Honors Chemistry Midterm Review

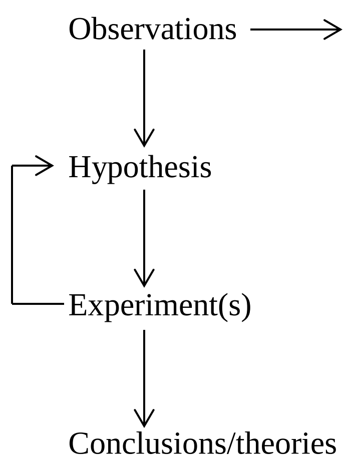
CHAPTER 1: CHEMISTRY IN OUR LIVES

1.1: Chemistry and Chemicals

- **Chemistry** is the study of substances in terms of **composition** (what they're made of), **structure** (how they're put together), **properties** (their characteristics), and **reactions** (how they behave with other substances).
- **Chemicals** are substances that always have the same composition and properties.

1.2: Scientific Method: Thinking Like a Scientist

- The **scientific method** is a set of general principles that helps describe how scientists think. It involves **observations**, **hypotheses**, **experiments**, and **theories**.



(The hypothesis is modified if the results of the experiments do not support it)

CHAPTER 2: CHEMISTRY AND MEASUREMENTS

2.1: Units of Measurement

Measurement	**Metric**	**SI**	**Tool**
Length	Meter (m)	Meter (m)	Ruler/meter stick/measuring tape
Volume	Liter (L)	Cubic meter (m^3)	Graduated cylinder/beaker
Mass	Gram (g)	Kilogram (kg)	Balance or electronic scale
Temperature	Degree Celsius (°C)	Kelvin (K)	Thermometer
Time	Second (s)	Second (s)	Timer/watch

<u>2.2: Measured Numbers and Significant Figures</u>

- A **measured number** is the number you get when you measure a quantity, such as the length of your pencil
- **Significant figures** of measured numbers:
  - All nonzero digits (ex. 765 has 3 SFs)
  - A zero between any nonzero digits (ex. 30005 has 5 SFs)
  - A zero at the end of a number with a decimal point (ex. 500.0302 has 7 SFs)
  - A zero in the coefficient of a number written in scientific notation (ex. 6.01×10^{14} has 3 SFs)
  - ➢ A zero is <u>not</u> significant if it is at the beginning of a decimal number or if it is used as a placeholder at the end of a number without a decimal point (ex. 4000000 and .00002 both have only 1 SF)
- **Exact numbers** are obtained by counting items or using a definition that compares two units in the same measuring system; numbers that you wouldn't use a measuring tool to obtain

<u>2.4: Prefixes and Inequalities</u>

Prefix	**Symbol**	**Numerical Value**	**Scientific Notation**
Peta-	P	1000000000000000	10^{15}
Tera-	T	1000000000000	10^{12}
Giga-	G	1000000000	10^{9}
Mega-	M	1000000	10^{6}
Kilo-	K	1000	10^{3}
UNIT			
Deci-	d	.1	10^{-1}
Centi-	c	.01	10^{-2}
Milli-	m	.001	10^{-3}
Micro-	mc or µ	.000001	10^{-6}
Nano-	n	.000000001	10^{-9}
Pico-	p	.000000000001	10^{-12}
Femto-	t	.000000000000001	10^{-15}

CHAPTER 3: MATTER AND ENERGY

<u>3.1: Classification of Matter</u>

Matter is anything that has mass and volume.

- **Pure substances**
  - Matter that has a fixed or definite composition

  - **Elements** are the simplest type of pure substance. Each element is composed of only one type of material.
  - **Compounds** are another type of pure substance, which consist of two or more elements chemically combined in a fixed proportion.
- **Mixtures**
  - Where two or more different substances are physically mixed, but not chemically combined
  - **Homogenous mixtures**, or **solutions**, are mixtures with uniform compositions, which means that the individual substances that form the mixture cannot be distinguished.
  - **Heterogeneous mixtures** do not have uniform compositions, so the individual substances are distinguishable.

<u>3.2: States and Properties of Matter</u>

- **States of matter**
  - **Solids** have a fixed shape and fixed volume
  - **Liquids** have a variable shape and fixed volume. They take the shape of their container.
  - **Gases** have a variable shape and variable volume.
- **Physical properties**
  - Properties that can be observed or measured without affecting the identity of a substance, such as color, shape, melting and boiling points, and state of matter
  - A **physical change** is a change that occurs without affecting the composition of the substance, such as change in state or size.
- **Chemical properties**
  - Properties that describe the ability of a substance to change into a new substance
  - A **chemical change** is when the original substance is converted into one or more new substances, which have different physical and chemical properties.

<u>3.3: Temperature</u>

- Celsius to Fahrenheit: $T_F = 1.8(T_C) + 32$
- Fahrenheit to Celsius: $T_C = (T_F - 32)/1.8$
- Celsius to Kelvin: $T_K = T_C + 273$

<u>3.4: Energy</u>

Energy is the ability to do work.

- **Kinetic energy** is the energy of motion
- **Potential energy** is determined by the position of an object or by the chemical composition of a substance
- **Heat** is the energy associated with the motion of particles

- Energy is measured in **joules (J)** or **calories (cal)**
  - One calorie is the amount of energy to change the temperature of 1 g of water by 1°C
  - 1 cal = 4.184 J

3.5: Specific Heat

The **specific heat** (SH) of a substance is defined as the amount of heat (q) needed to change the temperature of exactly 1 g of a substance by exactly 1°C.

$$SH = \frac{q}{m * \Delta T}$$

- Water has a specific heat of 1 cal / g °C or 4.184 J / g °C, which is pretty large compared to other substances.
- Substances with low specific heats transfer energy more efficiently.
- The specific heat can be rearranged to solve for heat, mass, or change in temperature. The heat equation is given by

$$q = SH * m * \Delta T$$

3.6: Energy and Nutrition

The **energy values** for food are the kilocalories or kilojoules obtained from burning 1 g of carbohydrate, fat, or protein.

Food Type	kcal/g	kJ/g
Carbohydrate	4	17
Fat	9	38
Protein	4	17

CHAPTER 4: ATOMS AND ELEMENTS

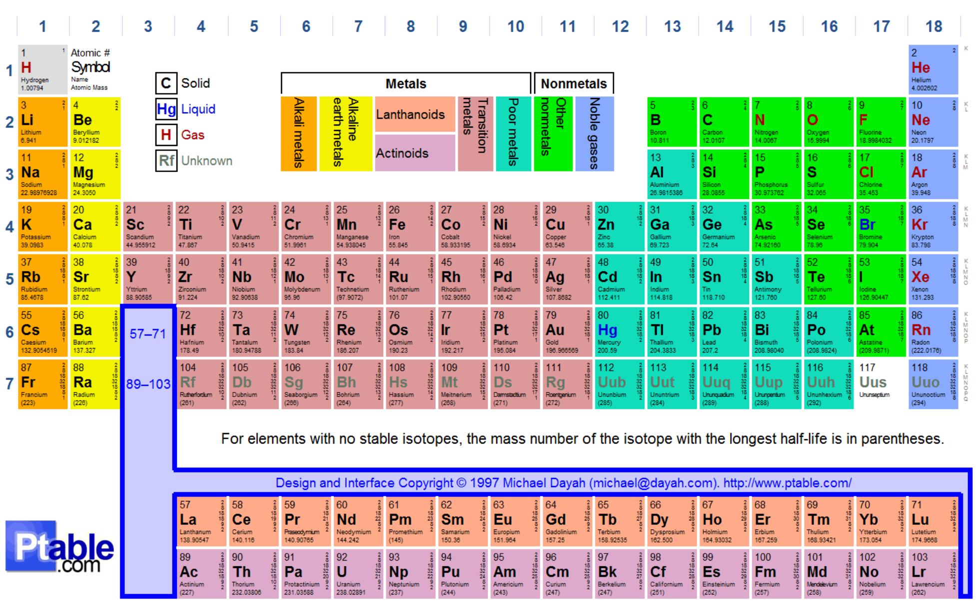
4.1 Elements and Symbols

- Currently, there are 118 different elements, 88 of which occur naturally and make up all the substances in the world
- Each element has a name and **chemical symbol**
  - If the symbol has two letters, then the first is always upper case and the second is always lower case.
  - Most periodic tables list each element by its symbol.
  - ➢ Mnemonic for remembering the first 20 elements in order (courtesy of Mr. Taylor!): **H**arry **He**ard **Li**b**Be**y **B**. **C**a**N** **O**ft**Ne** **NaMg**e **Al**l **Si**gnificant **P**eople **S**outh of **ClArK**, **Ca**lifornia.

(Harry heard Libbey B. can often name all significant people south of Clark, California.)

4.2: The Periodic Table

- The periodic table organizes the 118 known elements and is pretty much my favorite table ever (IT'S SO COOL!!)
- Each horizontal row is called a **period**.
  - Each period represents one energy level (which is further detailed in chapter 5).
- Each vertical column is called a **group**.
  - The elements in each group share similar chemical properties since they all have the same number of **valence electrons**, or electrons in the outermost shell.
  - Each group has a **group number** associated with it. The **representative elements** have group numbers 1A to 8A, and the **transition elements** have group numbers 1B to 8B. A different system of group numbers assigns the numbers 1 to 18 going across the top of the table.
  - The first group forms a family of elements called **alkali metals**, the second group makes up the **alkaline earth metals**, group 7A makes up the **halogens**, and group 8A makes up the unreactive **noble gases**. (Fun fact! Some scientists have actually figured out how to force some of these elements to bond with highly reactive elements such as fluorine. ☺)
- Elements become less metallic in their properties as you move to the right across the table. **Metals** are shiny solids that are ductile (can be shaped into wires), conductive, and malleable (can be hammered into a flat sheet without breaking). **Nonmetals** are not ductile, conductive, or malleable, but they are good insulators, and have low melting points and low densities. **Metalloids** have some metallic properties and some nonmetallic properties- they're semiconductors, since they can be used as conductors or insulators. The metalloids are boron, silicon, germanium, arsenic, antimony, tellurium, polonium, astatine, and tennesine. These elements make a sort of staircase pattern on the periodic table.



4.3: The Atom

An **atom** is the smallest particle of an element that retains the characteristics of that element.

- **Dalton's Atomic Theory**
  1. All matter is made up of atoms
  2. All atoms of a given element are similar to one another and different from atoms of other elements.
  3. Atoms of two or more different elements combine to form compounds. Any particular compound contains the same elements in a fixed proportion.
  4. A chemical reaction involves the rearrangement, separation, or combination of atoms. Atoms are neither created nor destroyed during a chemical reaction.
- Atoms are made up of smaller bits of matter called **subatomic particles**.
  - J.J. Thomson is credited for the discovery of **electrons** through his cathode ray experiment. He proposed the **plum-pudding model**, in which negatively charged particles are scattered randomly throughout a dense, positively charged cloud. Since atoms are neutral, scientists also found that they contain positively charged particles called **protons**, which are much heavier than electrons.
  - Thomson's friend, Ernest Rutherford, used his **gold foil experiment** to propose that an atom was made up of a small, positively charged center called the **nucleus**, surrounded by a region of space where electrons traveled.
  - Eventually, scientists realized that the mass of the nucleus was greater than the mass of protons, so they ended up discovering the **neutron**, a particle with no charge.

Particle	**Symbol**	**Charge**	**Mass (amu)**	**Location in atom**
Proton	p or p^+	1+	1.007	Nucleus
Neutron	n or n^0	0	1.008	Nucleus
Electron	e^-	1-	.00055 (negligible)	Outside nucleus

4.4: Atomic Number and Mass Number

- The **atomic number** of an element is equal to the number of protons in every single atom of that element. It is also equal to the number of electrons in every atom of that element with a neutral charge. It shows up on the periodic table above the symbol for each element.
- The **mass number** of an element is the total number of protons and neutrons in an atom. It is not found on the periodic table because atoms of an element can have varying numbers of neutrons. Atoms of the same element with different numbers of neutrons are called **isotopes**.

4.5: Isotopes and Atomic Mass

- An isotope can be referred to by its name or symbol, followed by its mass number (ex. chromium-50 or Cr-50). It can also be written as

$$^{50}_{24}Cr$$

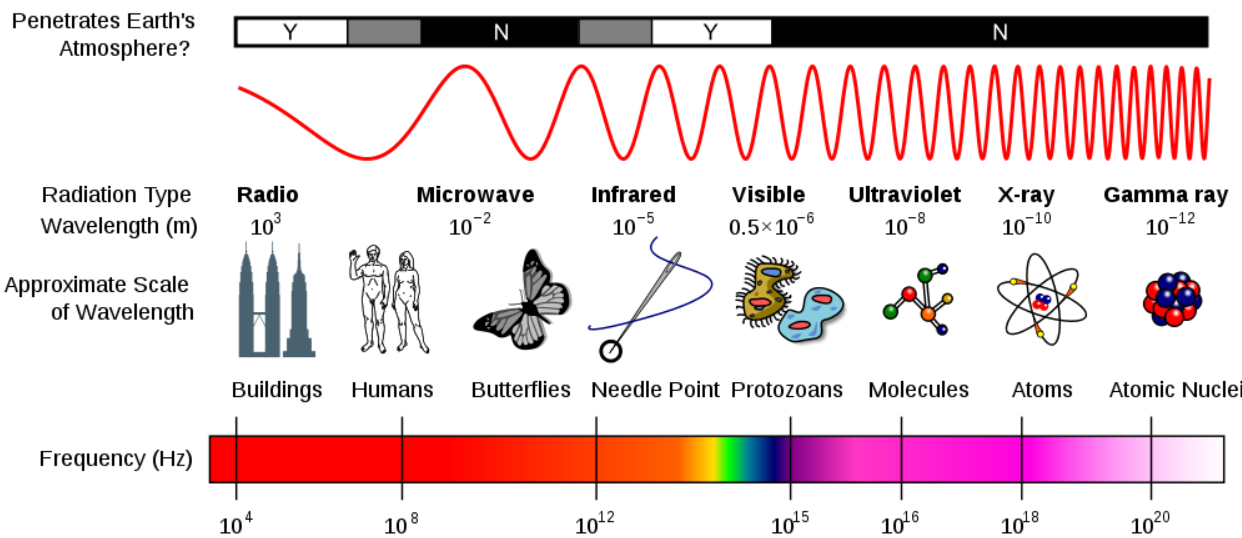
  where the number in the top left is the mass number and the number in the bottom left is the atomic number.

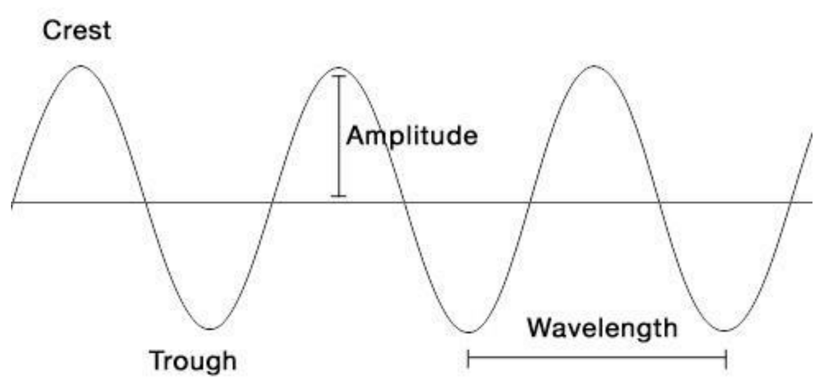
- The **atomic mass** of an element is a weighted average of the masses of all the naturally occurring isotopes of that element. This is the number that is found below an element's symbol on the periodic table.

CHAPTER 5: ELECTRONIC STRUCTURE OF ATOMS AND PERIODIC TRENDS

5.1: Electromagnetic Radiation

- **Electromagnetic radiation** comprises a wide spectrum containing radios, microwaves, visible light, and x-rays, among other forms.





- The **frequency** is the number of times the crests of a wave pass through a point in one second.
  - Wave equation:

$$\text{Speed of light (c)} = 3.00 \times 10^8 \text{ m/s} = \text{wavelength } (\lambda) \times \text{frequency } (\nu)$$

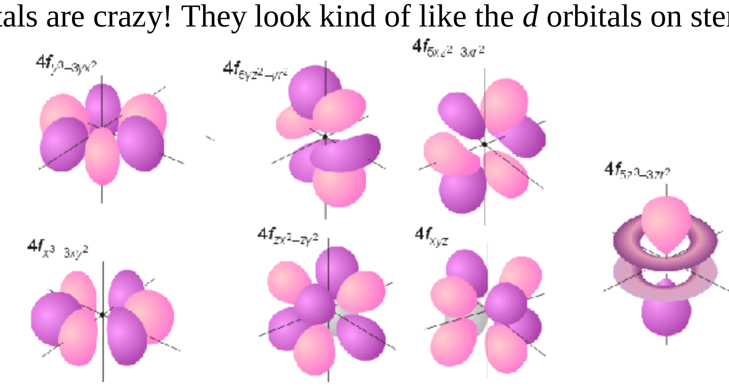
***Note that waves further to the left of the EM spectrum have longer wavelengths and smaller frequencies, while waves further to the right have shorter wavelengths and larger frequencies.

5.2: Atomic Spectra and Energy Levels

- **Photons** are packets of energy with characteristics of both particles and waves that travel at the speed of light.
- In an atom, each electron has a specific **energy level**, which is assigned a value called the **principal quantum number (n)**. Electrons in lower energy levels are closer to the nucleus and electrons in the higher energy levels are farther away. The energy of an electron can only have specific energy values, but not any values between those values (if that makes sense ☹)
- When an atom gains energy, its electrons move up from their **ground state** to higher energy levels, or an **excited state**. When the atom then loses energy, its electrons move back down to their ground state, and the atom emits energy in the form of different wavelengths of visible light. These wavelengths make up an element's **atomic spectrum**. Each element produces unique wavelengths, so the atomic spectrum can be used to identify an unknown element.

5.3: Sublevels and Orbitals

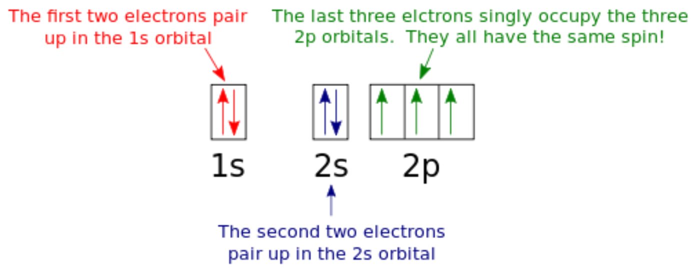
- Each energy level consists of one or more **sublevels**, which represent where the electrons of identical energy are most likely to be found.
  - Sublevels are identified by the letters *s*, *p*, *d*, and *f*.
  - The first energy level, n=1, contains one sublevel, 1*s*. n=2 contains 2*s* and 2*p*, n=3 contains 3*s*, 3*p*, and 3*d*, and n=4 contains 4*s*, 4*p*, 4*d*, and 4*f*.
  - The *s* sublevel has the least energy, and the *f* sublevel has the most energy.
- Each sublevel contains **orbitals**, the three-dimensional volumes in which electrons have the highest probability of being found. They have wacky shapes!
  - The *s* orbitals have a spherical shape
  - The *p* orbitals have a dumbbell shape
  - The *d* orbitals have a sort of plus-sign shape, with four lobes.
  - The *f* orbitals are crazy! They look kind of like the *d* orbitals on steroids.



- The **Pauli exclusion principle** says that each orbital can hold up to two electrons, which have opposite spins. In any sublevel, each orbital must contain one electron before they begin to pair up. The whole sublevel must be filled before moving on to the next sublevel.
  - Any *s* sublevel can hold up to 2 electrons.
  - Any *p* sublevel can hold up to 6 electrons, since they contain 3 orbitals.
  - Any *d* sublevel can hold up to 10 electrons, since they contain 5 orbitals.
  - Any *f* sublevel can hold up to 14 electrons, since they contain 7 orbitals.

5.4: Orbital Diagrams and Electron Configurations

- In an **orbital diagram**, electrons are shown as arrows that are places in boxes to represent the orbitals in order of increasing energy.



(orbital diagram for nitrogen)

- Scientists use a notation called an **electron configuration** to show the arrangement of electrons in an atom. It can be written in two different forms: full or abbreviated.

Some examples:

Element	**Atomic Number**	**Electron Configuration**	**Abbreviated EC**
Oxygen	8	$1s^2 2s^2 2p^4$	$[He]2s^2 2p^4$
Aluminum	13	$1s^2 2s^2 2p^6 3s^2 3p^1$	$[Ne]3s^2 3p^1$
Silver	47	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^9$	$[Kr]5s^2 4d^9$
Iodine	53	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$	$[Kr]5s^2 4d^{10} 5p^5$

5.6: Trends in Periodic Properties

- The chemical properties of representative elements are mostly determined by their valence electrons. This explains why elements in the same group have very similar chemical properties.
- **Lewis symbols** represent the valence electrons of an element.