Chapter 2 - The Gas Laws

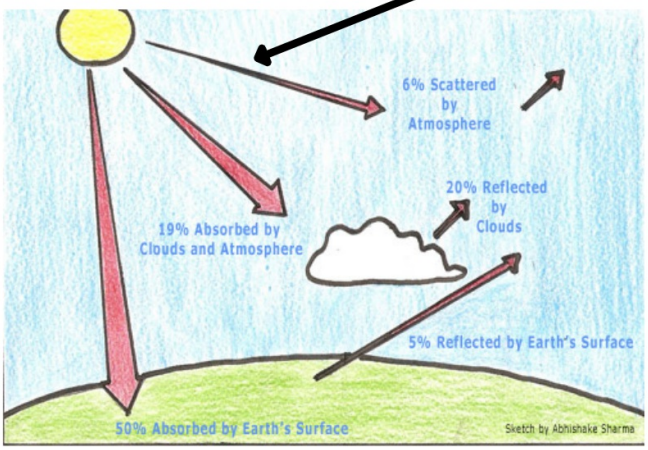
1. The atmosphere - "ocean"of different gases mixed together.

Composition:

Nitrogen (N_2) --> 78%
Oxygen (O_2) --> 21%
Argon --> 0.93%
Water Vapor (H_2O) --> 0.1%
Carbon Dioxide (CO_2) --> 0.03%

Trace amounts of: He, Ne, Rn, SO_2, CH_4, etc...

2. The Greenhouse Effect



High energy, short λ light passes through our atmosphere

Earth absorbs 50% of light that passes through in the form of heat

The lower energy, long λ, reflects off of the surface of the Earth and heads back to space

CO_2 blocks it and is absorbed into the atmosphere which heats it

a. Good thing --> without it the Earth would be too cool

b. Bad thing --> too much CO_2 --> too warm

c. Why is there more CO_2 in the atmosphere?

- More People
  - ↳ Respiration
- Less trees → Deforestation
- Pollution
  - ↳ cars
  - ↳ production of energy
  - ↳ industry
- Burning Fossil fuels
  - ↳ old CO_2
- Volcanoes
- Coral Reefs

3. Depletion of the ozone layer

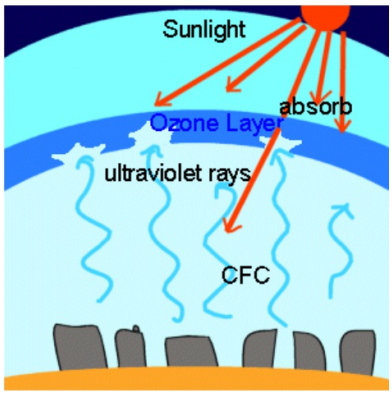
a. Ozone (O_3) is a charged particle that in the upper atmosphere blocks UV Rays

i. UV rays cause cancer and cataracts

b. O_3 depletion is caused by chlorofluorocarbons (CFCs)

i. Uses for CFCs included refrigerants and aerosal propellants

ii. CFCs were banned in the USA and much of the world



c. Ozone is formed everytime a strike of lightning occurs

4. Common Units used when describing Gases

a. Temperature: K and °C

Conversion °C = K - 273

b. Pressure: kPa, mm Hg, atm, psi

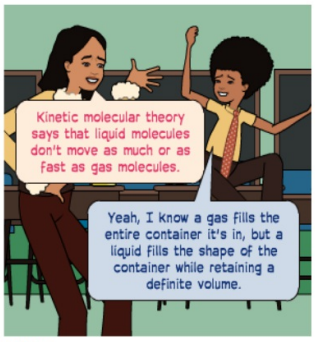
Conversions: 1 kPa = 7.5 mm Hg

1 atm = 101.3 kPa

1 atm = 760 mm Hg

1 atm = 14.7 psi

5. The Kinetic Molecular Theory (KMT)



a. explains why gases behave as they do
b. deals with "ideal" gas particles

c. The 5 claims that the KMT makes about gases are:

Air molecules:

1. are so small they are assumed to have zero volume
2. are in constant, straight-line paths
3. experience elastic collisions
   i. no energy is lost
4. have no attractive or repulsive forces acting towards each other
5. have an average kinetic energy that is proportional to the absolute temperature of the gas

10. Gas Pressure - A force that is exerted on an area by air molecules

Pressure = Force / Area P = F/A

If F acts on a large area - pressure is small

But if F acts on a small area - pressure is large

At Sea Level, air pressure = standard pressure

1 atm, 101.3 kPa, 760 mm Hg, 14.7 lb/in^2

Key important things about gas pressure:

1. Gases exert force in all directions

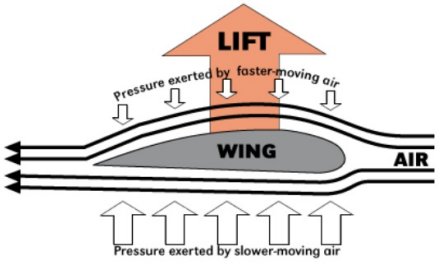
2. Atmospheric pressure changes with altitude

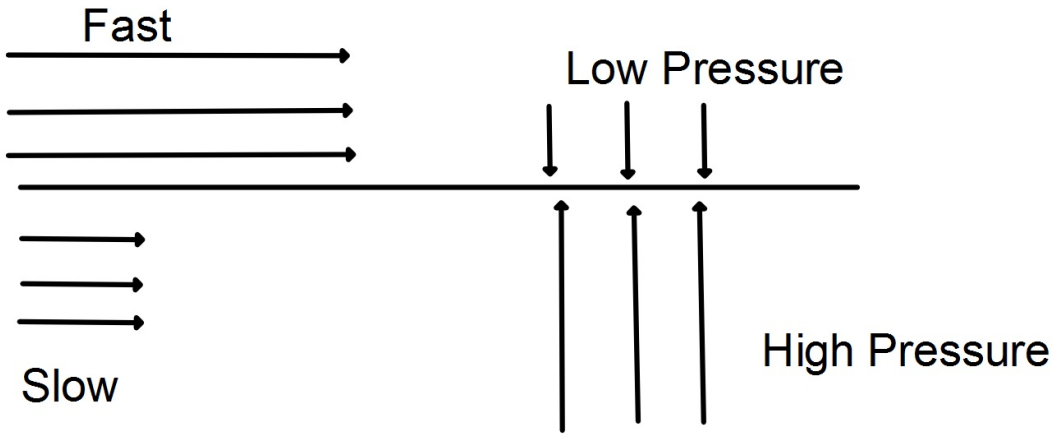
   As altitude increases, pressure decreases

3. Barometer is the tool we measure pressure

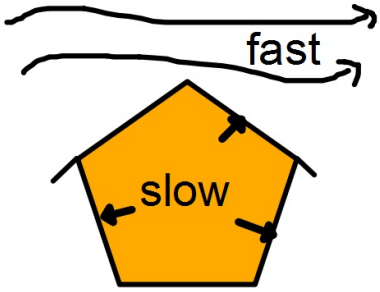
Bernoulli's Principle

- For a fluid traveling parallel to a surface
- Fast moving fluid exerts Low Pressure
- Slow moving fluids exert High Pressure





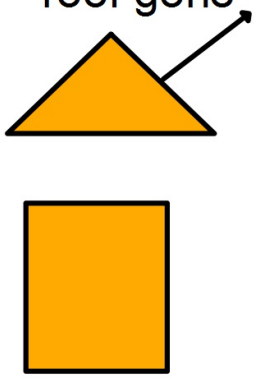
Roof in Hurricane



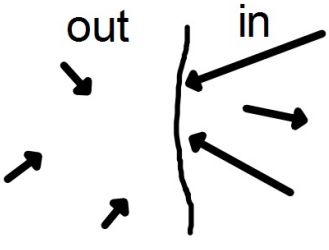
Speed

Pressure

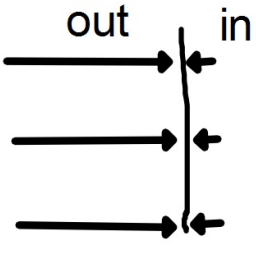
roof gone



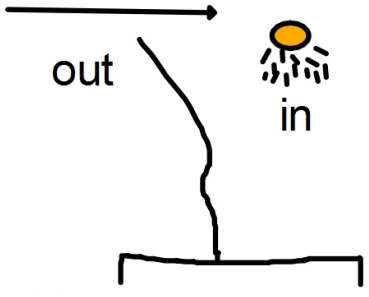
Creeping Shower Curtain



Speed



Pressure



Shower curtain moves in

Boyle's Law

- The relationship between Pressure and Volume

- At constant temperature and number of particles

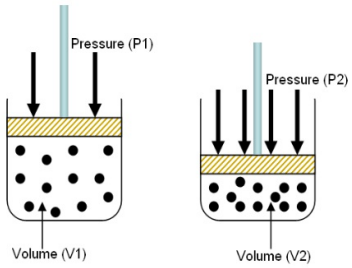
- As pressure increases, volume decreases

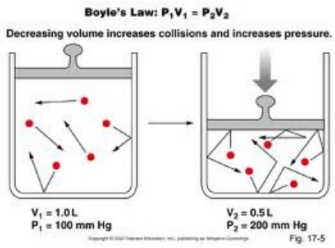
- As pressure decreases, volume increases

$$P_1V_1 = P_2V_2$$

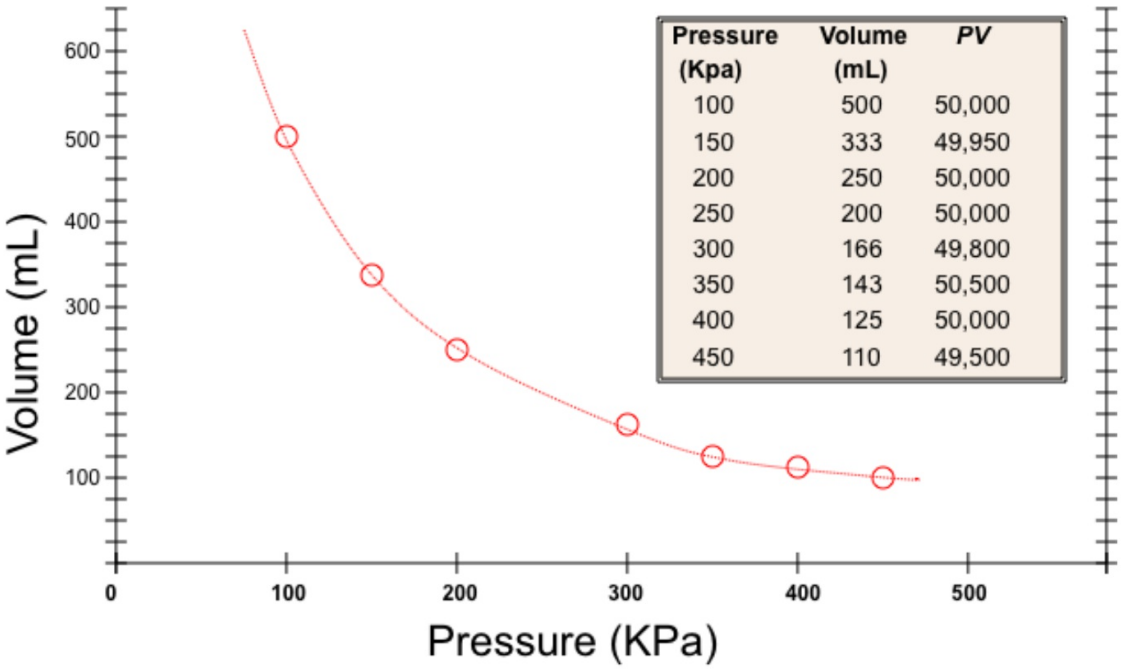
P = Pressure of the gas
V = Volume of the gas

Temperature must be constant



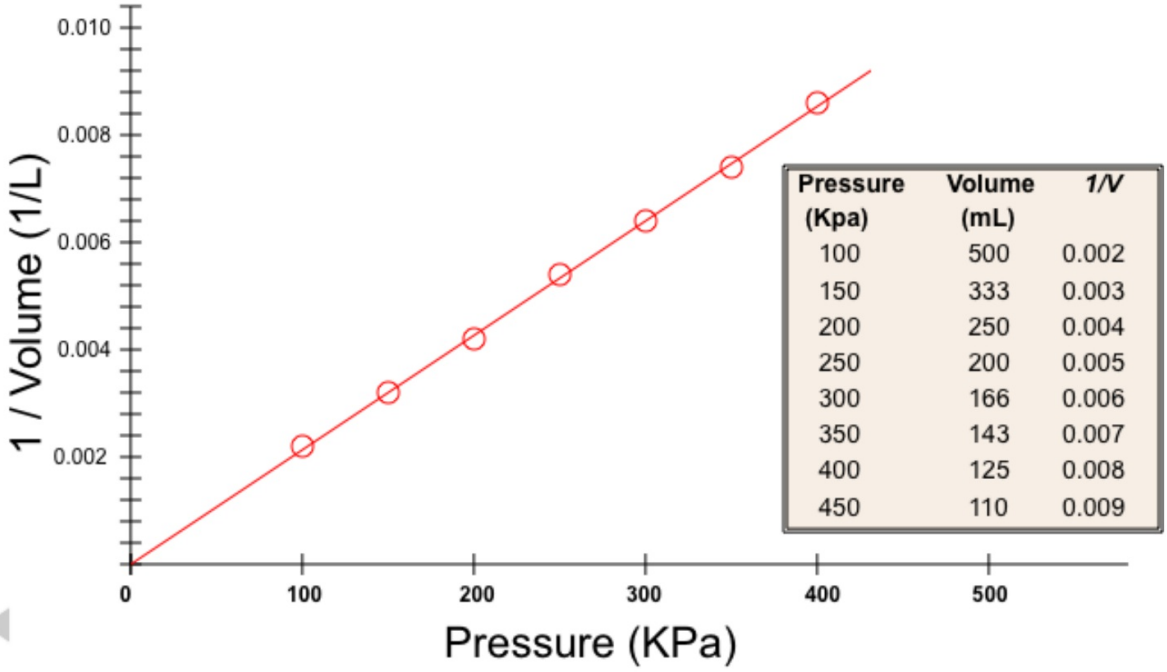


Pressure vs. Volume for a Fixed Amount of Gas
(Constant Temperature)



Pressure (Kpa)	Volume (mL)	*PV*
100	500	50,000
150	333	49,950
200	250	50,000
250	200	50,000
300	166	49,800
350	143	50,500
400	125	50,000
450	110	49,500

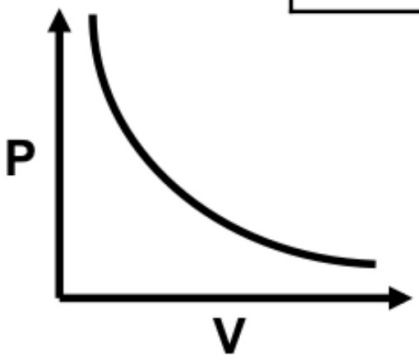
Pressure vs. Reciprocal of Volume for a Fixed Amount of Gas
(Constant Temperature)



Pressure (Kpa)	Volume (mL)	*1/V*
100	500	0.002
150	333	0.003
200	250	0.004
250	200	0.005
300	166	0.006
350	143	0.007
400	125	0.008
450	110	0.009

Boyle's Law

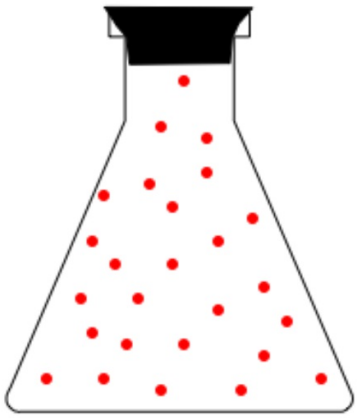
Volume (mL)	Pressure (torr)	P·V (mL·torr)
10.0	760.0	7.60×10^3
20.0	379.6	7.59×10^3
30.0	253.2	7.60×10^3
40.0	191.0	7.64×10^3



$$PV = k$$

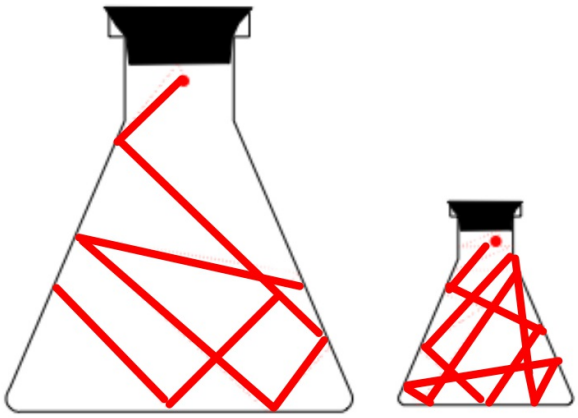
Volume and Pressure

Two-liter flask



One-liter flask

The molecules are closer together; the density is doubled.



The average molecules hits the wall twice as often. The total number of impacts with the wall is doubled and the pressure is doubled.

Charle's Law

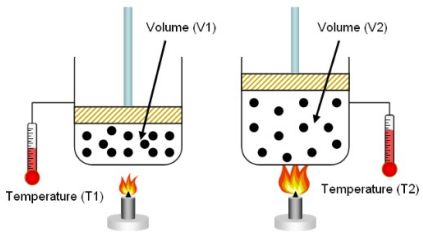
- Relationship between Temperature and Volume

- At constant Pressure and number of particles

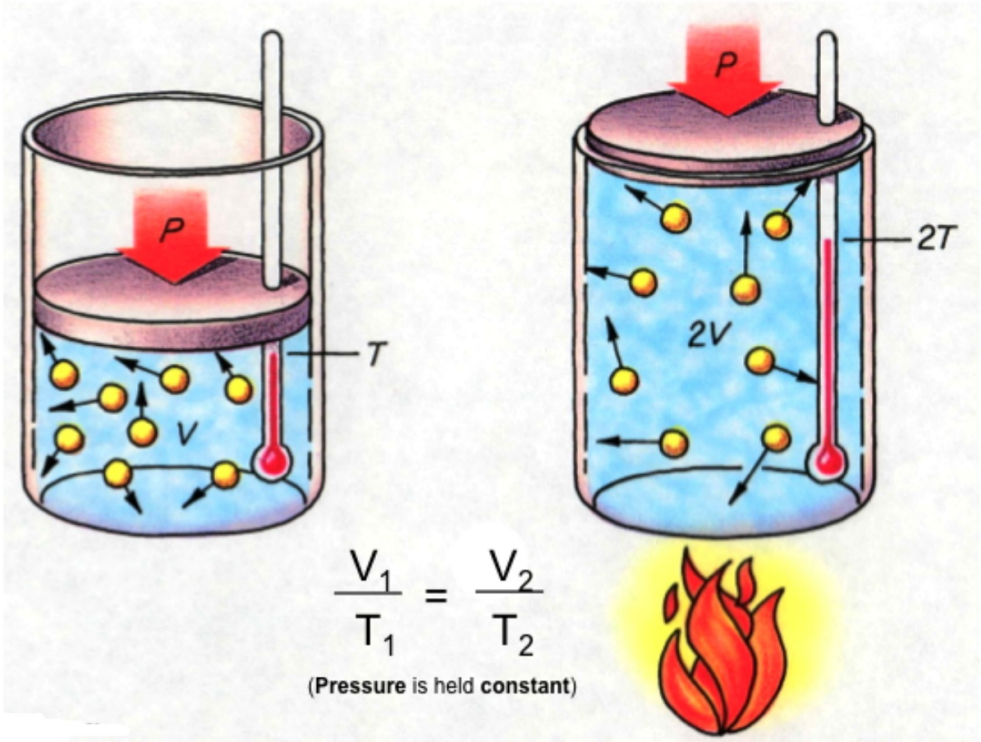
- As temperature increases, volume increases

- As temperature decreases, volume decreases

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

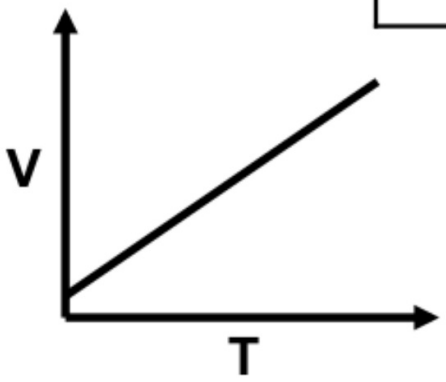


Charles' Law



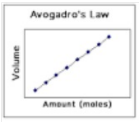
Charles' Law

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

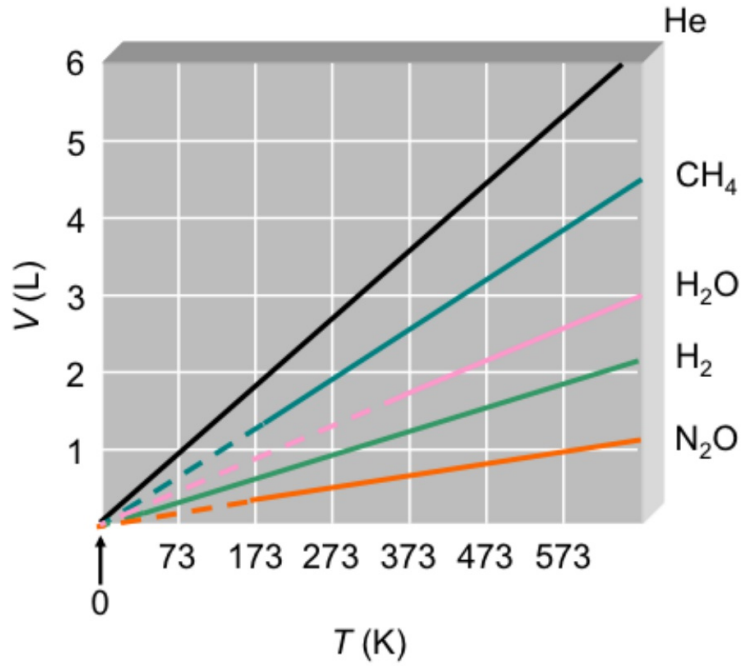


$$\frac{V}{T} = k$$

Courtesy Christy Johannesson www.nisd.net/communicationsarts/pages/chem



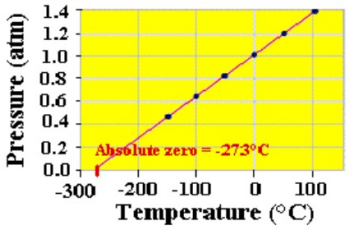
Plot of V vs. T (Kelvin)



Amonton's Law / Gay-Lussac's Law

- Relationship between Pressure and Temperature
- At a constant volume and number of particles
- As temperature increases, pressure increases
- As temperature decreases, pressure decreases

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

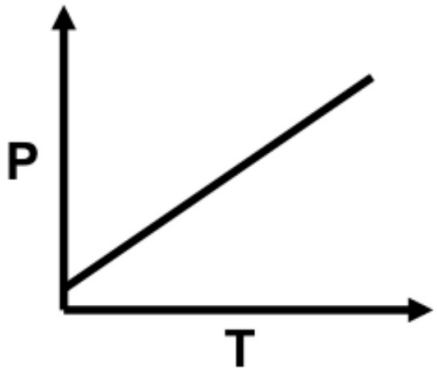


Amonton

Gay-Lussac

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

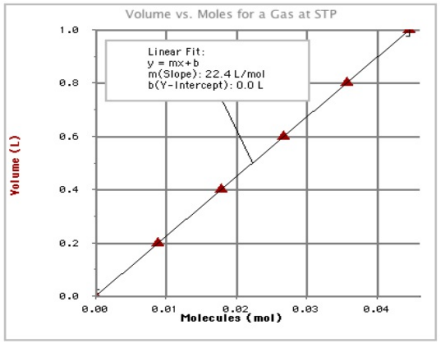


$$\frac{P}{T} = k$$

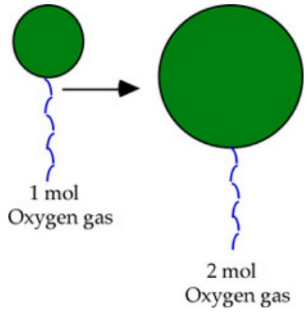
Courtesy Christy Johannesson www.nisd.net/communicationsarts/pages/chem

Avogadro's Law

- Relationship between amount of gas and Volume
- At a constant pressure and temperature
- As amount of gas increases, volume increases
- As amount of gas decreases, volume decreases



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



The Combined Gas Law

(This "gas law" comes from "combining" Boyle's, Charles', and Gay-Lussac's law)

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

$PV = k$
$P/T = k$
$V/T = k$

P = pressure (any unit will work)
V = volume (any unit will work)
T = temperature (must be in Kelvin)
1 = initial conditions
2 = final conditions

STP --> Temp = 0 °C or 273 K
Pressure = 1 atm

A sample of methane occupies 126 cm^3 at -75°C and 985 mm Hg. Find its volume at STP.

$T_1 = -75°C + 273 = 198\ K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \rightarrow \frac{985\ mm\ Hg\ (126\ cm^3)}{198\ K} = \frac{760\ mm\ Hg\ (V_2)}{273\ K}$$

Cross-multiply and divide:

$985\ (126)\ (273) = 198\ (760)\ V_2$

$V_2 = 225\ cm^3$

$$P_1V_1T_2 = P_2V_2T_1$$

Gas Laws Practice Problems

QUESTION #1

Ammonia gas occupies a volume of 450. mL at 720. mm Hg. What volume will it occupy at standard pressure?

ANSWER #1

V_1 = 450. mL
P_1 = 720. mm Hg
V_2 = ?
P_2 = 760. mm Hg

QUESTION #2

A gas at STP is cooled to -185°C.
What pressure in atmospheres will it have at this temperature (volume remains constant)?

ANSWER #2

P_1 = 1 atm
T_1 = 273 K
P_2 = ?
T_2 = -185°C
= 88 K