Agenda

- Skills to help you Succeed in Science Class
- Acids, Bases, and pH scale
- Organic and Inorganic Compounds
- Molecules of Life
- Water

Skills to help you Succeed in Science Class

Get Ready!
- Eat something
- Look over PowerPoint
- Read assigned material
- Print out stuff for class
- Use the same notebook

Get Set!
- Get there early
- Sit in a good spot
- Use your own method of shorthand
- Highlight concepts emphasized by instructor
- Attend every class
Get an A!

- Study in 30-minute bursts
- Realize material builds off previous chapters
- Question mark stuff you don’t understand
- Review notes before head hits pillow
- Stop studying an hour prior to test

Study Nuggets

- Relate principles to familiarities
- Choose a quiet place to study
- Describe concepts to others
- Ask for help if you need it
- Get someone to quiz you
- Study in smaller groups
- Imagine test questions
- Establish momentum

Get Comfortable

- Establish a regular study area
  - Clutter free, comfortable, quiet
  - Stocked with supplies
- Schedule time without distractions
  - Turn off TV, phone, kids
- Test yourself
- Reward yourself

Measurement

- Why do we take measurements?
- What are some types of measurement?
- What are some common units of these measurements?
- What types of instruments do we use to take these measurements?
Units of Measurement and Their Abbreviations

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Metric</th>
<th>SI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>meter (m)</td>
<td>meter (m)</td>
</tr>
<tr>
<td>Volume</td>
<td>liter (L)</td>
<td>cubic meter (m³)</td>
</tr>
<tr>
<td>Mass</td>
<td>gram (g)</td>
<td>kilogram (kg)</td>
</tr>
<tr>
<td>Temperature</td>
<td>degree Celsius (°C)</td>
<td>kelvin (K)</td>
</tr>
<tr>
<td>Time</td>
<td>second (s)</td>
<td>second (s)</td>
</tr>
</tbody>
</table>

Learning Check

Length, Mass, or Volume?

1. A bag of onions has a mass of 2.6 kg.
   - Mass
2. A person is 2.0 m tall.
   - Length
3. A medication contains 0.50 g of aspirin.
   - Mass
4. A bottle contains 1.5 L of water.
   - Volume

pH Scale

- pH scale measures how acidic or basic a substance is
- Ranges from 0 to 14
- 7 is neutral, less than 7 is acidic, more than 7 is basic
- The scale is logarithmic. Each whole value change represents a tenfold change in hydrogen ion concentration.
- Both hydrogen and hydroxide ions are present in any solution - a solution is acidic if the H⁺ is in excess and basic if OH⁻ is in excess.

Acids and Bases

- Proton donors (H⁺ ions) are acids and usually have prefix of “hydro” and suffix of “ic” in the name.
- Proton acceptors (OH⁻ ions) are bases and are named hydroxides.
- When water is ionized, it produces H⁺ ions and OH⁻ ions; therefore, it behaves both like an acid and a base.
Acids and Bases

**Acid Properties**
When dissolved in water, acids:
1. Conduct electricity
2. Change blue litmus to red
3. Have a sour taste
4. React with bases to neutralize their properties
5. React with metals to liberate hydrogen

**Base Properties**
When dissolved in water, bases:
1. Conduct electricity
2. Change red litmus to blue
3. Have a slippery feeling
4. React with acids to neutralize their properties

Is it an Acid or a Base?

- Vinegar: Acid
- Baking Soda: Base
- Lemon Juice: Acid
- Soda: Acid
- Laundry detergent: Base
- Ammonia: Base
- White bread: Acid
- Yogurt: Acid
- Bleach: Base
- Eggs: Base
- Saliva: Mildly basic
- Beer: Acid
- Milk: Mildly acidic
- Blood: Almost neutral (7.35-7.45)

Water

- The compound water makes up a majority of most organisms and is a critical component making the processes of life possible.
- Water consists of two hydrogen atoms covalently bonded to one oxygen atom.

Water - Hydrogen Bonds

- The slightly negative oxygen atom of one water molecule is attracted to the slightly positive hydrogen atoms of nearby water molecules, forming hydrogen bonds.
  - Each water molecule can form hydrogen bonds with up to four neighbors.
  - Hydrogen bonds hold water molecules together.
  - They form, break, and reform with great frequency.
- Extraordinary Properties that are a result of hydrogen bonds:
  - Cohesive and adhesive behavior
  - Resists changes in temperature
  - High heat of vaporization
  - Expands when it freezes
  - Versatile solvent

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Water - Cohesion/Adhesion

Cohesion
- The attraction of like molecules to each other, i.e., water molecules cling to other water molecules.

Adhesion
- The attraction of water molecules to other substances.
- Water is adhesive to any substance with which it can form hydrogen bonds.

Surface Tension

Surface tension is a measure of the force necessary to stretch or break the surface of a liquid due to cohesion.

- Water has a greater surface tension than most other liquids because hydrogen bonds among surface water molecules resist stretching or breaking the surface.
- Water behaves as if covered by an invisible film.
- Some animals can stand, walk, or run on water without breaking the surface.

Capillarity

Capillarity is the ability of water to be drawn up a narrow tube.

- Is a combination of surface tension, cohesion, and adhesion.
- This action helps pull water up through the microscopic vessels of plants.
- It is also responsible for transporting fluids and nutrients in and out of cells.

Temperature

Water can absorb or release relatively large amounts of heat with only a slight change in its own temperature.

Water serves as a large heat sink responsible for:
1. Prevention of temperature fluctuations that are outside the range suitable for life.
2. Coastal areas having a mild climate.
3. A stable marine environment.

<table>
<thead>
<tr>
<th>Celsius Scale at Sea Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>100°C</td>
</tr>
<tr>
<td>37°C</td>
</tr>
<tr>
<td>23°C</td>
</tr>
<tr>
<td>0°C</td>
</tr>
</tbody>
</table>
Specific Heat

The specific heat of a substance is the amount of heat that must be absorbed or lost for 1 g of that substance to change its temperature by 1°C.

- Water has a high specific heat, absorbs and releases heat very slowly, which minimizes temperature fluctuations to within limits that permit life.
- Heat is absorbed when hydrogen bonds break.
- Heat is released when hydrogen bonds form.
- The specific heat of water is 1 cal/g/°C
- Water resists changing its temperature because of its high specific heat.

Density of Water

Ice is about 10% less dense than water at 4°C.

What’s so cool about this?

The density of water:

- Prevents water from freezing from the bottom up.
- Ice forms on the surface first—the freezing of the water releases heat to the water below creating insulation.
- If ice sank, all bodies of water would eventually freeze solid, making life impossible on Earth.
- Makes transition between seasons less abrupt.

Evaporative Cooling

Evaporation is the transformation of a substance from liquid to gas.

Heat of vaporization is the quantity of heat a liquid must absorb for 1 gram of it to be converted from a liquid to a gas.

- Water requires a great amount of heat to change to a gas.
- Evaporative cooling - Allows water to cool a surface due to water’s high heat of vaporization.
- The cooling of a surface occurs when the liquid evaporates.
- This is responsible for:
  - moderating earth’s climate
  - stabilizing temperature in aquatic ecosystems
  - preventing organisms from overheating

Water: Polarity

Water is polar thus having positive & negative partial charges on its ends.

How does this happen?

- Oxygen has a greater attraction for electrons than does hydrogen due to electronegativity.
- The oxygen atom gains a slight excess of negative charge (partial negative charge), and the hydrogen atoms become slightly positive (partial positive charge).
- An individual water molecule has a bent shape therefore the dipoles do not cancel.
**Water: Universal Solvent**

Water is a versatile solvent due to its polarity.

- It can form aqueous solutions.
- The different regions of the polar water molecule can interact with ionic compounds called solutes and dissolve them.

![Diagram of water molecules with ions](image)

**Solvency**

Solvency is the ability to dissolve other chemicals

- **Solvent** - the part of a solution present in the largest amount
- **Solute** - the substance that is present in a solution in a smaller amount and is dissolved by the solvent
- **Hydrophilic** (charged, ionic or polar substances) dissolve easily in water - salt
- **Hydrophobic** (neutral or non-polar substances) do not easily dissolve in water - oil

- Water = universal solvent

**Break**

**Carbon**

Carbon is a central element to life

- Carbon’s outer shell has only four of the eight electrons necessary for maximum stability in most elements
  - This allows carbon to form stable, covalent bonds with a wide variety of atoms, including other carbon atoms
- Carbon has great linkage capacity
  - This capacity allows for the creation of complex molecules
  - Most biological molecules are built on a carbon framework
Organic vs Inorganic Compounds

INORGANIC:
- does NOT contain carbon - carbon bonds.
  - Water (H₂O)
  - Oxygen (O₂)
  - Ammonia (NH₃)
  - Salt (NaCl)

ORGANIC:
- does contain carbon - carbon bonds.
  - Methane (CH₄)
  - Ethane (C₂H₆)
  - Sugar
  - Lipids

Organic Compounds

- Always contain carbon and hydrogen, and sometimes oxygen, sulfur, nitrogen, phosphorus, or a halogen
- occur in nature and are also found in fuel, shampoos, cosmetics, perfumes, and foods
- are the foundation for understanding biochemistry
- are not soluble in water and are less dense than water
- undergo combustion, burning vigorously in air

- Formulas for organic compounds are written with carbon first, followed by hydrogen and then other elements.

Organic vs Inorganic Compounds

<table>
<thead>
<tr>
<th>Property</th>
<th>Organic</th>
<th>Example: C₂H₆</th>
<th>Inorganic</th>
<th>Example: NaCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements</td>
<td>C and H</td>
<td>C and H</td>
<td>Most metals and nonmetals</td>
<td>Na and Cl</td>
</tr>
<tr>
<td>Bonding</td>
<td>Mostly covalent</td>
<td>Covalent (4 bonds to each C)</td>
<td>Mostly ionic</td>
<td>Ionic</td>
</tr>
<tr>
<td>Type of Compound</td>
<td>Molecular</td>
<td>Molecular</td>
<td>Mostly ionic</td>
<td>Ionic</td>
</tr>
<tr>
<td>Melting Point</td>
<td>Usually low</td>
<td>~188 °C</td>
<td>Usually high</td>
<td>801 °C</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>Usually low</td>
<td>~42 °C</td>
<td>Usually high</td>
<td>1413 °C</td>
</tr>
<tr>
<td>Flammability</td>
<td>High</td>
<td>Burns in air</td>
<td>Low</td>
<td>Does not burn</td>
</tr>
<tr>
<td>Solubility in Water</td>
<td>Not usually soluble</td>
<td>No</td>
<td>Most are soluble</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Molecules of Life
Monomers and Polymers

Biological molecules are made by monomers bonding to form polymers

**Monomers**
- Molecules that are building blocks for larger molecules
- Simple sugars, fatty acids, amino acids, nucleotides

**Polymers**
- Molecules that consist of multiple monomers
- Carbohydrates, lipids, proteins, nucleic acids

Carbohydrates

Carbohydrates are formed from simple sugars (monomers), such as glucose.

- These monomers can be linked to form larger polymers. Which are known as disaccharides, such as sucrose, or polysaccharides, such as starch.

Disaccharides are two simple sugars bonded together.

**Examples**
- Sucrose - table sugar
- Lactose - milk sugar
- Maltose - found in malt products

Polysaccharides are made up of many monomers joined together.

Four polysaccharides are critical in the living world:
- Starch - nutrient storage in plants
- Glycogen - nutrient storage in animals
- Cellulose - found in the cell walls of many organisms
- Chitin - external skeleton of arthropods.
**Lipids**

- Do not readily dissolve in water
- Do not possess the monomers-to-polymers structure seen in other biological molecules
- No one structural element is common to all lipids

**Lipids include:**

- Triglycerides
- Steroids
- Phospholipids
- Waxes

**Lipids are used to:**

- Store energy
- Insulate and cushion
- Hormones - steroids
- Waterproof
- Cell membranes

**Steroids, Phospholipids, & Waxes**

**Steroids** - have a core of four carbon rings with various functional groups attached

- Examples: cholesterol, testosterone and estrogen

**Phospholipids** - composed of two fatty acids, glycerol, and a phosphate group

- Phosphate end is polar (attracts water); Fatty acid end is nonpolar (repels water)
- Found in the outer membrane of cells

**Waxes** - composed of a single fatty acid linked to a long-chain alcohol

- Function as “sealants” in the living world
- Almost all plant surfaces exposed to air have a protective covering made largely of wax

**Triglycerides**

- Composed of a glyceride and three fatty acids
- Most of the fats consumed by humans are triglycerides
- Saturated fats
  - Hydrogenated fats are artificially created saturated fats made from cis fats.
- Unsaturated fats: Cis fat (naturally occurring) and Trans fat (artificially created)

**Proteins**

Proteins are composed of amino acids

**Amino Acids**

- Building block of proteins (monomer)
- 20 common amino acids found in human proteins

- Sequences of amino acids are strung together to produce polypeptide chains, which fold into working proteins
Types of Proteins

<table>
<thead>
<tr>
<th>Type</th>
<th>Role</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzymes</td>
<td>Quicken chemical reactions</td>
<td>Sucrase: Positions sucrose (table sugar) in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>such a way that it can be broken down</td>
</tr>
<tr>
<td></td>
<td></td>
<td>into component parts of glucose and fructose.</td>
</tr>
<tr>
<td>Hormones</td>
<td>Chemical messengers</td>
<td>Growth hormone: Stimulates growth of bones</td>
</tr>
<tr>
<td>Transport</td>
<td>Move other molecules</td>
<td>Hemoglobin: Transports oxygen through blood</td>
</tr>
<tr>
<td>Contractile</td>
<td>Movement</td>
<td>Myosin and actin: Allow muscles to contract</td>
</tr>
<tr>
<td>Protective</td>
<td>Healing; defense against invader</td>
<td>Fibrinogen: Stops bleeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Antibodies: Kill bacterial invaders</td>
</tr>
<tr>
<td>Structural</td>
<td>Mechanical support</td>
<td>Keratin: Hair</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collagen: Cartilage</td>
</tr>
<tr>
<td>Storage</td>
<td>Stores nutrients</td>
<td>Ovalbumin: Egg white, used as nutrient for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>embryos</td>
</tr>
<tr>
<td>Toxins</td>
<td>Defense, predation</td>
<td>Bacterial diphtheria toxin</td>
</tr>
<tr>
<td>Communication</td>
<td>Cell signaling</td>
<td>Glycoprotein: Receptors on cell surface</td>
</tr>
</tbody>
</table>

The Beginning of a Protein

The linkage of several amino acids...

Nucleotides

- Nucleotides contain:
  - Sugar
  - Deoxyribose for DNA
  - Ribose for RNA
- Pyrimidines include:
  - In DNA: Cytosine (C) and Thymine (T)
  - In RNA: Cytosine (C) and Uracil (U)
- Purines include:
  - Adenine (A)
  - Guanine (G)

- Nucleic Acids always pair up (via hydrogen bonds)
  - C to G, and A to T in DNA; C to G and A to U in RNA.
Nucleic Acids

Nucleic acids are polymers composed of nucleotides.

Two types of nucleic acids:
DNA (deoxyribonucleic acid)
- Repository of genetic information
- The sequences of bases in DNA encodes the information necessary for production of proteins in living things.

RNA (ribonucleic acid)
- RNA transports the information in encoded in DNA to the sites of protein synthesis.

Questions?

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http://www.daytonastate.edu/asc/ascsciencehandouts.html