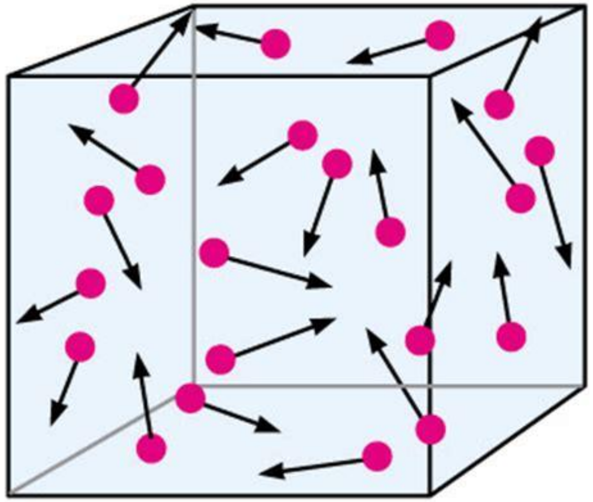
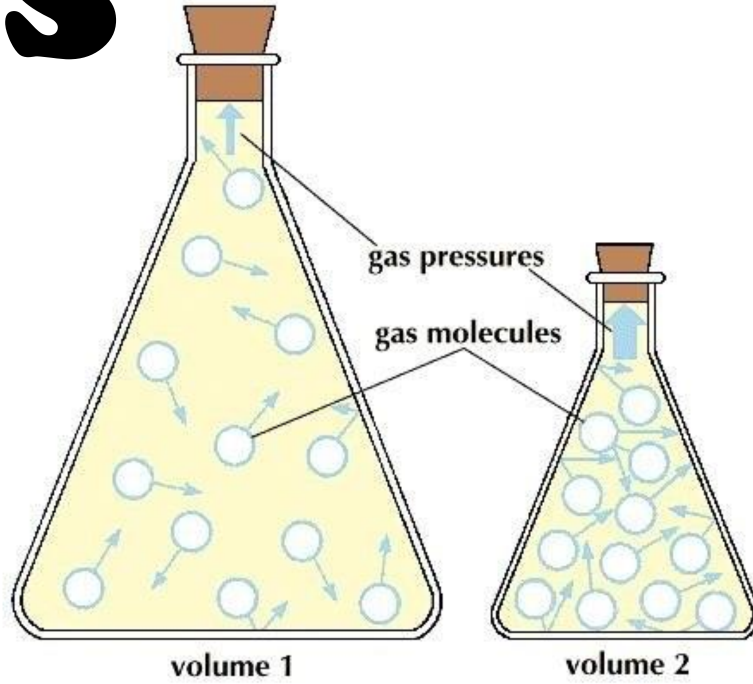
[6.4] Gas Laws



$$PV = nRT$$

Boyle's Law	$P_1V_1 = P_2V_2$
Charle's Law	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
Gay-Lussac's Law	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$
Avogadro's Law	$\frac{V_1}{n_1} = \frac{V_2}{n_2}$



Introduction to Gas Laws

- Gases are important substances in chemistry, they have many important **properties** that is important to understand
- We will be learning about four gas laws:

1. **Boyle's Law**
2. **Charles' Law**
3. **Gay-Lussac's Law**
4. **Ideal Gas Law**

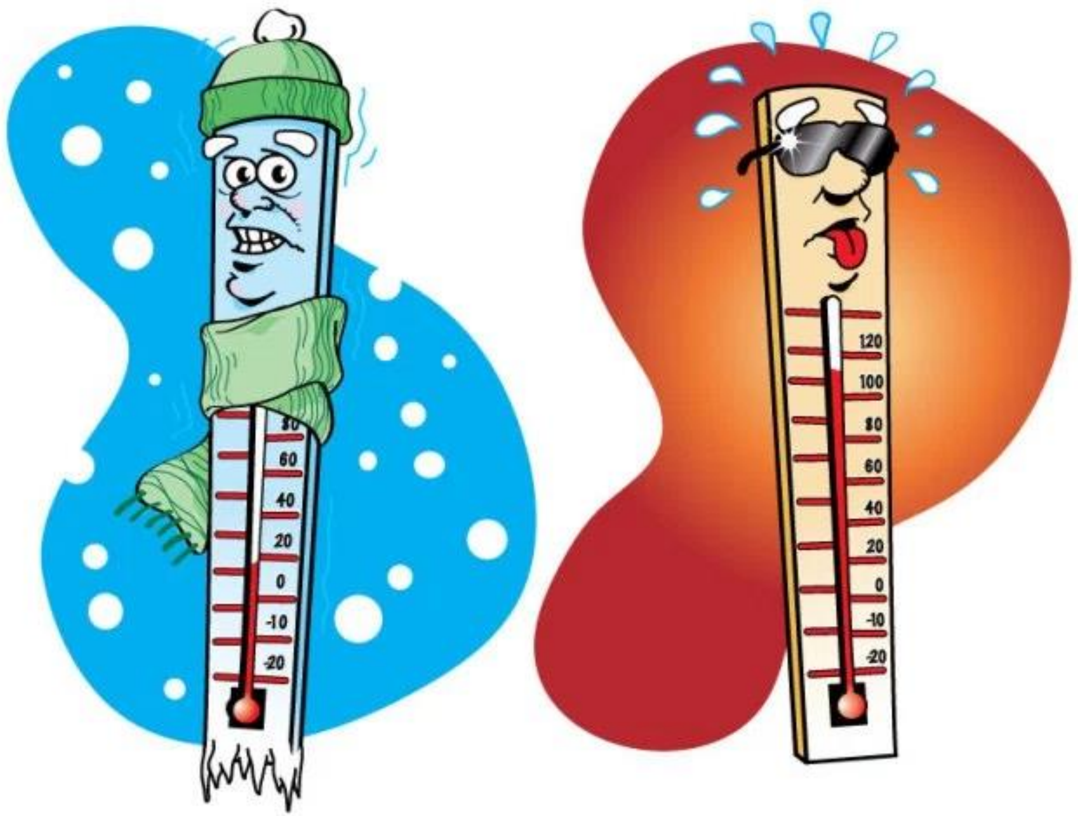
What is Pressure?

- A type of physical force acting on an object
- SI Units: **Pascals (Pa)** or **Kilopascals (KPa)**
- Older units: **torr = 1 mm of Hg**
- STP (Standard Temperature & Pressure)
  = 760 mmHg = 760 torr = 1 atm = 100.3 KPa

What is Temperature?

- The amount of **heat** in a substance
- Normally in degrees Celsius, but you may have to convert to Kelvin
- **0 Kelvin = -273.15 ^{o}C**
- **Convert K → ^{o}C (add (+) 273.15)**
- **Concert ^{o}C → K (minus (-) 273.15)**

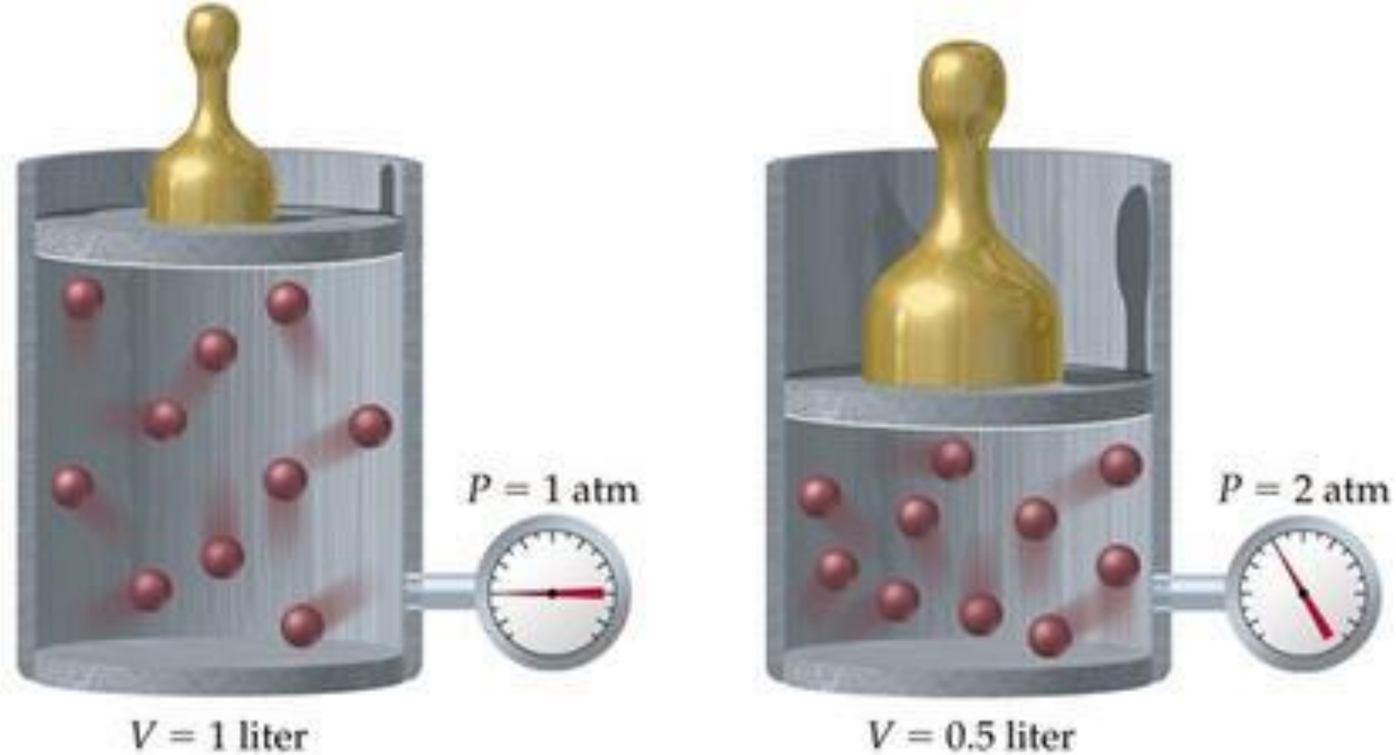
$$[^{o}C] = [K] – 273.15$$

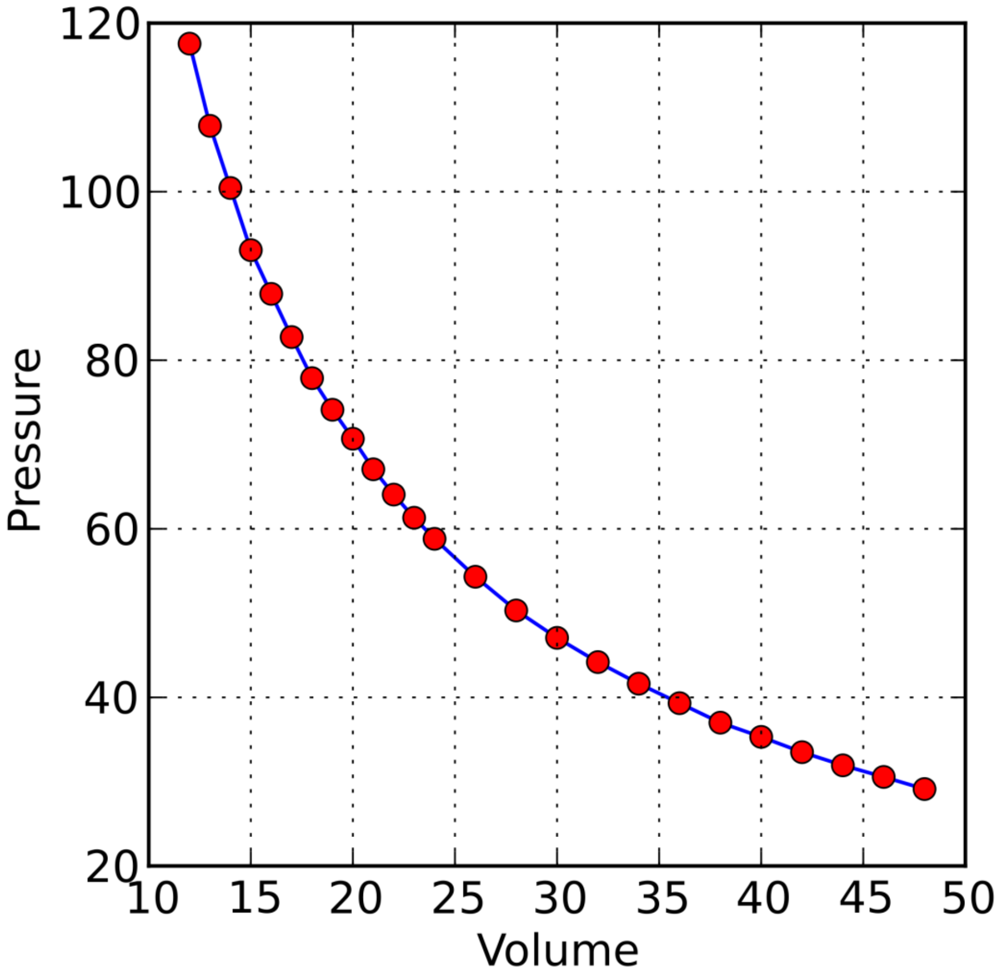


Examples: 350K = ______ ^{o}C
35 ^{o}C = ______ K

Boyle's Law

- If you decrease the **volume** of a gas, the pressure will go up.
- If you increase the volume of a gas, the **pressure** will go down





Boyle's Law

- The relationship of pressure & volume of gasses

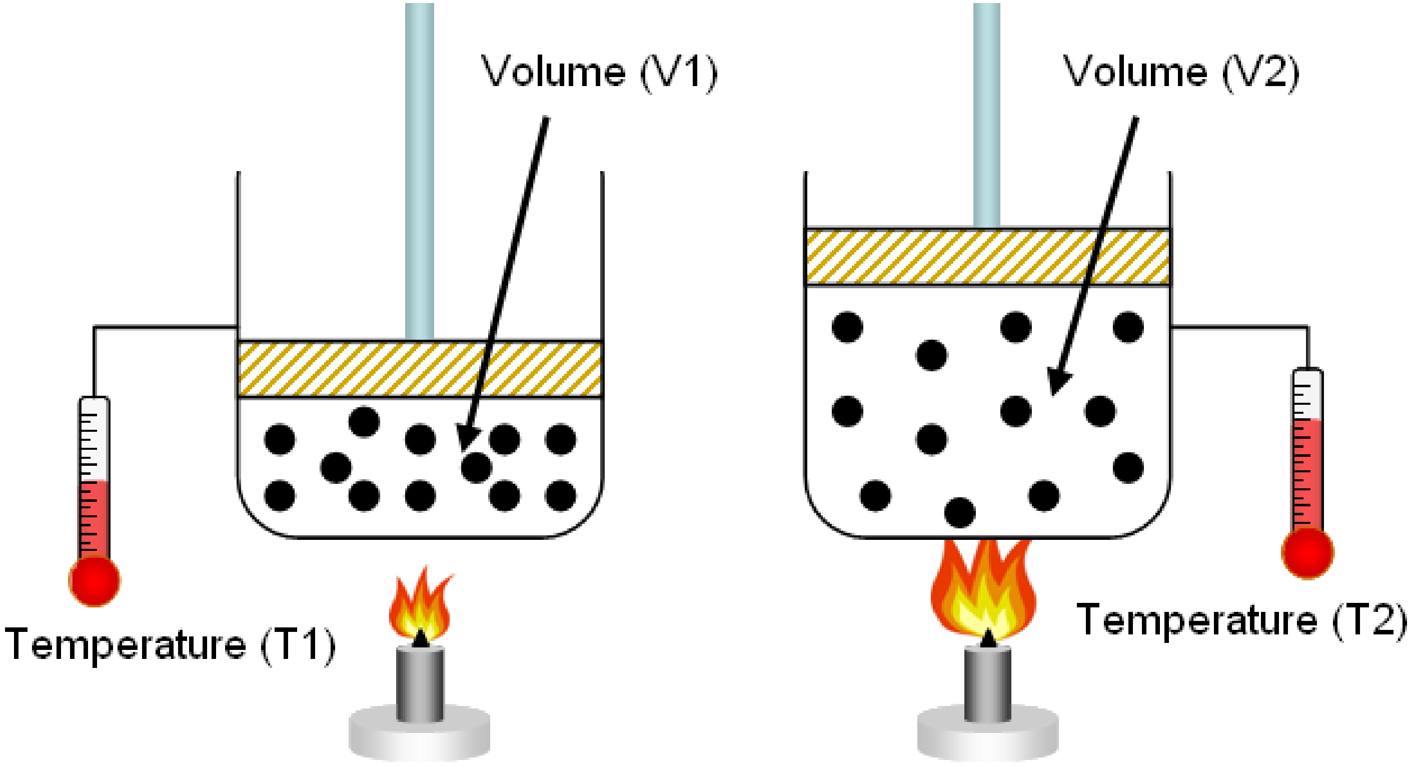
Volume | L |

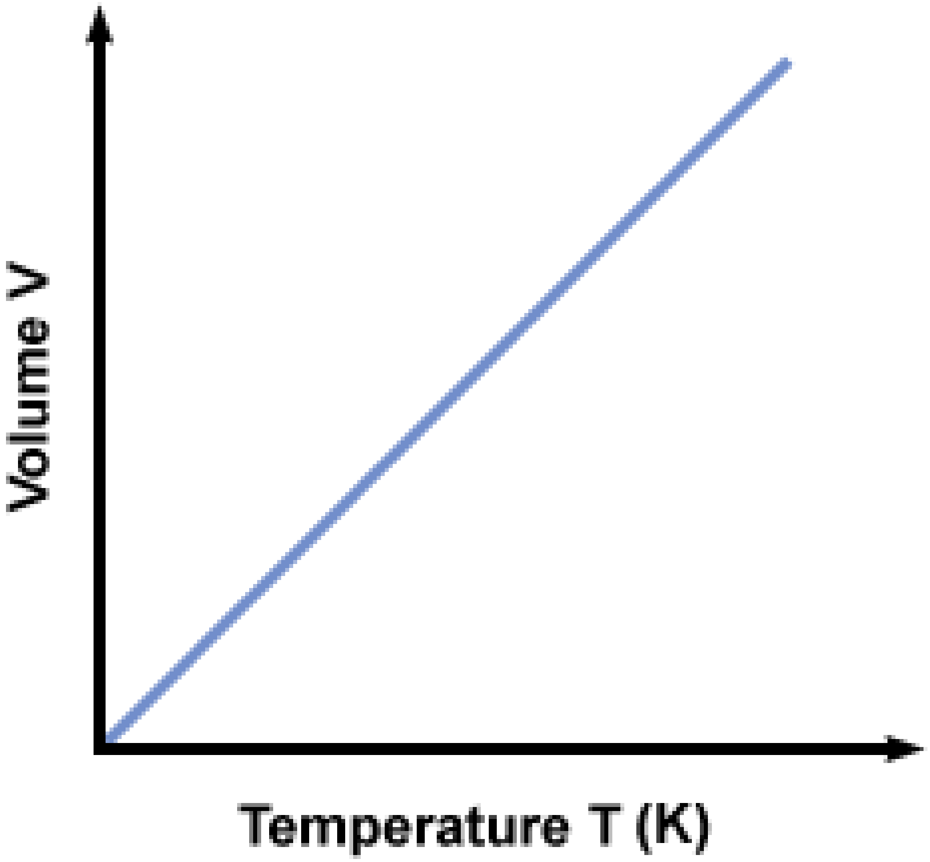
Pressure | Atm or kPA |

$$P_1V_1=P_2V_2$$

Charles' Law

- If you increase the temperature of a gas, the **volume** will go up.
- If you decrease the **temperature** of a gas, the volume will go down





Charles' Law

- The relationship of temperature & volume of gases

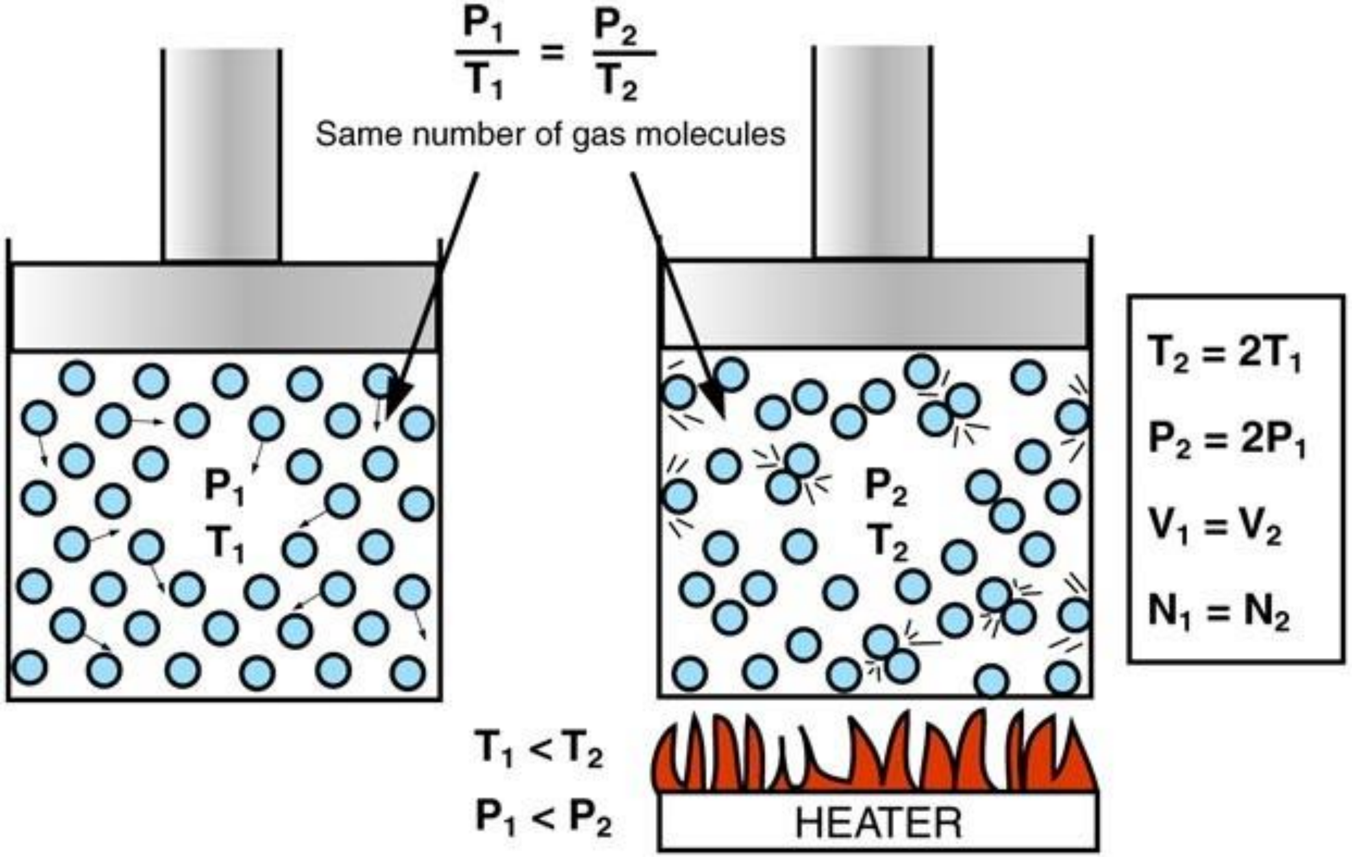
Temperature | K or °C |

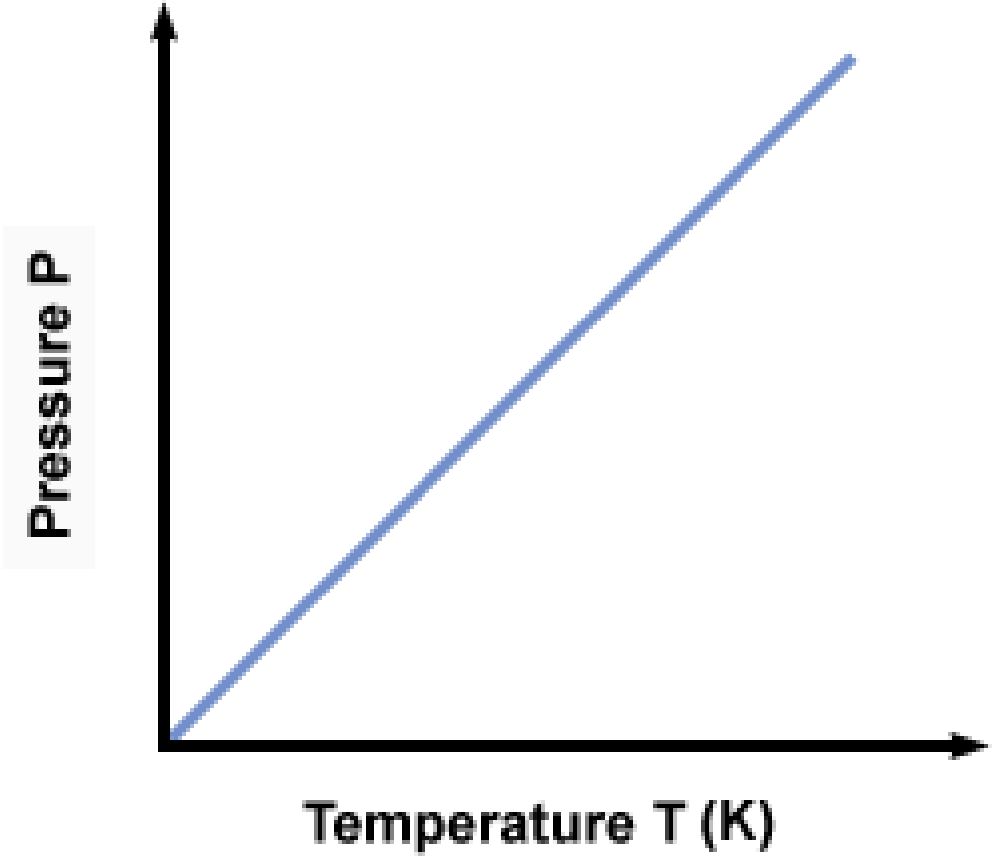
Volume | L |

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

Gay-Lussac's Law

- If you increase the **temperature** of a gas, the pressure will go up.
- If you decrease the temperature of a gas, the pressure will go **down**





Gay-Lussac's Law

- The relationship of temperature & pressure of gases

Temperature

K
or
ºC

Pressure

Atm
or
kPA

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

*Avogadro’s Law

- P, V, and T are **not** the only factors that affect gases though. Avogadro’s hypothesis states:

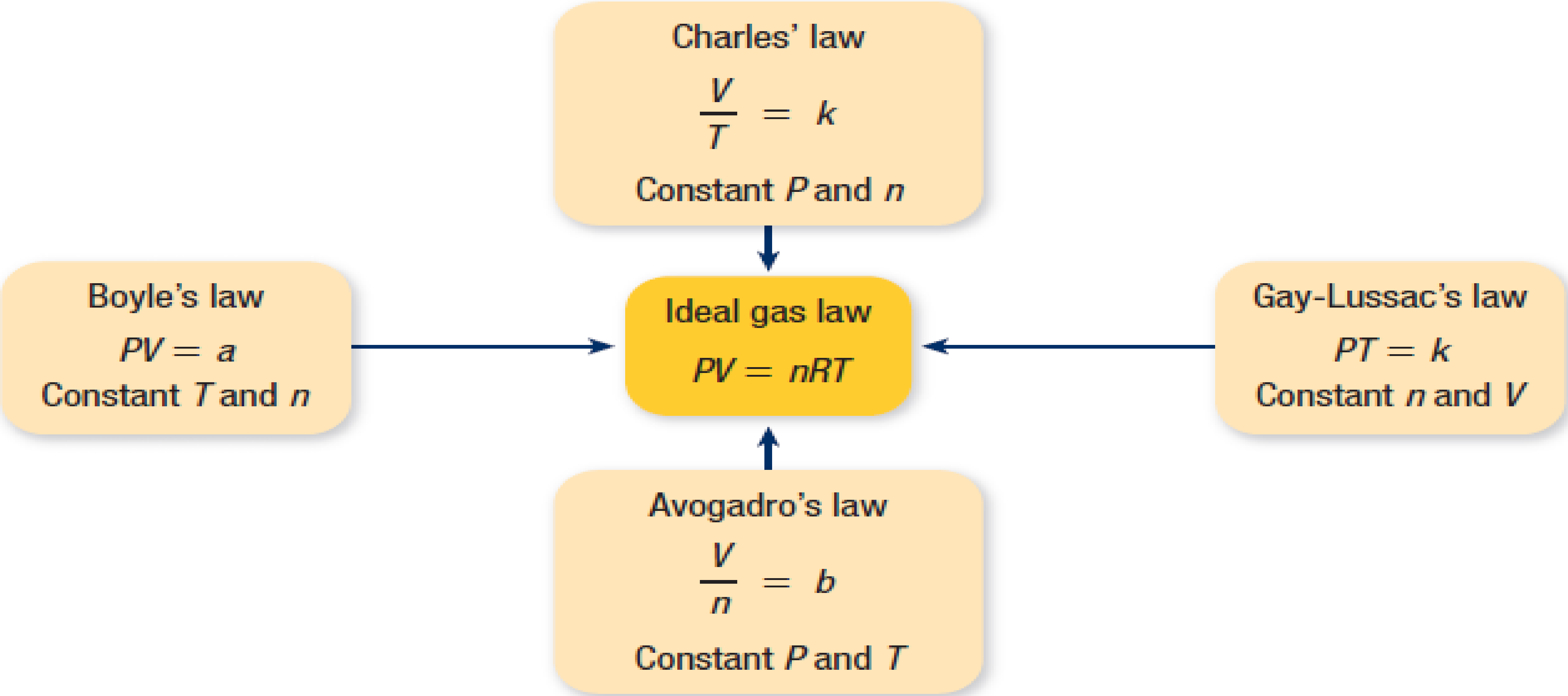
"equal volumes of all gases, at the same temperature and pressure, have the same number of particles"

- There is one more gas variable: n, which stands for the number of moles.

- The second part of Avogadro's hypothesis states that

For a given mass of an ideal gas, the moles and volume are directly proportional if the temperature and pressure are constant.

$$\frac{V}{n} = d \quad \text{or} \quad \frac{V_1}{n_1} = \frac{V_2}{n_2}$$


Charles' law
V/T = k
Constant P and n
Boyle's law
PV = a
Constant T and n
Ideal gas law
PV = nRT
Gay-Lussac's law
PT = k
Constant n and V
Avogadro's law
V/n = b
Constant P and T

Combined Gas Law

- **Take the formulas given from Boyle's Law, Charles' Law, Gay-Lussac's Law & Avogadro's Law & write a combined gas law**
- **Your combined gas law should include volume, temperature & pressure**

$$\frac{PV}{nT} = R \quad \text{or} \quad PV = nRT$$

R is a constant. R changes depending on the **units** for P. Here are common values of R. You do NOT need to memorize these numbers, they will be given to you on tests and quizzes.

- $R = 8.314 \frac{\text{L·kPa}}{\text{K·mol}}$

$R=0.082057 \frac{\text{L·atm}}{\text{K·mol}}$

- The formula you need to know for a test!!!!!

Practice Problem 1

Using the ideal gas law, PV= nRT, we can find out where the number STP for liters came from

n = 1.00 mole, R = .0821 L atm/mole k, P = 1.00 atm, T = 273.15K,

PV=nRT

$$1.00 \text{ atm} \times V = (1.00 \text{ mol} \times .0821 \text{ L} \bullet \text{atm/mole} \bullet \text{k} \times 273.15\text{K})$$

$$V = \frac{(1.00 \text{ mol} \times .0821 \text{ L} \bullet \text{atm/mole} \bullet \text{k} \times 273.15\text{K})}{1.00 \text{ atm}}$$

$$V = \boxed{22.4 \text{ L}}$$

Practice Problem 2

At what temperature will 0.654 moles of neon gas occupy 12.30 liters at 1.95 atmospheres?

$$PV=nRT$$

$$1.95 \text{ atm} \times 12.30\text{L}=(0.654 \text{ mol} \times .0821 \text{ L}\bullet\text{atm/mole}\bullet\text{k} \times T)$$

$$\frac{1.95 \text{ atm} \times 12.30\text{L}}{0.654 \text{ mol} \times .0821\text{L} \bullet \text{atm/mole}\bullet\text{k}} = T$$

$$447 \text{ K} = T$$

Practice Problem 3

Find the number of moles of xenon gas that is present in a 5.00L container with a pressure of 58.6 kPa and temperature of 60.0ºC.

[ºC] = [K] – 273.15

60.0ºC= [K] – 273.15
333.15=[K]

PV=nRT

58.6kPa x 5.00L=n x 8.314L • kPa/mole•k x 333.15K

$$\frac{58.6\text{kPa} \times 5.00\text{L}}{8.314\text{L} \bullet \text{kPa/mole}\bullet\text{k} \times 333.15\text{K}} = n$$

0.106 mol = n

HOMEWORK

- See word problems on handout [6.4]