Ch. 14 - Gases

I. Physical Properties

A. Kinetic Molecular Theory

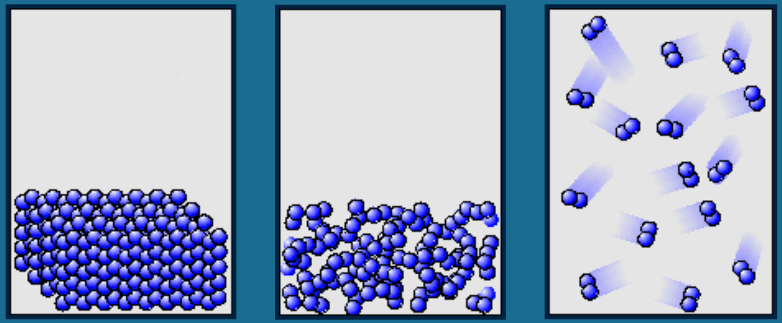
- Particles in an ideal gas…
  - have no volume.
  - have elastic collisions.
  - are in constant, random, straight-line motion.
  - don't attract or repel each other.
  - have an avg. KE directly related to Kelvin temperature.

B. Real Gases

- Particles in a REAL gas…
  - have their own volume
  - attract each other
- Gas behavior is most ideal…
  - at low pressures
  - at high temperatures
  - just like students (think summer!)

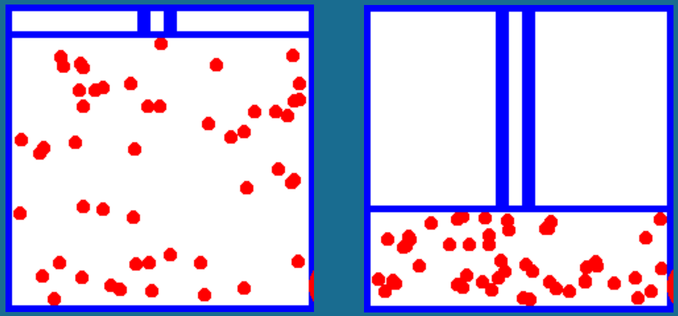
C. Characteristics of Gases

- Gases expand to fill any container.
  - random motion, no attraction
- Gases are fluids (like liquids).
  - no attraction
- Gases have very low densities.
  - no volume = lots of empty space



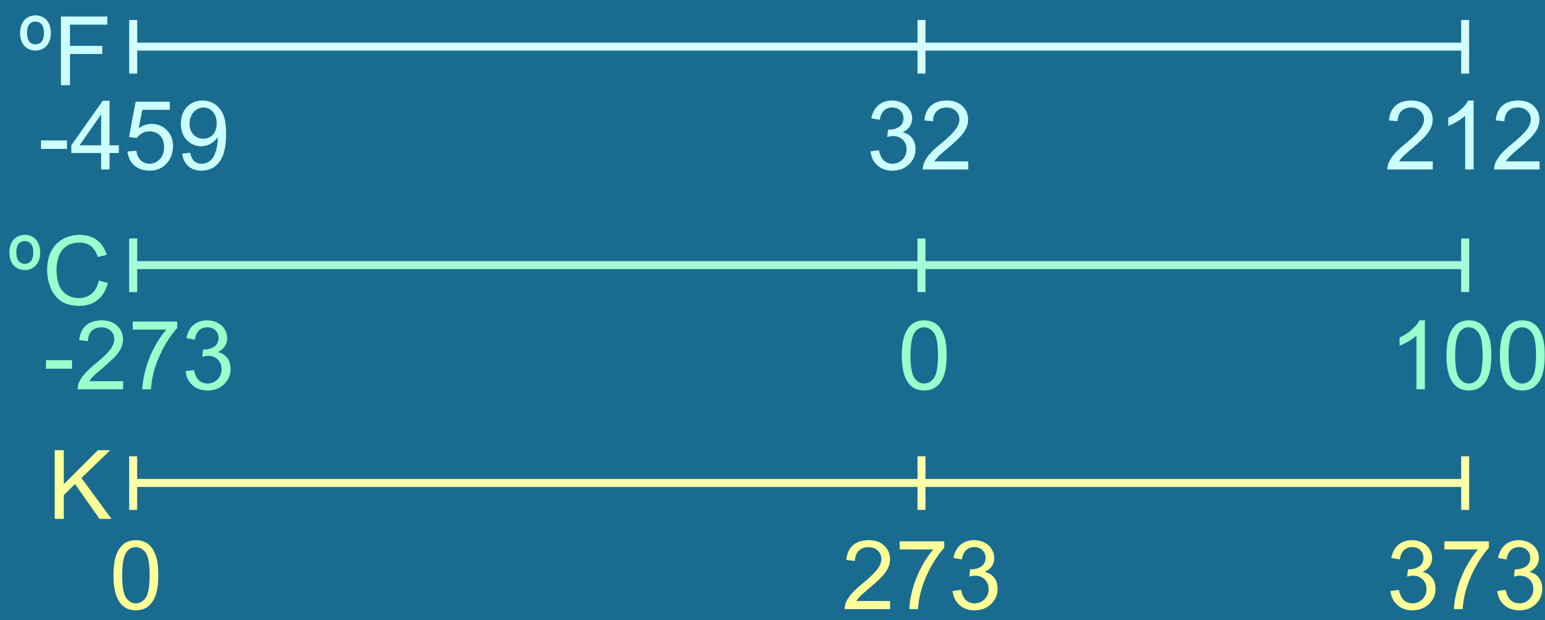
C. Characteristics of Gases

- Gases can be compressed.
  - no volume = lots of empty space
- Gases undergo diffusion & effusion.
  - random motion



D. Temperature

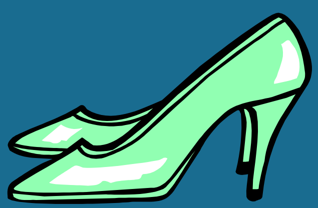
- Always use absolute temperature (Kelvin) when working with gases.



$$°C = \frac{5}{9}\left(°F - 32\right) \qquad K = °C + 273$$

E. Pressure

$$pressure = \frac{force}{area}$$



Which shoes create the most pressure?

F. STP

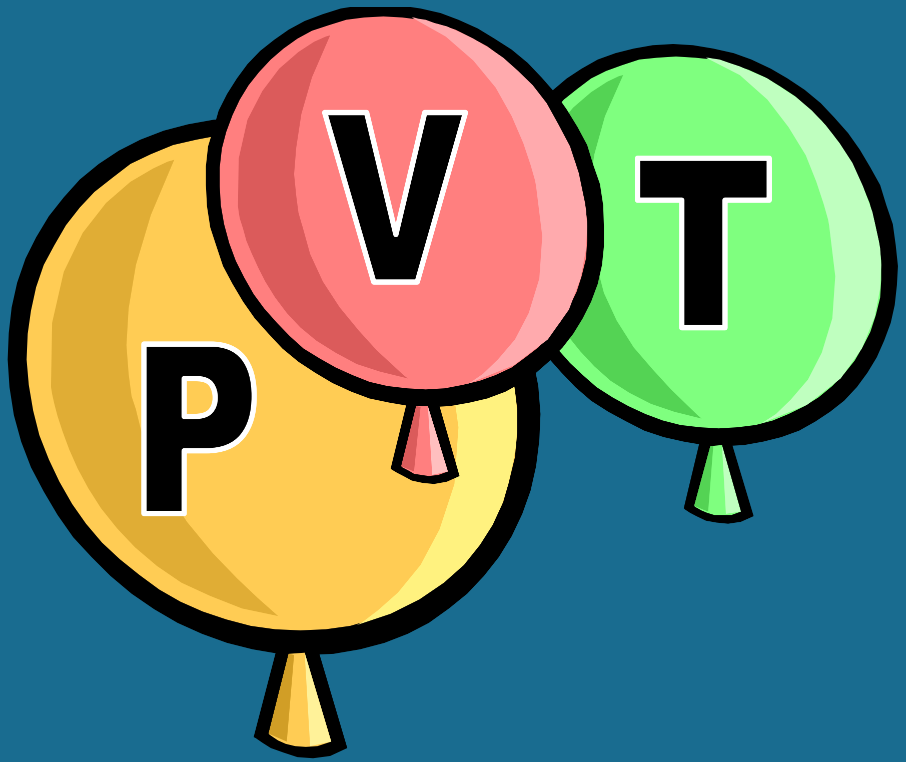
STP

Standard Temperature & Pressure

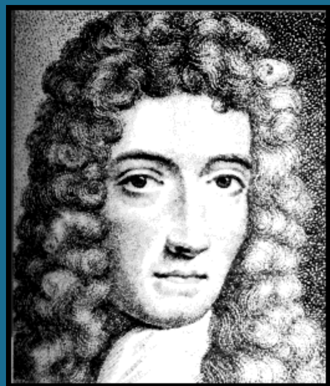
0°C | -OR- | 273 K

1 atm | | 101.325 kPa

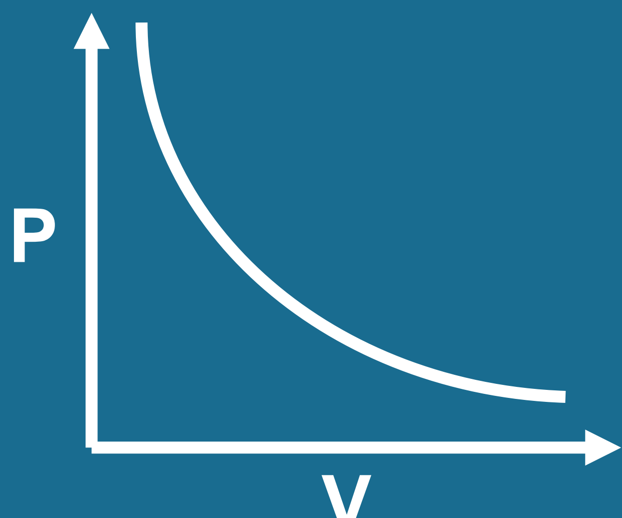
Ch. 14 - Gases



A. Boyle's Law



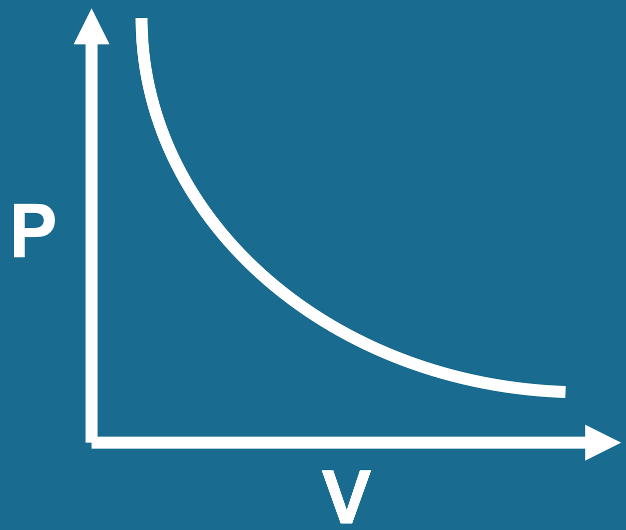
Volume (mL)	Pressure (torr)	P·V (mL·torr)
10.0	760.0	7.60×10^3
20.0	379.6	7.59×10^3
30.0	253.2	7.60×10^3
40.0	191.0	7.64×10^3



$$PV = k$$

A. Boyle's Law

- The pressure and volume of a gas are inversely related
  - at constant mass & temp

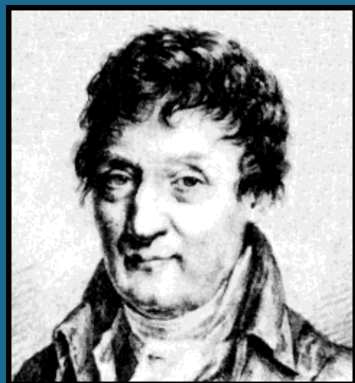


$$PV = k$$

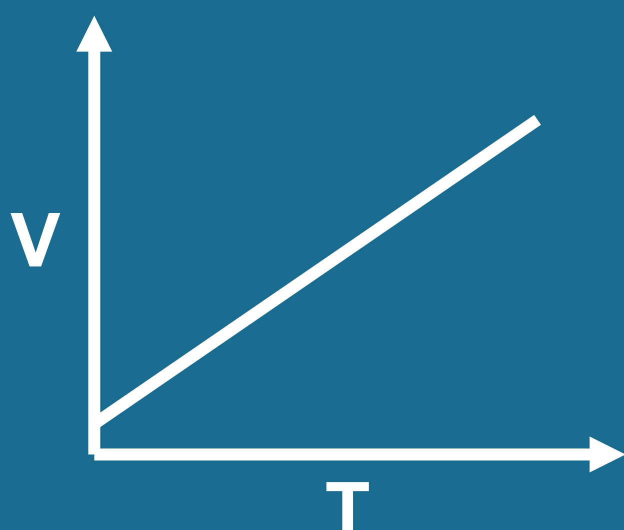
A. Boyle's Law

Boyle's Law Video

B. Charles' Law



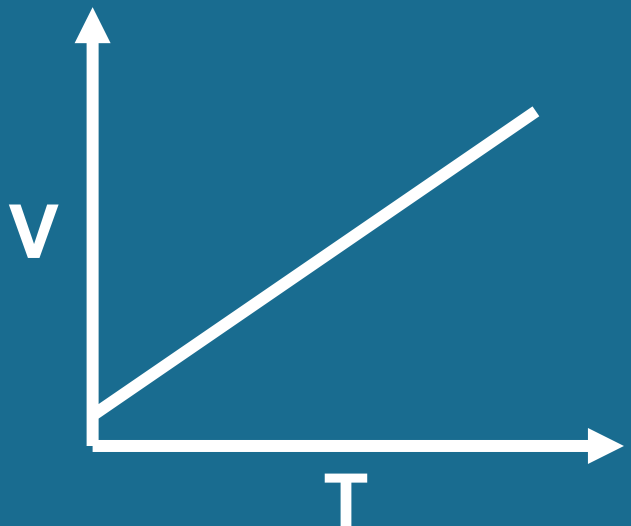
Volume (mL)	Temperature (K)	V/T (mL/K)
40.0	273.2	0.146
44.0	298.2	0.148
47.7	323.2	0.148
51.3	348.2	0.147



$$\frac{V}{T} = k$$

B. Charles' Law

- The volume and absolute temperature (K) of a gas are directly related
  - at constant mass & pressure



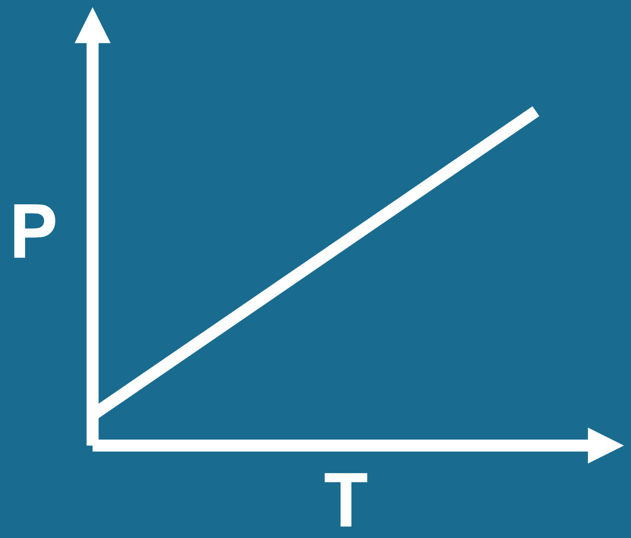
$$\frac{V}{T} = k$$

B. Charles' Law

Charles' Law

C. Gay-Lussac's Law

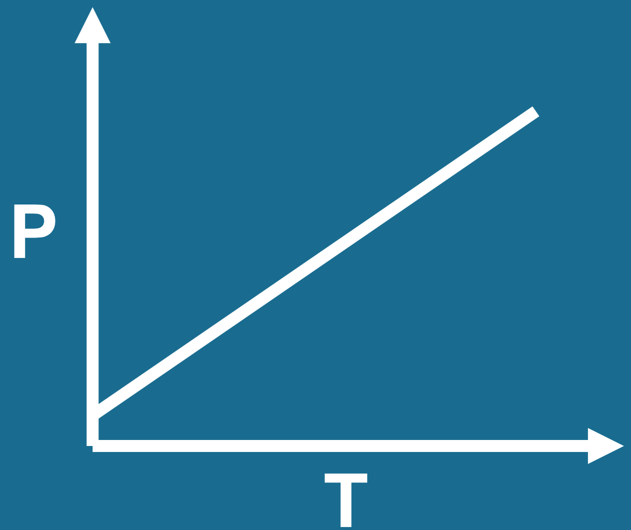
Temperature (K)	Pressure (torr)	P/T (torr/K)
248	691.6	2.79
273	760.0	2.78
298	828.4	2.78
373	1,041.2	2.79



$$\frac{P}{T} = k$$

C. Gay-Lussac's Law

- The pressure and absolute temperature (K) of a gas are directly related
  - at constant mass & volume



$$\frac{P}{T} = k$$

C. Gay-Lussac' s Law

- Gay-Lussac's Law

Equations for the three Gas Laws

- Charles's Law

$$V_1/T_1 = V_2/T_2$$

- Boyle's Law

$$P_1V_1 = P_2V_2$$

- Gay-Lussac's Law

$$P_1/T_1 = P_2/T_2$$

D. Combined Gas Law

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

STP

Standard Temperature & Pressure

0°C		273 K
	-OR-	
1 atm		101.325 kPa

E. Gas Law Problems

- A gas occupies 473 L at 36°C. Find its volume at 94°C.

CHARLES' LAW

GIVEN: **T↑ V↑**	WORK:
V_1 = 473 L T_1 = 36°C = 309K V_2 = ? T_2 = 94°C = 367K	$$V_1/T_1 = V_2/T_2$$ (473 L)(367 K)=V_2(309 K) **V_2 = 562 L**

E. Gas Law Problems

- A gas occupies 100. mL at 1.5 atm. Find its volume at 2 atm.

BOYLE'S LAW

GIVEN: **P↑ V↓**	WORK:
V_1 = 100. mL P_1 = 1.5 atm V_2 = ? P_2 = 2 atm	$$P_1V_1 = P_2V_2$$ (1.5 atm)(100.mL)=(2 atm)V_2 **V_2 = 75.0 mL**

E. Gas Law Problems

- A gas occupies 7.84 cm^3 at 0.709 atm & 25°C. Find its volume at STP.

COMBINED GAS LAW

GIVEN: **P↑ T↓ V↓**	WORK:
$V_1 = 7.84$ mL $P_1 = 0.709$ atm $T_1 = 25°C = 298$ K $V_2 = ?$ $P_2 = 1$ atm $T_2 = 273$ K	$P_1V_1T_2 = P_2V_2T_1$ (0.709 atm)(7.84 mL)(273 K) =(1 atm) V_2 (298 K) **V_2 = 5.09 mL**

E. Gas Law Problems

- A gas' pressure is 1 atm at 23°C. At what temperature will the pressure be 0.737 atm?

GAY-LUSSAC'S LAW

GIVEN: **P↓ T↓**	WORK:
P_1 = 1 atm T_1 = 23°C = 296K P_2 = 0.737 atm T_2 = ?	$$P_1/T_1 = P_2/T_2$$ (1atm)T_2 = (0.737 atm)(296K) **T_2 = 218 K = -55°C**

Ch. 14 - Gases

III. Ideal Gas Law

Ideal Gas Assumptions…

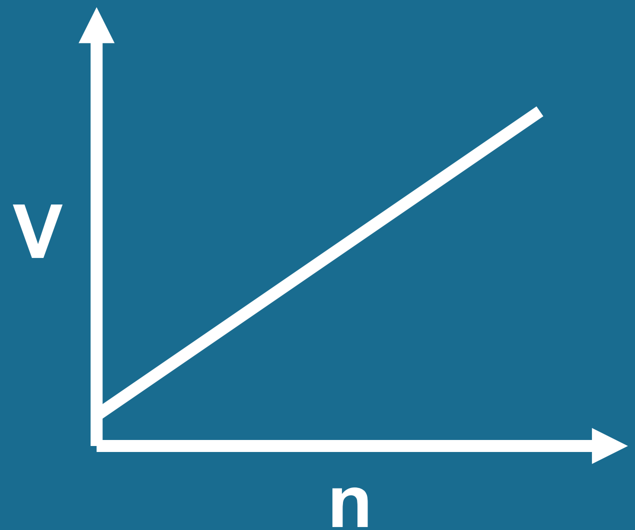
- Particles in an ideal gas…
  - have no volume.
  - have elastic collisions.
  - are in constant, random, straight-line motion.
  - don't attract or repel each other.
  - have an avg. KE directly related to Kelvin temperature.

B. Real Gases

- Particles in a REAL gas…
  - have their own volume
  - attract each other
- Gas behavior is most ideal…
  - at low pressures
  - at high temperatures
  - just like students (think summer!)

A. Avogadro's Principle

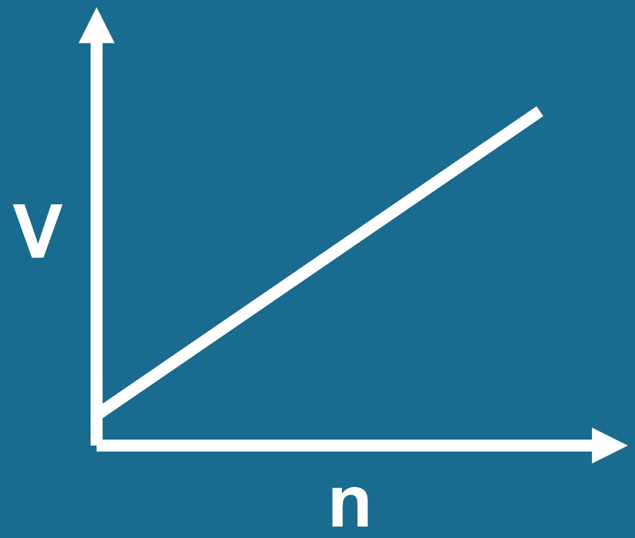
Gas	Volume (mL)	Mass (g)	Moles, n	V/n (L/mol)
O_2	100.0	0.122	3.81×10^{-3}	26.2
N_2	100.0	0.110	3.93×10^{-3}	25.5
CO_2	100.0	0.176	4.00×10^{-3}	25.0



$$\frac{V}{n} = k$$

A. Avogadro's Principle

- Equal volumes of gases contain equal numbers of moles
  - at constant temp & pressure
  - true for any gas



$$\frac{V}{n} = k$$

B. Ideal Gas Law

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

UNIVERSAL GAS CONSTANT

R=0.0821 L·atm/mol·K

R=8.315 L·kPa/mol·K

B. Ideal Gas Law

$$PV=nRT$$

UNIVERSAL GAS CONSTANT

$R=0.0821\ L\cdot atm/mol\cdot K$

$R=8.315\ L\cdot kPa/mol\cdot K$

B. Ideal Gas Law

- Calculate the pressure in atmospheres of 0.412 mol of He at 16°C & occupying 3.25 L. **IDEAL GAS LAW**

GIVEN:	WORK:
$P = ?$ atm	$PV = nRT$
$n = 0.412$ mol	$P(3.25) = (0.412)(0.0821)(289)$ L mol L·atm/mol·K K
$T = 16°C = 289$ K	
$V = 3.25$ L	$P = 3.01$ atm
$R = 0.0821$ L·atm/mol·K	

B. Ideal Gas Law

- Find the volume of 85 g of O_2 at 25°C and 1 atm.

IDEAL GAS LAW

GIVEN:	WORK:
V = ?	$\frac{85\ \text{g} \mid 1\ \text{mol}}{\mid 32.00\ \text{g}} = 2.7\ \text{mol}$
n = ?	
T = 25°C = 298 K	(1)V=(2.7mol) (0.0821) (298)
P = 1 atm	V = 64 L
R = 0.0821L·atm/mol·K	

$PV=nRT$ is all you need!

- Just know this one equation and you can derive all the others!