Glossary of Chemical Process Terms

- **Absorption**
  - **A process in which a gas mixture contacts a liquid solvent and component (or several components) of the gas dissolves in the liquid. In an *absorption column* or *absorption tower* (or simply absorber), the solvent enters the top of a column, flows down, and emerges at the bottom, and the gas enters at the bottom flows up (contacting the liquid), and leaves at the top. (1)**
  - **The physical or chemical process by which a substance in one state becomes incorporated into and retained by another substance of a different state. Absorption differs from adsorption in that the first substance permeates the entire bulk of the second substance, rather than just adhering to the surface. The process by which matter (typically electrons bound in atoms) takes up the energy of electromagnetic radiation and transforms it into any of various types of internal energy, such as thermal energy. This type of absorption is the principle on which spectrophotometry is based. (2)**
- **A diabatic**
  - **A term applied to a process in which no heat is transferred between the process system and its surroundings. (1)**
  - **An adiabatic process is a type of thermodynamic process which occurs without transferring heat or mass between the system and its surroundings. Unlike an isothermal process, an adiabatic process transfers energy to the surroundings only as work. It also conceptually supports the theory used to explain the first law of thermodynamics and is therefore a key thermodynamic concept. (2)**
- **Adsorption**
  - **A process in which a gas or liquid mixture contacts a solid (the adsorbent) and mixture component (the adsorbate) adheres to the surface of the solid. (1)**
  - **Is the adhesion of atoms, ions or molecules from a gas, liquid or dissolved solid to a surface. This process creates a film of the adsorbate on the surface of the adsorbent. This process differs from absorption, in which a fluid (the adsorbate) is dissolved by or permeates a liquid or solid (the absorbent), respectively. Adsorption is a surface phenomenon, while absorption involves the whole volume of the material, although adsorption does often precede absorption. The term sorption encompasses both processes, while desorption is the reverse of it. (2)**
- **Barometer**
  - **A device that measures atmospheric pressure. (1)**
  - **Is a scientific instrument that is used to measure air pressure in a certain environment? Pressure tendency can forecast short-term changes in the weather. Many measurements of air pressure are used within surface weather analysis to help find surface troughs, pressure systems and frontal boundaries. (2)**

- **Boiler**
    - **A process unit in which tubes pass through a combustion furnace. *Boiler feedwater* is fed into the tubes, and heat transferred from the hot combustion products through the tube walls converts the feedwater to steam.** [1]
    - **Is a closed vessel in which fluid (generally water) is heated. -The fluid does not necessarily boil. The heated or vaporized fluid exits the boiler for use in various processes or heating applications, including water heating, central heating, boiler-based power generation, cooking, and sanitation.** [2]
- **Boiling Point**
    - **(at a giving pressure) For a pure species, the temperature at which the liquid and vapor can coexist in equilibrium at the given pressure. When applied to the heating of a mixture of liquids exposed to a gas at the given pressure, the temperature at which the mixture begins to boil.** [1]
    - **The boiling point of a substance is the temperature at which the vapor pressure of a liquid equals the pressure surrounding the liquid and the liquid changes into a vapor. The boiling point of a liquid varies depending upon the surrounding environmental pressure. A liquid in a partial vacuum has a lower boiling point than when that liquid is at atmospheric pressure. A liquid at high pressure has a higher boiling point than when that liquid is at atmospheric pressure. For example, water boils at 100 °C (212 °F) at sea level, but at 93.4 °C (200.1 °F) at 1,905 meter (6,250 ft) [altitude. For a given pressure, different liquids will boil at different temperatures.** [2]
- **Bubble point**
    - **(of a mixture of liquids at a given pressure) The temperature at which the first vapor bubble appears when the mixture is heated.** [1]
    - **In thermodynamics, the** bubble point **is the temperature (at a given pressure) where the first bubble of vapor is formed when heating a liquid consisting of two or more components. Given that vapor will probably have a different composition than the liquid, the bubble point (along with the dew point) at different compositions are useful data when designing distillation systems. For a single component, the bubble point and the dew point are the same and are referred to as the boiling point.** [2]
- **Calibration**
    - **(of a process variable measurement instrument) A procedure in which an instrument is used to measure several independently know process variable values, and a *calibration curve* of know variable values versus the corresponding instrument readings is plotted. Once the instrument has been calibrated, readings obtained with it can be converted to equivalent process variable values directly from the calibration curve.** [1]
    - **In measurement technology and metrology, calibration is the comparison of measurement values delivered by a device under test with those of a calibration standard of known accuracy. Such a standard could be another measurement device of known accuracy, a device generating the quantity to be measured such as a voltage, a sound tone, or a physical artifact, such as a meter ruler. Strictly speaking, the term "calibration" means just the act of comparison and does not include any subsequent adjustment. The calibration standard is normally traceable to a national /international standard held by a national metrology body.** [2]

- **Catalyst**
  - **A substance that significantly increases the rate of chemical reaction, although it is neither a reactant nor a product.** [(1)]
  - **Catalysts are not consumed in the catalyzed reaction but can act repeatedly. Often only very small amounts of catalyst are required. The global demand for catalysts in 2010 was estimated at approximately US$29.5 billion.** [(2)]
- **Compressibility factor**
  - **z = PV/nRT for a gas. z = 1, then PV = nRT (the ideal gas equation of state) and the gas is said to behave ideally.** [(1)]
  - **Compressibility factor (Z), also known as the compression factor or the gas deviation factor, is a correction factor which describes the deviation of a real gas from ideal gas behavior. It is simply defined as the ratio of the molar volume of a gas to the molar volume of an ideal gas at the same temperature and pressure.** [(2)]
- **Compressor**
  - **A device that raises the pressure of a gas.** [(1)]
  - **A compressor is a mechanical device that increases the pressure of a gas by reducing its volume. An air compressor is a specific type of gas compressor. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible, while some can be compressed, the main action of a pump is to pressurize and transport liquids.** [(2)]
- **Condensation**
  - **A process in which an entering gas is cooled and/or compressed, causing one or more of the gas components to liquefy. Uncondensed gases and liquid condensate leave the condenser as separate streams.** [(1)]
  - **Is the change of the physical state of matter from the gas phase into the liquid phase, and is the reverse of vaporization. The word most often refers to the water cycle. It can also be defined as the change in the state of water vapor to liquid water when in contact with a liquid or solid surface or cloud condensation nuclei within the atmosphere. When the transition happens from the gaseous phase into the solid phase directly, the change is called deposition.** [(2)]
- **Critical Temperature T_c/Pressure P_c**
  - **The highest Temperature/pressure at which distinct vapor and liquid phases can coexist for a species.** [(1)]
  - **In thermodynamics, a critical point (or critical state) is the end point of a phase equilibrium curve. The most prominent example is the liquid–vapor critical point, the end point of the pressure–temperature curve that designates conditions under which a liquid and its vapor can coexist. At higher temperatures, the gas cannot be liquefied by pressure alone. At the critical point, defined by a critical temperature T_C and a critical pressure P_C, phase boundaries vanish. Other examples include the liquid–liquid critical points in mixtures.** [(2)]

- **Crystallization**
  - **A process in which liquid solution is cooled or solvent is evaporated to an extent that solid crystals of solute from the crystals in the *slurry* (suspension of solids in a liquid) leaving the crystallizer may subsequently be separated from the liquid in a filter or centrifuge.** (1)
  - **Is the process by which a solid forms, where the atoms or molecules are highly organized into a structure known as a crystal. Some of the ways by which crystals form are precipitating from a solution, freezing, or more rarely deposition directly from a gas. Attributes of the resulting crystal depend largely on factors such as temperature, air pressure, and in the case of liquid crystals, time of fluid evaporation.** (2)
- **Decanter**
  - **A device in which two liquid phases or liquid and solid phase separate by gravity.** (1)
  - **Is a vessel that is used to hold the decantation of a liquid (such as wine) which may contain sediment. Decanters, which have a varied shape and design, have been traditionally made from glass or crystal. A carafe, which is also traditionally used for serving alcoholic beverages, is similar in design to a decanter but is not supplied with a stopper.** (2)
- **Degrees of freedom**
  - **When applied to a general process, the difference between the number of unknown process variables and the number of equations relating those variables; the number of unknown variables for which values must be specified before the remaining values can be calculated. When applied to a system at equilibrium, the number of intensive system variables for which values must be specified before the remaining values can be calculated. The degrees of freedom in the second sense is determined using the Gibbs Phase Rule.** (1)
  - **In many scientific fields, the degrees of freedom of a system is the number of parameters of the system that may vary independently. For example, a point in the plane has two degrees of freedom for translation: its two coordinates; a non-infinitesimal object on the plane might have additional degrees of freedoms related to its orientation.** (2)
- **Dew Point**
  - **(of gas mixture) The temperature at which the first liquid droplet appears when the mixture is cooled at constant pressure.** (1)
  - **Is the temperature to which air must be cooled to become saturated with water vapor. When cooled further, the airborne water vapor will condense to form liquid water (dew). When air-cools to its dew point through contact with a surface that is colder than the air, water will condense on the surface. When the temperature is below the freezing point of water, the dew point is called the frost point, as frost is formed via deposition rather than condensation to form dew. The measurement of the dew point is related to humidity. A higher dew point means there is more moisture in the air.** (2)
- **Distillation**
  - **A process in which a mixture of two or more species is fed to a vertical column that contains either a series of vertically spaced horizontal plates or solid packing through which fluid can flow. Liquid mixtures of the feed components flow down the column and vapor mixtures flow up. Interphase contact, partial condensation of the vapor, and partial vaporization of the liquid all take place throughout the column. The vapor flowing up the column becomes progressively richer in the more volatile components**

of the feed, and the liquid flowing down becomes richer in the less volatile components. The vapor leaving the top of the column is condensed: part of the condensate is taken off as the *overhead product* and the rest is recycled to the reactor as *reflux*, becoming the liquid stream that flows down the column. The liquid leaving the bottom of the column is partially vaporized: the vapor is recycled to the reactor as *boilup*, becoming the vapor stream that flows up the column, and the residual liquid is taken off as the *bottoms product*. (1)

  - **Distillation, or classical distillation, is the process of separating the components or substances from a liquid mixture by using selective boiling and condensation. Dry distillation is the heating of solid materials to produce gaseous products (which may condense into liquids or solids). Dry distillation may involve chemical changes such as destructive distillation or cracking. Distillation may result in essentially complete separation (nearly pure components), or it may be a partial separation that increases the concentration of selected components in the mixture. In either case, the process exploits differences in the relative volatility of the mixture's components. In industrial applications, distillation is a unit operation of practically universal importance, but it is a physical separation process, not a chemical reaction. (2)**

- **Drying**
  - **A process in which a wet solid is heated or contacted with a hot gas stream. Causing some or all of the liquid wetting the solid o evaporate. The vapor and the gas it evaporates into emerge as one outlet stream, and the solid and remaining residual liquid emerge as a second outlet stream. (1)**
  - **Is a mass transfer process consisting of the removal of water or another solvent by evaporation from a solid, semi-solid or liquid. This process is often used as a final production step before selling or packaging products. To be considered "dried", the final product must be solid, in the form of a continuous sheet (e.g., paper), long pieces (e.g., wood), particles (e.g., cereal grains or corn flakes) or powder (e.g., sand, salt, washing powder, milk powder). A source of heat and an agent to remove the vapor produced by the process are often involved. In bio-products like food, grains, and pharmaceuticals like vaccines, the solvent to be removed is almost invariably water. Desiccation may be synonymous with drying or considered an extreme form of drying. (2)**
- **Enthalpy (KJ)**
  - **Property of a system defined as $H = U + PV$, where U = internal energy, P = absolute pressure, and V = volume of the system. (1)**
  - **Is a property of a thermodynamic system, defined as the sum of the system's internal energy and the product of its pressure and volume. It is a convenient state function standardly used in many measurements in chemical, biological, and physical systems at a constant pressure. The pressure-volume term expresses the work required to establish the system's physical dimensions, i.e. to make room for it by displacing its surroundings. As a state function, enthalpy depends only on the final configuration of internal energy, pressure, and volume, not on the path taken to achieve it. (2)**
- **Evaporation**
  - **(vaporization) A process in which a pure liquid, liquid mixture, or solvent in a solution is vaporized. (1)**
  - **Is a type of vaporization that occurs on the surface of a liquid as it changes into the gas phase. The surrounding gas must not be saturated with the evaporating substance. When the molecules of the liquid collide, they transfer energy to each other based on**

how they collide with each other. When a molecule near the surface absorbs enough energy to overcome the vapor pressure, it will escape and enter the surrounding air as a gas. When evaporation occurs, the energy removed from the vaporized liquid will reduce the temperature of the liquid, resulting in evaporative cooling. [2]

- **Extraction**
    - **(liquid extraction) A process in which a liquid mixture of two species (the *solute* and the *feed carrier*) is contacted in a mixer with a third liquid (the *solvent*) this is immiscible or nearly immiscible with the feed carrier. When the liquids are contacted, solute transfers from the feed carrier to the solvent. The combined mixture is then allowed to settle into two phases that are then separated by gravity in a decanter. [1]**
    - **Is a separation process consisting in the separation of a substance from a matrix. Common examples include liquid-liquid extraction, and solid phase extraction. The distribution of a solute between two phases is an equilibrium condition described by partition theory. This is based on exactly how the analytic moves from the initial solvent into the extracting solvent. The term washing may also be used to refer to an extraction in which impurities are extracted from the solvent containing the desired compound. Types of extraction (Liquid–liquid, extraction, Solid-phase extraction, Acid-base extraction, Supercritical fluid extraction, Ultrasound-assisted extraction, Heat reflux extraction, Mechanochemical-assisted extraction, Microwave-assisted extraction…etc).[2]**
- **Filtration**
    - **A process in which a *slurry* of solid particles suspended in a liquid passes through a porous medium. Most of the liquid passes through the medium (e.g., a filter) to form the *filtrate*, and the solids and some entrained liquid are retained on the filter to form the *filter cake*. Filtration may also be used to separate solids or liquids from gases. [1]**
    - **Is a physical, biological or chemical operation that separates solid matter and fluid from a mixture with a filter medium that has a complex structure through which only the fluid can pass. Solid particles that cannot pass through the filter medium are described as oversize and the fluid that passes through is called the filtrate. Oversize particles may form a filter cake on top of the filter and may also block the filter lattice, preventing the fluid phase from crossing the filter, known as blinding. The size of the largest particles that can successfully pass through a filter is called the effective pore size of that filter. The separation of solid and fluid is imperfect; solids will be contaminated with some fluid and filtrate will contain fine particles (depending on the pore size, filter thickness and biological activity). Filtration occurs both in nature and in engineered systems; there are biological, geological, and industrial forms. [2]**
- **Flash vaporization**
    - **A process in which a liquid feed at a high pressure is suddenly exposed to a lower pressure, causing some vaporization to occur. The vapor product is rich in the more volatile components of the feed and the residual liquid is rich in the less volatile components. [1]**
    - **(Or partial evaporation) is the partial vapor that occurs when a saturated liquid stream undergoes a reduction in pressure by passing through a throttling valve or other throttling device. This process is one of the simplest unit operations. If the throttling valve or device is located at the entry into a pressure vessel so that the flash evaporation occurs within the vessel, then the vessel is often referred to as a flash drum. If the saturated liquid is a single-component liquid (for example, propane or**

liquid ammonia), a part of the liquid immediately "flashes" into vapor. Both the vapor and the residual liquid are cooled to the saturation temperature of the liquid at the reduced pressure. This is often referred to as "auto-refrigeration" and is the basis of most conventional vapor compression refrigeration systems. If the saturated liquid is a multi-component liquid (for example, a mixture of propane, isobutene and normal butane), the flashed vapor is richer in the more volatile components than is the remaining liquid. Uncontrolled flash evaporation can result in a boiling liquid expanding vapor explosion (BLEVE). [2]

- **Heat**
  - Energy transferred between a system and its surroundings as a consequence of a temperature difference. Heat always flows from a higher temperature to a lower one.[1]
  - In thermodynamics, heat is energy in transfer to or from a thermodynamic system, by mechanisms other than thermodynamic work or transfer of matter. Like thermodynamic work, heat transfer is a process involving more than one system, not a property of any one system. In thermodynamics, energy transferred as heat contributes to change in the system's cardinal energy variable of state, for example its internal energy, or for example its enthalpy. This is to be distinguished from the ordinary language conception of heat as a property of an isolated system. [2]
- **Heat exchanger**
  - A process unit through which two fluid streams at different temperature flow on opposite sides of a metal barrier. Heat is transferred from the stream at the higher temperature through the barrier to the other stream. [1]
  - Is a system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant. [2]
- **Internal Energy (U)**
  - The total energy possessed by the individual molecules in a system (as opposed to the kinetic and potential energies of the system as a whole). U s strong function of temperature, phase, and molecular structure and a weak function of pressure (it is independent of pressure for ideal gases). Its absolute value cannot be determined. So it is always expressed relative to a reference state at which it is defined to be zero. [1]
  - The internal energy of a thermodynamic system is the energy contained within it. It is the energy necessary to create or prepare the system in any given internal state. It does not include the kinetic energy of motion of the system as a whole, nor the potential energy of the system as a whole due to external force fields, including the energy of displacement of the surroundings of the system. It keeps account of the gains and losses of energy of the system that are due to changes in its internal state. The internal energy is measured as a difference from a reference zero defined by a standard state. The difference is determined by thermodynamic processes that carry the system between the reference state and the current state of interest. [2]

- **Membrane**
    - **A thin solid or liquid film through which one or more species in a process stream can permeate. [1]**
    - **Is a selective barrier; it allows some things to pass through but stops others. Such things may be molecules, ions, or other small particles. Biological membranes include cell membranes (outer coverings of cells or organelles that allow passage of certain constituents); nuclear membranes, which cover a cell nucleus; and tissue membranes, such as mucosae and serosae. Synthetic membranes are made by humans for use in laboratories and industry (such as chemical plants). The degree of selectivity of a membrane depends on the membrane pore size. Depending on the pore size, they can be classified as Microfiltration (MF), Ultrafiltration (UF), Nano filtration (NF) and Reverse osmosis (RO) membranes. Membranes can also be of various thickness, with homogeneous or heterogeneous structure. Membranes can be neutral or charged, and particle transport can be active or passive. The latter can be facilitated by pressure, concentration, chemical or electrical gradients of the membrane process. Membranes can be generally classified into synthetic membranes and biological membranes. [2]**
- **Overhead product**
    - **The product that leaves the top of a distillation column. The overhead product is relatively rich in the most volatile component of the feed to the column. [1]**
    - **Overhead stream that is totally condensed into a liquid product using water or air-cooling. However, in many cases, the tower overhead is not easily condensed totally and the reflux drum must include a vent gas outlet stream. [2]**
- **Pump**
    - **A device used to propel a liquid or slurry from one location to another, usually through a pipe or tube. [1]**
    - **Is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action, typically converted from electrical energy into Hydraulic energy. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. [2]**
- **Scrubber**
    - **An absorption column designed to remove an undesirable component from a gas stream. [1]**
    - **Scrubber systems (e.g. chemical scrubbers, gas scrubbers) are a diverse group of air pollution control devices that can be used to remove some particulates and/or gases from industrial exhaust streams. [2]**
- **Shaft work**
    - **All work transferred between a continuous system and its surroundings other than that done by on the process fluid at the system entrance and exit. [1]**
    - **Is a kind of contact work, because it occurs through direct material contact with the surrounding matter at the boundary of the system. A system that is initially in a state of thermodynamic equilibrium cannot initiate any change in its internal energy. [2]**
- **Stack gas**
    - **The gaseous products exiting from a combustion furnace. [1]**
    - **Is the gas exiting to the atmosphere via a flue, which is a pipe or channel for conveying exhaust gases from a fireplace, oven, furnace, boiler or steam generator. (Flue gas). [2]**
- **Stripping**

- A process in which a liquid containing a dissolved gas flows down a column and a gas (stripping gas) flows up the column at conditions such that the dissolved gas comes out of solution and is carried off with the stripping gas. (1)
- Is a physical separation process where one or more components are removed from a liquid stream by a vapor stream. In industrial applications the liquid and vapor streams can have co-current or countercurrent flows. Stripping is usually carried out in either a packed or trayed column. (2)

- **Vapor pressure**
  - The pressure at which pure liquid A can coexist with its vapor at a given temperature. In this text, vapor pressures can be determined from tabulated data, the Antoine equation, or the Cox chart. (1)
  - Vapor pressure or equilibrium vapor pressure is defined as the pressure exerted by a vapor in thermodynamic equilibrium with its condensed phases (solid or liquid) at a given temperature in a closed system. (2)
- **Volume percent (%v/v)**
  - For liquid mixtures, the percentage of the total volume occupied by a particular component; for ideal gases, the same as mole percent. For nonideal gases, the volume percent has no meaningful physical significance. (1)
  - Volume percent is the concentration of a certain solute, measured by volume, in a solution. It has as a denominator the volume of the mixture itself, as usual for expressions of concentration, rather than the total of all the individual component's volumes prior to mixing. Volume percent is usually used when the solution is made by mixing two fluids, such as liquids or gases. However, percentages are only additive for ideal gases. The percentage by volume (vol%) is one way of expressing the composition of a mixture with a dimensionless quantity; mass fraction (percentage by weight, wt%) and mole fraction (percentage by moles, mol%) are others. In the case of a mixture of ethanol and water, which are miscible in all proportions, the designation of solvent and solute is arbitrary. The volume of such a mixture is slightly less than the sum of the volumes of the components. Thus, by the above definition, the term "40% alcohol by volume" refers to a mixture of 40 volume units of ethanol with enough water to make a final volume of 100 units, rather than a mixture of 40 units of ethanol with 60 units of water. (2)
- **Work**
  - Energy transferred between a system. and its surroundings as consequence of motion against a restraining force, electricity or radiation, or any other driving force except a temperature difference. (1)
  - In thermodynamics, work performed by a system is energy transferred by the system to its surroundings, by a mechanism through which the system can spontaneously exert macroscopic forces on its surroundings. In the surroundings, through suitable passive linkages, the work can lift a weight, for example. Energy can also transfer from the surroundings to the system; in a sign convention used in physics, such work has a negative magnitude. The externally measured forces and external effects may be electromagnetic, gravitational, or pressure/volume or other macroscopically mechanical variables. For thermodynamic work, these externally measured quantities are exactly matched by values of or contributions to changes in macroscopic internal state variables of the system, which always occur in conjugate pairs, for example pressure and volume or magnetic flux density and magnetization. (2)

References:

1- **Elementary Principles of Chemical Processes 3rd Edition, Richard M. Felder and Ronald W. Rousseau.**
2- **https://www.wikipedia.org**