
Water
Done by-
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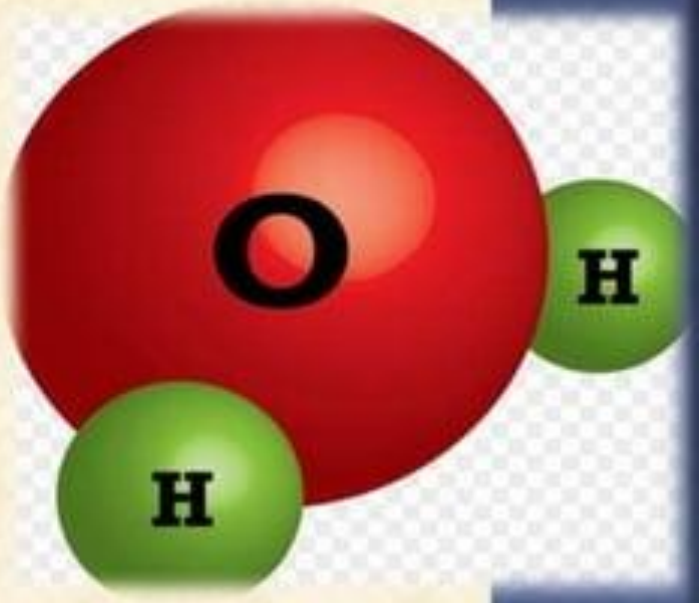
WHY IS COMPOUND CONSIDERED A COMPOUND?

- Water is a considered a compound, as it is a combination of two hydrogen atoms and one oxygen atom. Water is also considered an amphoteric, meaning it acts both as an acid and a base as it produces H+ and OH- ions by self-ionisation.



AS A CHEMICAL COMPOUND, ITS PROPERTIES ARE:

- In a water molecule, hydrogen and oxygen are combined in a fixed ratio by mass (1:8).
- Components cannot be separated by physical means.
- It has a definite and constant composition.
- It has definite and constant melting point, boiling point, freezing point and density.
- Properties of water are different from properties of constituent elements.
- Water can react with metals to form the corresponding hydroxides. The ease with which the reaction occurs depends on the position of the metal in the reactivity series.

WHY IS WATER CALLED AN UNIVERSAL SOLVENT?

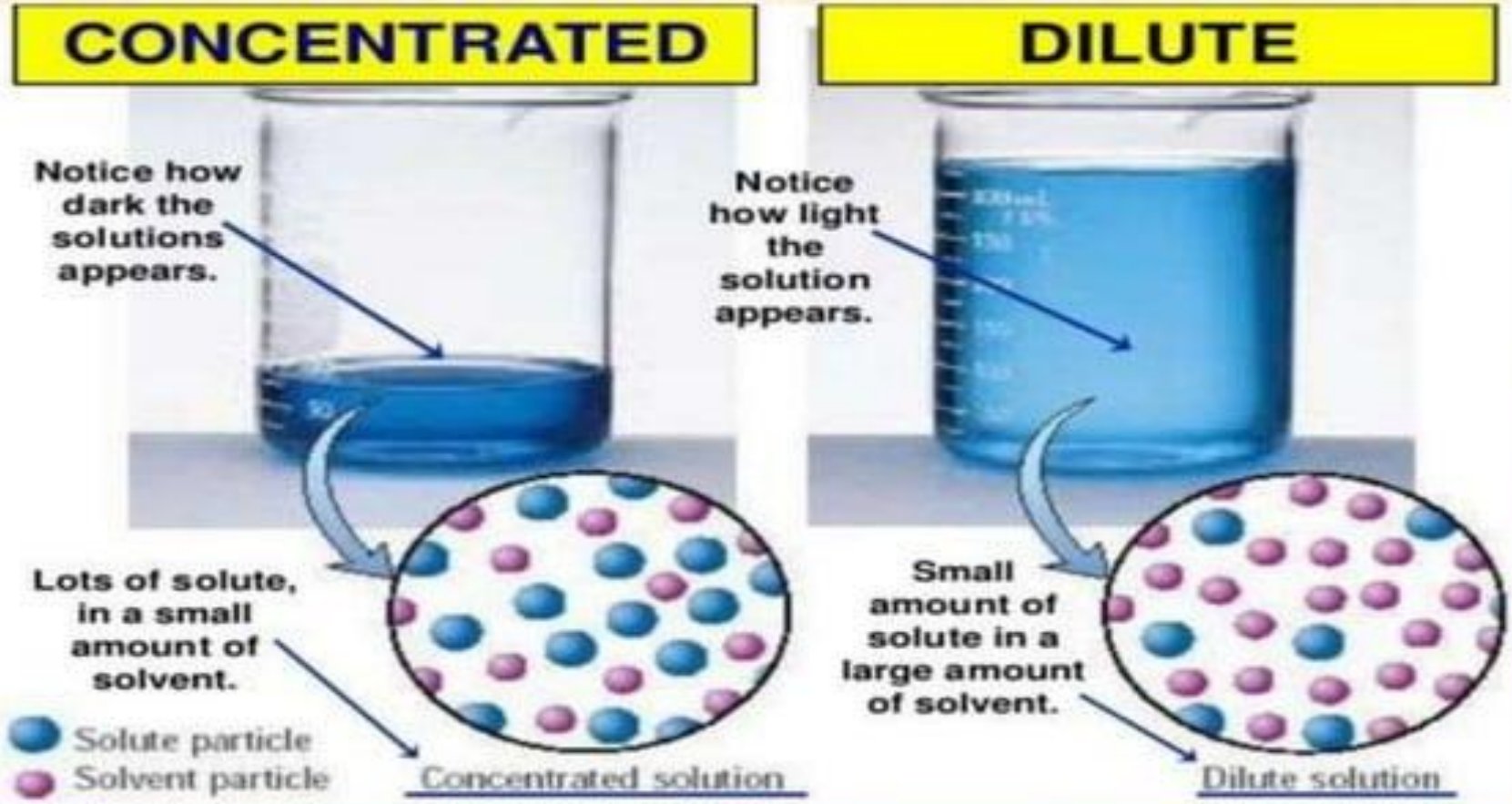
- Water is called the universal solvent since it is capable of dissolving a variety of different substances more than any other liquid.
- From a biological point of view, this is important for living organisms, as water is capable of transporting nutrients and minerals from the surrounding elements into their bodies and inside their bodies as well.
- Water can dissolve more substances than any other compound because of its polar nature. The water molecules because of their composition – hydrogen with a positive charge on one side and oxygen with a negative charge on another, are able to attract other molecules easily.
- https://www.youtube.com/watch?v=PXdbwMc4d0M

IMPORTANT TERMS:-

- A solvent is a liquid that dissolves a solid, liquid or gaseous solute.
- A solute is a substance dissolved in another substance.
- A solute and a solvent make up a solution
- The solute is usually present in a smaller amount than the solvent.
- An example of this would be dissolving a teaspoon of table salt (NaCl) in water (H_2O). Water is the solvent and the salt is the solute and together they make a salt (saline) solution. Water is the most comment solvent on earth.
- https://www.youtube.com/watch?v=e-2EoyDYamg

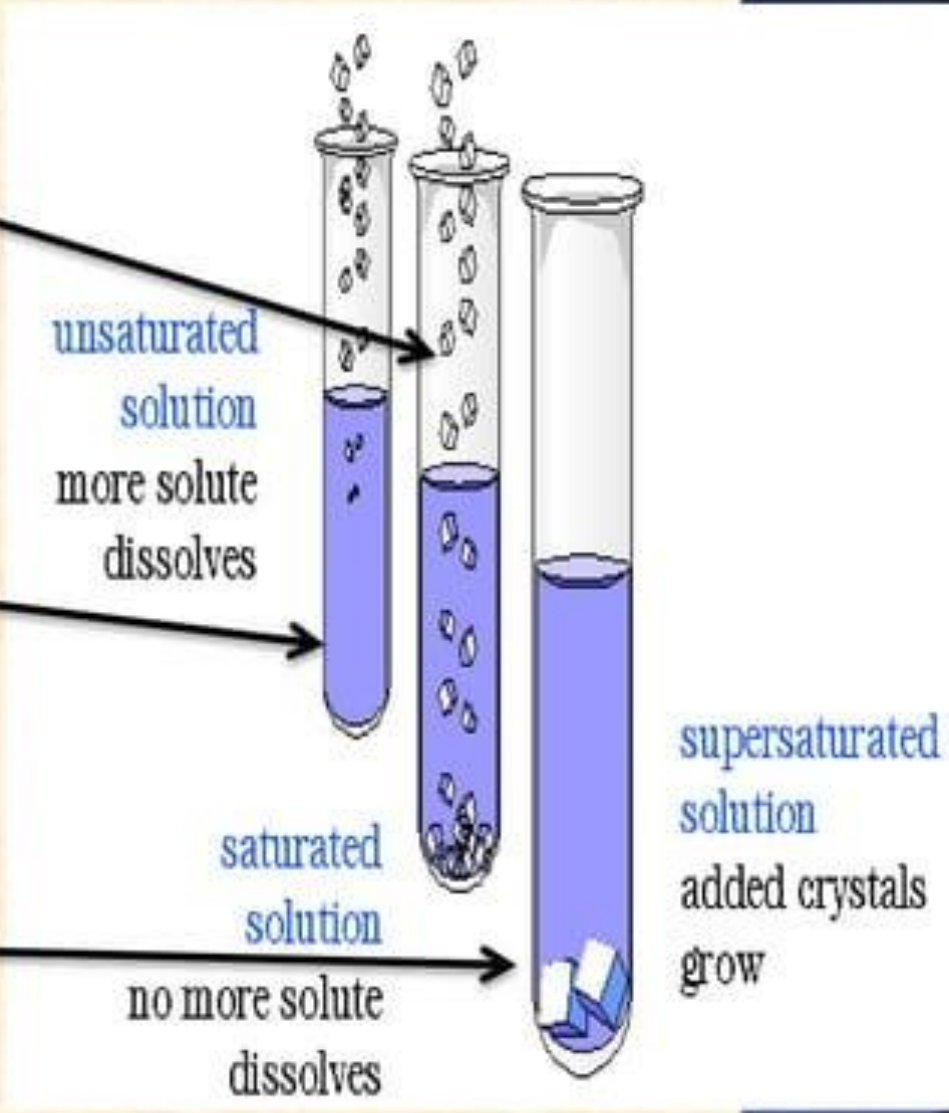
DILUTE AND CONCENTRATED

- A **dilute solution** is a solution that has very little solute in the solvent.
- A **concentrated solution** is a solution where the solvent has a lot of solute in the solution.



SATURATED SOLUTION

- A **saturated solution** is a solution that contains the maximum amount of solute that is capable of being dissolved.
- An **unsaturated solution** is a solution that contains less than the maximum amount of solute that is capable of being dissolved.
- Super-saturation is a solution that contains more of the dissolved material than could be dissolved by the solvent under normal circumstances.
- https://www.youtube.com/watch?v=-mnk_89BXmM



TRUE SOLUTION

(i) A true solution (or simply a solution) is a homogeneous mixture. That is in a true solution, the solute and solvent molecules cannot distinguish even under microscope. The composition and properties of a true solution are the same throughout.

(ii) In a true solution, the solute particles are very small, of the order of about 10^{-10} m.

(iii) A true solution is clear and transparent.

(iv) A true solution does not scatter light.

(v) The components of a true solution (the solute and the solvent), cannot be separated by filtration. This is because both solute particles and the solvent molecules are very small as compared to the pores in the filter paper.

(vi) The solute particles in a true solution do not settle down.

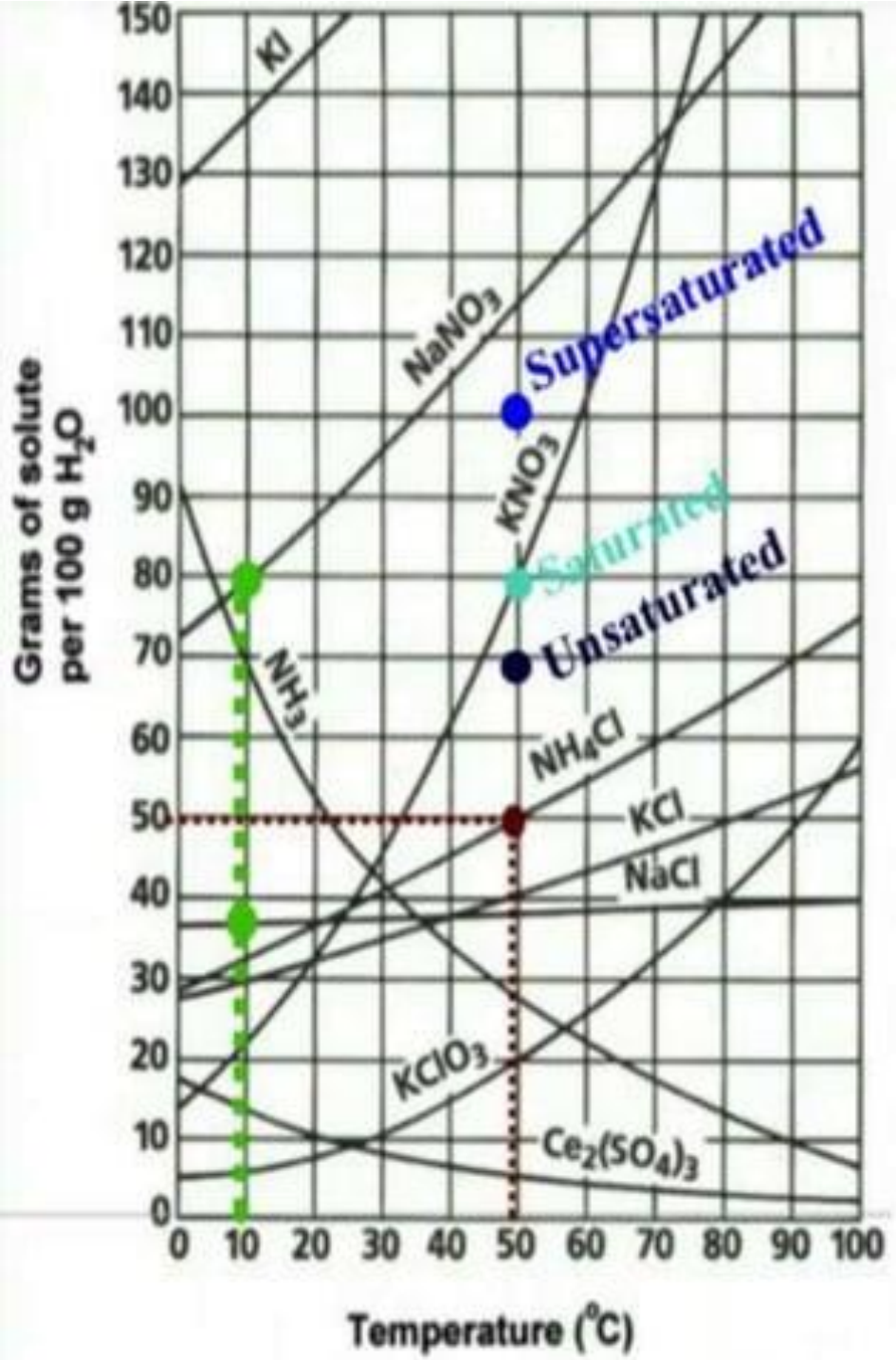
SOLUBILITY

- Solubility is the property of a solid ,liquid or gaseous chemical substance called solute to dissolve in a solid ,liquid or gaseous 100 gm solvent of that temperature.

SOLUBILITY CURVES

- Solubility curves is used to determine the mass of solute in grams per 100 grams of water(g/100gm) at the given temperature.

https://www.youtube.com/watch?v=6sJ6kWB_8ag



What mass of Ammonium Chloride (NH_4Cl) will dissolve at 50°C in 100 g of water?

What is less soluble in 100 g of water at 10°C sodium nitrate or sodium chloride?

Will 100 g of poassium nitrate at 50°C in 100 g of water create a saturated? unsaturated? or supersaturated solution?

10 g of which substance will dissolve at 90°C in 100 g of water?

QUALITATIVE AFFECT OF TEMPERATURE ON SOLUBILITY

- increases with rise in temperature.eg KNO_3
- increases slightly with rise in temperature.eg NaCl
- decreases with rise in temperature.eg $CaSO_4$
- $Na_2SO_4.10H_2O$ –shows a solubility curve with sharp break at 36 degree c.
- KNO_3 has the highest solubility at 100 degree C.

APPLICATIONS OF CURVE

- Applications of curve;

1. It gives an idea about the ability of a solute to dissolve in water at different temperature.
2. The solubility of a solute at any temperature can be measured.
3. The mass of crystals deposited can be calculated.

AFFECTS OF PRESSURE ON GASES

- An increase in pressure on surface of water causes increase in solubility of gas in water.
- Solubility of gases in water at a fixed temperature can be correlated by the following law [Henry's Law].
- ✓ At a given temperature the mass of gas dissolved by a fixed volume of liquid is directly proportional to the pressure on the surface of the liquid.
- ✓ https://www.youtube.com/watch?v=Pt_k82fh2sg

For both temperature and pressure.

AFFECTS OF PRESSURE

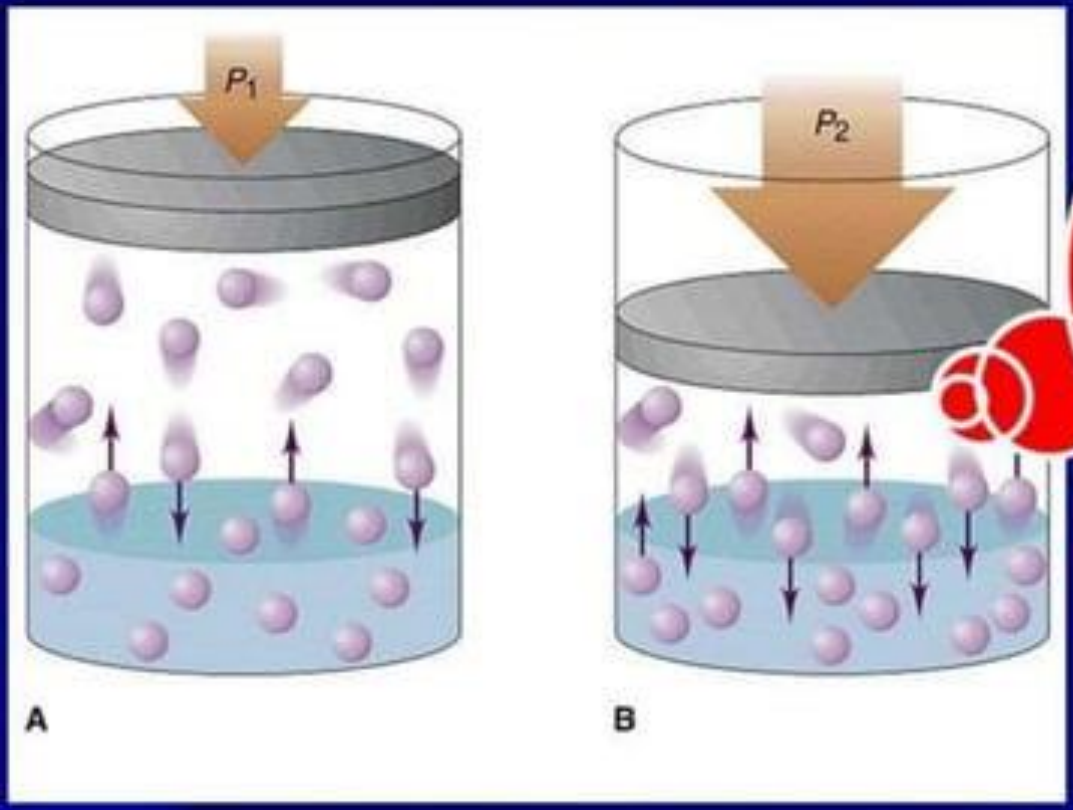
- Evolution of gas is seen when a bottle of soda water is opened:-

✓ Soda Water- contains carbon dioxide dissolved in water under pressure.

✓ Solubility of carbon dioxide under normal atmospheric pressure is very low, but when subjected to high pressure ,it dissolves to a great extent as in the case of soda water in carbon dioxide is dissolved in water under pressure and the bottle corked. On opening the bottle the gas rapidly bubbles out since the pressure on the surface of the water suddenly decreases and so dus the solubility of carbon dioxide gas in water.

Pressure Effect

Effect of pressure on solubility of solids and liquids is ignorable.However, solubility of gases increases with increase in pressure.



When the pressure increased from P_1 to P_2, concentration of gas molecules in solvent and therefore solubility of gas increases.

AFFECTS OF TEMPERATURE ON GASES

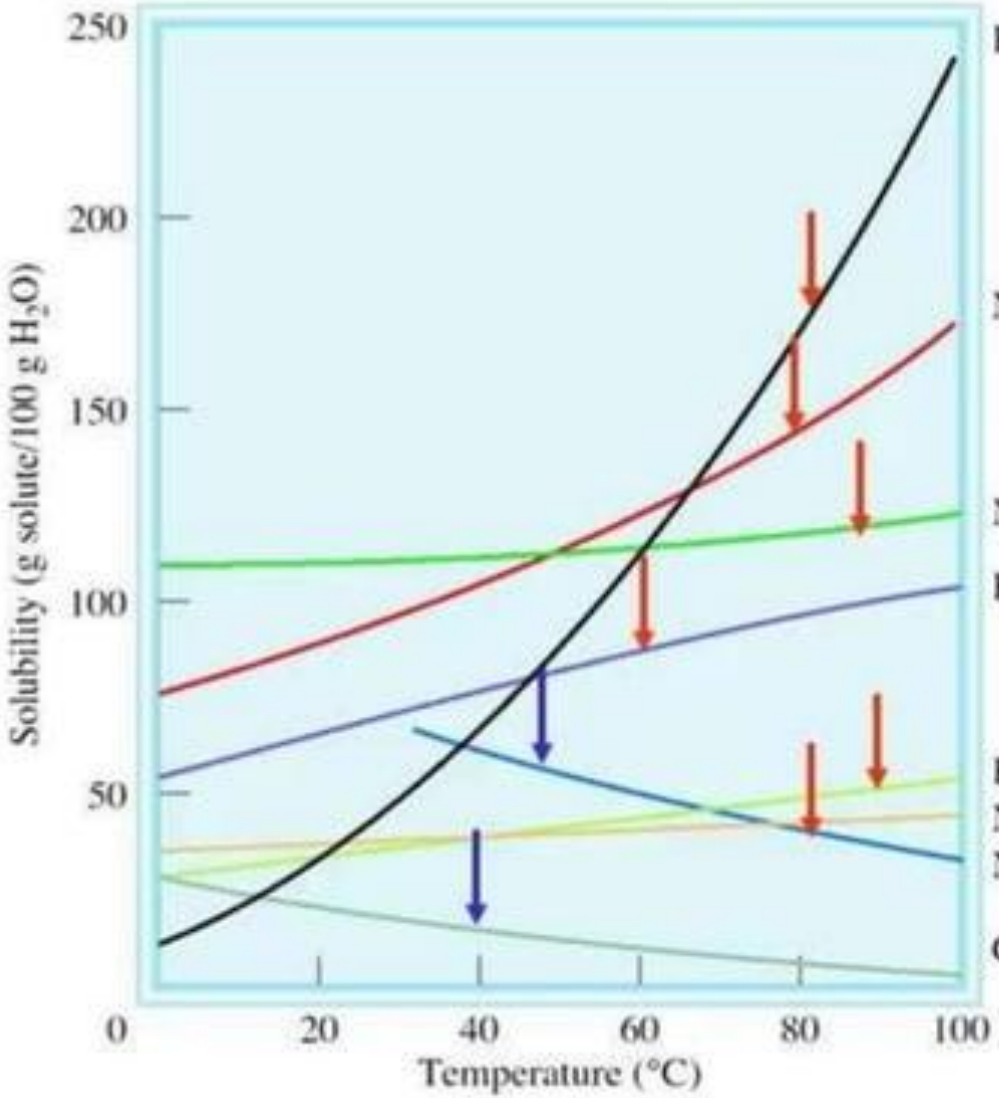
- An increase in temperature –of water.
- Causes decrease in solubility of gas-of water.

On boiling water loses its taste.

- ✓ water contains soluble gases which contribute to the taste of water .
- ✓ on boiling the temperature of water increases , therebythe solubility of the dissolved gases [air] decreases and the dissolved gases are hence expelled out
- ✓ if the above water is once again shaken with air , the water gets back its taste, due to dissolution of the air in water.
- ✓ Gases are more soluble in cold water then in water at high temperatures.

Temperature and Solubility

Solid solubility and temperature

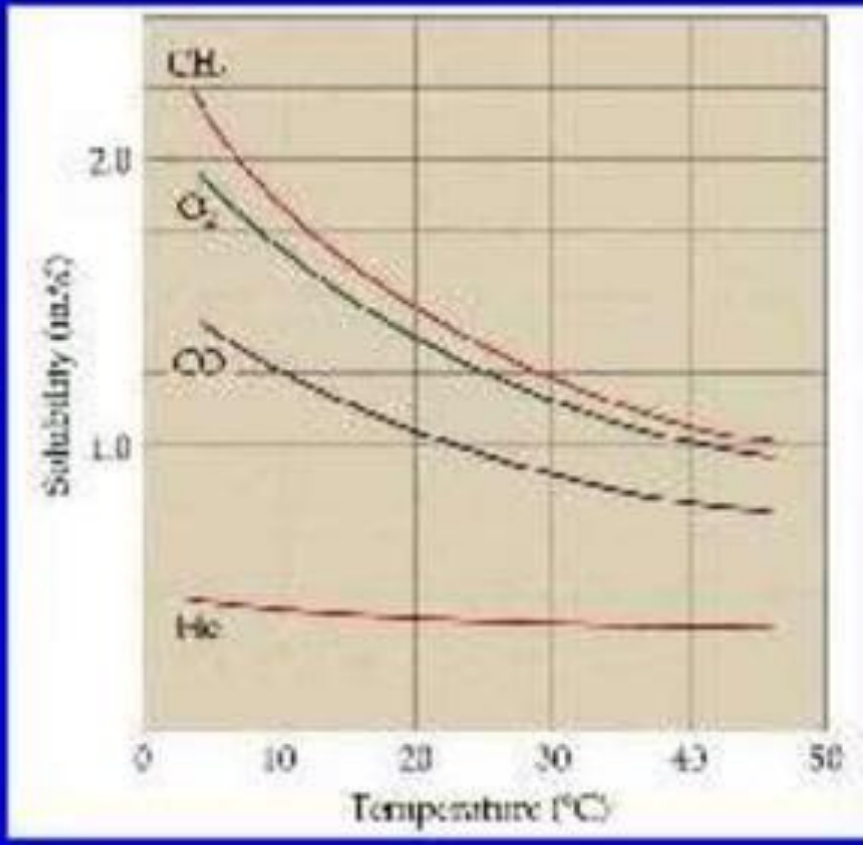


solubility increases with increasing temperature

solubility decreases with increasing temperature

Effect of Temperature on Solubility

- The solubility of gases in water decreases with increasing temperature. The solubility goes to zero at the boiling point of water.
- Why does the taste of water change if it is boiled?



CRYSTALLIZATION

- Crystallization is the solidification of atoms or molecules into a highly structured form called a crystal. Usually, this refers to the slow precipitation of crystals from a solution of a substance.
- Examples of Crystallization

Snowflake formation

Crystallization of honey in a jar

Stalactite and stalagmite formation

Gemstone crystal deposition

- Examples of artificial crystallization include:

Growing sugar crystals in a jar

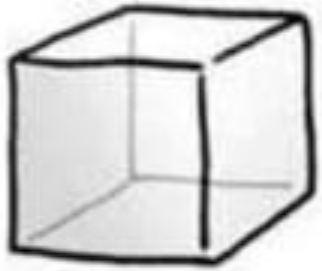
Production of synthetic gemstones

https://www.youtube.com/watch?v=M7BZcfCUrYA

CRYSTAL: PHYSICAL PROPERTIES OF CRYSTALS

- Crystals differ in physical properties, i.e., in hardness, cleavage, optical properties, heat conductivity, and electrical conductivity. These properties are important since they sometimes determine the use to which the crystals are put in industry.

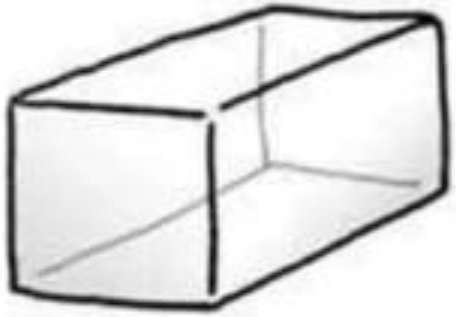
SHAPES OF CRYSTALS



cubic

tetragonal

triclinic



orthombic

hexagonal

monoclinic

trigonal

WATER OF CRYSTALLIZATION

- The fixed number of water molecules which enters into a loose chemical combination with the substance when the substance is crystallized from its hot saturated solution is called water of crystallization.
- It is responsible for the geometric shape and colour of the crystals.
- https://www.youtube.com/watch?v=BGhIPzx49ik
- https://www.youtube.com/watch?v=nztV4w0DtOo

Water of crystallization

HYDRATED SUBSTANCE

- A hydrous compound (a hydrate) is a chemical compound with water in its structure. For example, hydrated salts have water within their crystals. Hydrates form naturally when ionic compounds are exposed to air and make bonds with water molecules. Specifically, the bond is formed between the cation of the molecule and the water molecule. The water that remains is usually known as water of hydration or water of crystallization.
- https://www.youtube.com/watch?v=BK--OEks4B4

ANHYDROUS SUBSTANCE

- An anhydrous compound (an anhydrate) is a compound with no water in its structure. After water is removed from a hydrate, it becomes an anhydrate. The water molecules are removed by suction or heating the compound to a high temperature. For example, an anhydrous salt has had water driven out from its crystals. An anhydrous compound from a hydrate is generally highly soluble in water, and when dissolved in water it will be a similar color to that of the original hydrate, even if it changed color transforming from the hydrate to the anhydrous compound.
- https://www.youtube.com/watch?v=lLUH13rXvVs

Hydrates

- A **hydrate** is a solid crystalline substance that has a certain number of water molecules as part of its structure.
  - Example: $CoCl_2 \cdot 6H_2O$

- An **anhydrous salt** is the hydrate minus the water.
  - Example: $CoCl_2$

Hydrated Salt vs Anhydrous Salt

More Information Online WWW.DIFFERENCEBETWEEN.COM

	Hydrated Salt	Anhydrous Salt
DEFINITION	Salt compounds having water molecules attached to the salt molecules.	Compounds having no water molecules attached to the salt molecules.
PRESENCE OF WATER	Contain water of crystallization.	Have no water in the salt crystals.
HEATING	When hydrated salts are heated, water molecules evaporate.	There is no water evaporation from anhydrous salts.
SELF-DISCHARGING EFFECT	Have a high self-discharging effect	Have a low self-discharging effect
DRYING AGENTS	We cannot use hydrated salts as drying agents.	We can use anhydrous salts as drying agents because they can absorb water.

Deliquescence

- Deliquescence is a reverse of efflorescence.
- If a hydrated substance has a lower vapour pressure, than the surrounding atmosphere than the water molecule transfer from the atmosphere to the less hydrated substance to make them more hydrated and to produce a equilbrium.This phenomenon is called deliquescence. e.g.: NaOH

- https://www.youtube.com/watch?v=ky7MsH0omT0

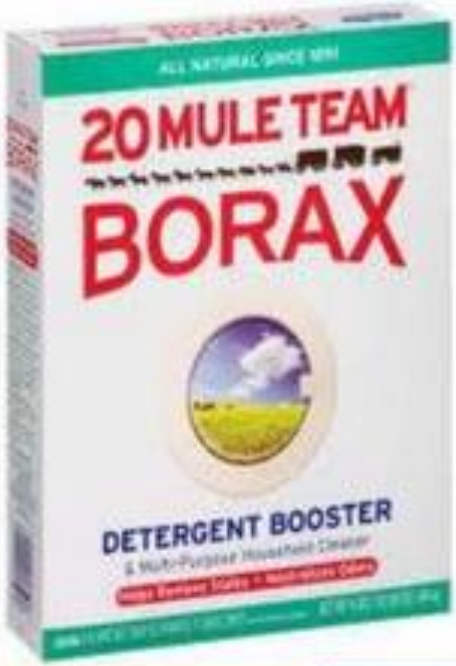
Pellets of sodium hydroxide are deliquescent.

For this reason, containers of NaOH should always be tightly stoppered.

The solution formed by a deliquescent substance has a lower vapor pressure than that of the water in the air.

EFFLORESCENCE

- This phenomenon is called efflorescence.
- In simple words efflorescence is the loss of water of crystallization from the hydrated substances into the atmosphere so that an equilibrium is formed b/w the hydrated substance and the surrounding atmosphere.



- https://www.youtube.com/watch?v=weHr_xASffc

DELIQUESCENCE	EFFLORESCENCE
The phenomenon by which substances exposed to air absorb moisture from the atmosphere	This is the phenomenon by which substances when exposed to atmosphere loose moisture
These substances change their state when they absorb moisture	These loose water and change from amorphous to crystalline
these are mostly salts	These are mostly salts having water of crystallization
$NaOH$, $CaCl_2$, $FeCl_3$	$Na_2CO_3.10H_2O$, $FeSO_4.7H_2O$

HYGROSCOPIC SUBSTANCES

- https://www.youtube.com/watch?v=srfsz9UsXSQ
- A **hygroscopic substance** is one that readily attracts water from its surroundings, through either absorption or adsorption.
- Examples include honey, glycerin, ethanol, methanol, concentrated sulfuric acid, and concentrated sodium hydroxide (lye).

DRYING AGENTS

- **Drying agents** (also called desiccants) come in various forms and have found widespread use in the foods, pharmaceuticals, packing, electronics and many manufacturing industries. A desiccant is a hygroscopic substance that induces or sustains a state of dryness in its vicinity.
- Examples -: calcium chloride, **sodium** sulfate, magnesium perchlorate, etc
- The **drying agents** commonly used in the organic laboratories are the anhydrous forms of calcium chloride ($CaCl_2$), sodium sulfate (Na_2SO_4) Calcium sulfate ($CaSO_4$ (as Drierite) and magnesium sulfate ($MgSO_4$).
- Calcium chloride, magnesium sulfate, and sodium sulfate are the three most **commonly used agents**

DEHYDRATING AGENT

- https://www.youtube.com/watch?v=IKOdTZtAVF4
- A **dehydrating agent** is a substance that dries or removes water from material. It may be a chemical compound used to drive a **dehydration** reaction or a substance that absorbs moisture from its surroundings.
- Examples :- Aluminium Phosphate, Burgess Reagent, Calcium Oxide,Cyanuric Chloride,Iron(III)Chloride ,Orthoformic acid, Phosphorous pentoxide, Phosphoryl Chloride.

HARD AND SOFT WATER

- **Hard water** is any **water** containing an appreciable quantity of dissolved minerals. **Soft water** is treated **water** in which the only cation (positively charged ion) is sodium. The minerals in **water** give it a characteristic taste.
- https://www.youtube.com/watch?v=ebygQes5Wig

	HARD WATER	SOFT WATER
APPLIANCES	• Leaves deposits of limescale • Stains water fixtures • Can leave clothes discolored	• Can contain high levels of corrosive salt • Cleans dishes with less water
DRINKING	• Has potential health benefits from calcium and magnesium • Generally tastes better	• Can deprive drinkers of vital minerals • Has higher levels of sodium
SKIN	• May harm your hair • Can trigger eczema • Strips skin of surface oils	• Lathers soap well • Rinses shampoo from hair easier and quicker

ADVANTAGES OF SOFT AND HARD WATER

- **Advantages of hard water -**Calcium ions in the **water** are good for children's teeth and bones. Limescale (a **hard** crust) forms inside kettles. This wastes energy whenever you boil a kettle. It helps to reduce heart disease.
- **Advantages of Soft Water**

Better Plumbing. **Hard water** contains a high concentration of minerals, namely calcium and magnesium. ...

Extra Savings. Not only does **soft water** save your pipes, but it also preserves your cleaning supply. ...

Longer Lasting Appliances. **Water** services your appliances just like it circulates through your pipes. ...

DISADVANTAGE OF SOFT AND HARD WATER

- **The disadvantages of soft water**
- Soft water can easily lead to lead poisoning if it is transferred through lead pipes or kept in lead containers. ...
- Soft water does not help in strengthening our bones and teeth since it contains no calcium.
- Soft water has a taste which is not pleasant in the mouth.
- **Disadvantages of hard Water**
- This causes wastage of soap being used. ...
- (ii) Bathing: **Hard water** does not lather freely with soap solution, but produces sticky scum on the bath-tub and body. ...
- (iii) Cooking: Due to the presence of dissolved hardness-producing salts, the boiling point of **water** is elevated.

CAUSES OF HARDNESS IN WATER

- The two main cations that **cause water hardness** are calcium (Ca^{2+}) and magnesium (Mg^{2+}). Calcium is dissolved in **water** as it passes over and through limestone deposits. Magnesium is dissolved as **water** passes over and through dolomite and other magnesium bearing formations
- Sources - Hard and very hard waters are found in some of the streams in most of the regions throughout the country. The hardest waters (greater than 1,000 ppm) are in streams in Texas, New Mexico, Kansas, Arizona, Utah, parts of Colorado, southern Nevada, and southern California.

TYPES OF HARDNESS IN WATER

- There are two types of water hardness, temporary and permanent.

- ***Temporary Hardness-*** is due to the bicarbonate ion, HCO_3^-, being present in the water. This type of hardness can be removed by boiling the water to expel the CO_2, as indicated by the following equation:
- $Ca(HCO_3)_2 \rightarrow\leftarrow CaCO_3 + CO_2 + H_2O$

- ***Permanent hardness*** **-** is due to calcium and magnesium nitrates, sulphates, and chlorides etc. This type of hardness cannot be eliminated by boiling.
- https://www.youtube.com/watch?v=lNAMfROxbZI

REMOVAL OF TEMPORARY HARDNESS IN WATER

- https://www.youtube.com/watch?v=g367YLFJRNQ
- **Temporary hardness of water** can be **removed** by heating the **water**. **water** is heated the calcium and magnesium carbonates are precipitated out of the **water** and collect as residue, the **water** can then be recollected and is free of these minerals. **Temporary hardness of water** can also be **removed** with other chemicals.
- Permanent **hardness** present in the **water** can be **removed** by treating it with soda **water** and using permutit process. Soluble salts of calcium and magnesium change into insoluble salts due to the treatment with sodium carbonate (washing soda).

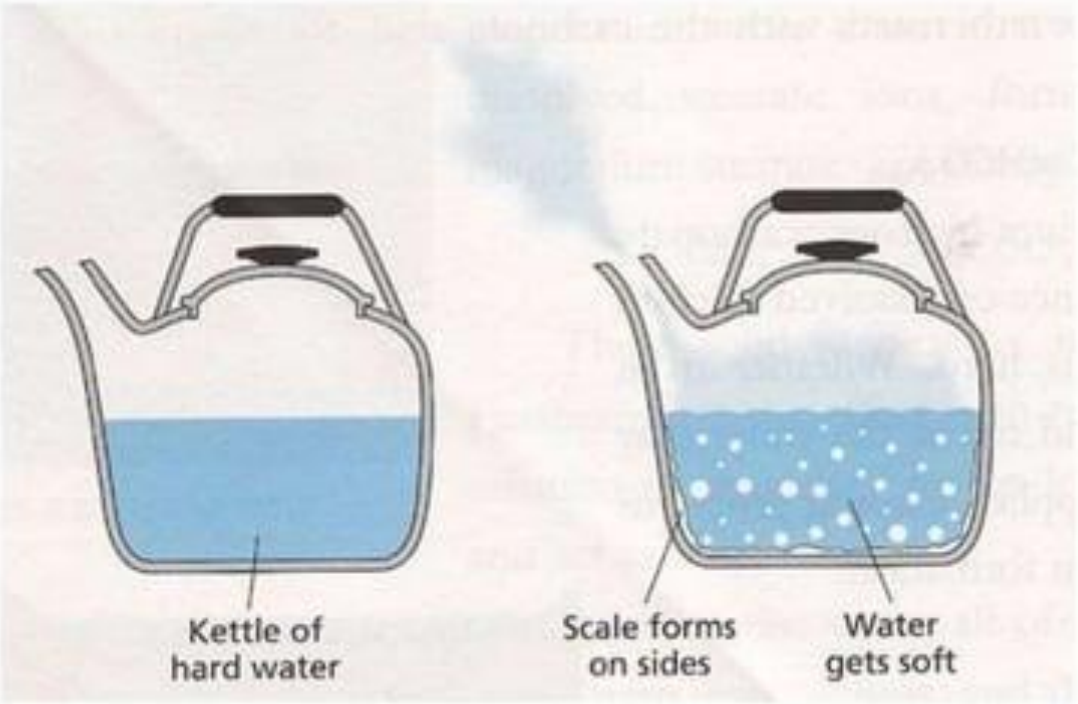
REMOVAL BY BOILING

- As you can se boiling the water causes the precipitation of solid calcium carbonate or solid magnesium carbonate. This removes the calcium ions or magnesium ions from the water, and so removes the hardness. Therefore, hardness due to hydrogen carbonates is said to be temporary.
- https://www.youtube.com/watch?v=vJraBGGY_yE

Please go through the video on boiling method only.

Removing temporary hardness from water

- 1. It can be removed by boiling!



This reaction occurs:

- $Ca(HCO_3)_2 + \text{heat} \longrightarrow CaCO_3 + H_2O + CO_2$

REMOVAL BY ADDITION OF WASHING SODA

- https://www.youtube.com/watch?v=bKcBdI8wRpI
- Hard **water** can be softened by **adding washing soda** (**sodium carbonate**) which removes the calcium ions in a precipitation reaction. Alternatively, the hard **water** can be passed through an ion-exchange resin in a column

Permanent Hardness

It is the hardness caused by the presence of chlorides and sulphates of Ca^{2+}, Mg^{2+} and Fe^{2+}.

It can be removed by :

Treatment with Washing Soda (Sodium carbonate) :

Sodium carbonate converts calcium and magnesium salts to insoluble carbonates which can be filtered off.

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + Na_2SO_4$$

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2NaCl$$

THANK YOU