Mrudula R. Jadhav

Date ___/___/_____

Engineering Chemistry - II (IA - 2)

Q1. Choose the correct option for following questions. All the questions are compulsory and carry equal marks

1. Selection rule to produce rotational spectra is
→ b) Molecule must have permanent dipole moment

2. According to the sacrificial anode method, the metallic object to be protected from corrosion should be connected to the metal having
→ a) Reduction potential higher than the object

3. Which of the following statement is incorrect about galvanic cell
→ c) cell can work indefinitely

4. If a metal rod exhibits holes on its surface, the type of corrosion is
→ c) pitting

5. A good fuel has
→ d) Moderate ignition temperature & high calorific value

6. Spin multiplicity for the two unpaired electron is excited singlet state is
→ a) 3

7. Cell reaction will be spontaneous if its EMF is
→ a) Positive

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8. Spectroscopy in which interaction of UV light with molecule is studied is known as

→ b) Electronic spectroscopy

9. Season cracking and caustic embrittlement are special case of

→ b) Stress corrosion

10. Calculate the % atom economy

$C_6H_5NH_2 + (CH_3CO)_2O \longrightarrow C_6H_5NHCOCH_3 + CH_3COOH$

Acetanilide

→

11. The feedstock used for greener route synthesis of Adipic acid.

→

12. In impressed current cathodic protection, anode is provided with a gypsum backfill because.

→

13. Arrange n-heptane, iso-octane, Naphthalene in increasing order of their knocking tendency in Petrol IC ~~eg~~ engine.

→ c) n-heptane < Naphthalene < iso-octane

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14. As per Pilling-Bedworth rule, Greater the specific volume ratio

→ a) Higher is the oxidation corrosion

15. Calculate Gross calorific value of coal sample containing C = 83%, H = 6%, O = 3%, S = 3.7%, N = 2.5% ash = 1.8%.

→ $GCV = \frac{1}{100}\left[8080C + 34500\left(H - \frac{O}{8}\right) + 2240S\right]$

$GCV = \frac{1}{100}\left[8080(83) + 34500\left[\frac{6 - 3}{8}\right] + 2240(3.7)\right]$

$GCV = \frac{1}{100}\left[670640 + 194062.5 + 8288\right]$

$GCV = 8729.905$

∴ c) 8729.90 Kcal/Kg

16. Which of the following is not true about the catalytic reaction.

→

17. Rate of metallic corrosion will be relatively higher in which of the following case

→ a) When the surface area of cathode is greater than surface area of anode

18. Which of the following is the standard EMF of the following Galvanic cell

$Ni_{(s)} | Ni^{2+}_{(1M)(aq)} || Cu^{2+}_{(1M)(aq)} | (Cu_{(s)})^{+}$

[$E^\circ_{Ni^{2+}/Ni} = -0.257$ V and $E^\circ_{Cu^{2+}/Cu} = 0.337$ V)

→ $E_{cell} = E^\circ_{cell} - 2.303\frac{RT}{nF}\log_{10}$

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19. Traditional and greener routes of synthesis of ___ contain the exact same reactants but only the sequence in which they are made to react is different.

→

20. Which of the following is not the disadvantage of leaded petrol.

→ c) leaded ~~petrol~~ has better anti-knocking properties

Q2. Solve the following.

1. What is absorption spectroscopy? Explain different types of absorption spectroscopy explaining nature of interaction with molecules.

→ Absorption spectroscopy is kind of spectroscopy in which absorption of radiation is radiation is observed as function of wavelength.
Absorption of radiation by electron in ground state
Different types of absorption spectroscopy:

Type	Transition	Region
Rotational spectroscopy	• Absorption of microwaves • transition b/w rotational energy levels	Microwave

	• molecule must passes permanent dipole moment	
Vibrational spectroscopy	• Absorption of Infrared • transition b/w vibration energy level • Dipole moment of molecule must change during vibration.	Infrared
Electronic Spectroscopy	• Absorption b/w electronic energy levels • presence of chromophore in the molecule	UV and visible region
NMR spectroscopy	• between magnetic energy level of nuclei • Non-zero spin of the nuclei must be there.	Radio frequency region

2 Write the Nernst Equation and calculate Emf of following cell at 298K : $Mg_{(s)} / Mg^{2+}(0.001\ M) \| Cu^{2+}(0.0001\ M) / Cu_{(s)}$

$E^\circ_{Cu^{2+}/Cu} = 0.34V$ and $E^\circ_{Mg^{2+}/Mg} = -2.37\ V$

→

$$Mg \longrightarrow Mg^{2+} + 2e^-$$

$$Cu^{2+} + 2e^- \longrightarrow Cu$$

$$Mg_{(s)} + Cu^{2+} \longrightarrow Mg^{2+} + Cu_{(s)}$$

$$E_{cell} = E^\circ_{cell} - \frac{2.303RT}{nF} \log \frac{[Mg^{2+}]}{[Cu^{2+}]}$$

$$E_{cell} = (0.34 - (-2.37)) - \frac{2.303RT}{nF} \log \frac{(0.001)}{(0.0001)}$$

$$E_{cell} = 2.71 - \frac{0.059}{2} \times \log 10$$

$$E_{cell} = 2.71 - 0.0295$$

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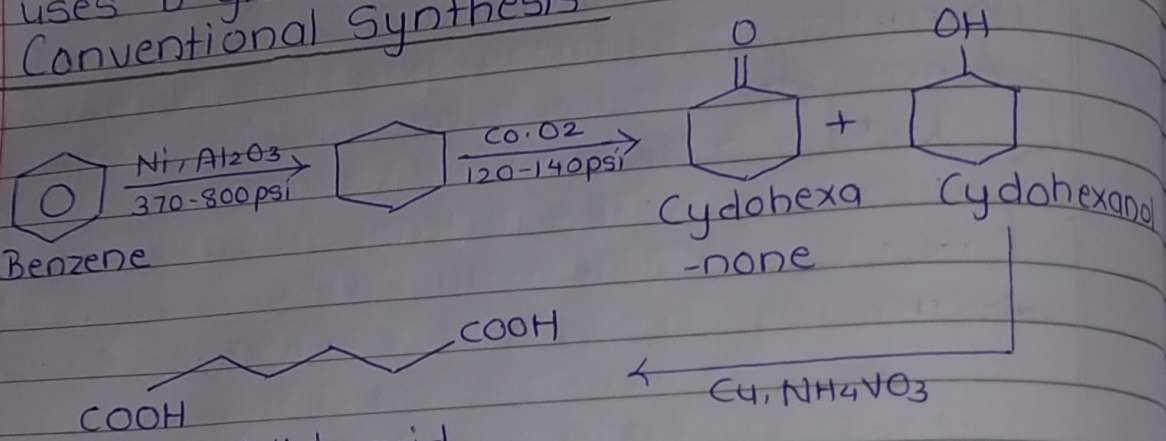
$E_{cell} = 2.6805\ V$

3. Write the conventional and greener route reaction for the synthesis of Adipic acid and highlight the green chemistry principle involved.

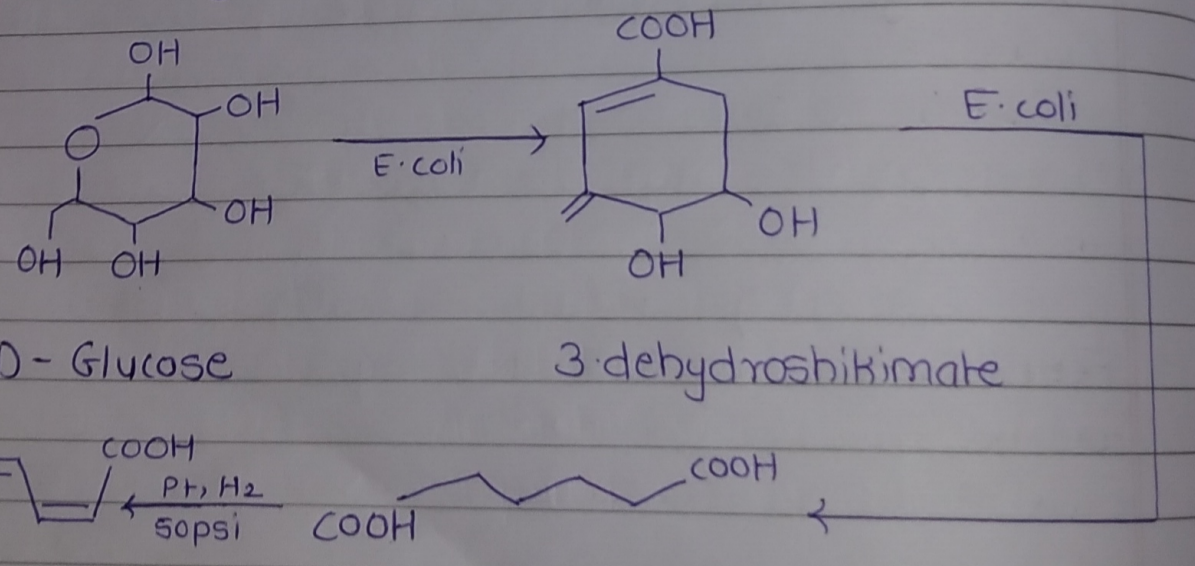
→ The traditional starting material for adipic acid synthesis is benzene and green synthesis uses D-glucose

Conventional Synthesis



Adipic acid

Green Synthesis



D-Glucose

3-dehydroshikimate

cis cis muconic acid.

Adipic acid

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4. What is Differential Aeration corrosion? Explain with neat diagram, reactions and examples.

→ ① Differential aeration is the most important type of concentration cell corrosion.

② It occurs when one part of a metal is exposed to a different air concentration from the other part of metal.

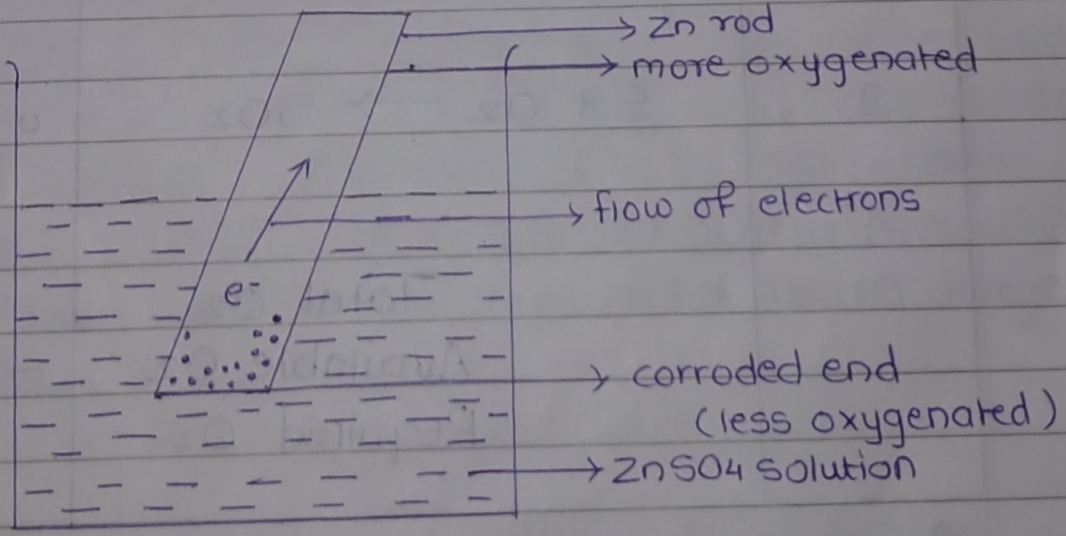
③ This causes a difference in potentials between different aerated areas.

④ Poor oxygenated part of a metal acts as a ~~cathode~~ anode and it is this part of the metal which undergoes corrosion.

⑤ Highly oxygenated part of the metal acts as a cathode and remains unaffected.

⑥ A differential aeration of metal causes a flow of current, called differential aeration current.

Eg: A rod of Zn is partially immersed in a dilute soln of $ZnSO_4$



Reactions:

At anode, $Zn \longrightarrow Zn^{++} + 2e^-$

At cathode, $1/2O_2 + H_2O + 2e^- \longrightarrow 2OH^-$

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Net reaction. $Zn + 1/2O_2 + H_2O \longrightarrow Zn^{++} + 2OH^-$

⑦ As oxygen concentration cells are formed as a result of differential aeration, such a corrosion is also called as differential aeration corrosion.

5. A sample of coal was found to contain C = 80%, H = 5%, O = 1%, N = 2%, S = 5%, Ash = 7%. Calculate the weight and volume of air required for complete combustion of 10kg of coal sample.

→ 1kg coal contains,

C = 0.80 kg, H = 0.05kg, O = 0.01 kg

N = 0.02 kg, S = 0.05 kg, Ash = 0.07 kg

Sr.no.	Combustion Reaction	Weight of O_2 required
1.	$C + O_2 \longrightarrow CO_2$	$\frac{0.80 \times 32}{12} = 2.13$
2.	$H_2 + 1/2O_2 \longrightarrow H_2O$	$\frac{0.05 \times 16}{2} = 0.4$
3.	$S + O_2 \longrightarrow SO_2$	$\frac{0.05 \times 32}{32} = 0.05$
	Total O_2	2.58
	Available O_2	− 0.01
	Required O_2	2.57

Air contains 23% of O_2 by weight

wt of air needed = $\frac{2.57 \times 100}{23} = 11.17$ kg.

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Molecular weight of air = 28.94 kg

28.94 kg of air at NTP weights $22.4\ m^3$

11.17 kg of air = $\frac{22.4 \times 11.17}{28.94} = 8.64\ m^3$

For 10kg of coal sample,

weight of air = $11.17 \times 10 = 111.7$ kg

Volume of air = $8.64 \times 10 = 86.4\ m^3$

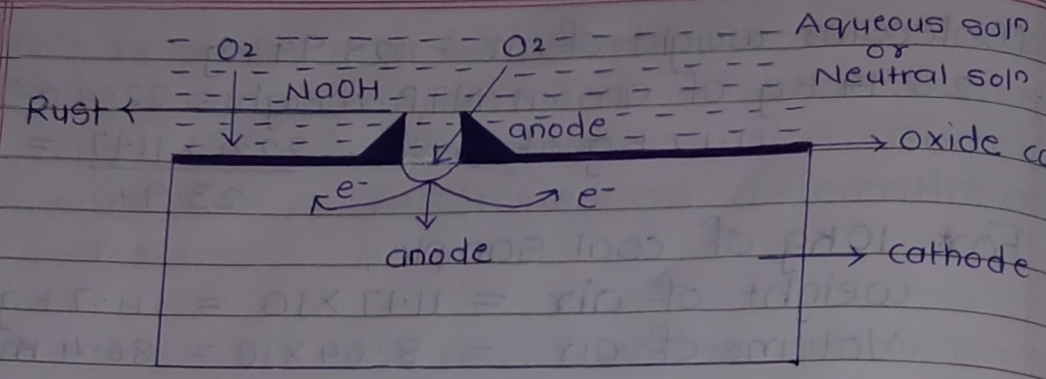
6. Define electrochemical corrosion With suitable diagram and reactions explain electrochemical mechanism of rusting of iron in neutral aqueous medium.

→ Electrochemical corrosion occurs where a conducting liquid is in contact with metal or when two dissimilar metals or alloys are either immersed or dipped partially in a solution.

Rusting Of Iron in Neutral aqueous Solution:

① Rusting of iron in water containing dissolved oxygen occurs by oxygen absorption mechanism.
② At anodic area iron will disolve by oxidation.
③ The surface of iron is usually coated with thin film of iron oxide. But if this iron oxide film develops some cracks, anodic areas are created on the surface. while metal acts as cathode.
④ Here the anodic areas are small surface while rest of the surface of the metal forms large cathodes.

P.T.O.



At anode, $Fe \longrightarrow Fe^{2+} + 2e^-$

At cathode, $1/2O_2 + H_2O + 2e^- \longrightarrow 2OH^-$

Net reaction,

$Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2 \downarrow$

ferrous hydroxide

If enough O_2 is present, ferrous hydroxide oxidises to ferric hydroxide

$2Fe(OH)_2 + 1/2O_2 + H_2O \longrightarrow 2Fe(OH)_3 \downarrow$

ferric hydroxide

This product called yellow rust, which is nothing but $Fe_2O_3 \cdot H_2O$. If O_2 is limited the corrosion product will be black unhydrous magnetite Fe_3O_4.

If environment is aqueous solution of NaCl containing dissolved O_2

$NaCl \xrightarrow{H_2O} Na^+ + Cl^-$

At cathode, $Na^+ + OH^- \longrightarrow NaOH$

At anode, $Fe^{2+} + 2Cl^- \longrightarrow FeCl_2$.

Both products are soluble in water. They react with each other and ferrous hydroxide precipitates which further oxidizes to ferric hydroxide

$4Fe(OH)_2 + 2H_2O + O_2 \longrightarrow 4Fe(OH)_3 \downarrow$

$\uparrow\downarrow$

$Fe_2O_3 \cdot H_2O$

(yellow rust)

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7. Distinguish between anodic coating and cathodic coating. Which is preferred and why?

→

Anodic coating	Cathodic coating
① It protects the base metal sacrificially.	① It protects the base metal due to noble nature.
② It continues to protect the metal by galvanic action, even if coating is broken.	② It protects the metal till the coating is perfect.
③ It cannot be used for storing foodstuffs.	③ It can be used for storing acidic food-stuffs.
④ Example: Galvanizing, coating of Zn of Fe.	④ Example: Tinning, coating of Sn on Fe

① Cathodic coating is preferred over anodic coating as it is non-toxic
② It protects the metal from corrosion and avoids any food poisoning.

8. List 12 principles of green chemistry. Describe prevention of waste with suitable example.

→ Following are the 12 principles of green chemistry
① Prevent waste
② Maximize atom economy
③ Less hazardous chemical synthesis
④ Safer chemicals and products
⑤ Safer solvents and reaction conditions
⑥ Increase energy efficiency.
⑦ Use renewable feedstocks

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⑧ Avoid chemical derivatives
⑨ Use catalyst
⑩ Design chemicals and products to degrade after use
⑪ Real time analysis for pollution prevention
⑫ Inherently safer chemistry for accident prevent

Prevention of waste:

a) It is better to design chemical synthesis to prevent waste rather than leaving no waste to treat or cleanup.
b) In most of the cases, the cost involved in the treatment and disposal of wastes adds to the overall cost of production.
c) The unreacted starting materials also form part of the waste. The waste is discharged in the atmosphere, sea or land not only causes pollution but also requires expenditure for cleaning up.
d) Examples: avoiding the use of disposable utensils, napkins, paper towels and other products and buying durable items.

9. What is cathodic protection? Explain impressed current method with its application.

→ When electric current flows between anode and cathode of a metal, higher the current, faster will be the corrosion. If the current is applied to nullify the corrosion, it is called as cathodic protection. In cathodic protection, the metal to be protected ~~as~~ is forced to behaved as cathode.

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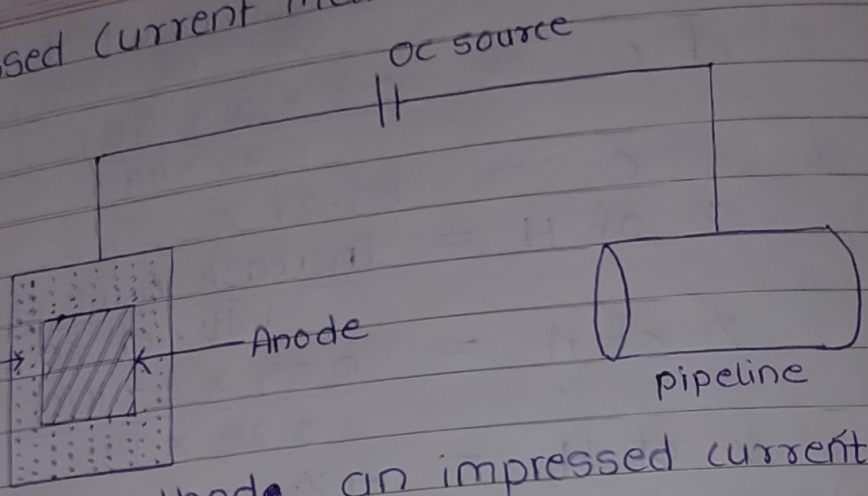
Impressed Current Method:



① In this method, an impressed current is applied to convert anode to cathode.
② The metal structure to be protected is connected to a direct current source.
③ In this, anode is inert material such as graphite, stainless steel, platinium, etc.
④ Anode is buried in backfill such as gypsum to increase the electrical contact between soil and metal.
⑤ Application: This method is used for protecting underground structures like pipelines, water tank, transmission towers, etc.

10. Determine C, H, N elements as % from the following observations in experiments of analysis of coal 0.25 g coal on burning in a combustion tube and passing the gases through tubes containing anhydrous $CaCl_2$ and KOH increases their weight by 0.09 g and 0.8g resp. In Kjeldah's method, ammonia evolved by 0.42g coal was absorbed in 49.5ml of 0.12N HCl solution. After absorption, the excess acid required 36.5ml of 0.12N NaOH for neutralization.

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→ % of C = Increase in wt of KOH × 12 × 100 / Wt. of coal taken × 44

% of C = 0.8 × 12 × 100 / 0.25 × 44

% of C = 87.27 %.

% of H = Increase in wt. of $CaCl_2$ × 2 × 100 / Wt. of coal × 18

% of H = 0.09 × 2 × 100 / 0.25 × 18

% of H = 4 %.

Volume of acid taken = 49.5ml of 0.12N HCl

Volume of excess acid = 36.5ml of 0.12 N NaOH

Volume of acid used = (49.5 - 36.5) = 13.0

% of N = Volume of acid used × Normality × 1.4 / wt of coal taken

% of N = 13.0 × 0.12 × 1.4 / 0.42

% of N = 5.2 %.

11. Explain synthesis of bio-diesel with help of reaction. Mention 2 advantages and 2 disadvantages

→ ① Bio-diesel is a liquid biofuel obtained by trans-esterification process from vegetable oil or animal fats that can be used in diesel engine, alone or blended with diesel oil.

② Biodiesel can be obtained from various oils by esterification reaction with an alcohol using an alkaline catalyst.

③ Trans-esterification is the process of converting one ester to another ~~ee~~ ester

④ Vegetable oils or fat ~~of~~ is filtered and heated at 110°C with stirring to remove water molecules

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⑤ Catalyst NaOH and methanol then added to it
⑥ The mixture is then heated for half an hour with stirring. The mixture is cooled and mixed with water.
⑦ The by-product, glycerol and soaps get dissolved in water. The water insoluble phase that is bio-diesel is separated.

Advantages
a) It is prepared from renewable resources
b) It is bio-degradable and non-toxic

Disadvantages
a) Bio-diesel is way more expensive than petroleum
b) It is not suitable for use in low temperature

12. Explain the effect of following factors on rate of corrosion.
① Position of metal in Galvanic series
② Hydrogen overvoltage
③ pH
④ Humidity
⑤ Purity of metal

→ ① Position of metal in Galvanic series:
The extent of corrosion depends upon the position of metal in the electrochemical series and galvanic series. When two metals or alloys are in electrical contact in presence of an electrolyte, the metal or alloy higher up in the galvanic series for more active metals become anode and undergoes corrosion. Further, the more are the two metal apart in the

galvanic series the greater is the difference in their oxidation potential and hence faster will be the corrosion of anodic metal.

② Hydrogen overvoltage:

Overpotential of H_2 is the difference between the potential of the electrode at which evolution of H_2 gas is observed and the theoretical value of potential at which H_2 gas evolution takes place. If pure Zn is placed in H_2SO_4 it undergoes corrosion forming a film and evolving H_2 gas. The initial rate of corrosion is slow due to its high over voltage which reduces the effective electrode potential to a small value. However if few drops of $CuSO_4$ are added, the corrosion rate is accelerated as some copper gets deposited on zinc metal. Thus reduction in over voltage of the corroding metal accelerates the corrosion rate.

③ pH.

Acidic media are generally more corrosive than alkaline and neutral media. However, amphoteric metals like Al, Zn, Pb form complete ions in alkaline solution and mix with the solutions. The corrosion of iron is slow in oxygen free water until the pH falls below 5. The corrosion rate is much higher in presence of oxygen at pH of 4.

④ Humidity.

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(5) Purity of Metal

Presence of impurity in the metal ~~slightly~~ greatly effects the rate of corrosion. If the metal contains impurity metal, tiny galvanic cells are setup. This increases rate of corrosion.

13. A coal sample ~~of~~ has following composition by mass. C = 85%, H = 6%, O = 8%, S = 0.5%, Ash = 0.5%. Calculate HCV and LCV using Dulong's formula.

→ $$HCV = \frac{1}{100}\left[8080C + 34500\left(H - \frac{O}{8}\right) + 2240S\right]$$

$$HCV = \frac{1}{100}\left[8080(85) + 34500\left(6 - \frac{8}{8}\right) + 2240(0.5)\right]$$

$$HCV = \frac{1}{100}\left[686800 + 172500 + 1120\right]$$

$$HCV = \frac{1}{100}(860420)$$

$$HCV = 8604.2\ \%.$$

$$LCV = HCV - \frac{9}{100} \times H \times 587$$

$$LCV = 8604.2 - \frac{9}{100} \times 6 \times 587$$

$$LCV = 8287.22\ \%.$$

14. 2.5 gm of coal sample was taken in silica crucible and heated in oven maintained at 110°C for one hour. The weight after heating was 2.368 gm. The same sample was analyzed for volatile matter and weight obtained was 1.75 gm. The sample was further treated to get a fixed weight of 0.95 gm. Calculate percentage of moisture, V.M. ash and F.C of this sample.

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→ ① Weight of coal taken = 2.5

Mass of moisture in coal = 2.5 - 2.368

= 0.132

% of moisture = $\frac{\text{Loss in wt of coal}}{\text{Wt of coal taken}} \times 100$

% of moisture = $\frac{0.132 \times 100}{2.5}$

% of moisture = 5.28 %.

② Mass of volatile matter = 2.368 - 1.75

= 0.618

% of volatile matter = $\frac{\text{Loss of wt in v.m}}{\text{wt of coal}} \times 100$

% of volatile matter = $\frac{0.618 \times 100}{2.5}$

% of volatile matter = 24.72 %.

③ % of ash = $\frac{\text{wt of ash left}}{\text{wt of coal taken}} \times 100$

% of ash = $\frac{0.95 \times 100}{2.5}$

% of ash = 38 %.

④ % of fixed carbon = 100 - (% M + % VM + % Ash)

= 100 - (5.28 + 24.72 + 38)

= 100 - (68)

= 32 %.

15. The composition of a gas was found to be H_2 = 10% CH_4 = 16%, C_2H_6 = 20%, N_2 = 6%, CO = 22%, CO_2 = 18%, O_2 = rest. Calculate the volume of air required for complete combustion of 10 m^3 of this gas.

→ 1 m^3 of coal contains,

$H_2 = 0.10$, $CH_4 = 0.16$, $C_2H_6 = 0.20$

$N_2 = 0.06$, $CO = 0.22$, $CO_2 = 0.18$, $O_2 = 0.08$

Sr.no.	Combustion reaction	Vol. of O_2 required
1.	$H_2 + 1/2\ O_2 \rightarrow H_2O$	$1/2 \times 0.10 = 0.05$
2.	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	$2 \times 0.16 = 0.32$
3.	$C_2H_6 + 7/2\ O_2 \rightarrow 2CO_2 + 3H_2O$	$7/2 \times 0.20 = 0.7$
4.	$CO + 1/2\ O_2 \rightarrow CO_2$	$1/2 \times 0.22 = 0.11$
	Total O_2	1.18
	Available O_2	- 0.08
	Required O_2	1.1

Air contains 21% O_2 by volume

$$\text{Volume needed} = \frac{1.1 \times 100}{21} = 5.238\ m^3$$

Volume of air required $= 5.238\ m^3 \times 10\ m^3$

$= 52.38\ m^3$

16. Explain dry oxidation corrosion by oxygen with metal

→ ① Oxygen present in atmosphere in absence of moisture directly attack the metal surface at low as well as high temperature. However metals like Na, K, Li, Be, Ca, Mg, etc are rapidly oxidised at low temperatures.

② At high temperature almost all metals except Ag, Au, Pt, etc. are oxidised During oxidation corrosion a thin layer of oxide film is formed on the surface of the metal.

③ The nature of this oxide film decides the prevention of continuation of corrosion of metal as

film may be

① Stable

A stable metal oxide film is made up of fine grained structure. It firmly sticks to the surface of metal. Such a film does not allow access of oxygen to the inner fresh surface of metal, thus further corrosion of metal is prevented. Metals like Al, Cr, Cu, Pb, Sn form stable oxide film.

② Unstable

In case, as soon as metal oxide film is formed it breaks up into original metal and oxygen due to this oxidation corrosion is not possible in such cases. Eg: metals like Ag, Au, Pt do not undergo oxidation corrosion as they form unstable metal oxide film.

③ Volatile

In the case of volatile metal oxide film formation as soon as oxide layer is formed it evaporates eating a part of metal exposing fresh surface of metal for further corrosion. This causes rapid and continuous corrosion leading to severe destruction of metal. Eg: Molybdenum oxide MoO_3 is volatile in nature.

④ Porous

In this case the oxide film formed is always less than total surface of the metal on which it is formed. As a result it tries to cover a larger area and undergoes stress and leads to formation of cracks. Through these pores O_2 enters and attacks fresh metal surface below the film and hence corrosion continues.

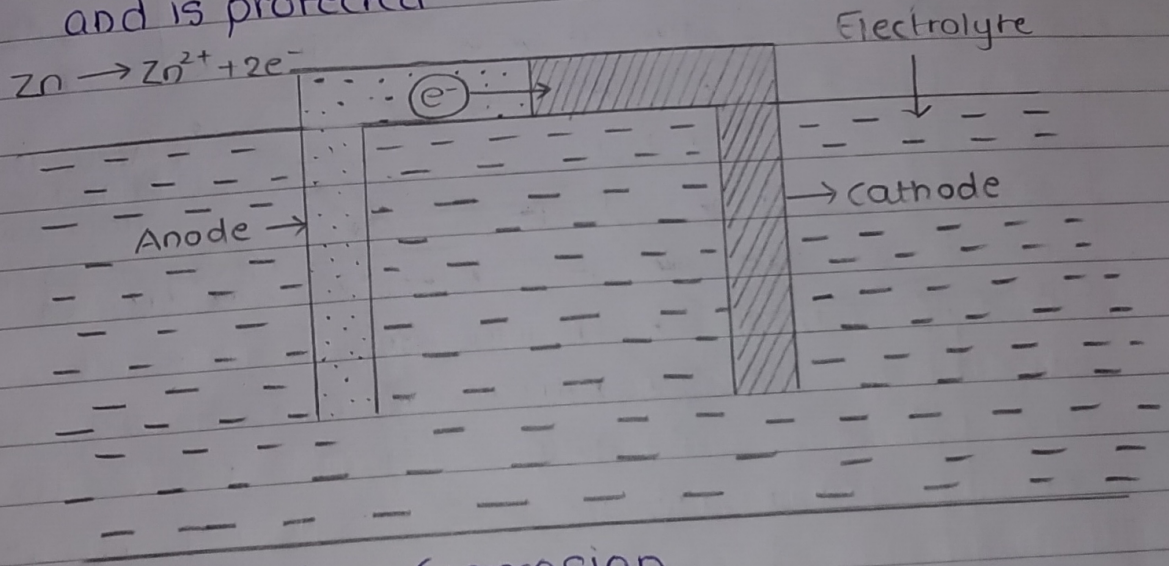
Eg: Metals like Na, K, Li, Be, Mg, etc.

17. Write a short note on Galvanic and Intergranular corrosion

→ Galvanic Corrosion

When two dissimilar metals are electrically connected and exposed to an electrolyte, the metal which is at higher position than other metal in electrochemical series undergoes corrosion. Such type of corrosion is known as galvanic corrosion.

Eg: If Zinc and copper form a galvanic cell then Zn which is higher in electrochemical series form an anode and is attacked where as Cu being lower in electrochemical series acts as cathode and is protected.



Intergranular Corrosion

① It is a form of corrosion where the boundaries of crystallites of the material are more susceptible to corrosion than their insides.

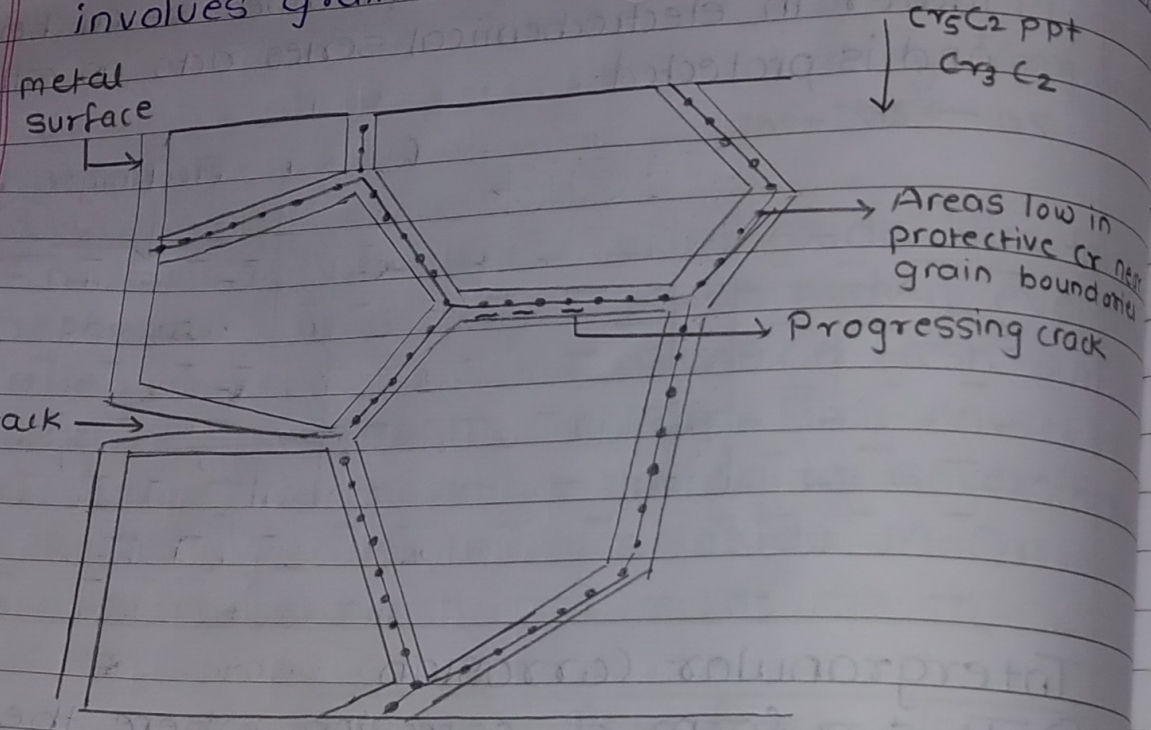
② This situation can happen in otherwise corrosion resistant alloys, when the grain boundaries are depleted, known as grain boundary depletion,

③ In nickel alloys and austeniticstainless steel

where chromium is added for corrosion resistance the mechanism involved is precipitation of chromium carbide at the grain boundaries, resulting in the formation of chromium-depleted zones adjacent to the grain boundaries

④ Around 12% chromium is minimally required to ensure passivation, a mechanism by which an ultra thin invisible film, known as passive film. This passive film protects the metal from corrosive environment.

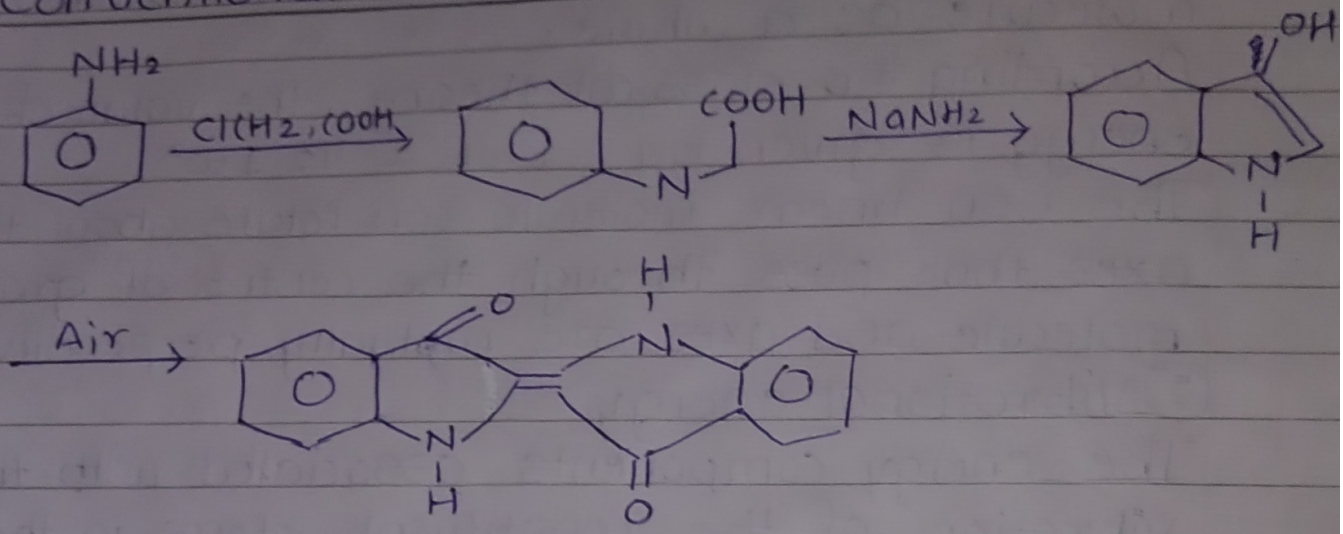
⑤ The self-healing property of the passive film on the steel stainless. Selective leaching often involves grain boundary depletion mechanism



18 Write the conventional and greener route reactio for the synthesis of indigo dye and highlight the green chemistry principle involved

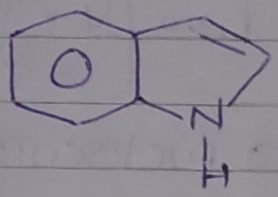
→ Indigo is the dye which is used to colour blu jeans.

Conventional Route:

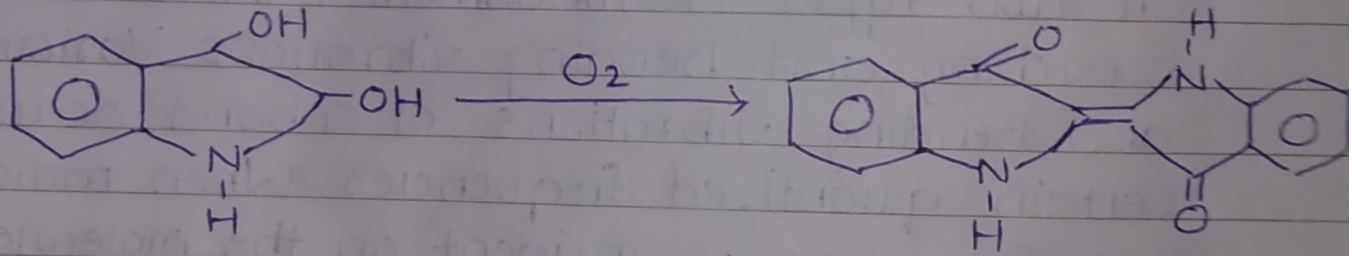


Green Route:

L-tryptophan Tryptophanase



Naphthalene Dioxygenase



Indigo

Green chemistry principle applied in green route are less hazardous chemical synthesis.

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19. Explain the different types of molecular energies. Write an informative note on selection rules in spectroscopy.

→ Following are the types of molecular energies:

① Rotational energy

It is associated with rotational motion of the molecule as a whole.

According to classical theory, the value of rotational energy is given by, $E_{rot} = 1/2\, I\omega^2$.

The non-linear molecule can rotate about the three axes that pass through the centre of gravity of molecule and axes are mutually perpendicular.

② Vibrational energy

The energy components associated with the vibration of the constituent atoms in the molecule is called vibrational energy. The energy of each vibrational level may be expressed as

$$E_{vib} = h\nu_0 \left(V + \frac{1}{2}\right), \text{ for } V = 0, 1, 2, 3\ldots$$

When a molecule is set ~~of~~ into vibration, there are two types of fundamental vibrations; stretching and bending vibrations. Various stretching and bending vibrations of a bond occur at certain quantized frequencies. When radiation of that frequency is incident on the molecule, energy is absorbed and the amplitude of vibration is increased.

③ Electronic Energy

Electronic energy is associated with motion of electrons while considering the nuclei of atoms in molecule as fixed points. The increase in the electronic energy of a molecule is due to the

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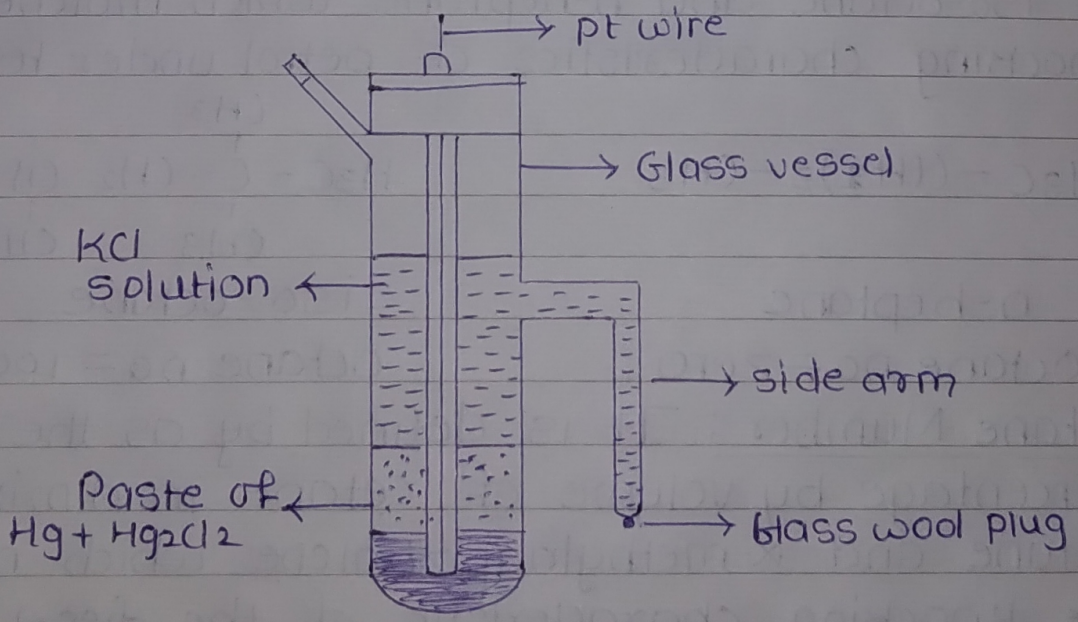
increase in the kinetic and potential energies of the electrons in the molecule.

20. Write a short note on Saturated Calomel electrode

→ ① The Calomel electrode consists of a glass tube having a side arm.
② At the bottom of glass tube, there is a layer of pure mercury and Pt wire is sealed into it at the bottom part for electrical connections
③ The wire runs through a separate glass tube to the top of the tube
④ Just above the Hg, there is paste of mercurous chloride in mercury.
⑤ The rest of the glass tube is filled with saturated KCl solution.
⑥ KCl solution of other concentrations can also be used but then the electrode potential will be different
⑦ Sidearm is plugged with glass wool.



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Electrode reaction:

At cathode, $Hg_2Cl_2 \longrightarrow 2Hg^+ + 2Cl^-$

At anode, $2Hg^+ + 2e^- \longrightarrow 2Hg$

Net reaction, $Hg_2Cl_2 + 2e^- \longrightarrow 2Hg + 2Cl^-$

Advantages:

a) It is easy to setup

b) No need to separate salt bridge as the side arm can be used as salt bridge

Disadvantage

a) The potential of the electrode depends on concentration of KCl

21. Define knocking. Define Octane number and cetane number. Name two anti-knocking agents other than TEL

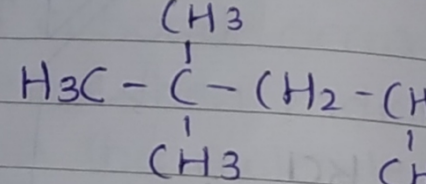
→ A sharp metallic sound produced in the internal combustion engine and results into a loss of energy.

Octane Number: It is defined as the percentage by volume of iso-octane in a mixture of iso-octane and n-heptane which matches the knocking characteristics of petrol under test.

$H_3C-(CH_2)_5-CH_3$

n-heptane

Octane no = zero



iso-octane

Octane no = 100

Cetane Number: It is defined by as the percentage by volume of cetane in a mixture cetane and α-methylnaphthalene which matches the knocking characteristic of the diesel fuel under test.

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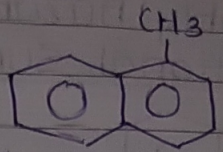
$CH_3-(CH_2)_{14}-CH_3$

cetane

cetane no = 100



α-methylnaphthalene

cetane no = zero

Knocking in Petrol engine

① The combustion of petrol in spark ignition type engine should follow following 4 steps.
   a) Intake of fuel and air mixture
   b) Compression of fuel and air mixture
   c) Combustion of fuel and air mixture by spark provided
   d) Exhaust gases are thrown out of the engine.

② But because of certain reasons, the rate of combustion will not be ~~perform~~ uniform. This causes a sharp metallic sound in the engine, which is called as knocking.

③ The factors that affect knocking are design of engine increased temperature inside this engine lower compression ratio and chemical composition of gasoline.

④ The knocking tendency of fuel depends on nature and structure of hydrocarbon.

Examples of anti-knocking agents other than TEL

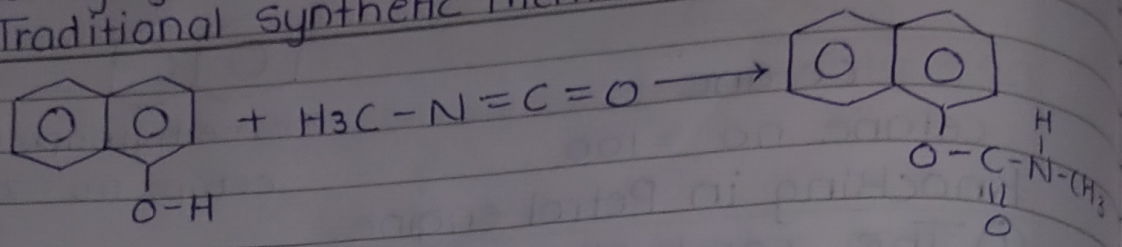
a) methanol
b) iso-octane

22. Write the conventional and greener route reaction for synthesis of Carbaryl and highlight the green chemistry principle involved.

→ The traditional method involves use of 1-naphthol and methylisocyanate as reactants. Methylisocyonate

is highly hazardous.

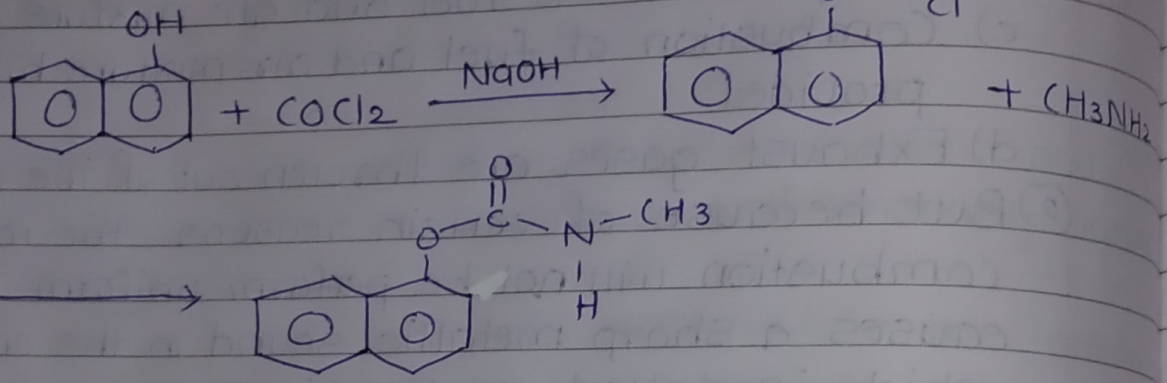
Traditional synthetic method :



1-naphthol

Carbonyl

Green Method



carbonyl

The principle of green chemistry involved in green synthesis is minimize use of hazardous materials.