# Chemistry Honors Study Guide

Test 1 S1

Test date: September 25, 2024

(All links are clickable!)

## 1 Basic Scientific Concepts

### Definitions

- ***scientific law:*** A statement describing or predicting natural phenomena.
- ***scientific theory:*** An explanation for natural phenomena.
- ***accuracy:*** A measure of how close measurements are to the true value.
- ***precision:*** A measure of how close measurements are to each other.
- ***physical property:*** A characteristic of a substance that can be observed or measured without altering its identity.
- ***chemical property:*** A characteristic of a substance that can only be observed or measured when a chemical reaction occurs (the substance is converted into a different substance).

### The Scientific Method

make an **observation** → ask a **question** → background **research** → form a **hypothesis** → **test** the hypothesis → **analyze** the data → **communicate** your findings... and repeat!

### Law v. Theory

**Law** is the **"what"**, while **theory** is the **"why"**. Both have been proven but can be disproven and are supported by scientific consensus.

Example: Newton's First Law, also known as the law of inertia, states that an object at rest will remain at rest unless acted upon by an outside force. This is an example of a law because it simply explains what happens (i.e. it is predictive). On the other hand, the theory of evolution by natural selection is classified as theory because it is a comprehensive explanation based on an observation.

### Accuracy v. Precision

Having both accuracy and precision (see definitions above) is ideal for data collection. Here are some examples of one, both, or neither (where true value = 1.0):

**Accurate, but not precise:** 1.17, 1.28, 0.85
**Precise, but not accurate:** 2.8, 2.75, 2.9
**Accurate and precise:** 1.1, 1.0, 1.01
**Neither accurate nor precise:** 6.08, 3.1, 0.5

## Physical v. Chemical Properties

(not an exhaustive list)

### Physical Properties

- Color
- Melting/Boiling point
- Density
- Solubility
- Conductivity

### Chemical Properties

- Reactivity
- Smell
- Flammability
- Toxicity
- pH

## Classifying Matter

### Classifying By Phase

**Solid:** holds its shape, not compressible, closely packed, fixed relative positions.
**Liquid:** conforms to container, not compressible, unfixed relative positions, closely packed.
**Gas:** conforms to container, compressible, unfixed relative positions, loosely packed.
**Plasma:** an ionized gas with electrical charge.

### Classifying By Composition

Matter: **pure substance** or **mixture**
Pure substance: **element** (Au, Ag, Fe, Pb, $S_8$) or **compound** ($H_2O$, $NaCO_3$, $CO_2$, $C_6H_{12}O_6$)
mixture: **homogeneous**, uniformly mixed (solutions, alloys, dish soap) or **heterogeneous**, not uniformly mixed (oil + water, sand + salt, salad, milk)

# 2 Basic Mathematical Concepts

## Significant Digits

### Rules for Significant Digits:

1. All nonzero digits are significant.

2. Leading zeros (to the left of the first nonzero digit) are never significant.
3. Trailing zeros are only significant if there is a decimal point.
4. All zeros between nonzero digits are significant.

## Scientific Notation

$$3.14 \times 10^3$$

The first number must be $\geq$**1** and $\leq$**10**. When changing a number from scientific notation to standard form (or vice versa), **the number of significant figures stays the same.**

## Metric Units

| **Prefix** | **Abbreviation** | **Value** |
|---|---|---|
| kilo- | k | $10^3$ |
| centi- | c | $10^{-2}$ |
| milli- | m | $10^{-3}$ |
| micro- | $\mu$ | $10^{-6}$ |
| nano- | n | $10^{-9}$ |

### Metric Unit Conversions

Question: How many micrometers are in 456 kilometers? (1 kilometer = 1,000,000,000 micrometers)

$$456\ km \times \frac{1,000,000,000\ \mu m}{1\ km} = 456,000,000,000\ \mu m$$

The first number is the number of kilometers there were in the original question; the second is the unit fraction (equal to 1). The original unit ($km$, in this case) should be put at the bottom of the fraction so it cancels out.

# 3 The Periodic Table of Elements

Online Periodic Table

## Definitions

- ***Aufbau principle:*** States that electrons first occupy the orbitals with the lowest energy.
- ***isotopes:*** Atoms of the same element (same number of protons) with different atomic masses (different number of neutrons).
- ***Pauli exclusion principle:*** States that no two electrons in the same atom can have the same four quantum numbers.

## Classifications

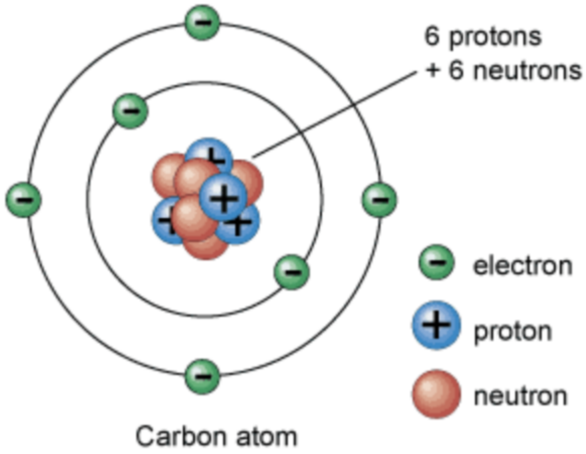
- Group 1: **alkali metals**
- Group 2: **alkali earth metals**
- Groups 3-12: **transition metals**
- Group 17: **halogens**
- Group 18: **noble gases**

## Properties

**Metals** are **good conductors of heat and electricity**, **malleable**, **ductile**, and **shiny**.
**Nonmetals** are **insulators** (not conductive) and **brittle.**
**Metalloids**, also known as semi-conductors, are **semi-conductive**.

## The Atom[1]

| Name | Mass (amu) | Charge | Location |
|---|---|---|---|
| proton | 1 | +1 | nucleus |
| neutron | 1 | 0 | nucleus |
| electron | negligible | -1 | orbitals |

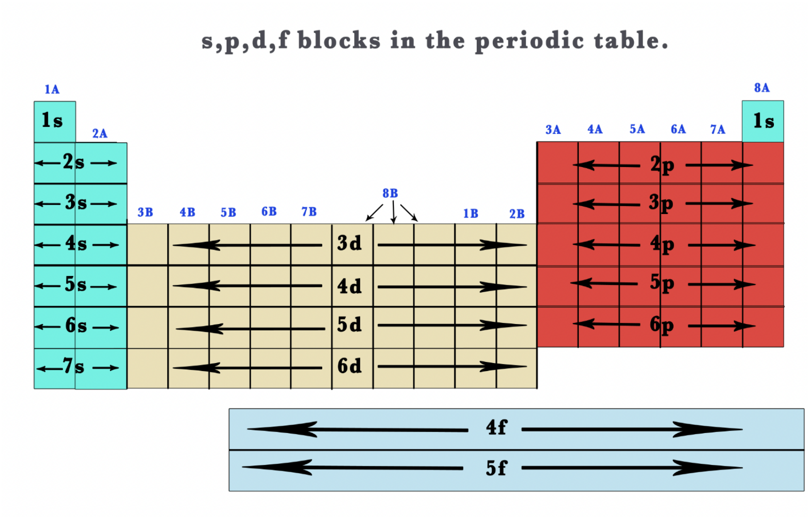



## Electron Configuration

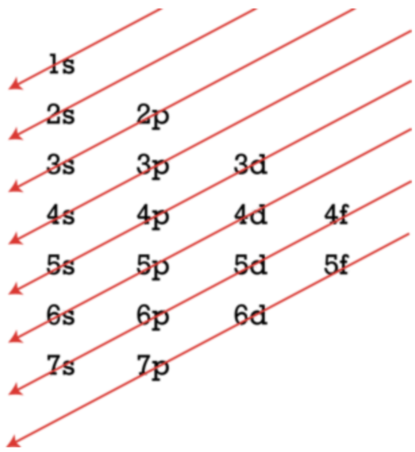
### Full Electron Configuration[2]

Electrons can exist in 4 types of orbitals: s, p, d, and f. **s, p, and d** are the only orbitals that will appear on the test. Each orbital can hold a maximum of **2 electrons.**

[1] www.universetoday.com/56469/atom-diagram/#google_vignette
[2] https://madoverchemistry.com/2017/03/14/41-the-periodic-table-spdf-blocks/




There is/are **1 $s$ orbital**, **3 $p$ orbitals**, and **5 $d$ orbitals**[3] per energy level. More energy levels are added with more rows on the periodic table. The electron configuration is a notation that specifies the energy level, the type of orbital, and the number of electrons in that specific orbital. According to the Aufbau Principle, orbitals are filled in this order:




In the following example, the superscript indicates the number of electrons, the letter indicates the orbital type, and the number indicates the energy level.

Example: Bromine (Br): $1s^2 2s^2 2p^6 3s^2 3p^5$

### Noble Gas Configuration

For noble gas configurations, take the name of the last noble gas, put it in brackets, then write the rest of the configuration, omitting that of the noble gas.

Example: Bromine (Br): $[Ne]3s^2 3p^5$

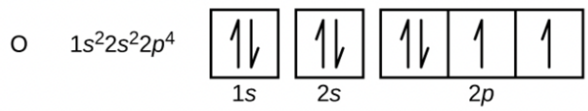
[3] $d$ orbitals appear only after $4s$.

## Electron Box Diagrams

In electron box diagrams, each box represents an orbital. (The boxes will already be drawn on the test.)

**Things to remember:**

- Two arrows in the same box should be pointing in different directions (one up, one down).
- For multiple orbitals, place an arrow in each orbital first.




## Ions

The charge on particles is determined by adding the number of negative charges (adding a negative number) to the number of positive charges.

Example: The charge on an element with 5 protons and 2 electrons is +3.

## Isotopic Symbols

${}^{A}_{B}X$ or ${}^{A}X$ or X-A

where:

- X = atomic symbol
- A = mass number (protons + neutrons)
- B = atomic number

## Quantum Numbers

$n$, the **principle quantum number,** indicates the **orbital shell** in which an electron is in (1, 2, 3, 4, etc.)

$l$, the **angular quantum number,** indicates the **orbital type.**
$s$ orbital $\rightarrow$ 0
$p$ orbital $\rightarrow$ 1
$d$ orbital $\rightarrow$ 2

$m_l$, the **magnetic quantum number,** indicates the specific orbital in which the electron is located. The number of possibilities for $m_l$ correspond to the number of orbitals.
$s$ orbital $\rightarrow$ 0
$p$ orbital $\rightarrow$ -1, 0, 1
$d$ orbital $\rightarrow$ -2, -1, 0, 1, 2

$m_s$, the **spin quantum number,** indicates the spin on the electron. Electrons in the same orbital have opposite spins. The only two possibilities for this number are $+\frac{1}{2}$ and $-\frac{1}{2}$.