Which are thermal neutrons?

NUCLEI

Continued from November 24th..

5) In foods preservation: By exposing vegetables and other food stuffs to radiations from radio-active isotopes, their shelf life can be increased.

6) In agriculture:

a) Radio phosphorus(P^{12}) is used to study the uptake of phosphorus by plants using.

b) Radio sulphur (S^{14}) is used to study the transport of minerals in plants.

c)Radio zinc is used to develop new species of plants by causing genetic mutation.

d) Irradiation by γ - radiations of seeds to improve yields.

7) In chemistry :

a) Ratio oxygen (O^{18}) is used to study the mechanisms of photosynthesis and hydrolysis of ester

b) Radio isotopes are used in the chemical analysis of solubility of sparingly soluble salts such as $PbSO_4$ and AgCl and determination of trace amounts of elements in industrial raw materials and products.

NEUTRON

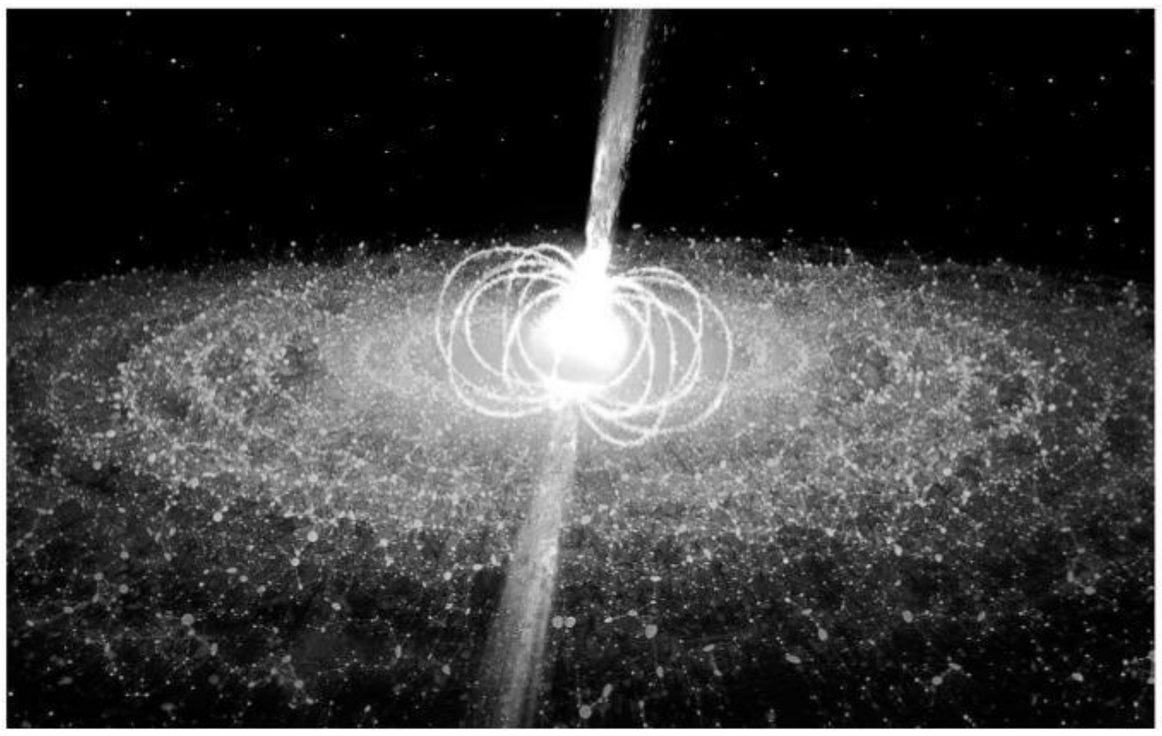
- It is electrically neutral and its mass is slightly greater than that of proton. It was discovered by Chadwick
- Both-Becker equation :
  $_4Be^9 + {}_2He^4 \rightarrow [{}_6C^{13}] \rightarrow {}_6C^{12} + {}_0n^1$
- Neutron is unstable outside the nucleus.
  $_0n^1 \rightarrow {}_1H^1 + {}_{-1}e^0 + \bar{\nu}$ (anti neutrino)
- It has high penetrating power and low ionizing power
- Slow moving neutrons are called thermal neutrons. Fast moving neutrons convert into thermal neutrons when they pass through a substance called moderator.
- Thermal neutrons have an average energy of nearly 0.025eV. Find moving neutrons have an average energy of 2MeV.

NUCLEAR FISSION

- Nuclear Fission is a nuclear reaction in which a heavy atomic nucleus like U^{235} splits into two approximately equal parts, emitting neutrons and liberating large amount of energy.
- Bohr and wheeler proposed liquid drop model to explain this fission process.
- Nucleus of U^{235} undergoes fission when it is struck by slow neutrons. This is not due to the impact of neutron.
- Energy of about 200MeV is released during one fission reaction of $_{92}U^{235}$. The most probable nuclear fission reaction is
  $_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3{}_0n^1$+energy
  There is no guarantee that U^{235}always breaks into Barium and Krypton.
- On an average, in the fission of U^{235},2.5 neutrons are emitted per fission when fission occurs due to slow neutrons.U^{235} undergoes fission with fast neutrons also. But this probability is minimum.
- Fission fragments are unstable and emit neutrons some time after fission reaction which are called "delayed neutrons"
- 99% of neutrons emitted during fission process are prompt
- Delayed neutrons play an important role in chain reaction.

CHAIN REACTION :

- If the mass of fissionable material exceeds a critical value, chain reaction or self propagating fission reaction takes place.
- The rate of reaction increases in geometric progression during uncontrolled chain reaction.



INTERMEDIATE special SENIOR

- Chain-reaction: The process of continuation of nuclear fission which when one started continues spontaneously without the supply of additional neutrons from outside is defined as chain reaction.

  Reproduction factor(K) : "it is the ratio of number of neutrons in any particular generation to the number of neutrons in the proceeding generation.
  Case(i): K <1:Chain reaction is not maintained.(sub – critical state)
  Case(ii) : K=1: Chain reaction is maintained at steady rate.(critical state).In the state electricity is produced in the reactors at steady rate.

  Case(iii):K>1:Chain reaction becomes self sustained and lead to atomic explosion(super critical state).
- Uncontrolled chain reaction takes place in atom bomb.

NUCLEAR REACTOR OR ATOMIC PILE:

- Nuclear reactor is a device in which nuclear fission is produced by controlled self sustaining chain reaction. And is used for the production of nuclear power (energy).
- The essential parts of a nuclear reactor are (i)the fuel, (ii) moderator, (iii) control rods, (iv) coolant (v) radiation shields.
- The Fuel: The common fuels used are uranium (U^{235}), enriched uranium(U^{235}) and plutonium (Pu^{236}) and Th^{232}

MODERATOR:

- The function of a moderator is to slow down the fast moving neutrons to increase the rate of fission
- The commonly used moderators in the order of efficiency are (i) Heavy water (ii) graphite,(iii) Berillium and Berillium Oxide
- Heavy water is a best moderator
- A good moderator should have
  (1)low atomic mass
  (2)Poor absorption of neutrons
  (3)good scattering property.
  (4)The size of moderator atom should be nearly of same size as that of the size of a prompt neutron.

CONTROLRODS:

- The function of a control rod is to absorb (capture) the neutrons.
- Cadmium, Boron and steel rods are used as control rods in a nuclear reactor.
- Cadmium rods are best control rods
- They regulate the net rate of neutron production and hence they control the intensity of fission process

COOLANT :

- The function of a coolant is to keep the reactor temperature at a low value so that there may not be any danger of heat damage to the reactor.
- Air and CO_2 are used as gaseous coolants. Water, Organic liquids, Helium, liquid Sodium are used as liquid coolants. Liquid sodium best coolant
- Protective shield: The process of preventing radioactive effect around nuclear reactor is called protective shield.
- During the working of a nuclear reactor dangerous radiations such as high energy neutrons, gamma rays and thermal radiations are produced. To protect the persons working there, the reactor is thoroughly shielded with concrete wall of several feet thick and lined with metals like lead.

POWER OF ANUCLEAR REACTOR: In the nuclear reactor, large amount of heat will be generated in the core. These reactors have elaborate cooling systems that use water. This water absorbs the heat and produces steam. This steam in turn is used to run steam turbines which ultimately generate electric power. Such reactors are called power reactors.

The power generated by a nuclear reactor is

$\boxed{P = \frac{nE}{t}}$ here $\frac{n}{t}$ be the number of fissions per second and E be the energy released in each fission E = 200MeV = $200 \times 10^6 \times 1.6 \times 10^{-19}$J

$= 3.2 \times 10^{-11}$J

Note: Number of fissions per sec in a reactor of power 1 W is given by $\frac{n}{t} = \frac{P}{E} = \frac{1}{3.2\times10^{-11}} = 3.125 \times 10^{10}$ fissions per sec

Note: If only x% of energy released in fission is converted into electrical energy then out put power of reactor is $P = \frac{x}{100}\left(\frac{nE}{t}\right)$

Note: If 'x' gm of fuel with mass number 'A' completely undergo nuclear fission in time t sec in a reactor then its power is given by

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Number of moles in x gm of fuel = $\frac{x}{A}$

$n = \left(\frac{x}{A}\right)N_A$. where N_A is Avogadro number

$\therefore$ power $P = \frac{nE}{t} \Rightarrow \boxed{P = \frac{xN_AE}{At}}$

Uses of Nuclear Reactions:

1) To generate electric power.

2) To produce nuclear fuel plutonium – 239 and other radioactive materials which have a wide variety of applications in the fields of medicine industry and research.

USES OF ATOMIC ENERGY:

1. Generation of electric power : the coolant in a nuclear reactor absorbs the heat generated as a result of the chain reaction and it releases the heat to the water which is converted into high pressure steam. This steam is used to drive turbine and operate the electric generator.

2. Production of radio isotopes: A small amount of the pure element is placed in an aluminium container and the container is placed in the reactor for a few days. The element absorbs neutrons and the element becomes radioactive isotope.

3.Source of neutrons: A large number of neutrons are produced in a reactor. They are used in research. The effect of neutrons on biological tissues is studied. A new branch of physics called Neutron physics has come up.

4.Atomic energy is used to create artificial lakes, to divert the course of a river, to make tunnels for laying new railway tracks etc.

5. Atomic energy is used for driving automobiles, submarines and war-planes.

6.Atomic energy is used in war-fare for creating destructive atom bombs and hydrogen bombs.

NUCLEAR FUSION:

- The phenomenon in which two lighter nuclei combine to form a heavier nucleus of mass less than the total mass of the combining nuclei is called nuclear fission. This mass defect appears as energy.
- At temperature of about 10^7K, light nuclei combine to give heavier nuclei, Hence, fusion reactions are called thermo nuclear reactions.
- Nuclear fusion takes place in the sun and other stars.
- Energy produced in a single fission of $_{92}U^{235}$ is larger than that in a single fusion of hydrogen into Helium.
- But fusion produces more energy than fission per nucleon.
- In fission,0.09% of mass is converted into energy. In fusion 0.66% of mass is converted into energy
- Hydrogen bomb is a fission – fusion bomb

What is called fermentation?

ALCOHOLS

- Alcohols are the hydroxyl derivatives of hydrocarbons i.e., obtained by the replacement of one or more H atoms $R\text{-}H \xrightarrow[+OH]{-H} R\text{-}OH$
- The compound in which a hydroxyl group is attached to a **saturated carbon** atom are called **alcohols**.

  Eg:- 1)CH_3OH 2)C_2H_5OH
- The compounds in which hydroxyl group is attached to an **unsaturated carbon** atom of a double bond are called **'enols'**.Eg;- $H_2C{=}CH\text{-}OH$

Classification: Alcohols are classified according to the number of hydroxyl groups present in their molecules.

- **Monohydric** alcohols contain **one –OH** group, **dihydric two** and **trihydric three**, respectively.
- Monohydric alcohols are further classified according to the hybridization of carbon atom to which the –OH group is attached.

Compounds containing C_{sp^3}-OH bond: In these alcohols the –OH group is attached to a **sp^3** hybridised carbon atom of an alkyl group. These are further subdivided as follows

- **Primary Alcohols (1^0):** In these alcohols the –OH group is attached with primary carbon atom They posses a general formula **RCH_2OH**. R may be H in the first member and alkyl group in the rest of the members.

Eg: HCH_2OH **Methyl alcohol**
CH_3CH_2OH **Ethyl alcohol**
$CH_3CH_2CH_2OH$ **n – propyl alcohol**

- **Secondary Alcohols (2^0):**In these alcohols the –OH group is attached with secondary carbon atom.They posses a general formula **R_2CHOH.**

Eg: $CH_3\text{-}\underset{OH}{CH}\text{-}CH_3$ $CH_3\text{-}\underset{OH}{CH}\text{-}CH_2\text{-}CH_3$

Isopropyl alcohol **Secondary butyl alcohol**

- **Tertiary Alcohols (3^0):** In these alcohols the –OH group is attached with tertiary carbon atom They posses a general formula **R_3C-OH**

Eg: $C_2H_5\text{-}\underset{CH_3}{\overset{CH_3}{C}}\text{-}OH$ **Tert. amyl alcohol**

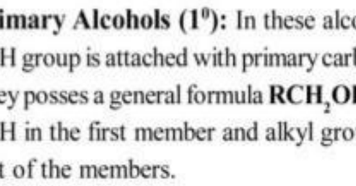
Allyl alcohols: In these alcohols the –OH group is attached a sp^3 hybridized carbon atom next to the carbon – carbon double bond i.e. to an allylic carbon.

Eg: $H_2C{=}CH\text{-}CH_2\text{-}OH$ $H_2C{=}CH\text{-}\underset{OH}{CH}\text{-}CH_3$

Allyl alcohol But-3-en 2-ol

Benzyl Alcohols: In these alcohols, the –OH group is attached to **sp^3** hybridised carbon next to an aromatic ring.

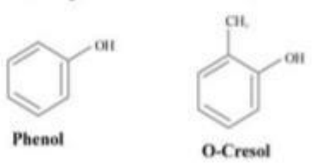
Eg:-



- Hence, allylic and benzylic alcohols may be primary, secondary or tertiary.

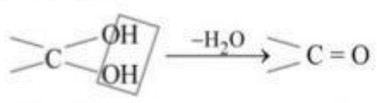
Compounds containing C_{sp2}-OH bond: In these alcohols, the –OH group is attached to a carbon atom of the double bond, i.e., vinylic carbon or to an aryl carbon.

Eg: $H_2C{=}CH\text{-}OH$ – Vinyl alcohol



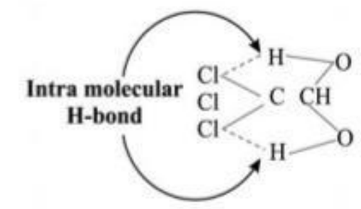
Note:

- When two or more hydroxyl groups are attached to the same carbon atom, the compound is usually unstable. This unstable compound looses a water molecule and gets converted to a stable compound.



Unstable

- But inspite of having two hydroxyl groups to the same carbon atom, chloral hydrate $CCl_3CH(OH)_2$ is a stable compound. The unusual stability of chloral hydrate has been attributed to the –I effect of chlorine and to the formation of intramolecular hydrogen bonds.



Nomenclature: There are three systems of naming the alcohols.

Common system: In this system alcohols are named as **alkyl alcohols** i.e., the word alcohol is added to the name of alkyl group.

- In higher members, it is always indicated whether the –OH group is attached to primary, secondary or tertiary carbon atom by prefixing ***'n'*** for **primary**, ***sec*** for **secondary** and ***tert*** for **tertiary**.

Eg; CH_3OH Methyl alcohol
CH_3CH_2OH Ethyl alcohol
$CH_3CH_2CH_2OH$ n-propyl alcohol

$CH_3-\underset{OH}{\overset{}{CH}}-CH_2-CH_3$ **Sec.butyl alochol**

Carbinol system: The simplest monohydric alcohol CH_3OH is called carbinol.

- All other members are considered its alkyl derivatives.
- The alkyl groups attached to the carbon atom carrying –OH group are named in alphabetical order.

Eg:- CH_3OH CH_3CH_2OH
Carbinol Methyl carbinol

$(H_3C)_2CH\text{-}OH$ **Dimethyl carbinol**

IUPAC system: According to this system alcohols are called alkanols.

Eg:- CH_3OH Methanol
CH_3CH_2OH Ethanol
$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}OH$ Butan – 1 - ol

Isomerism: Alcohols may exhibit chain, positional and functional isomerism.

- Functional isomers of **alcohols** are **ethers**.

Eg: $CH_3\text{–}CH_2\text{–}CH_2\text{–}\underset{OH}{CH_2}$ and $CH_3\text{–}\underset{CH_3\ OH}{CH}\text{–}CH_2$

are chain isomers

$CH_3\text{–}CH_2\text{–}CH_2\text{–}\underset{OH}{CH_2}$ and $CH_3\text{–}\underset{OH}{CH}\text{–}CH_2\text{–}CH_3$

are position isomers

- $CH_3\text{–}CH_2\text{–}OH$ and $CH_3\text{–}O\text{–}CH_3$ are functional isomers.
- Unsaturated alcohols and carbonyl compounds are tautomers.

$CH_3\text{–}\underset{OH}{C}{=}CH_2$ and $CH_3\text{–}\underset{O}{C}\text{–}CH_3$ are tautomers.

- Alcohols containing chiral centres can exhibit optical isomerism.
- The simplest monohydric alcohol that can exhibit enantiomerism is **butan–2–ol**.

$CH_3\text{–}\underset{OH}{\overset{H}{C}}\text{–}C_2H_5$

Preparation methods of Alcohols:

1. **From Alkenes:** It is an electrophilic addition reaction .

$H_2C = CH_2 + H_2O \xrightarrow{H^+} CH_3\text{-}CH_2\text{-}OH$

- In this reaction there is a possibility of formation of carbocation .

$CH_3\text{-}\underset{CH_3}{CH}\text{-}CH{=}CH_2 \xrightarrow[H^+]{HOH} CH_3\text{-}\underset{CH_3}{\overset{OH}{C}}\text{-}CH_2\text{-}CH_3$

3 methyl prop 2 ene 2 methyl 2 butanol

By hydroboration oxidation of alkenes: It is used to get **primary alcohol** from **terminal alkene**.

- Reagent used in this method is **diborane** followed by **alkaline H_2O_2**.
- The product obtained in this reaction seems to follow **anti markownikoff's** addition of water over alkene.
- **Hydroboration** is regioselective.
- With unsymmetrical alkenes, the boron atom bonds to the less substituted carbon atom.

$H_3C-CH=CH_2 \xrightarrow{BH_3} CH_3-\underset{H}{\overset{}{CH}}-\underset{BH_2}{CH_2}$

- In this reaction **borane** serves as **electrophile**.

Oxymercuration demercuration of Alkenes: The addition of **H_2O** over alkene **without rearrangement** follows **markownikoff's rule**.

- Reagent used is **mercuric acetate** followed by **reduction with $NaBH_4$.**

$R-CH=CH_2 \xrightarrow[2)NaBH_4,OH^-]{1)Hg(OAc)_2,H_2O,THF} R-\underset{OH}{\overset{}{CH}}-CH_3$

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Note:No carbocation is formed in hydroboration oxidation reaction and oxymercuration and demercuration reaction.

From Grignard's reagent: Treatment of carbonyl compound with RMgX followed by aicidic hydrolysis forms an alcohol with new carbon – carbon bond.

$R-Mg-X + R^1CHO \xrightarrow{H^+/H_2O} R-\underset{OH}{\overset{}{CH}}-R^1$

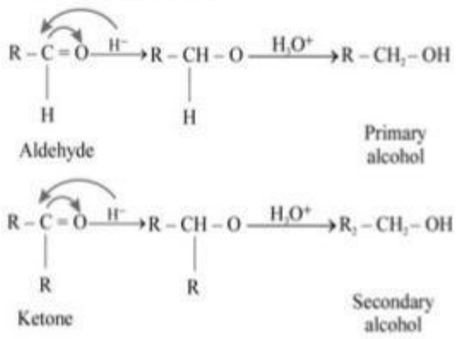
2^0 *alcohol*

$R-Mg-X + R^1COR^{11} \xrightarrow{H^+/H_2O} R^1-\underset{OH}{\overset{R}{C}}-R^{11}$

3^0 *alcohol*

Aqueous alkali hydrolysis of alkyl halide: This reaction is a nucleophilic substitution reaction and in the reaction nucleophile HO^- ion becomes hydrated to give the substituted product. $R\text{-}Br + KOH_{(aq)} \rightarrow R\text{-}OH + KBr$

Reduction of Aldehyde and Ketone: **Aldehyde** on reduction with **$LiAlH_4$** gives **primary alcohol**, whereas ketones gives secondary alcohols.



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In this reaction reducing agent may be
1) Zn/ HCl 2) Na/C_2H_5OH
3) $LiAlH_4$ 4) $NaBH_4$

Note:$NaBH_4$ is a selective reducing agent. It reduces only aldehydes, ketones, carboxylic acids without affecting C = C, N = N, esters, nitriles and nitro group.

- $LiAlH_4$ is used to reduce carbonyl compounds, acids, esters, acid chlorides and anhydrides to alcohols without normally affecting the double bond. However, the double bond gets reduced when a phenyl group is present at β position.

Eg: $C_6H_5-\overset{\beta}{C}H=\overset{\alpha}{C}H-COOH \xrightarrow{LiAlH_4} C_6H_5-CH_2-CH_2-CH_2-OH$

Hydrolysis of Ester: Esters on hydrolysis gives acid and alcohol.

$RCOOR^1 + H_2O \xrightarrow[or\,HO^-]{H^+} R\text{-}COOH + R^1\text{-}OH$

- Alcohols being more volatile than acid an hence it can easily be separated by distillation.

Ester hydrolysis involves the cleavage of C–O bond of $-\underset{O}{\overset{|}{C}}-OR^1$

By Fermentation: Decomposition of large compounds into simple compounds by enzymes derived by mirco organisms like yeast is called fermentation.

- Enzymes are biocatalysts which are non living nitrogenous compounds.
- They catalyse reactions taking place in living organism and act as specific catalysts. Yeast is a single cell microorganism.

From Molasses: Molasses is the mother liquor left after seperation of sugar from sugar cane juice.

- It is black and viscous and still contains 20-40% sucrose.
- It is diluted with water so that the percentage of sugar in it is 10%.
- Then H_2SO_4 is added to maintain the pH at 4.
- Ammonium sulphate or phosphate is added which serves as food for yeast. Then yeast is added and the mixture is taken and retained in large wooden tank for 2–3 days at 30°C – 40°C.
- An enzyme, invertase produced by yeast converts sucrose into glucose and fructose.

$C_{12}H_{22}O_{11} + H_2O \xrightarrow{INVERTASE} C_6H_{12}O_6 + C_6H_{12}O_6$

- Another enzyme, zymase converts glucose and fructose into ethyl alcohol.

$C_6H_{12}O_6 \xrightarrow{ZYMASE} 2CH_3CH_2OH + 2CO_2$

- The fermented solution contains 6–10% ethyl alcohol and is called wash or wort.
- This dilute solution on fractional distillation gives rectified spirit containing 93-95% alcohol.
- Generally 95-96% alcohol is called as Rectified spirit (or) industrial alcohol.
- It is converted to absolute alcohol by drying on treating with quick lime and then over calcium. Absolute alcohol is 99.6 to 100% pure ethyl alcohol.