

Section-A

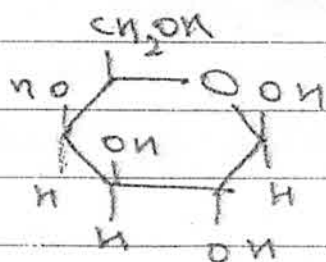
1. In emulsion : physical state of dispersed phase :- liquid  
(e.g. milk, hair cream etc) physical state of dispersion medium :- liquid  
but, In gel : physical state of dispersed phase :- liquid  
(e.g. cheese, jellies etc). physical state of dispersion medium :- solid  
So, these colloids differ in physical states of their dispersion medium.

2. Increasing order of basic strength (gas phase)  
 $C_2H_5NH_2 < (C_2H_5)_2NH < (C_2H_5)_3N$

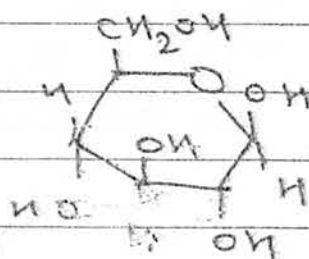
3. Phosphorus is a pentavalent element. Therefore, when Silicon is doped with phosphorus one of the electrons remains unbonded and is delocalised in the lattice. This electron can be easily excited to conduction band and move in the presence of external electric field. This way, doping Si with P increases the number of charge carriers and hence its conductivity.

The semi-conductor thus formed is an extrinsic one (n-type).

4. Products of hydrolysis of lactose :-  $\beta$ -D-galactose,  $\beta$ -D-glucose.

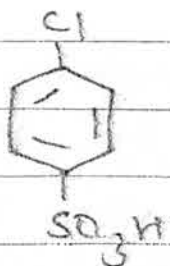


$\beta$ -D-galactopyranose

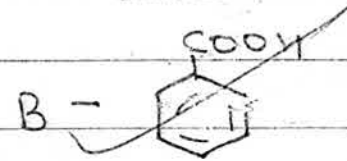
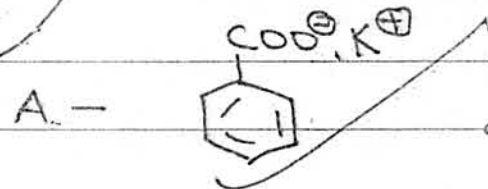


$\beta$ -D-glucopyranose.

5. IUPAC name: 4-Chlorobenzene sulphonic acid

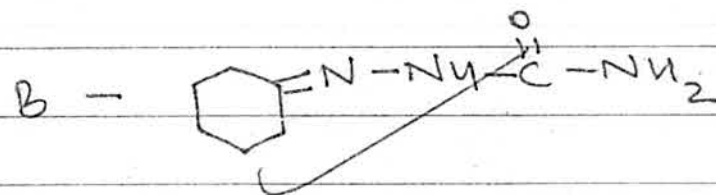
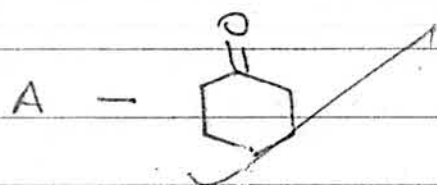


6. (i)



Section-B

(ii)



7. (i) Rate law for the reaction

Rate =  $k [H_2O_2][I^-]$ , where  $k$  is the rate constant for the given reaction.

(ii) Overall order of reaction =  $1+1=2$

(iii) Step (1) is the rate determining step because it is the slowest step (elementary reaction) in the proposed mechanism. Hence, the rate of reaction is determined by this reaction (step).

### Ideal Solution

(a) The solution obeys Raoult's law over the entire range of concentration. The vapour pressure of solution is nearly equal to that predicted by Raoult's law.

(b) The intermolecular interactions between solute-solvent particles are of similar order to that of solute-solute particles and solvent-solvent particles.

$$\text{i.e. } \Delta_{\text{mix}} H = 0 \text{ \& } \Delta_{\text{mix}} V = 0$$

e.g. Solution of n-hexane & n-heptane

### Non-Ideal Solution

(a) The solution does not obey Raoult's law. The vapour pressure of the solution is either higher or lower than that predicted by Raoult's law.

(b) The intermolecular interactions between solute-solvent particles is either stronger or weaker than that existing between solute-solute particles & solvent-solvent particles.

$$\text{i.e. } \Delta_{\text{mix}} H > 0, \Delta_{\text{mix}} V > 0 \quad \begin{matrix} \text{+ve} \\ \text{diss} \\ \text{-ation} \end{matrix}$$

OR  $\Delta_{\text{mix}} H < 0, \Delta_{\text{mix}} V < 0$   
e.g. Solution of ethanol & acetic acid - (H-bonding)

9. A -  $K_2MnO_4$   
Potassium manganate

B -  $KMnO_4$   
Potassium permanganate

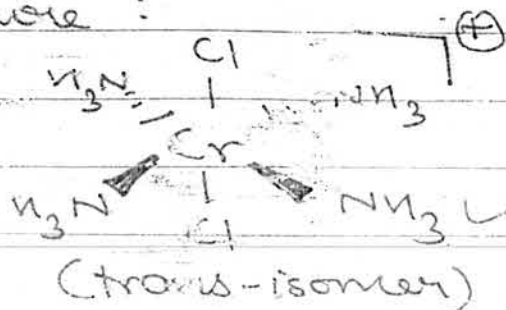
C -  $KIO_3$  (or  $IO_3^-$ )  
Potassium iodate

D -  $I_2$   
Iodine

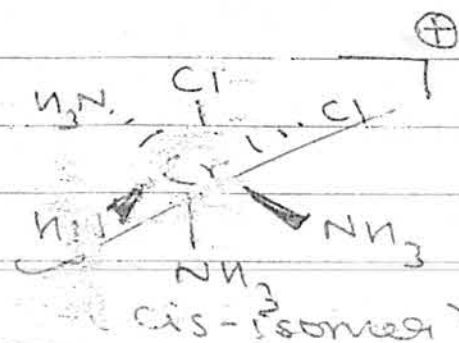
10. IUPAC name of  $[Cr(NH_3)_4Cl_2]^+$  :-

Tetraammine dichlorido chromium(III) ion

Structure :



OR



Geometrical isomers of the given complex ion

11. (i) Diamagnetic complex :-  $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$   
 (ii) More stable complex :-  $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$  (Chelate effect)  
 (iii) Outer orbital complex :-  $[\text{CoF}_6]^{3-}$   
 (iv) Low spin complex :-  $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$

12. (i) Increasing acidic character  
 $\text{H}_2\text{O} < \text{H}_2\text{S} < \text{H}_2\text{Se} < \text{H}_2\text{Te}$   
 (ii) Decreasing bond enthalpy  
 $\text{HF} > \text{HCl} > \text{HBr} > \text{HI}$

### Section-C

13. edge length of unit cell,  $a = 300 \text{ pm}$   
 $= 3 \times 10^2 \times 10^{-10} \text{ cm}$   
 $= 3 \times 10^{-8} \text{ cm}$   
 Volume of 1 unit cell  $= a^3 = 27 \times 10^{-24} \text{ cm}^3$   
 Density of element  $= \rho = 10.8 \text{ g cm}^{-3}$  (given)  
 Mass of 1 unit cell  $= \rho a^3 = 10.8 \times 27 \times 10^{-24} \text{ g}$

Given mass of element = 108 g

So, Total number of unit cells in this mass of element

$$N = \frac{108 \text{ g}}{\text{mass of 1 unit cell}} = \frac{108 \text{ g}}{10.8 \times 27 \times 10^{-24} \text{ g}}$$

OR,  $N = \frac{10 \times 10^{24}}{27} \text{ unit cells}$

Number of atoms present in one unit cell,  $n = 4$  (fcc lattice)

$$\text{So, total number of atoms} = nN = \frac{4 \times 10 \times 10^{24}}{27} \text{ atoms}$$

$$= \frac{40}{27} \times 10^{24} \text{ atoms}$$

$$= 1.481481 \times 10^{24} \text{ atoms}$$

Hence, a total of  $1.481481 \times 10^{24}$  atoms of element are present in 108 g of the given element.

14. Concentration of <sup>sucrose</sup> solution = 40% (w/w)

Considering 100g of solution

Mass of sucrose = 4g ( $m_s$ )

Mass of water =  $100 - 4 = 96$ g ( $m_w$ )

Molar mass of sucrose,  $M_s = 342$  g mol<sup>-1</sup>

Moles of sucrose molecules

$$n_s = \frac{m_s}{M_s} = \frac{4}{342} \text{ mol} = \frac{2}{171} \text{ mol}$$

$$\text{Molality of solution} = \frac{n_s}{m_w (\text{in kg})}$$

$$m = \frac{2 (1000)}{171 (96)} \text{ mol kg}^{-1}$$

$$m = \frac{2000}{171 \times 96} \text{ mol kg}^{-1}$$

Freezing point of solution = 271.15 K

$$\begin{aligned} \text{Depression in freezing point} &= (273.15 - 271.15) \text{ K} \\ &= 2 \text{ K} = \Delta T_f \end{aligned}$$

Now,  $\Delta T_f = K_f m$

where  $K_f$  = molal depression constant of water

Substituting values,

$$2 = K_f \times \frac{2000}{171 \times 96}$$

$$\text{OR } K_f = \frac{2 \times 171 \times 96}{2000} = \frac{171 \times 96}{1000} \text{ K kg mol}^{-1} \quad \text{--- (1)}$$

Now, given 5% glucose solution.

Considering 100 g of solution.

Mass of glucose = 5g =  $m_g$  [Mass of water = 95g]

Molar mass of glucose =  $180 \text{ g mol}^{-1} = M_g$

$$\text{moles of glucose, } n_g = \frac{m_g}{M_g} = \frac{5}{180} \text{ mol} = \frac{1}{36} \text{ mol}$$

Molality of solution =  $\frac{n_g}{m}$

mass of water (in kg)

$$m = \frac{1}{36} \times \frac{1000}{95} \text{ mol kg}^{-1} = \frac{1000 \text{ mol}}{3420 \text{ kg}}$$

Using

$$\Delta T_f = K_f m$$

$$\Delta T_f = \frac{171 \times 96}{1000} \times \frac{1000}{36 \times 95} \quad (\text{from ①})$$

$$\Delta T_f = \frac{171 \times 96}{36 \times 95} \text{ K} = 4.8 \text{ K}$$

$$\text{So, actual freezing point} = 273.15 \text{ K} - 4.8 \text{ K}$$

$$= 273.15$$

$$4.80$$

$$268.35$$

$$= 268.35 \text{ K}$$

Hence, the freezing point of 5% glucose solution in water is 268.35 K.



$$\text{Rate of reaction} = -\frac{d[\text{NH}_3]}{dt} = k [\text{NH}_3]^0$$

$$\text{where } k = 4 \times 10^{-3} \text{ s}^{-1} \text{ (given)}$$

So, differential rate equation becomes,

$$-\frac{d[NH_3]}{dt} = k$$

$$\int d[NH_3] = -\int k dt$$

$$[NH_3] = -kt + C \quad \text{--- (1)}$$

At  $t=0$ ,  $[NH_3] = [NH_3]_0$  (initial concentration)

So,  $[NH_3]_0 = C$

∴ (1) becomes,

$$[NH_3] = [NH_3]_0 - kt$$

Now,  $[NH_3]_0 = 0.1 M$

$$[NH_3] = 0.064 M$$

and  $k = 4 \times 10^{-3} \text{ Ms}^{-1}$

So,

$$0.064 M = 0.100 M - kt$$

$$kt = 0.036 M$$

$$t = \frac{0.036 M}{4 \times 10^{-3} M s^{-1}} = 36 s = 9 s$$

Hence, it will take 9s to reduce the initial concentration of  $NH_3$  from 0.1 M to 0.064 M.

16. (i) Activated charcoal acts as an adsorbent in gas masks and adsorbs <sup>and</sup> harmful & poisonous gases like  $\text{SO}_2$  & fumes of As etc on itself, thus protecting the wearer of the mask from these gases.

(ii) The hydrated ferric oxide colloid is negatively charged in this case. (because it adsorbs  $\text{OH}^-$  from solution)  
Sol can be represented as  $\boxed{\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O} / \text{OH}^-}$

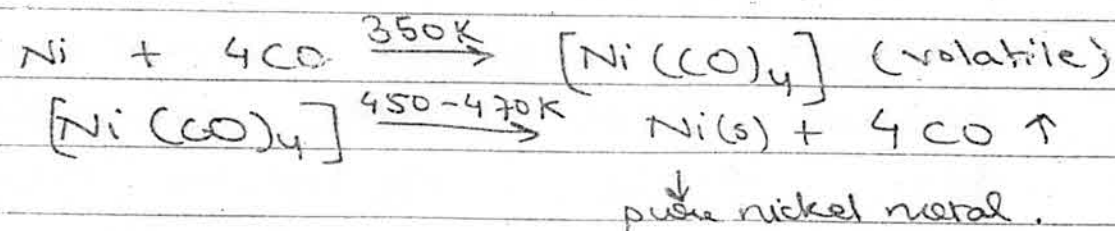
OR  $\text{Fe}(\text{OH})_3 / \text{OH}^-$

(iii) The degree <sup>(or extent)</sup> of chemisorption increases with increasing temperature, as chemical bond formation between the adsorbate and adsorbent molecules takes place in this case. Therefore, an appreciable amount of activation energy ( $E_a$ ) is present, which can be easily overcome at high temperatures (according to Arrhenius equation)  $[k = A e^{-\frac{E_a}{RT}}]$ . However, at even very high temperature, the extent of chemisorption decreases.

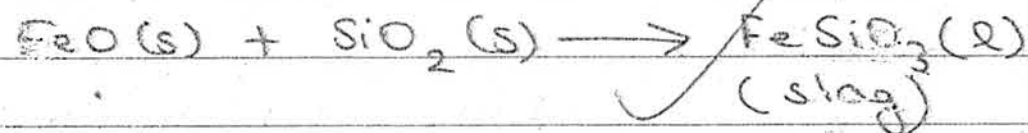
due to increasing thermal energy of gas particles (but that is very high temperature  $\therefore$  not much perceptible).

17. (i) CO acts as a complexing agent and combines with Nickel atoms to form  $[\text{Ni}(\text{CO})_4]$  complex (volatile).

The compound thus formed is highly volatile in nature <sup>and is collected elsewhere</sup>, which allows us to separate pure <sup>pure</sup> Nickel from the impurities present in crude nickel. Hence, helps in refining of Nickel metal.



(ii) Silica ( $\text{SiO}_2$ ) acts as an acidic flux and combines with basic impurities (gangue -  $\text{FeO}$ ) to form slag. The slag thus produced is a fusible component and immiscible with molten metal (Cu). Being lighter, slag can be easily removed from pure molten Cu and helps in further purification and reduction of Cu metal.



This way, iron is removed from  $\text{CuFeS}_2$  and other Cu ores containing iron.

(iii) Highly Electropositive elements such as Na, Mg, Al etc. are generally extracted through electrolytic method. This is so, because these metals are themselves the strongest ~~oxidising~~ <sup>reducing</sup> agent, therefore, no other element or compound can reduce these metals from their salts to metal form. Hence, electrolytic principles have to be used and external voltage is used to drive the non-spontaneous chemical reaction.

e.g. Extraction of Aluminium (Hall-Heroult Process)

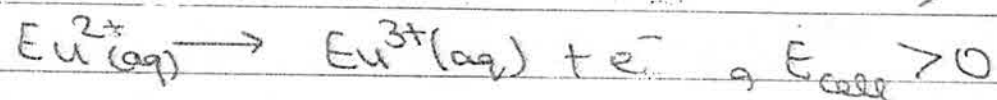
8. (i) Transition metals have a large number of unpaired - d-electrons, are of small size and have vacant orbitals <sup>(d, sp)</sup> available for bonding (metallic bond). This makes the metals to

homogeneously mix with one another (solid solution) leading to the formation of alloys. Also, in a period, the size of the elements are almost similar, and therefore, atoms of one element when present ~~along~~ <sup>metallic</sup> with other elements do not interfere with corresponding lattices and are able to fuse with one another quite effectively e.g. German Silver (Cu, Zn & Ni), Brass (Cu & Zn), Bronze (Cu & Sn).

(ii) In  $Mn_2O_3$ , Manganese is present in +3 oxidation state, whereas in  $Mn_2O_7$ , Manganese is present in +7 oxidation state. Since, higher the oxidation state, more is the polarising power of the metallic ion (Fajan's Rule), Mn-O bonds in  $Mn_2O_7$  are more covalent as to those in  $Mn_2O_3$ . This increase in covalent nature and high oxidation state of Mn atom makes the solution of  $Mn_2O_7$  in water more acidic as that of the solution of  $Mn_2O_3$  in water. Hence,  $Mn_2O_7$  is more acidic than  $Mn_2O_3$ .

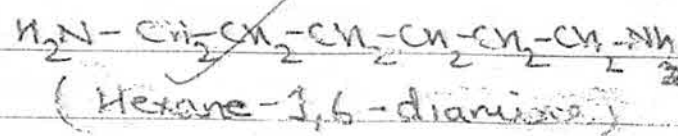
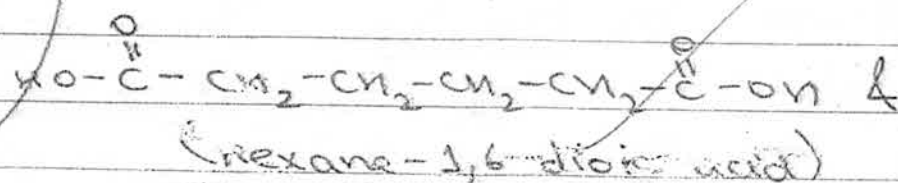
(iii) Eu (Europium) belongs to the 4f-series (lanthanoids) and has a more stable oxidation state of +3, (+3 oxidation state for all lanthanoids is the most stable).

Hence,  $\text{Eu}^{2+}$  ion has a strong tendency to go to  $\text{Eu}^{3+}$  state (+3 oxidation state) and thus acts as a strong reducing agent.

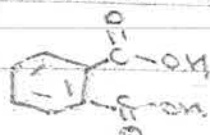


Also,  $E_{\text{cell}} > 0$  for this reaction, making it much more favourable.

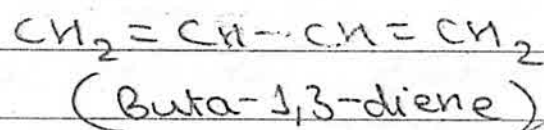
Q. (i) Monomers of Nylon-6,6



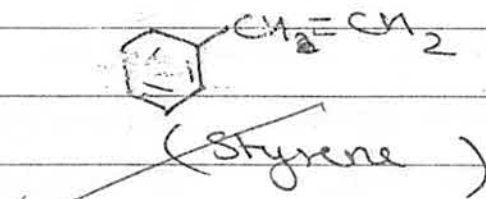
(ii) Monomers of Glyptal



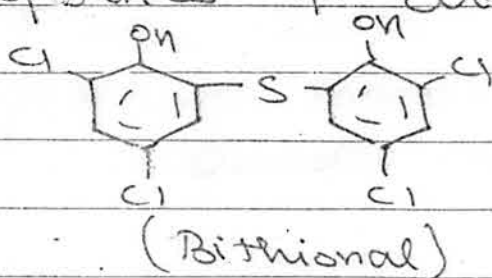
(iii) Monomers of Buna-S



and



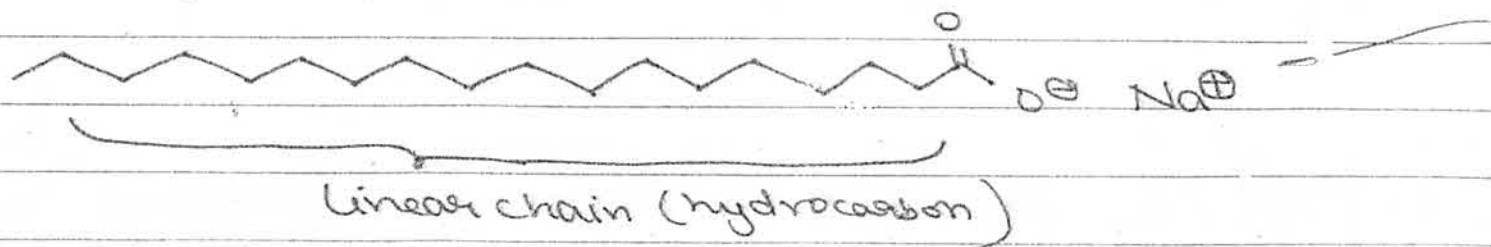
20. (i) Bithional is added to soap to impart ~~to it~~ antiseptic properties to it.



(ii)  $\text{Mg}(\text{OH})_2$  is a mild base as compared to  $\text{NaHCO}_3$ . Therefore, if we use  $\text{NaHCO}_3$ , it will <sup>make</sup> the medium of our stomach alkaline, which will lead to even further secretion of HCl from the cells present in wall of our stomach (according to Le Chatelier's principle). This is undesirable. Therefore,  $\text{Mg}(\text{OH})_2$  is preferred.

ing place of  $\text{NaHCO}_3$  as being a weaker base, it only neutralises the excess acid and relieves the person from symptoms of hyperacidity. It does not make the stomachic medium alkaline and hence does not promote further secretions of acid.

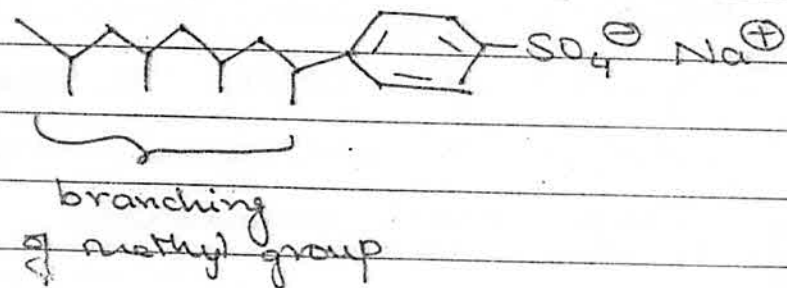
(ii) Soaps are generally sodium salts of long chain fatty acids which are linear in structure and do not consist of extensive branching. For e.g. Sodium Stearate.



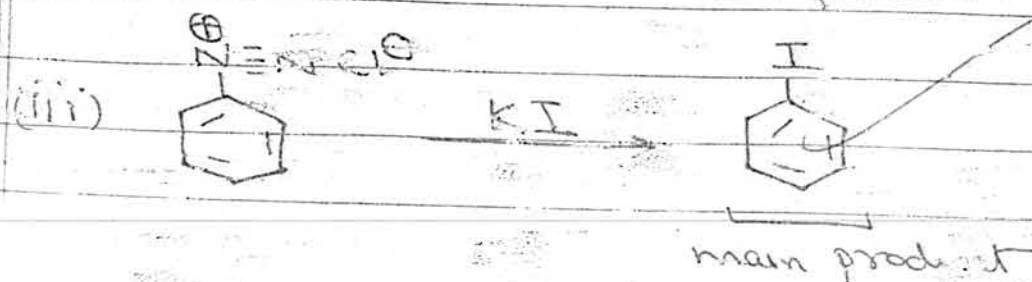
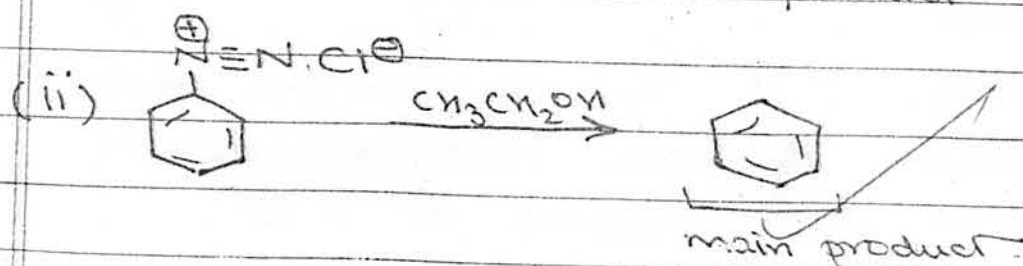
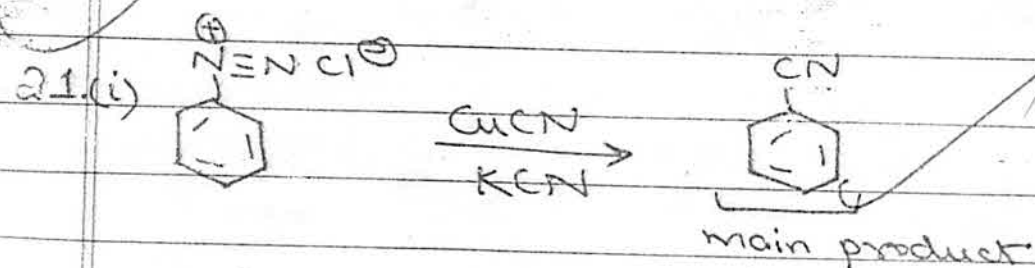
OR Sodium oleate, Sodium palmitate etc.

On the other hand, detergents are usually branched, which makes it difficult for microorganisms (like bacteria) to break them down (degrade them). Thus, they sustain themselves in the environment and cause pollution (in water etc.)

These, thus are generally non-biodegradable in nature.  
e.g. Sodium - 4-(1,3,5,7-tetramethyloctyl)benzene sulphonate

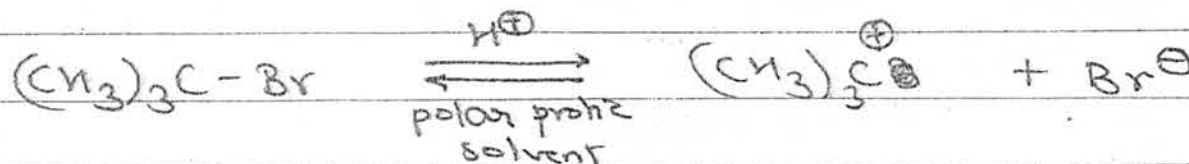
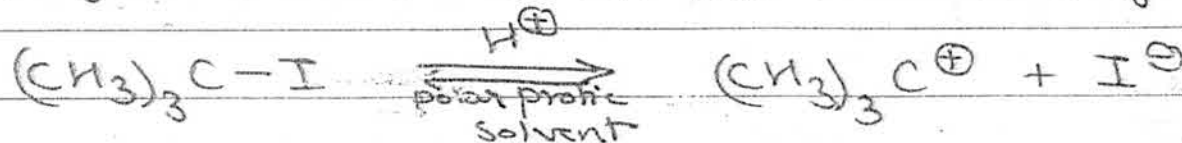


many other ABS  
(alkyl benzene Sulphonates) are  
heavily also branched and are  
hence, non-biodegradable.



22. (i)  $(\text{CH}_3)_3\text{C-I}$  is more reactive than  $(\text{CH}_3)_3\text{C-Br}$  towards  $\text{S}_\text{N}1$  reaction, because  $\text{I}^\ominus$  is a better leaving group than  $\text{Br}^\ominus$ . Because of its larger size as compared to  $\text{Br}^\ominus$ ,  $\text{I}^\ominus$  is able to effectively stabilise the negative charge on itself, therefore, making the cleavage step more favourable.

Also, C-I bond is weaker than C-Br bond (i.e. C-I bond is longer than C-Br bond due to large size of  $\text{I}^\ominus$  ion)

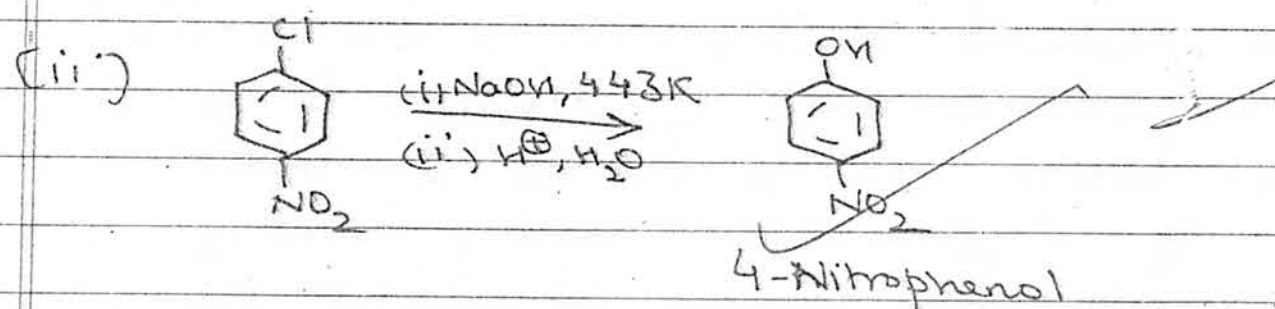


$\text{I}^\ominus$  is more stable and hence, cleavage takes easily

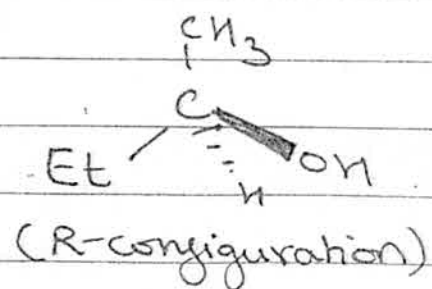
Also, we know that H-I is a stronger acid than H-Br, because of low bond-dissociation enthalpy of H-I bond as compared to H-Br.

∴ by Bronsted theory of acids and bases, the conjugate base  $\text{I}^\ominus$  should be a weaker base than  $\text{Br}^\ominus$ , and we know that a stronger base can replace a weaker base more easily in a nucleophilic substitution reaction. Hence,  $\text{I}^\ominus$  is more

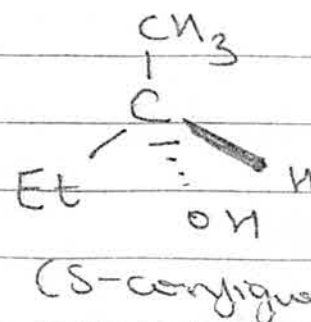
easily replaced by other nucleophiles as compared to  $\text{Br}^\ominus$ .  
Thus increasing the rate of reaction.



(iii) 'dextro' and 'laevo' rotatory forms of Butan-2-ol, mainly constitute the enantiomers of the same compound. i.e.



and



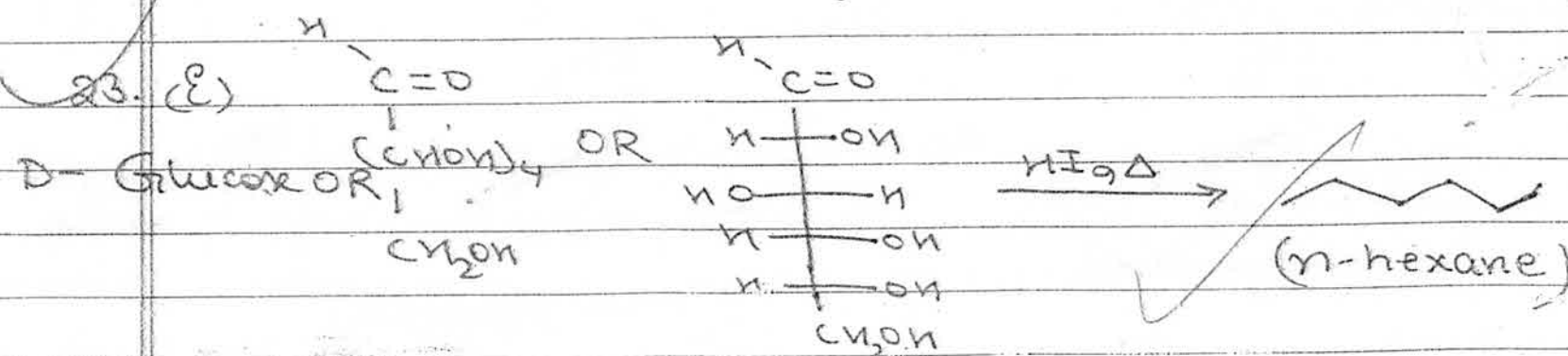
Key:

Et = ethyl group

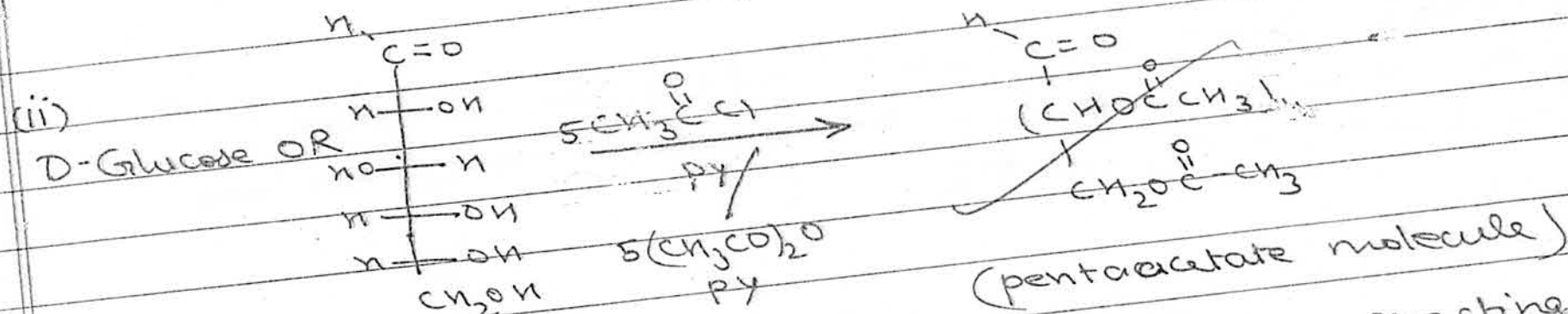
These two forms of Butan-2-ol differ only in their spatial arrangement of molecules:  $\text{Me}$ ,  $\text{Et}$ ,  $\text{H}$ ,  $\text{OH}$  around the chiral carbon, and therefore have the same

physical properties like - melting point, boiling point, electrical conductivity, solubility etc.

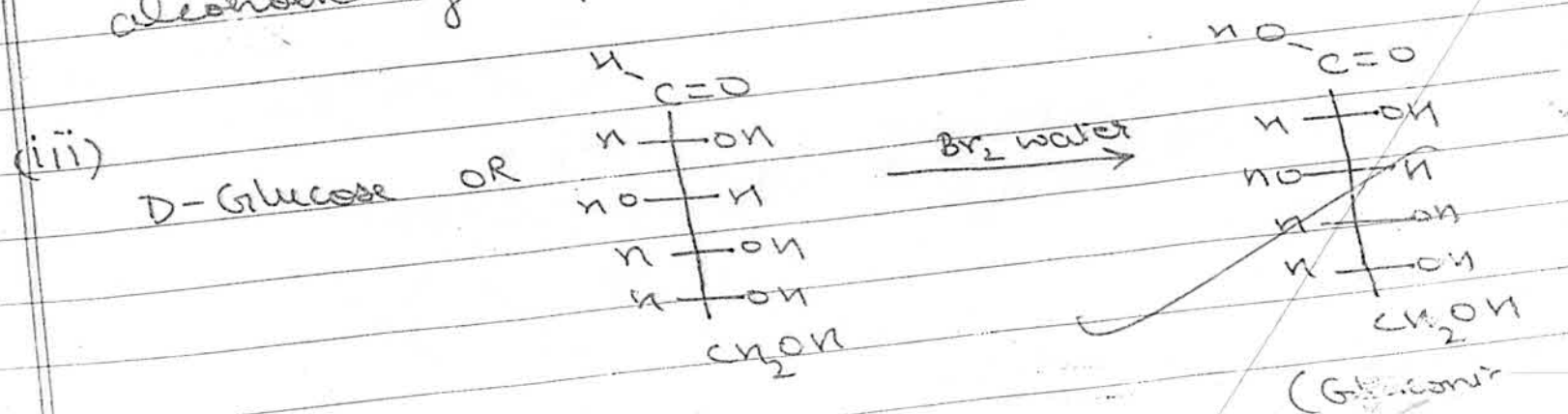
Hence, it is difficult to separate these two isomers (optical stereoisomers) of Butan-2-ol by fractional distillation, as fractional distillation makes use of difference in boiling point of two substances (which should be greater than  $20-25^{\circ}\text{C}$ ). But in this case, both the isomers have identical boiling points and thus, these are not separable by this method.



The prolonged heating of glucose molecule with HI to produce n-hexane, proved that the open structure of D-glucose contains a straight chain.



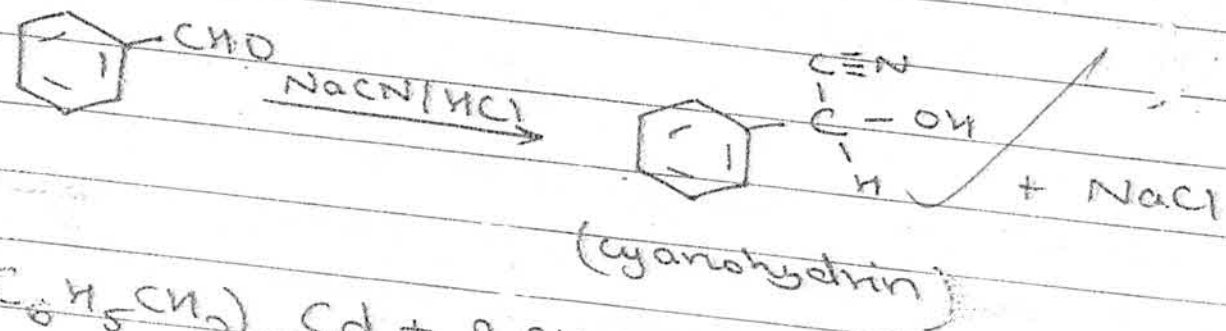
This formation of pentaacetate molecule on reacting glucose with acetyl chloride in presence of pyridine proved that open structure of glucose contains five alcoholic groups.



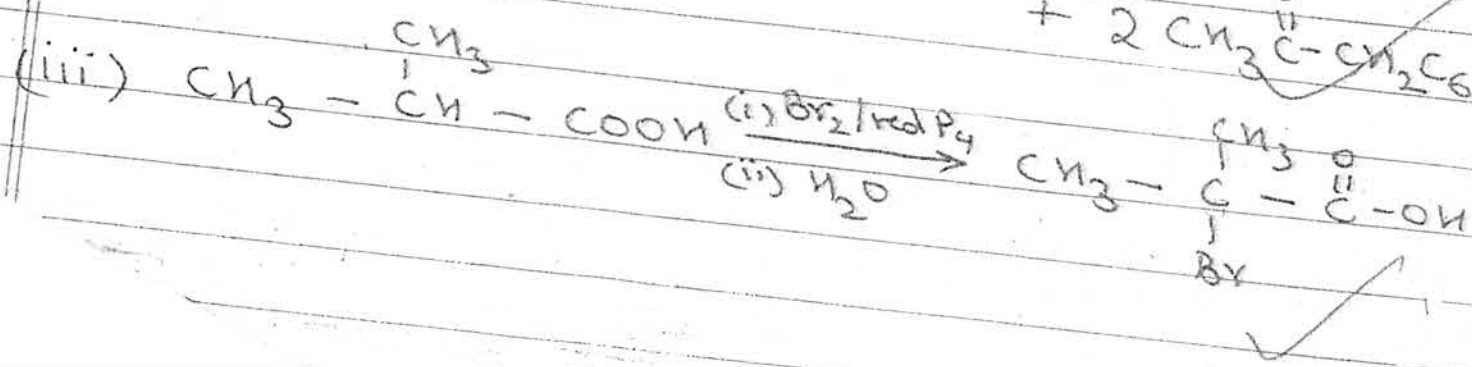
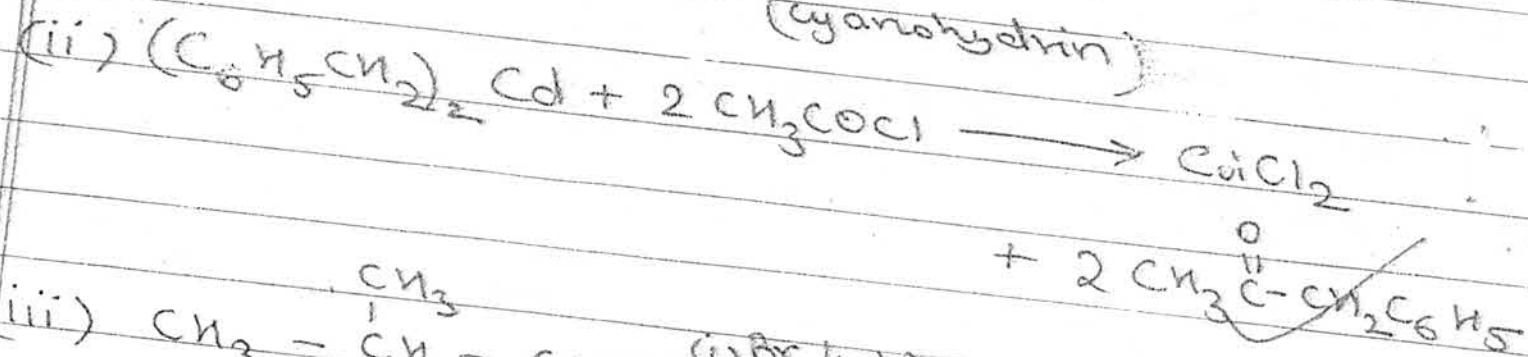
D-Glucose on treatment with mild-oxidant form gluconic

open structure of D-glucose contains an Aldehyde  
as carbonyl group (as ketone would not have been  
oxidised by  $\text{Br}_2$  water).

24. (ii)



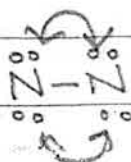
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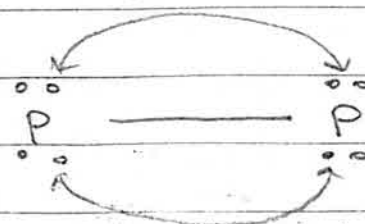
### Section-D

25. (a) (i) Sulphur in vapour state exists as  $S_2$  molecules. In  $S_2$  like  $O_2$ , unpaired electrons are present in  $\pi^*_{3p_x}$  and  $\pi^*_{3p_y}$  orbital respectively. These unpaired electrons impart  $S_2$  gas paramagnetic behaviour.

(ii) N-N bond length is shorter than P-P bond length. (Because of smaller size of nitrogen as compared to phosphorus)  
Due to this reason, the interelectronic repulsion between the non-bonding electrons in N-N is significantly higher as compared to that in P-P single bond. This makes the N-N bond weaker than P-P single bond.



Large repulsions,  
make bond weaker.



Small repulsions,  
strong bond.

(iii) Ozone is thermodynamically less stable than oxygen because for the reaction,



change in enthalpy of reaction  $\Delta_r H$  is highly negative as ozone has a high tendency to go to oxygen state (more stable).

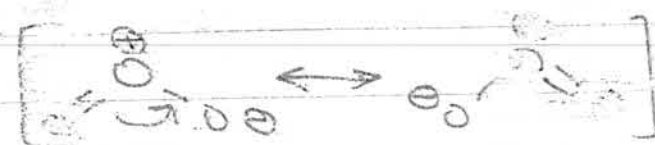
Also,  $\Delta_r S$  for the reaction is positive, as from two moles of ozone (gas), we are getting three moles of oxygen (gas).

Therefore, in total,

$\Delta_r G = \Delta_r H - T\Delta_r S$  is highly negative as  $\Delta_r H < 0$  and  $\Delta_r S > 0$ , making the reaction highly favourable at all temperatures. Hence,  $\text{O}_3$  is thermodynamically less stable than  $\text{O}_2$ .

Also, comparing structures.

Ozone

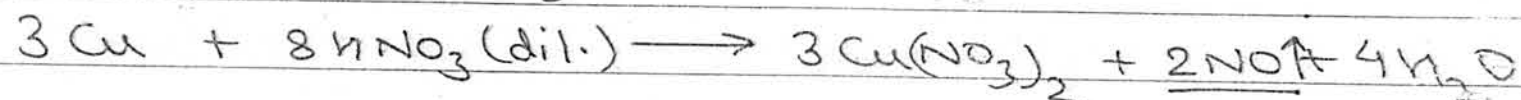


Oxygen

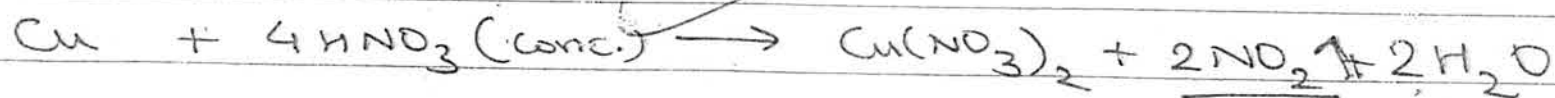


The bond order in ozone is nearly 1.5 due to two resonating structures, whereas it is 2 in oxygen. Since, more is the bond order, <sup>more</sup> stable is the compound, we can conclude again that  $O_2$  is thermodynamically more stable than  $O_3$ .

(b) (i) Nitric oxide (NO)

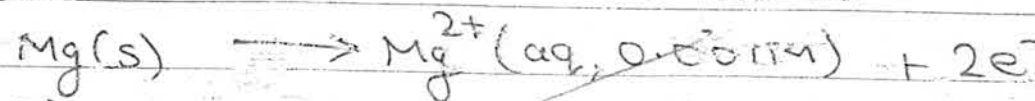


(ii) Nitrogen dioxide ( $\text{NO}_2$ )

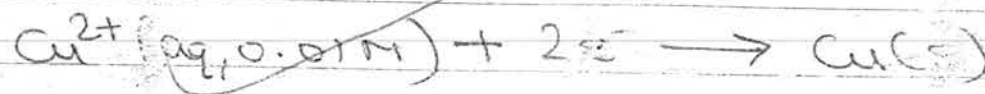


26. Cell Reaction:  $\text{Mg}(\text{s}) + \text{Cu}^{2+}(\text{aq}, 0.01\text{M}) \rightarrow \text{Mg}^{2+}(\text{aq}, 0.001\text{M}) + \text{Cu}(\text{s})$

Anode Reaction:



Cathode Reaction:



Total Electrons exchanged during redox reaction =  $n = 2$  mol

$$\text{Reaction quotient of the reaction, } Q = \frac{[\text{Mg}^{2+}]}{[\text{Cu}^{2+}]} = \frac{0.001 \text{ M}}{0.01 \text{ M}} = \frac{1}{10} = 0.1$$

Using Cell Representation:



Standard potential  $E^\circ_{\text{cell}} = 2.71 \text{ V}$  (given)

Using Nernst's equation,

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.059}{n} \log Q \quad (\text{at } T = 298 \text{ K})$$

Substituting the values,

$$E_{\text{cell}} = 2.71 - \frac{0.059}{2} \log(10^{-2})$$

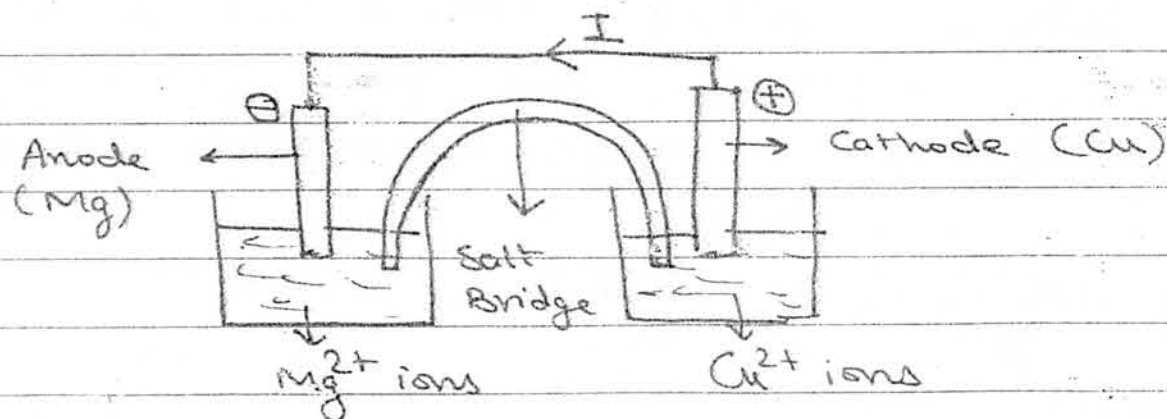
$$E_{\text{cell}} = 2.71 + \frac{0.059}{2}$$

$$E_{\text{cell}} = 2.71 + 0.0295$$

$$E_{\text{cell}} = 2.7395 \text{ V}$$

Hence, the  $E_{\text{cell}}$  for the reaction is  $2.7395 \text{ V}$

Cell Construction:



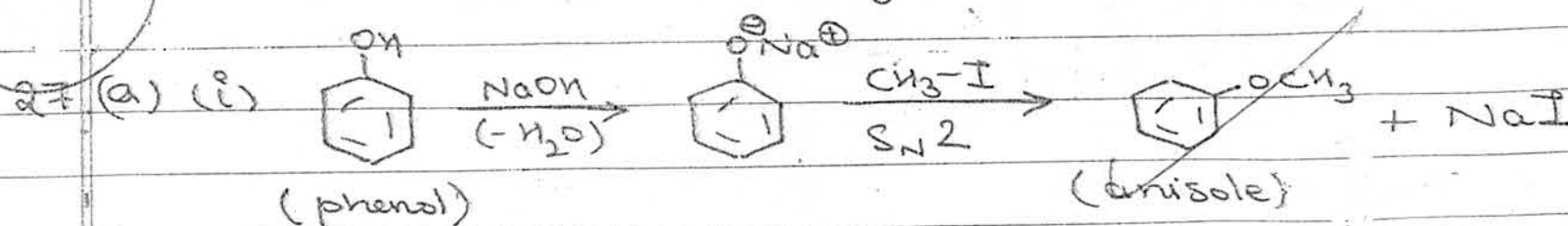
When no external voltage is applied  
(Current flows from Cu cathode to Mg anode)

(i) In standard conditions as well as in the given conditions ( $E_{\text{cell}} = 2.7395 \text{ V}$ ), the current will flow from cathode (Cu) to anode (Mg) as long as external applied voltage is less than  $2.71 \text{ V}$ .

ii) However, if external applied voltage exceeds  $2.71V$ , current will start <sup>flowing</sup> from Mg electrode to Cu electrode in standard conditions.

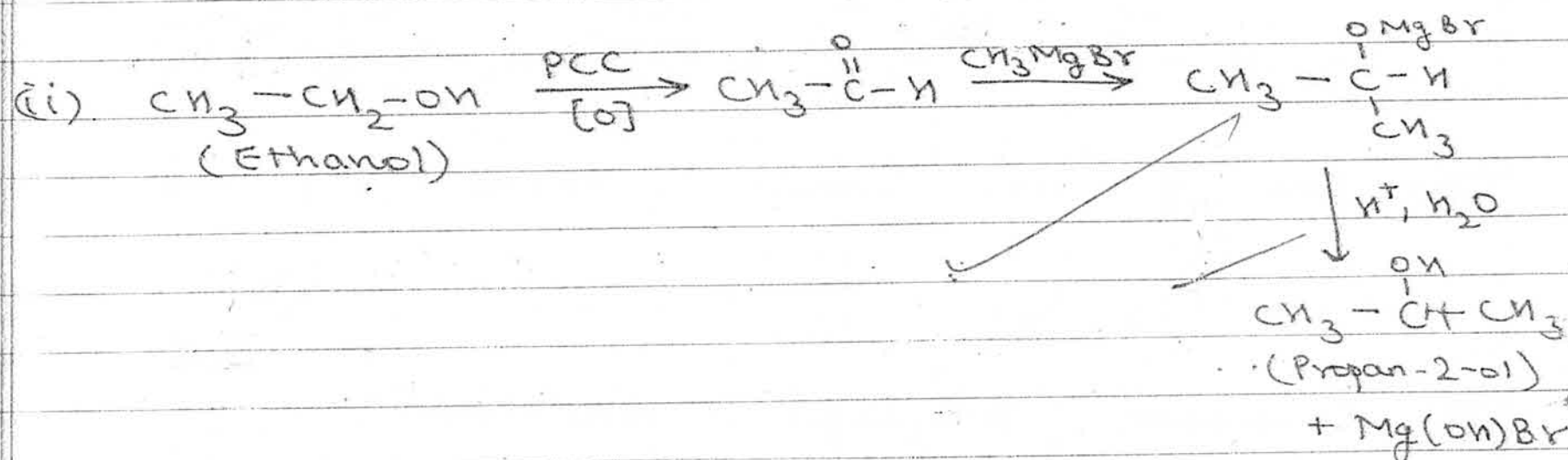
But in given conditions, the current will <sup>keep</sup> flowing from Cu electrode to Mg electrode as long as  $2.71V < V_{\text{external}} < 2.7395V$ .

But, when external applied voltage exceeds even  $2.7395V$ , current will flow from Mg electrode to Cu electrode in given conditions as well.



Williamson's  
ether synthesis

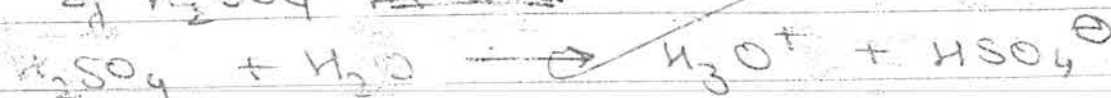
We can convert phenol into anisole, by first converting it into phenoxide form by treating it with NaOH, and then carrying out Williamson's ether synthesis ( $S_N2$  attack on  $CH_3-I$  in polar aprotic solvent like DMSO ( $\text{CH}_3-S-CH_3$ )).

अपना अनुक्रमांक इस उत्तर-पुस्तिका  
पर न लिखेंPlease do not write your  
Roll Number on this Answer-Bookअतिरिक्त उत्तर-पुस्तिका(ओं) की संख्या.....  
Supplementary Answer-Book(S) No. 1

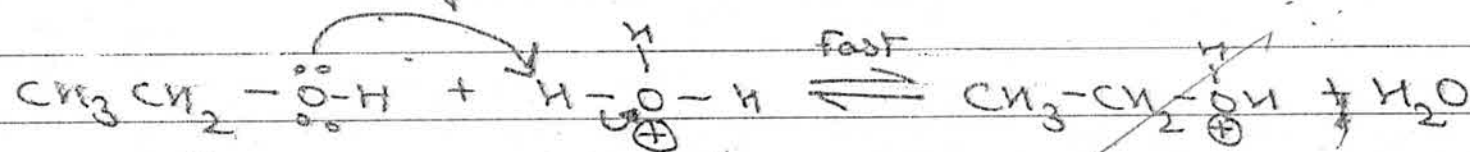
We can convert ethanol into isopropyl alcohol by first oxidising it into ethanal by reacting it with PCC (pyridinium chloro chromate). Then treating it with  $\text{CH}_3\text{MgBr}$  (grignard reagent) followed by hydrolysis.

(b) Mechanism of dehydration of alcohol in concentrated acid  $\text{H}_2\text{SO}_4$  at  $443\text{K}$ .

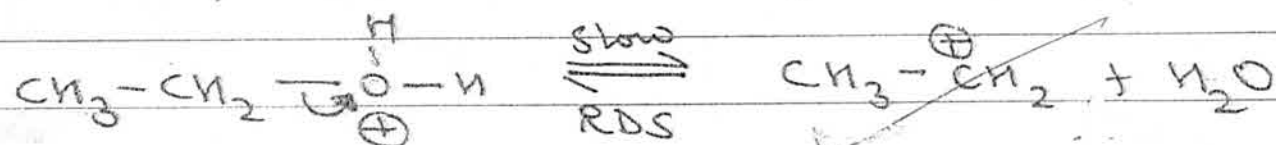
(I) Ionization of  $\text{H}_2\text{SO}_4$  in water



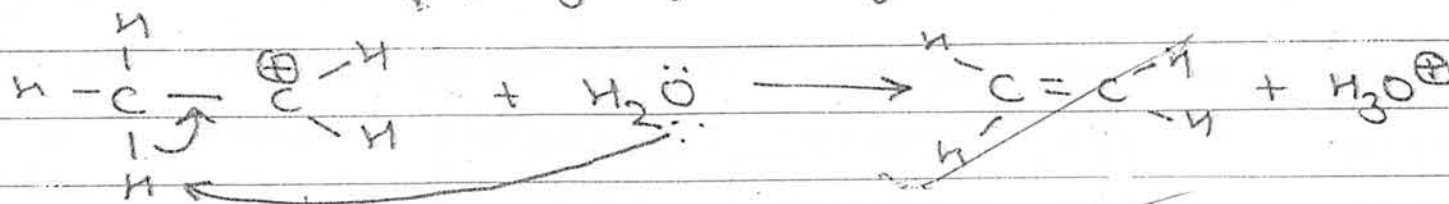
(II) Protonation of alcohol



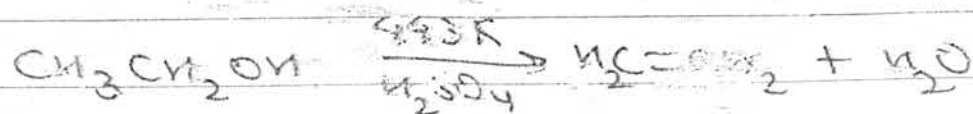
(III) Loss of water molecule by cleavage of C-O bond



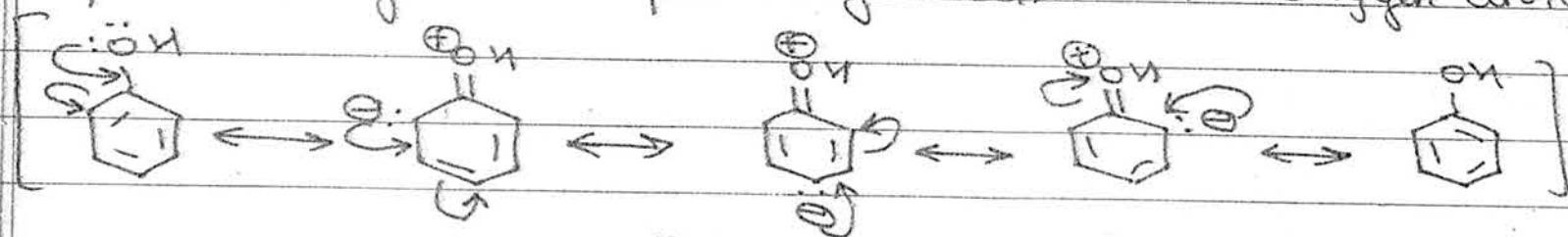
(IV) Elimination of  $\beta$ -hydrogen to form ethene.



So, in totality, a loss of water molecule from ethanol takes place and the reaction can be represented as :-



(C) Phenol consists of  $-OH$  group attached to benzene ring which increases the electron density of the benzene ring due to <sup>strong</sup> +R-effect of  $-OH$  group, by virtue of presence of lone pair of electron on Oxygen atom:



It is

Clear from the resonating structures, that the electron density is greatly increased at o, p-positions, and the ring is activated towards attack by an electrophile. Also, +R-effect of  $-OH$  group is more pronounced than its  $-I$ -effect, thus activating the ring.

In Benzene, no such activation of ring takes place, hence it is less reactive towards electrophilic substitution as compared to phenol.

