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Chemistry review

Chemistry is a science of matter dealing with composition, structure, properties, and transformations of matter as we commonly know it, that is, the substance of physical objects that we can sense directly around us such as liquids, solids, and gases. One way to define matter is, "anything that occupies space and has mass." Matter as we know it is composed of particles called atoms which cannot be easily created or destroyed and it is the relations of different kinds of atoms that are the main area of chemistry.

In contrast to chemistry, physics is a more fundamental science of matter dealing with the nature of matter, and force, motion, and energy, and all kinds of matter not just atoms but particles smaller than atoms, and kinds of matter that do not form objects or substances as we commonly know them.

Thus while chemistry and physics both deal with aspects of matter and energy, chemistry deals more with the external relationships of and between material substances, while physics deals more with what's under the dashboard.

Atoms, elements, molecules, and compounds

The atom is a particle that is the basic unit of substances, and it is the smallest unit into which a substance can be subdivided. An atom is a generally stable particle which consists of a positively charged dense central nucleus containing at least one proton and sometimes one or more neurons, around which is a negatively charged cloud of electrons. The element is a type of element, determined by the number of protons in the nucleus of the atom, which vary from one for the smallest type of atom, hydrogen, to 92 for the largest and heaviest naturally occurring element, uranium. The atomic number of hydrogen is 1 and that of uranium is 92.

Even though the number of protons is the same for all atoms of an element, the number of neutrons can vary within certain numbers. For example, hydrogen naturally has either zero or one neutron. The simple hydrogen called has only one proton in the nucleus and has the atomic weight of approximately 1. Since the neutron weighs about the same as a proton, the type of hydrogen with one proton and one neutron has an atomic weight of 2. These two forms are called "isotopes" hydrogen-1 and hydrogen-2 and they are commonly designated with a superscript, ^{1}H and ^{2}H. Two common isotopes of uranium include uranium-238 or ^{238}U and uranium-235 or ^{235}U from atomic bombs are made.

A molecule is a particle that is formed from atoms of two different elements, for example, hydrogen oxide or H_2O is water. Molecules can also be homonuclear diatomic molecules such as the normal occurring forms of hydrogen, oxygen, and nitrogen, H_2, O_2, and N_2 and all the halogens, e.g., Cl_2. Ozone, O_3, is a homonuclear triatomic form, and large homonuclear molecules exist for sulfur, e.g., and S_8, and carbon, C_{60}, also known as buckminsterfullerene.

A compound is a material formed of molecules. Generally ionic substances, e.g., sodium chloride, NaCl, do not exist in a true molecular state but exist as a positively charged cation for sodium, Na^+ and a negatively charged anion for chlorine, or Cl^-. This is ionic bonding involving the exchange of one or more electrons from an electropositive element such as sodium to an electronegative element such as chlorine.

Chemical changes involve change of substance through the interaction of reactants which may be atoms and molecules and the production of products which may be atoms and molecules, and the release (exothermic) or absorption (endothermic) of energy. Even an exothermic reaction may require activation energy, that is, the energy "to push the rock down the hill."

The periodic table of the elements

The periodic table lists the elements in columns or groups from the most electropositive in group 1 on the left to the most electronegative group 17 on the right. In addition, the rightmost column includes group 18, the noble gases such as Helium, He, Neon, Ne, etc., which are relatively inert and undergo few chemical transformations.

Valence

The electrons in the outer energy level can be lost or gained and the valence number is the number lost or gained. For example, Fe^{++} indicates and iron atom that has lost two electrons, and Fe^{+++} has lost three electrons.

Ions

Common monoatomic ions include Fe^{++} or Fe^{2+} (ferrous) and Fe^{3+} (ferric), and other positively charged cations H^+ (hydrogen), chloride (Cl^-). Polyatomic ions include NO_3^- and SO_4^{2-} and CO_3^{2-} which is not organic even though it has a C (carbon) atom.

Acids, bases, and salts

An acid is a compound that when dissolved in water gives hydrogen H^+ activity greater than water and a base is a compound that when dissolved gives hydroxide OH^- activity greater than water, or pH 7.0, a measure of the inverse log-base 10 of the concentration of hydrogen ions. Acids and bases neutralize one another to produce salts, which are ionic compounds containing positive and negative ions other than hydrogen and hydroxide.

Oxidation and reduction

Oxidation and reduction are bookkeeping systems to keep track of the oxidative state of an element. When iron goes from an oxidative state of Fe^{2+} (ferrous) to Fe^{+++} (ferric), it is reduced, and when it goes the other direction it is oxidized.

Hydrolysis

Hydrolysis is a chemical reaction in which water molecules are split into hydrogen and hydroxide. A common example of hydrolysis can occur when a pesticide is decomposed under conditions of high or low pH.

The covalent bond

Molecules can have strong bonds between the atoms in the form of covalent bonds, which involve an exchange of electrons. Many strong compounds involve carbon or C as the basic chain, usually with hydrogen (H), the hydrocarbons, and oxygen (O) including sugars and

other carbohydrates, and often nitrogen (N), e.g., the amino acids.

Organic molecules

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Hydrocarbon derivatives

Alcohols, aldehydes, carboxylic acids, ketones, ethers, amines, and amino acids are more complex. Sugars have a ring.

Aromatic hydrocarbons

The benzene ring is very stable and consists of a single 6-carbon ring and six hydrogen atoms, formula C_6H_6 and a double ring is naphthalene, and the triple ring is anthracene. These are the building blocks of many pesticides. When these rings are added onto with functional groups, they are numbered clockwise from the top, so the number 1 position is in the "12:00" position, the number 2 position is in the "2:00 position, and the number 3 position is in "4:00" position.

Functional groups

The covalent bond (sharing of electrons) makes organic molecules relatively strong. There are single, double, and triple bonds that can occur between two carbon atoms. Rings such as the benzene ring (represented by the phenyl functional group) tend to be very stable. An herbicide has a basic structure with variable functional groups. The atoms of an herbicide molecule are primarily H, C, O, and N.

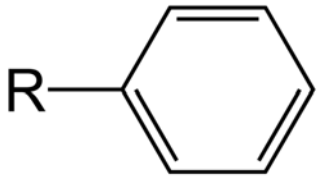
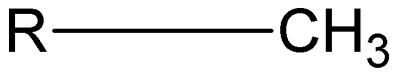
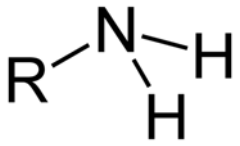
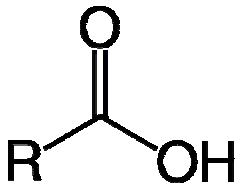
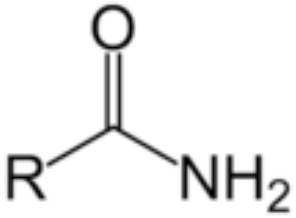
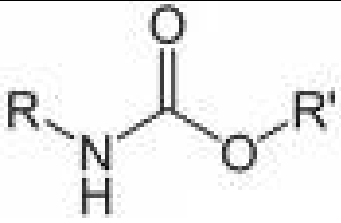
Isomers and stereoisomers

An isomer is a variation of a chemical molecule with the same formula and different arrangement. A stereoisomer is a variation with the same arrangement but different chirality or handedness so that one form looks like the other in the mirror. The two forms of a chiral molecule are called enantiomers.

Chemical characteristics

Common chemical characteristics are color, solubility, pH, odor, boiling point, corrosivity, carcinogenicity, LD_{50}, specific gravity, miscibility, reactivity, and physical state.

Functional groups, their base molecules, and structure

Base molecule	Functional group	Illustration
benzene	**phenyl**	
methane	**methyl**	
primary amine, e.g., ammonia	**amino**	
carboxylic acids, e.g. formic acid or methanoic acid	**carboxyl**	
formamide	**amide**	
carbamic acid	**carbamate**	

Brief history of chemistry

German chemists who were later joined by other nations advanced organic chemistry from the early 1800s and the early products included explosives, chemical warfare, fertilizers, dyes, plastics, and ultimately in 1943, pesticides in the form of the herbicide 2,4-D. (Other chemicals were used previously, such as copper salts for selective weed control in cereals in the late 1800s.) The age of "better living through chemistry" (a motto of Dupont) eventually shifted to a more responsible approach after the publication of Rachel Carson's Silent Sprint in 1962, showing the concerns about the effects on birds of the insecticide DDT, and the birth of the Environmental Protection Agency under the Nixon administration in 1970.

In 2008, herbicides are enormously important in commercial weed control, however some of the downsides, besides environmental concerns, are the large carbon footprint of petrochemical pesticides and the development of herbicide-resistant weed populations.

The basic concepts and terminology of herbicides include absorption (into the plant), translocation (through the plant), and metabolism (in the plant). Herbicides may be selective or nonselective, systemic and translocated or non-systemic and contact, soil-applied or foliage-applied, preemergence (kills seedlings after they germinate and before they emerge from the soil) or postemergence. There are also fumigants, gaseous herbicides or pesticides that usually allow nothing to survive. Herbicides are classified in 40 to 50 families.