
Professional Certificate in Artificial Intelligence for Process Safety Analysis in Chemical Engineering

Fundamentals of Chemical Engineering

A

Activation Energy:

The minimum amount of energy required for a chemical reaction to occur. It is the energy barrier that must be overcome for the reaction to proceed. Higher activation energy means the reaction is slower. Activation energy is denoted by E_a .

Amine:

A type of organic compound derived from ammonia by replacing one or more hydrogen atoms with alkyl or aryl groups. Amines are commonly used in chemical processes as catalysts or reactants.

Ammonia:

A colorless gas with a pungent odor, composed of one nitrogen atom and three hydrogen atoms. Ammonia is widely used in the chemical industry as a fertilizer, refrigerant, and in the production of various chemicals.

Atom:

The basic unit of matter that consists of a nucleus containing protons and neutrons, surrounded by electrons. Atoms are the building blocks of all chemical substances.

Atomic Number:

The number of protons in the nucleus of an atom, which determines the element's identity. It is denoted by the symbol Z .

Avogadro's Number:

The number of particles (atoms, molecules, ions) in one mole of a substance, approximately equal to 6.022×10^{23} . Avogadro's number is a fundamental constant in chemistry.

B

Binary Mixture:

A mixture composed of two different chemical substances. Binary mixtures are common in chemical engineering processes and can exhibit unique properties based on the components and their interactions.

Boiling Point:

The temperature at which a substance changes from liquid to vapor at a given pressure. The boiling point is a characteristic property of a substance and can be used to identify and separate different compounds.

Buffer Solution:

A solution that resists changes in pH when an acid or base is added to it. Buffer solutions are essential in chemical processes to maintain a stable pH environment.

C

Catalyst:

A substance that increases the rate of a chemical reaction without being consumed in the process. Catalysts lower the activation energy required for the reaction to occur.

Chemical Equilibrium:

A state in a chemical reaction where the rates of the forward and reverse reactions are equal, resulting in no net change in the concentrations of reactants and products. Chemical equilibrium is a dynamic process.

Chemical Kinetics:

The study of reaction rates and mechanisms, including factors that influence the speed of a chemical reaction. Chemical kinetics helps in understanding the dynamics of chemical processes.

Chemical Reactor:

A device or vessel where chemical reactions take place. Chemical reactors are designed to optimize reaction conditions such as temperature, pressure, and residence time.

Concentration:

The amount of a substance present in a unit volume of a solution. Concentration can be expressed in various units such as molarity, molality, and weight percent.

Critical Point:

The temperature and pressure at which a substance exists as a supercritical fluid, exhibiting properties of both liquids and gases. The critical point is a unique state of matter.

D

Distillation:

A separation process that utilizes the differences in boiling points of components in a mixture to separate them. Distillation is a common technique in chemical engineering for purifying liquids.

Double Bond:

A covalent bond formed by sharing two pairs of electrons between two atoms. Double bonds are found in many organic compounds and influence their reactivity and physical properties.

E

Electrolyte:

A substance that dissociates into ions when dissolved in a solvent, thus allowing the solution to conduct electricity. Electrolytes are essential in many chemical processes, such as batteries and electrolysis.

Element:

A pure substance composed of only one type of atom. Elements are the simplest form of matter and are listed in the periodic table according to their atomic number.

Enthalpy:

A measure of the heat content of a system at constant pressure. Enthalpy is denoted by the symbol H and is often used in thermodynamic calculations.

Entropy:

A measure of the disorder or randomness in a system. Entropy is denoted by the symbol S and is a key concept in thermodynamics related to the second law of thermodynamics.

Equilibrium Constant:

A numerical value that describes the ratio of concentrations of products to reactants at chemical equilibrium. The equilibrium constant is denoted by K and varies with temperature.

F**Fugacity:**

A measure of the escaping tendency of a component in a mixture or solution. Fugacity accounts for non-ideal behavior and is used in thermodynamics to calculate equilibrium conditions.

G**Gibbs Free Energy:**

A thermodynamic potential that measures the maximum reversible work that can be performed by a system at constant temperature and pressure. Gibbs free energy is denoted by the symbol G and is used to predict the spontaneity of a reaction.

H**Heat Capacity:**

The amount of heat energy required to raise the temperature of a substance by one degree Celsius. Heat capacity is an extensive property that depends on the mass of the substance.

Hydrogen Bond:

A type of strong intermolecular force that occurs between a hydrogen atom bonded to an electronegative atom (such as oxygen or nitrogen) and another electronegative atom. Hydrogen bonds play a crucial role in determining the properties of many substances.

I**Inhibitor:**

A substance that slows down or prevents a chemical reaction. Inhibitors are used in chemical processes to control reaction rates and minimize unwanted side reactions.

Ion:

An atom or molecule that has a net electrical charge due to the loss or gain of electrons. Ions play a key role in many chemical processes, such as electrolysis and ionic bonding.

Isomer:

Two or more compounds that have the same molecular formula but different arrangements of atoms. Isomers exhibit different chemical and physical properties.

J

K

Kinetic Energy:

The energy possessed by an object due to its motion. Kinetic energy is related to the speed and mass of the object and is a fundamental concept in thermodynamics.

L

Lewis Structure:

A diagram that represents the bonding between atoms in a molecule using lines to indicate shared electrons. Lewis structures are essential for understanding the structure and properties of chemical compounds.

M

Molar Mass:

The mass of one mole of a substance, expressed in grams per mole. Molar mass is calculated by summing the atomic masses of all atoms in a molecule.

Mole:

A unit of measurement used in chemistry to express the amount of a substance. One mole is equal to Avogadro's number of particles.

N

Nernst Equation:

An equation that relates the equilibrium constant of a reaction to the standard electrode potential of the reaction. The Nernst equation is used in electrochemistry to calculate cell potentials under non-standard conditions.

O

Oxidation:

A chemical reaction in which a substance loses electrons, resulting in an increase in oxidation state. Oxidation reactions are vital in many chemical processes, such as combustion and corrosion.

P

pH:

A measure of the acidity or basicity of a solution, determined by the concentration of hydrogen ions. pH is a logarithmic scale ranging from 0 to 14, with 7 being neutral.

Periodic Table:

A tabular arrangement of elements based on their atomic number and chemical properties. The periodic table is a fundamental tool in chemistry for predicting the behavior of elements.

Phase Diagram:

A graphical representation of the equilibrium conditions between different phases of a substance (solid, liquid, gas) at various temperatures and pressures. Phase diagrams are used to understand phase transitions.

Q**Quantum Mechanics:**

The branch of physics that describes the behavior of particles at the atomic and subatomic levels. Quantum mechanics is essential in understanding the electronic structure of atoms and molecules.

R**Rate Constant:**

A proportionality constant that relates the rate of a chemical reaction to the concentrations of reactants. Rate constants are determined experimentally and depend on temperature.

Reaction Rate:

The speed at which a chemical reaction takes place, usually expressed in terms of the change in concentration of reactants or products over time. Reaction rates depend on factors such as temperature and catalysts.

S**Saturated Solution:**

A solution that contains the maximum amount of solute that can dissolve at a given temperature. Saturated solutions are in equilibrium with undissolved solute at the bottom of the container.

Stoichiometry:

The quantitative relationship between reactants and products in a chemical reaction. Stoichiometry involves balancing chemical equations and determining the amounts of substances involved.

T**Thermodynamics:**

The branch of science that deals with the study of energy and its transformations in chemical and physical systems. Thermodynamics governs the behavior of matter and energy.

U**Unsaturated Solution:**

A solution that contains less solute than the maximum amount that can dissolve at a given temperature.

Unsaturated solutions have the capacity to dissolve more solute.

V

Valence Electrons:

The electrons in the outermost energy level of an atom that are involved in bonding with other atoms.

Valence electrons determine the chemical properties of an element.

Viscosity:

A measure of a fluid's resistance to flow. Viscosity is influenced by factors such as temperature and molecular structure and is essential in designing fluid systems.

W

Work:

The transfer of energy due to a force acting over a distance. Work can be done on or by a system and is a key concept in thermodynamics related to energy transformations.

X

Xenon:

A noble gas element with the symbol Xe and atomic number 54. Xenon is used in various applications, such as lighting, anesthesia, and as a propellant in ion thrusters.

Y

Yield:

The amount of product obtained in a chemical reaction compared to the theoretical maximum amount that could be obtained. Yield is expressed as a percentage and indicates the efficiency of the reaction.

Z

Zinc:

A metallic element with the symbol Zn and atomic number 30. Zinc is commonly used in alloys, batteries, and as a coating to prevent corrosion in steel.