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You can & download or print using the browser document reader options.50%(2)50% found this document useful (2 votes)5K viewsThe document is a worksheet classifying different types of matter as homogeneous or heterogeneous, pure substances or mixtures, and checking them in multiple categories of heterogeneous, homAI-enhanced title and descriptionSaveSave Classification of Matter ANSWER KEY.pdf For Later50%50% found this document useful, undefined 2.1 INTRODUCTIONIn the previous chapter, we have learnt in detail about the classification based on physical properties. In this chapter, let us explore the details of the classification based on chemical composition. Based on chemical composition, we can classify matter on the basis of puresubstances and mixtures. However, before we start classification of matter on the above basis, we must make ourselves very clear about what are pure substances and mixtures. For a layman, pure substances are pure honey, pure milk, pure cheese, pure water, etc. However, to a chemist none of the above mentioned substances are pure. For example, pure milk is made of a number of substances like proteins, carbohydrates, mineral salts, vitamins, water etc., present in variable amounts in the milk of different animals of same breed. Thus, milk can be called a mixture in which amount of various substances are not present in same fixed ratio. Before we answer the question: What is a pure substance, let us see the broad classification of matter. Classification of matter 2.2 PURE SUBSTANCESTo answer this question, let us see, with what, gold and water are made of. If you consider gold, it is made up of only one type of particles called gold atoms. Water is also made up of only one type of particles called water molecules. Such substances are called pure substances. Thus, a homogeneous material which contains particles of only one kind and has a definite set of properties is called pure substance.Iron, silver, oxygen, sulphur are pure substances, because each one has only one kind of particles.However, if a substance is composed of two or more different kinds of particles combined together in fixed proportion by weight, then the substance is also regarded as a pure substance.Sodium chloride is a pure substance because it has a fixed number of sodium and chlorine particles combined together in fixed proportion by weight.Similarly, magnesium oxide and carbon dioxide are pure substances.Note: It does not imply that all homogeneous substances are pure. For example, common salt solution in water is a homogeneous solution, yet it cannot be called a pure substance, as it is made of two different substances, e.g. salt and water.Characteristics of a pure substancei) A pure substance is homogeneous in nature.ii) A pure substance has definite set of properties. These properties are different from the properties of other substances.iii) The composition of a pure substance cannot be altered by any physical means.2.3 ELEMENTTo understand it, let us consider silver. What happens if you break it into tiny pieces? Do you get any new substances?You get tinier particles of silver but you will not end up with gold or copper. Thus, silver remains as silver. Such substances are called element.Thus, an element is a pure substance that cannot be broken into two or more simpler substances by any known physical or chemical means.An element is made of only one kind of atoms. Chemists have discovered 115 elements so far. Amongst 115 elements, 82 are normal elements and 33 are radioactive elements.Normal elements are those which do not give harmful radiation. Radioactive elements are those which give harmful radiation.Thus, we can say, Eighty-two elements are non-radioactive and Thirty-three elements are radioactive elements.Characteristics of Elementsi) An element is a pure homogeneous substance, made up of only one kind of atoms.ii) Except during nuclear reactions, an element cannot be broken into two or more smaller parts.iii) An atom is the smallest unit of an element. It shows all the properties of that element. iv) Elements may occur in free state in nature or are found in the form of their compounds.v) Some elements (radioactive elements) can be prepared artificially by the nuclear reactions.vi) Any element may chemically react with other element(s) to form compound (s).Types of elementsThe elements are further classified into: Metals, Non-metals, Metalloids and Noble gases.1.MetalsThe solid state of matter, in which the atoms are very closely packed together and have a special type of bond known as metallic bond is called a metal. Because of close packing, the metals are quite hard. Out of 115 elements, nearly 70 elements are found to be metals.Characteristics of metals1. Appearance:Metals usually have a silver or grey colour(except copper and gold).Copper has a reddish-brown colour whereas gold has a yellow colour. Metals are widely used in our daily life for a large number of purposes. The cooking utensils, electric fans, sewing machines, cars, buses, trucks, trains, ships and aeroplanes, are all made of metals or mixtures of metals called alloys. In fact, the list of articles made of metals which we use in our daily life is unending.2. Physical state:Metals are solids at the room temperature.Generally, metals are very hard solids. All the metals like iron, copper, aluminium, silver and gold, etc., are solids at the room temperature.Exceptions: Mercury is the only metal in liquid state at the room temperature. Whereas gallium is a liquid at 30 C.3. Melting and Boiling points:Metals generally have high melting points and boiling points. This means that most of the metals melt and vapourise at high temperatures. Iron is avery important metal. We use about nine times more iron than all the other metals put together. Iron is made into steel and used for making large things like bridges (see above), as well as small things like needles. For example, iron is a metal having a high melting point of 1535C. This means that solid iron melts and turns into liquid iron (or molten iron) on heating to a high temperature of 1535C. Copper Exceptions: Metals like sodium and potassium have low melting points (of less than 100C). Another metal gallium has such a low melting point that it starts melting in hand (by the heat of our body).4. HardnessMetals are generally hard. Most of the metals are hard. But all the metals are not equally hard. The hardness varies from metal to metal. Most of the metals like iron, copper, aluminium, etc., are very hard. They cannot be cut with a knife.Exceptions: Sodium and potassium are soft metals which can be easily cut with a knife.5. Tensile strengthThe ability to hold large weights without breaking is called tensile strength. Metals are hard and have high tensile strength. For example, iron metal (in the form of steel) is very strong having a high tensile strength. Due to this, iron metal is used in the construction of bridges, buildings, railway lines, gliders, machines, vehicles and chains, etc. Though most of the metals are strong but some of the metals are not strong. For example, sodium and potassium metals are not strong. They have low tensile strength.6. DensityMetals have high densities. This means that metals are heavy substances. For example, the density of iron metal is 7.8 g/cm3g/which is quite high. There are, however, some exceptions. Sodium and potassium metals have low densities. They are very light metals.7. MalleabilityMetals can be beaten into thin sheets with a hammer (without breaking). This property of metals is called Malleability.Gold and silver metals are some of the best malleable metals. Aluminium and copper metals are also highly malleable metals. All these metals can be beaten with a hammer to form very thin sheets called foils. For example, silver metal can be hammered into thin silver foils because of its high malleability. The silver foils are used for decorating sweets. Similarly, aluminium metal is quite malleable and can be converted into thin sheets called aluminium foils. Aluminium foils are used for packing food items like biscuits, chocolates, medicines, cigarettes, etc. Milk bottle caps are also made of aluminium foil. Aluminium sheets are used for making cooking utensils. Copper metal is also highly malleable. So, copper sheets are used to make utensils and other containers.Thus, malleability is an important characteristic property of metals.8. DuctilityThe property of metals by which they can be drawn (or stretched) into thin wires is called ductility. All the metals are not equally ductile. Some are more ductile than the others. Gold and silver are among the best ductile metals. For example, just 100 milligrams of a highly ductile metal like silver can be drawn into a thin wire about 200 metres long.Copper and aluminium metals are also very ductile and can be drawn into thin wires which are used in electrical wiring. So, we can say that metals are malleable and ductile. It is due to the properties of malleability and ductility that metals can be given different shapes to make various articles.9. LustrousnessMetals are lustrous (or shiny), and can be polished. Gold, silver and copper are shiny metals and they can be polished. The property of a metal of having a shining surface is called metallic lustre (chamak). The shiny appearance of metals makes them useful in making jewellery and decoration pieces. For example, gold and silver are used for making jewellery because they are bright and shiny. The shiny surface of metals makes them goodreflectors of light. Silver metal is an excellent reflector of light.10. Heat and electrical conductivityConductivity is the ability of a substance allow heat and electricity to pass through them easily. Metals are generally good conductors of heat (The conduction of heat is also called thermal conductivity). Silver metal is the best conductor of heat. It has the highest thermal conductivity. Copper and aluminium metals are also very good conductors of heat. The cooking utensils and water boilers, etc., are usually made of copper or aluminium metals because they are very good conductors of heat. The poorest conductor of heatamong the metals is lead. Mercury metal is also a poor conductor of heat.Metals are good conductors of electricity. The metals offer very little resistance to the flow of electric current and hence show high electrical conductivity. Silver metal is the best conductor of electricity. Copper metal is the next best conductor of electricity followed by gold, aluminium and tungsten. The electric wires are made of copper and aluminium metals because they are very good conductors of electricity. The metals like iron and mercury offer comparatively greater resistance to the flow of current, so they have lower electrical conductivity.11. SonorityMetals are sonorous. This means that metals make a ringing sound when we strike them. It is due to the property of sonorousness of metals that they are used for making bells, plate type musical instruments like cymbals (manjira), and wires (or strings) for stringed musical instruments such as violin, guitar, sitar and tanpoora, etc.LIST OF COMMON METALS Name in English Symbol 1. Lithium Li 2. Sodium Na 3. Magnesium Mg 4. Aluminium Al 5. Potassium K 6. Calcium Ca 7. Vanadium V 8. Chromium Cr 9. Manganese Mn 10. Iron Fe 11. Cobalt Co 12. Nickel Ni 13. Copper Cu 14. Zinc Zn 15. Gallium Ga 16. Silver Ag 17. Tin Sn 18. Barium Ba 19. Platinum Pt 20. Gold Au 21. Mercury Hg 22. Lead Pb 23. Radium Ra 24. Uranium U 25. Tungsten W 26. Thorium Th 2. Non-metalsAs the name suggests, non-metals are opposite to metals, which means that their properties are quite different, from the metals. They are comparatively less in number. Out of 115 elements, only about 14 to 15 elements are found to be non-metals. Characteristic properties of non-metals1. AppearanceNon-metals are dull in appearance and are present in different colours. For example, sulphur is yellow, phosphorus is white or red, graphite is black, chlorine is yellowish-green, bromine is red- brown whereas hydrogen and oxygen are colourless.2. Physical StateNon-metals can exist in all the three physical states: solid, liquid and gaseous. For example, carbon, sulphur and phosphorus are solid non-metals; bromine is a liquid non- metal; whereas hydrogen, oxygen, nitrogen and chlorine are gaseous non-metals. Diamond (a non-metal) is the hardest substance known.3. Melting and boiling pointsNon-metals have comparatively low melting points and boiling points .This means that non-metals melt and vapourise at comparatively low temperatures. For example, sulphur is a non-metal having a low melting point of 119C. The majority of non- metals have very low boiling points due to which they exist as gases at room temperature.Exception: Graphite (C) has a very high melting point (of 3700C).4. HardnessNon-metals are generally soft. Most of the solid non-metals are quite soft. They can be easily cut with a knife. For example, sulphur and phosphorus are solid non-metals which are quite soft and can be easily cut with a knife.Exception: Diamond (C) is very hard. In fact, diamond (an allotropic form of carbon) is the hardest natural substance known.5. Tensile strengthNon-metals are not strong. They have low tensile strength. This means that non-metals cannot hold large weights (without breaking). For example, graphite is a non-metal which is not strong. It has a low tensile strength. When a large weight is placed on a graphite sheet, it breaks.6. Densities Non-metals have low densities. This means that non-metals are light substances. For example, sulphur is a solid non-metal having a low density of 2g/cm3, which is quite low. The density of gaseous non-metals is very, very low.Exception: Iodine has higher density compared to other non-metals.7. MalleabilityNon-metals are not malleable and are brittle. This means that non- metals cannot be beaten into thin sheets with a hammer. Non-metals break into small pieces when hammered. For example, sulphur and phosphorus are solid non-metals which are not malleable, they cannot be beaten into thin sheets with a hammer. Thus, we cannot get thin sheets from non-metals. Sulphur and phosphorus non-metals are brittle. When beaten with a hammer, they break into small pieces. Brittleness is a characteristic property of solid non-metals.8. DuctilityNon-metals are not ductile. This means that non-metals cannot be drawn into wires. They are easily snapped on stretching. For example, sulphur and phosphorus are non-metals and they are not ductile. When stretched, sulphur and phosphorus break into pieces and do not form wires. Thus, we cannot get wires from non-metals.Note: Non-metals are neither malleable nor ductile. Non- metals are brittle.9. LustrousnessNon-metals are not lustrous (not shiny). They are dull in appearance. Non-metals do not have lustre which means that non-metals do not have a shining surface. The solid non-metals have a dull appearance. For example, sulphur and phosphorus are non-metals which have no lustre, that is, they do not have a shining surface. They appear to be dull.Exception: Iodine is a non-metal having lustrous appearance. It has a shining surface (like that of metals).10. Heat and electrical conductivityNon-metals are bad conductors of heat and electricity. This means that non-metals do notallow heat and electricity to pass through them. For example, sulphur and phosphorus are non-metals which do not conduct heat or electricity. Many of the non-metals are, in fact, insulators.Exception: A form of the carbon element, diamond is a non-metal which is a good conductor of heat. And another form of carbon element, graphite is a non-metal which is a good conductor of electricity. Being a good conductor of electricity, graphite is used for making electrodes (as that in dry cells).11. SonorityNon-metals are not sonorous. This means that solid non-metals do not make a ringing sound when we strike them.LIST OF COMMON NON-METALS Non-metal State Colour Hydrogen Gas Colourless Nitrogen Gas Colourless Oxygen Gas Colourless Fluorine Gas Colourless Chlorine Gas Greenish yellow Bromine Liquid Reddish brown Iodine Solid Greyish brown Carbon Solid Grey Phosphorus Solid Waxy yellow Sulphur Solid Yellow Silicon Solid Grey 3. METALLOIDSElements that exhibit some properties of metals and some properties of non-metals are called metalloids.Examples: Boron (B), Silicon (Si), Germanium (Ge), Arsenic (As), Antimony (Sb), Tellurium (Te) and Polonium (Po)4. NOBLE GASESThese elements are found in air in the form of gas in very small amounts. Therefore, they are sometimes called rare gases.They are also called noble gases, because they do not react chemically with any known element. LIST OF NOBLE GASES Noble gases Symbol Helium He Neon Ne Argon Ar Krypton Kr Xenon Xe Radon Rn Note: Helium is the second lightest element after hydrogen.Radon is given out by the radioactive emission from earth.5. Abundance of elements in earths crust Element Percentage by weight Oxygen 49.58 Silicon 26.03 Aluminium 7.28 Iron 4.12 Calcium 3.18 Sodium 2.33 Potassium 2.33 Magnesium 2.11 Hydrogen 0.97 Titanium 0.41 Other elements 1.39 6. Atomicity of an ElementGenerally, elements exist as single atoms. However, sometimes two or more atoms of an element combine with one another to form a compound atom or molecule. Depending upon the number of atoms present in its molecule, the elements can be classified as under:i) The molecule of a monoatomic element contains only one atom.Ex: He, Ne, Ar, Kr, Xeii) The molecule of a diatomic element contains two atoms, e.g., hydrogen(H_2), oxygen (O_2), nitrogen (N_2),etc.iii) The molecule of a polyatomic element contains more than two atoms, e.g., ozone (O_3), phosphorus (P_4), sulphur (S_8), boron (B_{12}) and carbon (C_{60})2.4 COMPOUNDA compound is a pure substance, which is composed of two or more elements, combined chemically in a fixed proportion by weight, and can be broken into smaller parts or elements by chemical methods only.Most of the elements do not exist in elementary form in nature. Two or more different elements combine in a fixed proportion by weight to form a compound. The combination of elements takes place due to chemical reaction.Characteristics of a Compoundi) Nature: The nature of elements constituting a chemical compound remains same.Examples: In case of water, the constituting elements are hydrogen and oxygen only. In case of mercury (II) oxide, the constituting elements are mercury and oxygen only.ii) Behaviour: A pure chemical compound is homogeneous in nature.Example: If one molecule of water contains hydrogen and oxygen in some fixed pattern, then all other molecules of water will also contain hydrogen and oxygen combined with each other in the same pattern.iii) Separation: A chemical compound can be broken into two or more different elements. It can be synthesized from these elements by chemical means.Examples: Water can be broken into hydrogen and oxygen, and the gases so formed can be made to form water by chemical means. Similarly, mercuric oxide can be broken into mercury and oxygen. Mercury and oxygen can be made to combine chemically to form mercury (II) oxide.iv) Composition: A chemical compound has a fixed composition, i.e., its constituent elements combine together in a fixed ratio by weight.Examples: Hydrogen and oxygen combine in the Similarly, in magnesium oxide, magnesium and oxygen combine in the fixed ratio of 3:2 by weight.v) Properties: A chemical compound has distinct set of properties which do not resemble the properties of its constituent elements.Examples: Water is a colourless liquid which extinguishes fire, whereas hydrogen is acombustible gas and oxygen is a supporter of combustion.Similarly, common salt (sodium chloride) is harmless when we use it as table salt, whereas its constituents sodium and chlorine are highly dangerous. Sodium is a waxy white metal, which catches fire when placed in air or water. Chlorine is a greenish yellow gas with a suffocating smell and is highly poisonous in nature.vi) Mechanical separation: During the formation of a chemical compound, its constituent elements completely lose their individual properties. Thus, it is not possible to separate the constituent elements by simple means like nitrate ion; evaporation sublimation, etc. However, we can separate the constituent elements by applying suitable chemical means.Examples: It is not possible to separate hydrogen and oxygen gas from water by simple processes like heating, cooling filtration, etc., unless we break molecules of water chemically with the help of electric current. Similarly, sodium and chlorine cannot be separated from sodium chloride unless electric current is passed through its saturated solution in water.vii) Energy exchange: Formation of a compound involves energy changes: It is impossible to form a chemical compound, unless the constituent elements either absorb energy or give out energy. The energy is generally in the form of heat energy.However, in certain cases it could be electrical energy, light energy or sound energy.Examples: Sodium and chlorine react with the liberation of heat and light energy to form sodium chloride.Similarly, carbon dioxide gas and water react in the presence of chlorophyll to form carbohydrates and oxygen only, when sunlight is absorbed by the leaves of the plant.COMPARISON BETWEEN ELEMENTS AND COMPOUNDS Element Compound Nature An element is a pure and homogeneous substance. A compound is also a pure and homogeneous substance. Types of atoms An element contains only one type of atoms A Compound contains different types of atoms. Separation of constituents An element cannot be broken down into any other simpler substances by physical or chemical means. A compound may be broken down into simpler substances by chemical means. Nature of properties An element has characteristic physical and chemical properties. A compound has characteristic physical and chemical properties, but these are entirely constituent elements. 2.5 MIXTURESIf two or more substances (elements, compounds or both) mixed together in any proportion, do not undergo any chemical change, but retain their characteristics, the resulting mass is called a mixture.Kinds of Mixturesa) Heterogeneous mixture: A mixture in which various constituents are not mixed uniformly is called heterogeneous mixture.Examples: A mixture of sand, salt and sulphur is a heterogeneous mixture. Similarly, a handful of soil is a heterogeneous mixture. b) Homogeneous mixture: A mixture in which different constituents are mixed uniformly is called homogeneous mixture.Examples: Brass is an alloy of copper and zinc and is a homogeneous mixture. Similarly, all solutions are homogeneous mixtures.Characteristics of a Mixturei. Variable composition: The constituents of a mixture are present in any ratio.Example: A mixture of sand and salt can be in a ratio of 1:2 or 5:6, etc, by weight.ii. Physical change: The mixture is a result of physical change. The constituents of a mixture do not bind each other by chemical bonds.Example: In air the main constituents, i.e., oxygen, nitrogen and carbon dioxide, do not bind each other with chemical bonds.iii. No specific properties: The properties of a mixture are the average of the properties of its constituents.Example: The properties of air are midway between properties of nitrogen and oxygen.iv. Homogeneity: Most of the mixtures are heterogeneous, i.e., their constituents are not spread evenly throughout. However, some mixtures are homogeneous.Example: In the mixture of iron and sulphur, at some places iron is more and at some places sulphur is more.v. Separation: Generally, the constituents of mixture can be separated by employing suitable physical means.Example: Iron can be separated from the mixture of iron and sulphur with the help of a magnet.vi. Energy changes: The formation of heterogeneous mixture, does not involve any energy (heat) change, but, that of a homogeneous mixture generally does.For example during the formation of heterogeneous mixtures like: Sand + common salt,Sand + water and Oil + water no heat is exchanged. But during the formation of homogeneous mixtures like magnesium sulphate + water, concentrated sulphuric acid + water and hydrogen chloride + water heat is evolved and during the formation of glucose + water, heat is absorbed.Exception: During the formation of homogeneous mixture like nitrogen + oxygen, no heat is evolved. DIFFERENCES BETWEEN A MIXTURE AND A COMPOUND Property Mixture Compound Nature When two or more elements or compounds or both are mixed together, such that they do not combine chemically, a mixture is formed. When two or more elements unite chemically, a compound is formed. Structure Mixtures are generally heterogeneous. However, some mixtures can be homogeneous. Compounds are always homogeneous. Composition In case of mixtures their constituents can be present in any ratio, i.e., mixtures have variable composition. In case of compounds, the constituents are present in a fixed ratio by weight. Properties The constituents of a mixture retain their individual chemical and physical properties. The properties of a compound are entirely different from the properties of its constituents Separation of constituents The constituents of a mixture can be separated by applying physical methods like solubility, filtration, evaporation, distillation, use of magnet, etc. The constituents of a compound cannot be separated by applying physical methods. However, constituents of a compound can be separated by chemical means. Energy change There may or may not be energy change during the formation of mixture. During the formation of a compound either the energy is absorbed or given out. Is air a mixture or a compound?We know that, matter that can be separated into different kinds of substances, by any physical process is called a mixture and substance which can be broken further by chemical means is called a compound.Air is made up of different constituents like oxygen, nitrogen, carbon dioxide, water vapour, etc., and these constituents may be separated, by means of water vapour etc., and these constituents may be separated, by means of physical process like fractional distillation.Moreover, air has a variable composition, because, it contains different amounts of variable gases at different places and hence, it has no definite formula. On the other hand, the constituents in a compound are present in a fixed ratio and hence, the compound has a definite formula. Therefore, due to the above reasons air is considered a mixture and not a compound.Is water a mixture or a compound?Water is considered a compound because of the following reasons: (i) Water cannot be separated into its constituents, hydrogen and oxygen, by the physical methods (such as filtration, evaporation, distillation, sublimation, magnet, etc.).(ii) The properties of water are entirely different from those of its constituents, hydrogen and oxygen. For example, water is a liquid whereas hydrogen and oxygen are gases; water does not burn whereas hydrogen burns; water does not support combustion whereas oxygen supports combustion.(iii) Heat and light are given out when water is prepared by burning hydrogen in oxygen.(iv) The composition of water is fixed. It contains hydrogen and oxygen combined together in a fixed proportion of 1: 8 by mass. It has a definite formula, H_2O.(v) Water has a fixed boiling point of 100C under standard atmospheric pressure.Alloys are mixtures but not compoundsAlloys are homogeneous mixtures of metals and cannot be separated into their components by physical methods. Even then an alloy is considered a mixture because: (i)it shows the properties of its constituents, and (ii) it has a variable composition. For example, brass is a homogeneous substance composed of copper and zinc, and cannot be separated into its constituents by physical methods. Brass is considered a mixture because: (i) it shows the properties of its constituents, copper and zinc, and (ii) it has a variable composition (The amount of zinc in brass can vary from 20 to 35 per cent).2.6 SOLUTIONSBefore we discuss the solutions, suspensions and colloids in detail, we should know the meaning of two terms: solute and solvent. The substance which is dissolved in a liquid to make a solution is called solute, and the liquid in which solute is dissolved is known as solvent. For example, salt solution is made by dissolving salt in water, so in salt solution, salt is the solute and water is the solvent. Similarly, the substances like sugar, ammonium chloride, copper sulphate and urea, etc., which are dissolved in water to make solutions are called solutes, whereas water is the solvent. Usually, the substance present in lesser amount in a solution is considered the solute, and the substance present in greater amount in a solution is considered the solvent. Please note that the solute particles are also called dispersed particles and solvents are also known as dispersion medium. Lets now define a solution. A solution is a homogeneous mixture of two or more substances. A homogeneous mixture means that the mixture is just the same throughout. Some common examples of solutions are: Salt solution, Sugar solution, Vinegar, Metal alloys (such as Brass) and Air. Saltsolution is a homogeneous mixture of two substances, salt and water, whereas sugar solution is a homogeneous mixture of two substances, sugar and water. Some more examples of the solutions are: Sea-water, Copper sulphate solution, Alcohol and water mixture, Petrol and oil mixture, Soda water, Soft drinks (like Coca Cola and Pepsi, etc.), and Lemonade (which is a sweetened drink made from lemon juice or lemon flavouring). The substances like salt, sugar, etc., which dissolve in water completely are said to be soluble in water.Note: Alloys are homogeneous mixtures of metals and cannot be separated into their components by physical methods. But still, an alloy is considered as a mixture because it shows the properties of its constituents and can have variable composition. For example, brass is a mixture of approximately 30% zinc and 70% copper.Properties of a solutionFrom the above activity, we can now state the properties of a true solution are as follows:1. A solution is a homogeneous mixture.2. The size of solute particles in a solution is extremely small. It is less than 1 nm in diameter (1 nanometre = 109metre).3. The particles of a solution cannot be seen even with a microscope.4. The particles of a solution pass through the filter paper. So, a solution cannot be separated by filtration.5. The solutions are very stable. The particles of solute present in a solution do not separate out on keeping.6. A true solution does not scatter light (This is because its particles are very, very small).2.7 TYPES OF SOLUTIONSWe usually think that solutions are formed when solid substances are dissolved in liquids. Though most of the common solutions are made by dissolving solids in liquids, but this is not always so. In fact, solutions can be made by dissolving: solids in solids; solids in liquids; liquids in liquids ; gases in liquids ; and gases in gases. Please remember that as long as the mixture is homogeneous, the term solution applies to it. The various types of solutions are: 1. Solution of Solid in a Solid.Metal alloys are the solutions of solids in solids. For example, brass is a solution of zinc in copper. Brass is prepared by mixing molten zinc with molten copper and cooling their mixture.2. Solution of Solid in a Liquid.This is the most common type of solutions. Sugar solution and salt solution are the solutions of solids in liquids. A solution of iodine in alcohol called tincture of iodine is also a solid in a liquid type of solution. This is because it contains a solid (iodine) dissolved in a liquid (alcohol). A solution of water and sugar is called syrup. A solution of sodium chloride (common table salt) in water is called brine.3. Solution of Liquid in a Liquid.Vinegar is a solution of acetic acid (ethanoic acid) in water. Milk is an example of liquid in liquid type of solution.4. Solution of Gas in a Liquid.Soda-water is a solution of carbon dioxide gas in water.5. Solution of Gas in a Gas.Air is a solution of gases like oxygen, argon, carbon dioxide and water vapour, etc., in nitrogen gas. Nitrogen is the solvent in air and all other gases are solutes.2.8 SUSPENSIONS AND COLLOIDSWe have studied that homogeneous mixtures are regarded as solutions, or true solutions. The heterogeneous mixtures in which the components or constituents are present in more than one phase are of two types. These are known as suspensions and colloidal solutions. Thus, we conclude that there are three types of mixture solutions. These are solutions (or true solutions), colloidal solutions and suspensions. They differ mainly in the size of the particles which are also responsible for the difference in their properties. In a true solution, the size of the particles is less than 1 nm 1nm=109m=107cm. In a colloidal solution, it is between 1 to 100 nm while in a suspension, the size of the particles is more than 100 nm as shown in the figure. SuspensionsWe have just studied that the substances which are soluble in water (or any other liquid) form solutions. But do you know what we call those substances which are insoluble in water. They are called suspensions.A suspension is a heterogeneous mixture in which the small particles of a solid are spread throughout a liquid without dissolving in it.Examples:Chalk-water mixture, Muddy water, Milk of magnesia, Sand particles suspended in water, and Flour in water. Chalk-water mixture is a suspension of fine chalk particles in water; muddy water is a suspension of soil particles in water; and milk of magnesia is a suspensionof magnesium hydroxide in water. Please note that solid particles and water remain separate in a suspension. The particles do not dissolve in water. We will now study the properties of a suspension.Properties of a Suspension1. Heterogeneous in nature: A suspension is a heterogeneous mixture. There are two phases. The solid particles represent one phase while the liquid in which these are suspended or distributed forms the other phases.2. Size: The size of solute particles in a suspension is quite large. It is larger than 100 nm (107m) in diameter.3. Visibility: The particles of a suspension can be seen easily seen with our naked eyes and also under a microscope.4. Separation: The solid particles reset in the suspension can be easily separated by ordinary filter papers. No special filter papers are needed for the purpose. So, a suspension can be separated by filtration. 5. Instablility: The suspensions are unstable. The particles of a suspension settle down after some time. The settled particles of a suspension is known as a precipitate.6. Scattering of light: A suspension scatters a beam of light passing through it (because its particles are quite large).ColloidsA colloid is a kind of solution in which the size of solute particles is intermediate between those in true solutions and those in suspensions. The size of solute particles in a colloid is bigger than that of a true solution but smaller than those of a suspension. Though colloids appear to be homogeneous to us but actually they are found to be heterogeneous when observed through a high power microscope. So, a colloid is not a true solution. Some of the examples of colloids (or colloidal solutions) are: Soap solution, Starch solution, Milk, Ink, Blood, Jelly and Solutions of synthetic detergents. Colloids are also known as colloidal solutions.Types of colloidal solutionsWe have stated earlier that the colloidal solutions are the heterogeneous mixtures. This means that the constituents are not present in a single phase. Actually there are two phases in a colloidal solution. These are known as dispersed phase and dispersion medium. The component present in smaller proportion is the dispersed phase while the one present in greater proportion is the dispersion medium. NOTE:Please note that the dispersed phase in a colloidal solution is comparable with solute in a true solution. Similarly, the dispersion medium can be compared with the solvent. However, they differ in the sense that in a true solution, solute and solvent are present in a single phase but in colloidal solution, they represent separate phases. In other words, a true solution is homogeneous while colloidal solution is of heterogeneous nature. All this happens because of the difference in the particle size.Just as in case of true solutions, the substances belonging to all the three states of matter can act as dispersed phase or dispersion medium depending upon their relative amounts or proportions. Thus, nine different types of colloidal solutions are also possible. But there areactually eight and not nine as we notice in true solutions. When two different gases are mixed, they always form a homogeneous and not heterogeneous mixture. The different types of colloidal solutions along with a few examples are listed in the form of a table.Although eight different types of colloidal solutions are possible, but the most common among them have liquid acting as the dispersion medium while solid or gas as the dispersed phase. Colloidal solutions are also known as colloidal sols. S no Dispersed phase Dispersion Medium Name of colloidal Solutions Examples 1. Gas Liquid Foam Soap leather, whipped cream, soda water 2. Gas Solid Solid foam Pumice stone, rubber, bread 3. Liquid Gas Aerosol Mist, fog, cloud, insecticide spray 4. Liquid Liquid Emulsion Milk, cod liver oil, tonics in liquid form 5. Liquid Solid Gel Jelly, butter, cheese, boot polish, curd 6. Solid Gas Aerosol Smoke, dust storm, volcanic dust and haze 7. Solid Liquid Sols Paints, starch dispersed in water, gold sol 8. Solid Solid Solid sols Alloys, coloured glasses, gem stones, ruby glass Properties of colloidal solutionsThe important properties of colloidal solutions are briefly discussed below:1. Colloidal solutions are heterogeneous in nature.Colloidal solutions appear to be homogeneous but are actually heterogeneous in nature. This happens because of particle size (1 nm to 100 nm) which is quite close to particles in true solution. We cannot see the particles in a colloidal solution as we do in case of suspension. But these can be seen under a microscope.2. Colloidal solutions are a two phase systemThe colloidal solutions represent a two phase system. These are dispersed phase and dispersion medium. Therefore, the colloidal solutions are of heterogeneous nature.3. Colloidal particles pass through ordinary filter papersIn most of the cases, the colloidal solutions pass through ordinary filter papers like true solutions. This is because of the fine size of the dispersed phase or colloidal particles. Special filter papers known as ultra-filter papers have to be used to separate these particles from the dispersion medium.4. Colloidal particles carry chargeIn the dispersed phase particles in a colloidal solution remain dispersed or suspended. They do not come close to one another as in case of suspension. This happens due to the presence of some charge (positive or negative) on these particles. Please remember that all the particles belonging to a particular colloidal solution carry the same charge. That is why, these similarly charged particles repel each other and remain dispersed or suspended.5. Particles in a colloidal solution follow zig-zag pathIt is normally not possible to see the colloidal particles because of their very small size. However, their path can be seen under a microscope. These particles follow a zig-zag path. You can observe this motion while watching a film in a theater. The beam of light which falls on the screen from behind has dust particles present in it. They follow zig-zag path. Such type of movement of the colloidal particles was noticed for the first by Robert Brown,an English scientist in 1828. This is known as Brownian movement. 6. Colloidal solution scatters the beam of light passing through itWhen a beam of light from a certain source is focused or passed through a colloidal solution kept in the dark, its path becomes visible while passing through the solution. Along with this, the colloidal particles can also be seen following a zig-zag path. But it does not happen when the same beam is passed through a true solution (e.g., sodium chloride solution). Actually, the particles present in a colloidal solution have size big enough to scatter or disperse the light rays present in the beam as they fall on them. As a result, these rays as well as the colloidal particles become visible. This scattering of light by colloidal particles is known as Tyndall effect. This effect is not noticed in a true solution because the particles present in it are too small to scatter the light. 7. Colloidal solutions in which only liquids participate are known as emulsionsIn the table giving the different types of colloidal solutions, it has been mentioned that the solutions in which liquid acts as the dispersed phase and other in which liquid as the dispersion medium, are known as emulsions. However, these are not miscible with each other. If they mix up or become miscible, we get a true solution and not an emulsion. In an emulsion, one of the constituents is generally oily while other is water soluble. Thus, the emulsions are oil-water in nature. We know that normally oil and water form separate layers and are not expected to mix up. But certain substances known as emulsifiers help in forming stable emulsions of oil and water. These emulsifiers are generally proteins in nature. A few common examples of emulsions are: Milk, cod-liver oil, both cold and vanishing creams, moisturising creams, paints etc. Applications of colloidal solutionsThe field of colloids is so vast that it may not be possible to describe the same at this level. Similarly, the colloidal solutions have wide range of applications. Only a few out of these are being discussed to generate some interest about this field.1. Bleeding from a cut can be immediately stopped by applying alum or ferric chlorideBlood consists of haemoglobins which are negatively charged colloidal particles. On applying alum or ferric chloride, these particles take up positively charged ions (cations) from these substances. They get their charge removed and get precipitated (or coagulated) As a result, the bleeding stops because blood becomes very thick.2. Delta is formed when river water comes in contact with sea water for a long periodRiver water is mostly muddy. These mud particles are charged colloidal particles. When river comes in contact with sea, the dissolved salts present in sea water provide ions with charge opposite to the charge on mud particles. These particles get uncharged and combine with each other to form bigger particles. Over the years, deltas appear at these places.3. Sky appears to be blue in colourWhen we look at the sky, it appears to be blue in colour. It is for your knowledge that there is no blue colour as such in the sky. Actually, fine particles of dust etc. are always present in the atmosphere. When sun light falls on these particles, they scatter light with a blue colour or tinge. That is why sky is blue.2.9 CONCENTRATION OF A SOLUTIONA solution may have a small amount of solute dissolved in it while may have a large amount of solute dissolved in it. The solution having small amount of solute is said to have low concentration. It is known as a dilute solution. The solution having a large amount of soluteis said to be of high concentration. It is known as a concentrated solution (see the figure). We can now define the concentration of a solution as follows:The concentration of a solution is the amount of solute present in a given quantity of the solution.The concentration of a solution can be expressed in a number of different ways. The most common way of expressing the concentration of a solution is the percentage method. The percentage method of expressing the concentration of a solution refers to the percentage of solute present in the solution. The percentage of solute can be by mass or by volume. This point will become clearer from the following discussion.Case-1: Solid solute dissolved in liquid solventIf the solution is of a solid solute dissolved in a liquid, then we consider the mass percentage of solute in calculating the concentration of solution. So, in the case of a solid solute dissolved in a liquid solvent:The mass percentage of a solution is defined as the mass of solute in grams present in 100 grams of the solution.For example, a 20 per cent solution of sodium chloride means that 20 grams of sodium chloride are present in 100 grams of the solution. Please note that the 100 grams of solution also include 20 grams of the sodium chloride. This means that the 100 grams of sodium chloride solution contain 100 20 = 80 grams of water in it. Thus, we can prepare a 20 per cent solution of common salt by dissolving 20 grams of common salt in 80 grams of water (so that the total mass of the solution becomes 20+ 80= 100 grams).Note: The mass percentage of a solution refers to the mass of solute in 100 grams of the solution and not in 100 grams of the solvent. We can calculate the concentration of a solution in terms of mass percentage of solute by using the following formula: Mass percentage=Mass of soluteMass of solution100 The mass of solution is equal to the mass of solute plus the mass of solvent. That isMass of solution = Mass of solute + Mass of solventSo, we can obtain the mass of solution by adding the mass of solute and the mass of solvent.In the above given example:Mass of solute (sodium chloride) = 20 gMass of solvent (water) = 80gSo, Mass of solution =Mass of solute + Mass of solvent = 20 + 80 =100 gNow, putting these values of mass of solute and mass of solvent in the above formula, we get Mass percentage=20100100=20percent (by mass) Thus, the concentration of this sodium chloride solution is 20 per cent (or 20 %) by mass. Please note that if the concentration is in terms of mass, then the words by mass are usually not written with it. For example, in the above case we just say that it is a 20per cent solution of sodium chloride . Since sodium chloride is a solid, so it is understood that the percentage is by mass. This is because we do not consider the volume of solids in making solutions.Case-2: Liquid solute Dissolved in a Liquid SolventIf the solution is of a liquid solute dissolved in a liquid solvent, then we usually consider the volume percentage of solute in determining the concentration of solution. So, in the case of a liquid solute dissolved in a liquid solvent:The volume percentage (concentration) of a solution is defined as the volume of solute in millilitres present in 100 millilitres of the solution.For example, a 10 percent solution of alcohol means that 10 ml of alcohol are present in 100 ml of solution. Please note that the 100 ml volume of solution also includes 10 ml volume of alcohol. This means that the 100 ml of alcohol solution contain 100 10 = 90 ml of water in it.Thus, we can prepare a 10 per cent solution of alcohol by mixing 10 ml of alcohol in 90 ml of water (so that the total volume of the solution becomes 10+ 90 = 100 ml).Note: The concentration of solution refers to the volume of liquid solute in 100 mL of solution and not in 100 mL of solvent. In general, we can calculate the concentrationof a solution in terms of volume percentage of solute by using the formula: Volume percent=Volume of soluteVolume of solution100 In the above example:Volume of solute (alcohol) = 10 mLAnd, Volume of solvent (water) = 90 mLSo, Volume of solution = Volume of solute + Volume of solvent = 10 + 90 = 100 mLNow, putting these values of volume of solute and volume of solution in the above formula, we get: Volume percent=10100100=10per cent (by volume) Thus the concentration this alcohol solution is 10 percent or that it is a 10 % alcohol solution (by volume). 2.10 SATURATED AND UNSATURATED SOLUTIONSWhen we dissolve a solute in a solvent, then a solution is formed. We can dissolve different amounts of solute in the same quantity of the solvent. In this way, we can get many solutions having different concentrations of the same solute. A particular solution may contain less amount of the dissolved solute whereas another solution may contain more amount of the solute in it. For example, we can prepare many salt solutions of differentconcentrations by dissolving different amounts of salt in the same quantity of water. So, depending upon the amount of solute present, the solutions can be classified into two groups: Unsaturated solutions and Saturated solutions. Let us discuss it in detail.1. A solution in which more quantity of solute can be dissolved without raising its temperature, is called an unsaturated solution. For example, if in an aqueous solution of salt, more of salt can be dissolved without raising its temperature, then this salt solution will be an unsaturated solution. Actually, an unsaturated solution contains lesser amount of solute than the maximum amount of solute which can be dissolved in it at that temperature.2. A solution in which no more solute can be dissolved at that temperature is called a saturated solution. For example, if in an aqueous salt solution, no more salt can be dissolved at that temperature, then that salt solution will be a saturated solution.Thus, a saturated solution contains the maximum amount of solute which can be dissolved in it at that temperature. It is obvious that a saturated solution contains greater amount of solute than an unsaturated solution. (i) A maximum of 32 grams of potassium nitrate can be dissolved in 100 grams of water at atemperature of 20C. So, a saturated solution of potassium nitrate at 20C contains 32 grams of potassium nitrate dissolved in 100 grams of water.(ii) A maximum of 36 grams of sodium chloride (common salt) can be dissolved in 100 grams of water at a temperature of 20C. So, a saturated solution of sodium chloride at 20C contains 36 grams of sodium chloride dissolved in 100 grams of water.In order to test whether a given solution is saturated or not, we should add some more solute to this solution and try to dissolve it by stirring (keeping the temperature constant). If more solute does not dissolve in the given solution, then it will be a saturated solution; but if more solute gets dissolved, then it will be an unsaturated solution.Effect of heating and cooling of a saturated solutionA solution is saturated at a particular temperature only. So, if a saturated solution at a particular temperature is heated to a higher temperature, then it becomes unsaturated. This is because the solubility of solute increases on heating and more of solute can be dissolvedon raising the temperature of the solution. Please note that the solubility of a solute in a solution, however, cannot be increased indefinitely on raising the temperature of the solution. We will now describe the effect of cooling on a saturated solution. If a saturated solution available at a particular temperature is cooled to a lower temperature, then some of its dissolved solute will separate out in the form of solid crystals. This is because the solubility of solute in the solution decreases on cooling. We will now discuss how a saturated solution can be prepared. 2.11 SOLUBILITYThe maximum amount of a solute which can be dissolved in 100 grams of a solvent at a specified temperature is known as the solubility of that solute in that solvent (at that temperature).If the solvent is water, then we can define solubility as follows:The maximum amount of a solute which can be dissolved in 100 grams of water at a given temperature, is the solubility of that solute in water (at that temperature).Please note that solubility is always stated as mass of solute per 100 gram of water (or any other solvent).Examples:(i) A maximum of 32 grams of potassium nitrate can be dissolved in 100 grams of water at 20C, therefore, the solubility of potassium nitrate in water is 32 grams at 20C.(ii) A maximum of 36grams of sodium chloride (common salt) can be dissolved in 100 grams of water at 20C, therefore, the solubility of sodium chloride (or common salt) in water is 36 grams at 20C.From the above discussion it is obvious that the solubility of a substance (or solute) refers to its saturated solution. So, we can write a yet another definition of solubility as follows: The solubility of a solute in water at a given temperature is the number of grams of that solute which can be dissolved in 100 grams of water to make a saturated solution at that temperature. The solubility of different substances in water is different. Since the solubility depends on temperature, so while expressing the solubility of a substance, we have to specify the temperature also. The solubilities of some of the substances (or solutes) are given on the next page. All these values of solubilities are per 100 grams of water. Substance Solubility in water (at 20C) 1. Copper sulphate 2. Potassium nitrate 3. Potassium chloride 4. Sodium chloride 5. Ammonium chloride 6. Sugar 21g 32g 34g 36g 37g 204g Solubility=Wt.of soluteWt.of solvent100 Effect of Temperature and Pressure on SolubilityThe effect of temperature and pressure on the solubility of a substance is as follows:(i) The solubility of solids in liquids usually increases on increasing the temperature; and decreases on decreasing the temperature.(ii) The solubility of solids in liquids remains unaffected by the changes in pressure.(iii) The solubility of gases in liquids usually decreases on increasing the temperature; and increases on decreasing the temperature.(iv) The solubility of gases in liquids increases on increasing the pressure; and decreases ondecreasing the pressure.We will describe the effect of temperature on the solubility of a solid substance in water in a little more detail. Look at the solubilities of copper sulphate in water at various temperatures given below: Temperature Solubility of copper sulphate 00C 14g 100C 17g 200C 21g 300C 24g 400C 29g 500C 34g 600C 40g 700C 47g We can see from this data that as the temperature is increased from 0C to 70C, the solubility of copper sulphate in water increases from 14 grams to 47 grams. Now, let us see what happens when we cool a saturated solution of copper sulphate from a higher temperature to a lower temperature.The solubility of copper sulphate at 70C is 47 grams and the solubility of copper sulphate at 20C is 21 grams (as shown in the above table). This means that 100 grams of water can dissolve a maximum of 47 grams of copper sulphate at 70C but only 21 grams at 20C. So, if we cool a saturated solution of copper sulphate made in 100 grams of water from 70C to 20C, then the solubility of copper sulphate will decrease and 47 grams 21 grams = 26 grams of copper sulphate will separate out from the solution in the form of solid crystals.2.12 PHYSICAL AND CHEMICAL CHANGESThere are some changes during which no new substances are formed. On the other hand, there are some other changes during which new substances are formed. So, on the basis of whether new substances are formed or not, we can classify all the changes into two groups:physical changes and chemical changes. We will now discuss physical changes and chemical changes in detail, one by one. Let us start with the physical changes.Physical ChangesThose changes, in which no new substances are formed, are called physical changes. In a physical change, the substances involved do not change their identity. They can be easily returned to their original form by some physical process. This means that physical changes can be easily reversed. The changes in physical state, size and shape of a substance are physical changes. Some common examples of physical changes are: Melting of ice (to form water); Freezing of water (to form ice); Boiling of water (to form steam); Condensation of steam (to form water); Making a solution; Glowing of an electric bulb; and Breaking of a glass tumbler.These physical changes are discussed below.(i) When ice is heated, it melts to form water. Though ice and water look different, they are both made of water molecules. Thus, no new chemical substance is formed during the melting of ice. So, the melting of ice to form water is a physical change. When water is cooled (as in a refrigerator), then water solidifies to form ice. This is called freezing of water. The freezing of water to form ice is also a physical change.(ii) When water is heated, it boils to form steam. Though steam and water look different, they are both made of water molecules. Thus, no new chemical substance is formed during the boiling of water. So, the boiling of water to form steam is a physical change. When steam is cooled, it condenses (liquefies) to form water. The condensation of steam to form water is also a physical change.(iii) We take water in a china dish and dissolve some common salt in it. The salt disappears in water and forms a salt solution. So, a change has taken place in making salt solution. Let us now heat this china dish containing salt solution on a burner till all the water evaporates. A white powder is left behind in the china dish. If we taste this white powder, we will find that it is common salt. It is the same common salt which we had dissolved in water earlier. This means that no new chemical substance has been formed by dissolving common salt inwater to make salt solution. Thus, making of a solution is a physical change.(iv) When an electric bulb is switched on, an electric current passes through its filament. The filament of bulb becomes white hot and glows to give light. When the current is switched off, the filament returns to its normal condition and the bulb stops glowing. No new substance is formed in the bulb during this process. So, the glowing of an electric bulb is a physical change(v) When a glass tumbler breaks, it forms many pieces. Each broken piece of glass tumbler is still glass. So, during the breaking of a glass tumbler, only the size and shape of glass has changed but no new substance has been formed. So, the breaking of a glass tumbler is a physical change.Characteristics of Physical changesi) No new substances are formed during physical change.ii) Physical changes can be generally reversed.iii) There is no change in weight during physical change:iv) Only a little heat (if any) is absorbed or given off during physical change:Chemical ChangesThose changes in which new substances are formed, are called chemical changes.In a chemical change, the substances involved change their identity. They get converted into entirely new substances. The new substances usually cannot be returned to their original form. This means that chemical changes are usually irreversible. Some commonexamples of chemical changes are: Burning of a magnesium wire ; Burning of paper ; Rusting of iron ; Formation of curd from milk ; and Cooking of food. Some of these chemical changes are discussed below.(i) When a magnesium wire is heated, it burns in air to form a white powder called magnesium oxide. This magnesium oxide is an entirely new substance. Thus, a new chemical substance is formed during the burning of a magnesium metal wire. So, the burning of a magnesium wire is a chemical change.(ii) If we burn a piece of paper with a lighted match stick then entirely new substances like carbon dioxide, water vapour, smoke and ash are produced. So, the burning of paper is a chemical change.Characteristics of chemical changesi) When a chemical change occurs new substance, with entirely new properties are formed.ii) Chemical change cannot be easily reversed.iii) There is usually a change in weight during chemical reaction.iv) Lot of heat is usually given off or absorbed during a chemical change. 2.13 KINDS OF MIXTURESA mixture can exist in a solid, liquid or gaseous state. Furthermore, a mixture can be homogeneous or heterogeneous. Depending on the physical state of mixtures, they can be classified as under: Nature of mixture Constituents of mixture Examples Homogeneous Solid-Solid mixture Alloys (brass, fusible alloy, bronze) Heterogeneous Solid-Solid mixture i) Charcoal and salt ii) Iron and sulphur Homogeneous Solid-Liquid mixture i) Common salt in water ii) Iodine in alcohol Heterogeneous Solid-Liquid mixture i) Sulphur in water ii) Sand in water Homogeneous Liquid-Liquid mixture i) Alcohol in water ii) Petrol in kerosene oil Heterogeneous Liquid-Liquid mixture i) Oil in water ii) Carbon disulphide in water Homogeneous Liquid-Gas mixture i) Sulphur dioxide gas in water ii) Ammonia gas in water Homogeneous Gas-Gas mixture i) Air (oxygen and nitrogen) ii) Hydrogen and ammonia. 2.14 SEPARATION OF MIXTURESPrinciples involved in the separation of components of a mixtureThe method/methods necessary to separate the components of a mixture depend upon:1. The physical state of the constituents of the mixture.2. The difference in one or more physical properties of the constituents of the mixture.Following physical properties are considered in the separation of constituents of a mixture.a) Density of the constituents.b) Melting point and boiling point of the constituents of the mixture.c) Property of volatility of one or more constituents of the mixture.d) Solubility of the constituents of the mixture in various solvents.e) Ability of the constituents of the mixture to sublime.f) Magnetic properties of the constituents of mixture.g) Ability of the constituents of the mixture to diffuse.2.15 SEPARATION OF SOLID SOLID MIXTURESThe various methods or techniques employed in separation of solid-solid mixtures are:1. Magnetic separation2. Gravity Method3. Using solvent4. Fractional crystallization5. Sublimation.I. Magnetic SeparationPhysical property involved in separation: One of the components of the mixture is a magnetic substance (iron, cobalt; nickel and steel or their oxides are magnetic in nature).Example: Let us consider a mixture of iron filings and sulphur. Method:1. Spread the mixture evenly in the form of a thin layer over a piece of paper.2. Place another sheet of paper over the mixture.3. Place a powerful horse shoe magnet over the paper and then lift. Some iron filings will cling to paper.4. Remove the magnet from the paper. The iron filings will fall down.5. Repeat the process a number of times, till all the iron filings are removed.II. Using Gravity MethodPhysical property involved in separation: One of the components is heavier than water, whereas the other components are either lighter or soluble in water.In this method one of the components of mixture is either lighter than the other or is soluble in water. This method is suitable for mixtures given below: Solid-Solid mixture Heavier component Lighter component or soluble component Sand and saw dust sand saw dust (lighter) Salt and sand sand salt (soluble) Charcoal and limestone limestone charcoal (lighter) Method:1. Stir the mixture in water or any other suitable solvent.2. Allow the mixture to stand, so that the heavier component settles down.3. Decant off or filter the water along with lighter or soluble component. III. Using SolventsPhysical property involved in separation: One of the components is soluble, but the other is insoluble in a specific solvent.The following shows the examples of the mixtures that can be separated by the above method. Solid-Solid mixture Solvent Soluble Component Insoluble Component Sand and sulphur Carbon disulphide Sulphur Sand Charcoal and sulphur Carbon disulphide Sulphur Charcoal Sand and wax Turpentine oil Wax Sand Common salt and marble powder Water Common salt Marble powder Nitre and charcoal Water Nitre Charcoal Gun powder (nitre; carbon and sulphur) Water Carbon disulphide Nitre Sulphur Sulphur and carbon Carbon Following is the list of some important solvents and the substance it dissolves Substance Solvent Chlorophyll Methylated spirit Grease Petrol Iodine Ethyl alcohol Nail polish Acetone Nitre Water Oil Petrol Paraffin wax Turpentine oil Phosphorus Carbon disulphide Rust Oxalic acid Rubber Benzene Sulphur Carbon disulphide Shellac Ethyl alcohol Paint Turpentine oil Method:1. Choose the solvent, such that only one particular component of the mixture is soluble in it, and other component is insoluble.2. Dissolve the mixture in a good amount of solvent such that the soluble component of the mixture completely dissolves.3. The above solution is filtered. The insoluble component of the mixture is left on the filter paper. The soluble content collects as filtrate.How to recover the components in the above method?1. The insoluble component is left on filter paper. It is dried either in hot air or in the folds of filter paper.2. The filtrate is evaporated either on slow heat or in the sunlight. The solvent evaporates, leaving behind a soluble component.IV. Fractional CrystallisationPhysical property involved in separation: Both the components are soluble in water, but their solubilities are different, i.e., one is more soluble than the other. Furthermore, they do not sublime. The process of separation of two different soluble substances from their solution by crystallisation at controlled temperature, such that one of the solid crystallises, is called fractional crystallisation.This method is suitable for mixtures mentioned below: Solid-Solid mixture More soluble component Less soluble component Potassium nitrate and sodium chloride Potassium nitrate Sodium chloride Potassium chloride and potassium chlorate Potassium chlorate Potassium chloride Sodium nitrate and sodium chloride Sodium nitrate Sodium chloride Method:1. Choose the solvent (generally water) and warm it to around 60 C.2. Add the mixture in solvent, till it stops dissolving.3. Allow the mixture to cool. Large amount of more soluble solid crystallises out along with some amount of less soluble solid.4. Filter the crystals and re dissolve them in minimum amount of warm solvent.5. Recrystallise the crystals, when large amount of more soluble salt crystallises out.6. Concentrate the filtrate containing less soluble solid. On cooling, the crystals of less soluble solid separate out. V. By SublimationPhysical property involved in separation: One of the components of the mixture sublimes on heating. Solid-Solid mixture Sublimable solid Ammonium chloride and common salt Ammonium chloride Iodine and sand Iodine Iodine and common salt Iodine Sodium sulphate and benzoic acid Benzoic acid Naphthalene and iron filing Naphthalene Method:1. The mixture is placed in a china dish and heated by a low flame.2. An inverted dry funnel is placed over the china dish and its stem is closed with cotton wool.3. The sublimable component of the mixture sublimes and its vapours condense on the sides of the funnel to form fine powder.4. The fine powder (sublimable component) is scrapped from the sides of the funnel.5. The residue left behind is a non-sublimable component. SUMMARY OF TECHNIQUES FOR THE SEPARATION OF SOLID-SOLID MIXTURES Technique employed Physical property involved in separation Examples Magnetic separation One of the components of the mixture is a magnetic substance (iron, cobalt; nickel and steel or their oxides which are magnetic in nature). (i) Separation of iron ore from rocky material (gangue) (ii) Separation of nickel from mixture of nickel and lead. Using gravity One of the components is heavier than water, whereas the other components are either lighter or soluble in water. i) A mixture of sawdust and sand ii) A mixture of common salt and sand. Using solvents One of the components is soluble, but the other is insoluble in a specific solvent. i) Sulphur and sand [sulphur dissolves in carbon disulphide] ii) Ammonium chloride and iodine [ammonium chloride dissolves in water.] Fractional crystallization Both the components are soluble in water, but their solubilities are different, i.e., one is more soluble than the other. Furthermore, they do not sublime. i) Potassium nitrate and sodium chloride. ii) Potassium chlorate and potassium chloride. Sublimation Both the components are soluble in water, but of them one can sublime but not the other, and both the components are insoluble in water. i) Ammonium chloride and common salt. ii) Iodine and sand. 2.16 SEPARATION OF SOLID-LIQUID MIXTURESThe solid-liquid mixtures can be separated by thetechniques like:1. Sedimentation and Decantation2. Filtration3. Evaporation4. Distillation.1. Separation by sedimentation and DecantationSedimentation: The process in which a suspension of insoluble fine particles suspended in a liquid are allowed to stand undisturbed, such that the solid particles settle down, leaving the clear liquid above is called sedimentation.Sediment: The insoluble solid material which settles down when a suspension is allowed to stand undisturbed is called sediment. Supernatant liquid: The clear liquid above the sediment, when a suspension is allowed to stand undisturbed is called supernatant liquid.Decantation: The process of pouring out the clear supernatant liquid above the sediment, thus helping the separation of solid particles from liquid is called decantation.Drawbacks of Decantationi) The constituents of the mixture of a solid and a liquid do not get separated completely.ii) The constituents of a solid lighter than liquid cannot be separated as they float on the surface of liquid, rather than settling down. 2. Separation by FiltrationFiltration: The process of separation of insoluble solid constituent of a mixture from its liquid constituent, by passing it through some porous material is called filtration.Filtrate: The clear liquid obtained from a mixture of a solid and a liquid by the process of filtration is called filtrate.Residue: The insoluble solid constituent left on the filter paper when a mixture of an insoluble solid and a liquid is filtered is called residue.The method of filtration is employed for the following solid-liquid mixtures: Solid-Liquid mixture Residue Filtrate Silver chloride and water Silver chloride Water Barium sulphate and water Barium sulphate Water Chalk and water Chalk Water Method:1. A filter paper generally available in the form of a circular disc is folded to form a cone as illustrated above.2. A glass funnel is moistened with water. The filter paper cone is inserted in the cavity of the funnel and is pressed on the sides. This expels out the air and the filter paper cone sticks tightly to the walls of the funnel.3. The funnel is clamped in an iron stand and under its stem is placed a beaker, such that the wall of the beaker is in contact with the stem of the funnel.4. The suspension of the solid-liquid is poured in the funnel slowly with the help of a glass rod, as shown in the figure.5. The filtrate collects in the beaker. The residue is left on filter paper. The residue is dried either in hot air or in the folds of filter paper. Advantages of Filtration over Sedimentation and Decantation1. It is a quicker process than sedimentation and decantation.2. The insoluble solid is completely removed, which is not possible in the case of decantation.3. Separation by EvaporationThe process of changing a liquid into a gaseous state, below its boiling point by the supply of external heat, is called evaporation.The process of evaporation is suitable for the separation of non-volatile soluble solid from its liquid solvent. This method of evaporation is employed for the following solid-liquid mixtures. Solid-Liquid mixture Non-volatile solid Liquid Common salt and water Common salt Water Sodium sulphate and water Sodium sulphate Water Carbon disulphide and sulphur Sulphur Carbon disulphide Method:1. Heat the sand in an iron vessel by placing it over a tripod stand. This arrangement is called sand bath.2. Take the clear solution of soluble non-volatile substance in a china dish. Place the china dish on the sand bath.3. Heat gently, such that water (liquid) evaporates, but does not boil. Continue heating till liquid completely evaporates.4. When almost dry solid is left, reduce the flame, but go on heating for another five minutes. This helps in forming (i) completely dry solid (ii) will prevent the spurting (jumping out) of solid from the china dish due to excessive heat. Note: Do not heat the mixture of sulphur and carbon disulphide, as carbon disulphide is highly inflammable. Instead, evaporate the solution in sunshine. 4. SEPARATIONBY DISTILLATION:The process of conversion of a liquid into gaseous state on boiling and then re-condensing the gas so formed into liquid by condensation in another vessel, is called distillation.It is used in the situations where the liquid component of solid-liquid mixture is required in pure state. The solid-liquid mixtures which can be separated by distillation are as follows: Solid-Liquid mixture Liquid Non-volatile solid Salt and water (sea water) Pure water Salt Iodine and methyl alcohol Methyl alcohol Iodine Iodine and chloroform Chloroform Iodine Method:1. The solid-liquid mixture is placed in a distillation flask. The distillation flask is connected to Liebigs condenser, at the end of which is placed a receiver to collect distilled liquid (distillate) as shown in figure.2. When the distillation flask is heated, the liquid starts boiling. The vapour of the liquid passes through the Liebig condenser, where they condense to form the liquid. The liquid so formed trickles into the receiver.3. The solid component of mixture forms residue in the flask. SUMMARY OF SEPARATION TECHNIQUES OF SOLID-LIQUID MIXTURES Technique employed for separation of mixture Physical property involved in separation Examples Sedimentation and Decantation One of the components is heavier than the liquid and is insoluble. Muddy water. Water containing sand. Filtration One of the components is a solid and is insoluble in the liquid. Silver chloride precipitates in water. Barium sulphate precipitates in water. Evaporation One of the components is nonvolatile. It may or may not be soluble in water. Common salt solution, sodium sulphate solution. Distillation One of the components is soluble solid in the liquid. Iodine in chloroform. 2.17 SEPARATION OF LIQUID -LIQUID MIXTURESThe liquid-liquid mixtures can be separated by the techniques given below:1. Separating funnel 2. Fractional distillation1. Separation of liquid-liquid mixtures by separating funnelSeparating funnel is a long glass tube provided with a tap as shown. The liquid-liquid mixture of immiscible components is poured into the funnel and allowed to stand. The liquids separate out on account of difference in their densities. Immiscible liquid-liquid mixture Heavier liquid Lighter liquid Benzene and water Water Benzene Kerosene oil and water Water Kerosene oil Turpentine oil and water Water Turpentine oil Carbon disulphide and water Water Carbon disulphide Chloroform and water Chloroform Water Mercury and alcohol Mercury Alcohol Method:1. The tap of the separating funnel is closed. The separating funnel is clamped in the vertical position in an iron stand.2. The immiscible liquid-liquid mixture is poured into the separating funnel. The mixture is allowed to stand for half an hour or more.3. The immiscible components of the mixture separate out into two distinct layers. The heavier and denser liquid forms the lower layer. The lighter and less dense liquid forms the upper layer. 4. A conical flask is placed under the nozzle of separating funnel. The tap is gently opened so that the heavier liquid trickles in to the flask drop by drop. Once the denser liquid is drained out, the tap is closed.5. Another conical flask is placed under the nozzle of separating funnel. The tap is opened to drain the lighter liquid. 2. Separation of liquid-liquid mixtures by fractional distillationIn case two liquids have very close boiling points, both the liquids tend to distil over in different proportions. It means lesser the boiling point of a liquid, the more is the proportion of its distilling over. The above problem can be avoided by using a fractionating column. It gives the effect of repeated distillation by offering resistance to the passage of vapours.The process of separation of two miscible liquids by the process of distillation, making use of their difference in boiling points, is called fractional distillation. This process is useful only if the difference in the boiling points of the two miscible liquids is between 10C to 20C or more.Table given shows various miscible liquids, which can be separated by fractional distillation. Miscible liquid-liquid mixture Component which distils over EthylalcoholB.P=78C+WaterB.P=100C Ethyl alcohol MethylalcoholB.P=64.5C+EthylalcoholB.P=78C Methyl alcohol EthylalcoholB.P=78C+ChloroformB.P=61C Chloroform AcetoneB.P=56.5C+WaterB.P=100C Acetone AcetoneB.P=56.5C+EthylalcoholB.P=78C Acetone Method:1. The process of fractional distillation is similar to the process of distillation, except that afractionating column is attached in fractional distillation.2. The design of a fractionating column is such that the vapour of one liquid (with a higher boiling point) is preferentially condensed as compared to the vapour of the other liquid (with lower boiling point)3. Thus, the vapours of the liquid with low boiling point pass on to Liebigs condenser where they condense. The liquid so formed is collected in the receiver. 4. The thermometer shows a constant reading as long as the vapour of oneliquid are passing to Liebigs condenser. As soon as the temperature starts rising, the receiver is replaced by another receiver to collect the second liquid. SUMMARY OF TECHNIQUES USED IN THE SEPARATION OF LIQUID-LIQUID MIXTURES Technique employed Physical property involved Examples 1. Separating funnel The liquid components i) do not dissolve in one another (immiscible) ii) have different densities 1. Kerosene oil and water. 2. Carbon disulphide and water 2. Fractional distillation The liquid components i) dissolve in each other (miscible) ii) have different boiling points 1. Ethyl alcohol (b.p. 78C) and water (b.p. 100C) 2. Methyl alcohol (64.5C) and acetone (b.p. 56.5C) 2.18 SEPARATION OF LIQUID-GAS MIXTURESThe solution of a gas in water (liquid) is called liquid-gas mixture. The separation of gas from water is based on the principle that solubility of a gas decreases with the rise in temperature. Following gases can be separated from a liquid-gas mixture. Liquid-Gas mixture Liquid-Gas mixture Air-water mixture Air Carbon dio xide-water mixture Carbon dioxide Sulph ur d ioxide-water mixture Sulphur dioxide Method:1. The liquid-gas mixture is filled in a flask and the apparatus is set up as shown in figure.2. On heating gently (do not boil), the solubility of gas decreases. The bubbles of gas collect over water.Note: Mixture of ammonia in water or HCl gas in water cannot be separated by this process because of their extreme solubility in water.2.19. SEPARATION OF GAS-GAS MIXTURESThe various techniques used in the separation of gasgas mixtures is as follows:1. Diffusion2. Dissolution in a suitable solvent3. Preferential liquefaction4 Fractional evaporation of mixture of liquefied gases.I. Separation of a gas-gas mixture by diffusionThe rate of diffusion of any gas through a porous partition is inversely proportional to the square root of its vapour density (or molecular weight). Thus, if a mixture of two gases of different densities is passed through porous partitions, then the lighter gas (having less vapour density) will diffuse out more rapidly than the heavier gas.The various gaseous mixtures that can be separated by diffusion are as follows: Gas-Gas mixture Lighter component of gas which diffuses out first Carbon dioxide and hydrogen Hydrogen Sulphur dioxide and nitrogen Nitrogen Carbon monoxide and carbon dioxide Carbon monoxide Ammonia and nitrogen Ammonia Method:If a mixture of carbon dioxide and hydrogen is passed through a long tube having a number of porous partitions, hydrogen molecules will diffuse more rapidly as compared to carbon dioxide molecules.Thus, if there are a sufficient number of partitions, in the end hydrogen comes out, as illustrated in figures.II. Separation of gas-gas mixture by dissolution in suitable solventsThe constituents of two gases can be separated if1. One of the constituents is soluble in some particular liquid (generally water).2. One of the constituents reacts chemically with a liquid from which the constituent can be recovered by chemical action. Gas-Gas mixture Solvent used Soluble gas Insoluble gas N_2andCO_2 KOH solution CO_2 N_2 NH_3andN_2 Water NH_3 N_2 Cl_2andHCl Water HCl Cl_2 SO_2andO_2 KOH solution SO_2 O_2 Method: Let us imagine there is a mixture of nitrogen and carbon dioxide gas.1. Pass the mixture slowly through potassium hydroxide solution contained in a conical flask. Carbon dioxide reacts with KOH solution chemically to form potassium hydrogen carbonate. However, nitrogen, being insoluble, bubbles out.2. Collect nitrogen over water, as shown in figure3. The carbon dioxide can be recovered from potassium hydrogen carbonate solution, by treating it with dilute hydrochloric acid. III. Separation of gas-gas mixture by preferential liquefactionThis method is generally employed for industrial separation of a homogeneous mixture of two gases, such that one of the components of the mixture under high pressure liquefies when the gases are suddenly allowed to expand. The component which escapes on liquefaction is separated from the other component.For example, when a mixture of hydrogen and ammonia under a very high pressure is suddenly allowed to expand in another vessel, the ammonia liquefies and separates from hydrogen. Mixture of gases Component which liquefies Ammonia + nitrogen Ammonia Sulphur dioxide + oxygen Sulphur dioxide Chlorine + nitrogen Chlorine Carbon dioxide + oxygen Carbon dioxide Carbon monoxide + carbon dioxide Carbon dioxide IV. Separation by fractional evaporation of liquefied mixture of two gasesSometimes, when a mixture of two gases under extremely high pressure is allowed to expand, both the gases liquefy. For example, when cold air under very high pressure is suddenly allowed to expand, both the constituents of air, i.e., nitrogen and oxygen liquefy.The boiling point of liquid oxygen is 183 C and that of liquid nitrogen is 196 C.When the above liquid is maintained at 196 C, nitrogen starts boiling to produce nitrogen gas. It is collected separately. Oxygen is left in liquid state as it does not boil off. Components of liquefied gas Component which boils off Hydrogen and oxygen Hydrogen Sulphur dioxide and chlorine Sulphur dioxide SUMMARY OF THE TECHNIQUES OF SEPARATION OF GAS-GAS MIXTURES Technique employed for the separation of gas-gas mixture Physical property involved in separation Examples Diffusion The rate of diffusion of less dense gas (lighter gas) is higher as compared to a heavier gas. Hydrogen and carbon dioxide; Nitrogen and chlorine. Dissolution in a suitable solvent One of the components of gas is soluble in a particular solvent. Ammonia and hydrogen; HCl gas and chlorine Preferential liquefaction One of the gaseous components can be easily liquefied as compared to other components. Chlorine and oxygen; Carbon dioxide and hydrogen Fractional evaporation of mixture of liquefied gases. The component of liquefied gas having lower boiling point evaporates first. Liquefied air; Liquefied nitrogen and hydrogen gases. Updated on April 14, 2021 Matter in our SurroundingsAtoms and Molecules

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