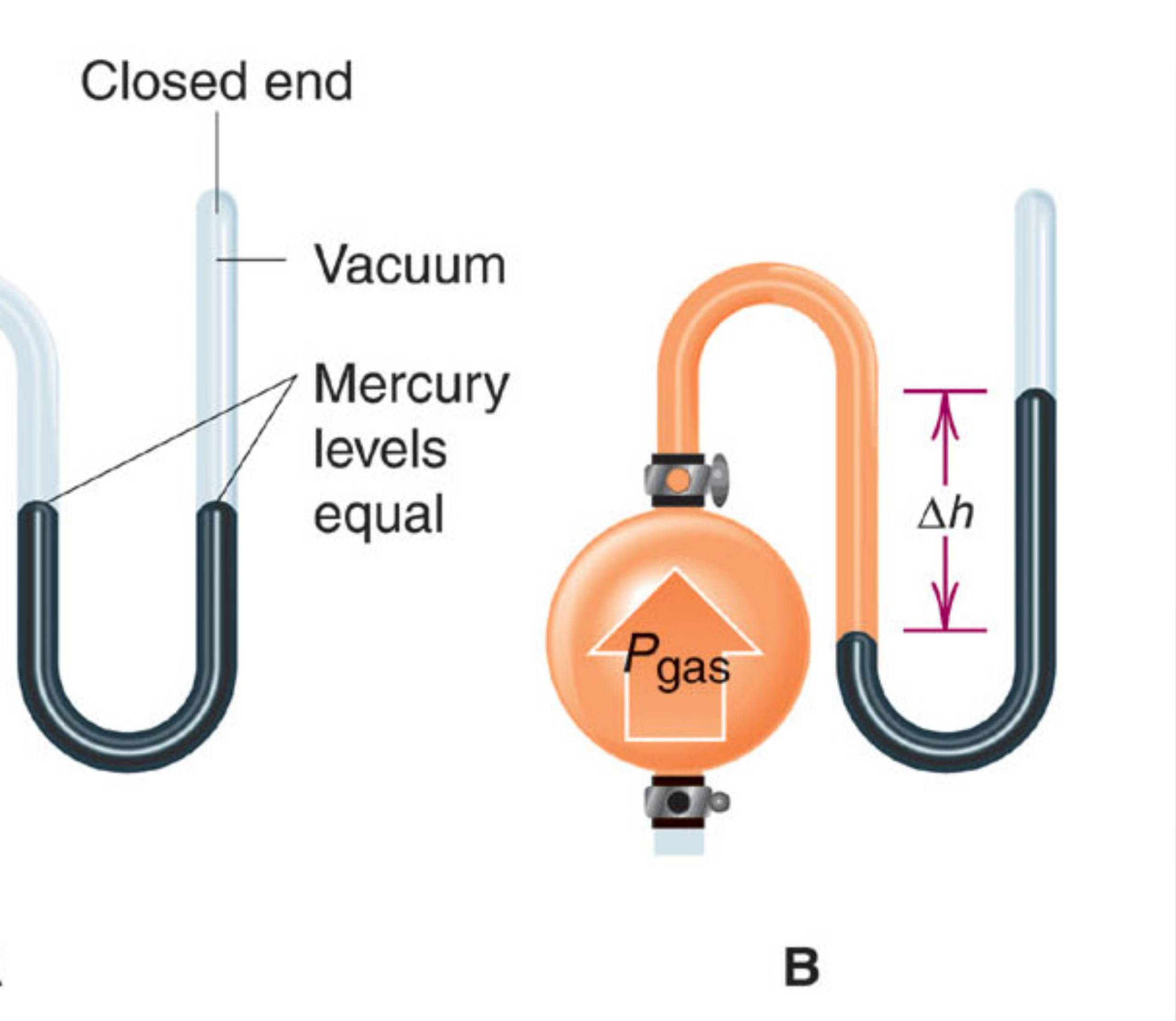
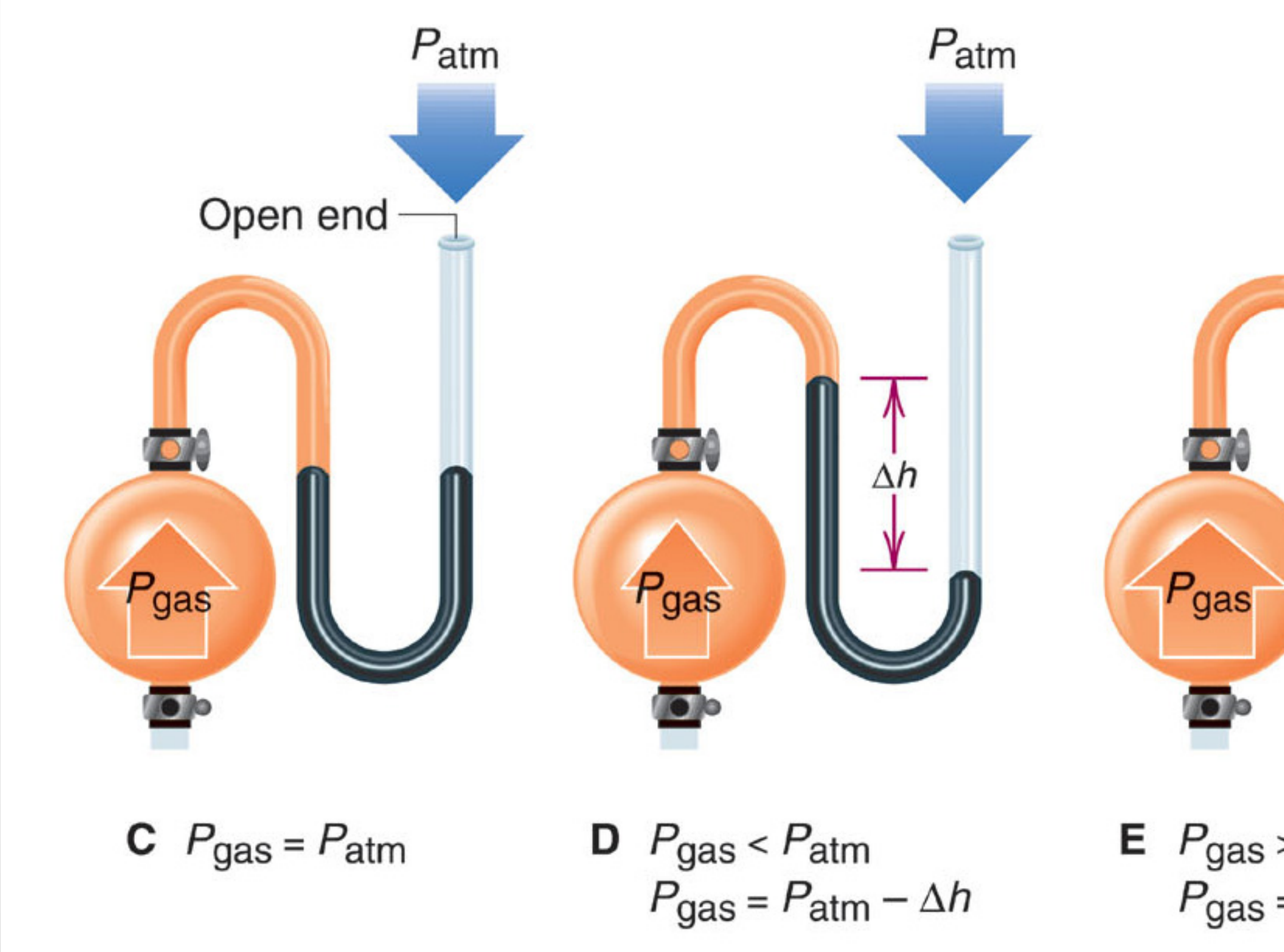
Manometer

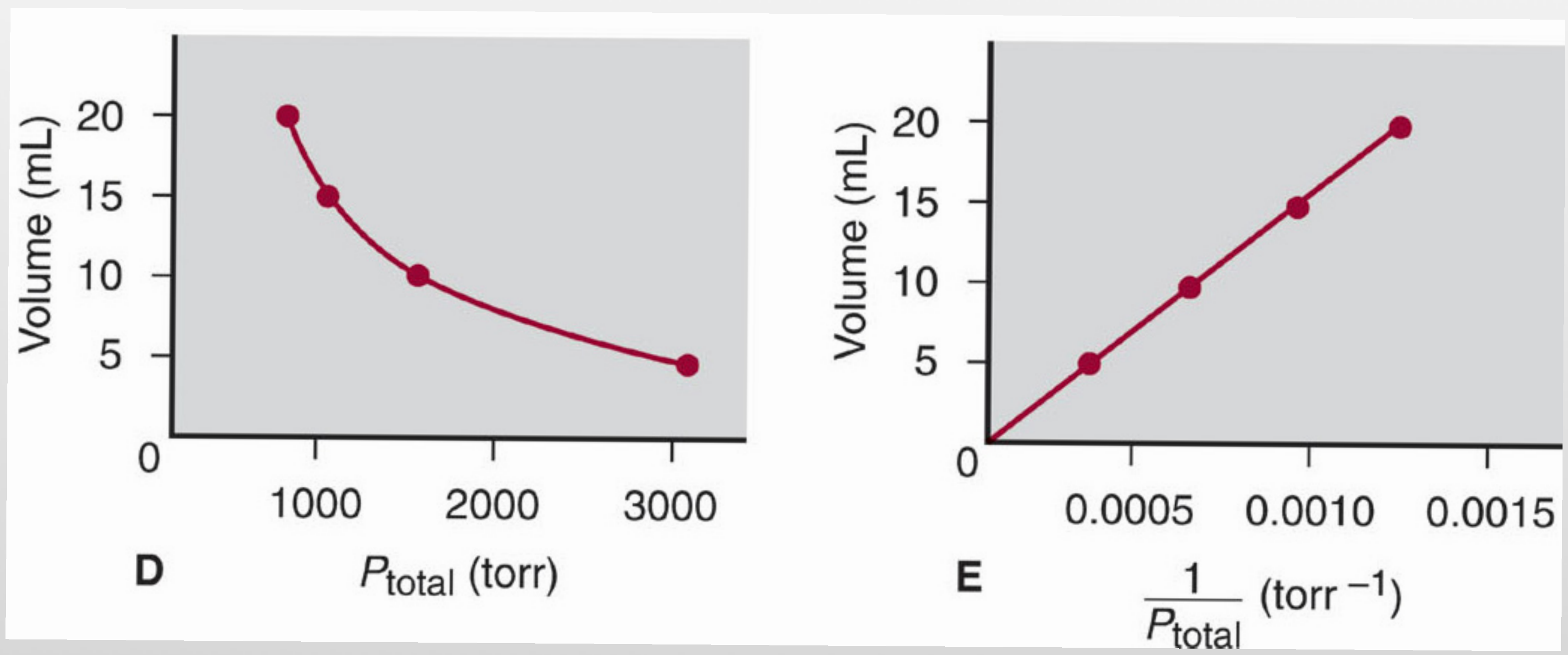




losed End Manometer

Open End Manometer

Relationship between Volume and Pressure: Boyle's Law



$$\text{Boyle's Law: } V \propto \frac{1}{P} \quad \text{(constant T and n)}$$

$$P \cdot V = \text{constant}$$

Boyle's Law

A cylinder with a movable piston has a volume of 5.75 L under an applied pressure of 3.60 atm what is the pressure in Pa when the piston is expanded to 7.60 L

$P_1 = 3.60$ atm $\quad P_2 = ?$

$V_1 = 5.75$ L $\quad V_2 = 7.60$ L

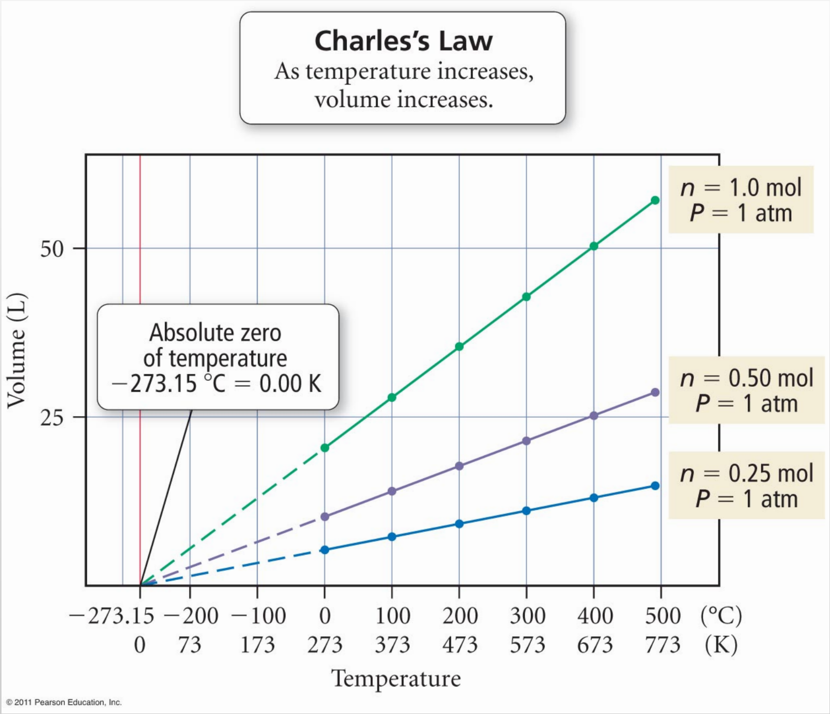
$P_1 V_1 = P_2 V_2 \qquad P_2 = \frac{P_1 V_1}{V_2}$

$P_2 = 3.60 \text{ atm} \cdot \frac{5.75 \text{ L}}{7.60 \text{ L}} = 2.72 \text{ atm}$

$P_2 = 2.72 \text{ atm} \cdot \frac{101325 \text{ Pa}}{1 \text{ atm}} = 275977 \text{ Pa}$

$= 276 \text{ kPa}$

Relationship between Volume and Temperature: Charles's Law



Charles's Law: $V \propto T$ (constant P and n)

$$V = \text{constant} \cdot T$$

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

Charles Law

$$V \propto T$$

$$\frac{V}{T} = \text{const.}$$

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

For all gas calc., the temp. has to be expressed in Kelvin

A sample of gas has a volume of 3.10L at 20°C. What is the volume at -57°C?

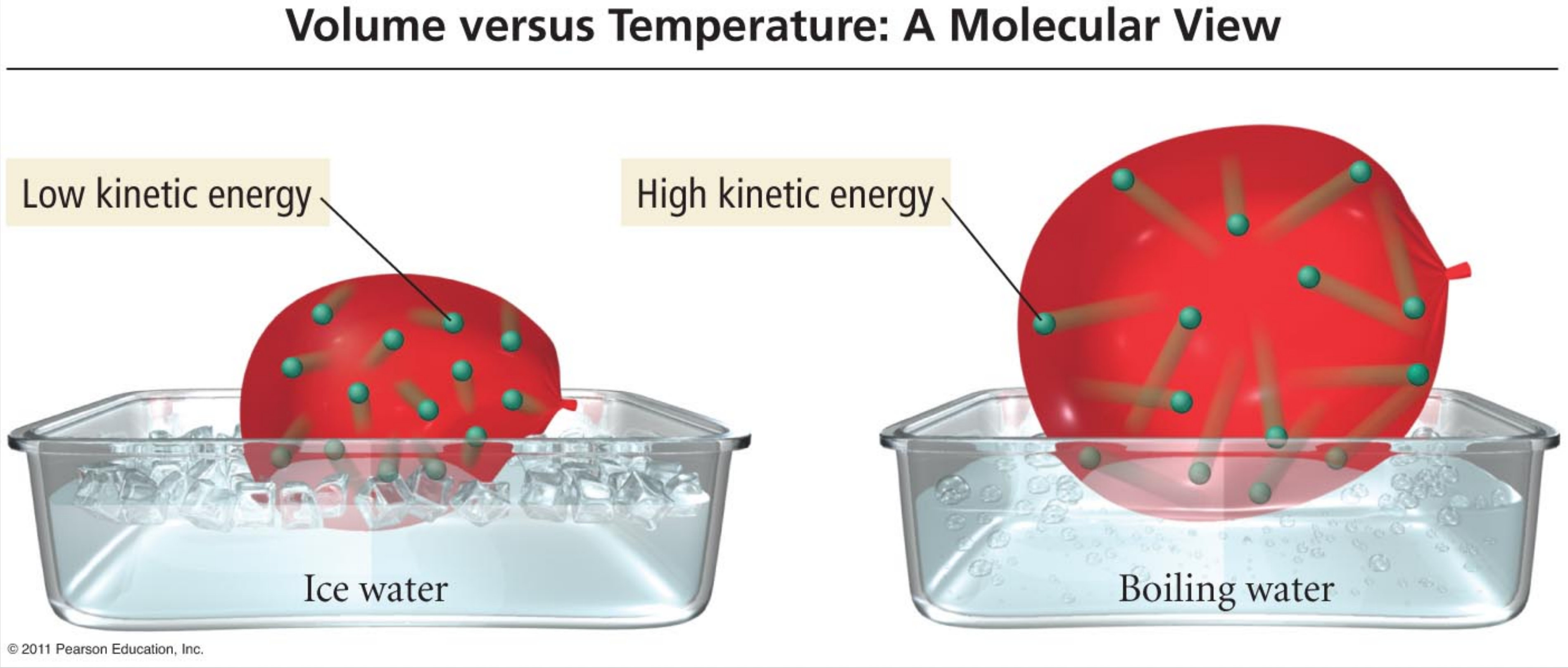
$T_1 = 20°C + 273.15K = 293.15K = 293 K$

$T_2 = -57°C + 273 = 216 K$

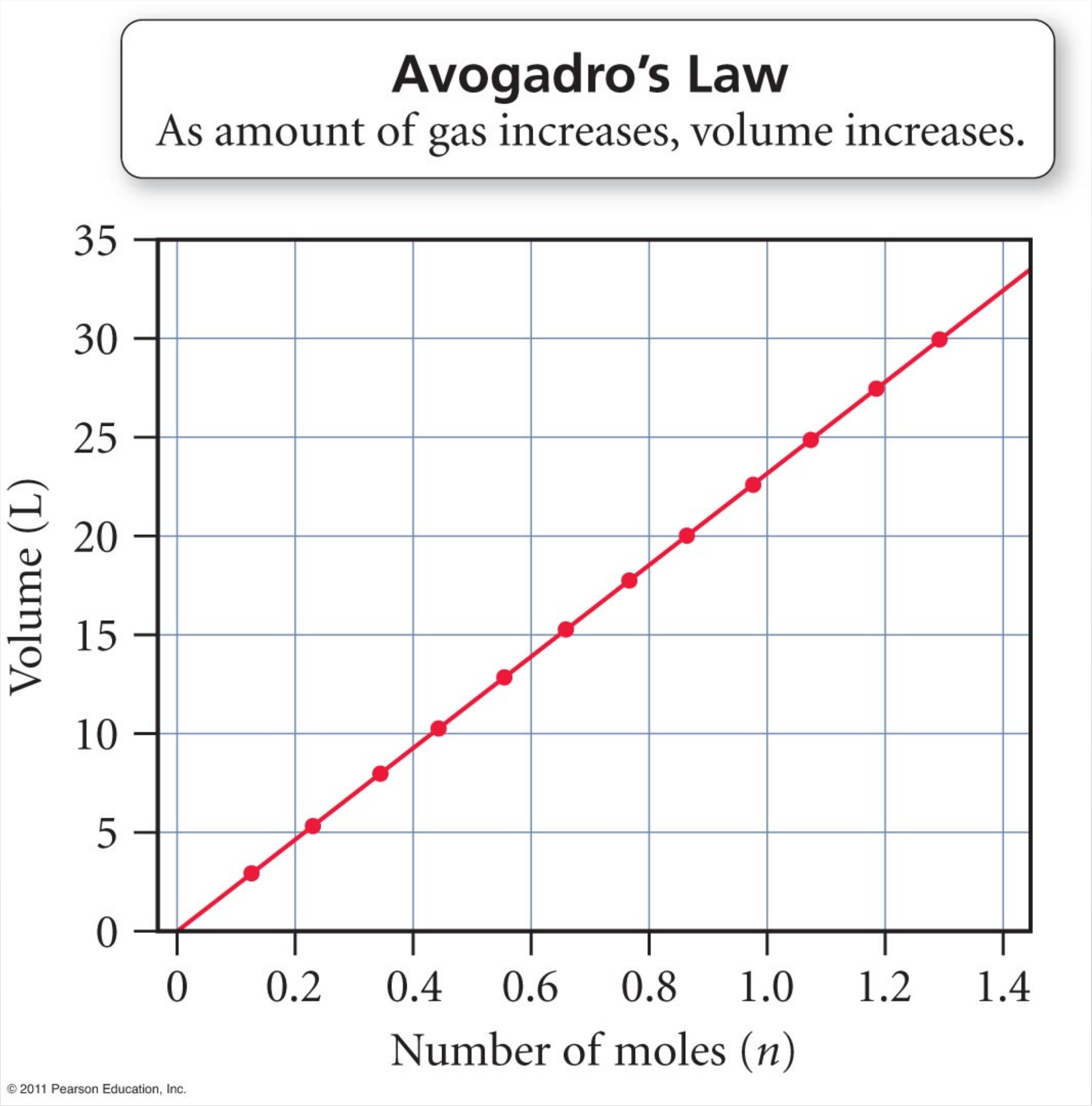
$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow V_2 = \frac{T_2}{T_1} V_1$$

$$V_2 = \frac{216K}{293K} \cdot 3.10L = 2.29L$$

Molecular Interpretation of Charles Law



Relationship between Volume and Amount: Avogadro's Law



Avogrado's Law: $V \propto n$ (constant T and P)

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

Ideal Gas Law

Boyle's Law : $V \propto \frac{1}{P}$

Charles Law : $V \propto T$

Avogadro Law : $V \propto n$

$V \propto \frac{nT}{P}$ or $PV \propto nT$

$$PV = nRT$$

Ideal Gas Law

$$PV = nRT$$

constant n and T	constant n and P	constant P and T
$V = \frac{nRT}{P}$	$V = \frac{nRT}{P}$	$V = \frac{nRT}{P}$
$V \propto \frac{1}{P}$	$V \propto T$	$V \propto n$
Boyle's Law	Charles's Law	Avogadro's Law

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R can be calculated based upon standard conditions:

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

$$R = \frac{1\ atm \cdot 22.414\ L}{1\ mol \cdot 273.15\ K}$$

$$R = 0.082058\ \frac{atm \cdot L}{mol \cdot K}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad \text{at const. } n$$

A steel tank has a volume of 438L and, is filled with 0.885 kg of O_2. Calculate the pressure (in atm) of O_2 at 21°C

Given:

$V = 438L$

$T = 21.0°C + 273K = 294K$

$n(O_2) = 0.885 kg \cdot \frac{1000g}{1kg} \cdot \frac{1mol}{32.00g} = 27.7 mol$

$PV = nRT \Rightarrow P = \frac{nRT}{V}$

$$P = \frac{27.7 \cancel{mol} \cdot 0.0821 \frac{\cancel{L}atm}{\cancel{mol}\cancel{K}} \cdot 294\cancel{K}}{438\cancel{L}}$$

$P = 1.53 atm$

Molar Volume of Gases at STP

STP: Standard Temperature and Pressure

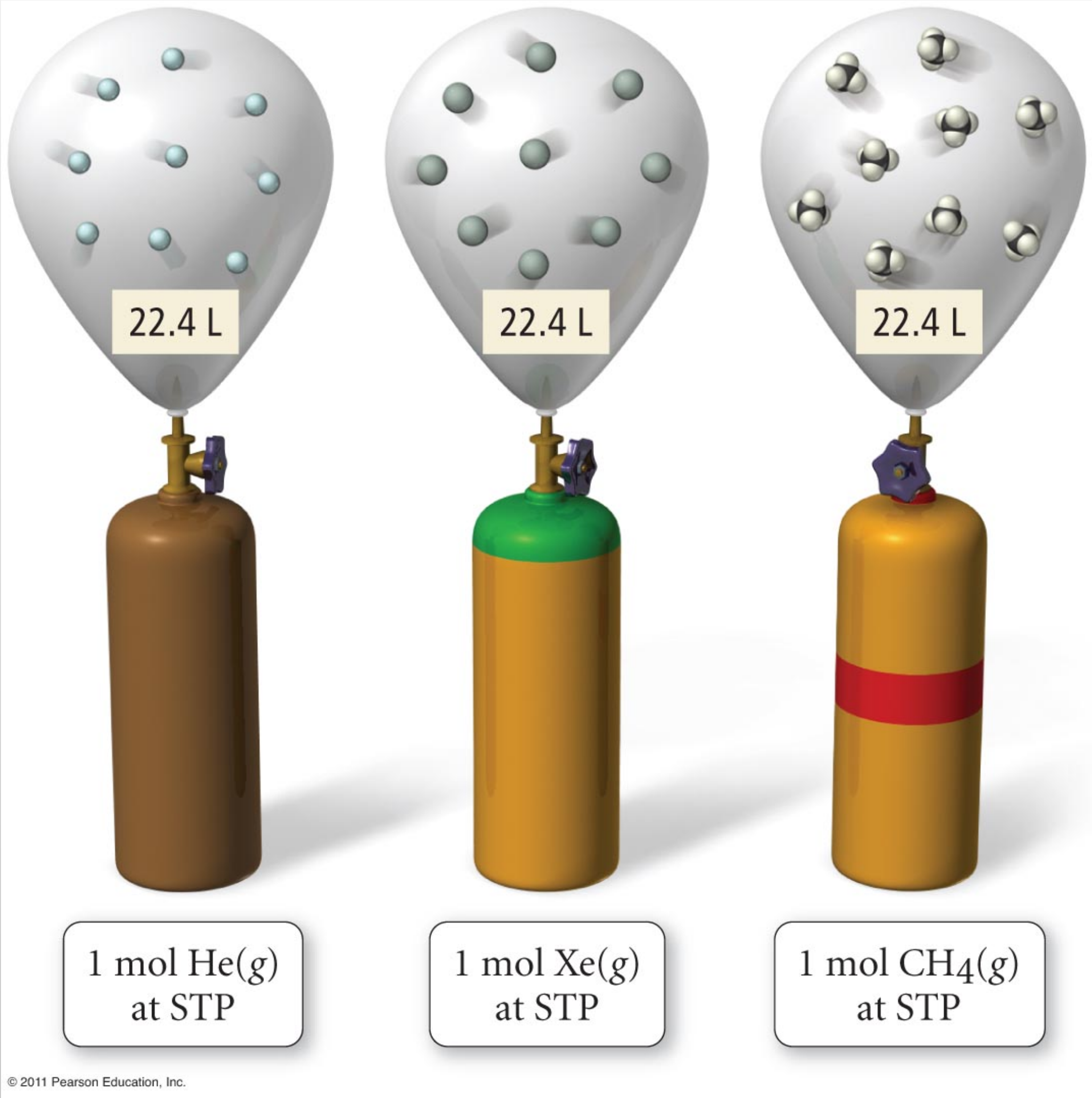
Standard Temperature: 0°C or 273 K

Standard Pressure: 1 atm

$$V = \frac{nRT}{P}$$

$$V = \frac{1.00\ mol \cdot 0.08206 \frac{L \cdot atm}{mol \cdot K} \cdot 273\ K}{1\ atm}$$

$$V = 22.4\ L$$



The molar volume of gases at standard temperature and pressure is

22.4 L

Density of gases

$$\text{Density} = \frac{\text{molar mass}}{\text{molar volume}}$$

$$d_{N_2} = \frac{28.02\ \text{g mol}^{-1}}{22.4\ \text{L mol}^{-1}} = 1.25\ \text{g/L}$$

For non-standard conditions:

$$PV = nRT \Rightarrow \frac{n}{V} = \frac{P}{RT}$$ molar density

Multiply with molar mass

$$M\frac{n}{V} = M\frac{P}{RT} \Rightarrow \frac{\text{mass}}{V} = d = \frac{P \cdot M}{R \cdot T}$$

Find the density in g/L of CO_2 at STP and at room conditions (20°C, 1 atm)

a). $T = 273\ K \quad p = 1\ atm$

$M = 44.01\ g/mol$

$$d = \frac{M \cdot P}{R \cdot T} = \frac{44.01\ g/mol \cdot 1\ atm}{0.0821\ \frac{L\ atm}{mol\ K} \cdot 273\ K} = 1.96\ g/L$$

b). $T = 20°C + 273\ K = 293\ K$

$$d = \frac{44.01\ g/mol \cdot 1\ atm}{0.0821\ \frac{L\ atm}{mol\ K} \cdot 293\ K} = 1.83\ g/L$$