

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, S₈) or **compound** (H₂O, NaCO₃, CO₂, C₆H₁₂O₆)

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 ≥ 1 and ≤ 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-	μ	10^{-6}
nano-	n	10^{-9}

Metric Unit Conversions

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

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

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

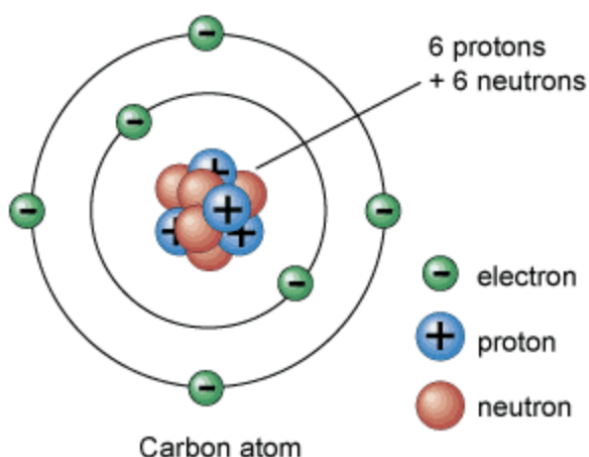
Metals are **good conductors of heat and electricity**, **malleable**, **ductile**, and **shiny**.

Nonmetals are **insulators** (not conductive) and **brittle**.

Metalloids, also known as semi-conductors, are **semi-conductive**.

The Atom¹

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



Electron Configuration

Full Electron Configuration²

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**.

¹www.universetoday.com/56469/atom-diagram/#google_vignette

²<https://madoverchemistry.com/2017/03/14/41-the-periodic-table-spdf-blocks/>

The diagram illustrates the periodic table with orbitals filled in order of increasing energy. The orbitals are labeled as follows:

- 1s** (top left, blue box)
- 2s** (second row, left, cyan box)
- 3s** (third row, left, cyan box)
- 4s** (fourth row, left, cyan box)
- 5s** (fifth row, left, cyan box)
- 6s** (sixth row, left, cyan box)
- 7s** (seventh row, left, cyan box)
- 3d** (fourth row, middle, yellow box)
- 4d** (fifth row, middle, yellow box)
- 5d** (sixth row, middle, yellow box)
- 6d** (seventh row, middle, yellow box)
- 8B** (above the 3d, 4d, 5d, and 6d orbitals, with arrows pointing to each)
- 1B** (fourth row, right, yellow box)
- 2B** (fifth row, right, yellow box)
- 2p** (second row, right, red box)
- 3p** (third row, right, red box)
- 4p** (fourth row, right, red box)
- 5p** (fifth row, right, red box)
- 6p** (sixth row, right, red box)
- 7A** (seventh row, right, red box)
- 6A** (sixth row, right, red box)
- 5A** (fifth row, right, red box)
- 4A** (fourth row, right, red box)
- 3A** (third row, right, red box)
- 8A** (top right, blue box)

Arrows indicate the filling order: 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p, 8s.

Diagram illustrating the filling order of atomic orbitals (s, p, d, f) for principal quantum numbers 1 through 7. Red arrows indicate the sequence: 1s, 2s, 2p, 3s, 3p, 3d, 4s, 4p, 4d, 4f, 5s, 5p, 5d, 5f, 6s, 6p, 6d, 7s, 7p.

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

Example: Bromine (Br): $[Ne]3s^23p^5$

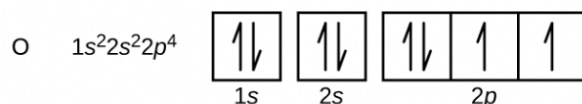
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Electron Box Diagrams

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

${}^A_Z\text{X}$ or ${}^A\text{X}$ 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 $-\frac{1}{2}$.