PHYSICAL STATES OF MATTER

In this section, we will discuss the Ideal Gas Laws. First, we will review the properties of solids, liquids, and gases. Second, we will discuss the kinetic-molecular theory of gases, which explains why they are so unique compared to other states of matter. Finally, we will discuss gas law equations, and practice using them to solve for different parameters. This unit has many strong connections to our daily lives as we are surrounded by examples of the materials we are studying. Our breathing depends on the gas laws we will be studying.

Particles are tightly packed in a set pattern, with a fixed volume and shape.	Solid
Particles are close together with no regular pattern of arrangements; has a set volume that will take the shape of the container it is placed in	Liquid
Particles are well separated with no arrangement, and does not have a set volume but rather adapts to the entire volume of the container it is placed in	Gas

CHARACTERISTICS OF STATES OF MATTER

This is important in terms of chemical reactions, because particles must be in close proximity in order to react. In solids, the particles are closely packed together; the rigid conformity to their packed structure often prohibits extensive reactions, but nonetheless chemical reactions occur in the solid state. Most known chemical reactions take place in the liquid state, because the particles are closely interacting, but also have some flexibility of movement. Gases are unlike solid and liquids because the particles have very few interactions, and the interactions are transient.

Solid	**Liquid**	**Gas**
Fixed shape	No fixed shape	No fixed shape
Shape not set by container	Takes shape of filled portion of the container	Takes shape of container
Shape remains rigid	Can be poured	Fills container
Particles fixed in place but vibrate around a fixed position	Particles move past one another	Particles move through space
Little or no volume change under moderate pressure	Can be compressed slightly by moderate pressure	Compressed under moderate pressure
Little free space between particles	Some free space between particles	Particles are widely separated with much free space

Regardless, all states of matter are capable of chemical reactions. For example, solid wood can react with gaseous oxygen (O_2) and a spark to create a fire, producing CO_2 and H_2O gases.
The human body brings in gaseous oxygen (O_2) which dissolves into liquid blood and expels gaseous CO_2 as waste.

Oxygen **gas** is inhaled to the lungs, and brought into the blood, which is a **liquid**. Our bodies exchange the oxygen for carbon dioxide, which is a **gas**. The carbon dioxide is forced out of lungs by increasing the pressure of the lungs.

Is the quality associated with solids, liquids, or gases, or multiple? Note yes/no for each.

	Solid	**Liquid**	**Gas**
Shape is fixed	Yes	No	No
Shape depends on container	No	Yes	Yes
Volume is fixed	Yes	Yes	No
Particles touch, with some but not much space between particles	Yes	Yes	No
Particles move through space easily, with much free space between particles	No	No	Yes

KINTETIC MOLECULAR THEORY OF GASES

The gas laws allow us to approximate how a gas will behave in a given situation. We will be looking at several of these gas laws: Boyle's Law, Charles' Law, Avogadro's Law, and the Ideal Gas Law. These laws are useful but not perfect as these laws rely on a set of assumptions that makes these gases "ideal":

- When gas molecules collide, they bounce off each other but have no chemical reaction
  - This is called a perfectly elastic collision, such as a ball bouncing on the floor
- **Ideal gas** molecules have no attraction to each other
  - They will neither be attracted nor repelled
- **Ideal gas** molecules themselves take up no volume
  - The gas as a whole has the volume of the container, but the volume of the individual molecule is negligible

As part of the kinetic molecular **theory of gases**, we can correctly assume that gas molecules are in constant motion. This energy is directly proportional to the temperature of the gasses: more energy means higher temperature. Additionally, as the number of collisions increases the pressure will increase as these collisions apply force to the walls of the container. If the container is flexible, such as car tires or a balloon, as the collisions increase the volume can increase as a result. If the **gas** is in a fixed container such as an oxygen tank, spray can, or fire extinguisher, the volume is fixed and will not change.

Similarly, if there are fewer number of molecules, the number of collisions will decrease. This can happen when air is let out of a balloon and can affect the pressure and temperature by decreasing the total number of collisions.

Consider a hot air balloon: the flame heats up the gas in the flexible balloon. As the temperature increases, the pressure and volume of the balloon will increase. As the molecules take up more space, the density (mass per volume) decreases and allows the balloon to float. To land, the less dense hot air **is released, and the flame turned down, decreasing the volume and slowing the collisions, decreasing the pressure, and increasing the density of the air in the balloon**. This allows the balloon to land.

Does the property apply to an ideal gas, non-ideal gas, or both?

Ideal Gas

Week 4: The Ideal Gas Laws and Acid/Base

- No attractions
- Perfectly elastic collisions
- Molecules have no volume

Non-ideal Gas

- Molecules do have a small volume
- Collisions can cause chemical reactions

Both Ideal and Non-ideal Gas

- Molecules in constant motion

Determine if the quality best describes solid, liquid, or gas state of matter.

Can be compressed slightly by moderate pressure **Liquid**
Particles collide but otherwise do not interact **Gas**
Shape remains rigid **Solid**

As the number of collisions of an ideal gas increases, which of the following will also occur?

- the gas will become solid
- the gas will become compressed
- the number of chemical reactions will increase
- the temperature will increase
- the pressure will increase

For ideal gases, the molecules themselves____________, which is one assumption of the ideal gas law.

- will have no collisions
- will have no temperature
- will have no volume
- will have no

pressure Liquids and gasses

both…

- take the shape of the container they occupy
- have perfectly elastic collisions
- have molecules that do not touch or interact
- can be poured

We exhale CO_2, a **Gas**. We drink water which is a **Liquid**. Our blood transports oxygen, a **Gas.**

In a hot air balloon, the flame is turned down. What is the result?

- the density increases
- the pressure decreases
- the temperature decreases
- the volume decreases

A rigid can of compressed air is used, releasing half of the contents. Which of the following is the result?

- the temperature decreased
- the pressure decreased
- the volume of the rigid can decreased

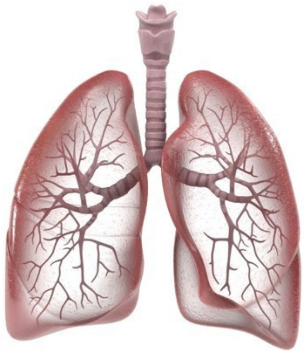
GAS LAWS

In this section, we will discuss the Ideal Gas Laws by drawing on the knowledge gained in the previous section. We will discuss gas law equations, and practice using them to solve for different parameters. This unit has many strong connections to our daily lives as we are surrounded by examples of the materials we are studying. Our breathing depends on the gas laws we will be studying.

Consider inflating a balloon. As you inflate the balloon, which of the following is true? Select all that apply.

- the gas collides with the inside surface of the balloon
- the gas takes the shape of its new container
- there are fewer gas molecules in the balloon once it is inflated
- the volume of the balloon increases
- the number of molecules of gas in the balloon increases
- the balloon becomes smaller

THE GAS LAWS: BOYLE'S LAW



Boyle's Law states that pressure and volume of a gas are inversely proportional at a constant temperature. In other words, as one goes up, the other goes down and vice versa. For example, as the pressure of a sample of ideal gas in a balloon increases, the
volume of the balloon decreases. In other words, if you compress a balloon, it will get smaller. Similarly, as the diaphragm pulls downward, it lowers the pressure in the lungs and causes gas to enter to expand the volume. As we exhale, the diaphragm will increase the pressure and the volume of the lungs will decrease, causing carbon dioxide to be expelled.

We express this law mathematically as:

The best way to understand these laws is to work through examples. A problem will relate to Boyle's law if the question involves pressure and volume of a gas at an initial state, and then after a change.

$P_1V_1=P_2V_2$

P stands for pressure and V stands for volume. In this and all subsequent gas laws, the "1"

For example, at a constant temperature, a sample of gas occupies 20 mL at a pressure of 2.3 ATM. What will be the volume of this sample, in mL, at a pressure of 3.4 ATM?