Chapter 9: Gaseous State

Nov 29, 2022

Chemistry Department, Cypress College

Class Announcements

Lecture

- Return exam 3 and go over answers
- Begin Ch 9 and 10
- Quiz and Homework assignment released Fri, Dec 2nd at 3pm

Outline

Smokey the Bear: Hot Air Balloon

Q: How do air balloons float in the air?

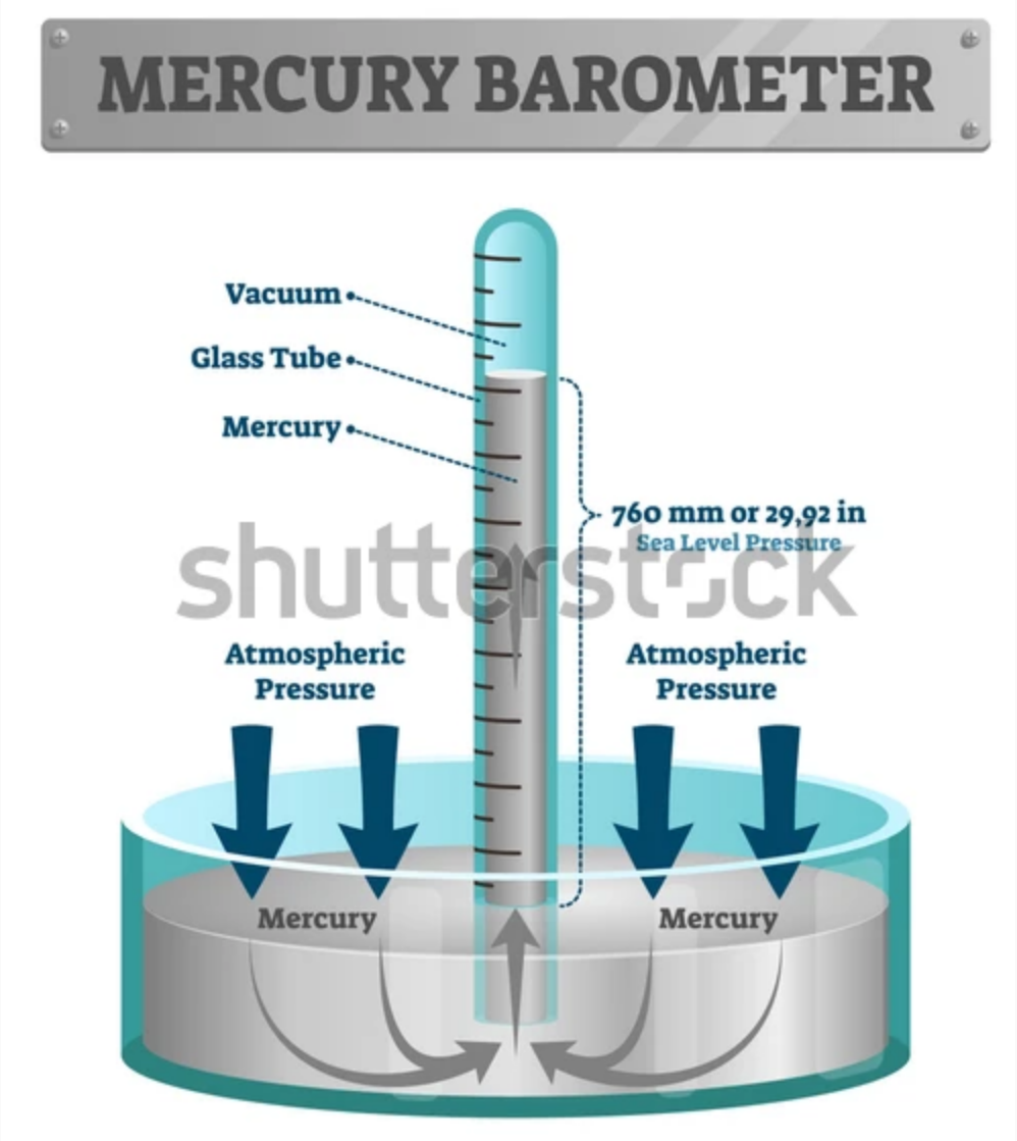
Defining Pressure

$$P = \frac{F}{A} \tag{1}$$

where P is the pressure ($\mathrm{N/m^2}$), F is the force (Newton or N) acting on the area, and A is the surface area ($\mathrm{m^2}$)

Common Units: Psi, Torr, Pa, atm, mm Hg, and $\mathrm{lb/in^2}$

Measuring Pressure



Common Pressure Units Conversion

Common Units: Psi, Torr, atm, mm Hg, and lb/in^2

$$1\text{atm} = 760\text{mm Hg}$$

$$1\text{atm} = 101,325\text{Pa}$$

$$1\text{atm} = 14.7\text{lb/in}^2$$

Practice: Unit Conversion

Convert the following units:

a) 845 Torr to atm

b) 1.73 atm to Pa

c) 32.1 lb/in^2 to atm

Outline

Defn: Standard Temperature and Pressure

Standard Temperature and Pressure (STP): the gas is at a given 0°C, 1 atm, and 22.414 L/mol

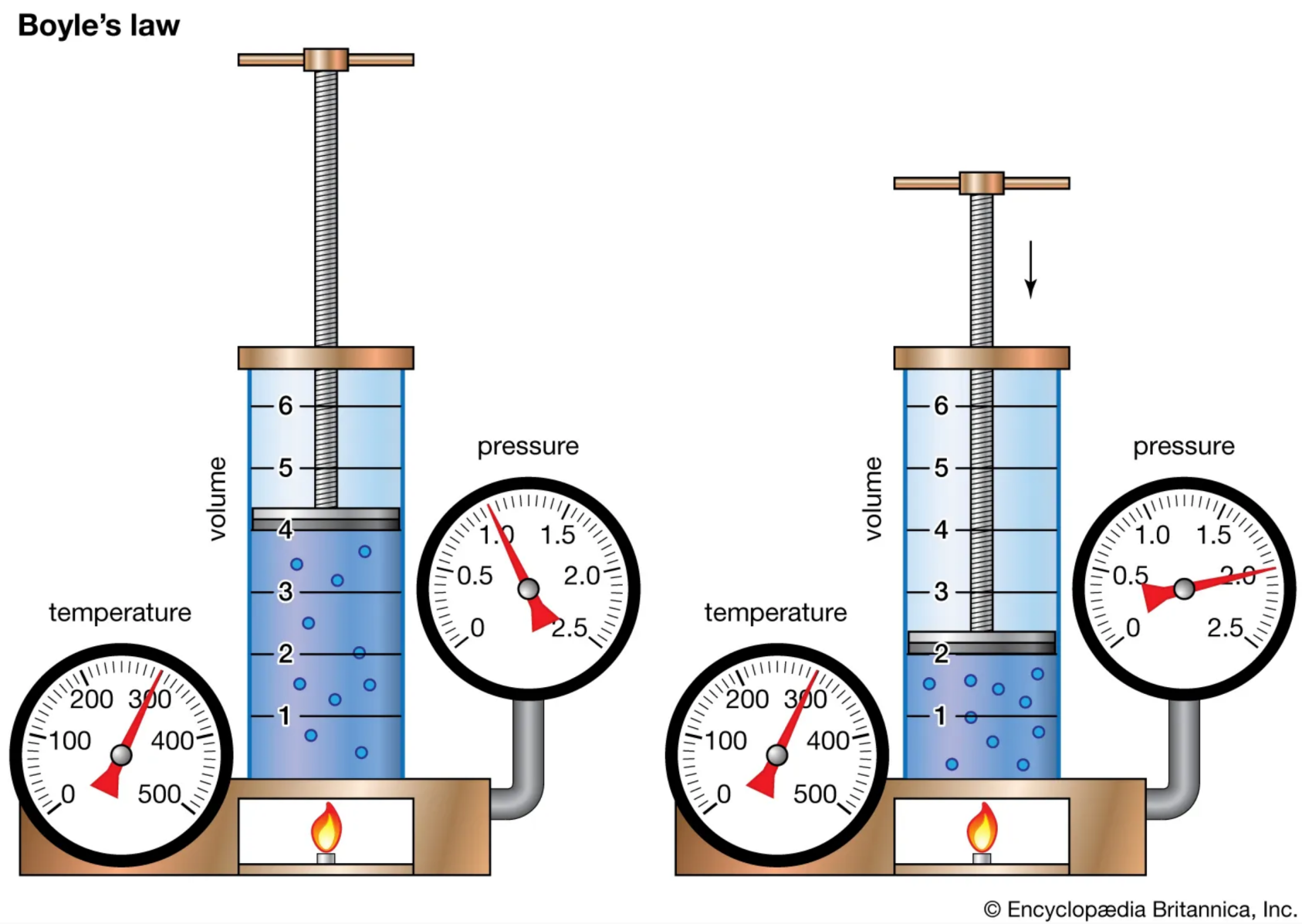
Boyle's Law

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

$$PV = \text{constant} \tag{2}$$

$$P_1 V_1 = P_2 V_2 \tag{3}$$

Boyle's Law


Boyle's law
volume
pressure
temperature
6
5
4
3
2
1
0.5
1.0
1.5
2.0
2.5
0
100
200
300
400
500
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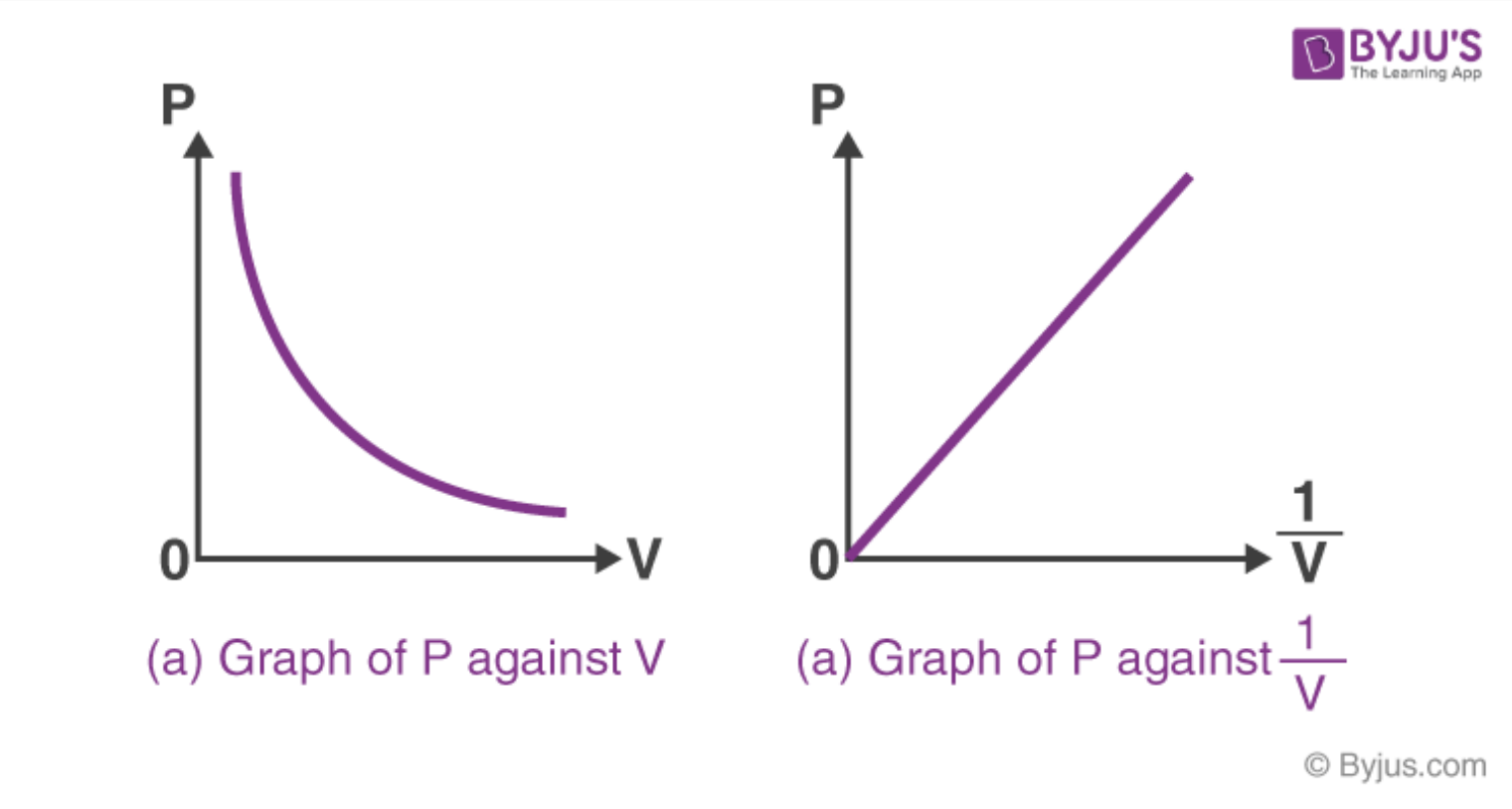
Graphing Boyle's Law



Practice: Boyle's Law

A balloon contains 510mL of helium when filled at 1.00atm. What would be the volume of the balloon if it were subjected to 2.50 atm of pressure?

Charles' Law

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

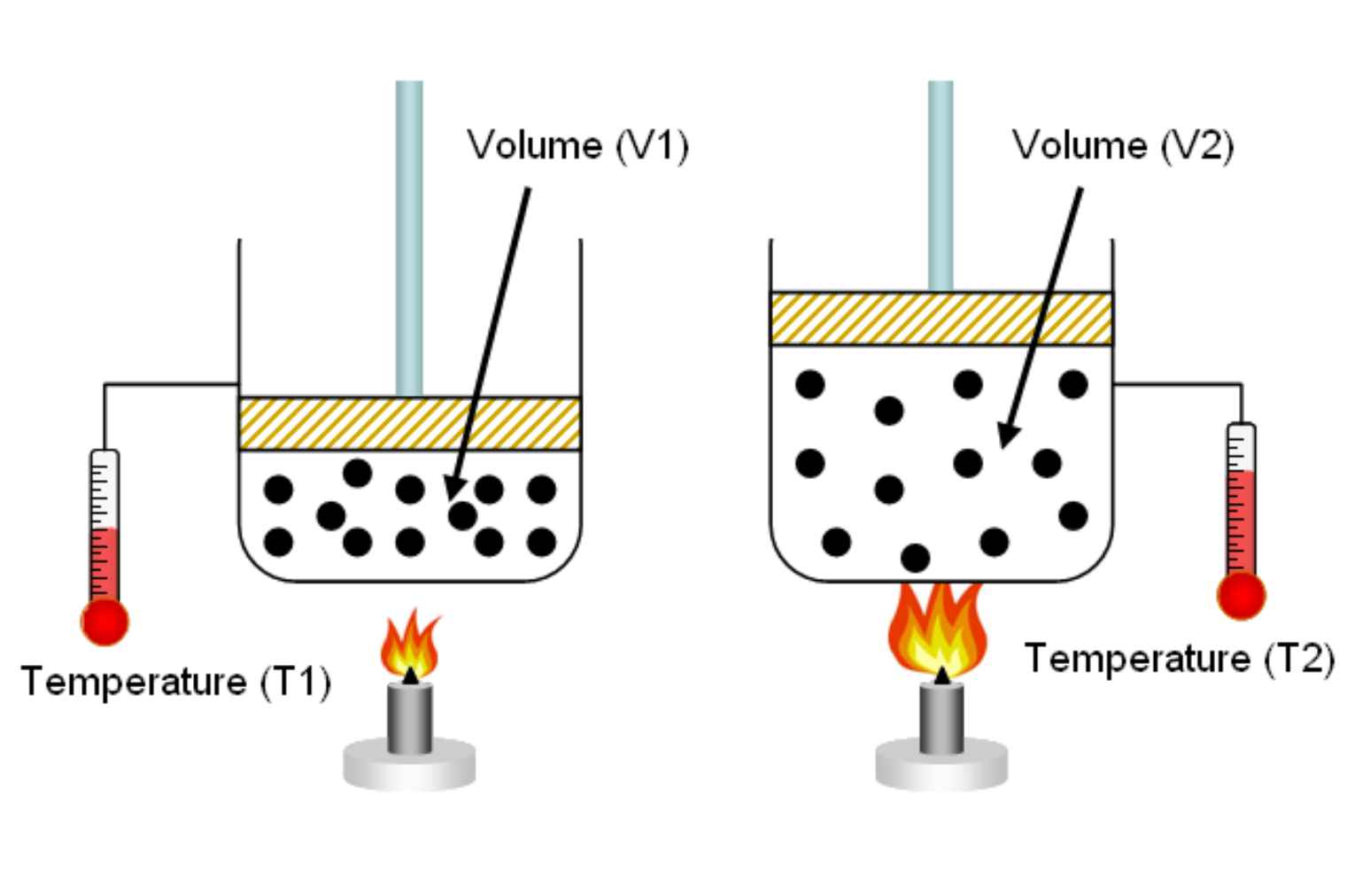
$$\frac{V}{T} = \text{constant} \tag{4}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \tag{5}$$

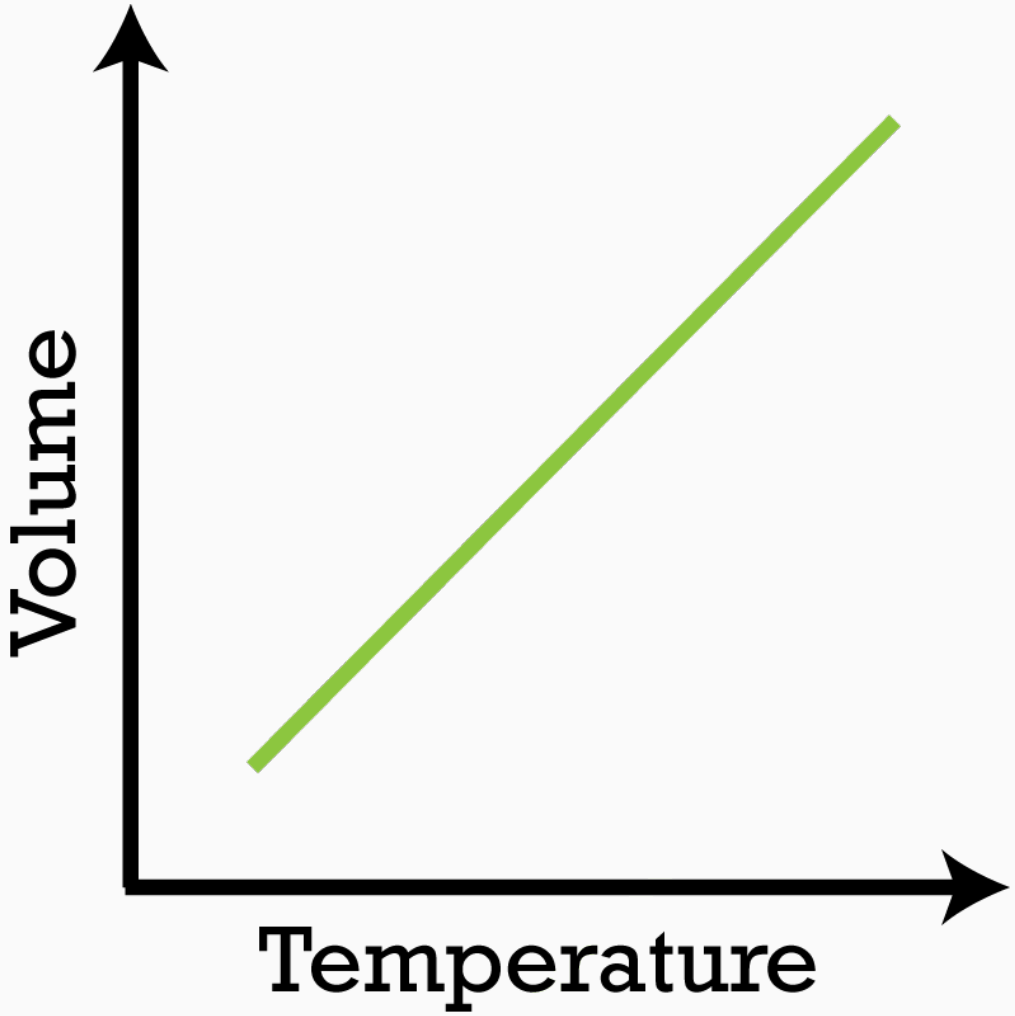
Note: Temperature is in Kelvin! Conversion from °C to K is defined:

$$K = {}^{\circ}C + 273.15 \tag{6}$$

Charles' Law



Graphing Charles' Law



Practice: Charles' Law

If a sample of chlorine gas occupies 50.0mL at 100.0°C, what is its volume at 25.0°C at constant pressure?

Avogadro's Hypothesis

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

$$\frac{V}{n} = \text{constant} \tag{7}$$

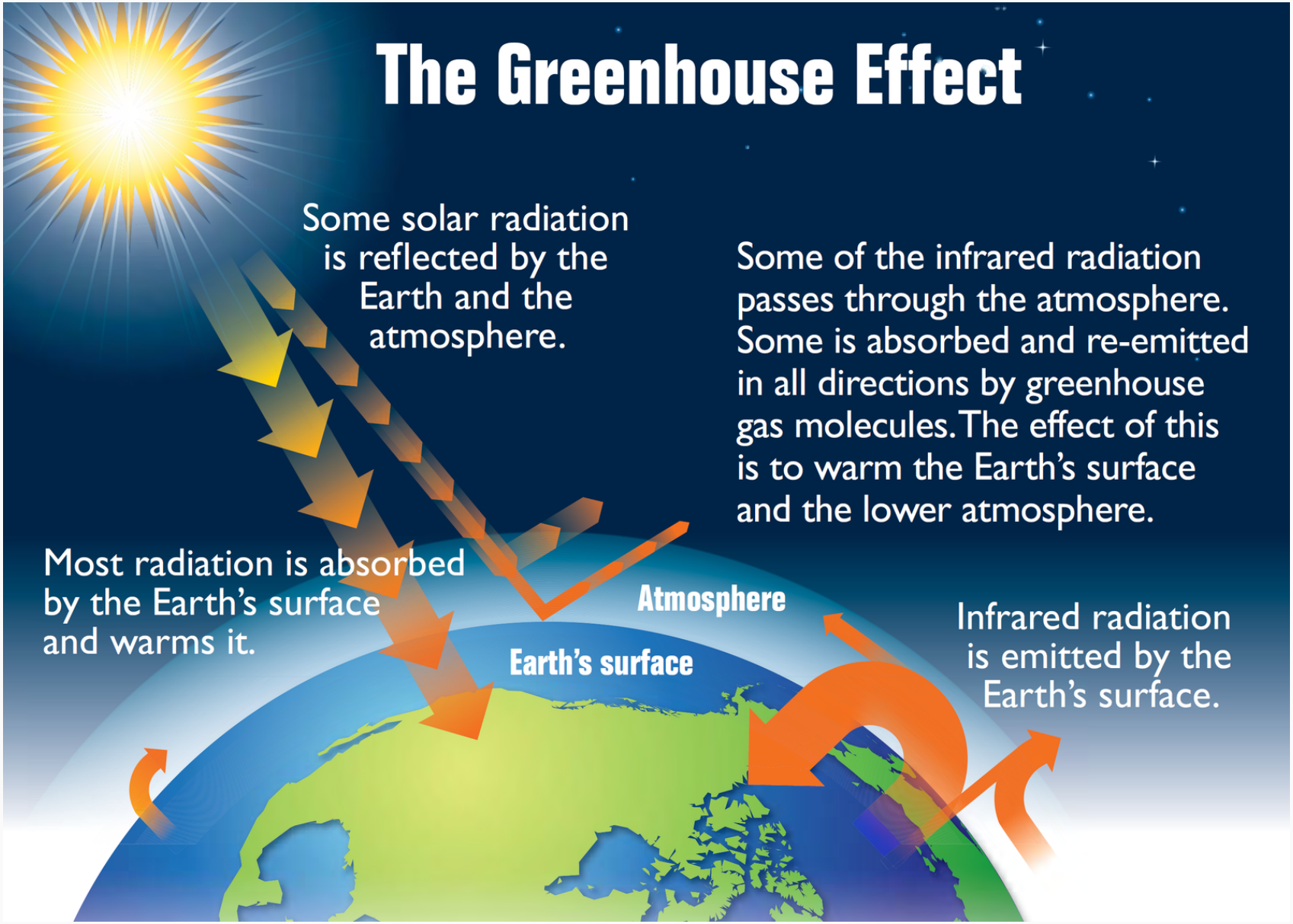
$$\frac{V_1}{n_1} = \frac{V_2}{n_2} \tag{8}$$

Practice: Volume and Moles of Gas

If a 10.0L balloon contains 0.80 mol of a gas, what wil be the volume of a balloon that contains 0.20 mol of the gas if temperature and pressure remain constant?

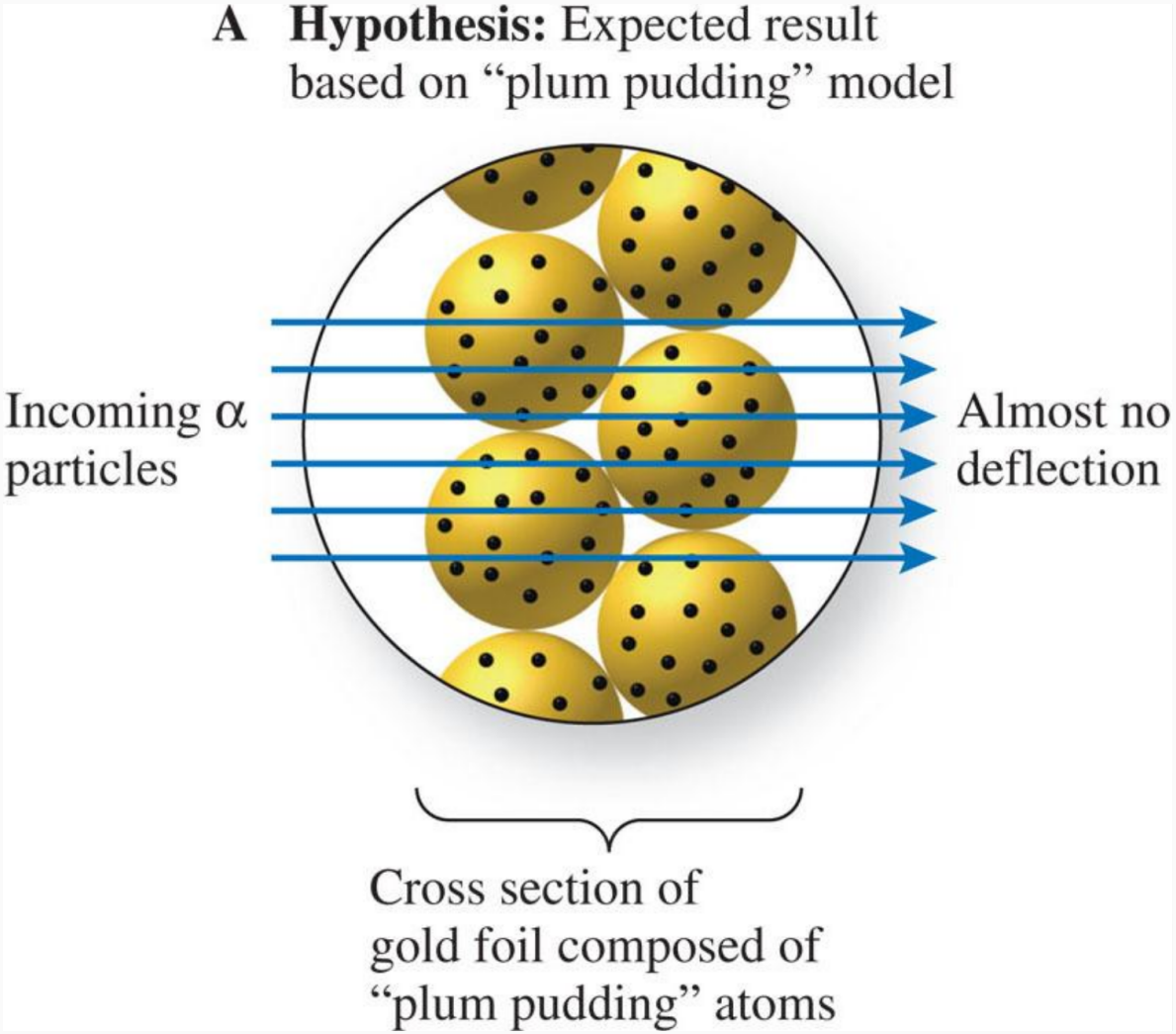
Outline

Greenhouse Effect



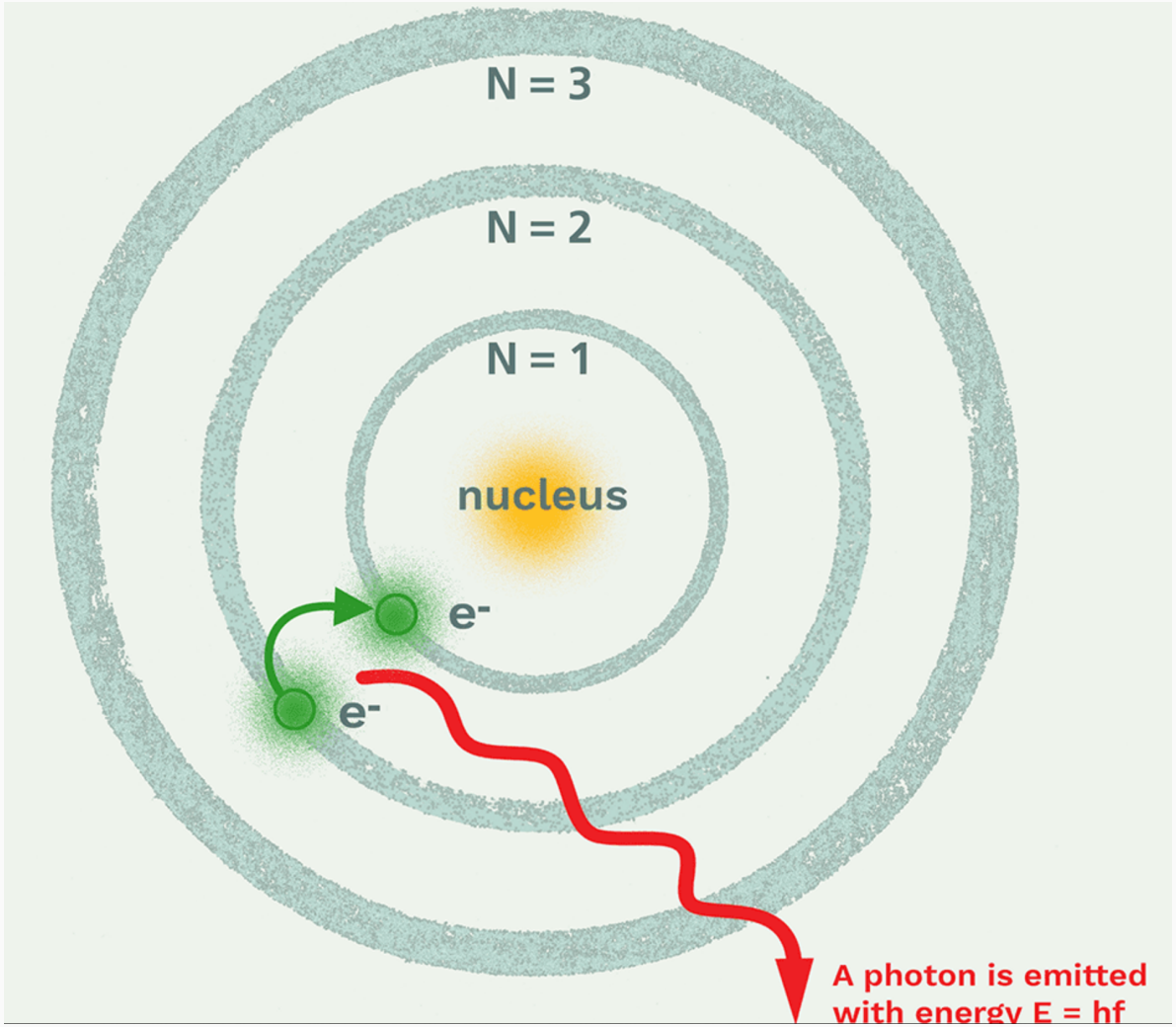
Recall the Models

Plum Pudding Model



Recall the Models

Bohr Model



Ideal Gas Model

$$PV = nRT \tag{9}$$

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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Charles' Law - hold n and P constant

$$\begin{aligned} PV &= nRT \\ \frac{V}{T} &= \frac{nR}{P} = \text{constant} \\ \frac{V_1}{T_1} &= \frac{V_2}{T_2} \end{aligned} \tag{11}$$

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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Finding Density from Ideal Gas Law

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

where MM is the molar mass

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).

Outline

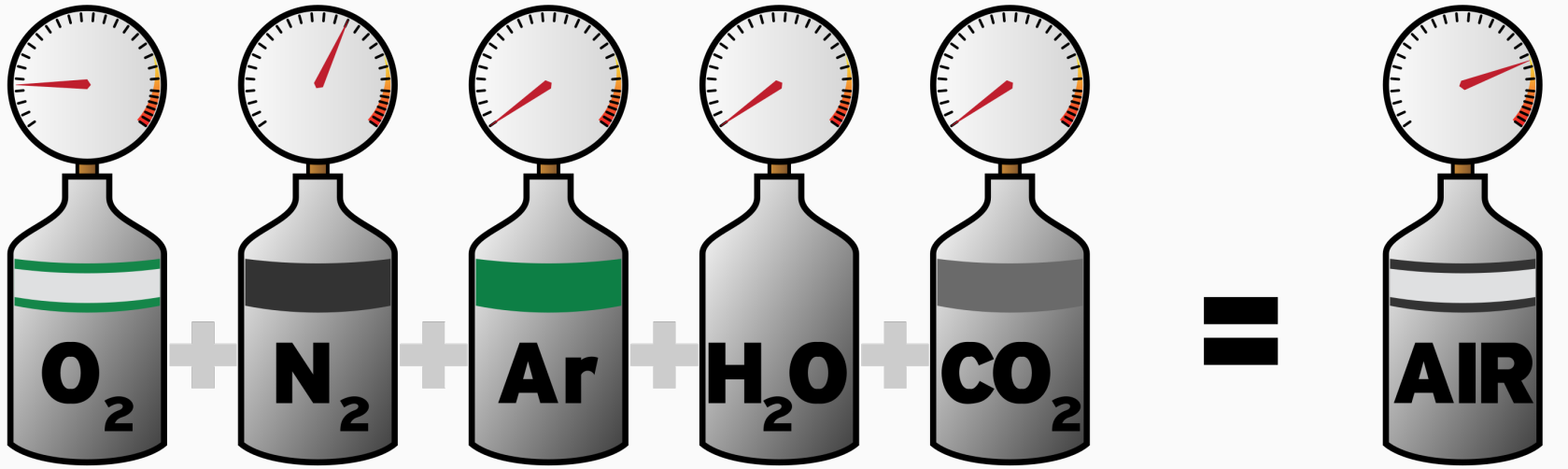
Dalton's Law of Partial Pressures

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

$$P_{\text{Total}} = P_A + P_B + P_C + \cdots \tag{12}$$

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

Dalton's Law of Partial Pressures



$$P_{\text{Total}} = P_{\text{O2}} + P_{\text{N2}} + P_{\text{Ar}} + P_{\text{H2O}} + P_{\text{CO2}}$$

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.