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## STUDY GUIDE: CHEMISTRY

Chemistry is the study of MATTER. Matter is anything that has mass and volume (takes up space), and everything in our world is matter, even air. The person who studies chemistry is called a CHEMIST.

Elements are the basic building blocks in chemistry. They are made only of themselves, and composed of ATOMS. Gold is an element. It is made of only gold atoms. Hydrogen is an element that is composed of only hydrogen atoms. No two things can be joined to make an element, because they are only composed of one type of atom.

### ALL ATOMS ARE ALIKE IN THESE WAYS:

1. Each atom has a central core called the NUCLEUS. The nucleus holds the PROTONS and the NEUTRONS. The protons are particles that have a positive (+) charge. The neutrons have no charge. They are neutral and are placed in the nucleus to add weight to the atom.
2. Each atom has electrons that spin around the nucleus in shells, or energy levels. The electrons have a negative charge and have no weight.

The first shell, or energy level, can hold only up to two electrons. The second shell can hold up to 8 electrons, and the third shell can hold up to 18 electrons.

3. Electrons are held in their shells by the pull of the positive protons within the nucleus. AN ATOM IS BALANCED IF THE NUMBER OF PROTONS AND THE NUMBER OF ELECTRONS ARE THE SAME.

If an atom loses an electron, it is no longer balanced. It is now positively charged, because there are more (+) charges within the nucleus than there are (-) charges traveling around the nucleus in the shells. The atom is now called an ION, because it is no longer balanced.

If an atom gains an electron, it is no longer balanced. It is also called an ION because now it has more (-) charges circling in the shells than it has (+) charges within its nucleus.

The 3 parts of an Atom: Protons, neutrons, and electrons.

The parts of the Atom in the nucleus: protons and neutrons.

The charges of the Atom parts: Protons (+)  
Electrons (-)  
Neutrons (no charge)

The parts of the Atom that have weight, or mass: protons and neutrons.

ELEMENT: something made only of itself.

ATOMS: The main component of an element.

ION: an atom that is not balanced, and has either gained or lost electrons.

ATOMIC NUMBER: The number of protons in the nucleus of an atom that identifies the kind of atom it is, by referring to the periodic table.

MASS NUMBER: The total number of protons and neutrons in the nucleus of the atom.

ISOTOPE: Atoms of the same element that have a different number of neutrons in the nucleus.

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Each element is given a chemical symbol. Below you will find a list of the more common chemical elements, their symbols, and a brief description or use for the element.

OXYGEN (gas)	O	A gas needed for combustion, or burning. The gas from the air that is used in animal respiration. A fuel for rockets.
NEON (gas)	Ne	A gas used in many colored lights and signs.
CHLORINE (gas)	Cl	A poisonous gas used as a disinfectant, and in bleach. Also combined with sodium to make table salt.
SODIUM (solid)	Na	A soft metal that combines with chlorine to make table salt.
CALCIUM (solid)	Ca	Found in chalk, limestone, and bones. Needed for strong bones and teeth.
IRON (solid)	Fe	A strong metal used in building supports. When combined with oxygen, it forms rust.
TUNGSTEN (solid)	W	A metal with a very high melting point. Used as filaments in light bulbs.
PLATINUM (solid)	Pt	An inexpensive metal used in jewelry.
COPPER (solid)	Cu	A metal that conducts electricity well. Used for wires, cooking utensils, pennies, and jewelry.
ALUMINUM (solid)	Al	A light metal that does not rust. Used for airplane parts, house siding, cans and other food storage methods.
SULFUR (solid)	S	A yellow explosive solid, used for match heads, sulfuric acid, and pet powders.
ZINC (solid)	Zn	A metal used in dry cell batteries and in galvanizing to prevent rust.
SILVER (solid)	Ag	A metal that will tarnish. Used in jewelry, photography, medicines, and coins.
GOLD (solid)	Au	A soft yellow metal used for jewelry.

MERCURY (liquid)	Hg	A liquid metal that expands when heated. Used in thermometers. Poisonous!
NICKEL (solid)	Ni	A silver white metal used in alloys and for plating Other metals.
TIN (solid)	Sn	A very bendable soft white metal.
BROMINE (liquid)	Br	Used in medicines and for insecticides.
IODINE (solid)	I	A dark crystal that can be used as an antiseptic when dissolved in alcohol.
RADIUM (solid)	Ra	A radioactive metal used in treating cancer.
HELIUM (gas)	He	A gas that is less dense than air. Used to make objects rise, such as weather balloons.
HYDROGEN (gas)	H	The lightest of all the elements. The only element that has no neutrons in its nucleus.
CARBON (solid)	C	A black solid found in fuels, charcoal, and in any object that has been burnt.

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#### ELEMENTS JOIN TO FORM COMPOUNDS:

The following objects are compounds. Each compound has a chemical formula that identifies the elements that have been combined to make that compound.

1. water	H <sub>2</sub> O	hydrogen and oxygen
2. carbon monoxide	CO	carbon and oxygen
3. carbon dioxide	CO <sub>2</sub>	carbon and oxygen
4. table salt NaCl	NaCl	sodium and chlorine
5. rust	Fe <sub>2</sub> O <sub>3</sub>	iron and oxygen
6. sugar	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	carbon, hydrogen, and oxygen
7. sand	SiO <sub>2</sub>	silicon and oxygen
8. copper sulfate	C <sub>4</sub> SO <sub>4</sub>	copper, sulfur, and oxygen

9. hydrogen peroxide	H <sub>2</sub> O <sub>2</sub>	hydrogen and oxygen
10. hydrochloric acid	HCl	hydrogen and chlorine
11. calcium carbonate	CaCO <sub>3</sub>	calcium, carbon, oxygen
12. carbon tetrachloride	CCl <sub>4</sub>	carbon and chlorine

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**HYDROCARBONS** are compounds composed of only the elements carbon and hydrogen.

The following are common hydrocarbons and their formulas:

Butane	C <sub>4</sub> H <sub>10</sub>	portable stoves, heaters
Methane	CH <sub>4</sub>	cooking gas
Octane	C <sub>8</sub> H <sub>18</sub>	occurs in petroleum
Propane	C <sub>3</sub> H <sub>8</sub>	bottled gas

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**MIXTURE:** two or more elements or compounds that are mixed together, but can be easily separated, like iron filings and sand, or tossed salad.

**SUSPENSION:** a mixture of two or more substances that do not dissolve, but can often be separated by settling or filtering.

**SOLUTION:** a mixture of particles where one or more of the substances is dissolved in the other.

**SOLVENT:** the substance that dissolves the other substances in a solution.

**SOLUTE:** the substance that is dissolved by the solvent in a solution.

**EXAMPLE:** Salt water is a solution. Water is the solvent and the salt is the solute.

**SATURATED SOLUTION:** A solution that is filled with solute and no more can dissolve at that pressure or temperature.

EVAPORATION: the process by which fast moving molecules escape from a liquid and change into a gas.

CONDENSATION: process by which a gas changes into a liquid.

SUBLIMATION: process by which a gas is changed directly to a solid.

EMULSION: a suspension of two liquids.

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Acid: a chemical substance that releases hydrogen ions in water, or that reacts with metals to release hydrogen.

Base: a chemical substance that releases hydrogen and oxygen to form a hydroxide in water.

Properties of Acids:

1. Tastes sour
2. Conducts electricity
3. Neutralizes bases
4. Turns litmus red

Properties of Bases

1. Tastes bitter
2. Conducts electricity
3. Neutralizes acids
4. Feels slippery
5. feels slippery

Uses of Acids:

1. Cleaning products
2. In batteries
3. Etching
4. Found in citrus fruits
5. React with metals to release Hydrogen

Uses of Bases:

1. Soap
2. Milk of magnesia
3. Glass
4. Ammonia solutions
5. Do not react with metal

Examples of Common Acids:

1. Citrus fruits
2. Vinegar
3. Carbonated water
4. Stomach Acid

Examples of Common Bases

1. Antacids for stomachs
2. Baking soda
3. Soaps

Indicators that can identify acids and bases by creating color changes are tea, red cabbage, litmus, bromthymol blue, and methyl orange.

INDICATOR

1. litmus
2. bromthymol blue
3. methyl orange

COLOR IN ACID

- turns blue to red  
yellow  
red

COLOR IN BASE

- turns red to blue  
blue  
yellow

pH scale: a range of numbers from 0 – 14 that indicate the amount of acidic or basic characteristic of a solution.

Numbers 0 – 6: ACIDS with 6 being the weakest acid and the smaller numbers being the stronger acid.

Number 7: NEUTRALS solutions are neither acids or bases. PURE water is a neutral.

Number 8 – 14: BASES with 14 being the strongest base.

When an acid and a base are combined, they neutralize each other, forming a salt and water.

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THE PERIODIC TABLE: a list of the elements designed by Dmitri Mendeleev during the 1860's and 1870's, which lists the elements according to their atomic masses.

Each row is called a PERIOD. Each column is called a GROUP.

Metals are listed on the left side of the table and non-metals are listed on the right side. There are many more metals than non-metals.

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## CHEMICAL BONDING

Atoms are held together to form molecules by chemical bonding. There are two main types of chemical bonding: ionic and covalent.

IONIC BONDING: You should recall that an ion is formed when an atom loses or gains an electron. If a chlorine atom comes close to a sodium atom, and one of the electrons from the sodium atom is pulled into the outer shell of the chlorine atom, two different ions are formed. The sodium atom is now an ion because it has lost an electron and is now positively charged. The chlorine atom is now an ion because it has gained an electron and is now negatively charged. Negative and positive atoms attract. The two ions would bond together, forming an ionic bond, and would become a molecule of table salt, or sodium chloride.

In ionic bonding, usually a METAL and a NON-METAL join to make the bond and the METAL (like sodium) GIVES UP AN ELECTRON to the NON-METAL (like chlorine).

**CHARACTERISTICS OF IONIC COMPOUNDS:** Once the two ions are bonded together, they form a compound. All ionic compounds are alike in some basic ways:

1. The ions are arranged in an orderly way to form a crystal.
2. They ionic bonds are very strong and extend throughout the entire crystal.
3. Most are hard solids at room temperature.
4. They have high melting points.
5. In their solid form, they do not conduct electricity, but do conduct electricity well when dissolved in water.

**COVALENT BONDING:** Covalent bonding occurs when two atoms **SHARE** an electron, which is attracted by both nuclei, thus causing a force that holds the atoms together. Water is an example of a **COVALENT COMPOUND**, formed from the 2 hydrogen atoms sharing an electron with the oxygen atom. It is like two sisters sharing the same room. **COVALENT BONDING USUALLY OCCURS BETWEEN TWO NON-METALS.**

**CHARACTERISTICS OF COVALENT COMPOUNDS:**

1. Most do not conduct electricity.
2. The strength of the bonding varies. Some, like the diamond, are very hard and have a crystal type structure. Others, like sugar, are soft and melt at low temperatures.