Chemistry: ***<u>Properties of Matter</u>***

Name: ___________________ Hr: ___

Composition and Properties of Matter

In this unit, we will cover the composition and properties of matter.

composition = *what matter is made of; center of Earth – civilization of little men*

properties = *what the matter is like; how matter behaves; earthquakes*

Matter: The Substance of the Known Universe

matter = *anything that has mass and volume*

mass = *the amount of matter in an object*

In chemistry, we measure mass with an instrument called a *balance*.

Mass is related to weight, but it is NOT the same thing.

What does an object's **weight** depend on? *how hard gravity pulls on it*

this will vary, depending on location

An object's mass does NOT change, no matter where it is.

mass and weight for you on Earth, moon, Jupiter

Compare the definitions for matter and mass. What is wrong with these definitions?

each uses the definition of the other; circular argument

volume = *the amount of space an object occupies*

Is air matter? *takes up space; has mass (balloon demo)*

Examples of matter: *solids, liquids, gases*

NOT examples of matter: *ideas (truth, love, loyalty), heat, energy*

The most basic unit of matter is the **atom**. There are _____ different varieties of atom.

they are listed on the Periodic Table

oxygen (O), carbon (C), hydrogen (H) (draw lone shapes))

Often, atoms combine together to form a **molecule =** *a neutral group of atoms held together by chemical bonds*

Examples: carbon dioxide molecule water molecule

hydrogen molecule oxygen molecule

At the smallest level, all matter is **composed** of atoms.

How Do We Classify Matter?

All matter can be classified as either a pure substance or a mixture. For example:

pure gold	vs.	gold alloy
24 karat		*say, 18 karat, 18/24 gold*
pure substance		mixture

pure substance (sometimes, just "substance") = *a type of matter for which all samples have the same properties; they behave exactly the same way*

There are 2 types of pure substances, elements and compounds.

elements = *samples of a substance that contain only one type of atom*

An element CAN'T be broken down into simpler substances by chemical means.

From the Periodic Table of the Elements, there are ______ different elements.

Usually, we associate: "atoms" → "element"

Examples of elements: *aluminum (Al), nickel (Ni), nitrogen (N)*

Elements consist of: a) single atoms, or…

b) groups of atoms of the same type (molecules).

Example: diatomic gases *(pictures)*

atomic oxygen	molecular oxygen
atomic hydrogen	molecular hydrogen
atomic nitrogen	molecular nitrogen

Even though they differ slightly, we still say that the above examples are elements because they contain… *a single type of atom ONLY.*

Some elements have allotropic forms.

allotropes = *different forms of an element in the same physical state*

oxygen atom	oxygen gas	ozone
		χ
carbon atom	graphite	buckyball

compound = *a substance made up of 2 or more different elements that are chemically combined*

How many different types of compounds do you think there are? *millions*

Why? *the ~100 elements combine in any combo (analogy of letters and words)*

A compound CAN be broken down into simpler substances by chemical means.

Electrolysis of water: $2\ H_2O\ (l) \rightarrow 2\ H_2\ (g) + O_2\ (g)$

Usually, we associate: "molecules" → "compound"

Properties of Compounds - every sample of a particular compound has the same properties as every other sample

every sample of pure water (H_2O) smells, tastes, looks, and reacts the same

Sample Problem: In every 100 g sample of pure water, there are 11.2 g of hydrogen and 88.8 g of oxygen. How many grams of hydrogen are in a 120 g sample of pure water?

mixture = *a combo of 2 or more substances; each retains its individual properties*

In a mixture, there are no *chemical bonds* between the different substances.

There are 2 types of mixtures: homogeneous mixtures and heterogeneous mixtures.

homogeneous mixture = *all regions of a homogeneous mixture are identical in composition and properties*

Homogeneous mixtures are evenly-mixed, or uniformly distributed, at the *particle* level, and are also referred to as **solutions**. *(or microscopic)*

Examples: *soda pop, salt water, sugar water, Kool-Aid*

Solids can also form solutions. .

alloy = *a homogeneous mixture of 2 or more metals*

Examples: bronze = *copper + tin* brass = *copper + zinc*

steel alloys, aluminum alloys, titanium alloys

heterogeneous mixture = *some regions have different composition and properties than other regions*

In heterogeneous mixtures, although the particles may appear to be evenly mixed at the macroscopic level, they are NOT uniformly-distributed at the microscopic (particle) level.

Examples: *tossed salad, concrete, raisin-nut bread, oil-vinegar dressing, taco*

One special type of heterogeneous mixture is a …

suspension = *appears uniform while stirred; settles when agitation stops*

Examples: *Quik milk, muddy water, OJ with pulp, oil & vinegar dressing*

Why do many liquid medications say to "Shake Well Before Using"?

suspensions; medicine most effective when chemicals evenly mixed

Another special type of heterogeneous mixture is a…

colloid = *contains tiny particles that never settle out*

Examples: *gelatin, milk, smoke, fog*

Characteristics that Distinguish Pure Substances from Mixtures

1. A pure substance has only one set of properties, but a mixture retains the properties of each of its constituents.
2. The composition of a pure substance is fixed, but the composition of a mixture can vary widely.

Chart for Classifying Matter

Matter

Pure Substances **Mixtures**

Elements **Compounds** **Homogeneous** **Heterogeneous**

same atoms **different atoms** **solutions** **colloids** **suspensions**

How Can We Separate Mixtures?

There are many ways to separate mixtures. We can separate mixtures because the various constituents of the mixture have different properties. Since chemical reactions are NOT needed to separate mixtures, we say that we separate them physically (*without chemical reactions*), as opposed to separating them chemically (*WITH chemical reactions*.) What kinds of materials must we separate chemically?

compounds; chem. bonds between diff. atoms must be broken to separate the atoms

Methods of Separating Mixtures

Method	***Property Involved***	***Applications***
Magnet	*magnetism*	*recycling*
Filter	*particle size*	*water treatment plant*
Decant	*particle size; density*	*alcohol production*
Evaporation	*liquid evaporates, but solid stays behind*	*salt production*
Distillation	*liquid boiled off, removed, and re-condensed*	*purifying seawater (Saudi Arabia)*
Chromatography	*diff. materials in mixture have diff. attraction to chrom. media*	*nutrition studies, forensic analysis*
Centrifuge	*more dense materials go to the bottom*	*red blood cells from blood plasma*

Distillation Apparatus

Once again, **none** of the methods for separating mixtures involve *chemical reactions*.

Density: An Important Property of Matter

The **density** of a sample of matter is…*the quantity of mass of that substance that occupies one unit of vol.; density is a constant ratio of mass to volume*

Formula for density: $D = m/V$

Mass

Using algebra, write out the 2 variations of this formula…

Volume

$m = DV$ $V = m/D$

(TRIANGLE METHOD)

The **units for density** are always *mass* / *volume* units. We will most often use the units:

g/mL → for fluids (liquids and gases)

g/cm^3 → for solids

Example 1: A piece of lead (Pb) has a mass of 22.7 g and occupies a volume of 2.00 cm^3. What is the density of Pb?

Example 2: A piece of lead (Pb) takes up 16.20 cm^3 of space. Use your answer from Example 1 to find the mass of the Pb piece.

Example 3: A piece of lead (Pb) has a mass of 1544 g. Use your answer from Example 1 to find the volume of the piece of Pb.

Density Can Be Used To Identify Substances

Discovering the identity of an unknown metal.

Archimedes and the crown of King Hiero of Syracuse

(3rd century B.C., King ordered crown of pure gold from local goldsmith, skeptical – thought it was mixed with silver, analysis of crown wo/damaging it, A. knew that = vol. of same substance had = weight (mass), pure gold of same weight as crown should have same vol, how to find vol of crown? bathtub → vol. of submerged object = vol. of water that spilled out; did this on the crown and block of gold = in weight to crown; vol. of water spilled out was NOT = ; beheaded?

Properties of Matter

The **properties** of matter: *the set of characteristics by which the substance is recognized*

Some properties are given below.

Property	***Description***	***Example***
electrical conductivity	conducts electrical energy	*metals: silver, copper*
heat conductivity	conducts heat energy	*metals are good conductors; wood is a poor conductor*
density	mass per unit volume	*wood ~ 1.0 g/cm*^{3}
melting point	the temp. at which a substance melts / freezes	H_2O *melts / freezes at* 0^oC *(273 K)*
boiling point	the temp. at which a substance boils / condenses	H_2O *boils / condenses at* 100^oC *(373 K)*
malleability	able to be hammered or stamped into shape	*metals*
ductility	able to be pulled into wire	*metals; reinforcing bars*

How would you tell the following about a substance? color, taste, odor, state of matter, flammability, density, temperature, whether it reacts with acids

We will group "properties" four different ways: extensive properties, intensive properties, physical properties, and chemical properties.

extensive properties depend on the size of the sample

Examples: *volume, weight, mass, heat content*

intensive properties DO NOT depend on the size of the sample

Examples: *density, temperature, hardness, color*

physical properties are observed wo/changing the chem. composition of the matter

Examples: *color, texture, mass, state of matter, melting point, elec. conductivity*

And for metals: *ductility, malleability, luster*

chemical properties = these describe how the substance reacts (or fails to react) with other substances to produce new substances

Examples: *reactivity with acid, reactivity with oxygen (flammability)*

(Mg reacts with oxygen and nichrome wire does NOT react with oxygen)

Keep in mind that these categories are NOT mutually exclusive. A single property can be classified in several ways. How would you classify these properties?

VOLUME	E I P C	FLAMMABILITY	E I P C
LUSTER	E I P C	COLOR	E I P C
ELECTRICAL CONDUCTIVITY	E I P C	DENSITY	E I P C

Changes in Matter

All around us, matter is constantly changing. In chemistry, we will classify changes as being either physical changes or chemical changes.

physical change = occurs when a physical property of a substance changes without any change in the substances chemical properties or composition

Physical changes DO NOT affect chemical composition.

Examples: *crushing glass, grinding sulfur, changing temp. of a substance*

chemical change = any change that results in the production of one or more substances that differ in chemical properties and composition from the original substances

Chemical changes only occur when *chemical reactions* take place.

Examples: *burning of sulfur, vinegar + baking soda, $CaCO_3$ + HCl, etc.*

Is a change in the **state of matter** a physical or a chemical change?

Energy added…		*melting*		*boiling (vaporization)*	
	solid (s)		**liquid (l)**		**gas (g)**
Energy removed…		*freezing*		*condensing*	
Energy content:	*LOW*		*"MEDIUM"*		*HIGH*

A change in the state of matter is a physical change because the chemical comp. of the matter remains the same.

Changes in Energy

All physical and chemical changes are accompanied by changes in energy.

Do you think that a physical or a chemical change would involve the greater energy change?

chemical; atoms are being rearranged

energy = *the ability to do work, to move something through a distance*

In chemistry, we will discuss 2 basic types of energy.

potential energy = *stored energy; specifically, stored in chemical bonds*

Examples: *food, batteries, gasoline, explosives contain stored energy*

kinetic energy = *energy of motion*

Examples: *moving vehicles, gas molecules, flowing liquids*

Some changes release heat into the environment; others absorb heat.

exothermic change = *heat is given off; heat exits (leaves) the materials; feels warm*

the products have *less* energy than the reactants

Examples: *hot pack, blue water bottle demo*

endothermic change = *heat is absorbed; heat goes into materials; feels cold*

the products have *more* energy than the reactants

Examples: *cold pack, dissolving NH_4Cl in water*

Identify each of the following as an "exothermic" or "endothermic" change.

melting of ice	condensing steam into liquid water
burning paper	combining hydrogen and oxygen to produce water

Chemical reactions, as a rule, need a slight "push" to get started.

activation energy = *the minimum amount of energy to start a chemical reaction*

pushing a bowling ball at top of hill; pop bottle boom demo

Graphically, the activation energy can be shown as follows:

exothermic reaction　　　　　　　　　　endothermic reaction

The Law of Conservation of Energy

In our introductory unit, we mentioned the Law of Conservation of Mass, which is quite similar to another fundamental idea in chemistry: the Law of Conservation of Energy.

law of conservation of energy = *in any chemical or physical change, the total amount of energy stays the same*

Energy is *transformed* from one form to another, but it cannot be *created* or *destroyed*.

How is energy from coal eventually able to power an electric fan in your home?

Is there any energy that is lost in these transformations?

Yes and No; the total amount of energy remains the same, but the useful energy decreases with each step in the process

heat is "lost" because we cannot use it

Changes in energy will be an important topic of study, especially in our units on chemical bonding and heat energy.

Conversion Factors

Many of the problems we will solve will require the use of conversion factors.

Example: Change (i.e., convert) 1.4 feet to inches

conversion factor = *a factor used to convert one unit of measure to another type of unit*

consists of a numerator and a denominator

What is the numerical value of any conversion factor? *1*

Why is this important? *any quantity multiplied by 1 is still the same quantity*

The set-up for conversion problems is very important because it will help you understand what you are doing. Your teacher will show you the proper method of setting up your solution to the problem. You must use this method, even if it seems strange at first. Much of what we will later learn depends upon you understanding how to correctly use conversion factors.

Example 1: Find the number of m in 2.35 km.

Example 2: Find the number of km in 756 m.

Example 3: How many g is 8503 mg?

Example 4: How many mm is 0.331 km?

Sometimes we will need to use more than 1 conversion factor. We can use as many as we want. Why?

Each factor = 1. We can multiply by 1 over and over and still have the same quantity.

Chemical Quantities: The Mole

The most important "new" quantity we will use in chemistry is the mole, which is abbreviated "mol".

1 mole of atoms = *6.022 x 10^{23} atoms*

1 mole of molecules = *6.022 x 10^{23} molecules*

Avogadro's number = *6.022 x 10^{23}*

Atoms and molecules are so small that it is impossible to efficiently count them one at a time, or even by the thousands or millions. We use the concept of the mole to more easily measure numbers of atoms and molecules.

How large a number is 6.022×10^{23}? *enormous – find some silly examples*

Do all atoms (gold atoms, uranium atoms, hydrogen atoms, etc.) have the exact same mass?

no; some are heavier than others (What if we took bunches –same number?)

demo w/coins → ratios, too

The mole concept is closely related to the Periodic Table. The Table has been set up so that…

One mole of any element (6.022×10^{23} atoms of that element) has the mass given by the decimal number (atomic mass) on the Periodic Table.

When doing "mole problems," we will use the standard set-up, just as we did with conversion factors.

Number of mol and Substance	***Mass of Substance***	***Number of Atoms of Substance***
1 mol of iron (Fe)		
2 mol of aluminum (Al)		
1.45 mol of neon (Ne)		
0.58 mol of calcium (Ca)		

Once you take the time to understand it, the **mole concept** is a very useful idea, and NOT an overly-difficult one. We will see it repeatedly in future units of this course.

Student Signature ________________________ **Date** ____________

Teacher Sign-off ________________________ **Points** ___________