Matters-1

Matter- Matter is anything which occupies space and has mass is called matter. Air and water, sugar and sand, hydrogen and oxygen etc. Matter is made up of very small tiny particles. Particles of matter have space between them they attract each other.

Forms of Matter

- Matter can be classified as solid, liquid and gas on the basis of interparticle forces and the arrangement of particles.
- These three forms of matter are interconvertible by increasing or decreasing pressure and temperature. For example, ice can be converted from solid to a liquid by increasing the temperature.

Property	**Solid**	**Liquid**	**Gas**
Shape and volume	Fixed shape and volume	No fixed shape but has volume	Neither definite shape nor volume
Energy	Lowest	Medium	Highest
Compressibility	Difficult	Nearly difficult	Easy
Arrangement of molecules	Regular and closely arranged	Random and little sparsely arranged	Random and more sparsely arranged
Fluidity	Cannot flow	Flows from higher to lower level	Flows in all directions
Movement	Negligible	Depends on interparticle attraction	Free, constant and random
Interparticle space	Very less	More	Large
Interparticle attraction	Maximum	Medium	Minimum
Density	Maximum	Medium	Minimum
Rate of diffusion	Negligible	It depends on interparticle attraction.	Maximum

Plasma

Plasma state is the 4th state of matter..
It is an ionized gas , a gas into which sufficient energy is provided to free electrons from atoms or molecules and to allow both species i.e. ions or electrons to co-exist.

Plasma is superheated matter – so hot that the electrons are ripped away from the atoms forming an ionized gas. It comprises over 99% of the visible universe. In the night sky, plasma glows in the form of stars, nebulas, and even the auroras that sometimes ripple above the north and south poles. That branch of lightning that cracks the sky is plasma, so are the neon signs along our city streets. And so is our sun, the star that makes life on earth possible.

Plasma is often called "the fourth state of matter," along with solid, liquid and gas. Just as a liquid will boil, changing into a gas when energy is added, heating a gas will form a plasma – a soup of positively charged particles (ions) and negatively charged particles (electrons).

Because so much of the universe is made of plasma, its behavior and properties are of intense interest to scientists in many disciplines. Importantly, at the temperatures required for the goal of practical fusion energy, all matter is in the form of plasma. Researchers have used the properties of plasma as a charged gas to confine it with magnetic fields and to heat it to temperatures hotter than the core of the sun. Other researchers pursue plasmas for making computer chips, rocket propulsion, cleaning the environment, destroying biological hazards, healing wounds and other exciting applications.

BEC

BEC (Bose Einstein Condensate) is a state of matter of a dilute gas of bosons cooled to temperature very closed to absolute zero .
Under such a conditions , a large fraction of bosons occupy the lowest quantum state , at which point macroscopic quantum phenomena become apparent.

- Discovered in 1995, Bose-Einstein condensates were made with the help of the advancements in technology.
- At the said temperature, the motion of the molecules becomes negligible. As this brings down the kinetic energy, the atoms no longer stay separate, but they begin to clump together. As the atoms join together they form a super-atom.
- Light slows down as it passes through a BEC helping scientists to study more about the nature of light as a wave and particle.
- BEC's also show properties of a super fluid which implies, it flows without friction

Pure Matter

A matter is called to be in the pure form if it is made up of just one type of molecules or particles. Pure matters normally cannot be separated by the means of simple physical methods and are widely classified as elements and compounds. An element contains only one kind of particles that can be atoms or molecules. Similarly, compounds are pure matters when they consist of two or more elements that are combined in a fixed proportion by their weight.

Additionally, pure compounds are easily decomposed to separate elements by using several suitable chemical methods.

Characteristics of Pure Matter

Let us now look at some of the characteristics of pure matter.

1. Pure matters have a perfectly homogeneous nature.
2. Pure matters are made up of only one type of atoms or molecules.
3. Pure matters have a fixed composition.
4. Pure matters have a fixed density, melting point, boiling point etc.

Impure Matter

A matter which is composed of different types of elements or molecules it is called to be impure. These kinds of matters are often known to be as mixtures. Mixtures are further classified as either homogenous mixtures or heterogeneous mixtures based on their composition. They are mostly made pure by using different kinds of separation techniques.

Characteristics of Impure Matter

Let us look at the characteristics of impure matter now.

1. Impure matters do not have any specific properties. The properties of the resulting mixture are a result of the average properties of all its constituents.
2. Impure matters are formed when there is a physical change.
3. Impure matters have a variable composition.
4. The mixtures of the impure matters are either homogeneous or heterogeneous in nature.

Properties of Compounds

Properties of Compounds:

1. They have a fixed composition.
2. They have definite properties.
3. They cannot be separated physically.

Property	**Ionic Compounds**
Type of elements	Metal and nonmetal
Bonding	Ionic - transfer of electron(s) between atoms
Representative unit	Formula unit
Physical state at room temperature	Solid
Water solubility	Usually high
Melting and boiling temperatures	Generally high
Electrical conductivity	Good when molten or in solution

Matters-2&3

Physical and Chemical change in Matter

- Physical changes only change the appearance of a substance, not its chemical composition.
- Chemical changes cause a substance to change into an entirely substance with a new chemical formula.
- Chemical changes are also known as chemical reactions. The "ingredients" of a reaction are called reactants, and the end results are called products.

Physical Changes

Another way to think about this is that a physical change does not cause a substance to become a fundamentally different substance but a chemical change causes a substance to change into something chemically new. Blending a smoothie, for example, involves two physical changes: the change in shape of each fruit and the mixing together of many different pieces of fruit. Because none of the chemicals in the smoothie components are changed during blending (the water and vitamins from the fruit are unchanged, for example), we know that no chemical changes are involved.

Blending a smoothie involves physical changes but no chemical changes.

Cutting, tearing, shattering, grinding, and mixing are further types of physical changes because they change the form but not the composition of a material. For example, mixing salt and pepper creates a new substance without changing the chemical makeup of either component.

Phase changes are changes that occur when substances are melted, frozen, boiled, condensed, sublimated, or deposited. They are also physical changes because they do not change the nature of the substance.

Chemical Changes

Chemical changes are also known as chemical reactions. The "ingredients" of a reaction are called the reactants, and the end results are called the products. The change from reactants to products is signified by an arrow:

Reactants → Products

The formation of gas bubbles is often the result of a chemical change (except in the case of boiling, which is a physical change). A chemical change might also result in the formation of a precipitate, such as the appearance of a cloudy material when dissolved substances are mixed.

Rotting, burning, cooking, and rusting are all further types of chemical changes because they produce substances that are entirely new chemical compounds. For example, burned wood becomes ash, carbon dioxide, and water. When exposed to water, iron becomes a mixture of several hydrated iron oxides and hydroxides. Yeast carries out fermentation to produce alcohol from sugar.

An unexpected color change or release of odor also often indicates a chemical change. For example, the color of the element chromium is determined by its oxidation state; a single chromium compound will only change color if it undergoes an oxidation or reduction reaction. The heat from cooking an egg changes the interactions and shapes of the proteins in the egg white, thereby changing its molecular structure and converting the egg white from translucent to opaque.

Tyndall Effect

Tyndall effect also called **Tyndall phenomenon**, scattering of a beam of light by a medium containing small suspended particles—e.g., smoke or dust in a room, which makes visible a light beam entering a window.

The Tyndall effect is the phenomenon in which the particles in a colloid scatter the beams of light that are directed at them. This effect is exhibited by all colloidal solutions and some very fine suspensions. Therefore, it can be used to verify if a given solution is a colloid. The intensity of scattered light depends on the density of the colloidal particles as well as the frequency of the incident light.

When a beam of light passes through a colloid, the colloidal particles present in the solution do not allow the beam to completely pass through. The light collides with the colloidal particles and is scattered (it deviates from its normal trajectory, which is a straight line). This scattering makes the path of the light beam visible, as illustrated below.

Examples of the Tyndall Effect

- Milk is a colloid that contains globules of fat and protein. When a beam of light is directed at a glass of milk, the light is scattered. This is a great example of the Tyndall effect.
- When a torch is switched on in a foggy environment, the path of the light becomes visible. In this scenario, the water droplets in the fog are responsible for the light scattering.
- Opalescent glass has a bluish appearance when viewed from the side. However, orange-colored light emerges when light is shined through the glass.

Solution, Suspension & Colloids

- A solution is always transparent, light passes through with no scattering from solute particles which are molecule in size. The solution is homogeneous and does not settle out. A solution cannot be filtered but can be separated using the process of distillation.
- A suspension is cloudy and heterogeneous. The particles are larger than 10,000 Angstroms which allows them to be filtered. If a suspension is allowed to stand the particles will separate out.
- A colloid is intermediate between a solution and a suspension. While a suspension will separate out a colloid will not. Colloids can be distinguished from solutions using the Tyndall effect. Light passing through a colloidal dispersion, such as smoky or foggy air, will be reflected by the larger particles and the light beam will be visible. A hydrocolloid can simply be defined as a substance that forms a gel when it comes in contact with water. Such substances include both polysaccharides and proteins .

Solutions	**Colloids**	**Suspensions**
Homogeneous	Heterogeneous	Heterogeneous
Particle size: 0.01-1 nm; atoms, ions, or molecules	Particle size: 1-1000 nm, dispersed; large molecules or aggregates	Particle size: over 1000 nm, suspended; large particles or aggregates
Do not separate on standing	Do not separate on standing	Particles settle out
Cannot be separated by filtration	Cannot be separated by filtration	Can be separated by filtration
Do not scatter light	Scatter light (Tyndall effect)	May either scatter light or be opaque

Terms Related to Solution

Solution, is a homogenous mixture of two or more substances in relative amounts that can be varied continuously up to what is called the limit of solubility. The term solution is commonly applied to the liquid state of matter, but solutions of gases and solids are possible. Air, for example, is a solution consisting chiefly of oxygen and nitrogen with trace amounts of several other gases, and brass is a solution composed of copper and zinc.

There are several ways to express the amount of solute present in a solution

Concentration Solution

The **concentration** *of a solution is a measure of the amount of solute that has been dissolved in a given amount of solvent or solution*. A **concentrated solution** *is one that has a relatively large amount of dissolved solute.*

Dilute solution

Concentrated solution	Dilute solution
A liquid with a high solute concentration is called a concentrated solution.	A liquid with a less solute concentration is called a dilute solution.
The solution becomes more concentrated as more solute is applied to a solution	The dissolved salt from a well in the drinking water is a dilute solution.
There is a significant amount of water in a concentrated solution.	By adding more water, the concentration of a solution can be further decreased and diluted

A **dilute solution** *is one that has a relatively small amount of dissolved solute*.

Saturated and Unsaturated solution

Unsaturated solution: The solution is unsaturated when it can still dissolve more solute.
Saturated solution: The solution is saturated when it can not dissolve further more solute.

Saturated solution

A chemical solution containing maximum amount of solute present in the solvent is called saturated solution. Saturated solution can dissolve no more of the solute.
Saturation point of any liquids depends on nature of the substance and temperature.

Unsaturated solution

A solute must be added to a solvent in order for a solution to form. At first, the solute dissolves in a solvent and forms a homogeneous solution. A solution in which solutes dissolve is referred to as an unsaturated solution. A solution is made up of two types of particles: solutes and solvents. Water is commonly used as a solvent (which is one of the reasons why water is also called the universal solvent).

examples of Unsaturated Solutions:

- Salt or sugar dissolved in water below the saturation point.
- Air or mist.
- Iced coffee.
- Vinegar is the acetic acid solution in water.

Solubilty

The solubility product is a kind of equilibrium constant and its value depends on temperature. Solubility is defined as a ***property of a substance called solute to get dissolved in a solvent in order to form a solution.*** The solubility of ionic compounds (which disassociate to form cations and anions) in water varies to a great deal. Some compounds are highly soluble and may even absorb moisture from the atmosphere whereas others are highly insoluble.

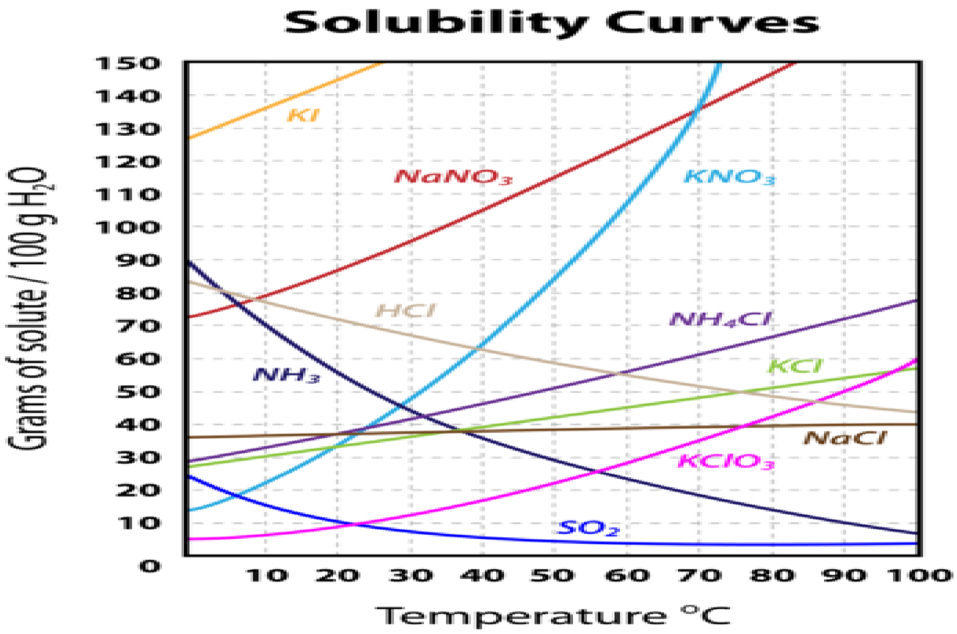
- When a salt is dissolved in a solvent the strong forces of attraction of solute (lattice enthalpy of its ions) must be overcome by the interactions between ions and the solvent.
- The solvation enthalpy of ions is always negative which means that energy is released during this process.
- The nature of the solvent determines the amount of energy released during solvation that is solvation enthalpy.
- Non-polar solvents have a small value of solvation enthalpy, meaning that this energy is not sufficient to overcome the lattice enthalpy.
- So the salts are not dissolved in non-polar solvents. Hence, for salt to be dissolved in a solvent, its solvation enthalpy should be greater than its lattice enthalpy.
- Solubility depends on temperature and it is different for every salt.

Salts are classified on the basis of their solubility in the following table.

Category I	Soluble	Solubility > 0.1M
Category II	Slightly soluble	0.01M< Solubility<0.1M
Category III	Sparingly soluble	Solubility < 0.1M

Effect of temperature on solubility

The **solubility** of a substance is the amount of that substance that is required to form a saturated solution in a given amount of solvent at a specified temperature. Solubility is often measured as the grams of solute per 100 g of solvent. The solubility of sodium chloride in water is 36.0 g per 100 g water at 20°C. The temperature must be specified because solubility varies with temperature. For gases, the pressure must also be specified. Solubility is specific for a particular solvent. We will consider solubility of material in water as solvent.The solubility of the majority of solid substances increases as the temperature increases. However, the effect is difficult to predict and varies widely from one solute to another. The temperature dependence of solubility can be visualized with the help of a **solubility curve** , a graph of the solubility vs.temperature



Separation of Mixtures

Not everyone is out searching for gold (and not many of those searchers is going to get much gold, either). In a chemical reaction, it is important to isolate the component(s) of interest from all the other materials so they can be further characterized. Studies of biochemical systems, environmental analysis, pharmaceutical research – these and many other areas of research require reliable separation methods.
Here are a number of common separation techniques:

Chromatography

Chromatography is the separation of a mixture by passing it in solution or suspension or as a vapor (as in gas chromatography) through a medium in which the components move at different rates. Thin-layer chromatography is a special type of chromatography used for separating and identifying mixtures that are or can be colored, especially pigments.

Distillation

Distillation is an effective method to separate mixtures comprised of two or more pure liquids. Distillation is a purification process where the components of a liquid mixture are vaporized and then condensed and isolated. In simple distillation, a mixture is heated and the most volatile component vaporizes at the lowest temperature. The vapor passes through a cooled tube (a condenser), where it condenses back into its liquid state. The condensate that is collected is called distillate.

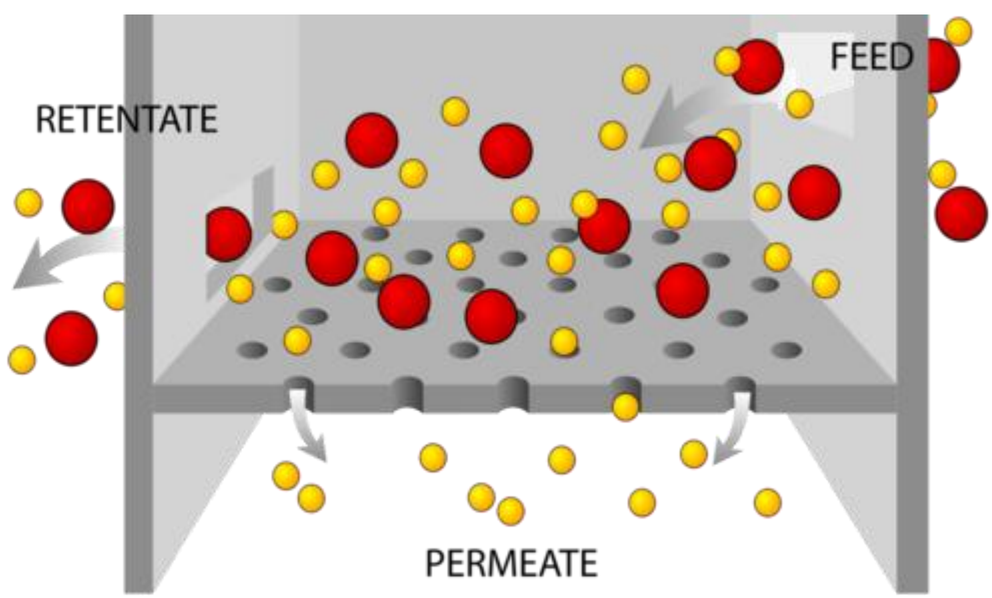
Evaporation

Evaporation is a technique used to separate out homogenous mixtures where there is one or more dissolved solids. This method drives off the liquid components from the solid components. The process typically involves heating the mixture until no more liquid remains, Prior to using this method, the mixture should only contain one liquid component, unless it is not important to isolate the liquid components. This is because all liquid components will evaporate over time. This method is suitable to separate a soluble solid from a liquid.

In many parts of the world, table salt is obtained from the evaporation of sea water. The heat for the process comes from the sun

Filtration

Filtration is a separation method used to separate out pure substances in mixtures comprised of particles some of which are large enough in size to be captured with a porous material. Particle size can vary considerably, given the type of mixture. For instance, stream water is a mixture that contains naturally occurring biological organisms like bacteria, viruses, and protozoans. Some water filters can filter out bacteria, the length of which is on the order of 1 micron. Other mixtures, like soil, have relatively large particle sizes, which can be filtered through something like a coffee filter.



Matters-4

Separation of Mixture

Crystallization

Crystallization is a technique used for the purification of substances. A separation technique to separate solids from a solution.

Crystallization can be defined as the process through which the atoms/molecules of a substance arrange themselves in a well-defined three-dimensional lattice and consequently, minimize the overall energy of the system. When a substance is subjected to crystallization, its atoms or molecules bind together through well-defined angles.

On adding a solid substance in a liquid and stirring it, the solid dissolves in the fluid. But when added more and more solid to the liquid, a point comes after which no more solid dissolves in the liquid. This point is called a saturation point and the fluid is called a saturation solution.

Crystallization Process

1. The solution is heated in an open container
2. The solvent molecules start evaporating, leaving behind the solutes
3. When the solution cools, crystals of solute start accumulating on the surface of the solution
4. Crystals are collected and dried as per the product requirement
5. The undissolved solids in the liquid are separated by the process of filtration
6. The size of crystals formed during this process depends on the cooling rate
7. Many tiny crystals are formed if the solution is cooled at a fast rate
8. Large crystals are formed at slow cooling rates

Sublimation

The process of sublimation is used to separate the components of a mixture that possesses one sublimable volatile component and a non- sublimable component often referred to as the impurity. Let us briefly understand the procedure of separation by Sublimation process:

• To separate the mixture of salt and ammonium chloride, take this mixture in a china dish.
• Then place an inverted funnel on the china dish with its end plugged with cotton so as to prevent the fumes of volatile components from escaping.
• Heat this mixture for some time.
• The sublime ammonium chloride vapourises and then cools and gets deposited back as solid on the inner walls of the funnel.

Two immiscible liquids

When two immiscible liquids (an oil and an aqueous phase), often of low viscosity, are agitated a system is created having dispersed liquid droplets in a continuous liquid phase. Such a situation is often created in solvent extraction units where a high interfacial area between the two immiscible liquid phases is necessary to achieve interphase mass transfer. Thus agitation is used to create conditions favorable for mass transfer and if stirring is stopped, the two phases will separate, leading to a greatly reduced interfacial area. Again, the term 'mixing' is seen to include mass transfer considerations

.Examples:

- Water and Hydrocarbon Solvents
- Water and Oil
- Methanol and Hydrocarbon Solvents

Fractional Distillation

Fractional distillation is a type of distillation which involves the separation of miscible liquids. The process involves repeated distillations and condensations and the mixture is usually separated into component parts. The separation happens when the mixture is heated at a certain temperature where fractions of the mixture start to vaporize.

The basic principle of this type of distillation is that different liquids boil and evaporate at different temperatures. So when the mixture is heated, the substance with lower boiling point starts to boil first and convert into vapours.

Fractional Distillation Process

Different-sized hydrocarbons have different boiling points. Fractional distillation separates hydrocarbons using their different boiling points. The steps of the process are:

- Evaporation
  - Crude oil is heated until it evaporates.
  - Crude oil vapour is put into a fractionating column at the bottom and rises upwards.
- Condensation
  - The temperature is highest at the bottom of the column. Long-chain hydrocarbons condense at the bottom and are collected as liquids.
  - Short-chain hydrocarbons have lower boiling points. They pass up the column and condense at lower temperatures nearer the top.
- Collection
  - The fractions are collected. They are then processed to create end products:
  - Fuels (e.g. petrol, diesel) are a common end product.
  - The petrochemical industry can use some fractions as feedstock (material used in an industrial process) to make solvents, lubricants, detergents etc

Separation Gases from Air

Air is a homogeneous mixture of gases. It consists of gases like nitrogen, oxygen, carbon dioxide, argon, etc. in different proportion. Since it is a homogeneous mixture, we need special separation techniques. Fractional distillation is the technique that is used for obtaining different components from the air.

Fractional distillation is a separation method where the difference in boiling points of components is used to separate the liquid mixture into fractions through distillation. The process begins with the

liquefaction of air. Let's try to understand the process with the help of an illustration of separation of nitrogen from the air.

In order to obtain nitrogen gas from air, we need to remove the rest of the constituents of air. Before we start, air is filtered to remove the dust particles and then liquefied.

Step 1:Conversion of air into liquid air

The air which is in gaseous form is converted into liquid air. This is done under high pressure. Under high pressure, the air is compressed and then cooled by reducing the temperature. This results in liquid air.

Step 2:Fractional Distillation

The liquid air is then passed through the fractional distillation column. Here, the liquid air is allowed to warm-up. The bottom of the fractionating column is warmer than the top. Each gas starts to separate at different temperatures according to its boiling point.

Nitrogen has a boiling point of -196°C while oxygen has -183°C. The nitrogen gas will start to escape through the outlet and it is collected. The liquid oxygen will be collected in the fractionating column.

Centrifugation

This principle helps in the separation of particles using centrifugation. Though most liquid mixtures can be separated by the filtration method, yet there are some liquid mixtures in which the solid particles are very small and thus can easily pass through the filter paper. It is not possible to separate such particles by filtration technique. In such cases, centrifugation is a useful method.

Let's have a look at the procedure of separation using centrifugation.

- To separate cream from milk, first take some full-cream milk in a test tube.
- Then, centrifuge the tube in a centrifuging machine for about two minutes. In the absence of a centrifuging machine, a mixer-grinder can also be used.

The lighter fat particles form cream at the surface while the heavier particles of the milk settle down at the bottom. This is how the cream is separated out from the milk.

Centrifugation has several other important applications:

• This technique is employed in diagnostic laboratories for blood and urine tests.
• In dairies and homes, centrifugation helps to separate butter from cream.
• This technique is also utilized in washing machines to squeeze out water from wet clothes.
• In laboratories and industries, centrifugation helps in separating suspended impurities from liquids.

Water purification

for human consumption purposes consists in the removal of different contaminants as chemicals (i.e., pollutants, toxic metals), biological contaminants (algae, bacteria, fungi, parasites, viruses), suspended solids, and gases.

There are several methods used in the water purification process, which include: (1) physical processes, such as filtration, sedimentation, or distillation; (2) biological processes, such as sand filters, active carbon; (3) chemical processes, such as flocculation, chlorination, the use of ultraviolet light.

OTHER METHODS:

Prefiltration

1) The uptake of water from surface waters or groundwater and storage in reservoirs. Aeration of groundwater and natural treatment of surface water usually take place in the reservoirs. Often softening and pH-adjustments already happen during these natural processes.

2) Rapid sand filtration or in some cases microfiltration in drum filters.

b: Addition of chemicals

3) pH adjustment through addition of calcium oxide and sodium hydroxide.

4) $FeCl_3$ addition to induce flocculation for the removal of humic acids and suspended particulate matter, if necessary with the addition of an extra flocculation aid. Flocs are than settled and removed through lamellae separators. After that the flocs are concentrated in sludge and pumped to the exterior for safe removal of the particulates and sludge dewatering.

5) Softening in a reservoir, through natural aeration or with sodium hydroxide, on to 8,5 $^{\circ}$D. This is not always necessary. For instance, in case natural filtration will be applied, softening takes place naturally.

c: Natural filtration

6) Infiltration of the water in sand dunes for natural purification. This is not applied on all locations The water will enter the saturated zone where the groundwater is located and it will undergo further biological purification. As soon as it is needed for drinking water preparation, it will be extracted through drains.

d: Disinfection

7) Disinfection with sodium hypochlorite or ozone. Usually ozonation would be preferred, because ozone not only kills bacteria and viruses; it also improves taste and odour properties and breaks down micro pollutants. Ozone diffuses through the water as small bubbles and enters microrganisms cells by diffusion through cell walls. It destroys microrganisms either by disturbance of growth or by disturbance of respiratory functions and energy transfers of their cells. During these processes ozone is lost according to the reaction O_3 -> O_2 +(O).

e: Fine filtration

8) Slow sand (media) filtration for the removal of the residual turbidity and harmful bacteria. Sand filters are backwashed with water and air every day.
9) Active carbon filtration for further removal of matter affecting taste and odour and remaining micro pollutants.