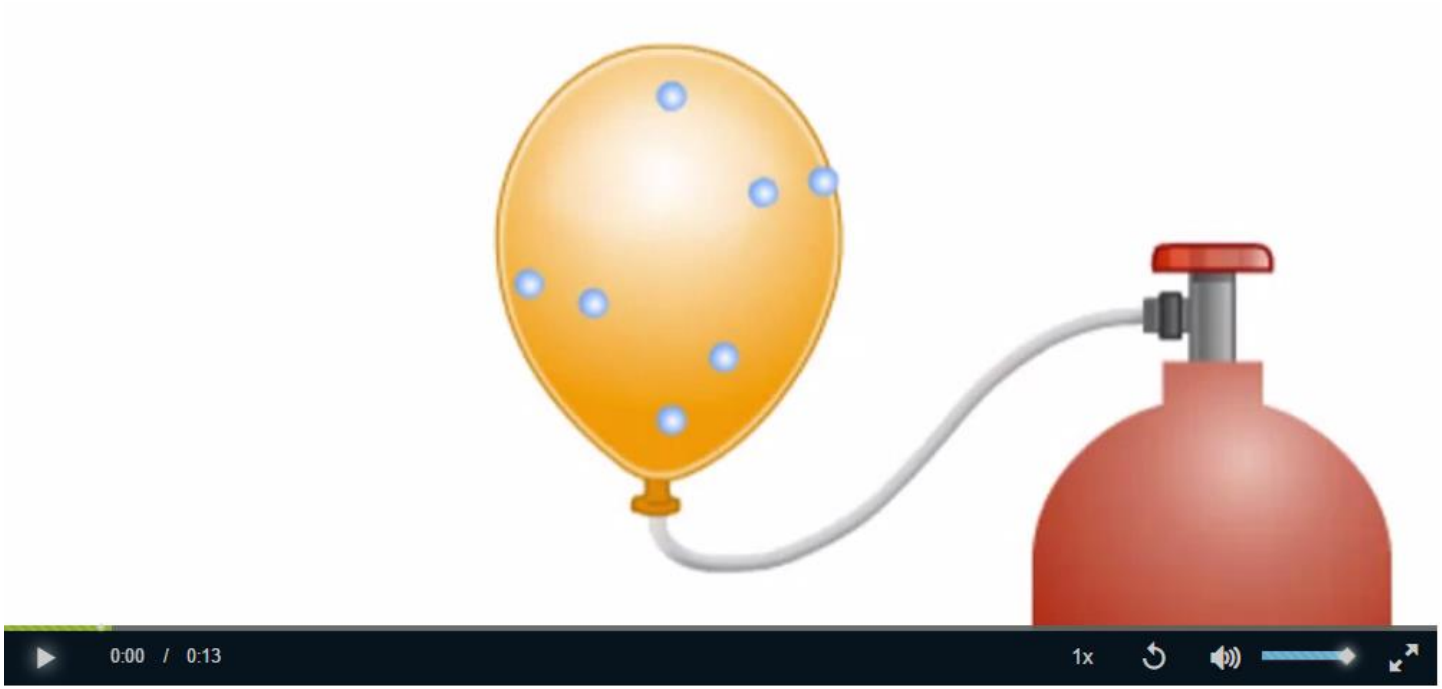
V and P may be in any units but T must be in Kelvin

Relating Moles and Volume: Avogadro's Law

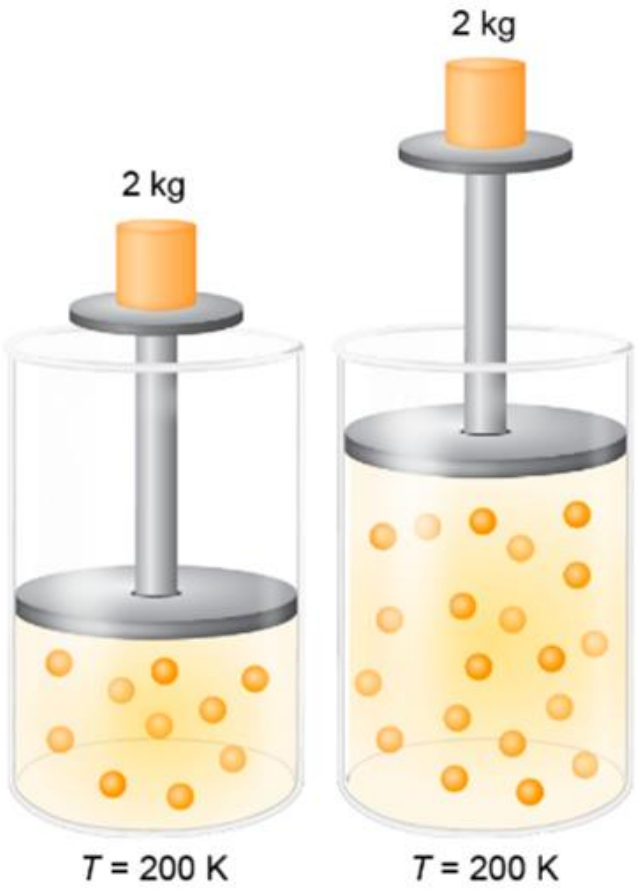
$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

- Volume and moles are directly proportional
- Volume may be in any units as long as V_1 and V_2 are in the same units
- Moles must be in moles

Avogadro's Law



Avogadro's Law



Avogadro's Law

A gas sample containing 75.2 g of methane (CH_4) occupies a volume of 10.3 L. Assuming no change in temperature or pressure, how many grams of methane must be added to increase the volume to 15.0 L?

From this we see several relations

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

If n and T are constant

$$P_1V_1 = P_2V_2$$

If P and T are constant

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

If n and P are constant

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

If n is constant

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

V and P may be in any units but T must be in Kelvin

Gas Laws

A cylinder containing 44 L of helium gas at a pressure of 170. atm is to be used to fill toy balloons to a pressure of 1.1 atm. Each inflated balloon has a volume of 2.0 L. What is the maximum number of balloons that can be inflated?

Gas Laws

At a certain pressure and temperature, a gas occupies 20 L. If pressure and temperature are held constant, what will be the volume if half the gas sample escapes?

A. 2 L
B. 10 L
C. 20 L
D. 40 L

Standard Temperature and Pressure (STP)

- Under standard temperature and pressure
  - $P = 1.00$ atm
  - $T = 273.15$ K

Gas Laws

A sample of hydrogen occupies 375 mL at STP. If the temperature were increased to 819.00°C, what final pressure would be necessary to keep the volume constant at 375 mL?