Chapter 3
Gas Laws and States of Matter

Physical Science

Motion

Kinetic theory

- Kinetic Theory

3 Parts

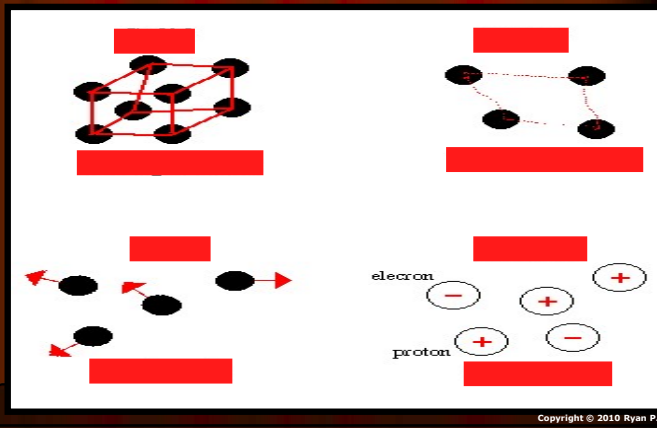
Atoms and Molecules

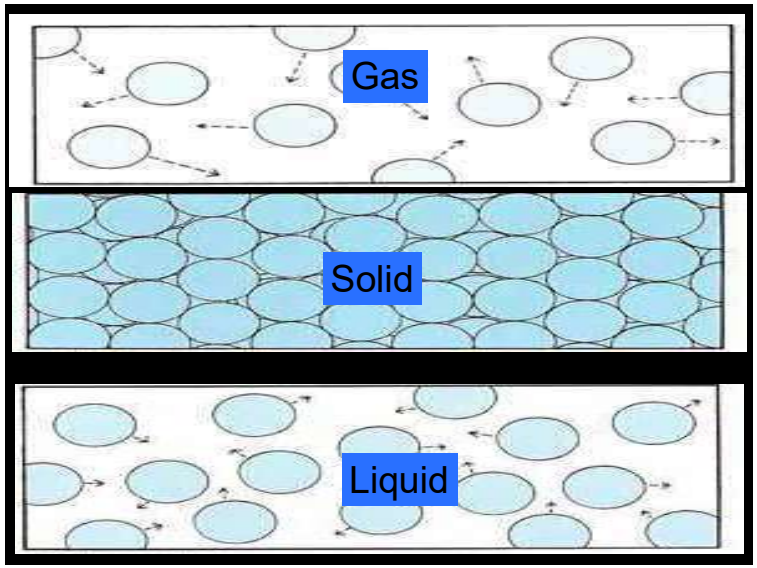
1. All matter is made of tiny particles.
2. These tiny particles are always in motion.
   - The higher the temperature, the faster the particles move.
3. At the same temperature, more massive (heavier) particles move slower

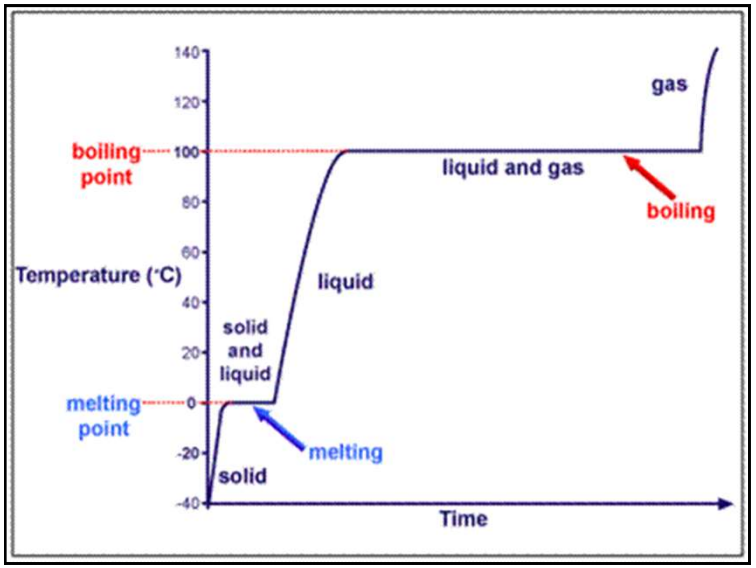
Energy's Role

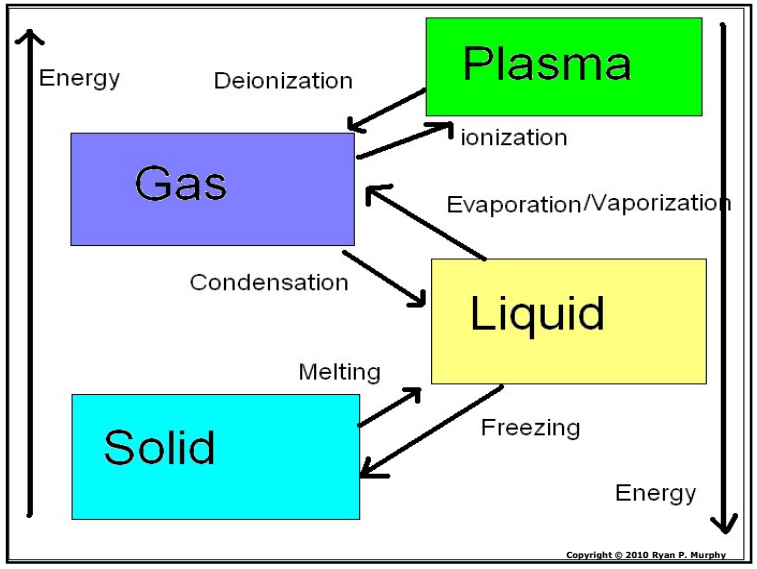
- Temperature is the measure of average kinetic energy
- Particles of matter are constantly moving, but they are not moving at the same speed.
  - The more kinetic energy, the higher the temperature.

- Kinetic Molecular Theory:
  - This motion is different for the 4 states of matter.




Gas
Solid
Liquid


140
120
100
80
60
40
20
0
-20
-40
boiling point
melting point
Temperature (°C)
gas
liquid and gas
boiling
liquid
solid and liquid
melting
solid
Time


Energy
Deionization
Plasma
ionization
Gas
Evaporation/Vaporization
Condensation
Liquid
Melting
Solid
Freezing
Energy
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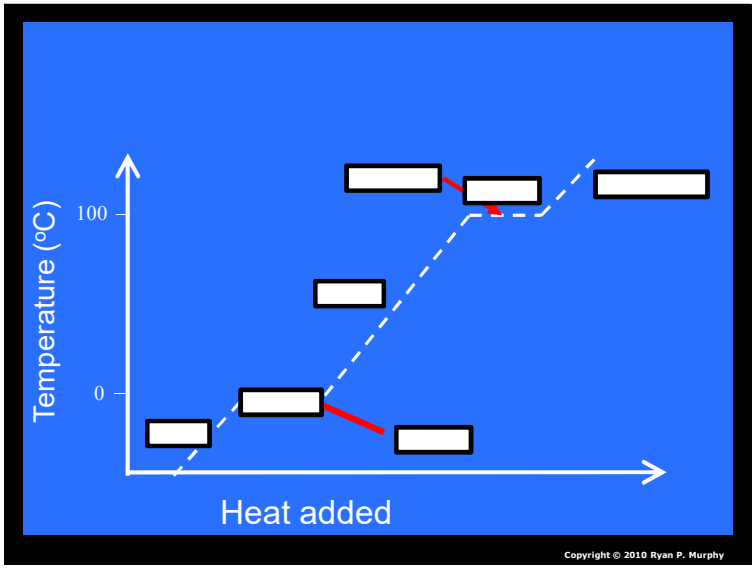
Temperature (°C)
100
0
Heat added
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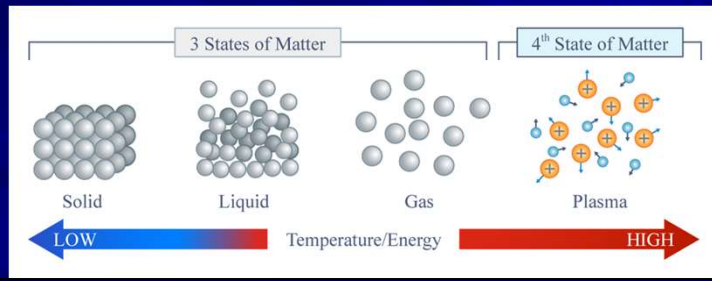
States of Matter

Familiar states

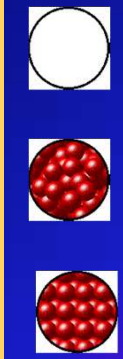
- Matter is classified as:
  a solid, a liquid, a gas, or plasma
- Determined by whether the shape and volume are definite or variable.



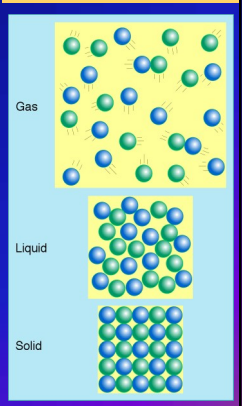
States of Matter

When a substance changes from one phase of matter to another, the identity of the substance does NOT change.

- **Water freezes to a solid and melts to a liquid, but it is still just water.**



Microscopic view of matter



- Activity! Describing Solid-Liquid-Gas

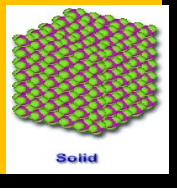
	Solid	Liquid	Gas	Plasma
Volume	Easy to find – in ml or cm^3	Easy to find. Use graduated cylinder – ml	⊗ No definite volume	Stars, nebulas. No Volume ⊗
Shape	Many different forms. Easy to mold.	Takes shape of the container.	No definite Shape ⊗	No Shape ⊗
Mass	Generally Heavy / Weigh in grams Easy to find.	Generally Heavy / Weigh in grams.	Lighter in mass / Harder to weigh ⊗	Electron & proton mass. Hard to weigh

States of Matter

SOLIDS

Characteristics of Solids

- Solids have a definite shape and volume
- The particles are held closely together by strong attractions
- Packed close together
- Vibrate in place.
- Don't flow



Characteristics of Solids

- Definite volume and a definite shape.
- Particles are packed close together in relatively fixed positions.
- Particles are held by strong attractive forces between them.
- Particles vibrate about in a fixed position.

States of Matter

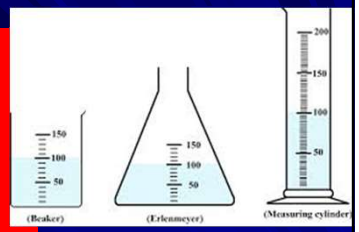
LIQUIDS

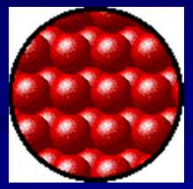
Characteristics of Liquids

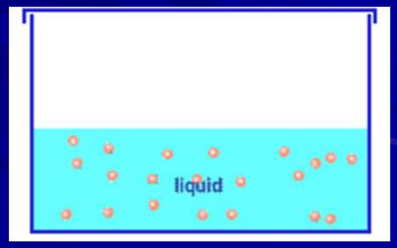
1. Has a definite volume but no definite shape.
   - Volume remains the same, but shape changes.
2. Take shape of container.
3. Particles are held close together but can flow freely.
4. The particles in a liquid move much faster than in a solid.
   - This allows the particles of a liquid to temporarily overcome the attractive forces between them.

Liquids can fill the bottom of their container.

Particles are close together, but not as close as particles in a solid.







Characteristics of Liquids

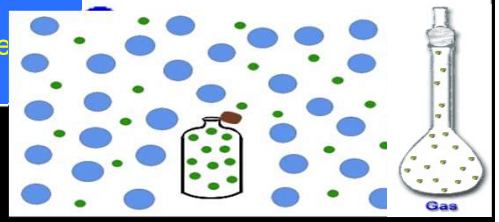
- Definite volume and not definite shape.
- Particles are close together
- Takes shape of container
- Particles flow freely and slide past each other

States of Matter

GASES

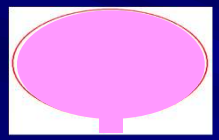
Characteristics of Gases

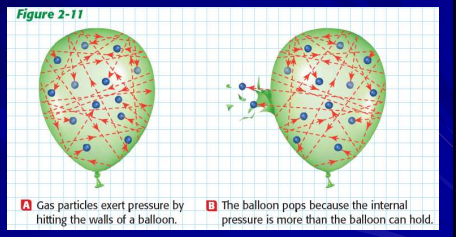
- Gases change both shape and volume.
- Particles are spread out
- Can flow
- Fill in available space



A _gas_ expands to fill any available space.

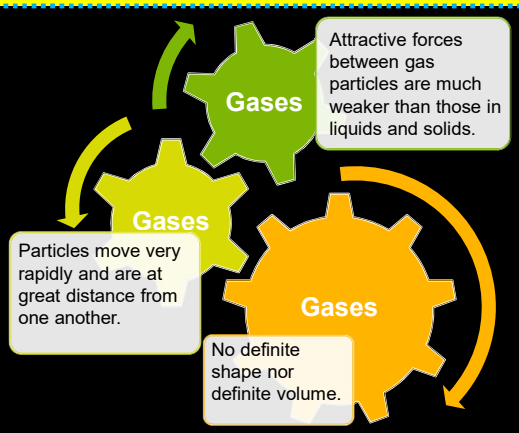
– _Gases_ can exert pressure on their container.





- These particles are approximately 10 times farther apart than those of a liquid or solid.

Characteristics of Gases



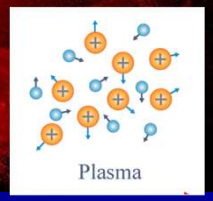
PLASMA

States of Matter

Characteristics of Plasma

- Most common state of matter
- Has no definite shape or volume
- Composed of electrically charged or ionized particles
- Found naturally in lightning, fire, stars, aurora borealis
- Most conduct electric current

High-energy plasma collides with gas particles.

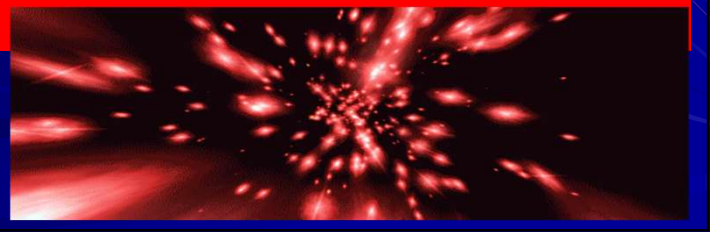


Ionized gas that emits electrons.

States of Matter

PLASMA

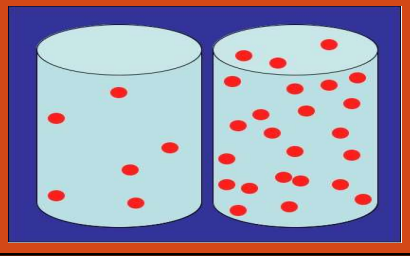
- Plasmas are similar to gases but have some properties that are different.
  - Example: plasmas conduct electric current, while gases do NOT!
  - The glow of fluorescent light is caused by artificial plasma which is formed by passing electric currents through gases.



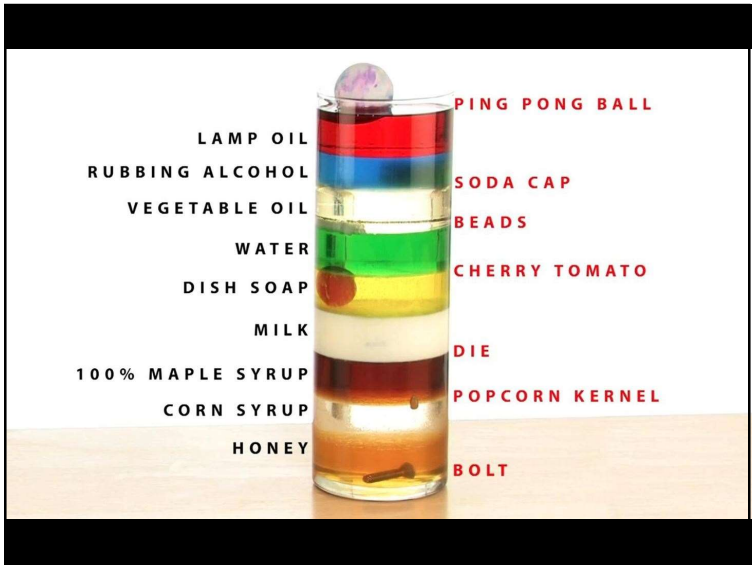
PHYSICAL PROPERTIES

DENSITY

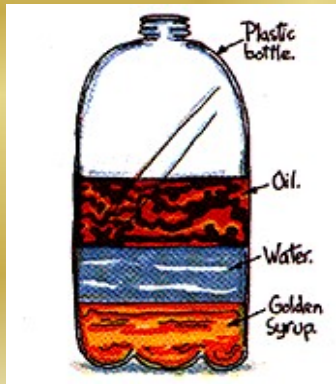
- **Density is the mass per unit volume of a substance.**
- **Tells us how light or heavy something is.**



Which is denser? Why?



Liquid Layers – Try with your neighbor



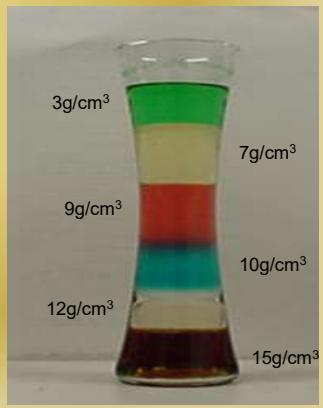
- Which liquid has the highest density?
- Which liquid has the lowest density?
- Which liquid has the middle density?

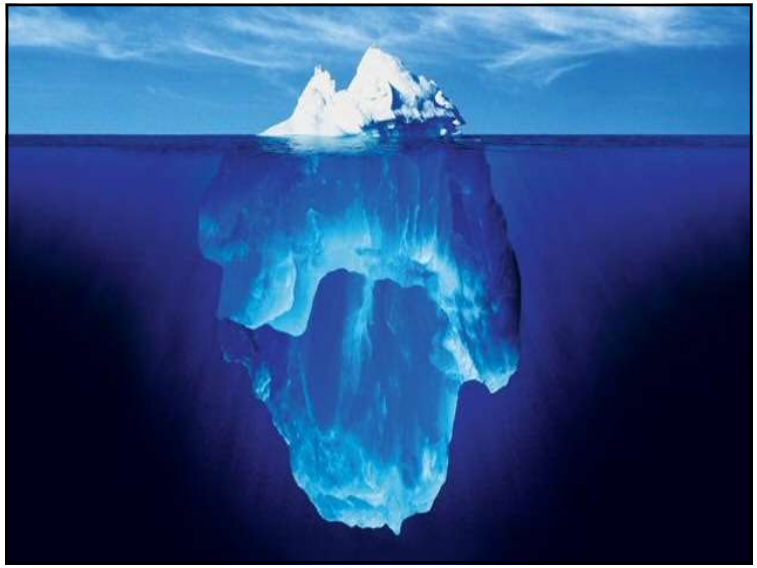
Liquid Layers
Try on your own!

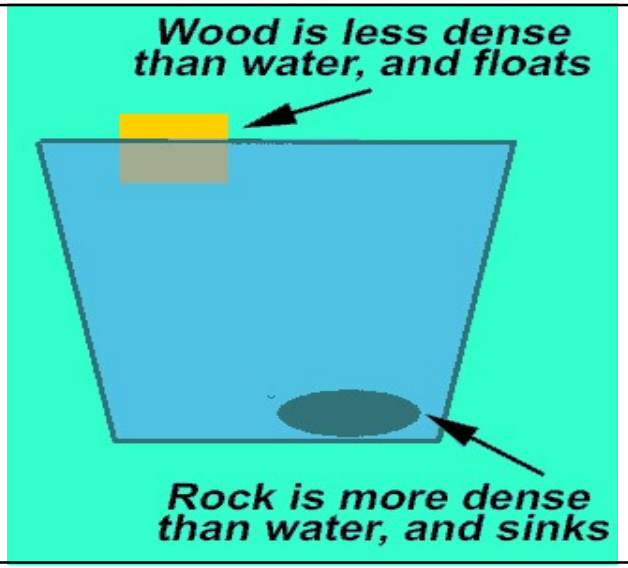
Imagine that the liquids on the right have the following densities:

- **15g/cm^3 10g/cm^3**
- **3g/cm^3 9g/cm^3**
- **7g/cm^3 12g/cm^3**

Match the colors to the correct densities.

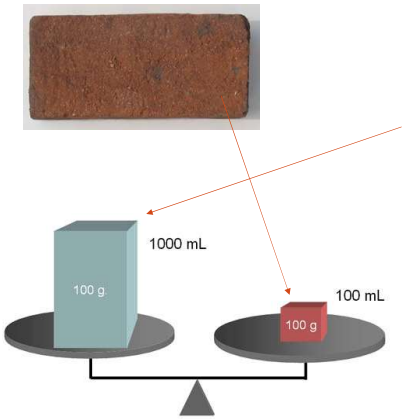






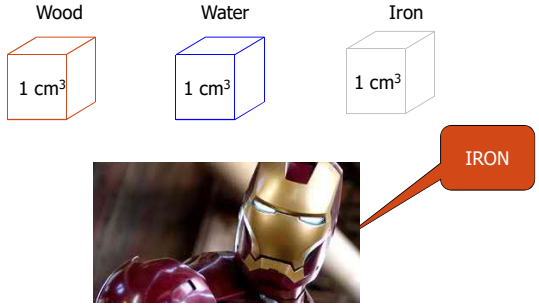
Why the difference in volume even though their weight is the same?

Tightness of the composition of substances in object



DENSITY IS DIFFERENT FROM WEIGHT

If you take the same volume of different substances, then they will weigh different amounts.



Q) Which has the greatest mass and therefore the most dense?

WHAT IS THE DENSITY OF WATER?

- 1.0 g/mL

HOW CAN YOU PREDICT WHETHER AN OBJECT WILL FLOAT OR SINK?

- **By comparing densities!**

HOW ELSE CAN DENSITY BE USED?

- **Density is useful because it can be used to identify a substance.**
- **For example, aluminum always has a density of 2.55 g/ml.**

Density Table

SUBSTANCE	DENSITY (G/CM^3)	SINK or FLOAT In Water (D = 1.0 g/mL)
AIR	0.0013	Float
WOOD (OAK)	0.85	Float
WATER	1.00	
ICE	0.93	Float
ALUMINUM	2.7	Sink
LEAD	11.3	Sink
GOLD	19.3	Sink
ETHANOL (alcohol)	0.94	Float
METHANOL (fuel)	0.79	Float

DETERMINING DENSITY

- Regular Shapes – mass, then determine the volume by formula

  EX: cubes, cylinders, spheres, cones, etc.

- Irregular shapes – mass, then measure displacement of a liquid (usually water) by that irregularly shaped object

1. Use a graduated cylinder
2. Add water to a predetermined level – record.
3. Gently drop in the irregularly shaped object.
4. Read the graduated cylinder – record.
5. Subtract the first water level from the second – this is the volume

CALCULATE DENSITY

- **Divide the mass of the object by the volume of the object**

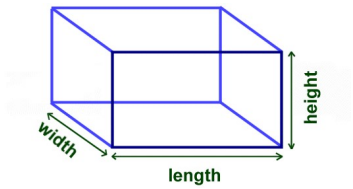
$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

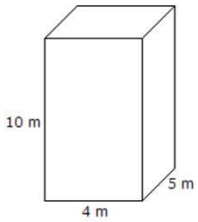
SI units

- Density = g/mL or g/cm^3
- Mass = g
- Volume = mL or cm^3
- Water has a density of 1 g/mL

How do you calculate volume?

Volume= length x width x height





What is the volume?

PRACTICE PROBLEMS OF DENSITY

1. A small block of wood has a volume of 25 cm^3 and a mass of 20 grams. What is the density of the block?

D =?
M = 20 grams
V = 25 cm^3

Density = $\frac{\text{mass}}{\text{volume}}$

Density = $\frac{20g}{25cm^3}$

Density = 0.8 g/cm^3

2. A piece of tin has a mass of 16.52 g and a volume of 2.26 cm^3? What is the density of tin?

D =?
M = 16.52 grams
V = 2.26 cm^3

Density = $\frac{\text{mass}}{\text{volume}}$

Density = $\frac{16.52\ g}{2.26\ cm^3}$

Density = 7.31 g/cm^3

PRACTICE PROBLEMS OF DENSITY

3. A man has bottle completely filled with 163 g of a slimy, green liquid and a density of 3.26 g/cm^3. What is the volume of the bottle?

D= 3.26 g/cm^3
M= 163 g
V= ?

Volume = $\frac{\text{Mass}}{\text{Density}}$

Volume = $\frac{163\ g}{3.26\ g/cm^3}$

Volume=50.0 cm^3

4. A piece of metal has a density of 11.3 g/cm^3 and a volume of 6.7 cm^3. What is the mass of this piece of metal?

D= 11.3 g/cm^3
M= ?
V= 6.7 cm^3

Mass = Density x Volume

Mass= 11.3 g/cm^3 x 6.7 cm^3

Mass= 76 g

Let's try some density problems! Get a piece of paper.

5. Frank has a paper clip. It has a mass of 9g and a volume of 3cm^3. What is its density?

6. Frank also has an eraser. It has a mass of 3g, and a volume of 1cm^3. What is its density?

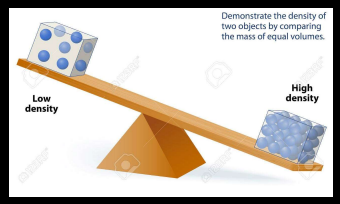
7. Jack has a rock. The rock has a mass of 6g and a volume of 3cm^3. What is the density of the rock?

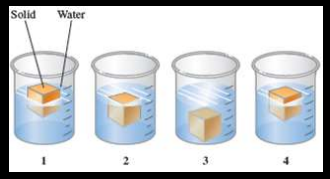
8. Jill has a gel pen. The gel pen has a mass of 8g and a volume of 2cm^3. What is the density of the rock?

Density: Buoyant Force

Density

- **An object will float or sink based on its density.**
- **You can determine if a substance will float or sink by comparing densities.**





Which one is more dense?

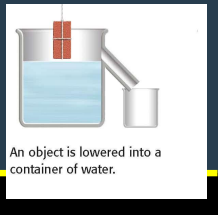
Buoyant Force

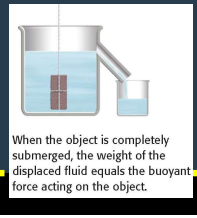
- **Buoyancy is the force with which a more dense fluid pushes a less dense fluid substance upward.**

How does this relate to me?

–Buoyancy tells me whether or not an object will float.

- **All fluids exert an upward buoyant force on matter.**

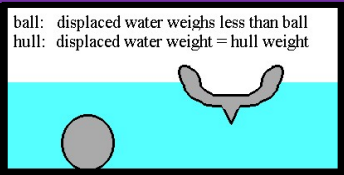

An object is lowered into a container of water.

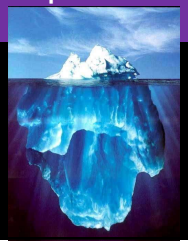

When the object is completely submerged, the weight of the displaced fluid equals the buoyant force acting on the object.

Buoyant Force

Archimedes Principle

- The buoyant force on an object in a fluid is an upward force that equals the weight of the fluid that the object displaces.



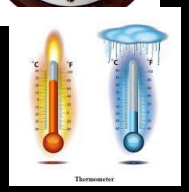


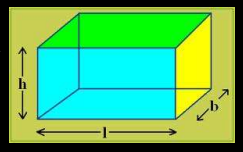
Behavior of Gases

- Remember Gases are far apart and their particle are moving quickly
- The gas laws relate temperature, pressure, and volume to one another.
- **Boyle's Law** ***(relates pressure to volume)***
- **Gay-Lussac's Law** ***(relates pressure to temperature)***
- **Charles's Law** ***(relates temperature to volume)***

Vocabulary

- Pressure-amount of force exerted on an object
- Temperature-intensity of heat present
- Volume-amount of space a substance occupies





Gases Laws

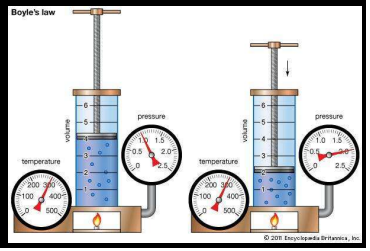
Robert Boyle (1627-1691). Son of Earl of Cork, Ireland.

Boyle's Law

- **For a gas at a constant temperature, pressure and volume are inversely proportional**
  - **Temperature stays the same**
  - **If the pressure decreases the volume increases**
  - **If the pressure increases the volume decreases**

Temperature is constant

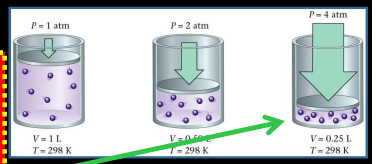
Pressure	Volume
↑↓	↓↑



Gases Laws

Boyle's Law

- A bicycle pump is an example.
- As the volume of the air trapped in the pump is reduced, its pressure goes up, and air is forced into the tire.



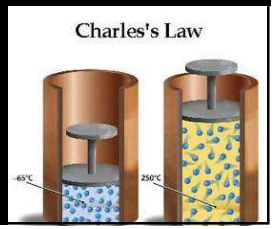
Gases Laws

Charles's Law

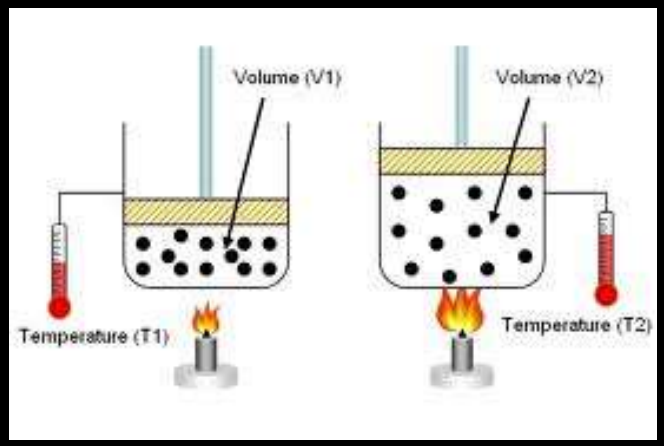
- For a gas at constant pressure, temperature and volume are directly proportional
  - Pressure stays the same
  - If the temperature increases, then the volume increases
  - If the temperature decreases, then the volume decreases

Pressure is constant

Volume	Temperature
↑ ↓	↑ ↓



Charles's Law



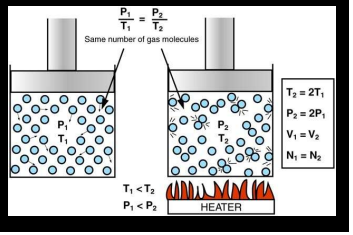
Gases Laws

Gay-Lussac's Law

- If the volume of a gas is constant, temperature and pressure are directly proportional
  - The volume of gas stays the same
  - If the temperature increases then the pressure increases
  - If the temperature decreases then the pressure decreases

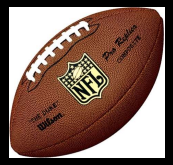
Volume is constant

Pressure	Temperature
↑ ↓	↑ ↓



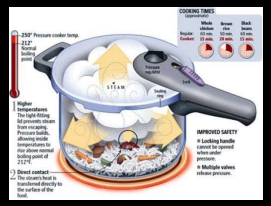
Gay-Lussac's Law

Footballs: Having one outside on a cold day deflates them.



Ping Pong Balls: Dip them in hot water to get rid of dents.

Pressure Cooker

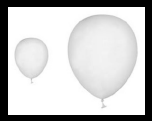


Tire pressure: The tires of your bike deflate in the cold.

Think about this…….

The gas in the toy balloon expands outward, as shown below. After this expansion, does the pressure of the gas

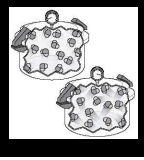
a. increase?
b. decrease?
c. remain unchanged?



Volume goes up
Pressure goes down

The temperature of the water vapor in the pressure cooker increases. Does the pressure of the gas

a. increase?
b. decrease?
c. remain unchanged?



Temperature increases
Pressure increases