Elements, Compounds & Mixtures

Elements
Mrs. LCC
Elements

• Big Idea: Matter can be classified into elements, compounds and mixtures

• In this section we will focus on elements.

• element = a pure substance in which there is only one type of atom
Element

- An element cannot be broken down into a simpler substance by physical or chemical methods.
- Each element can be grouped according to its special characteristics.
- These groups are: metals, non-metals, and metalloids.
Metals, non-metals & Metalloids
Elements

• pure substance = a substance in which all the atoms (particles) are the same.

• Elements are classified according to their physical and chemical properties.

• What is an example of a physical property?

• What makes a chemical property different from a physical property?
Grouping Elements

• There are 3 major categories of elements: metals, non-metals and metalloids.

• there are categories within these three that we will look at in later chapters.

• These are grouped according to their characteristics much like you group your music in iTunes.
Metals

- Metals are shiny
- Metals conduct heat
- Metals conduct electricity
- Metals are malleable (can be pounded or rolled into shape)
- Metals are ductile (can be made into thin wires)
• Examples of metals include: copper, lead, tin, gold and silver
Non-metals

- non-metals do not conduct heat
- non-metals do not conduct electric current
- solid non-metals are dull in appearance.
- solid non-metals tend to be brittle and unmaleable
• Examples of non-metals include: iodine, sulfur, and neon
Metalloids

- Metalloids have properties of both metals and non-metals

- Metalloids include: Boron, Silicon, Germanium, Arsenic, Antimony and Tellurium

- Turn to the periodic table in the back flap of your books to see the metalloids
Silicon

• Have you ever heard of Silicon Valley?
• Silicon is a widely-used semi-conductor
• pure silicon conducts electric current poorly
• but, the amount of electric current silicon conducts can be adjusted by the addition of other elements.
• A thin wafer of silicon forms the base of microprocessors
• http://youtu.be/RHAsolyM-D4
Math Challenge

• There are 8 elements that together make up 98.5% of the Earth’s crust.

• They are: oxygen (46.6%), aluminum (8.1%), iron (5%), calcium (3.6%), sodium 2.8%, potassium (2.6%), magnesium (2.1%) and silicon.

• What percentage of the earth’s crust is silicon?
Compounds

• A compound is formed by chemically combining two or more elements.

• What bonds change in a ‘chemical change’ or a ‘chemical reaction’?

• reaction = the process of a chemical change between two substances
Compounds

• When two different elements combine they form a compound.

• That compound has different characteristics than either of the elements it is made up of.

• Ex. Table salt is NaCl (sodium chloride); elemental sodium is a soft metal that combusts violently when added to water and chlorine gas is toxic.

• When is the last time you saw salt water randomly combust?
Common Compounds

- salt = NaCl
- Water = H₂O
- Citric acid (in lemon juice) = hydrogen, carbon and oxygen (C₆H₈O₇)
- Carbon dioxide = CO₂
- Baking soda (sodium bicarbonate) = sodium, hydrogen, carbon and oxygen (CHNaO₃)
Element Mass

- Each element is given a mass in amu
- amu = atomic mass unit
- The masses are based on hydrogen as a reference point
Mass Ratio

- Elements combine to form a compound in specific numbers.

- We can identify the compound by knowing the ratio of the mass of the elements within it.

- Ex. The ratio of the mass of the elements hydrogen : oxygen in water is always 1:8.

- Where do the 1 and the 8 come from? Look at hydrogen and oxygen on the periodic table.
Mass Ratio

• The mass ratio of elements always stays the same for a particular compound because the smallest unit of a compound always stays the same.

• Ex. Water is H2O where H = 1 amu and O = 16 amu.

• The mass ratio of water is H:O = 2:16.

• 2:16 can be reduced to 1:8.
Now you try...

- Salt is NaCl or sodium chloride
- If Na = 23 amu and Cl = 35 amu
- What is the mass ratio of NaCl?
Breaking Down Compounds

• The only way to break down a compound is through a chemical change

• Some compounds can be broken down into their elements

• Some compounds can be broken down into more simple compounds
Compound Breakdown and Energy

- To break down a compound you may need to add energy
- That energy can come from heat or electric current
Mixtures

- A mixture is a combination of two or more substances that are not chemically combined.

- Ex. when you mix sugar and water, the molecules themselves don’t change, but the sugar dissolves and the two become a mixture.
Separating Mixtures

• Mixtures can be separated by physical means.

• For example: distillation, filtration, and evaporation
Distillation

- Distillation = separates a mixture based on the molecules’ different boiling points.

- Ex. separating salt from water.

- Water boils (turns into a vapor) leaving the salt behind.
Filtration

• Some mixtures can be separating by pouring them through a filter

• Ex. Coffee filter
Evaporation

- A mixture may be separated by evaporating off one of the substances (for example, water)

- This is useful when one of the substances would change with heat or if you did not need to retain the pure water.
Centrifugal Force & Magnets

• Mixtures can be separated by spinning them in a centrifuge.

• Biologists rely heavily on centrifuge machines.

• Magnets are used to separate metals in recycling plants
Mixtures: Solutions

- There is no specific mass ratio for mixtures as there was for compounds.
- A solution is a type of mixture.
- Solution = a mixture where the particles of two or more substances appear to be a single substance
  - i.e. made up of particles of two or more substances that are evenly distributed (spread out)
  - Ex. Kool-aid appears to be one liquid; once mixed you don’t see the sugar and water as separate.
Solutions

- Dissolving = the process in which the substances separate and spread out evenly.
- Solute = the substance that is dissolved
- Solvent = the substance that the solvent is dissolved in.
- Ex. In our Kool-aid example, what is the solute and what is the solvent?
Solute vs. Solvent?

• Ex. Salt water
• Ex. carbonic acid in diet coke
• Ex. splenda in my Starbucks
• Ex. Red dye in vinegar
• Can you think of an example?
Homogeneous vs. Heterogeneous

- Solutions are homogeneous mixtures -- they are the same (uniform) throughout
- heterogeneous -- not uniform
Solvents are not necessarily...

- A gas can dissolve in a gas:
  - Letting the helium out of your balloon in a room.

- A gas can dissolve in a liquid:
  - Carbon dioxide dissolved in soda

- Liquid can dissolve in a liquid
  - Alcohol dissolved in water

- Solids can dissolve in a liquid
  - Salt dissolved in water

- Solids can dissolve in a solid
  - Metal alloys such as brass (zinc dissolved in copper)
  - Or, sterling silver (copper dissolved in silver)
Soluble vs. Insoluble

- soluble = able to dissolve
- insoluble = unable to dissolve
- Solubility = whether something is soluble or not in a given solvent at a given temperature

- Ex. wax is not soluble in water, but is soluble in benzene
- Ex. vinyl gloves are not soluble in water, but they are soluble in acetone (nail polish remover)
“Like dissolves like”

- A polar substance = a molecule that has a partial positive and a partial negative charge within the molecule
  - Ex. water: there is a partial negative charge around the oxygen and a partial negative charge around the hydrogens
  - the molecule has a ‘dipole’ (it has both negative and positive charges)
  - **Di = two; pole = side/charge**
  - The Earth could be considered as having a dipole; it has two poles...also a magnet has a dipole
A molecule becomes “polar” because the atoms don’t “share” the electrons evenly.

When one atom hogs the electrons, it becomes slightly negative.

Ex. Oxygen hogs the electrons in the water molecule, so it is slightly negative and the hydrogens are left slightly positive.
“Like Dissolves Like”

- A non-polar substance = a molecule that is neutral in charge
- (i.e. doesn’t have a difference in charges and it neither negative nor positive)
- Ex. benzene, toluene, xylene
- A non-polar substance does NOT have a dipole
“Like Dissolves Like”

• A polar solute will dissolve in a polar solvent
  • Ex. salt dissolves in water

• A non-polar solute will dissolve in a non-polar solvent
  • Ex. wax-stains dissolve in dry-cleaning detergents (which are polar)

• A non-polar solute is not likely to dissolve in a polar solvent
  • Ex. car oil stains won’t come off with water alone
“Like Dissolves Like”

- Proverbs 13:20 “Whoever walks with the wise becomes wise, but the companion of fools will suffer harm.”

- Do you want to be ‘dissolved’ and become apart of the world or the body of believers?
Don’t be a dipole Christian

• A polar compound has a dipole

• That is, it has two sides or two charges
  • A dipole Christian is a ‘two-faced’ Christian
  • What would that look like?

• Christ called us to give ourselves fully to the work of the Lord.
  • God looks at our hearts
Question...

• While bringing your Christmas tree home, you get tree sap on your favorite shirt.

• You know that tree sap is a sticky, non-polar substance.

• Would you rather use water or Murphy’s oil soap to remove the sap?
Solutions are a type of mixture

- How can you tell the difference between a solution and other mixtures?
  - particles in a solution are so small they:
    - won’t come out of solution
    - they don’t scatter light and
    - can’t be removed through filtration
Concentration of Solutions

• Concentration = the amount of solute dissolved in a given amount of solvent

• Units = grams of solute/mL of solvent

• Solutions can be described as dilute or concentrated
Temperature Affects Solubility

• For most **solids**, the **solubility** increases as the **temperature** increases

• i.e. More heat means more solute dissolves
Temperature increases Solid Solubility

- Solids are more likely to dissolve with higher temperature because the extra energy causes the solid molecules to move.
- When the molecules move more, there is more space in between them.
- The solvent can get in these spaces and spread the molecules apart.
Temperature affect solubility

- For **gasses**, the **higher the temperature, the less soluble the gas will be**
- i.e. the more temperature, the less gas will stay dissolved in solution.
- This is why soda goes ‘flat’ faster when its warm
Temperature decreases gas solubility

- In gasses, there is already a lot of space in-between the molecules.

- The increased temperature (an increase in energy) causes the molecules to move more.

- When the gas molecules move more, they leave the liquid solvent and return to the air above it.
Saturated Solutions

Salt will dissolve in water up to a point.

Once the salt water solution is saturated, the salt will no longer dissolve.

A super-saturated solution creates crystals.
carbon tetrahydrochloride

• This compound was used as a dry-cleaning detergent because of its non-polarity.

• The FDA found it is linked to causing cancer so it has been banned.
Hypervitaminosis

- Yes, you can have too much of a good thing!

- Vitamins B and C are polar water-soluble molecules

- Vitamins A, D, E and K are non-polar, fat soluble molecules.

- It is unlikely one would suffer from taking too much vitamin B and C because excess would be passed out through urine.

- However, vitamins A, D, E and K collect in body fat and are lost only by chemical breakdown.

- Patients may suffer nausea, headaches and liver damage
Solutions in the body

• Cytosol is the intra-cellular (within the cell) solution surrounding organelles.

• (Don’t get this confused with the cytoplasm)

• The cytosol is a complex solution of proteins, carbohydrates, nucleic acids, salts and other components dissolved in water.
Why can the cell membrane separate the polar solutions inside from the polar solutions outside of the cell?
Terms

• Polar terms: dipole, partial positive, partial negative, charged, ionic, hydrophilic (water-loving)

• Non-polar terms: neutral, hydrophobic (water-fearing)
Wrapping it all up...

- Solutions, compounds, mixtures Venn Diagram
- Flow Chart

Can it be separated by physical means?

Is the composition uniform (even throughout)?