Q. No. 2 Part (i)

Heating of Nitrates :-

$4LiNO_3 \xrightarrow{Heat} 2Li_2O + 4NO_2 + O_2$

Lithuim Nitrate — Lithuim oxide — Nitrogendioxide.

$2NaNO_3 \xrightarrow{Heat} 2NaNO_2 + O_2$

Soduim Nitrate — Soduim Nitrite — Oxygen

$2Mg(NO_3)_2 \xrightarrow{Heat} 2MgO + 4NO_2 + O_2$

Magnesuim Nitrate (White) — Magnesuim oxide (White) — Nitrogen-dioxide gas (Reddish) Brown — Oxygen gas.

Q. No. 2 Part (ii) **Electronic Configuration :-**

${}_{24}Cr = \underbrace{1s^2}_{K}, \underbrace{2s^2, 2p^6}_{L}, \underbrace{3s^2, 3p^6}_{M}, \underbrace{4s^1}_{N}, \underbrace{3d^5}_{M}$

Reason:- It violates the Auf Bao principle because it is more stable to have a partially filled d-orbital then to have a completely filled s-orbital.

${}_{29}Cu = \underbrace{1s^2}_{K}, \underbrace{2s^2, 2p^6}_{L}, \underbrace{3s^2, 3p^6}_{M}, \underbrace{4s^1}_{N}, \underbrace{3d^{10}}_{M}$

Reason:- It violates the Auf Bao Principle because it is much more stable to have a completely filled d-orbital than a partially filled one so one electron shifts from the s-orbital to d-orbital.

Q. No. 2 Part (iii) **Fajan's Rule** :- **Statement** :-

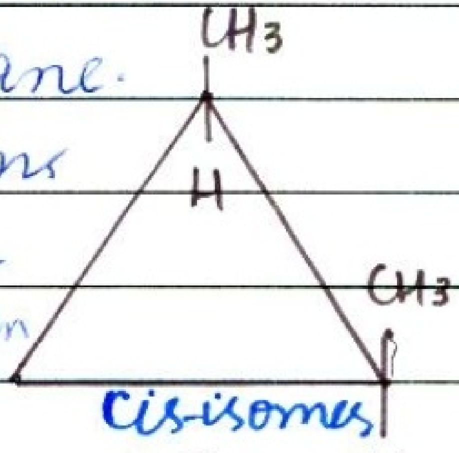
"The smaller cations with more charge density tend to make the bonds covalent."

Explaination :- This means that in group IV-A the cations that form compounds in which they have (+4) oxidation state, those compounds are covalent in nature. On the other hand, the larger cations with lesser charge density would make ionic compounds.

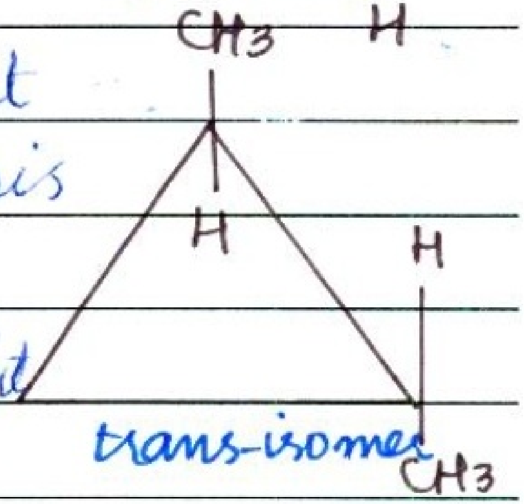
Example :- Sn^{+4} would make covalent compounds as compared to Sn^{+2} which has lesser charge density and so would make ionic compounds. Similarly, ~~G~~ Pb^{+4} would form covalent where Pb^{+2} would form ionic compounds.

Q. No. 2 Part (iv) **Geometrical isomerism**:- "Isomerism resulting from restriction about double bonds in alkenes or about single bonds in cyclic compounds."

Justification:- There would be cis-trans isomerism in 1-2 dimethyl cyclopropane. This is because it fulfills the conditions for isomerism in cyclic compounds:- (1) Different compounds should be (other than H) present (2) These shouldn't be on the same carbon rather on two adjacent carbon atoms of the compound. This compound has 2 methyl groups on adjacent atoms hence it would exhibit geometrical isomerism



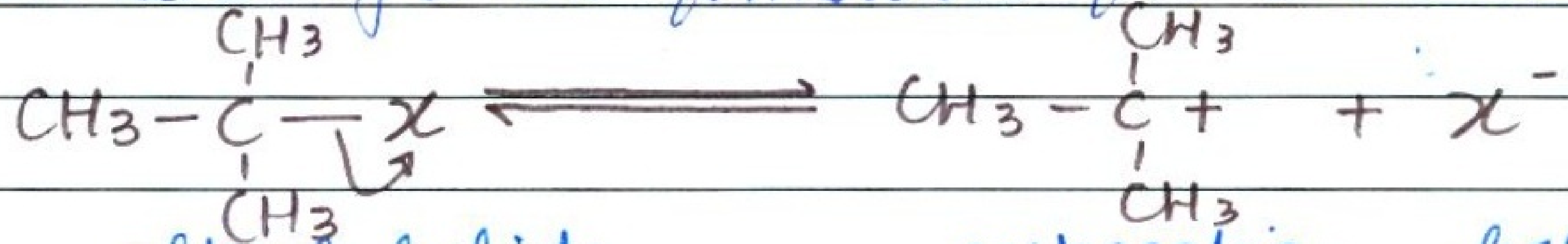
Cis-isomer



trans-isomer

Q. No. 2 Part (v) **S_N1 reactions** :- "Unimolecular substitution (neucleophilic) reactions of alkyl halides."

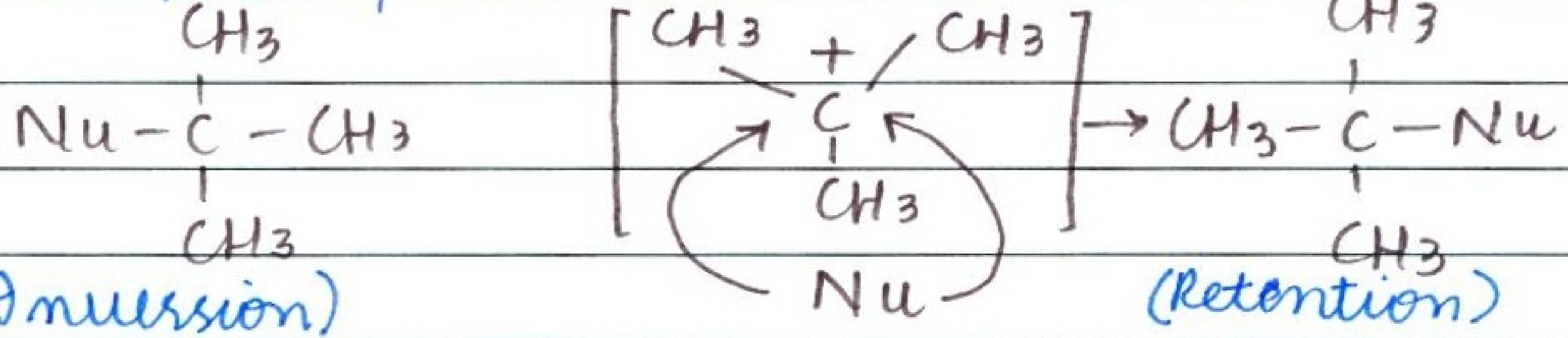
Mechanism :- **STEP # 1** :- Removal of the halide ion leading to the formation of a carbocation.



$$CH_3-\overset{CH_3}{\underset{CH_3}{C}}-X \rightleftharpoons CH_3-\overset{CH_3}{\underset{CH_3}{C}}+ \;+\; X^-$$

alkyl halide carbocation halide ion

STEP # 2 :- Attack of the Nucleophile on the electrophilic carbon of the carbocation leading to the nucleophilic addition product.



$$Nu-\overset{CH_3}{\underset{CH_3}{C}}-CH_3 \qquad \left[\overset{CH_3 \quad + \quad CH_3}{\underset{\underset{Nu}{CH_3}}{C}} \right] \rightarrow CH_3-\overset{CH_3}{\underset{CH_3}{C}}-Nu$$

(Inversion) (Retention)

Q. No. 2 Part (vi) **Equilibruim of CrO_4^{-2} & $Cr_2O_7^{-2}$**

CrO_4^{-2}:- When CrO_4^{-2} ions are dissolved in water a yellow solution is formed. When an acid is added, the H^+ ions increase and lead to the formation of dichromate ion.

$$2CrO_4^{-2} + 2H^+ \rightleftharpoons Cr_2O_4^{-2} + H_2O$$

$Cr_2O_4^{-2}$:- When a base is added, the OH^- ion concentration increases, leading to the reversal of equilibruim and increase in concentration of CrO_4^{-2} ions.

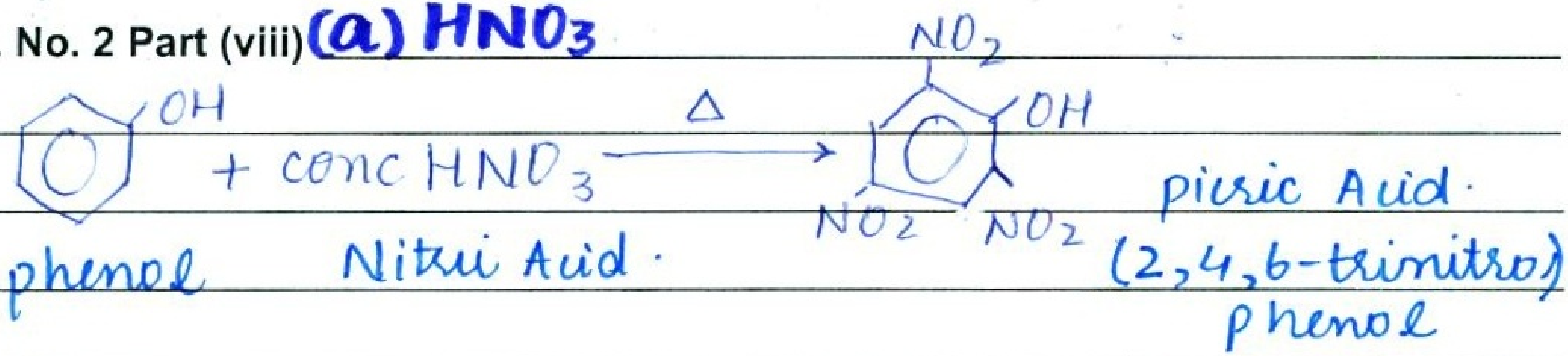
$$Cr_2O_4^{-2} + 2OH^- \rightleftharpoons 2CrO_4^{-2} + H_2O$$

Q. No. 2 Part (vii) Green House effect:-

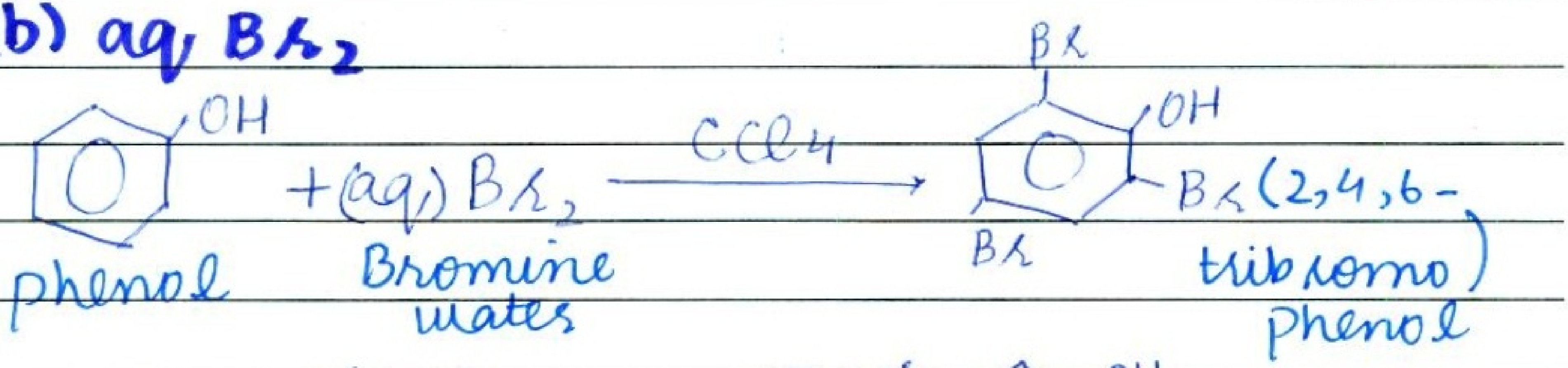
Statement:- "The increase in atmospheric temprature due to the presence of certain molecules (CO_2 & H_2O) which retain heat in the atmosphere is called greenhouse effect." **Explaination**:-

Sun sends various low wavelength ultraviolet radiations towards the Earth. The molecules on the earth's atmosphere vibrate and release high wavelength infrared radiations. These radiations are absorbed by the CO_2 & H_2O in our atmosphere leading to an increased temprature. This warms the environment as the H_2O & CO_2 act as an insulating sheet. So heat must be lost to attain equilibrium.

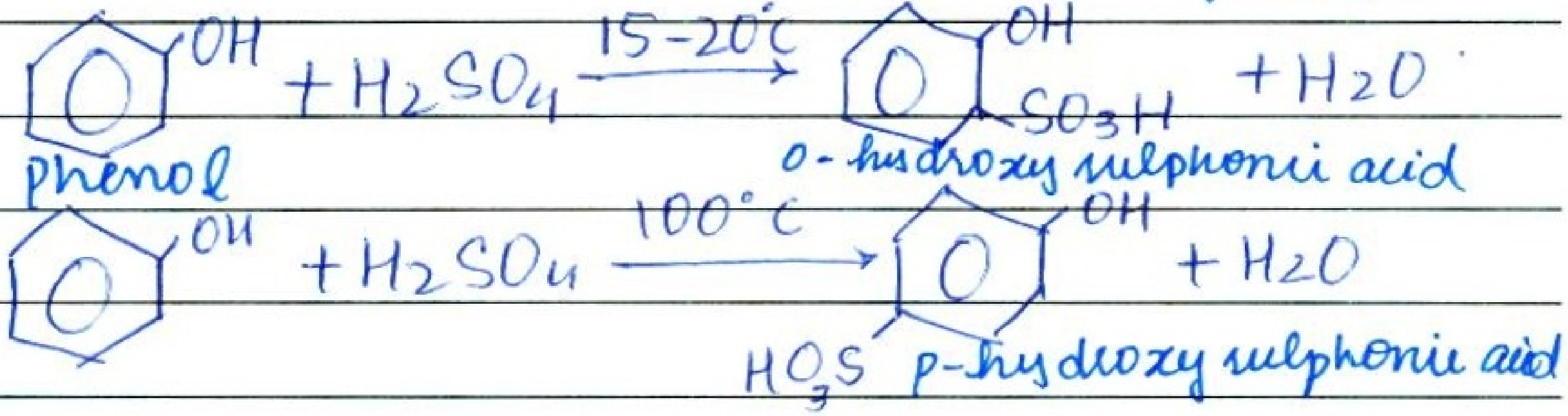
Q. No. 2 Part (viii) **(a) HNO_3**



(b) aq, Br_2



(C) H_2SO_4:-

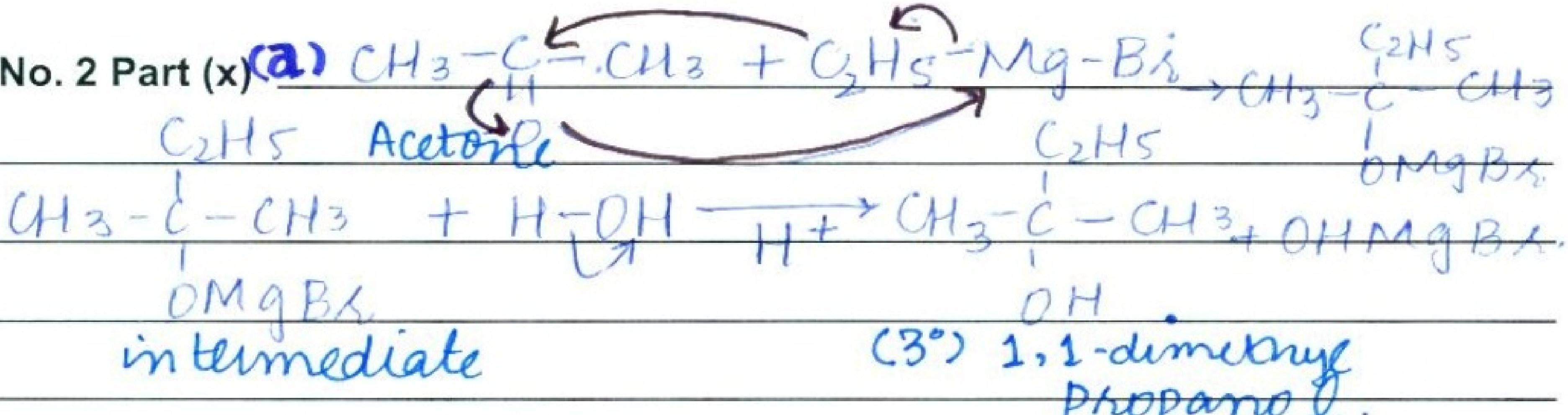


Q. No. 2 Part (ix)

E1	E2
Substrate	
Usually ter-halides give this reaction (tertiary halides).	Usually primary halides give this reaction (1°).
Order of Reaction:	
It is a 1st order reaction & ~~Rate~~ rate only dependson $[R-x]$. $Rate = K[R-x]$	It is a 2nd order reaction & rate dependson bothe alkyl halide & (Nu). $Rate = K[R-x][B]$
Solvents	
Preffered in polar solvents	Preffered in non-polar solvents.
Molecularity:	
Unimolecular reaction	Bimolecular reaction.

Q. No. 2 Part (x)

(a)



$$CH_3-\underset{H}{C}=CH_3 + C_2H_5-Mg-Br \rightarrow CH_3-\overset{C_2H_5}{\underset{OMgBr}{C}}-CH_3$$

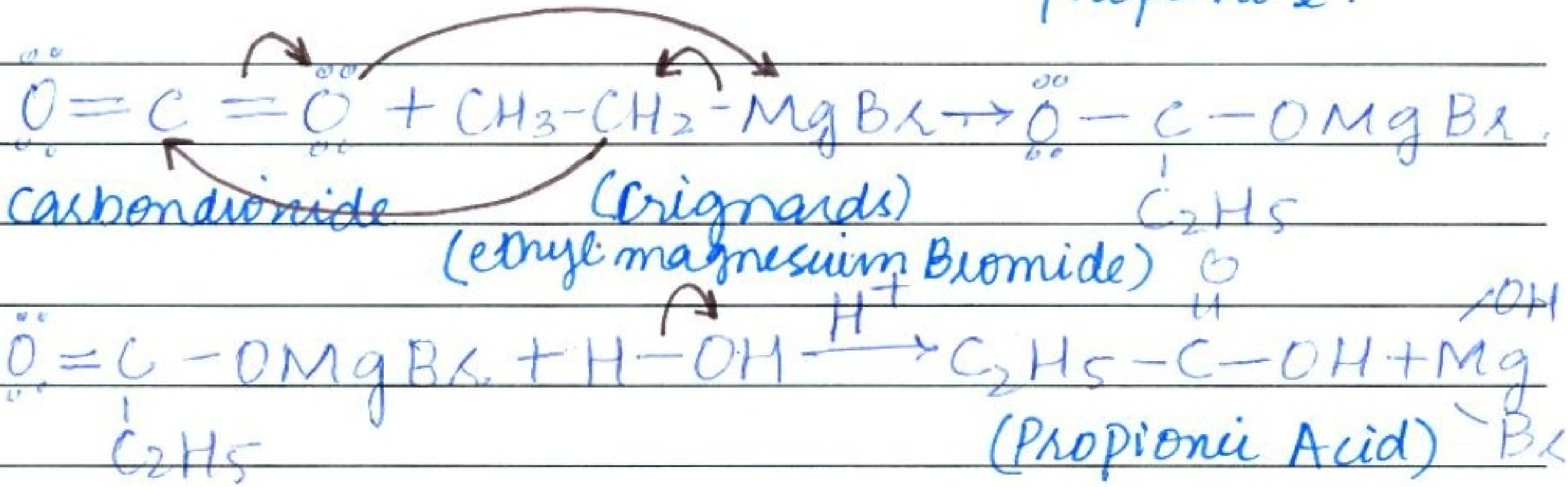
Acetone

$$CH_3-\overset{C_2H_5}{\underset{OMgBr}{C}}-CH_3 + H-OH \xrightarrow{H^+} CH_3-\overset{C_2H_5}{\underset{OH}{C}}-CH_3 + OHMgBr.$$

intermediate

(3°) 1,1-dimethyl propanol.

(b)



$$\ddot{O}=C=\ddot{O} + CH_3-CH_2-MgBr \rightarrow \ddot{O}-\underset{C_2H_5}{C}-OMgBr.$$

Carbondioxide

(Grignards)

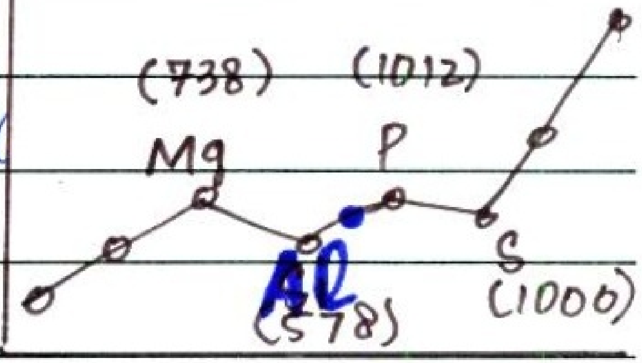
(ethyl magnesium Bromide)

$$\ddot{O}=\underset{C_2H_5}{C}-OMgBr + H-OH \xrightarrow{H^+} C_2H_5-\overset{\overset{\ominus}{O}}{\overset{\|}{C}}-OH + Mg\begin{matrix}OH\\Br\end{matrix}$$

(Propionic Acid)

Q. No. 2 Part (xi) **Ionization energy**:- Minimum amount of energy required to remove the outermost loosely held electrons of gaseous atoms to form uninegative gaseous ions."

Anamolous Reagent:- Although the I-A energies decrease down a group and increase along the period However there is an anamolous trend in 3rd period between **Mg** & **Al** **P** & **S**. The **Mg** & **Al** should not have higher ionization energies that Si & S but in the case of **Mg** $(3s^2)$ [illegible]) it is difficult to remove electrons from ~~partially~~ **fully filled S-orbital** In $P(3s^2 3p^3)$ It is difficult to remove electrons from a half filled porbital than from partially filled $S(3s^2 3p^4)$



Q. No. 2 Part (xii) **Chloroflorocarbons** :- Chloroflorocarbons like Freon 1($CFCl_3$) or Freon 2(CF_2Cl_2), are a great threat to the Ozone layer in the stratosphere. They are used in aerosoles and refrigents. When they go into the space they are broken down by th UV-radiations to give off chlorine freeradicals with break down O_3 to form $\overset{\circ}{Cl}O$. later are ∴ regenerated.

$$CF_2Cl_2 \xrightarrow{UV} \overset{\circ}{C}F_2Cl + \dot{Cl}$$

$$\overset{\circ}{Cl} + O_3 \longrightarrow O_2 + \overset{\circ}{Cl}O$$

$$\overset{\circ}{Cl}O + O \longrightarrow \overset{\circ}{Cl} + O_2.$$

Thus, they are reducing the ozone layer, causing it to deplete

Q. No. 2 Part (xiii) **Given :-** Mg mass = 24 amu %age = 78.70%

Mg25 = 25 amu , % Mg25 = 10.13%

Mg26 = 26 amu , % Mg26 = 11.17%

To find:- Relative abundance = ?

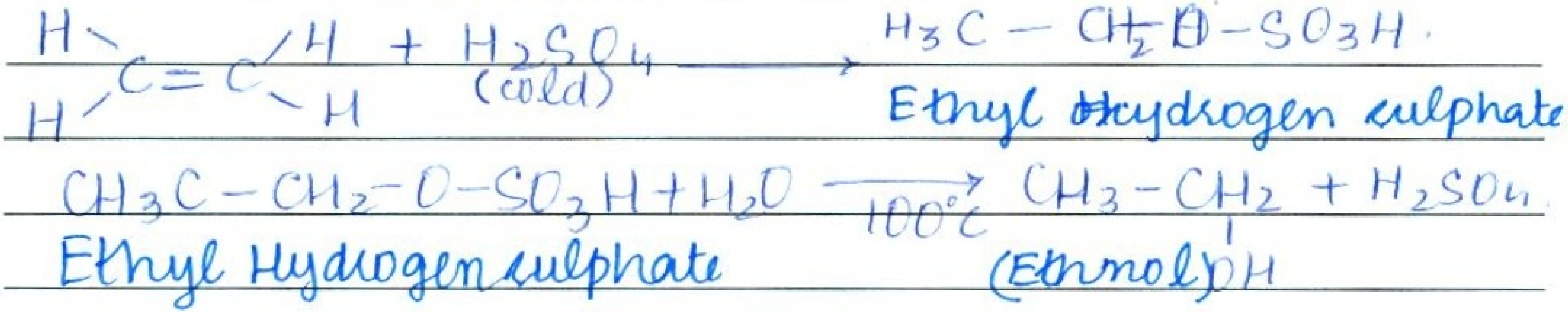
Solution :- ∴ Relative abundance = $\frac{\text{Total abundance}}{100}$

Relative abundance = $\frac{(24 \times 78.70) + (25 \times 10.13) + (26 \times 11.17)}{100}$

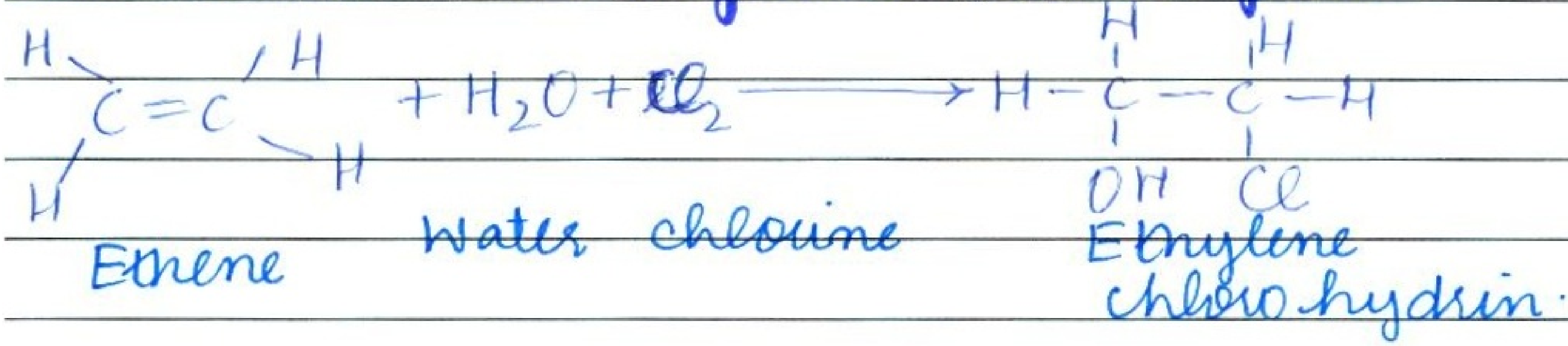
Relative abundance = $\frac{2432.47}{100}$

Relative abundance = 24.3 amu.

Q. No. 2 Part (xiv) Ethene → Ethanol :-



(b) Ethene → Ethylene chlorohydrin :-



Refinining of Crude oil :-

Definition :-

"The process of separating crude oil into its fractions is called refining process."

Fractional Distillation :-

The principle of fractional distillation is the prime principle of refining of crude oil.

"The process of separation of components (miscible) of a mixture from each other on the basis of difference in their boiling point is called fractional distillation."

Principle of Fractional Distillation

First of all, the substance is vapourized. The compounds having low boiling point are volatile in nature and tend to boil out first. The compounds having higher boiling points are less volatile and so they boil out next. This continous untill a a residue is left behind. Each of the component is achieved and condensed separately.

Refinining of Crude oil (Process):-

(1) **Heating**:- The crude oil is first vapourized by putting it in a furnace. This evaporated fume of petrol is then passed vertically through the fractionating coloumn from the bottom. (Furnace has a temprature of 350-400°C).

(2) **Condensation**:- The volatile compounds that boil out first are risen up to the top to be condensed and then collected according to the level of their boiling points. The h fractions that have high boiling points (almost 350-400°C); are condensed and collected almost at the bottom.

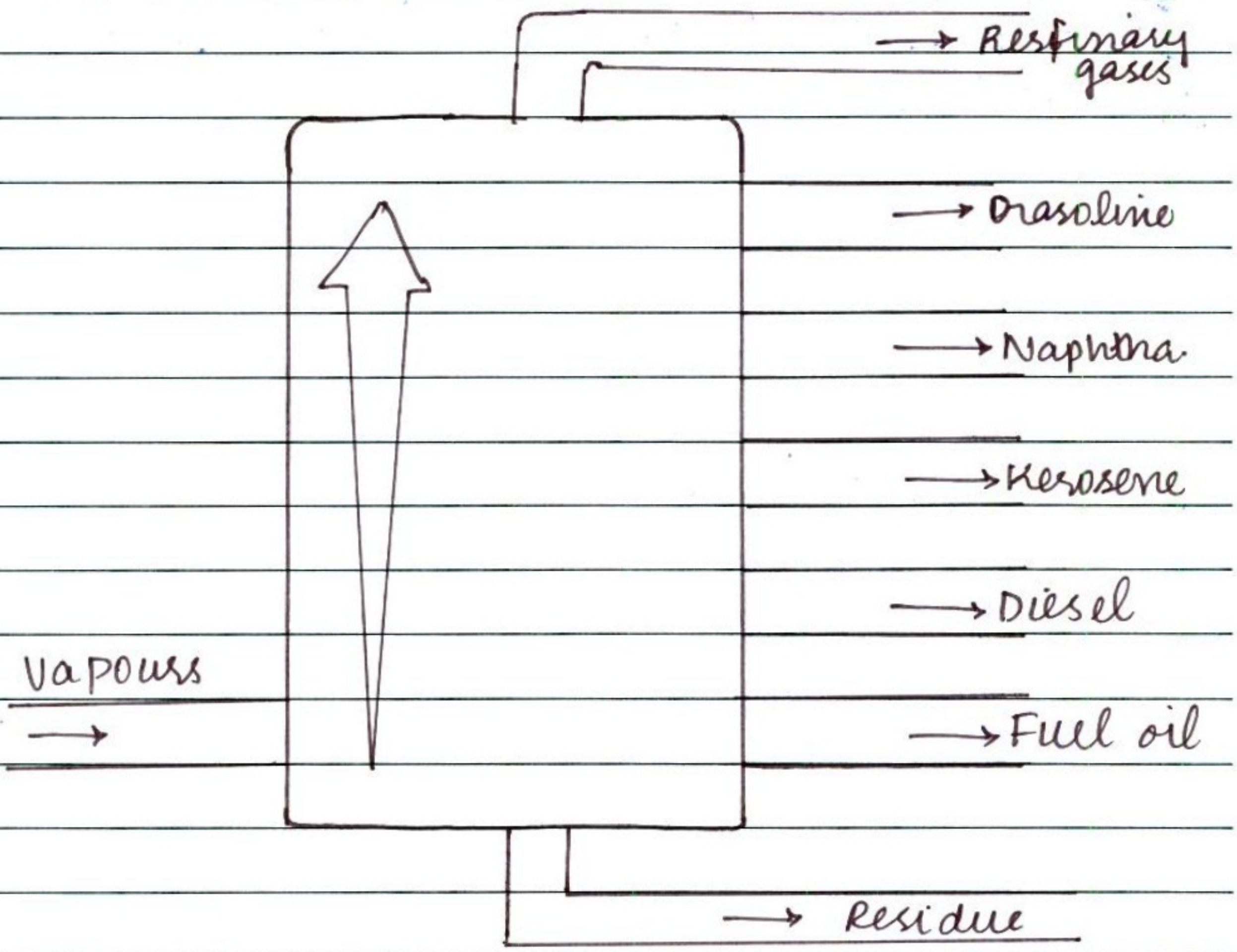
(3) **Residue**:- At the end, this whole process leaves only a residue at the end.

2. Fractions obtained

The fractions obtained as a result are:-

(1) Refinary gases.
(2) Grasoline
(3) Naphtha.
(4) Kerosene
(5) Diesel
(6) Fuel oil

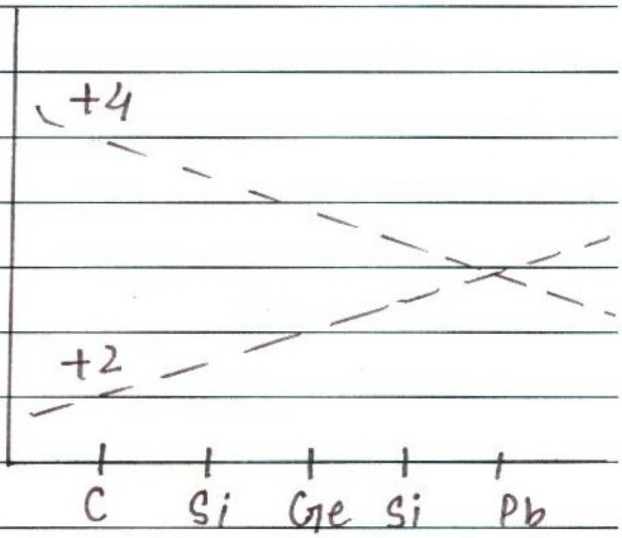
Q. No. 3 (Page 3)



→ Resfinary gases
→ Gasoline
→ Naphtha
→ Kerosene
→ Diesel
Vapours →
→ Fuel oil
→ Residue

Oxidation states

In group (IV-A), there is an oxidation state trend. The +4 oxidation state is at its highest stability at the top. Whereas, it stability decreases and thus, the stability of the +2 oxidation is the highest at the bottom i.e Pb^{+2} is more stable than Pb^{+4}.



Carbon and silicon, at the top, always appear in +4 oxidation state because that is their stable oxidation state. Moreover, they always make covalent compounds hence why always appear to be having the highest charge densities. i.e +4 state. Whereas, on the other hand Ge, Sn & Pb show dual oxidation states i.e +2 & +4.

This can be explained on the basis of inert pair effect.

⟹ Inert Pair effect

"When an atom looses 2 electrons to acquire +2 oxidation state, the pair of electrons present in the s-orbital remains inert and doesn't react. Therefore that pair is known as Inert pair and this phenomenon as inert pair effect."

Q. No. 4 (Page 2) This is why the group IV-A compounds show +2 & +4 oxidation states.

Ge^{+2} & Ge^{+4}:-

Ge^{+2} is less stable than Ge^{+4}. This is because of this, the Ge^{+2} is readily oxidized to form Ge^{+4} state. Therefore Ge^{+2} acts as a strong reducing agent.

$$\underset{\text{reducing agent}}{Ge^{+2}} \rightleftharpoons \underset{\text{oxidizing agent.}}{Ge^{+4}}$$

Ge^{+} Sn^{+2} & Sn^{+4}:-

Sn^{+2} is less stable than Sn^{+4}. Due to this, the Sn^{+2} is readily oxidized to form Sn^{+4}. Therefore Sn^{+2} acts as an reducing agent. And Sn^{+4} acts as a strong oxidizing agent.

$$\underset{\text{reducing agent}}{Sn^{+2}} \longrightarrow \underset{\text{Oxidizing agent.}}{Sn^{+4}}$$

Pb^{+2} & Pb^{+4}

Pb^{+2} is much more stable than Pb^{+4}. So Pb^{+4} is readily reduced to Pb^{+2}. So it acts as a strong oxidizing agent and Pb^{+2} acts as a strong reducing agent.

$Pb^{+4} \longrightarrow Pb^{+2}.$

oxidizing agent   Reducing agent

Relative stability:-

Thus. the relative stability is as follows.

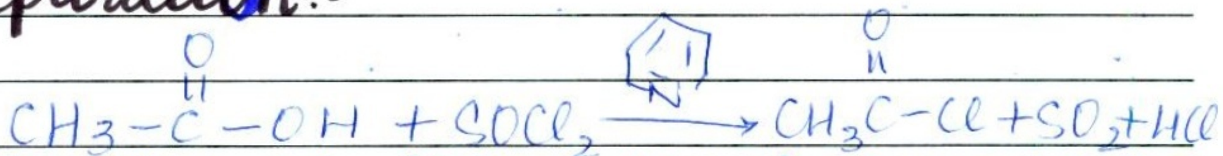
(1) $Ge^{+2} < Ge^{+4}$
(2) $Sn^{+2} < Sn^{+4}$
(3) $Pb^{+2} > Pb^{+4}$

So;

$Ge^{+2} < Ge^{+4}; Sn^{+2} < Sn^{+4}; Pb^{+2} > Pb^{+4}.$

Acetyl Chloride

Preparation:-



$$CH_3-\overset{O}{\overset{\|}{C}}-OH + SOCl_2 \xrightarrow{\text{pyridine}} CH_3\overset{O}{\overset{\|}{C}}-Cl + SO_2 + HCl$$

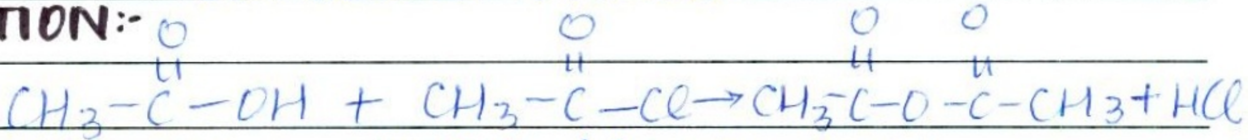
(Acetic Acid) (Thionyl chloride) (Acetyl chloride)

When acetic acid reacts with thionyl chloride in the presence of pyridine as a base, it forms acetyl chloride.

Reactions:-

(1) Acetic Acid:-

REACTION:-



$$CH_3-\overset{O}{\overset{\|}{C}}-OH + CH_3-\overset{O}{\overset{\|}{C}}-Cl \rightarrow CH_3-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-CH_3 + HCl$$

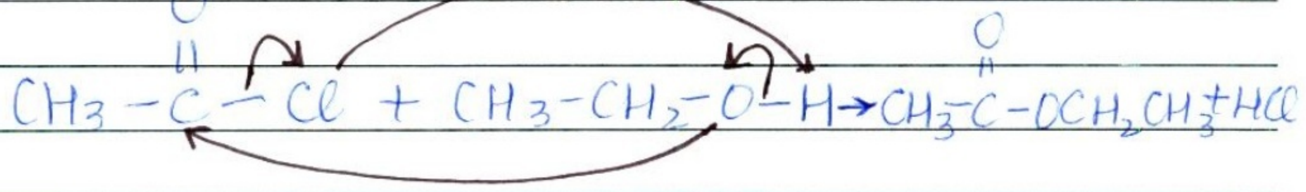
Acetic Acid Acetyl chloride Acetic (anhydride)

EXPLANATION:-

Acetyl chlorides react with acetic acid to form acid anhydraides by emitting a HCl molecule.

(2) Ethanol

REACTION:-



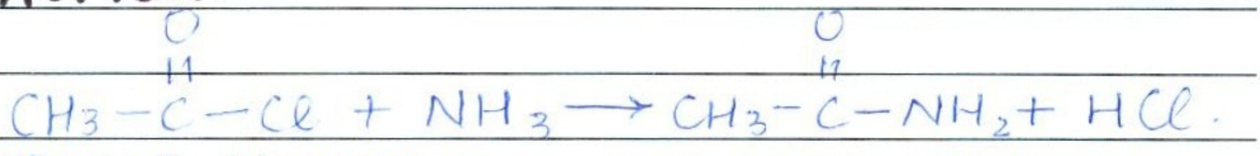
$$CH_3-\overset{O}{\overset{\|}{C}}-Cl + CH_3-CH_2-O-H \rightarrow CH_3-\overset{O}{\overset{\|}{C}}-OCH_2CH_3 + HCl$$

Acetyl chloride Ethanol Ethyl ethanoate

Q. No. 5 (Page 2) acetyl chloride reacts with alcohol to give rise to a ester which in this case is **Ethyl ethanoate** along with release of HCl (Hydrochloric acid).

(3) NH_3

REACTION:-



$$CH_3-\overset{\overset{\displaystyle O}{||}}{C}-Cl + NH_3 \longrightarrow CH_3-\overset{\overset{\displaystyle O}{||}}{C}-NH_2 + HCl.$$

(Acetyl chloride) (Ammonia) (Acetamide)

EXPLANATION:-

→Acetyl chloride reacts with ammonia to give rise to amides which in this case is **acid amide**. along with release of HCl.

Q. No. 5 (Page 3)

Acidic strength of Phenol, Alcohol & CA:-

(1) Order

Carbosylic Acid > Phenol > Alcohol.

(2) Justification

→ PKa value:-

PKa value of carbonylic acid is 5, phenol is 10 and that of alcohol is 16 - 20.

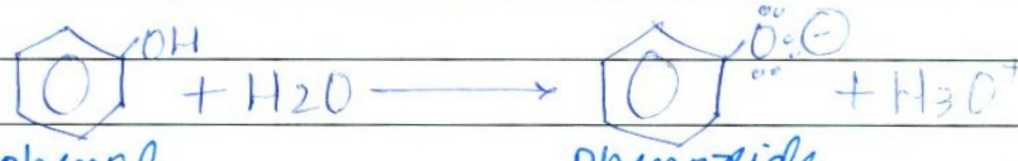
Since pKa carbonylic < pKa phenol < pKa alcohol therefore, carbonylic acid is the most acidic followed by phenol and then alcohol.

→ Conjugate bases:-

(1) Hydrolysis:-

$CH_3-\overset{O}{\overset{\|}{C}}-OH + H_2O \longrightarrow CH_3-\overset{O}{\overset{\|}{C}}-O^{\ominus} + H_3O^+$

carbonylic acid. Carbonylate ion



phenol Phenoxide ion

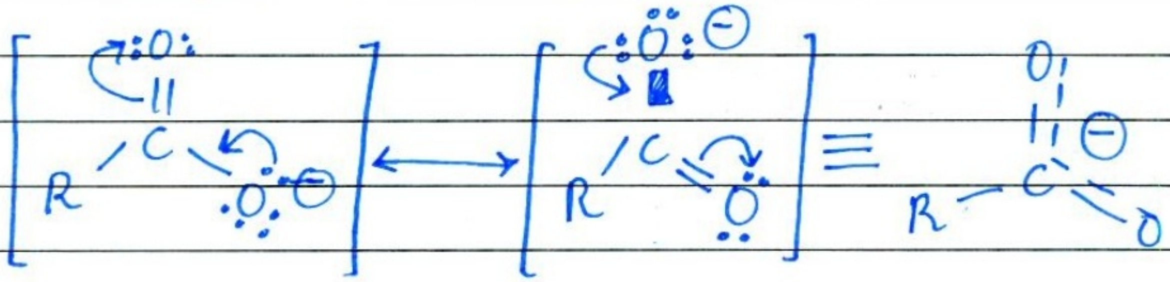
$R-\ddot{\underset{..}{O}}-H + H_2O \longrightarrow \underset{\text{alkoxide}}{R-\ddot{\underset{..}{O}}{:}^{\ominus}} + H_3O^+$

Q. No. 6 (Page 2)

Stability of Conjugate bases:-

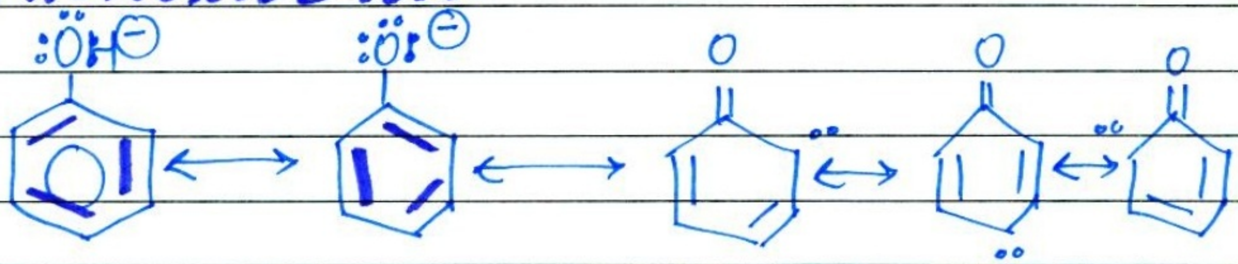
CARBOXYLATE ION:-

The carbonylate ion shows the following resonance structures



In carbonylic acid, the electron density is equally distributed between the two Oxygen atoms. Hence it is very stable.

PHENOXIDE ION:-



Stability also contributes to the number of resonance structures, the more the resonance structures the more stable it is.

ALKOXIDE ION:-

The electron density in alkoxide ion is only present in the O-atom and doesn't delocalazie. hence it is very unstable.

$R-\ddot{\underset{\cdot\cdot}{O}}:^{\ominus}$

(3) Conclusion:-

We can conclude that, the carbonylic acid is more acidic than phenols, which are more acidic than alcohols.

$R-COOH >$  $> R-\underset{\cdot\cdot}{\ddot{O}}H$

Acidity of Phenol:-

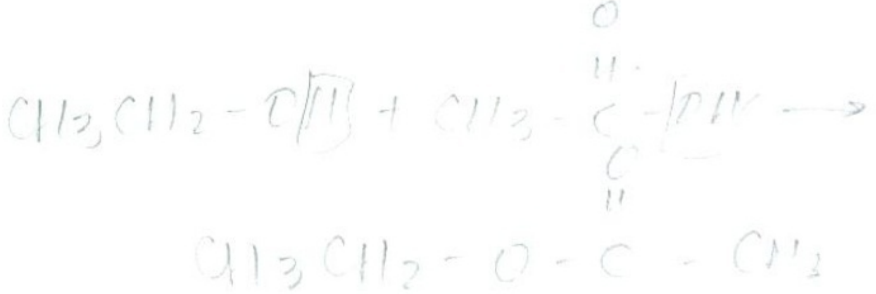
Electron withdrawing group:-

If electron withdrawing groups are added. to the ring, the put up a distributed structure of negative charges, thereby stablizing the ring and making it more acidic. For example Nitro phenol is more acidic than phenol.

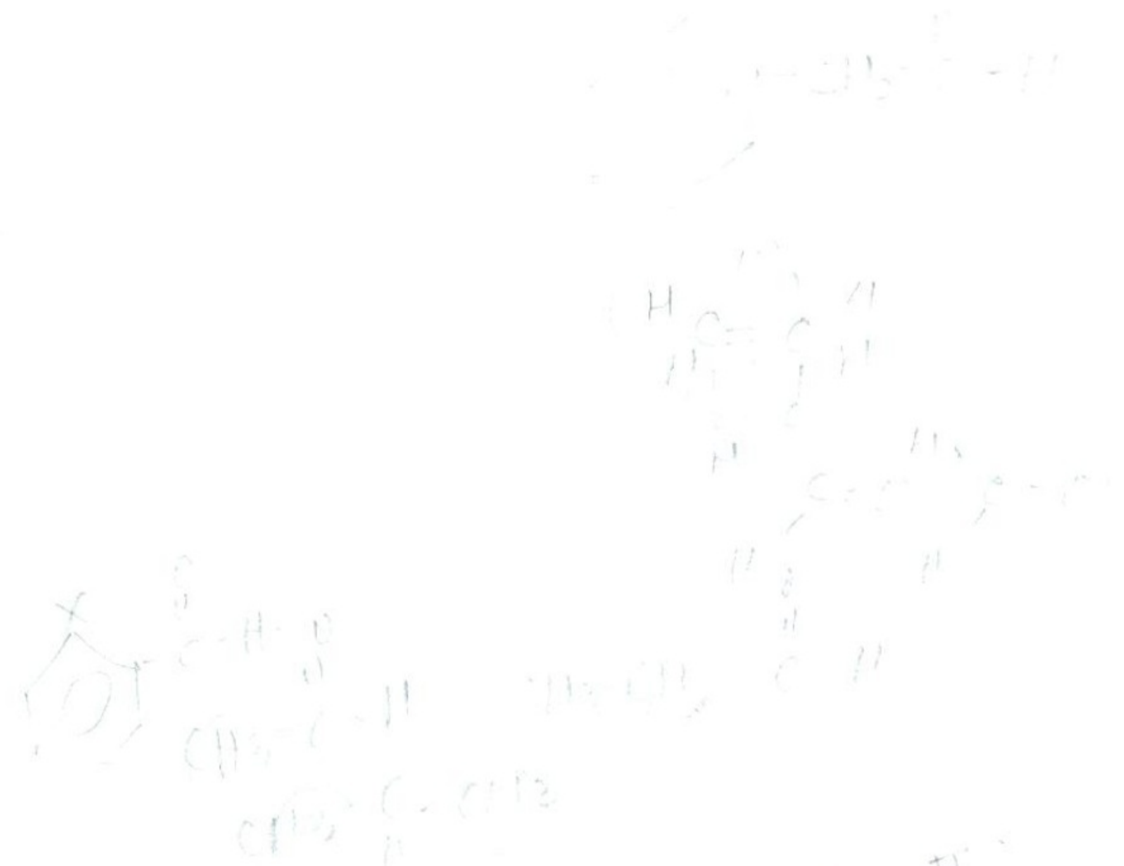
Electron donating group:-

If electron donating group is present. then it donates electrons towards the ring, making is more densly charged, destablizing it and reducing its acidity.

For example, alkyl phenol is less acidic than phenol.



$$CH_3CH_2-O\boxed{H} + CH_3-\overset{\overset{O}{\|}}{C}-\boxed{OH} \longrightarrow CH_3CH_2-O-\overset{\overset{O}{\|}}{C}-CH_3$$



$$CH_3-\overset{\overset{:O:}{\|}}{C}-H$$