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A Review on Solvents - Dilute, Dissolve and Disperse

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ABSTRACT

Introduction: The discourse herein explores the topic "Solvents- Dilute, Dissolve and Disperse" and details the importance of the techniques used in the manipulations of solvents to achieve specific needs. The phenomenon involved in "Solvents- Dilute, Dissolve and Disperse" is used in the chemical industries, in the atmosphere, in plants and animals' metabolism and in every aspect of life. The use of solutions and techniques such as dilution gives chemists control over the amounts of the substance they handle, to transfer substances from one medium to another particularly when only a little sample is available due to its rarity or cost. The phenomenon is used in ore analysis and in the analysis of contaminated food for traces of poison. It has a wide coverage of application in nature.

Background: Much of life's applications is found in mixtures and solutions. The atmosphere is a gaseous solution of Nitrogen, Oxygen, Carbon dioxide, Water vapour and the trace elements. The basis of the atmosphere lends its application in the creation of environments for deep-sea divers and food storage facilities. The ability of a substance to dissolve in another is studied. Solutions are stored in a concentrated form to save space and the concentrated solutions are diluted to variable concentrations as needs result. A microscopic amount of a substance is measured accurately through the dilution technique. When additional solvent is added to a given volume of solution, the number of moles of the solute occupies a larger volume of solution by the dilution. Literally, solvents are solute carriers.

Method: A literature review is taken from reputable authors to highlight the descriptions of the terms involved in the topic, "Solvents- Dilute, Dissolve and Disperse" and to elucidate the associated meanings and applications of the concept.

Conclusion: Solubility is the ability of a solvent to dissolve a solute. The technique of solubility is widely used in Nature: in Sciences and Arts. There is the need to understand the concept and principle of solubility. This write-up discusses the basis and applications of solubility as guided by the topic "Solvents- Dilute, Dissolve and Disperse".

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Introduction

Solvents

In either a mixture or solution, the component that is present in the larger amount is called the solvent and the dissolved substance(s) is the solute(s). The term dissolving describes the process of producing solution [1,2]. Solutes dissolve in solvents. Dissolution is quickened when the solute is shaken up or stirred in a solvent. The opposite of dissolving is crystallization. Crystallization occurs when the solute comes out of solution as crystals. Crystallization is illustrated in the following: liquid solutions in which the solvent is a liquid and the solute is a solid. Examples are Table salt (NaCl) in grease and liquid in liquid solution such as: Water in oil, etc.

The different types of solutions are

- Liquid solutions in which the solvent is a liquid, such as, aqueous solution like Table salt in Water and nonaqueous solutions like grease or dirt in Tetrachloroethene (C_2Cl_4)
- Solid solutions in which the solvent is a solid, examples include: Steel (an alloy of Iron and Carbon), Brass (a solution of Copper in Zinc), solid solutions of metalloids and nonmetals such as Silicon with tiny amount of Phosphorus as solute
- Gaseous solutions, such as the atmosphere of gaseous solution of Nitrogen as the solvent for Oxygen, Carbon dioxide, Water vapour and the trace elements.

A solvent is the component of a solution or mixture that is present in the largest amount. Solutes dissolve in solvents. A homogeneous mixture of a solvent and solute is called a solution. The amount of solvent required to dissolve a solute depends on temperature and the presence of other substances in a sample.[Solvent Definition in Chemistry (thoughtco.com)] A solvent is a substance that dissolves a solute, to give a mixture. The ability of a substance to dissolve in another substance is called solubility. [Solvent - Wikipedia] The substances in a solution (the solvent and the solutes) interact with one other at the molecular level. When dissolution occurs, molecules of the solvent arrange themselves around molecules of the solute. Heat transfer is involved in dissolution which leads to entropy change. The arrangement of the units such as molecules, atoms, ions, etc., in the solution is guided by the chemical properties of the solvent and solute. Such properties are hydrogen bonding, dipole moment, etc. Solvation is not a chemical reaction. Solubility describes the degree to which a substance dissolves in a solvent to form a solution. It is expressed in moles of solute per litre of solvent. Solubility of fluid in another one may be completely miscible such as Methanol in Water, solubility could be partially miscible such as Water in Diethyl ether or completely immiscible such as oil in Water. Separation methods such as absorption, extraction, etc., use the differences in solubility of solutes in a solvent. Distribution coefficient technique also depends on the differences in the solubility of the solutes in the solvent [1].

Dilute

The use of solutions and techniques like dilution give chemists control over the amounts of substance they are handling. This technique is appreciated more when the substance is in small quantity. The technique of solution preparation is used to transfer substances from one medium to another. [1] The application is used when a little sample is available due to its scarcity, cost or when the sample being examined contains little of the substance of interest. The concept is found in the analysis of an ore for a rare metal or the analysis of a contaminated food for traces of poison. It could be used to isolate a tiny amount of the active substances from contaminants.

When more solvent is added to a given volume of solution, the number of moles of the solute in the solution remains constant. The solute occupies a larger volume of solution by the dilution. The number of moles of the solute in the solution is given by the expression

$$n = M_{final} \text{ x } V_{final} \quad (1)$$

(where M_{final} = the molarity of the final solution and V_{final} = the volume of the final solution, n = the number of moles of the solute) Also,

$$n = M_{initial} \text{ x } V_{initial} \quad (2)$$

(where $M_{initial}$ = the molarity of the initial undiluted solution and $V_{initial}$ = the volume of the initial undiluted solution), n = the number of moles of the solute.

The moles of solute, n, are the same in the two expressions. Equations (1) and (2) are combined to give

$$V_{initial} = (M_{final} \text{ x } V_{final})/M_{initial} \quad (3)$$

Thus,

$$M_{initial} \text{ x } V_{initial} = M_{final} \text{ x } V_{final} \quad (4)$$

The amount of solute in the final volume of the solution is equal to the amount of solute in the initial volume of the solution. The use of solutions and techniques such as dilution gives the measure of control over the amounts of the substances to be handled. A microscopic amount of substance would be difficult to weigh accurately except by the solution dilution technique. Solutions are stored in concentrated forms to save space and are diluted to variable concentrations as the needs demand, in the laboratory [1].

Dissolve

The Molecular Nature of the Substances

Consider the formation of a solution from two substances such as Glucose and Water, at the surface of the crystal of Glucose (solute) in Water (solvent), the glucose molecules are in contact with the water molecules. Hydrogen bonds form between the two different molecules of Glucose and Water. The surface molecules of glucose are pulled into solution by Water molecules while they are held back by other glucose molecules. The surface glucose molecules break away from the crystal and drift into the solvent, surrounded by water molecules.

When an ionic solid dissolves in water, the oxygen atoms in water molecules (H_2O) have negative partial charges while the hydrogen atoms have positive partial charges. The negative partially charged atoms surround the cations from the ionic solid and pull them away from the crystal lattice. The water molecules form hydrogen bonds with the anions of the ionic solid at the crystal surface. The bonding attracts the anions and pulls them away from their cation partners. Stirring or shaking the mixture quickens the process because it brings more free water molecules to the surface of the solid and sweeps the hydrated ions away. Ions in solution which are free of any electric field undergo random movement characterized by chaotic swimming in the solution. In the solvation of ion by water molecules, the orientation of water molecules on the periphery of the ion depends on the charge that is either negative of positive [3]. Solids dissolve in water when individual molecules or ions are attracted to water molecules and are broken away from the solid, to be surrounded by water molecules [1].

A solution is a homogeneous mixture of two or more substances. [Liquid - Solutions, Solubility, Absorption, and Extraction | Britannica] The ability of a substance to dissolve another substance depends on the chemical nature of the substances, on temperature and pressure for gaseous substances. A solution is a homogeneous mixture whose components are uniformly distributed on a microscopic scale. The formation of a solution from a solute and a solvent is a physical process. [Properties of Solutions - Chemistry LibreTexts] A given quantity of solvent can dissolve only a certain amount of solute. A solution is saturated when the solvent has dissolved all the solute it can and still has some undissolved solute. A saturated solution represents the limit of a solute's ability to dissolve in a given quantity of solvent. The dissolved and undissolved solute are in dynamic equilibrium in a saturated solution. [Nature of Dissolved Species - Chemistry LibreTexts] When a solute is introduced into a solvent, the unit components of the solute (i.e., atoms, molecules or ions) interact with that of the solvent and become solvated. [Solubility and Structure - Chemistry LibreTexts]

Factors Affecting Solubility

The solubilities of all substances change with temperature. [Solubility and Structure - Chemistry LibreTexts] The solubility of any substance depends on the nature and identity of the solvent [5]. The solubility of a gas depends on its partial pressure[1]. [Properties of Solutions - Chemistry LibreTexts] The solubility characteristics of substances give the understanding of the behaviour of some common substances of everyday usage and the properties of minerals. Nitrates are found in arid coastal region where groundwater is absent because they are soluble in groundwater which infiltrates the ground. Nitrates ion (NO_3^-) is bulky and has only one negative charge. It is easy for water to detach the ions from the solid nitrates. Phosphate ions are bulkier than nitrates ions and they have three negative charges (PO_4^{3-}).

They are more strongly attracted to cations than the nitrate ions. It is harder for water to break these ions out of the solids (cation). Calcium hydrogen phosphate, ($CaHPO_4$) with $(HPO_4)^{2-}$ anion and two negative charge is more soluble than Calcium phosphate $Ca_3(PO_4)^2$ with the anion $(PO_4)^{3-}$ and three negative charges. Also, hydrogen carbonates with the anion (HCO_3^-) are more soluble than the carbonates with the anion (CO_3^{2-}). The solubility of a substance depends on the nature of the solvent and the solute. A compound such as Sodium chloride, an ionic compound dissolves in water, an ionic compound too. It does not dissolve in Benzene a nonionic compound. Grease, an organic compound dissolves in Benzene, an organic compound but does not dissolve in water, an inorganic compound. Generally, ionic and polar solvent such as water dissolves ionic and polar compounds. Nonpolar solvents such as Benzene dissolves nonpolar compounds such as wax. The attractions between solute molecules and the attraction between solvent molecules must be replaced by solute-solvent attractions, when a solution is formed [1,2]. Soaps and detergents usages are practical applications of solute-solvent dissolutions. Compounds of Group 1 elements, ammonium (NH_4^+) compounds, chlorides (Cl^-), bromides (Br^-) and iodides (I-) except those of Ag^+, Hg_2^{2+} and Pb^{2+} are soluble. Nitrates (NO_3-), acetates (CH_3CO_2-), chlorates (ClO_3-) and perchlorates (ClO_4-) are soluble. Sulfates (SO_4^{2-}) except those of Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, Hg_2^{2+} and Ag^+, are soluble [1].

Pressure and Solubility

The pressure of a gas comes from the impact of its molecules. When a gas comes in contact with liquid, the gas molecules flow into the liquid. The number of molecular impact increases as the pressure of the gas increases and the solubility of the gas increases with the increase in the pressure of the gas. If the gas above the liquid is a mixture such as air that contains Nitrogen, Oxygen, Carbon dioxide, Water vapour, Argon, etc., the solubility of each component depends on its partial pressure. This application is used in the production of soft drinks and champagne, following the pressure dependence of solubility. Carbon dioxide (CO_2) is dissolved in a liquid under pressure. When the bottle is opened, the partial pressure of CO_2 above the solution is reduced and the gas effervesces. The solubility of a gas is directly proportional to its partial pressure, P. From Henry's law

$$S = k_H \times P \qquad (5)$$

(S = Molar solubility, k_H = Henry's constant, P = partial pressure)

The solubility of a gas is proportional to its partial pressure. This is because increase in the pressure of the gas corresponds to the increase in the rate at which the gas molecules strike the surface of the solvent [1].

Temperature and Solubility

Some ionic and molecular solids are more soluble in hot water than in cold water. This application is used in the laboratory to dissolve substances and to grow crystals by allowing a saturated solution to cool slowly. A few solids such as Lithium sulfate are more soluble at low temperatures than at high temperature. A smaller number of compounds give a mixed characteristic under temperature. The solubility of Sodium sulfate increases up to 32°C and decreases as the temperature is raised higher. The variation of solubility with temperature is hard to define except in the case of gases where raising the temperature lowers the solubility most of the time. Many substances dissolve more quickly at higher temperatures and this does not mean that they are more soluble at higher temperatures.

Generally, like dissolves like. In dissolution, solvents pose the surroundings of the solute molecules. Partial charges on polar solvent molecules become ionic charges in the solution, hydrogen bonds form hydrogen bonds in solution and London forces formed in solvent molecules act in place of the solute intermolecular forces. The relative strengths of these forces are measured in the enthalpy of solution [1].

The Enthalpy of Solution

The heat released or absorbed per mole when a substance dissolves at constant pressure to form a dilute solution is called the enthalpy of solution. Some solids dissolves exothermically while others dissolve endothermically. Dissolution could be considered as a two-step process. The first stage involves the breaking up of the solute to produce a gas of molecules or ions to give the lattice enthalpy. The second stage involves the process of the separated gaseous molecules or ions moving into the solvent to give the enthalpy of hydration. Enthalpies of solution in dilute solution could be defined as the sum of the lattice enthalpy and the enthalpy of hydration (solvation) of a compound, for the case where the solvent is water [1].

Solubility and Disorder

A negative value of enthalpy of solution shows that the energy released during hydration is more than the energy needed to break the ions or molecules of the solute apart (lattice enthalpy). The substance is soluble because the ions or molecules have a lower energy in the solution than in the solid. However, not all the substances with a negative enthalpy of solution are soluble. Also, some soluble substances such as Ammonium nitrates dissolve with positive values of enthalpies of solution in water, showing that the ions have a higher energy in solution than in the solid. The question that arises is: how are the inconsistencies in dissolution explained? [1].

Disperse

The tendency of energy and matter to disperse is a fundamental scientific principle. Energy and matter spread out in a disorderly manner giving rise to the change in patterns and unit's (molecules, ions, etc.,) rearrangement. In dissolving a substance to form a solution, the disorderliness of the solution increases when a substance dissolves. The ions or molecules become more disordered in the solution. When the dissolution is exothermic, energy spreads into the surroundings, pushing the surroundings into disorder too. Exothermic dissolution of substances is spontaneous. The disorder increases in both the system and the surroundings when it occurs. When the presence of a solute causes the solvent molecules to take up a more organized arrangement than they had in the pure liquid, it gives the lower disorder of the solution than that in the pure liquid. Although energy is released into the surroundings, the increase in the disorder of the surroundings may not be enough to overcome the decrease in the disorder of the solution. Due to this, the solution of the solute and the solvent does not form. Some hydrocarbons do not dissolve in water though they have weakly negative enthalpies of solution [1].

Effects of a Solute in Contact with a Solvent

Surface tension, σ, is the phenomenon that makes the liquid surface to contract inwards. This behaviour is responsible for the resistance of a liquid to surface penetration and it affects the dissolution of the solute in the solvent. Surface tension is a property that is specific to any liquid. The surface tension of a liquid is the net inward pull of the molecules of the liquid. The surface of a liquid is smooth because intermolecular forces pull the water molecules together to form a smooth surface. Other evidences of surface tension are seen in the droplets of a liquid suspended in air. The shape is spherical because the surface tension pulls the molecules into the most compact shape which is a sphere. The attractive forces between water molecules dropped on a wax material are greater than those between water molecules and the wax material. The wax material is a hydrocarbon. The shape of the water molecules is spherical too, it does not spread [2,5].

Water has strong interactions with paper, wood, cloth, etc., because the molecules in their surfaces form hydrogen bonds which form strong attractions with water molecules. Due to this, water spreads over them, water wets them. The attraction between water and materials such as glass, cloth, towel, etc., accounts for the capillary action which is the rise of liquids up narrow tubes. The liquid rises because there are attractions between its molecules and the tube's inner surface. Adhesion force is the force that binds a substance to a surface. It is responsible for the rise of water up a capillary tube. Cohesion force is the force that binds the molecules of a substance together to form a bulk material.

The addition of a solute in a solvent is described by the following conditions

Case I: The solute dissolves completely in the solvent to form a solution. The dissolution of the solute in the solvent causes the increase in the surface tension although the increase is not large. Examples of these solutes are strong electrolytes, sucrose, aminobenzoic acid, etc., in water.

Case II: The solute dissolves in a solvent to produce a decrease in the surface tension of the solvent. The surface tension decreases with increase in the concentration of the solute. Examples of such solutes are the inorganic salts and organic acids of low molecular mass.

Case III: The solute deposits itself on the air-solvent interface. These substances are called surface active agents. The lower the surface tension of water to a low level even at low concentration. Examples of the solutes are surfactants which includes soaps and detergents.

Solutes that decrease the magnitude of surface tension of host solvents with increase in concentrations show positive surface activity and the solutes which increase the surface tension of host solvents have negative surface activity [2].

Spreading of Solutes on Solvents

Surfaces held on liquids show the following properties

- The liquid remains as droplet which could roll under dynamic equilibrium. The liquid has high value of cohesion force that holds the liquid molecules to the point without wetting the solid surface. In the powder size technology, there is the incorporation of powder particles into a liquid medium such that the particles disperse evenly on the medium. When the solid particles are hydrophobic, the dispersal of the solute molecules in the hydrophilic medium is difficult and vice versa.
- The liquid disperses on the surface. This dispersion is described as wetting.

The wetting of a solid surface by a solvent is enhanced by factors such as:

(a) Roughness of the surface
(b) Nature of the solvent
(c) Contact angle
(d) Interfacial tension etc.

The conditions of wetting of a solute in a solvent is described as follows

Given a column of liquid of 1cm^2 of cross section formed from the mixture of two immiscible solvents or partially immiscible solvents of surfaces, A and B.

The work of cohesion of the liquid B is given by

$$w_c = 2\sigma_B \qquad (6)$$

The work done to separate one of the surfaces from the other one against the acting interfacial tension is given as

$$w_a = \sigma_A + \sigma_B - \sigma_{AB} \qquad (7)$$

(where w_a = the work of adhesion, σ_A = work of cohesion of the molecules of the liquid A, σ_B = work of cohesion of the molecules of the liquid B and σ_{AB} = interfacial tension at the A-B liquids interface) [2].

Intermolecular Forces in Matter

Molecules are drawn together by intermolecular forces (van der Waal forces). The total intermolecular force acting between two molecules is the sum of all the types of the forces they exert on each other [1]. Such forces are

London Forces

London forces exist between all molecules. Electrons revolve around the nucleus in an atom. This movement produces a changing instantaneous dipole moment that creates disparities of charges in the molecules. As a result of the swirling, the electrons pile up at one end of the molecules leaving the nucleus at the other end partially exposed. This condition gives fleeting partial negative charge at one end and fleeting partial positive charge at the other end. The instantaneous partial charges on different molecules attract one another and the molecules stick together to form gases, liquids, solids, mixtures, etc. London forces act between all types of molecules, which could be polar or nonpolar molecules. London force increases in strength with increase in molar mass. Heavier molecules have more electrons and consequent bigger fluctuations in partial charges as the electrons shuttle between the different positions. The strength of molecular interactions increases when heavier atoms are substituted for hydrogen atom [1].

Hydrogen Bonding

Hydrogen bond forms when a hydrogen atom lies between two small but strongly electronegative atoms with lone pairs of electrons. Such electronegative atoms are: Nitrogen, N, Oxygen, O, Fluorine, F, etc. A hydrogen bond is represented as

O – H ---- F The broken line shows the hydrogen bond.

Each O-H bond is polar. The electronegative Oxygen atom (O) exerts a strong pull on the electrons in the bond and causes the proton (the Hydrogen atom, H) to be unshielded. The hydrogen atom has a partial positive charge that makes it to be attracted to one of the lone pairs of electrons on the Oxygen atom of another water molecule. The lone pair and the partial charge attract each other and form a bond. Hydrogen bonding occurs between Oxygen, Nitrogen, Fluorine, etc [1]. Oxygen-hydrogen groups in molecules promote intermolecular hydrogen bonding [4].

The Liquid Structure

The molecules in a liquid are in contact with their neighbours. A liquid is a form of matter that flows, has constant shape and takes the shape of its container. [6] The molecules can move past and tumble over one another, changing places with their neighbours. The strength of the intermolecular forces within the liquid governs the properties of the liquid. Such properties are

- The ability to flow (viscosity)
- The possession of sharply defined surface (surface tension)
- The ability to vapourize and exert vapour pressure
- Dissolution, etc [1].

Solid Structure

The nature of the solid depends on the types of forces that hold the atoms, ions or molecules together in a tightly packed array. The particles of matter in a solid are tightly packed [6]. Solids are classified as crystalline or amorphous. A crystalline solid is a solid in which the atoms, ions or molecules lie in an orderly array while amorphous solid is one in which the atoms, ions or molecules lie in a random disorderly manner [1]. In molecular solids, the molecules are held together by dispersion forces, dipole-dipole forces or hydrogen bonds. With larger molecules, many weak attractions can combine to hold the molecules together [6].

The Presence of a Solute in a Solvent

The physical properties of a solvent are affected by the presence of a solute in it, regardless of the identity of the solute. These properties are

- The lowering of the vapour pressure of the solvent
- The raising of the boiling point of the solvent
- The lowering of the freezing point of the solvent
- The tendency of a solvent to flow through a membrane into a solution

The magnitude of the properties above is dependent on the concentration of the solute involved [1].

Measures of Concentration

Concentration shows the relative numbers of a solute and solvent molecules. [1,5] Concentration is represented in

Mole fraction, x: The mole fraction is the ratio of the number of moles of a species to the total number of moles of all the species present in a mixture. Given the solute molecules in a nonelectrolyte solution, the mole ratio is written as

x_{solute} = moles of solute molecules/total moles of solute and solvent molecules (8)

In a two-component system, the mole ratio is given as:

$$x_{solute} = n_{solute}/(n_{solvent} + n_{solute}) \quad (9)$$

(b) **Molarity, M:** The molarity of a solution is the number of moles of solute molecules of formular units divided by the volume of the solution (in litres).

Molarity, M = number of moles of solute/volume of solution (litres) (10)

Molarity is defined in terms of the volume of solution and not the volume of solvent used to prepare the solution [1].

Raoult's Law

The Effect of a Solute in a Solvent

The vapour pressure of a solvent is lower when a non-volatile solute is present in it. Raoult's law states that the vapour pressure of a solvent in the presence of a non-volatile solute is proportional to the mole fraction of the solvent. Raoult's law is given as

$$P = x_{solvent} P_{pure} \quad (11)$$

(where P_{pure} = the vapour pressure of the pure solvent, $x_{solvent}$ = the mole fraction of the solvent and P = the vapour pressure of the solvent in the solution)

The vapour pressure of the solvent is directly proportional to its mole fraction in the solution. In an ideal solution, the intermolecular forces between solute and solvent molecules are the same as the intermolecular forces within solvent molecules. This makes the solute molecules to mix freely with the solvent molecules. At a constant temperature, solutes that form ideal solutions have similar composition and structure to the molecules of the solvent. Examples are: the solution of Glucose in Water, the solution of Methylbenzene in Benzene. Real solutions do not obey Raoult's law at all concentrations. Real solutions are approximately ideal at the solute concentrations of about 10^{-1}mol.kg^{-1} for nonelectrolyte solutions and 10^{-2} mol.kg^{-1} for electrolyte solutions [1].

Concentration Measurement

Titration is the controlled addition and measurement of the amount of a solution of known concentration needed to react completely with a measured amount of a solution of unknown concentration. When the concentration of a solution is known, the concentration of another solution is calculated by titration from the chemically equivalent volumes. The solution with a known solution is prepared and the volume is changed gradually to give the desired concentration. The concentration is determined more accurately by titrating the solution with a measured quantity of a solution of a primary standard. A primary standard is a purified solid compound that is used to check the concentration of a known solution in a titration. The known solution is used to determine the molarity of another solution [5].

Preparing Solutions

The following steps are observed in preparing solutions in the laboratory [5]

- **Weighing the Solute:** The amount of solute needed is weighed.
- **Transferring the Solute to a Graduated Volumetric Flask:** The solute is transferred to a volumetric flask that holds a known volume of solvent.
- **Dissolving the Solute in the Solvent (Water):** Enough water is added to the flask to dissolve the solute. More water is added to bring the volume of solution to the calibration mark on the flask.
- **Homogenizing the Solution:** The solution is shaken to mix the solute and the solvent well.
- **Storing the Solution:** The solution is stored in a stoppered container and labeled.

Aqueous Solvents

Aqueous solution is a solution in which the solute is dissolved in water, as the solvent. Aqueous solutions are represented in chemical equations with the unit (aq) beside the species involved. Example: $AgNO_3$(aq) + NaCl(aq) → AgCl(s) + $NaNO_3$(aq). The (aq) beside $AgNO_3$, NaCl and $NaNO_3$ shows that these species are dissolved in water. [Aqueous solution - Wikipedia] Solutions such as beverages, seawater, etc., are examples of aqueous solutions. The solvent in these solutions is water. Examples of aqueous solutions are represented in the cases below [1, 3]. [Notes on Types of Non-Aqueous and Aqueous Solvents and Their Significance in the Pharmaceutical Industry (unacademy.com)]

Case I: When an ionic crystal is put into water as solvent, the ions become separated from one another by water molecules, the water molecules surround the ions to produce hydrated ions. The solvation of ions produces ionic hydrosphere. The orientation of water molecules on the periphery of the ions depends on the charge that is either negative or positive. A solution that contains electric ions (electric charges) is called an electrolyte. The ions contribute to the electrical conduction of electrolytes.

Case II: It is important to know whether the solute is present as ions or as molecules. In a strong electrolyte solution, the solute is present as ions. In a weak electrolyte solution, the solute is incompletely ionized in solution, some molecules remain as molecule, unionized. Examples are acetic acid, etc.

Case III: Solutes such as: Glucose, Acetone, etc., when dissolved in water do not produce ions. Their solutions consist of molecules of the respective solutes moving among the water molecules. There are no ions in the solution and the solution does not conduct electricity. The molecules of the solute are dispersed among the molecules of water. A solution that does not conduct electricity is called a nonelectrolyte solution.

Nonaqueous Solvents

Nonaqueous solution is a solution in which the solvent is not water. Hydrophobic substances such as oil, organic products, etc., do not dissolve in water. [Aqueous solution - Wikipedia] Generally, solvents are used to dissolve solutes. The solutes and solvents could be in solids, liquids or gaseous states. Solvents and solutes form solutions when their components units interact with one another. Nonaqueous solvent is used in cases such as: dry cleaning, where the grease and dirt on fabrics are dissolved in Tetrachloroethane, C_2Cl_4. It is also used in brass, in the solution of Copper in Zinc, etc.

Nonaqueous solvents are used in non-aqueous titrations as aqueous solvents are used in aqueous titrations. Nonaqueous solvents are described in the following cases: [Notes on Types of Non-Aqueous and Aqueous Solvents and Their Significance in the Pharmaceutical Industry (unacademy.com)]

Case I: Examples are alcohols with long Carbon chain, weak organic acids, etc. They have both acidic and basic properties. Generally, protons migrate between water molecules, even in the absence of another acid or base, as shown in equation (12) [1]. Similar reactions like the autoprotolysis of water is observed in the examples in Case I.

$$\text{Thus:} \quad 2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq) \qquad (12)$$

In Eqn (12) above, one molecule transfers a proton to another molecule of the same kind.

Case II: Solvents such as liquid ammonia, amines, ketones, etc., have strong affinity for protons (H^+). They are basic. They can dissolve solutes that will lend protons to them.

Case III: Solvents such as Hydrochloric acid, Sulphuric acid, etc., have strong affinity for bases. They donate a proton to weak bases.

Case IV: Examples are solvents such as Chloroform, Benzene, etc. They are neither acidic or basic. They are chemically inert.

Conclusion

The technique used in "Solvents- Dilute, Dissolve and Disperse" is a fundamental basis observed in nature, in global metabolism. The principle is used in the laboratories to give control measures to processes in the industries and factories. Solvents are used in paints, paint removers, inks, dry cleaning service, paint thinners, nail polish removers, solvents of glue, spot removers, detergents, perfumes, in the chemical industries, pharmaceutical industries, oil and gas industries, chemical synthesis, purification processes etc.

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