Chemistry:

The Kinetic Molecular Theory and the theory of the atom explain the behaviour of matter.

- How does the KMT work? What are its applications?
- What is the relationship between the atomic molecular theory and kinetic molecular theory?

Student Objectives

Statement	Beginning	Approaching	Meeting	Succeeding	Exceeding
I can explain kinetic molecular theory					
I can provide evidence of existence of atoms and molecules					
I can describe changes of state and explain what happens to particles during changes of state					
I know the three subatomic particles, their location within the atom, and forces that bind them to the atom					
I can determine the number of protons, neutrons, and electrons of an atom using the periodic table					
I can draw a Bohr Model of an atom (elements 1-20)					

Summary:

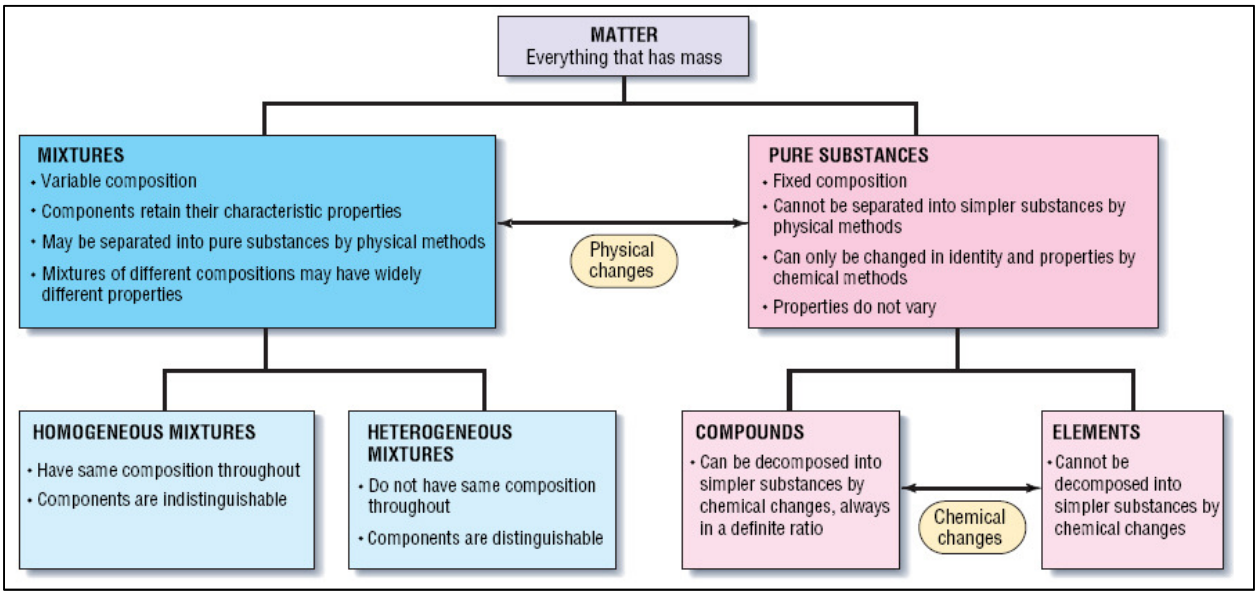
- A pure substance is made of one kind of substance and can be either an element or a compound.
- The kinetic molecular theory describes matter as made up of tiny particles in constant motion.
- Most of the volume of an atom is occupied by electrons, which exist in specific electron shells first discovered by Niels Bohr.
- Each element contains only one kind of atom, and all other forms of matter are made from combinations of these atoms and elements.
- The periodic table lists the elements in order of increasing atomic number, arranged into families according to their properties.
- In the periodic table, metals are on the left side, non-metals are on the right, and metalloids form a diagonal line near the right side.
- Electrons can be pictured as arranged in shells in a specific pattern around the nucleus.

- Atoms are composed of protons and neutrons, which make up the nucleus, and electrons, which surround the nucleus in patterns.
- Bohr diagrams show the arrangement of protons, neutrons, and electrons in atoms.

Kinetic Molecular Theory

Matter is anything with <u>mass</u> and <u>volume</u>.

<u>Classification of Matter:</u>



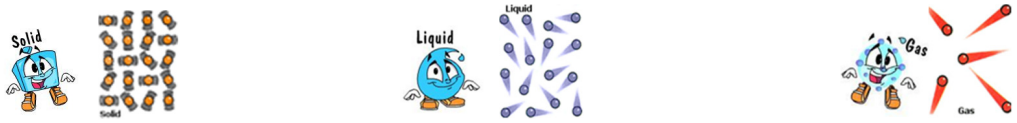
<u>Kinetic Molecular Theory:</u>

1. Matter made of small particles
2. Empty spaces are between particles
3. Particles always in motion
    - Solid particles are close together and vibrate back and forth
    - Liquid particles are further apart and move slightly faster than solid particles by sliding past one another.
    - Gaseous particles are the furthest apart and move the fastest
4. Heat and other forms of energy make particles move faster

Figure 1.8A The particles in a solid are packed together tightly. This means that solids will hold a definite shape. Even though a solid does not appear to move, the particles are constantly vibrating in place.

Figure 1.8B The particles in a liquid are in contact with each other, but they are not nearly as close as in solids. In fact, the particles in liquids can slip and slide past one another, changing their position. This slipping and sliding means liquids do not hold a shape and instead take the shape of their container.

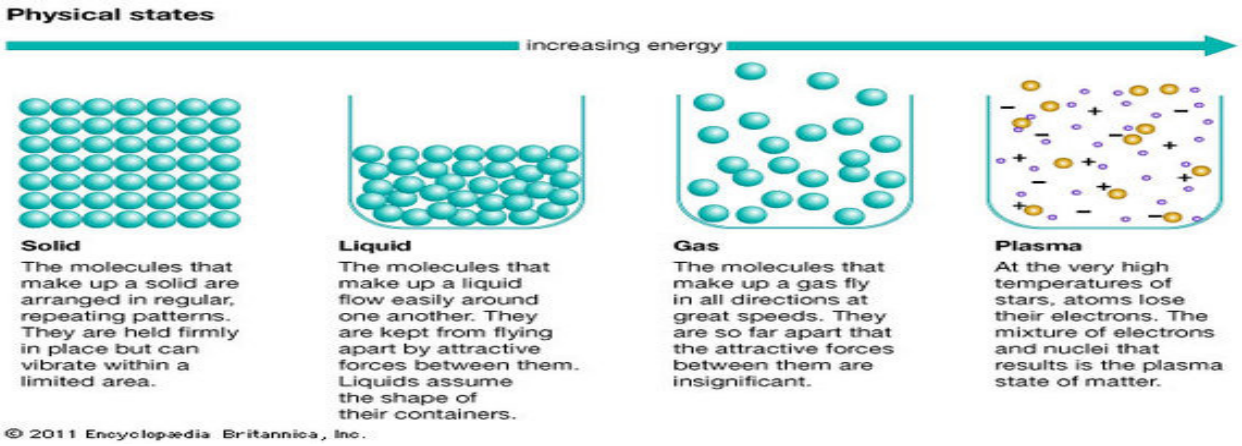
Figure 1.8C Gas particles have very large spaces between them. In fact, gases are mostly empty space. Gases are quite different from liquids and solids because the particles in a gas can move freely in all directions. This is why gases always spread out or diffuse to fill their container.



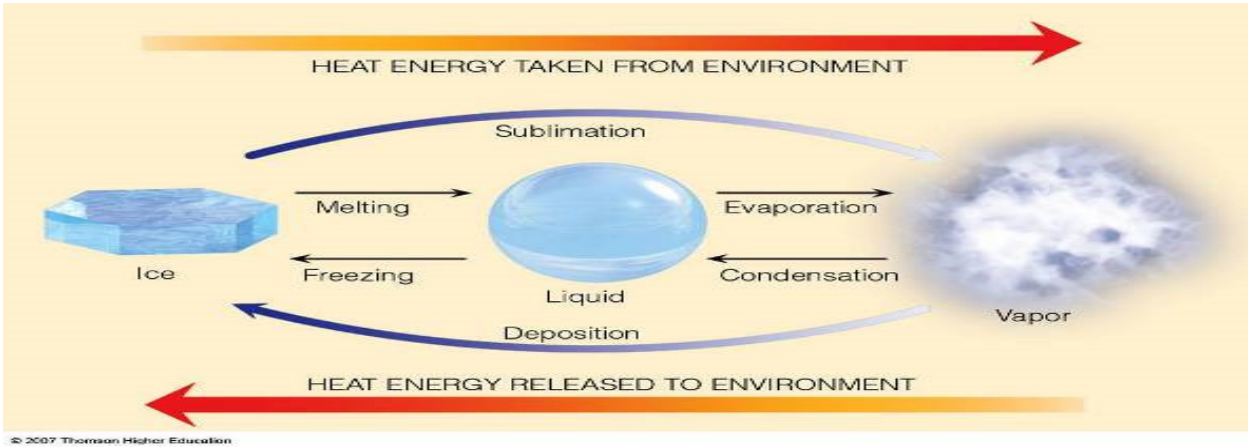
Thinking Beyond: _____

Plasma:

- a fourth state of matter distinct from solid or liquid or gas and present in stars and fusion reactors
- a gas becomes a plasma when it is heated until the atoms lose all their electrons
- **Examples include**: Gases in discharge tubes (fluorescent lamps and neon signs), Welding arcs, Lightning, Stars and the Sun, Comet tails



Changes of State:



Condensation: occurs when the particles in a gas cool enough (lose energy) to change to the liquid state. An example of condensation is when a glass of ice water forms water droplets on the outside.

Melting: occurs when a solid is heated until its particles reach a high enough energy to reach its melting point, changing it into the liquid state. An example of melting is an ice cube turning into liquid water when you set it on a surface, or hold it in your hand.

Freezing (Solidification): occurs when a liquid is cooled until its particles reach a low enough energy to reach its freezing point, changing it into the solid state. This occurs to liquid water when it is placed in a freezer. (Actually, anything that is solid is frozen!)

Sublimation: occurs when a solid changes into the gas state without passing through the liquid state. Iodine is an example of a substance that sublimes, as well as solid carbon dioxide (dry ice), snow, and ice in freezer.

Deposition: occurs when a gas changes into a solid without passing through the liquid state. Examples of deposition include the formation of snow in clouds, formation of frost on windows and the ground, and discharging a CO2 fire extinguisher.

Evaporation: occurs when the particles of a liquid are heated to its boiling point. Large bubbles of gas form throughout the liquid and move to the surface, leaving the liquid. Steam is the gaseous water molecules that form above boiling water.

Quick Check 1

1. **What is a mixture?**

   _____

   _____

   b) What is a pure substance?

   _____

   _____

2. **What are the 4 states of matter?** _____ _____ _____ _____
3. **In which state do particles move the:**

   Slowest? _____**Fastest?** _____

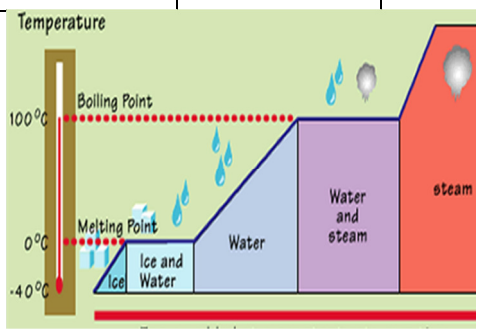
4. **Define the following terms using the <u>Changes of State</u> diagram above**

Change of State	Definition	Example
1. Melting		
2. Freezing (Solidification)		
3. Sublimation		
4. Evaporation		
5. Condensation		
6. Deposition		

5. **Using the diagram to the right answer the following questions:**

   a) What is the melting point of water?

   _____



b) **What is the boiling point of water? _____**
c) **At which temperature are the particles moving the fastest? _____**
d) **Water changing to Steam is also referred to as _____**

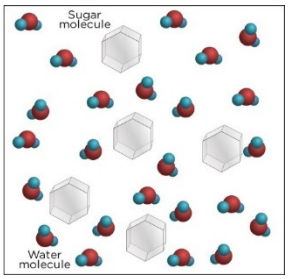
Evidence of the KMT

- ***Particles always in motion: Diffusion***

Diffusion: Diffusion is movement from an area of high concentration to an area of low concentration.
You can see when you spray cologne from a bottle or AXE body spray from a can. If diffusion didn't exist, then the spray scent would not travel from where it was sprayed.

- ***Empty spaces are between particles: Dissolving***

Dissolving: When water is in a liquid state, the molecules are vibrating and have space between them for sugar to enter into the water and dissolve.



Quick Check 2

1. **Using the information above, provide another piece of evidence for the KMT?**

_____
_____
_____
_____
_____

Can Compressor Olympics!

Purpose:

- To investigate the process by which we can cause a can to collapse and test the impact of certain variables in creating the most compressed can!

Materials:

- Pop Can
- Tongs
- Hot Plate
- Cold Water
- Min. 1000 mL Beaker

Procedure:

1. Make sure to clear off your lab area so that there are no items except those needed for the lab.

2. Fill your beaker up (about 2 inches from the top) cold water.

3. Place 20 mL of water in your empty pop can.

4. Plug in your hot plate. Turn the knob to the second highest setting.

5. Place your pop can on the hot plate until you see steam coming from the top of the can.

6. Once this happens, using the tongs invert the pop can (opening is facing downwards) into the beaker full of water.

7. Observe what happens

8. Clean off your work area and return all materials back to their designated locations.

In order to ensure that you have the most crushed can, you must try changing certain aspects of the above procedure to see if we produce better results. You will **conduct 4 trials** and in each one, **change one or more variables** before crushing the can. By **recording your results** you will try and determine the best procedure to win the CAN COMPRESSOR OLYMPICS!

Possible Variables to Test:

- Amount of water in the can
- Temperature of the water the can is submerged in
- Time that the can is allowed to warm before crushing
- Time between removing from heat and submerging in water
- Other?

Data and Results:

Trial 1	Variable 1	Variable 2	Result
	Variable 3	Variable 4	

Trial 2	Variable 1	Variable 2	Result
	Variable 3	Variable 4	

Trial 3	Variable 1	Variable 2	Result
	Variable 3	Variable 4	

Trial 4	Variable 1	Variable 2	Result
	Variable 3	Variable 4	

Discussion:

- **Look at your results… Which one produced the most crushed can? Why do you think this is? (what variables did you change?)**

- **Based upon your results, what would you do if you had one more trial?**

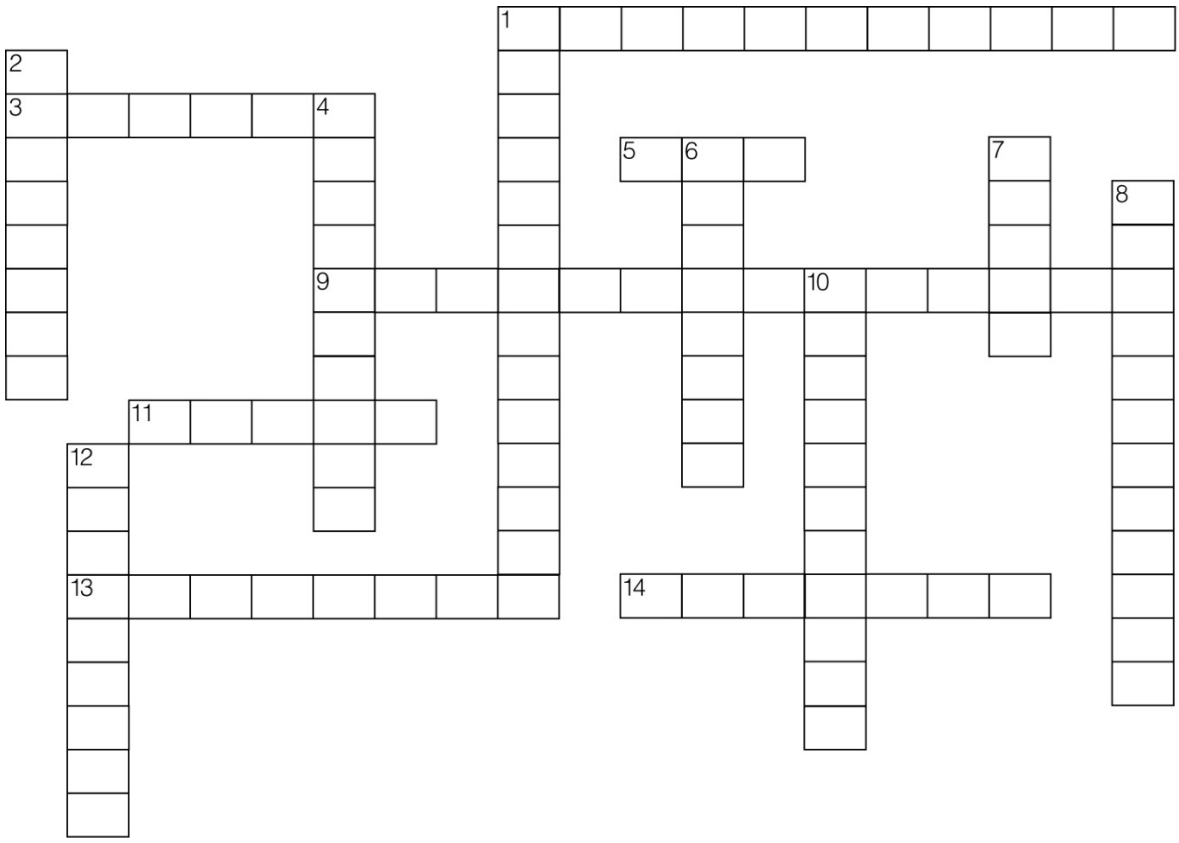
- **Using the Kinetic Molecular Theory and your understanding of atmospheric pressure, explain why the can imploded. (What happens to the water inside the can when heated? What happens to water vapor when the can is inverted in the beaker)**

Conclusion:

- **What do you think will produce the most compressed can? Why?**

Quick Check 2: Crossword Puzzle

Read the clues and complete the following crossword puzzle with the correct terms.



Crossword Clues

Across

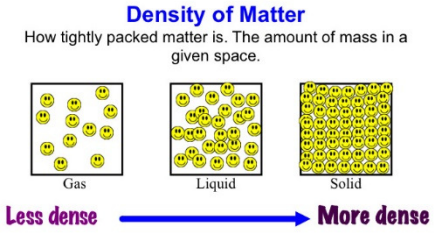
1. the change of state directly from a solid to a gas
3. the state of matter of a substance that has a definite volume and takes the shape of its container
5. the state of matter of a substance that has neither definite shape nor definite volume
9. liquid surface acts like a thin skin
11. the state of matter of a substance that has a definite shape and volume
13. particles of a fluid attract each other

Down

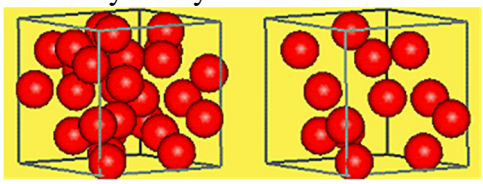
1. the change of state from liquid to solid
2. how fast a fluid "runs"
4. the change of state directly from gas to solid
6. attraction of two fluids to each other
7. any substance that flows
8. the change of state from gas to liquid
10. the change of state from liquid to gas
12. resistance to flow

DENSITY

- **Density** is a way to measure how tightly packed an object is. Denser objects have less empty space in them, they are less holey. In other words, **Density** is the degree of compactness of a substance.



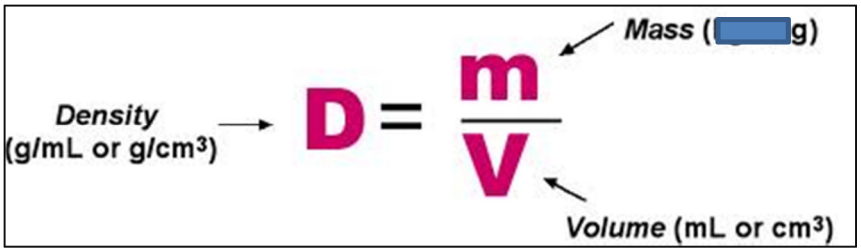
Take a look at the two boxes below. Each box has the same volume. If each ball has the same mass, which box would have a higher density? Why?



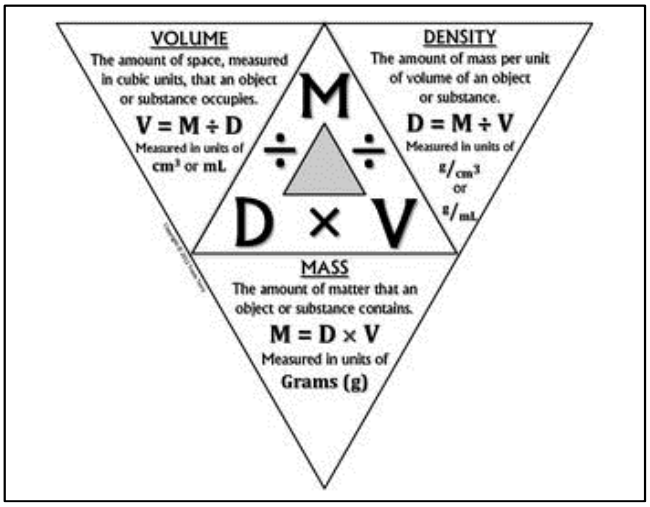
The box that has more balls has more mass per unit of volume or is more compact.

- The density of an object compared to the density of water tells us whether the object will float or not. The density of water is about 1.00 g/mL.
    - If the density of an object is less than the 1.00 g/mL, the object will float in water.
    - If the density of something is greater than 1.00 g/mL it will sink in water.

Density Equation



Density Triangle

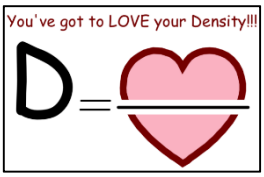


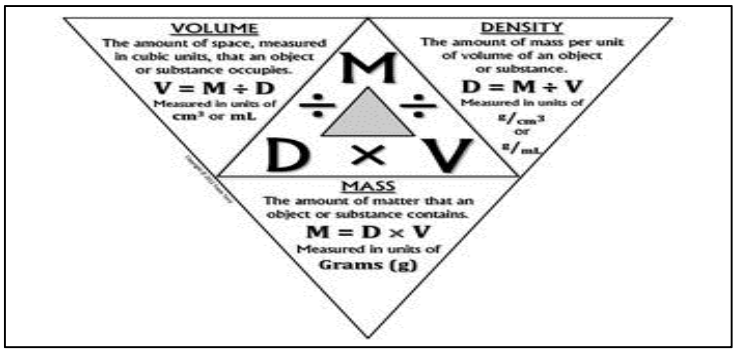
Density = _____ / _____

Volume=_____ / _____

Mass = _____ **X** _____

Quick Check 3: Density Questions





1. **Calculate the <u>mass</u> of a liquid with a density of 3.2 g/mL and a volume of 25 mL.**

2. **Calculate the <u>density</u> of a 500 g rectangular block with the following dimensions: length=8 cm, width=6 cm, height=5 cm.**

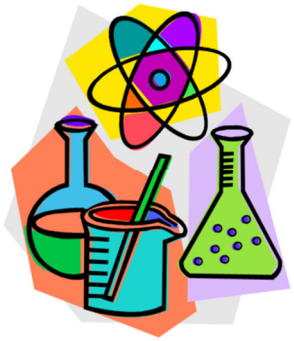
3. **Calculate the <u>Volume</u> of a solid metal cylinder with a density of 2.6 g/cm^3 and a mass of 14 g.**

4. **An irregular object with a mass of 18 000 g displaces 2500 mL of water when placed in a large overflow container. Calculate the <u>density</u> of the object.**

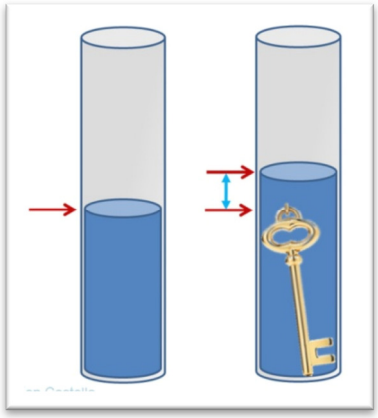
5. **A graduated cylinder has a mass of 80 g when empty. When 20 mL of water is added, the graduated cylinder has a mass of 100 g. If a stone is added to the graduated cylinder, the water level rises to 45 mL and the total mass is now 156 g. What is the <u>density</u> of the stone?**

Name_____ **Date:**_____

Activity: Measuring the Density of Solid Objects



Purpose: In this activity, you will use a balance to find the mass of irregularly shaped objects and use the displacement of water method to find the volume and finally the density.

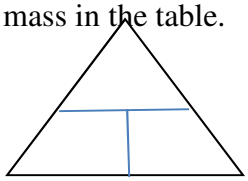


Materials:

- Water
- Graduated Cylinder
- Irregular Shaped Objects
- Digital Scale

Procedure:

1. Pour some water into a graduated cylinder and measure its volume. Tilt the graduated cylinder a little, and gently slide a small object into it. Do not allow any water to splash out. Any loss of water will cause an error in your results.
2. Record the total volume of the object and the water in the cylinder. Calculate the volume of the solid object.
3. Dry the item off and weigh the item using the balance. Record the mass in the table.
4. Determine the density using the Density formula
5. Repeat steps 2-5 for the other objects.



Data:

Fill in table and DO NOT FORGET UNITS

ITEM	Volume of Water Only (mL)	Total Volume of Object and Water (mL)	Volume of Object V	Mass of Object m	Density (g/mL or g/cm^3) D
Rock					
Rubber Stopper					
Cork					
Marble					

Extension: Determine the Density of Granular Solids (Rice and/or Sand) using the table below:

Material	Volume (mL)	Mass of the beaker (g)	Mass of the beaker and material (g)	Mass of the material (g)	Density (g/mL)
Rice					
Sand					

Atomic Molecular Theory.

I know the three subatomic particles, their location within the atom, and forces that bind them to the atom				
I can determine the number of protons, neutrons, and electrons of an atom using the periodic table				
I can draw a Bohr Model of an atom (elements 1-20)				

Atomic Theory

1. An **atom** is the smallest particle of an element that has the properties of that element.

2. An element is a pure substance that cannot be chemically broken down into simpler substances.
Example: Oxygen (O) is an element.

3. A **compound** is a pure substance that is made up of two or more different elements that have been combined in a specific way.
Example: H_2O is a compound made of the elements hydrogen and oxygen.

4. An atom includes smaller particles called protons, neutrons, and electrons**
- **Protons** are subatomic particles that have a 1+ (positive) charge.
- **Neutrons** are subatomic particles that do not have an electric charge.
- **Electrons** are subatomic particles that have a 1– (negative) electric charge.

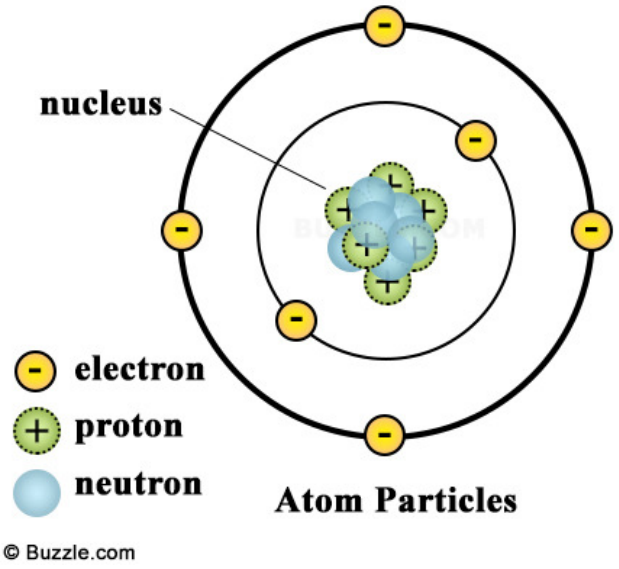
***These subatomic particles are made up of elementary particles. Refer to the Thinking beyond section.*

The Nucleus

1. The nucleus is at the centre of an atom
- The nucleus is composed of protons and neutrons.
- Electrons exist in the area surrounding the nucleus.

2. The number of protons = the number of electrons in every atom

3. The nuclear charge = the electric charge on the nucleus = the number of protons



4. The **atomic number** = the number of protons = the number of electrons

Thinking Beyond: _____

Quarks and Leptons (Elementary Particles)

What is an elementary particle?

An elementary particle is a particle that is not made up of any smaller particles. Elementary particles are the building blocks of the universe. All the other particles and matter in the universe are made up of elementary particles.

Types of Elementary particles

We won't go into a lot of detail on these particles, but it is interesting to know the names of some of these particles and how they make up larger particles such as the proton and neutron.

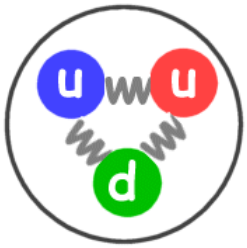
There are two main categories of elementary particles: **fermions and bosons**.

Fermions

Fermions are the matter particles. All matter is made up fermions. Fermions are divided into two types of particles: quarks and leptons.

Quarks - Quarks are the basic building blocks for protons and neutrons. There are six types of quarks and they have pretty interesting names including *up, down, charm, strange, top*, and *bottom*. The different types of quarks are called "flavors" by physicists.

Leptons - One type of lepton that you have probably heard of is the *electron*. Electrons are important building blocks for atoms.



A proton is made up of three quarks

Summary:

Name	Symbol	Charge	Location	Relative Mass
Proton	**p**	**1+**	**nucleus**	**1836**
Neutron	**n**	**0**	**nucleus**	**1836**
Electron	**e**	**1–**	**area surrounding the nucleus**	**1**

Quick Check # 1

1. Explain how an atom, an element, and a compound are different from each other.

_____

_____

_____

_____

2. What are the electrical properties of the following particles?

(a) protons _____

(b) neutrons _____

(c) electrons _____

3. Where is each particle located in an atom?

(a) proton _____

(b) neutron _____

(c) electron _____

4. What does "atomic number" mean?

_____

_____

5.

Atomic #	Name	Symbol	Atomic Mass (rounded)	# of protons	# of neutrons	# of electrons
40						
		Br				
				47		
						22

Organization of the Periodic Table

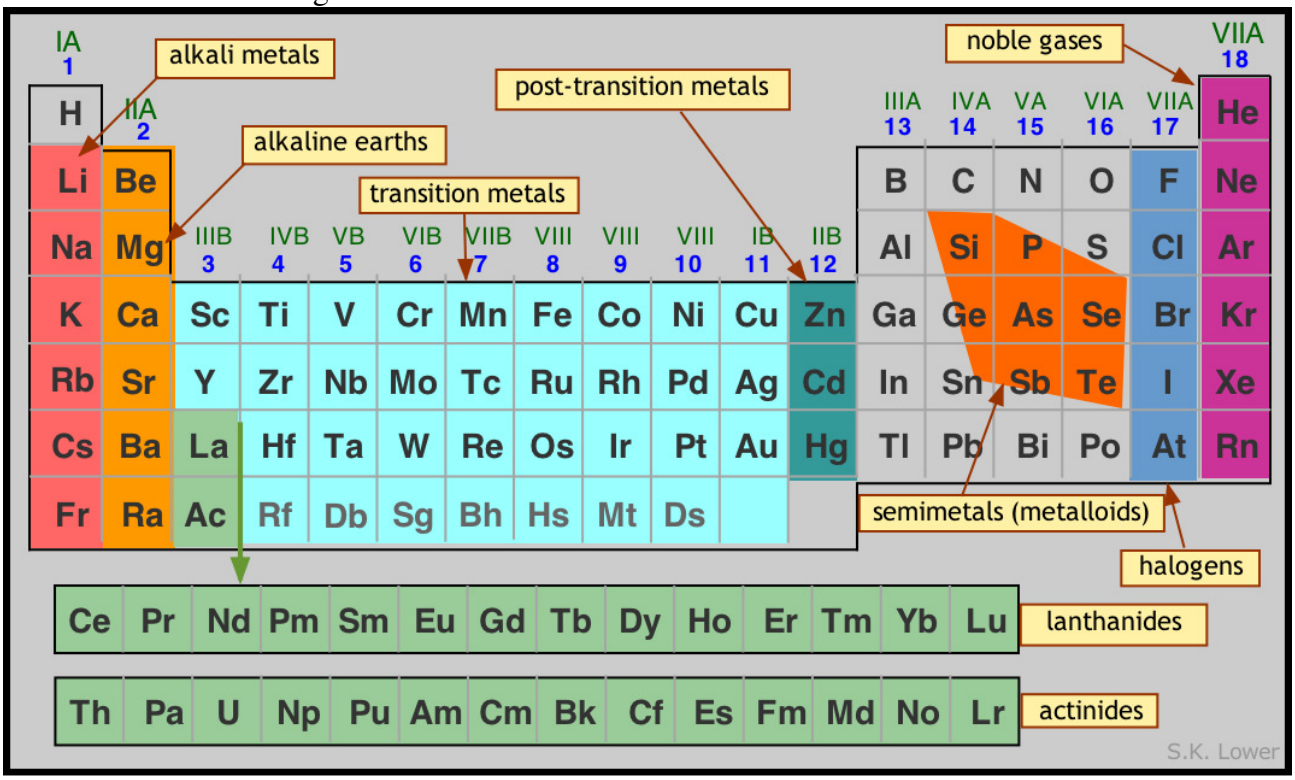
1. The periodic table organizes all known elements in order by atomic number.

2. Rows of elements (across) are called **periods**.

3. Columns of elements (down) are called **chemical families** or **groups**.
- All elements in a family have similar properties and bond with other elements in similar ways.

Group 1 = alkali metals
Group 2 = alkaline earth metals
Group 17 = halogens
Group 18 = noble gases

4. Metals are on the left side of the table, non-metals are on the right side, and the metalloids form a "staircase" toward the right side.



Quick Check # 2

1. What is the difference between a chemical family and a period in the periodic table?

_____

_____

2. List the name and group number of four families of elements.

_____ _____

_____ _____

Bohr Diagrams

1. A **Bohr diagram** is a model of the atom that describes the arrangement of an element's subatomic particles: neutrons and protons in the nucleus and electrons in electron shells

    - Electron **shells** are regular patterns or energy levels around the nucleus.
    - There is a maximum of two electrons in the first shell, eight electrons in the second shell, and eight electrons in the third shell.
    - Electrons in the outermost shell are called **valence electrons**.

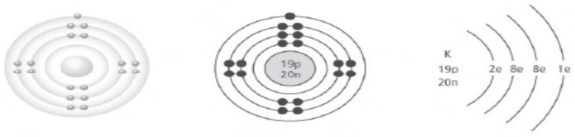


FIGURE 4.3 Bohr diagrams for potassium

2. Electrons can exist singly as **unpaired electrons**, or they can be in pairs, called **paired electrons**.

Quick Check # 3

1. Where are valence electrons found?

_____

_____

2. How many electrons can be in each of the first three shells in a Bohr model of an atom?
Shell 1: _____ Shell 2: _____ Shell 3: _____

3. Draw a Bohr diagram (with standard notation) showing the number of protons and electrons in an atom of:

Question 1: **Boron Atom** Step 1 (Standard Notation: PNE): Step 2: Valence electrons ___; Total energy level (shells): ___	Question 2: **Magnesium Atom** Step 1 (Standard Notation: PNE): Step 2: Valence electrons___;Total energy level (shells): ____
Question 3: **Chlorine Atom** Step 1 (Standard Notation: PNE): Step2 : Valence electrons ___; Total energy level (shells): ___	Question 4 : **Silicon Atom** Step 1 (Standard Notation: PNE): Step 2 : Valence electrons___; Total energy level (shells): ___

Quick Check 1-ANSWERS

6. **What is a mixture?**
   Made of 2+ pure substances

   b) What is a pure substance?
   Cannot be separated into similar substances physically. Made up of one type of molecule

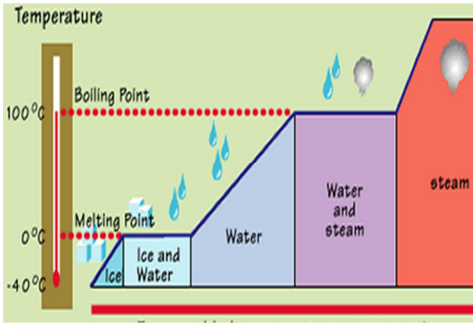
7. **What are the 4 states of matter? SOLID, LIQUID, GAS, PLASMA**

8. **In which state do particles move the:**
   Slowest? _____S_____Fastest? _____G_____

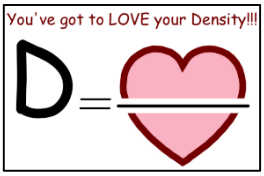
9. **Define the following terms using the Changes of State diagram above**

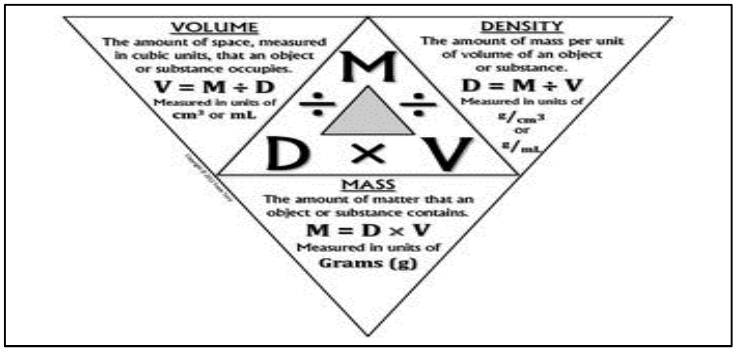
Change of State	Definition	Example
7. Melting	S- L	
8. Freezing (Solidification)	L -S	
9. Sublimation	S-G	
10. Evaporation	L-G	
11. Condensation	G-L	
12. Deposition	G-S	

10. **Using the diagram to the right answer the following questions:**
    e) **What is the melting point of water? 0°C**
    f) **What is the boiling point of water? 100°C**
    g) **At which temperature are the particles moving the fastest? +100°C**
    h) **Water changing to Steam is also referred to as EVAPORATION**



Quick Check 3: Density Questions





1. **Calculate the mass of a liquid with a density of 3.2 g/mL and a volume of 25 mL.**

m=? **m = D X V** ***3.2 X 25 = 80 g***
D= 3.2g/mL
V= 25 mL

2. **Calculate the density of a 500 g rectangular block with the following dimensions: length=8 cm, width=6 cm, height=5 cm.**

D=? **D = m/V** ***500/240 = 2.08 g/ cm^3***
M= 500g
V= 8x6x5= 240cm^3

3. **Calculate the Volume of a solid metal cylinder with a density of 2.6 g/cm^3 and a mass of 14 g.**

V= ? **V = m/D** ***14 / 2.6 = 5.38 cm^3***
D= 2.6 g/cm^3
M= 14 g

4. **An irregular object with a mass of 18 000 g displaces 2500 mL of water when placed in a large overflow container. Calculate the density of the object.**

m=18 000g **D = m/V** ***18000/2500= 7.2 g/mL or 7.2 g/ cm^3***
V= 2500 mL
D=?

5. **A graduated cylinder has a mass of 80 g when empty. When 20 mL of water is added, the graduated cylinder has a mass of 100 g. If a stone is added to the graduated cylinder, the water level rises to 45 mL and the total mass is now 156 g. What is the density of the stone?**

m= 156-100 = 56 g **D = m/V** ***56/25 = 2.24 g/mL or 2.24g/ cm^3***
V= 45-20 = 25mL
D= ?

Atomic #	Name	Symbol	Atomic Mass (rounded)	# of protons	# of neutrons	# of electrons
40	Zirconium	Zr	91	40	51	40
35	Bromine	Br	80	35	45	35
47	Silver	Ag	108	47	61	47
22	Titanium	Ti	48	22	26	22