



جامعة جنوب الوادي



كلية العلوم - قسم الكيمياء

General Chemistry (II)

For 2nd year students, faculty of Education, Basic&Science group, English program

اعداد أستاذ المقرر:

د/ إبراهيم عبدالله إسماعيل حسن

قسم الكيمياء - كلية العلوم بقنا - جامعة جنوب الوادي

Email: I.Hassan@bath.edu

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د. ابراهيم عبد الله إسماعيل حسن

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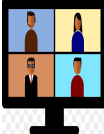
فيديو للمشاهدة. 

نص للقراءة والدراسة. 

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Content

Chapter I: Electrochemistry

- basics of Electrochemistry
- Faraday's Electrolysis experiments 1833
- Ionic (Arrhenius) theory 1880
- Electrolytes
- water as electrolyte:
- Experiment of electrical ions movements:
- Electrochemical Cells.
- Electrolytic cell
- Galvanic Cell

- **Anode and Cathode in Electrochemical Cells**
- **Electrolysis via Electrolytic cells.**
- **Mechanism of electrolysis**
- **Electrolysis of conc. HCl**
- **Selective discharge of ions**
- **Factors affecting on Selective discharge of ions**
- **Electrochemical series**
- **Electrolysis of dil. H₂SO₄**
- **Electrolysis of NaOH**
- **Producing electricity via Galvanic Cells**
- **Conversion of Chemical reaction into electricity**
- **leclanche cell**
- **Car Battery Chapter II: Colloids**
- **Solutions**
- **Solutions vs Colloids**
- **Suspensions and Colloids**
- **Types of Colloids**
- **The Tyndall Effect**
- **Brownian Motion**

- **Removal of Colloidal Particles**
- **Lyophilic & Lyophobic Colloids**
- **Preparation of Colloids.**
- **Preparation methods of Colloids**
- **Dispersion method.**
- **Electrical Disintegration (Bredig's Arc Method)**
- **Peptization.**
- **Condensation method.**
- **Purification of Colloids.**
- **Ultrafiltration.**
- **Dialysis and Electro-dialysis.**
- **Charge on Colloids.**
- **The source of the charge on the colloidal particles.**

Chapter III: Solutions.

- **True Solution**
- **Solubility**
- **Solution Formation**
- **Factors Affecting Solubility**
- **Miscible vs. Immiscible.**

- **The Chemical methods of expressing concentration.**
- **Types of Solutions**
- **Gases in Gases**
- **Gases in Liquids.**
- **Factors affecting the suitability of gases in liquids.**
- **The gas type**
- **Liquid type**
- **Effect of temperature.**
- **4. The effect of pressure (Henry's law)**

فيديو : كل المحاضرات على قناة اليوتيوب الخاصة باستاذ المادة والمتخصصة في المحاضرات للطلاب.

اسم القناة: Dr. Ibrahim A. I. Hassan

رابط القناة: <https://www.youtube.com/user/ihassanify>



General Chemistry (II)

2nd Primary Students -Sci. Group (English Program)

Dr. Ibrahim A. I. Hassan

Department of Chemistry, South Valley University

Email: I.Hassan@bath.edu



Lect. 1:

Electrochemistry

Electrochemistry

Which concerns with the study of chemical reactions and ions which involve an electrical current.

Some basics of Electrochemistry:

1. All metals are conductors such as Cu, Fe and Al.
2. Most of non-metals are insulators such as P, S, and gasses.
3. Semiconductors are between conductors and insulators.

Electrochemistry

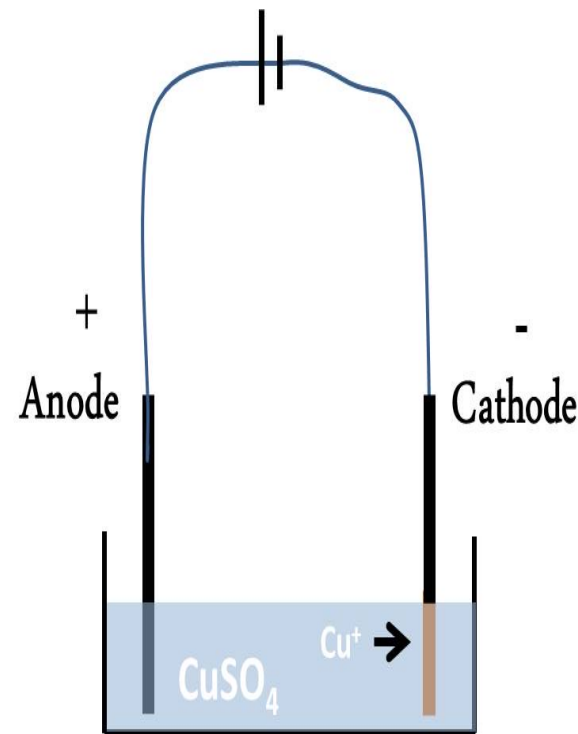
4. Electrolyte is the liquid (soln.) which connects electricity (e.g. NaCl soln.)
5. Non-electrolyte: is the liquid (soln.) which doesn't connect electricity (e.g. Sugar soln.).
6. Molten of some insulators are good conductors, such as PbI_2 molten.
7. **Solution of some insulators are good conductors.**
8. Pure water is insulator, while tap water is connector.

Electrochemistry

9. **Electrodes:** can be made from Carbon or any metal at which electrons enter or leave the electrolyte solution as current. These electrodes such as:

✓ **Anode:** is the electrode at which the electrons enter the external circuit.

✓ **Cathode:** is the electrode at which the electrons leave the external circuit.



Electrochemistry

Faraday

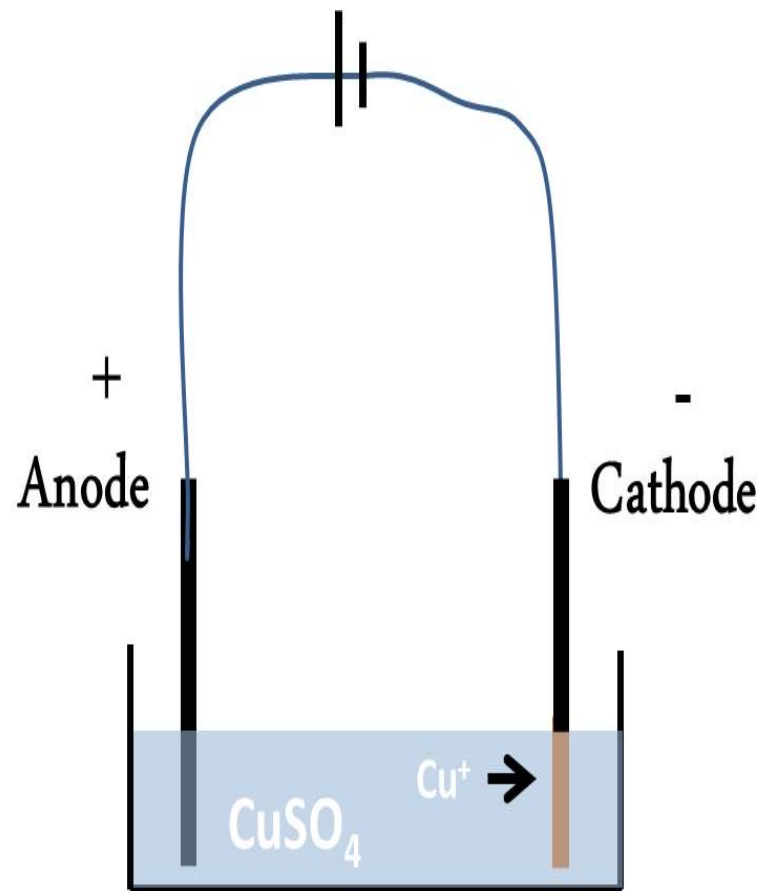


Faraday's Electrolysis experiments

1833:-

Electrolysis of CuSO_4 :

Cu deposited on Cathode, which discovered that there are positive and negative ions in solutions.



Ionic (Arrhenius) theory 1880

Arrhenius



It explained the electrolysis and it states that:-

- There are electrically conductor solutions called electrolytes which contain ions produced from atoms. These ions either positive such as H^+ and metal ions (basic part in salts) or negative ions such as non-metals ions or acidic part in salts. The number of charge represents the atom charge.

e.g. in $NaCl$; Na^+ is positive and Cl^- is negative.

- Ions are formed from atoms through losing or gaining of elect



Electrochemistry

Ions and atoms for the same element have different properties:

For examples:

- **Chlorine (Cl_2)** is yellow and remove the colours, while chloride (Cl^-) doesn't have these characters.
- **Sodium (Na)** attacks water releasing explosive Hydrogen, while Na^+ doesn't have this effect.

Electrolytes

1. **Strong Electrolytes:** Which is completely ionised such as mineral acids (HCl) and strong alkalises (NaOH) and strong salts (NaCl).
2. **Weak electrolytes:** Which is partially ionised such as CH_3COOH .
3. **Moderate electrolytes:** such as CCl_3COOH which is more ionised than CH_3COOH but less than HCl.

Non-Electrolytes

Which found in its molecular formula and can't be ionised in aqueous solns. Such as trichloro-Methane (CHCl_3), Cane Sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$), Alcohols ($\text{C}_2\text{H}_5\text{OH}$), and Urea (CON_2H_4)

water as electrolyte:

- Water is very weak electrolyte.



- It was found that in 600 m molecules of water; there is only one ionised molecule. So it is very weak conductor (insulator).
- If H^+ and OH^- were removed by electrolysis of water, water should be ionised to compensate the lose of ions to keep K_w as constant as 10^{-14} .

Experiment of electrical ions movements:

- If a crystal of KMnO_4 was put on a wet paper under a microscope.
- By applying 20 V potential the violet color (MnO_4^-) will move towards Anode in 15 minutes.

Any Questions

Dr. Ibrahim A. I. Hassan

Department of Chemistry - Faculty of Science - South Valley University

Email: I.Hassan@bath.edu

General Chemistry (II)

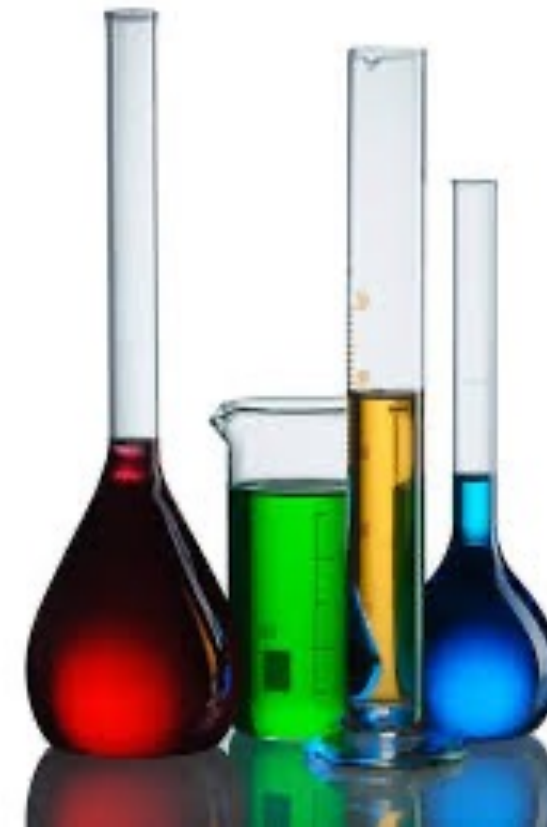
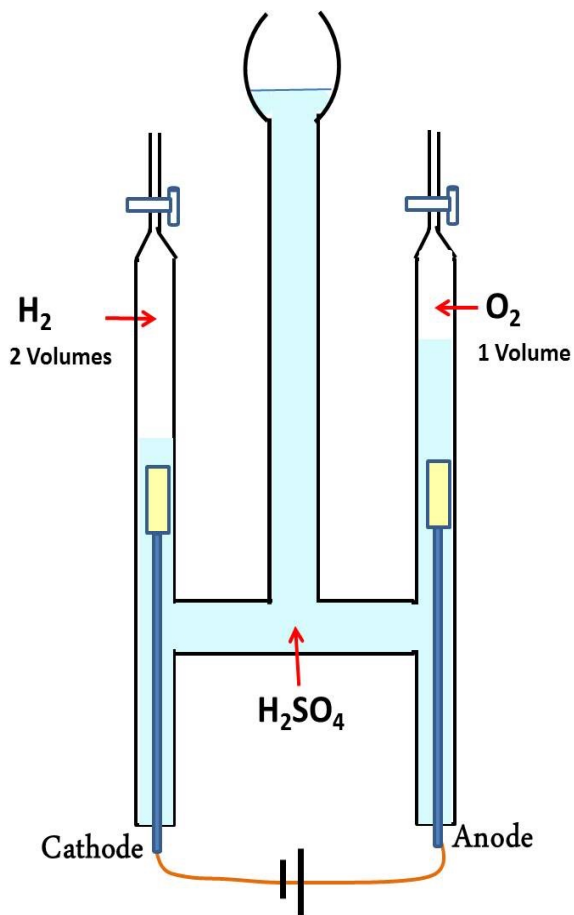
2nd Primary Students -Sci. Group (English Program)

Dr. Ibrahim A. I. Hassan

I.Hassan@bath.edu

Lect. 2:

Electrochemical Cells.



Electrochemical Cells

Electrochemical Cell:

In which a chemical reaction is taken place either producing or consuming electricity.

Types of electrochemical Cells:

1. Electrolytic cell:

In which an electrolysis of a chemical compound is taken place through consuming electricity.

2. Galvanic Cell:

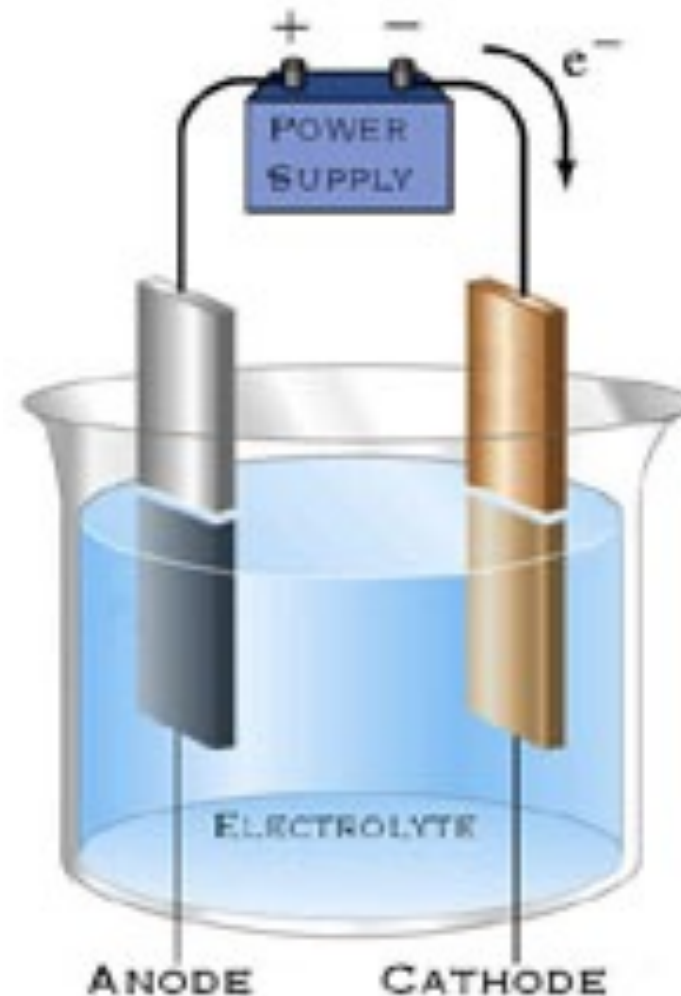
In which a chemical reaction is taken place producing electricity.

Anode and Cathode in Electrochemical Cells

electrolytic cell

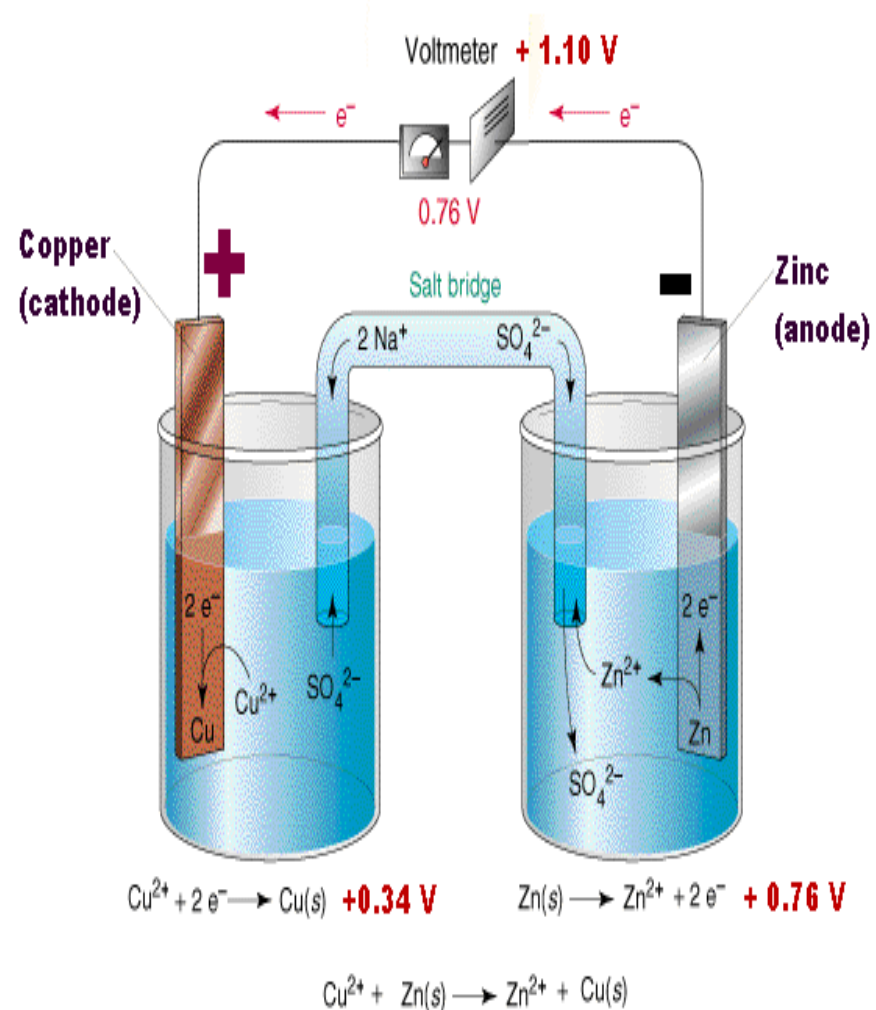
Cathode and Anode

- **Cathode (-):** is the electrode at which the electrons enter to electrolyte (leave the external circuit).
- **Anode (+):** is the electrode at which the electrons leave the electrolyte (enter the external circuit).



Galvanic cell

- **Anode (-)** : is the electrode at which the electrons leave the electrolyte (enter the external circuit).
- **Cathode (+)** : is the electrode at which the electrons enter to the electrolyte (leave the external circuit).



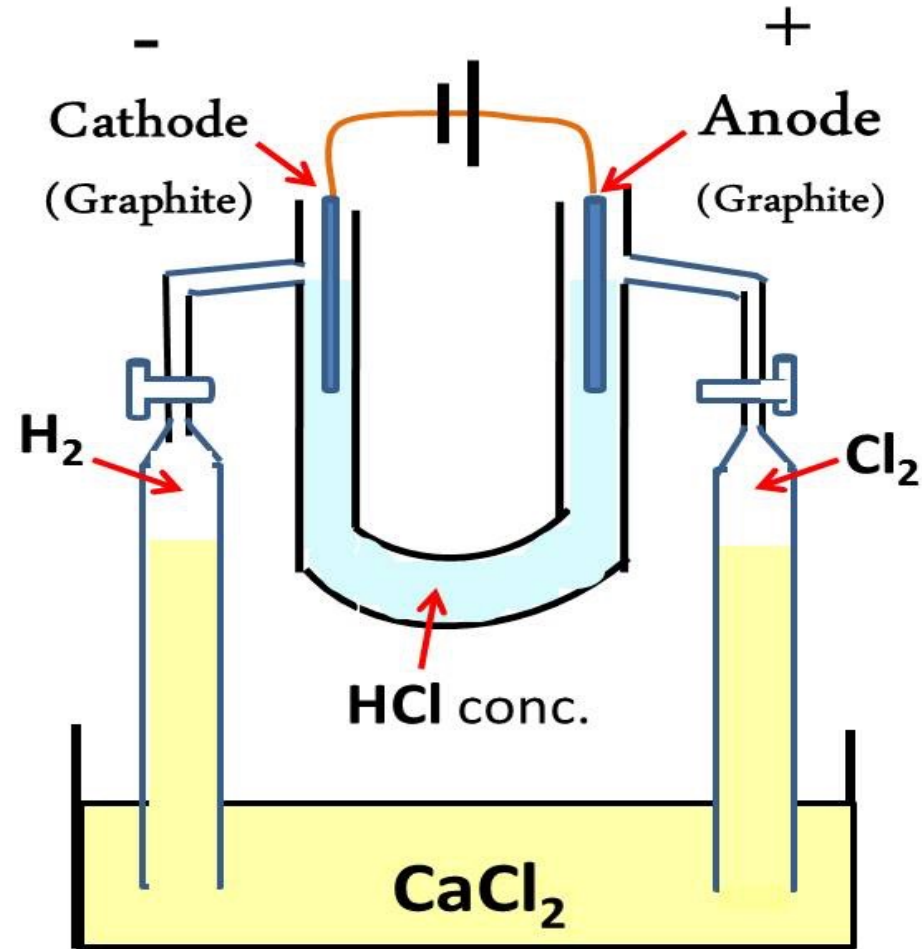


Electrolysis via Electrolytic cells

Mechanism of electrolysis

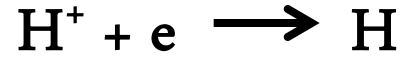
1. Electrolysis of conc. HCl

- H^+ will be reduced at Cathode forming colourless hydrogen gas.
- Cl^- will be oxidised at Anode producing Chlorine.

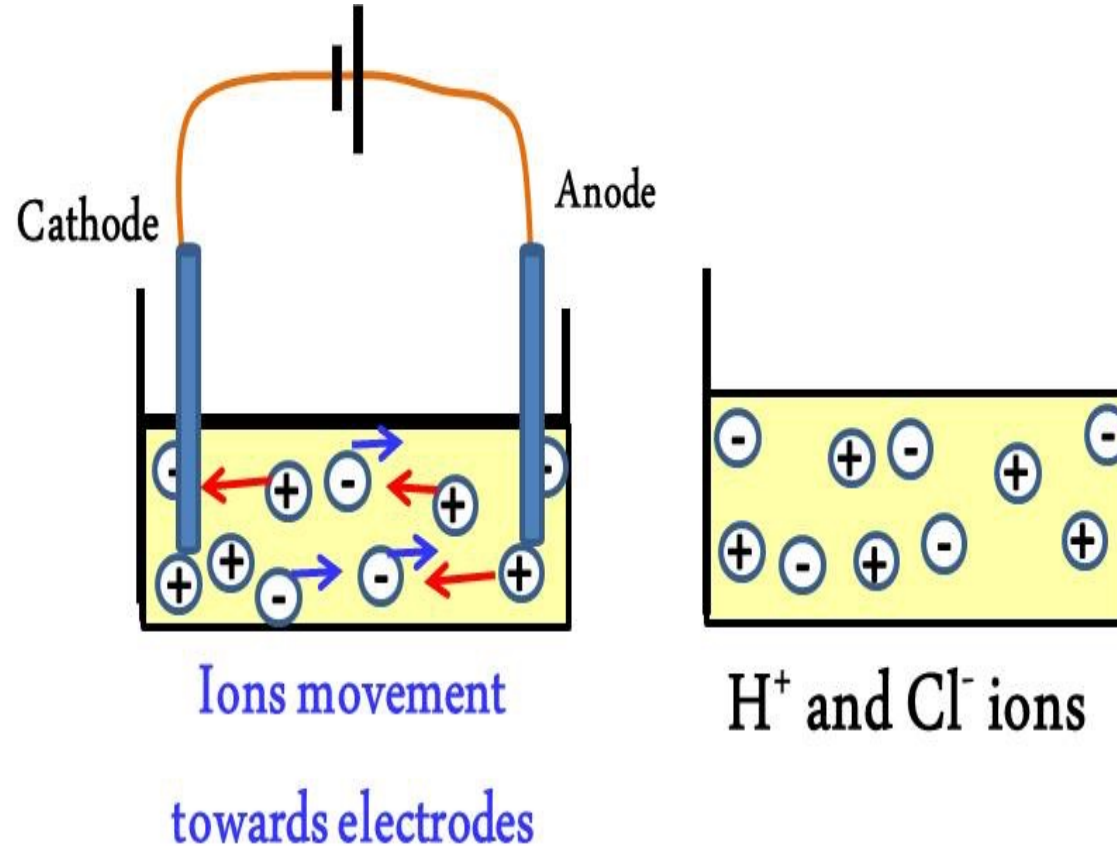
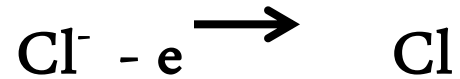


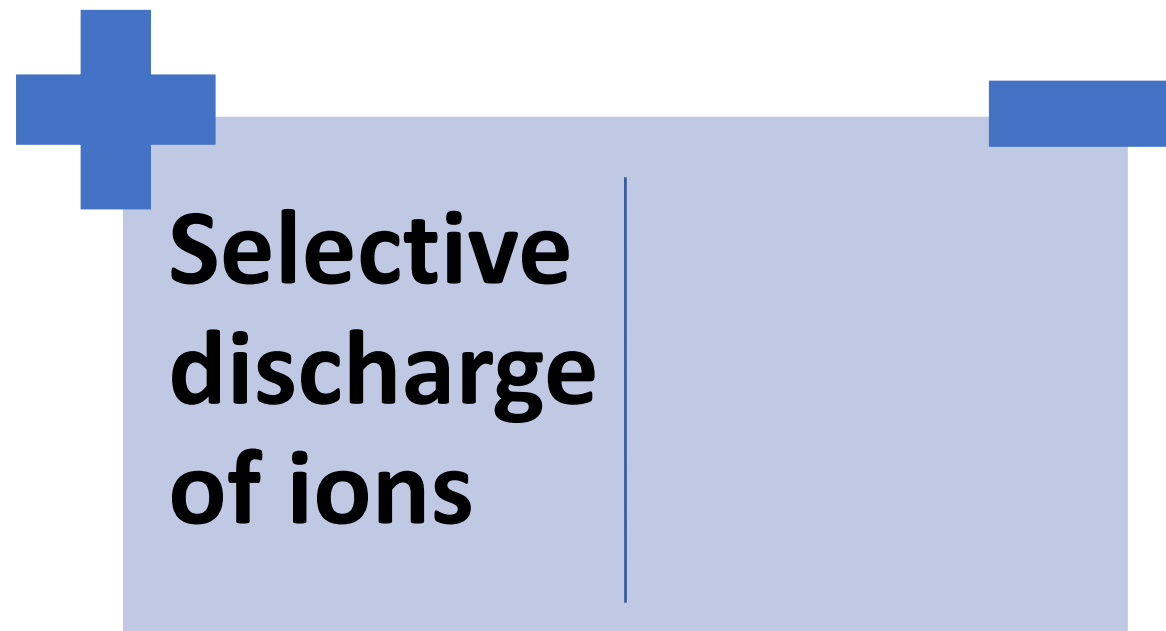
Mechanism of electrolysis

At Cathode:



At Anode:





Selective discharge of ions:

In case of presence more than one ion with the same charge such as SO_4^{2-} , OH^- or Na^+ , H^+ , one of these ions will be preferred to be discharged than the others.

Factors affecting on Selective discharge of ions:

1. Element location at electrochemical series?!



Electrochemical series



Electrochemical Series

<i>Element</i>	<i>Electrode rection</i>	<i>E°(V)</i>
Li	$\text{Li} + \text{e}^- \rightarrow \text{Li}$	-3.045
K	$\text{K}^+ + \text{e}^- \rightarrow \text{K}$	-2.925
Cs	$\text{Cs}^+ + \text{e}^- \rightarrow \text{Cs}$	-2.923
Ba	$\text{Ba}^{2+} + 2\text{e}^- \rightarrow \text{Ba}$	-2.906
Ca	$\text{Ca}^{2+} + 2\text{e}^- \rightarrow \text{Ca}$	-2.866
Na	$\text{Na}^+ + \text{e}^- \rightarrow \text{Na}$	-2.714
Mg	$\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$	-2.363
Al	$\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$	-1.662
H ₂	$\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$	-0.829
Zn	$\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$	-0.763
Fe	$\text{Fe}^{2+} + 2\text{e}^- \rightarrow \text{Fe}$	-0.440
Cd	$\text{Cd}^{2+} + 2\text{e}^- \rightarrow \text{Cd}$	-0.403
Pb	$\text{PbSO}_4 + 2\text{e}^- \rightarrow \text{Pb} + \text{SO}_4^{2-}$	-0.310
Co	$\text{Co}^{2+} + 2\text{e}^- \rightarrow \text{Co}$	-0.280
Ni	$\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$	-0.250
Sn	$\text{Sn}^{2+} + 2\text{e}^- \rightarrow \text{Sn}$	-0.136
Pb	$\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb}$	-0.126
Fe	$\text{Fe}^{3+} + 3\text{e}^- \rightarrow \text{Fe}$	-0.036
H ₂	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2(\text{SHE})$	0
Cu	$\text{Cu}^{2+} + \text{e}^- \rightarrow \text{Cu}^+$	+0.153
S	$\text{S}_4\text{O}_6^{2-} + 2\text{e}^- \rightarrow 2\text{S}_2\text{O}_3^{2-}$	+0.170
Cu	$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$	+0.337
I ₂	$\text{I}_2 + 2\text{e}^- \rightarrow 2\text{I}^-$	+0.534
Fe	$\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$	+0.77
Ag	$\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$	+0.799
Hg	$\text{Hg}^{2+} + 2\text{e}^- \rightarrow \text{Hg}$	+0.854
Br ₂	$\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Br}^-$	+1.066
O ₂	$\text{O}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}$	+1.230
Cr	$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1.330
Cl ₂	$\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$	+1.359
Au	$\text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au}$	+1.498
Mn	$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+1.510
F ₂	$\text{F}_2 + 2\text{e}^- \rightarrow 2\text{F}^-$	+2.870

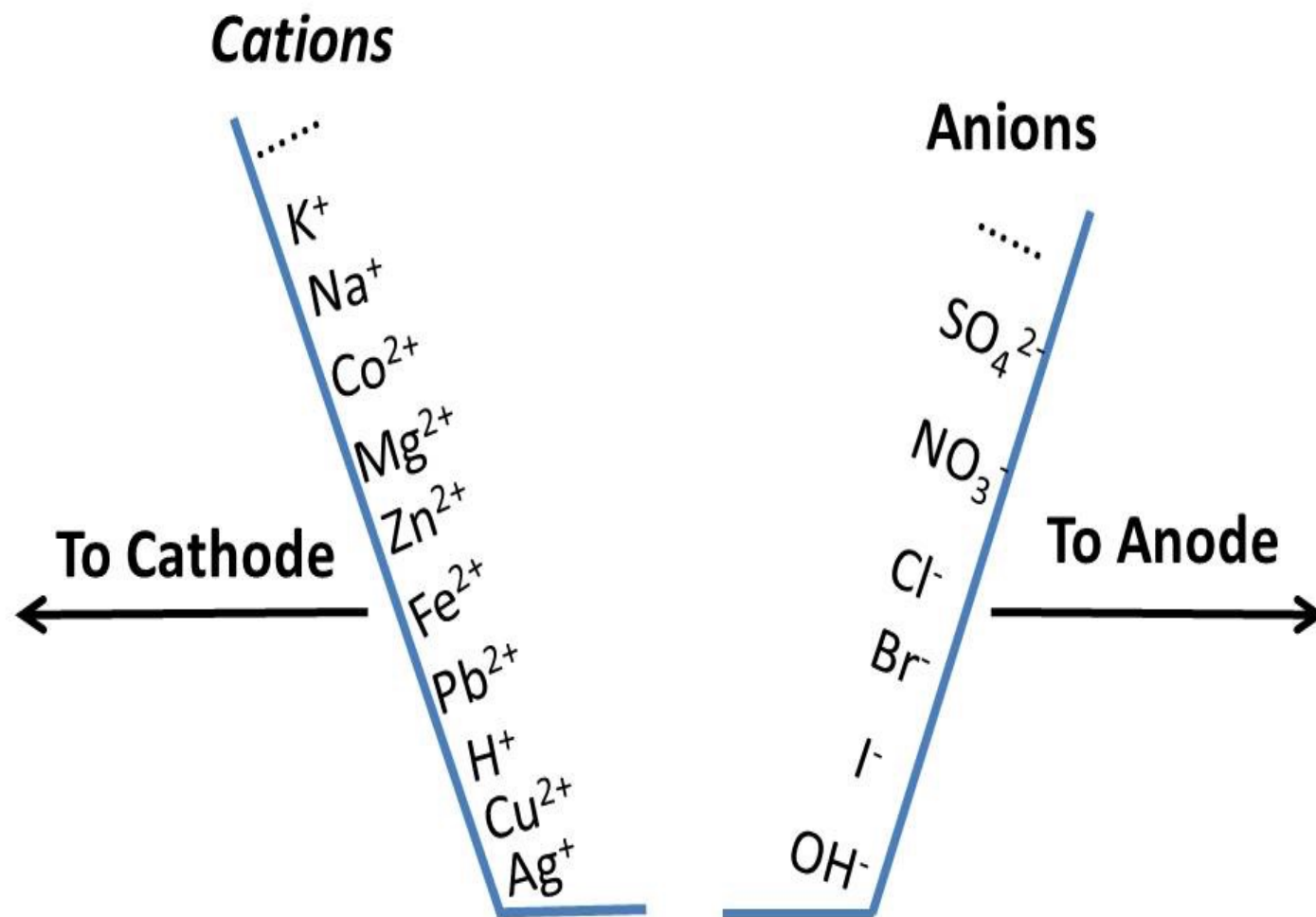
Factors affecting on Selective discharge of ions:

1. Element location at electrochemical series:

Ions discharged according to their location in the electrochemical series

- ❖ e.g. in NaOH soln., it contains H^+ (from water), Na^+ so it is preferred to discharge H^+ before Na^+ .
- ❖ In CuSO_4 , discharge OH^- before SO_4^{-2} .

Electrochemical Series



Factors affecting on Selective discharge of ions:

- 2. Concentration:** If the ions were found in high concentration, that will help in their discharge.

In conc. HCl which contains OH^- (from water) and Cl^- , the Cl^- is much higher concentration, so it will be discharged first. But if the acid was diluted, OH^- discharging will be preferred.

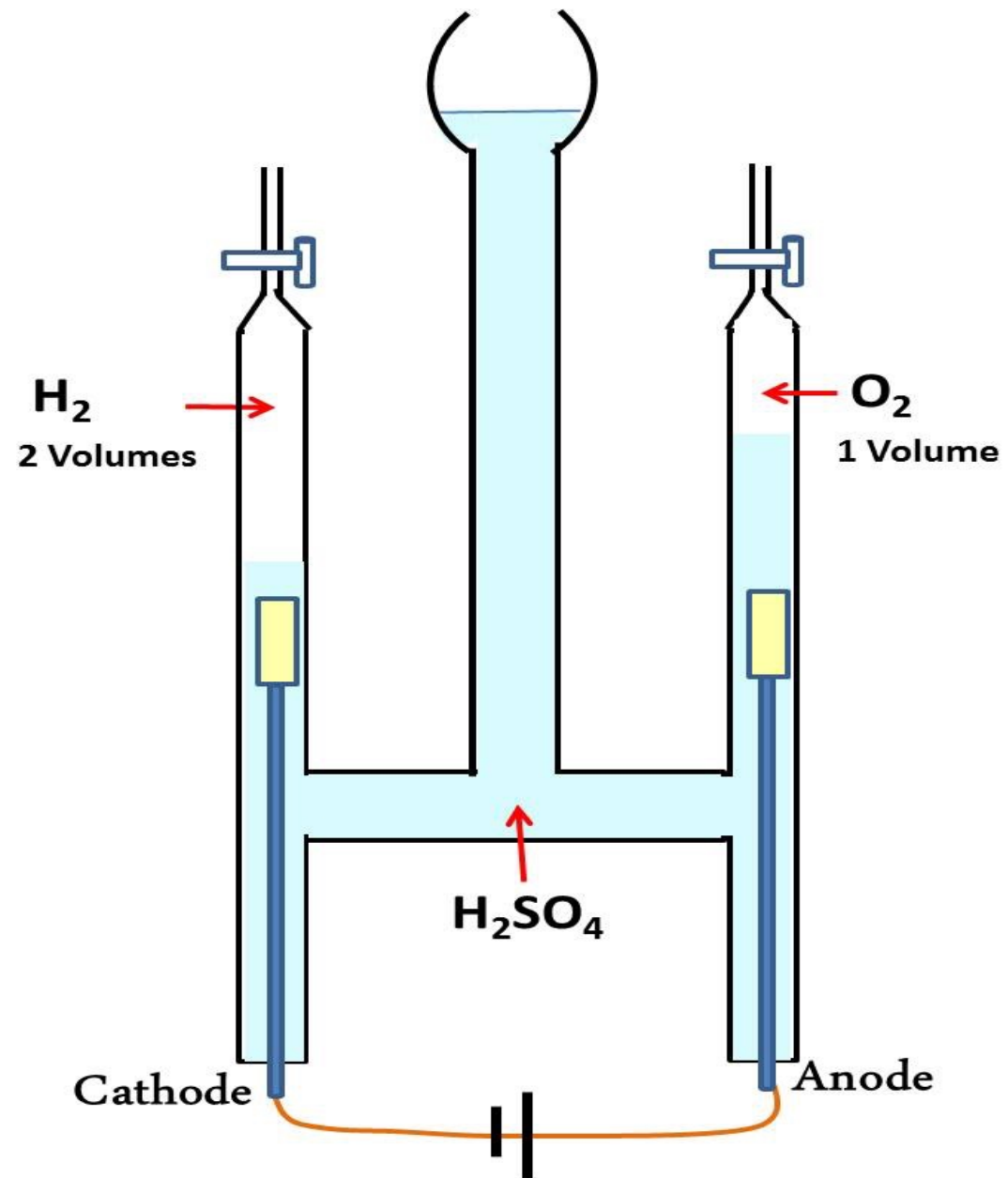
- 3. Electrode type:** some electrodes are selective in ions discharging.

e.g. In case of electrolysis of NaCl by using Pt as Cathode, H^+ (from water) will be discharged before Na^+ (according to electrochemical series).

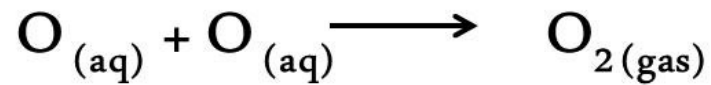
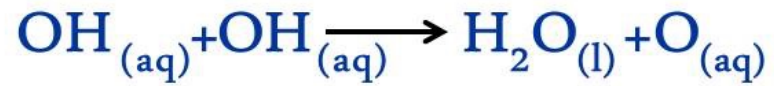
While if Hg was used as Cathode, Na^+ will be discharged first to form amalgam with Hg.

Electrolysis of dil. H_2SO_4

(it is called H_2O electrolysis)



Anode

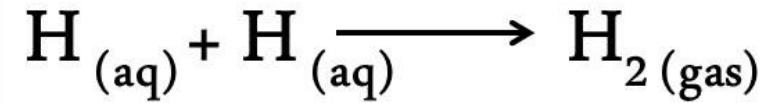
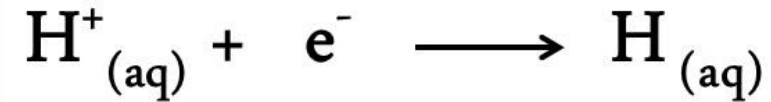


H^+ and SO_4^{2-} increase

Acidity increases

1 Volume Oxygen

Cathode



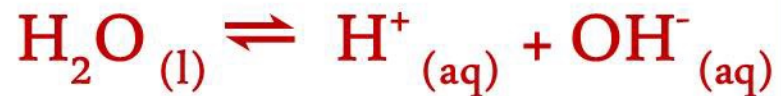
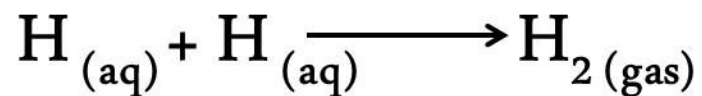
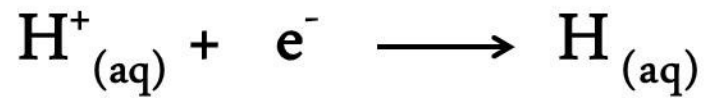
H^+ decreases

Acidity decreases

2 Volumes Hydrogen

Electrolysis of NaOH

Cathode

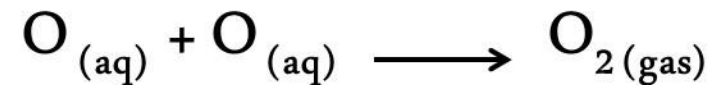
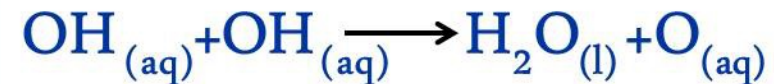
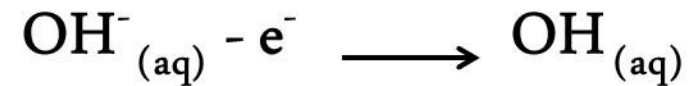


Na^+ & OH^- increase

Basicity increases

2 Volumes Hydrogen

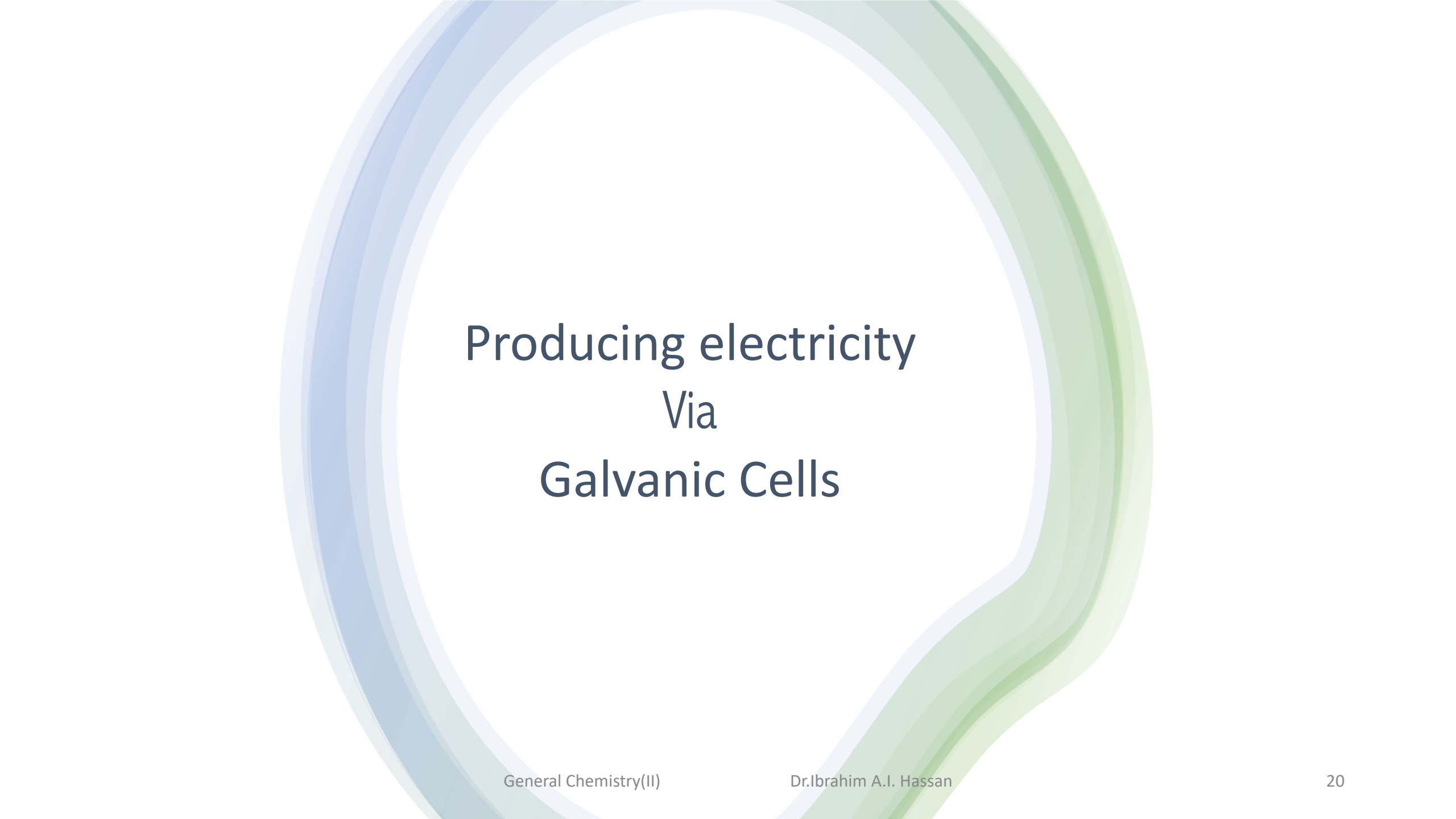
Anode



H^+ increases

Basicity decreases

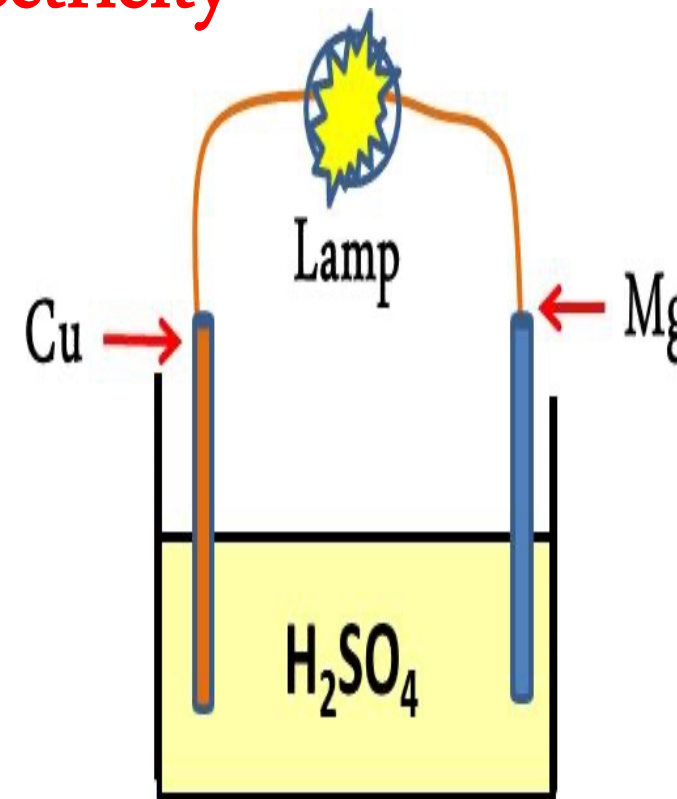
1 Volume Oxygen



Producing electricity Via Galvanic Cells

Conversion of Chemical reaction into electricity

- Cu-Mg Galvanic cell is constructed by connecting the two electrodes together and immersed them partially in H_2SO_4 solution (as shown).
- This cell gives 1.25 V.
- In this cell Mg is ionised producing 2 electrons which transfer through the wire into Cu electrode.
- Hydrogen will be reduced forming gas bubbles which prevents the contact of Cu to the electrolyte causing polarisation

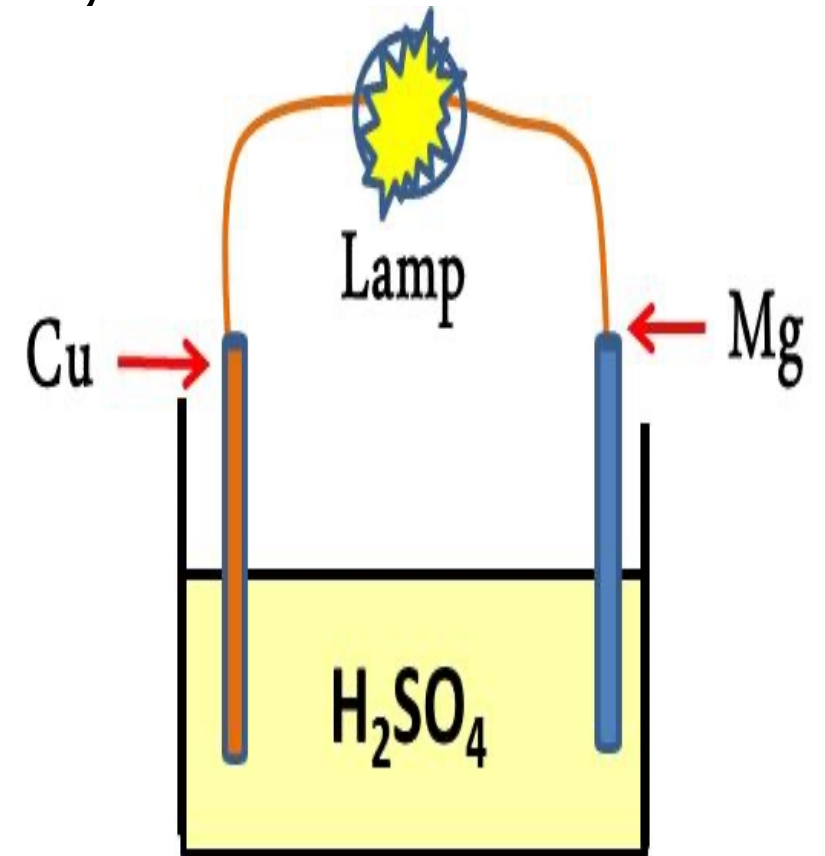
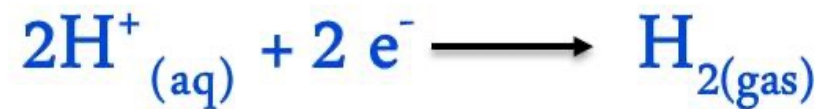


Conversion of Chemical reaction into electricity

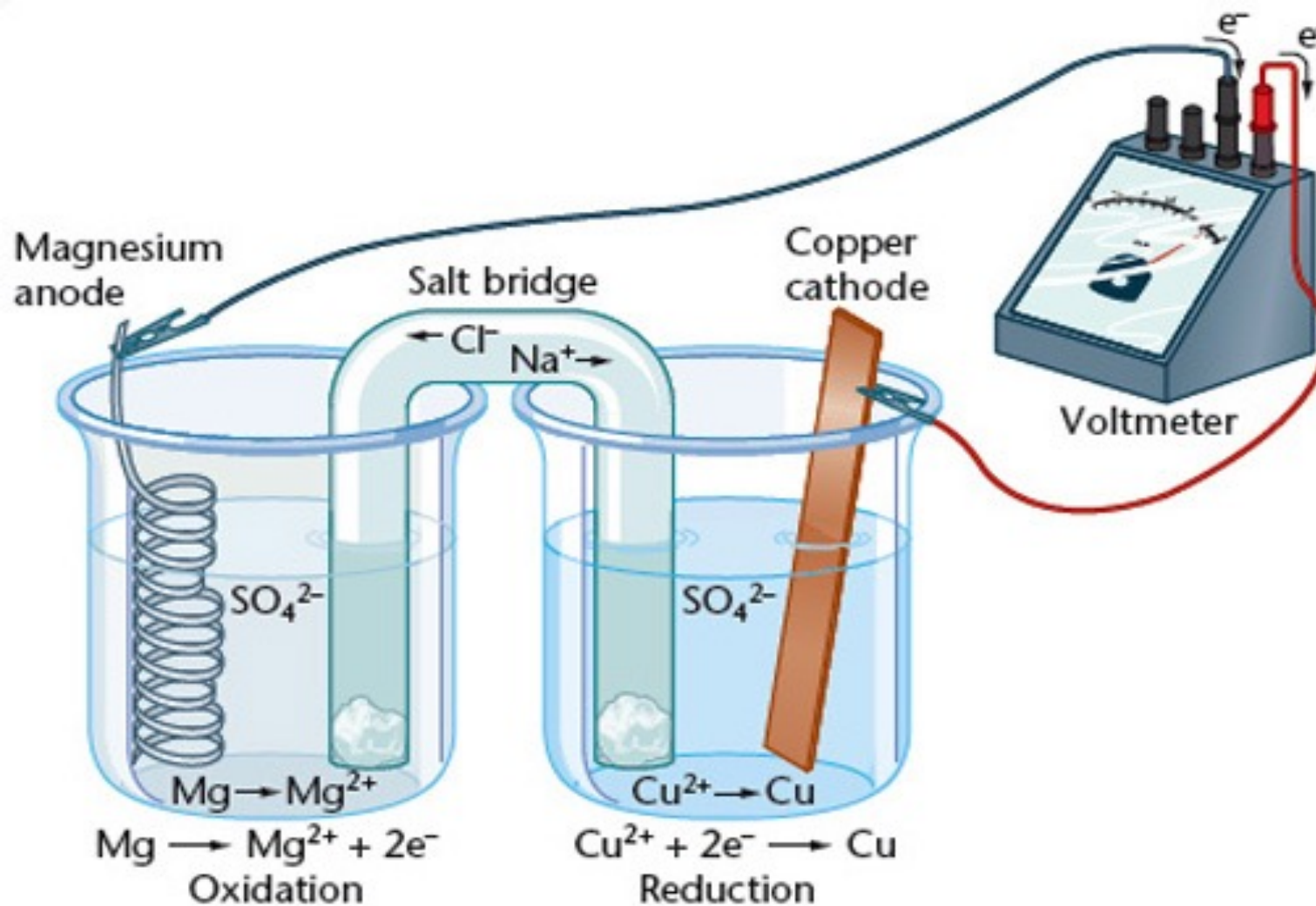
At Mg electrode:



At Cu electrode:



Conversion of Chemical reaction into electricity



leclanche cell

a primary electrochemical cell having a zinc Anode in contact with ammonium chloride (as a solution or a paste) as the electrolyte, and a carbon Cathode in contact with a mixture of manganese dioxide and carbon powder.

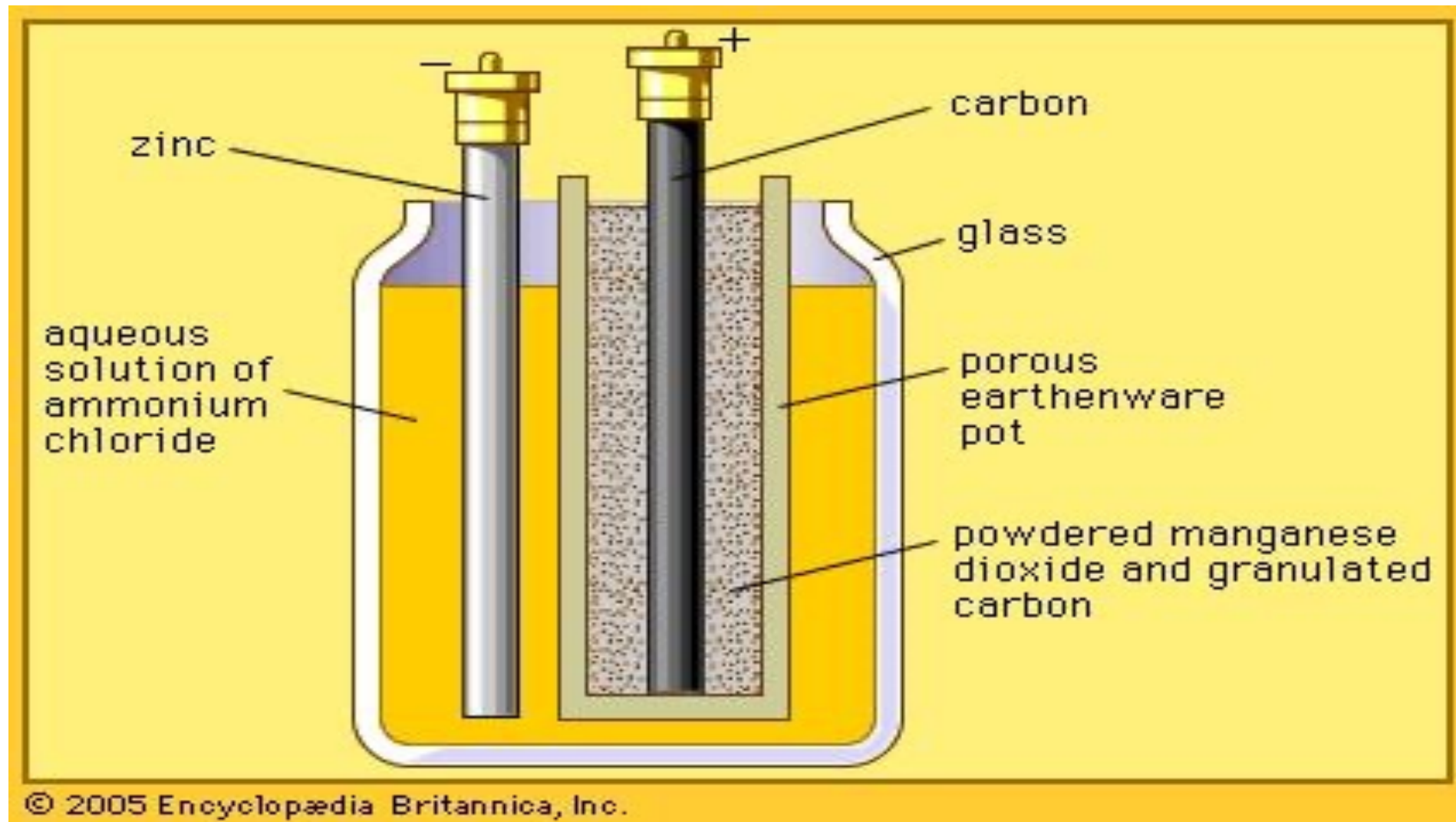
Cathode (+) = Carbon. **Anode (-) = Zn.** **Electrolyte = NH_4Cl soln.**

Cell working Mechanism

- when the two electrodes are connected, Zinc dissolves into its ions giving electrons which transfer to Carbon electrode through the wire doing the wanted work (e.g lightning the lamp).
- NH_4^+ is reduced at the Cathode into NH_3 producing hydrogen gas which is oxidised by using MnO_2 .

Conversion of Chemical reaction into electricity

leclanche cell



Car Battery: is a rechargeable Battery

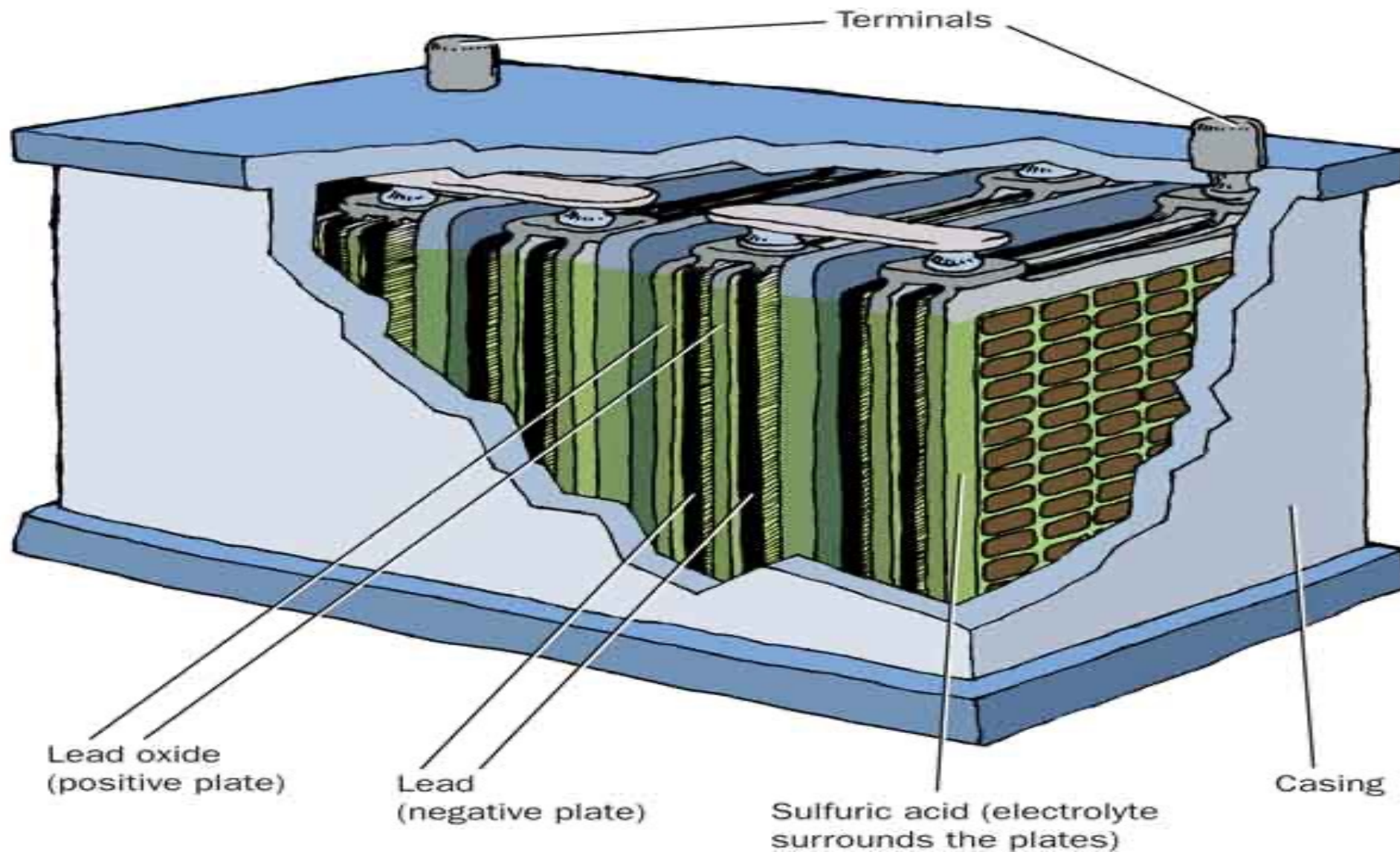
Cathode(+): Pb-Sb net

Anode (-) : Pb-Sb net

Electrolyte: H_2SO_4 soln.

Mechanism

- Both of Anode and Cathode nets are filled with PbSO_4 paste.
- Charging and discharging processes occur.



Charging Process:

- It occurs through passing an electrical current in one direction through the battery.

At Cathode



SO_4^{2-} into solution

At Anode



SO_4^{2-} into solution

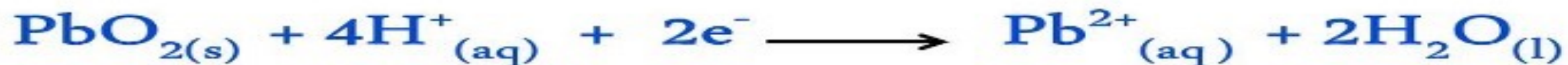
Charging Process:

- At charging process the filled paste of Cathode (-) net will be mainly Pb, and that for Anode (+) will become mainly PbO₂.
- Charging process will lead to accumulation of $2\text{SO}_4^{-2} : 4\text{H}^+$ which leads to increase the acidity.
- By full charged battery can provide 2 V e.m.f.

Discharging process:At Anode (-)

SO_4^{2-} taken from soln

PbSO_4 precipitated

At Cathode (+)

SO_4^{2-} , H^{+} taken from soln

PbSO_4 precipitated

Discharging process:

- ❖ The produced electrons at Anode (-) will pass through the external circuit doing the required electrical work and they will be consumed at Cathode (+).
- ❖ By consuming SO_4^{-2} at Anode area and H^+ at Cathode area with the ratio 2 : 4 respectively, that will lead to consume H_2SO_4 , so the e.m.f will decrease. So charging process should be taken place.

Any Questions

Dr. Ibrahim A. I. Hassan

Department of Chemistry - Faculty of Science - South Valley University

Email: I.Hassan@bath.edu



General Chemistry (II)

2nd Primary Students -Sci. Group (English Program)

Faculty of Education



Dr. Ibrahim A. I. Hassan

I.Hassan@bath.edu

Lect. 3

Colloids

Solutions

❖ **Homogeneous mixtures**

- **Solvent = dissolving medium and presents in the larger amount**
 - ▶ **often liquid; frequently water**
 - ▶ **gas in air and other gas solutions**
 - ▶ **rarely a solid**
- **Solute(s) = dissolved material(s) and present in the smaller amount(s)**
 - ▶ **solids, liquids, or gases**
 - ▶ **often more than one solute**

Solutions

- ❖ **A saturated solution contains the maximum amount of a solute that will dissolve in a given solvent at a specific temperature.**
- ❖ **An unsaturated solution contains less solute than the solvent has the capacity to dissolve at a specific temperature.**
- ❖ **A supersaturated solution contains more solute than is present in a saturated solution at a specific temperature.**

Solutions vs Colloids

□ Solution

- ❖ **Solute particles are of ionic or molecular size (a few nm across)**
- ❖ **Transparent to ordinary light**
- ❖ **Stable unless solvent evaporated**

□ Colloids

- **Solute (called “dispersed phase”) typically -1 nm to 1000 nm**
- **Giant molecules (or “clumps” of smaller ones)**
- **Not totally transparent – Tyndall Effect**
- **Dispersed phase may separate out (similar to separation of mayonnaise).**

Suspensions and Colloids

- ✓ **Suspensions and colloids are NOT solutions.**
- ✓ **Suspensions:** The particles are so large that they settle out of the solvent if not constantly stirred.
- ✓ **Colloids:** The particle is intermediate in size between those of a suspension and those of a solution.

Solutions

Colloidal Dispersions

Suspensions

Transparent (but often colored)

Often translucent or opaque, but may be transparent

Often opaque but, may appear translucent

No Tyndall effect

Tyndall effect

Not applicable

No Brownian movement

Brownian movement

Particles separate unless system is stirred

Cannot be separated by filtration

Cannot be separated by filtration

Can be separated by filtration

Colloids







□ Colloids are everywhere

- In the human body
- Washing powder, soup, toothpaste, etc.
- Many foods (yogurt, butter, milk)
- Nanotechnologies are based on chemistry of colloids

Types of Colloids

Examples	Dispersed Substance	Dispersing Medium	Colloid Type
Fog, aerosol sprays	Liquid	Gas	Aerosol
Smoke, airborne bacteria	Solid	Gas	Aerosol
Whipped cream, soap suds	Gas	Liquid	Foam
Milk, mayonnaise	Liquid	Liquid	Emulsion
Paint, clays, gelatin	Solid	Liquid	Sol
Marshmallow, Styrofoam	Gas	Solid	Solid foam

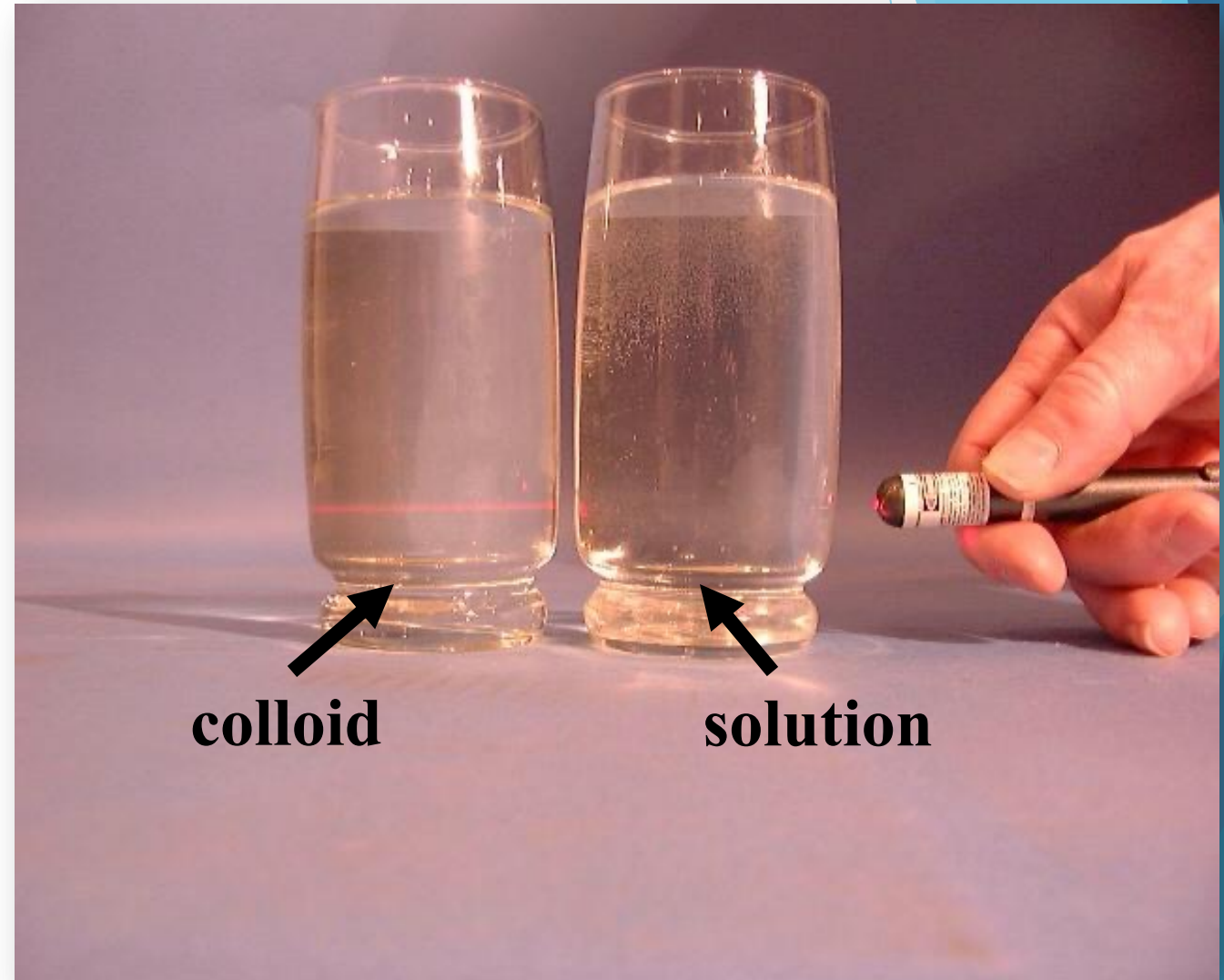
Some Colloidal Systems

System		Type	Example
Dispersed phase	Dispersion medium		
gas	liquid	foam	whipped cream 
gas	solid	foam	marshmallow 
liquid	liquid	emulsion	milk, mayonnaise 
liquid	gas	aerosol	fog, aerosols 
solid	gas	smoke	dust in air 
solid	liquid	sols and gels	egg white, jellies, paint, blood, colloidal gold, starch in water, gelatin 

The Tyndall Effect

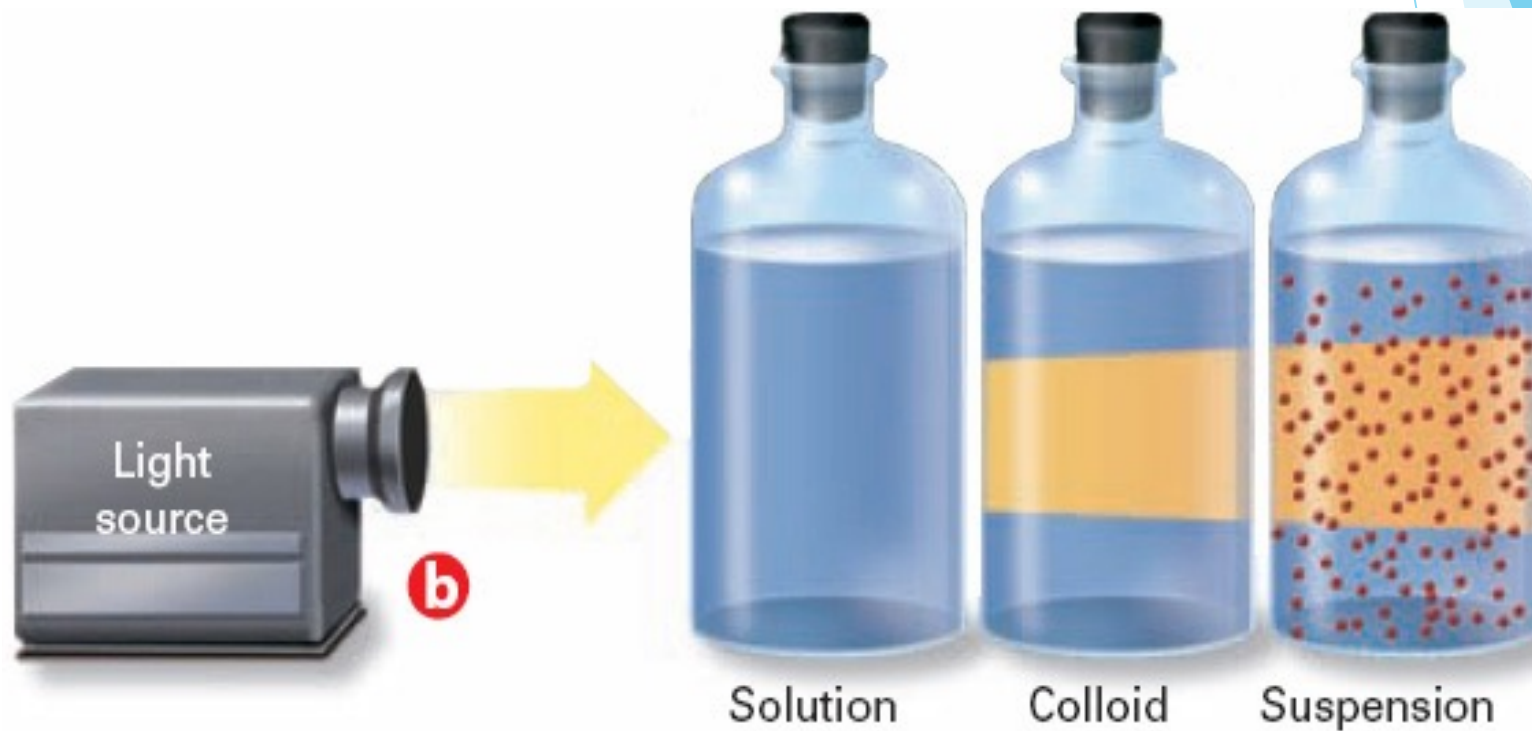
Colloids scatter light, making a beam visible. Solutions do not scatter light.

Which glass contains a colloid?



Colloids

Particles in colloids and suspensions reflect or scatter light in all directions. Solutions do not scatter light.



Colloids

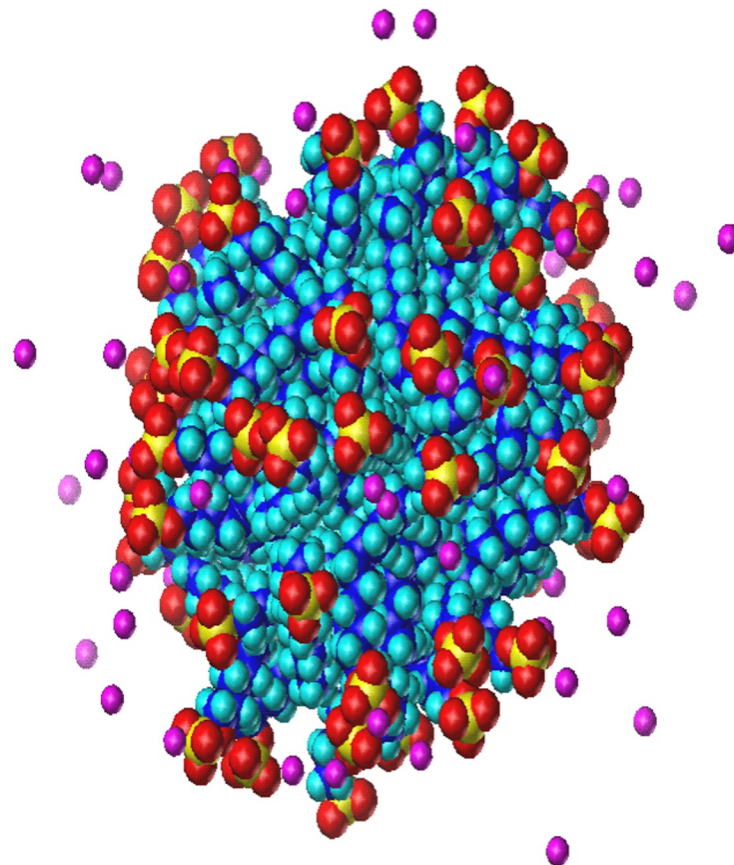
Brownian Motion

- **The chaotic movement of colloidal particles, which was first observed by the Scottish botanist Robert Brown (1773–1858), is called Brownian motion.**
- **Brownian motion is caused by collisions of the molecules of the dispersion medium with the small, dispersed colloidal particles.**

Removal of Colloidal Particles

❑ Colloid particles are too small to be separated by physical means (e.g. filtration).

❑ Colloid particles are coagulated (enlarged) until they can be removed by filtration.



Removal of Colloidal Particles

Methods of coagulation:

- ❑ **Heating:** (colloid particles move and are attracted to each other when they collide);
- ❑ **Adding an electrolyte:** (neutralize the surface charges on the colloid particles).
- ❑ **Dialysis:** using a semipermeable membranes separate ions from colloidal particles.

Lyophilic & Lyophobic Colloids

❑ If the colloids in water, it called **Hydrophilic & Hydrophobic Colloids**

❑ “Water loving” colloids: **hydrophilic.**

❑ “Water hating” colloids: **hydrophobic.**

Any Questions

Dr. Ibrahim A. I. Hassan

Department of Chemistry - Faculty of Science - South Valley University

Email: I.Hassan@bath.edu



General Chemistry (II)

2nd Primary Students -Sci. Group (English Program)

Faculty of Education

Dr. Ibrahim A. I. Hassan

I.Hassan@bath.edu

Lect. 4

Preparation of Colloids



Colloids



Preparation methods of Colloids

There are two methods: Dispersion method and Condensation method.

I- Dispersion method :

- ❖ The substance is crushed into small particles until its diameter reaches between (1 : 100 nm), then added to the dispersed medium with stirring.
- ❖ For examples: starch in hot water, and cappuccino coffee .

I- Dispersion method :

1- Electrical Disintegration (Bredig's Arc Method):

- It is the combination of dispersion and condensation.
- This technique is most commonly used for the preparation of colloidal solutions of metals such as gold, silver, platinum, etc.
- It involves the use of two metal electrodes dipped in a dispersion medium.

I- Dispersion method :

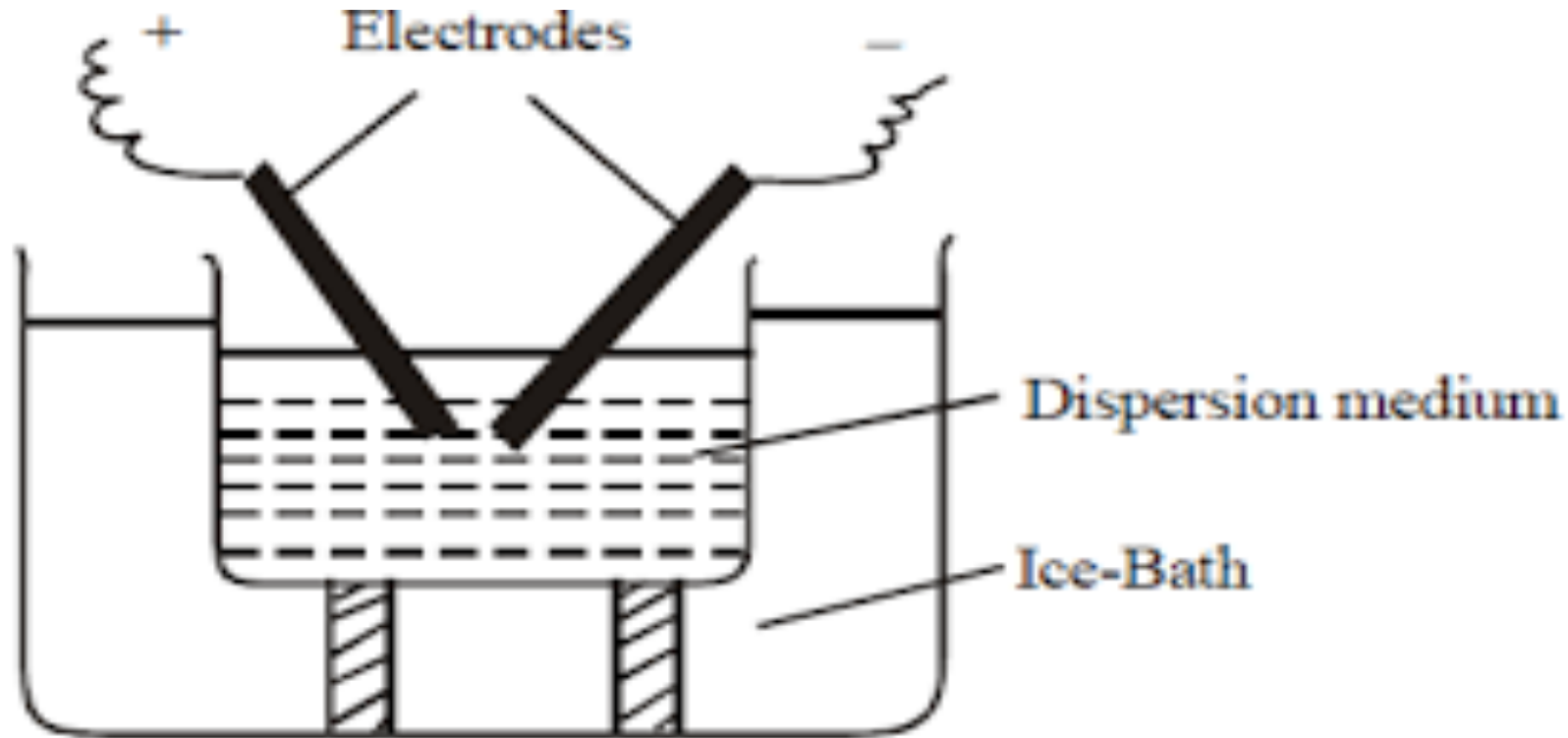
1- Electrical Disintegration (Bredig's Arc Method):

- **An electrical arc of intense heat is produced, vaporizing some of the metal.**
- **The vapours condense to form precipitate in colloidal dimensions.**

Preparation methods of Colloids

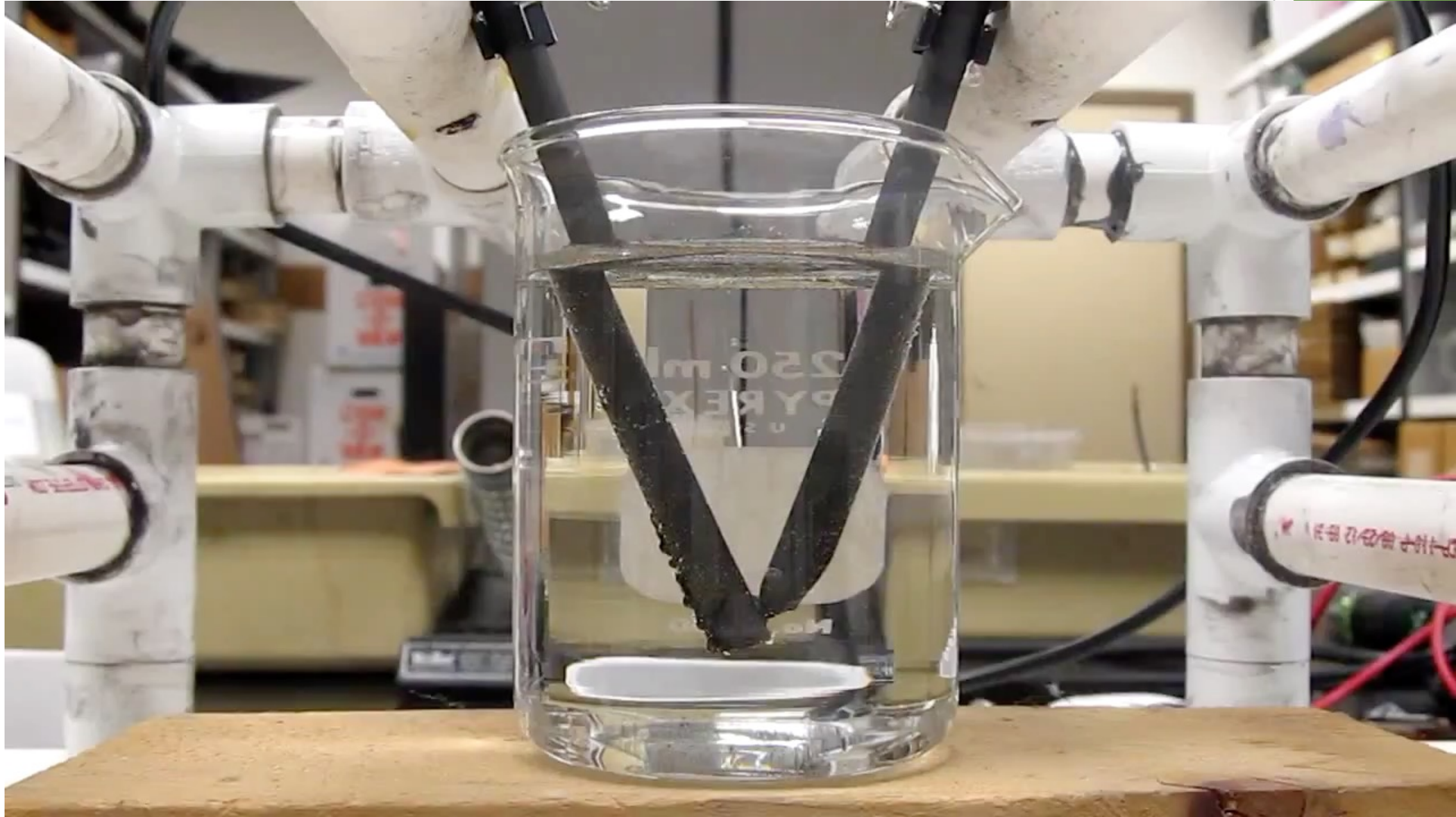
I- Dispersion method :

1- Electrical Disintegration (Bredig's Arc Method):



■ *Preparation of colloidal solution by Bredig's Arc Method*

Preparation methods of Colloids



I- Dispersion method :

2- Peptization:

Precipitate can be converted into colloidal form by shaking with dispersion medium in the presence of small amount of peptization agent (an electrolyte used to convert fresh precipitate into a colloidal solution).

For example: Adding Dilute HCl (as peptizing agent) to AgCl precipitate, so we can get a colloidal solution.

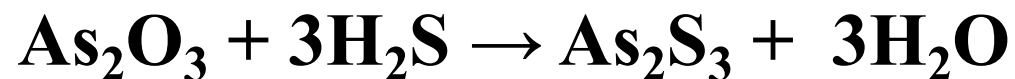
II- Condensation method:

The small particles are collected together into larger particles having the same volume of the colloid particles, by some processes like: Double Decomposition Technique, Oxidation, reduction, Hydrolysis, and Exchange of Solvent.

II- Condensation method:

a- Double Decomposition Technique:

When hydrogen sulphide is passed through a solution of arsenious oxide in distilled water, we get a colloidal solution of arsenious sulphide.



II- Condensation method:

b- Oxidation Technique:

Such as; in the reaction of hydrogen sulphide with Sulphur dioxide, where the atoms of Sulphur in water forms colloid.



Or exploring H_2S to air for a long time.



II- Condensation method:

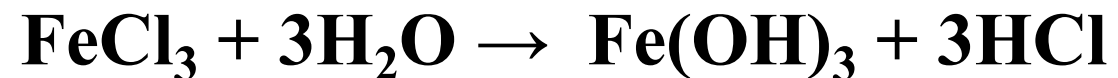
c- Reduction Technique:

Another technique of preparing colloidal solutions of metals such as silver, gold as well as platinum involves the use of reducing agent for reduction of the salt solutions of these metals. Example of reducing agent include stannous chloride.

II- Condensation method:

d- Hydrolysis Technique:

It involves the use of boiling water to obtain colloidal solution of Ferric Hydroxide by adding drops of Conc. ferric chloride.



II- Condensation method:

e- Exchange of Solvent

It involves the formation of a colloidal solution of an element by addition of its alcoholic solution to excess water. This colloidal formation can take place only when the element is more soluble in alcohol as compared to water.

II- Condensation method:

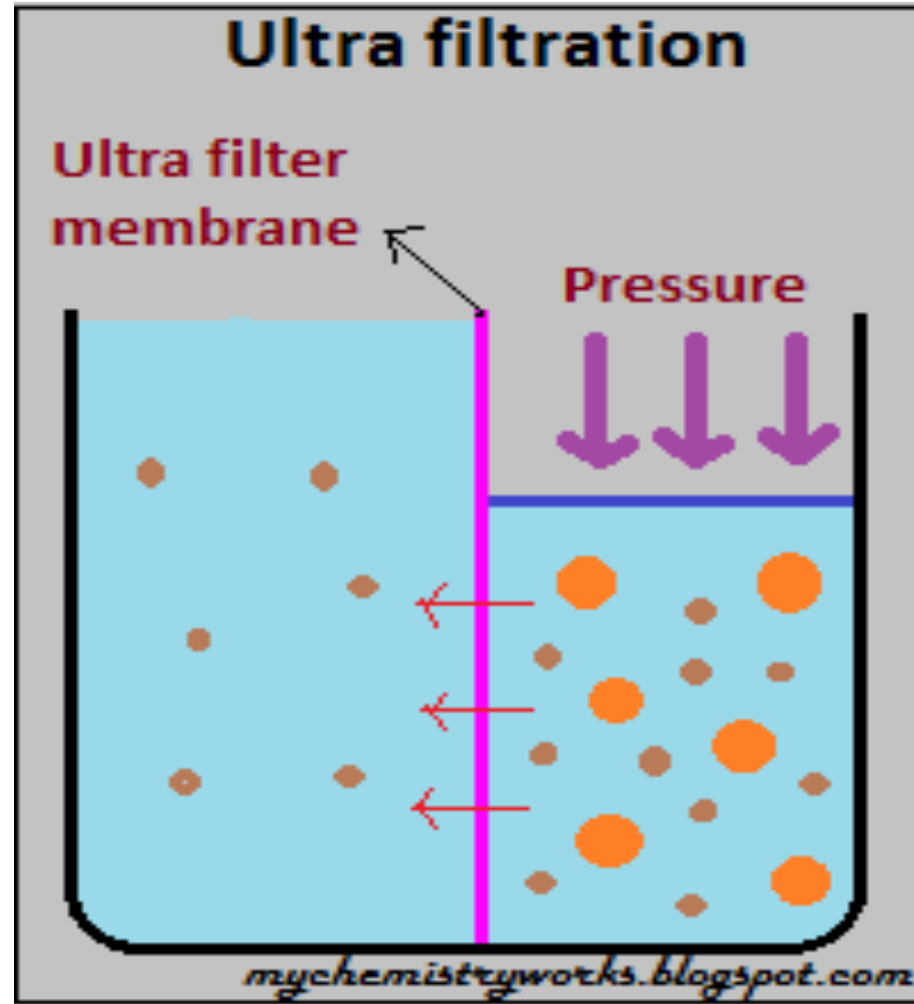
e- Exchange of Solvent

Example:

When an alcoholic solution of sulphur is made to pass through excess water it yields a colloidal solution of sulfur. This is because the solubility of sulphur is more in alcohol as compared to water.

Purification of Colloids:

1- Ultrafiltration:



Purification of Colloids:

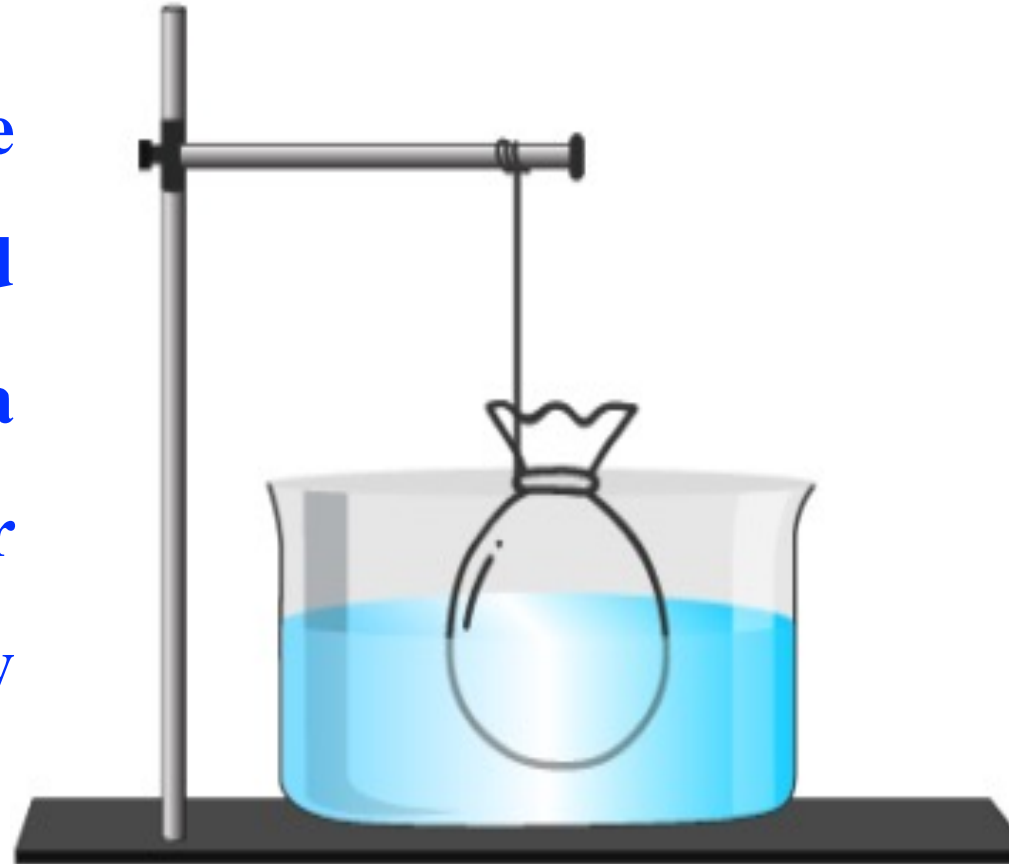
2- Dialysis and Electro-dialysis

- **After the preparation of the colloid, it becomes necessary to remove the excess electrolyte from the sol to impart stability to the sol.**
- **One could think of filtering the colloidal system, wash the colloid and re-disperse.**
- **But even the finest filter paper will retain little or none of the colloid.**

Purification of Colloids:

2- Dialysis and Electro-dialysis

- **Electrolytes or other soluble materials in sols are removed by putting the sol in a membrane of cellophane or parchment surrounded by water.**

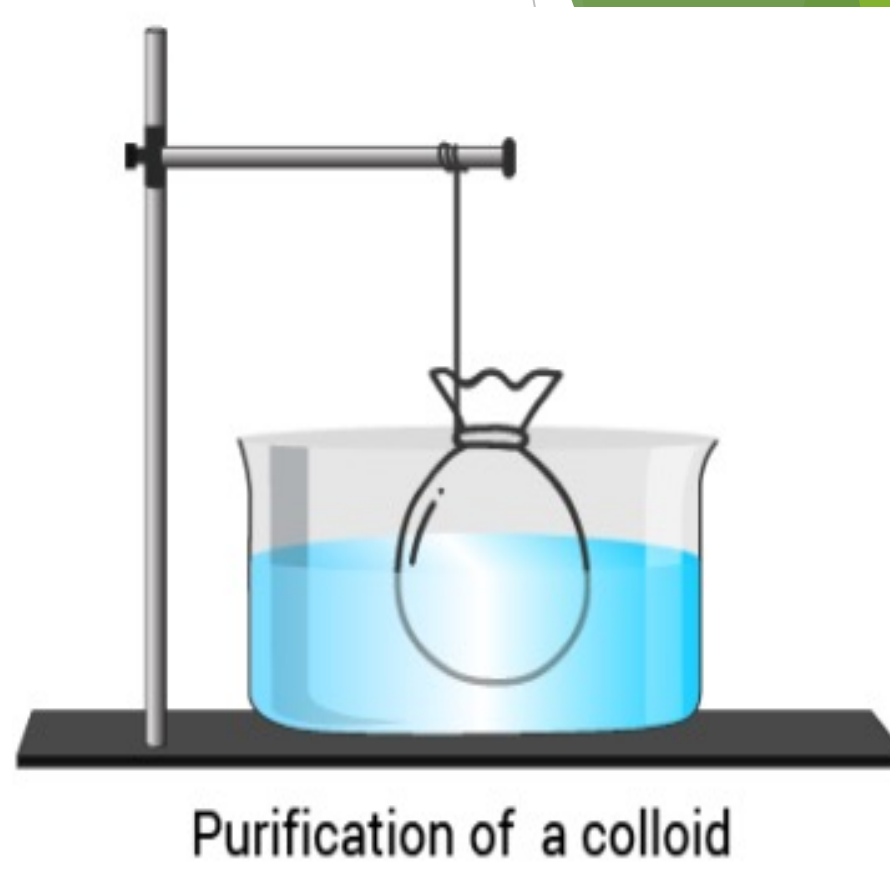


Purification of a colloid

Purification of Colloids:

2- Dialysis and Electro-dialysis

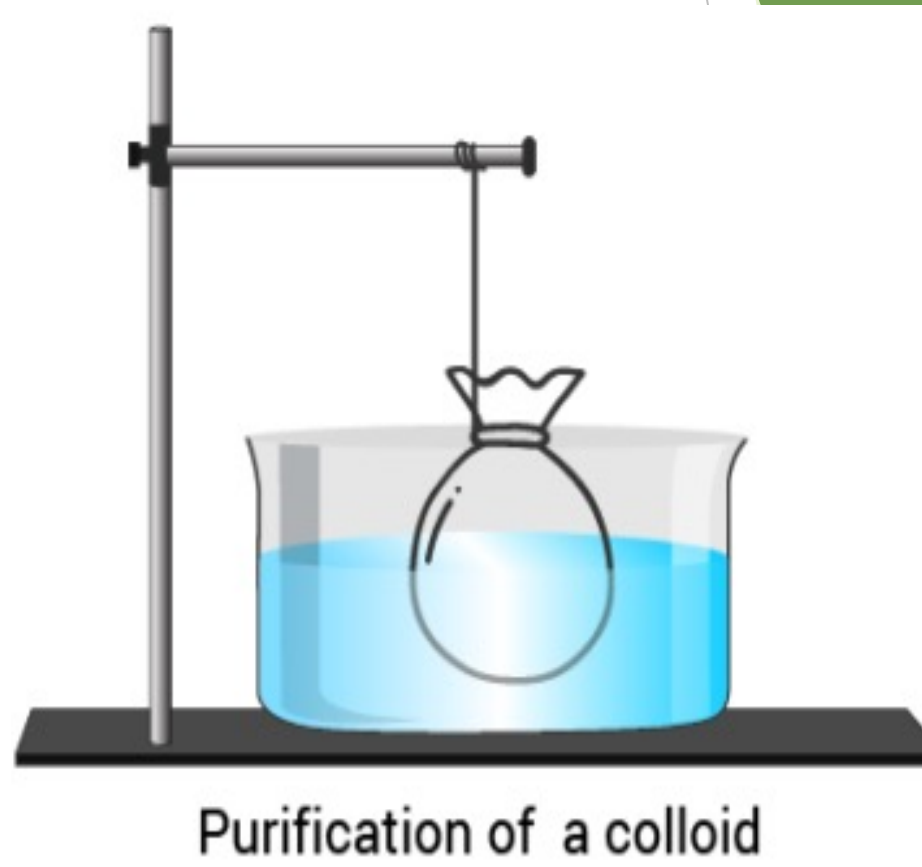
- The salts can pass through the membrane of parchment and are gradually washed away by running water whereas the colloid is left inside the Vessel.
- This process of separation of colloid and Graham's crystalloid is called dialysis.



Purification of Colloids:

2- Dialysis and Electro-dialysis

- The membrane through which dialysis is carried out serves as a sieve of extremely fine pore size so that only the small molecules or ions can pass, but not the relatively larger colloidal particles or large molecules of high polymers.



Purification of Colloids:

2- Dialysis and Electro-dialysis

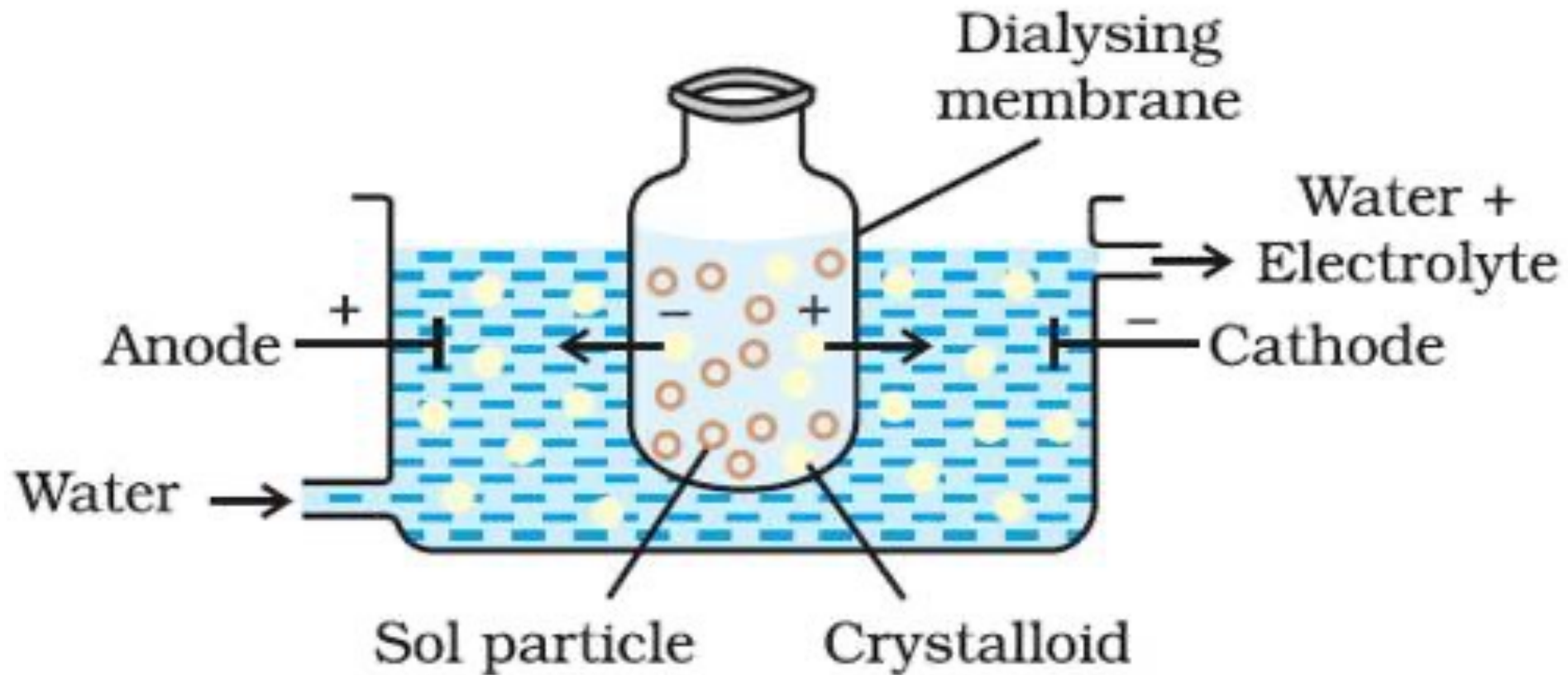
Electrodialysis

- ❑ The dialysis can be improved and made faster if the assembly is subjected to a suitable electric field.
- ❑ The migration of the ion of the electrolytes through the membrane becomes fast in the electric field and makes the process rapid.
- ❑ This is known as electrodialysis.

Purification of Colloids:

2- Dialysis and Electro-dialysis

Electrodialysis

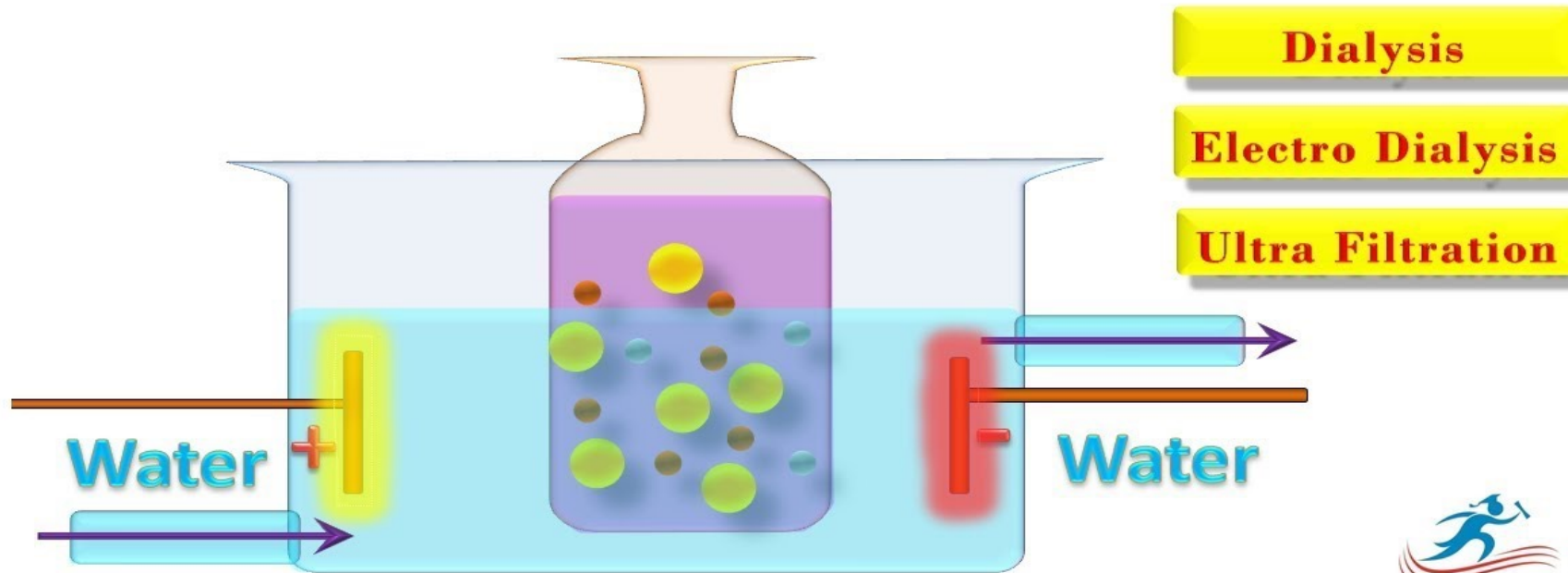


Purification of Colloids:

2- Dialysis and Electro-dialysis

Electrodialysis

Purification of Colloidal Solutions



Any Questions

Dr. Ibrahim A. I. Hassan

Department of Chemistry - Faculty of Science - South Valley University

Email: I.Hassan@bath.edu



General Chemistry (II)



2nd Primary Students -Sci. Group (English Program)

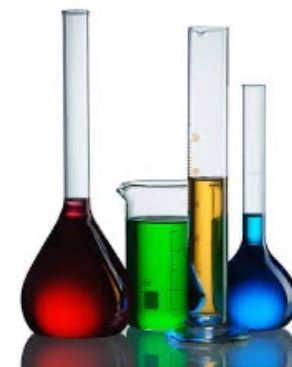
Faculty of Education

Dr. Ibrahim A. I. Hassan

I.Hassan@bath.edu

Lect. 6

Solutions



Solutions

True Solution

- It is a homogeneous mixture of two or more components.
- The particle diameter is < 1 nm.
- Examples: solutions of sugar, lactose, minerals, and vitamins.
- Solutions consists of two main components:
 1. Solvent = dissolving medium and present in the larger amount.

Solutions

Solvent can be:

- often liquid; frequently water
- gas in air and other gas solutions
- rarely a solid

2. Solute(s)=dissolved material(s) and present in the smaller amount(s).

- solids, liquids, and/or gases
- often more than one solute

Solutions

Solubility: It is the amount of solute required to prepare a saturated solution with a specific volume of solvent at a specific temperature.

According to the solubility, there are three types of solutions:

- 1. A saturated solution contains the maximum amount of a solute that will dissolve in a given solvent at a specific temperature.**

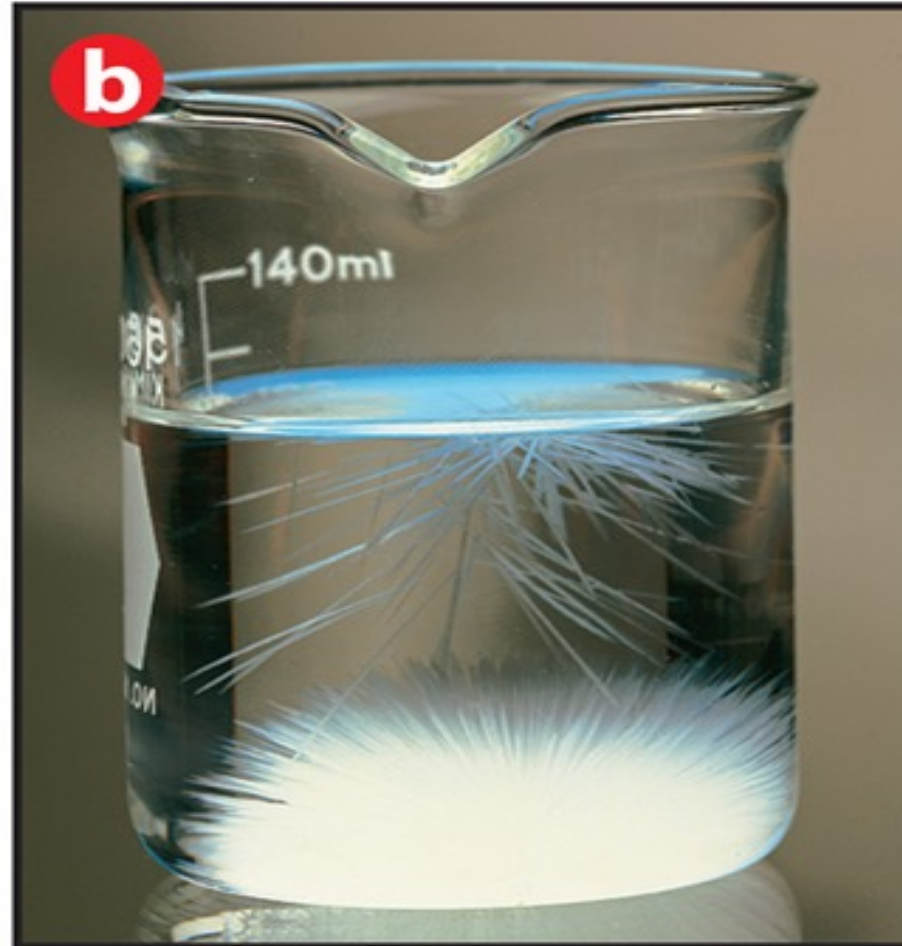
Solutions

2. An unsaturated solution contains less solute than the solvent has the capacity to dissolve at a specific temperature.
3. A supersaturated solution contains more solute than is present in a saturated solution at a specific temperature.

❖ A supersaturated solution is clear before a seed crystal is added.



❖ Crystals begin to form in the solution immediately after the addition of a seed crystal.



❖ **Excess solute crystallizes rapidly.**



Solution Formation

The compositions of the solvent and the solute determine whether a substance will dissolve.

The factors that determine how fast a substance dissolves are:-

❖ Nature of Solute / Solvent.

❖ Stirring (agitation).

❖ Temperature.

❖ The surface area of the dissolving particles.

Factors Affecting Solubility

1. Nature of Solute / Solvent.

□ Like dissolves like.

Organic solvents dissolve organic solute, and inorganic solvents dissolve inorganic solute.



Factors Affecting Solubility

1. Nature of Solute / Solvent.

2. Temperature :-

❖ Solids/Liquids Solubility increases with temperature.

Increasing Kinetic Energy (K.E.) increases motion and collision between solute / solvent, which leads to increasing the solubility.



Miscible vs. Immiscible

Miscible :- two liquids that dissolve in each other in all proportions.

Immiscible :- two liquids that are insoluble in one another.

The Chemical methods of expressing concentration

1. Percent (%w/v) - (Percentage weight in volume):

It expresses the number of grams of solute in 100 ml of solution.

2. g/L: Which means the number of grams of solute dissolved in one Liter of the solution.

3. Molarity (M):

Which is the number of moles (gram-molecular weights) of solute contained in 1000 ml (1 Litre) of solution.

The Chemical methods of expressing concentration

4. Molality (m):

Is the number of moles of a solute contained in 1000 gm of a solvent.

5. Normality (N):

Is the number of equivalents (gram- equivalent weight) of the solute in one litre of solution.

Any Questions

Dr. Ibrahim A. I. Hassan

Department of Chemistry - Faculty of Science - South Valley University

Email: I.Hassan@bath.edu



General Chemistry (II)

2nd Primary Students -Sci. Group (English Program)



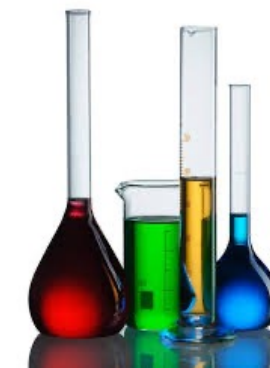
Dr. Ibrahim A. I. Hassan

I.Hassan@bath.edu



Lect. 7

Preparing of Solutions



The Chemical methods of expressing concentration

A. Equivalent weight of an acid

= Molecular weight of the acid / No. of replaceable hydrogen atoms.

= Molecular weight of the acid / Basicity of the acid



The Chemical methods of expressing concentration

A. Equivalent weight of an acid:-

For example, the basicity of Sulphuric acid is 2.

Equivalent weight of $\text{H}_2\text{SO}_4 = \text{Molecular weight of } \text{H}_2\text{SO}_4 / 2 = 98 / 2 = 49 \text{ gm.}$

Equivalent weight of $\text{CH}_3\text{COOH} = \text{molecular weight of } \text{CH}_3\text{COOH} / 1 = 60 / 1 = 60 \text{ gm}$



The Chemical methods of expressing concentration

B. Equivalent weight of a base = Molecular weight of the base/Number of replaceable hydroxide groups.

= Molecular weight of the base/acidity of the base.

Equivalent weight of KOH = 56 / 1 = 56

Equivalent weight of Ca(OH)₂ = 114 / 2 = 57



The Chemical methods of expressing concentration

C. Equivalent weight of a Salt = Molecular weight of the Salt / Oxidation number of one of its halves multiplied in number of its ions.

Examples:

Equivalent weight of $\text{Na}^+\text{Cl}^- = 58.5 / 1 = 58.5$

Equivalent weight of $\text{Ca}^{+2}\text{Cl}_2^{-1} = 114 / 2 = 57$



By Using the periodic table, in the next slide, calculate the molecular and equivalent weights for the following substances?



Periodic Table of the Elements

Element symbol represents state at room temperature.
Solid, Liquid or Gas

Atomic Number Atomic Mass

Symbol
Name

Electron Shells
Electron Configuration

1	2	13	14	15	16	17	18
1A 1A	2A 2A	3A 3A	4A 4A	5A 5A	6A 6A	7A 7A	8A 8A
1 1.008 H Hydrogen 1 1s ¹	2 4.003 He Helium 2 1s ²						
3 6.941 Li Lithium 2 [He]2s ¹	4 9.012 Be Beryllium 2 [He]2s ²						
11 22.990 Na Sodium 28 [Ne]3s ¹	12 24.305 Mg Magnesium 28 [Ne]3s ²						
19 39.098 K Potassium 28 [Ar]4s ¹	20 40.078 Ca Calcium 28 [Ar]4s ²						
37 84.468 Rb Rubidium 28 [Kr]5s ¹	38 87.62 Sr Strontium 28 [Kr]5s ²						
55 132.905 Cs Cesium 28 [Xe]6s ¹	56 137.328 Ba Barium 28 [Xe]6s ²						
87 223.020 Fr Francium 28 [Rn]7s ¹	88 226.025 Ra Radium 28 [Rn]7s ²						
21 44.956 Sc Scandium 28 [Ar]3d ¹ 4s ²	22 47.88 Ti Titanium 28 [Ar]3d ² 4s ²	23 50.942 V Vanadium 28 [Ar]3d ³ 4s ²	24 51.996 Cr Chromium 28 [Ar]3d ⁵ 4s ¹	25 54.938 Mn Manganese 28 [Ar]3d ⁵ 4s ²	26 55.845 Fe Iron 28 [Ar]3d ⁶ 4s ²	27 58.933 Co Cobalt 28 [Ar]3d ⁷ 4s ²	28 58.693 Ni Nickel 28 [Ar]3d ⁸ 4s ²
39 88.906 Y Yttrium 28 [Kr]4d ¹ 5s ²	40 91.224 Zr Zirconium 28 [Kr]4d ² 5s ²	41 92.906 Nb Niobium 28 [Kr]4d ⁴ 5s ¹	42 95.95 Mo Molybdenum 28 [Kr]4d ⁵ 5s ¹	43 98.907 Tc Technetium 28 [Kr]4d ⁵ 5s ²	44 101.07 Ru Ruthenium 28 [Kr]4d ⁷ 5s ¹	45 102.906 Rh Rhodium 28 [Kr]4d ⁸ 5s ¹	46 106.42 Pd Palladium 28 [Kr]4d ¹⁰
57-71 Lanthanide Series	72 178.49 Hf Hafnium 28 [Xe]4f ¹⁴ 5d ² 6s ²	73 180.948 Ta Tantalum 28 [Xe]4f ¹⁴ 5d ³ 6s ²	74 183.84 W Tungsten 28 [Xe]4f ¹⁴ 5d ⁴ 6s ²	75 186.207 Re Rhenium 28 [Xe]4f ¹⁴ 5d ⁵ 6s ²	76 190.23 Os Osmium 28 [Xe]4f ¹⁴ 5d ⁶ 6s ²	77 192.217 Ir Iridium 28 [Xe]4f ¹⁴ 5d ⁷ 6s ²	78 195.085 Pt Platinum 28 [Xe]4f ¹⁴ 5d ⁹ 6s ¹
89-103 Actinide Series	104 [261] Rf Rutherfordium 28 [Rn]5f ¹⁴ 6d ² 7s ² *	105 [262] Db Dubnium 28 [Rn]5f ¹⁴ 6d ³ 7s ² *	106 [266] Sg Seaborgium 28 [Rn]5f ¹⁴ 6d ⁴ 7s ² *	107 [264] Bh Bohrium 28 [Rn]5f ¹⁴ 6d ⁵ 7s ² *	108 [269] Hs Hassium 28 [Rn]5f ¹⁴ 6d ⁶ 7s ² *	109 [268] Mt Meitnerium 28 [Rn]5f ¹⁴ 6d ⁷ 7s ² *	110 [269] Ds Darmstadtium 28 [Rn]5f ¹⁴ 6d ⁸ 7s ² *

57 138.905 La Lanthanum 28 [Xe]5d ¹ 6s ²	58 140.116 Ce Cerium 28 [Xe]4f ¹ 5d ¹ 6s ²	59 140.908 Pr Praseodymium 28 [Xe]4f ³ 6s ²	60 144.243 Nd Neodymium 28 [Xe]4f ⁴ 6s ²	61 144.913 Pm Promethium 28 [Xe]4f ⁵ 6s ²	62 150.36 Sm Samarium 28 [Xe]4f ⁶ 6s ²	63 151.964 Eu Europium 28 [Xe]4f ⁷ 6s ²	64 157.25 Gd Gadolinium 28 [Xe]4f ⁷ 5d ¹ 6s ²	65 158.925 Tb Terbium 28 [Xe]4f ⁹ 6s ²	66 162.500 Dy Dysprosium 28 [Xe]4f ¹⁰ 6s ²	67 164.930 Ho Holmium 28 [Xe]4f ¹¹ 6s ²	68 167.259 Er Erbium 28 [Xe]4f ¹² 6s ²	69 168.934 Tm Thulium 28 [Xe]4f ¹³ 6s ²	70 173.055 Yb Ytterbium 28 [Xe]4f ¹⁴ 6s ²	71 174.967 Lu Lutetium 28 [Xe]4f ¹⁴ 5d ¹ 6s ²
89 227.028 Ac Actinium 28 [Rn]6d ¹ 7s ²	90 232.038 Th Thorium 28 [Rn]6d ² 7s ²	91 231.036 Pa Protactinium 28 [Rn]5f ² 6d ¹ 7s ²	92 238.029 U Uranium 28 [Rn]5f ³ 6d ¹ 7s ²	93 237.048 Np Neptunium 28 [Rn]5f ⁴ 6d ¹ 7s ²	94 244.064 Pu Plutonium 28 [Rn]5f ⁶ 7s ²	95 243.061 Am Americium 28 [Rn]5f ⁷ 7s ²	96 247.070 Cm Curium 28 [Rn]5f ⁸ 2s ² 9z ²	97 247.070 Bk Berkelium 28 [Rn]5f ⁹ 7s ²	98 251.080 Cf Californium 28 [Rn]5f ¹⁰ 7s ²	99 [254] Es Einsteinium 28 [Rn]5f ¹¹ 7s ²	100 257.095 Fm Fermium 28 [Rn]5f ¹² 7s ²	101 258.1 Md Mendelevium 28 [Rn]5f ¹³ 7s ²	102 259.101 No Nobelium 28 [Rn]5f ¹⁴ 7s ²	103 [262] Lr Lawrencium 28 [Rn]5f ¹⁴ 6d ¹ 7s ² *

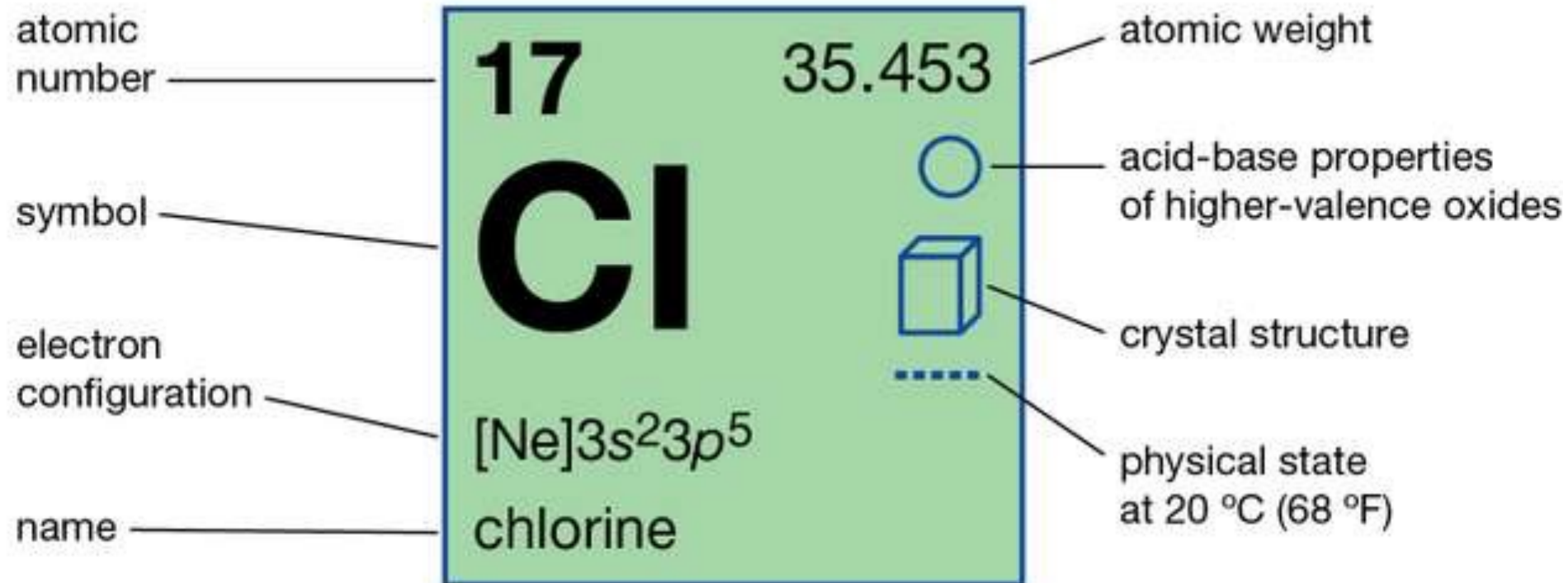
- Alkali Metal
- Alkaline Earth
- Transition Metal
- Basic Metal
- Metalloid
- Nonmetal
- Halogen
- Noble Gas
- Lanthanide
- Actinide



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Chlorine



Halogens	Gas
Orthorhombic	Strongly acidic

Types of Solutions according to the types of solvent and solute.

A. Gases in Gases: such as O₂ and N₂ in Air.

Gases mixed quickly in each other due to their quick distribution and the large interstitial distances among the gas particles.



Types of Solutions according to the types of solvent and solute.

B. Gases in Liquids solutions: such as ammonia and carbon dioxide in water.



Solubility of gas in liquid is defined as the gas volume which is required to prepare a saturated solution of 1 cm³ of the solvent.



Factors affecting the suitability of gases in liquids.

1. The gas type.

✓ The much easy liquefying gases the much easy for them to soluble in liquids.

for example solubility of carbon dioxide and water is much higher than the solubility of oxygen in water.

✓ The solubility of gases increases if the gas tends to react with the liquid.

For example ammonia soluble in water forming NH_4OH .

Factors affecting the suitability of gases in liquids.

2. Liquid type:

➤ **The solubility of gas is different from liquid to liquid.**

For example, the solubility of carbon dioxide in benzene much more than it's solubility in water.

3. Effect of temperature.

The solubility of gases in liquids is exothermic process, so these solubility decreases by increasing the temperature.

Any Questions

Dr. Ibrahim A. I. Hassan

Department of Chemistry - Faculty of Science - South Valley University

Email: I.Hassan@bath.edu



General Chemistry (II)

2nd Primary Students -Sci. Group (English Program)

Faculty of Education



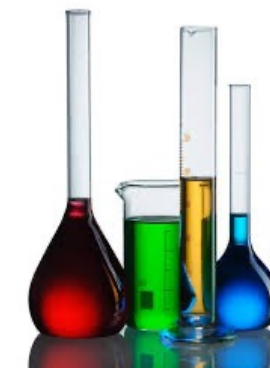
Dr. Ibrahim A. I. Hassan

I.Hassan@bath.edu



Lect. 8

Types of Solutions



Gases in liquids Solutions.

✓ **Solutions having solute in gaseous state and solvent in liquid state, are called Gas - Liquid Solutions.**

For example - Solution of oxygen in water, mixture of carbon dioxide in water.

Coca cola, is an example of gas - liquid solution, as it has carbon dioxide dissolved in water.



Factors affecting the solubility of gases in liquids.

3. Effect of temperature.

Decreasing of solubility by increasing the temperature can be due to increasing of the kinetic energy of the gas so it can escape from the solution. Meanwhile, decreasing the temperature can lead to condensation of the gas and decreasing the kinetic energy, consequently increasing the solubility of the gas in the liquid.

✓ 4. The effect of pressure (Henry's law)

According to Henry's law; at a specific temperature, the dissolved weight of a gas, in a specific volume of the liquid, is proportional to the gas pressure. So, if the applied pressure was doubled, that can lead to doubling the amount of the dissolved gas at the same volume of the liquid.

If m is the gas mass which is soluble at a specific volume of the liquid and P it's pressure so:

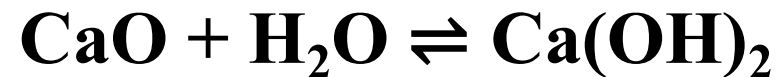
$$m \propto P$$

$$m = KP$$

C. Gases in solids solutions: such as hydrogen in Iron or Nickel or Platinum.

Gases are absorbed on the surface of the solids which can be done in three different forms:

❖ **Chemical absorption:** which can be done between the gas and the solid through a chemical reaction such as the absorption of CO₂ on the surface of lime (hydrated lime) to form calcium carbonate.



C. Gas is in solids solutions

❖ **Distribution:** which means the gas can distribute into the pores of the solid to form a homogeneous mixture as in the case of hot palladium with hydrogen.



Types of solutions according to the types of solute and solvent

C.Gas is in solids solutions

Adsorption: in which the gas particles can be adsorbed on the surface of the solid, which is followed by a slow distribution process of the gas into the solid.

For example, the adsorption of hydrogen on the surface of Carbon.

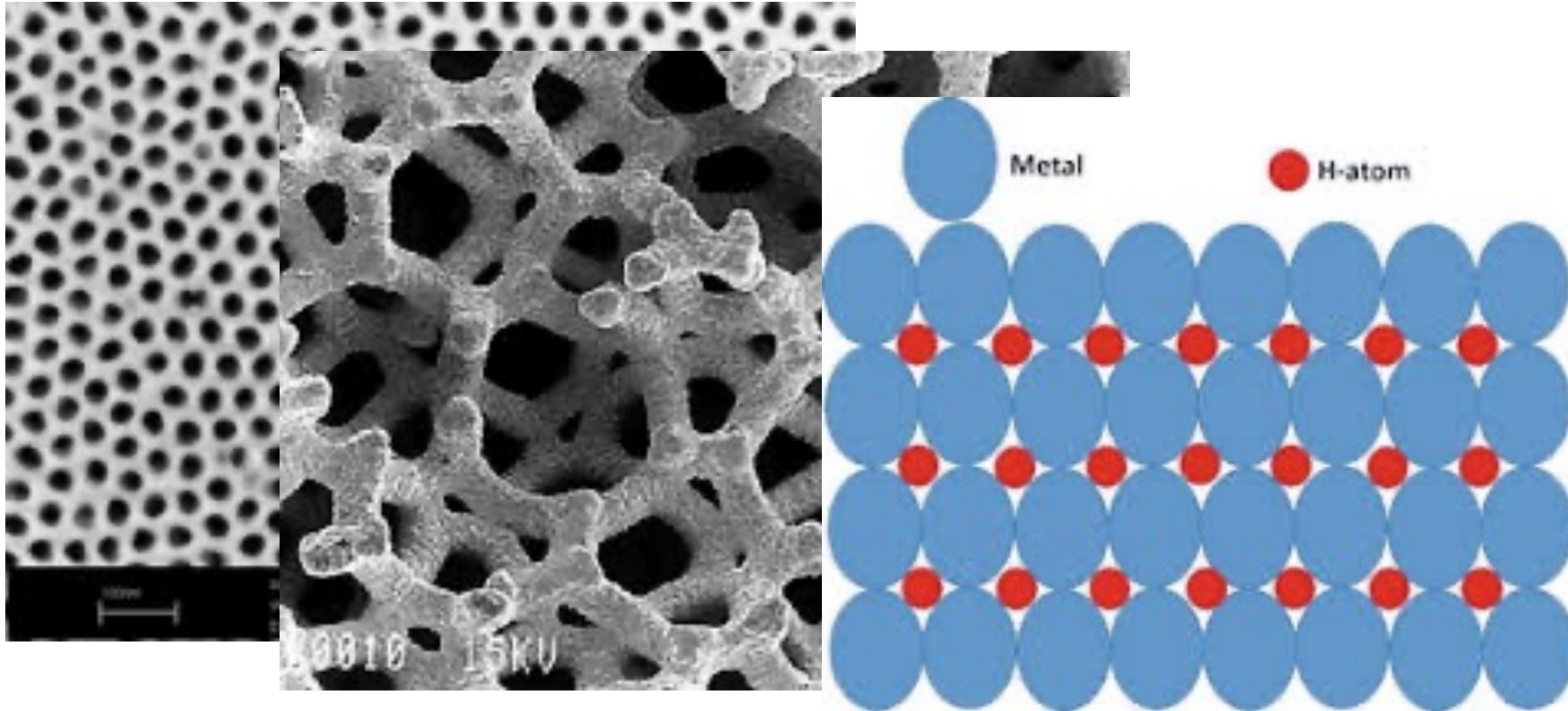


Types of solutions according to the types of solute and solvent

C. Gas is in solids solutions

Hydrogen adsorbed on Iron, Nickel, Platyidium or Carbon.

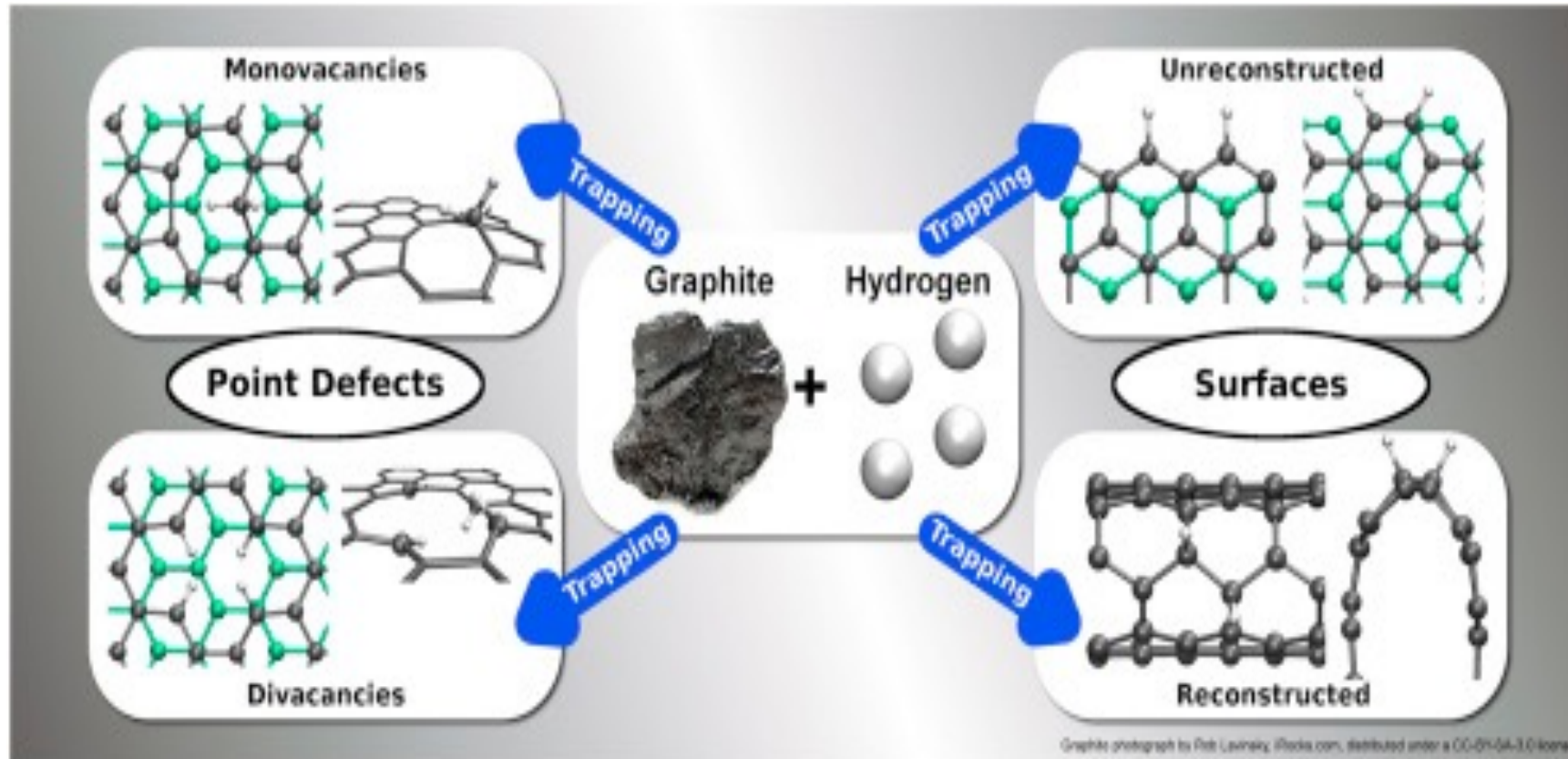
Metal Hydride (MH)



Types of solutions according to the types of solute and solvent

C. Gas is in solids solutions

The adsorption of hydrogen on the surface of carbon (Nano-Graphene).



<https://www.sciencedirect.com/science/article/abs/pii/S0008622317309788>

Types of solutions according to the types of solute and solvent

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- **The adsorption process is much faster than the distribution process.**
- **The adsorption process depends on :**
 - 1. Gas type:** as easy the gas can be liquified as much faster it's ability to be absorbed on the surface of solids



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Absorption depends also on:

2. The solid type: as the adsorption is different from a solid to a solid.

For example the adsorption of hydrogen on the surface of Nickel is much higher than the adsorption of hydrogen on the surface of Copper on the same conditions of the pressure and temperature.



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Adsorption depends also on:

3. The solid surface area: as much surface area of the solid as much gas amount can be absorbed.

For example; the powdered Platinum has ability to adsorb much bigger amount of gases than the polished Platinum does, that due to the bigger surface area of the divided Pt.

➤ **For that, when we use a catalyst in a chemical reaction, we use the divided material**



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Adsorption depends also on:

4. Temperature: adsorption is an exothermic process, for that and according to Le Chatelier's Principle; the adsorption process decreases by increasing the temperature.

➤ Moreover increasing the temperature leads to increasing the kinetic energy of the gas, so it can overcome the attractive force which connected it to the solid surface, consequently the amount of absorbed gas will decrease.

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Adsorption depends also on:

4. Pressure: adsorption increases by increasing the pressure at a specific temperature until it reaches a saturation, in which the solid surface can't accept any further gas molecules.



Any Questions

Dr. Ibrahim A. I. Hassan

Department of Chemistry - Faculty of Science - South Valley University

Email: I.Hassan@bath.edu