# Chapter 11.1: Gases

Name _____

## The Nature of Gases

- Gases _____ to fill their containers
- Gases are fluid – they flow
- Gases have low density
- 1/1000 the density of the equivalent liquid or solid
- Gases are _____
- Gases effuse and diffuse

## Kinetic Molecular Theory & Gas Properties

**Ki–Net–Ic**

**–pertaining to motion** **–caused by motion**

**–characterized by movement: running and dancing are kinetic activities**

- Gas particles are _____ in motion.
- Volume of individual gas particles is about zero.
- Collisions of gas particles with container walls cause the _____exerted by gas.
- Particles exert no forces on each other.
- Average kinetic energy is proportional to temperature (_____)

## Kinetic Energy of Gas Particles

At the same conditions of temperature, all gases have the same _____ kinetic energy.
At the *same temperature*, small molecules move _____ than large molecules

## GAS DIFFUSION AND EFFUSION

- _____ is the gradual mixing of molecules of different gases. (smaller molecules mix faster, increase temp speeds up process)
- _____ is the movement of molecules through a small hole into an empty container. (smaller molecules move faster)
- Graham's law calculates the effusion & diffusion _____ of gas molecules.
- Rate of effusion is inversely proportional to its molar mass- lighter moves faster!

## Graham's Law of Diffusion/Effusion:

$$\frac{\text{Rate gas 1}}{\text{Rate gas 2}} =$$

***$M_1$* = Molar Mass of gas 1** ***$M_2$* = Molar Mass of gas 2**

## Example: Will a balloon filled with He or $N_2$ deflate faster if P & T are constant?

He Molar mass= _____ $N_2$ molar mass = _____

**Which is lighter?** He or $N_2$ **Which effuses more rapidly?** He or $N_2$

Helium gas effuses _____ ***times faster*** than Nitrogen gas.

# Gas Laws:

## Variables that Describe a Gas

| | Pressure | Volume | Temperature | Number of moles |
|---|---|---|---|---|
| **Units** | | L | | mol |

## What happens if you…

**Decrease the volume of the container?**
Pressure may _____
Temperature may _____

**Increase the temperature?**
Pressure may _____
Volume may _____

**Increase the pressure?**
Temperature may _____
Volume may _____

## Boyle's Law $P_1V_1=P_2V_2$

**Volume and Pressure are INVERSELY related.**

If Volume goes up, Pressures goes _____. If Volume goes down, Pressure goes _____.

**Lets Practice:** A sample of oxygen occupies a volume of 250.0mL at 740.0 torr pressure. What volume will it occupy at 800.0 torr pressure?

- Identify what you know
- Solve for what you don't know

## Charles' Law $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

***MUST use KELVIN temperature*** $K = °C + 273$

**Volume and Temperature are DIRECTLY related.**

If Temperature goes up, Volume goes _____. If Temperature goes down, Volume goes _____.

**Lets Practice:** A Sample of Nitrogen gas occupies a volume of 250.0mL at 25°C. What volume will it occupy at 95C?

- Identify what you know
- Convert Temp to Kelvin
- Solve for what you don't know

## Gay-Lussac's Law

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

***MUST use KELVIN temperature*** $K = °C + 273$

**Temperature and Pressure are DIRECTLY proportional** if mass and volume are kept constant.
If Temperature goes up, Pressures goes _____. If Temperature goes down, Pressure goes _____.
Why? Think _____ - remember volume is constant.

**Let's Practice**
A gas has a pressure of 6.58 kPa at 540 K. What will the pressure be at 210 K if the volume remains constant?

- Identify what you know
- Convert Temp to Kelvin
- Solve for what you don't know

## The Combined Gas Law

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

**Lets Practice!**

A gas with a volume of 4.0L at 90.0kPa expands until the pressure drops to 20.0kPa. What is the new volume if the temperature remains constant?

- Identify what you know
- Solve for what you don't know

**Now you try!**
A gas with a volume of $3.00 \times 10^2$ mL at 150.0˚C is heated until its volume is $6.00 \times 10^2$ mL.What is the new temperature of the gas if the pressure remains constant at 1.0 atm during the heating.

- Identify what you know
- Solve for what you don't know

# Chapter 11.2 Ideal Gases & The Ideal Gas Law

Ideal gases are imaginary gases that perfectly fit all of the assumptions of the kinetic molecular theory.
Gases consist of tiny particles that are _____ relative to their size.
Collisions between gas particles and between particles and the walls of the container are elastic collisions
No kinetic energy is lost in elastic collisions
Gas particles are in _____. They therefore possess kinetic energy, the energy of motion
There are no forces of attraction between gas particles
The average kinetic energy of gas particles depends on temperature, not on the identity of the particle.

## Real Gases Do Not Behave Ideally

- Real gases DO experience intermolecular attractions
- Real gases DO have _____
- Real gases DO NOT have **elastic** collisions  Elastic =

### Deviations from Ideal Behavior:

| **Likely to behave nearly ideally** | **Likely NOT to behave ideally** |
|---|---|
| | |
| | |

## The Ideal Gas Law  PV=nRT

R= 8.31 $\frac{L \times KPa}{K \times mol}$ or 0.08206 $\frac{L \times atm}{K \times mol}$

• Allows us to solve for a property of an ideal gas when properties are constant!

**Two rules!**

- **Temp= K, Volume =L, and pressure= atm or kPa**
- **If you are given grams convert into moles.**

**Lets Practice**

Determine the volume occupied by 0.582 mol of a gas at 15˚C if the pressure is 81.1 kPa.

## Dalton's Law of Partial Pressures $P_{total} = P_1 + P_2 + P_3 ....$

Dalton's Law of Partial Pressures states that the total pressure of a gas mixture is the sum of the partial pressures of all the gases present. (at constant temp and pressure)

**Let's Practice**

What is the total pressure of a gas mixture if it contains **$CO_2$ at 40.8 torr** and **$O_2$ at 1009.9 torr** & **$H_2$ at 791.4 torr?**

What is the pressure of Ne gas if the total pressure of the gas is 100.6 atm, and the mixture contains 40.4 atm of He and 22.6 atm of HCl?

## Water Displacement

Gases produced in the laboratory are often collected over water. Thus, the gas is not pure but is always _____.

The collection process makes it so the total pressure inside the bottle would be the same as the atmospheric pressure.

Formula: _____

**Let's Practice**

Some hydrogen gas is collected over water at 20.0 °C. The levels of water inside and outside the gas-collection bottle are the same. The partial pressure of hydrogen is 742.5 torr. What is the barometric pressure at the time the gas is collected?

Formula: _____ (to find the Pressure use table A-8 pg. 859)

Some CO2 gas is collected over water at 15.0 °C. The levels of water inside and outside the gas-collection bottle are the same. The barometric pressure at the time the gas is collected is 780 mmHg. What is the partial pressure of CO2?

# The Gas Laws Practice (Worksheet B)

**Temperature conversions: K= 274 + C or C= K-273**

35.0˚C = ?K

**308K**

576.2K = ? ˚C

**303.2˚C**

**Pressure conversions: 1 atm= 760 mmHg=760 torr=14.7psi=101.3 kpa**

695mmHg = ?atm **0.914 atm**

1.34atm = ?kPa **136 kPa**

95.6kPa = ?mmHg **717.2 mmHg**

1. A sample of sulfur trioxide gas occupies a volume of 350ml at 100.1kPa. How many milliliters will the gas occupy at 175.5kPa if the temperature remains constant?

**199.6mL**

2. A sample of oxygen gas is compressed at constant temperature from a volume of 540ml to 320ml. If the initial pressure was 88.2kPa, what is the final pressure?

**148.8kPa**

3. A sample of $CO_2$ gas has a pressure of 655torr at 50.0˚C. To what Celsius temperature must it be heated to raise its pressure to 825torr if the volume remains constant? (hint: convert to K then answer back to ˚C)

**133.8 ˚C**

4. A sample of ammonia gas occupies 285ml at 25˚C. At what temperature in Celsius will it occupy 350.ml if the pressure remains constant?

**93 ˚C**

5. Nitrogen gas exerts a pressure of 350mmHg at 20˚C. How many kPa will it exert if its temperature is raised to 40˚C without a change in volume?

**373.9mmHg=49.8kPa**

6. Compare the rate of effusion of carbon dioxide gas with that of hydrogen chloride gas at the same temperature and pressure.

**HCL effuses 0.90 times faster**

7. A sample of nitrogen gas is collected over water at a temperature of 23.0˚C. What is the pressure of the nitrogen gas if the atmospheric pressure is 785mmHg? (Use Table A8 on page 859 in Appendix A of the Text)

**763.9 mmHg**