60004200132
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Div - J1

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ESE - Chemistry-II

Q.1 a) i)

→ Given: $T = 25^\circ C = 298\,K$

$[Zn^{+2}] = 0.1\,M$

$E^\circ_{cell\,Zn} = 0.76\,V$

$E_{cell} = ?$

$R = 8.314\,J/mol\,K$

$F = 96500\,C/mol$

Sol: $Zn^{+2} + 2e^- \longrightarrow Zn$

$$E_{cell} = E^\circ_{cell} - \frac{2.303\,RT}{nF} \log_{10} \frac{[red]}{[oxi]}$$

$$E_{cell} = E^\circ_{cell} - \frac{2.303\,RT}{nF} \log_{10} \frac{[Zn]}{[Zn^{+2}]}$$

$$\therefore E_{cell} = 0.76 - \frac{2.303 \times 8.314 \times 298}{2 \times 96500} \log_{10} \frac{[1]}{[0.1]}$$

$$E_{cell} = 0.76 - 0.0295$$

$$\therefore E_{cell} = 0.7304\,V$$

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Q. 1 (a)

→ ii) The main applications of the electrochemical series:

i) Oxidizing and reducing strengths.
ii) Displacement reactions.
iii) Predicting the liberation of hydrogen gas from acids by metals.
iv) Predicting feasibility of a redox reaction.
v) Calculation of the EMF of the cell.
vi) Comporision of reactivities of metals.

Q. 1 (b)

→ i) Cathodic Protection is nothing but a method use to reverse the flow of current between the two dissimilar metals, under corroding environment thereby reversing the action of the metals in contact. This is achieved by applying the external circuit and forcing the anodic metal to behave as a cathode.
ii) Anodic Protection involves suppression of anodic reaction by adjusting the potential of the more reactive metal i.e. making metal passive in the working environment.
iii) Cathodic protection can be achieved by two different methods as:
(i) By using sacrificial anode method/Auxiliary anode method.
(ii) By using impressed current method.

→ Impressed current:

i) In impressed current method, a current is applied in the opposite direction to that of corrosion current, thereby nullifying the effect of the later one on the base metal i.e. converting the base metal, to cathode from an anode.

ii) In this method, the insoluble anodic metal used is normally embedded underground. To this, with the help of d.c. current source, the impressed current is applied and whole of this assembly is connected to the metallic structure to be protected.

Q.2 a)

Constituents	% by weight	Weight of each / Kg fuel
CO	46	0.46
C_2H_4	1	0.01
N_2	3	Do not contribute
H_2	6	0.06
CO_2	Remaining	Do not contribute
CH_4	8	0.08

Combustion reaction are as follows:

(i) $CO + \frac{1}{2}O_2 \longrightarrow CO_2$

1 vol 0.5 vol

$\therefore$ 0.46 volume of CO requires $\frac{0.46 \times 0.5}{1} = 0.23\ m^3$ of oxygen.

(2) $C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

1 vol 3 vol

$\therefore$ 0.01 volume of C_2H_4 requires $0.01 \times 3 = 0.03\ m^3$ of oxygen.

(3) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

1 vol 2 vol

$\therefore$ 0.08 volume of CH_4 requires $0.08 \times 2 = 0.16\ m^3$ of oxygen.

(4) $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

1 vol 0.5 vol

$\therefore$ 0.06 volume of H_2 requires $0.06 \times 0.5 = 0.03\ m^3$ of oxygen

~~Q 2~~ b) $\therefore$ Total volume of oxygen required $= 0.23 + 0.03 + 0.16 + 0.03$
$= 0.45\ m^3$ of oxygen.

Now for finding volume of air, we know that air contains 21 % of oxygen.

$21\ m^3$ of oxygen is present in $100\ m^3$ of air

$\therefore 0.45\ m^3$ of oxygen will be present in $\frac{0.45 \times 100}{21}$

$= 2.119\ m^3$ of air

$\therefore$ For $5\ m^3$ of fuel volume of air required $= 5 \times 2.119$
$= 10.595\ m^3$ of air.

$\therefore$ Volume of air required for $5\ m^3$ of fuel is $10.595\ m^3$.

Q. 2 b)

→ Ultimate analysis is useful in classification of coal and in combustion calculations, it basically determines the percentage of elements.

Determination of carbon and hydrogen:

A known weight (about 1-2 gm) of air dried coal is taken and is burnt in a combustion apparatus. The apparatus consists of a silica tube which is packed with copper oxide and silver gauze. Silver gauze retains the oxidation products of elements like sulphur and Chlorine present in coal. The sample of coal is burnt in a combustion tube at 800°C in the presence of air, from carbon dioxide and moisture. Carbon and H_2 present in coal gets converted into CO_2 and H_2O respectively.

$$C + O_2 \longrightarrow CO_2$$
$$2H_2 + O_2 \longrightarrow 2H_2O$$

The difference in weights of calcium chloride U-tube and Potassium hydroxide bulb give the amount of H_2O and CO_2.

Calculations:

Let the weight of coal = W g
weight of H_2O = 'a' g
Weight of CO_2 = 'b' g

$$C + O_2 \longrightarrow CO_2$$

12g of carbon $\longrightarrow$ 44g of CO_2

$\therefore$ 'b' g of CO_2 contains = $\frac{12 \times b}{44}$ g of carbon

$\therefore$ 'W' g of coal contains = $\frac{12 \times b}{44}$ g of carbon.

$\therefore$ 100 g of coal contains = $\frac{100}{W} \times \frac{12 \times b}{44}$

$\therefore$ % of Carbon in coal = $\frac{12 \times b \times 100}{44 \times W}$

$2H_2 + O_2 \longrightarrow 2H_2O$

$4g$ of $H_2 \longrightarrow 36$ g of H_2O

$\therefore$ 'W' g of coal contains $= \frac{4 \times a}{36}$ g of hydrogen

$\therefore$ 100 g contains $\frac{4 \times a}{36} \times \frac{100}{w}$

$\therefore$ % of Hydrogen in coal $= \frac{4 \times a \times 100}{36 \times W}$

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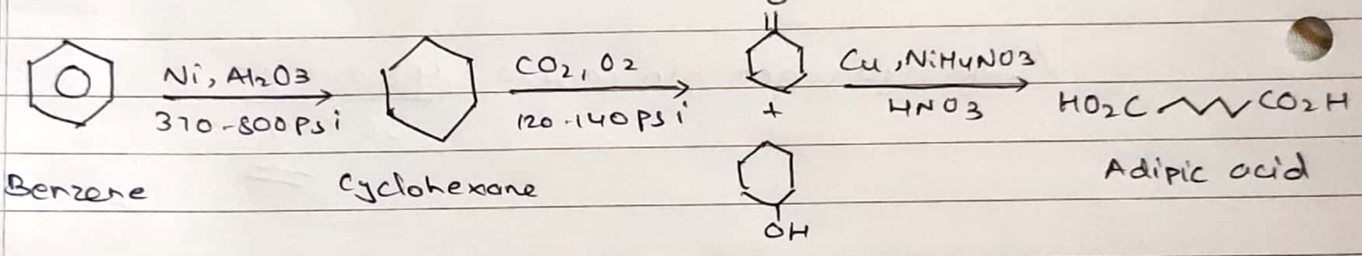
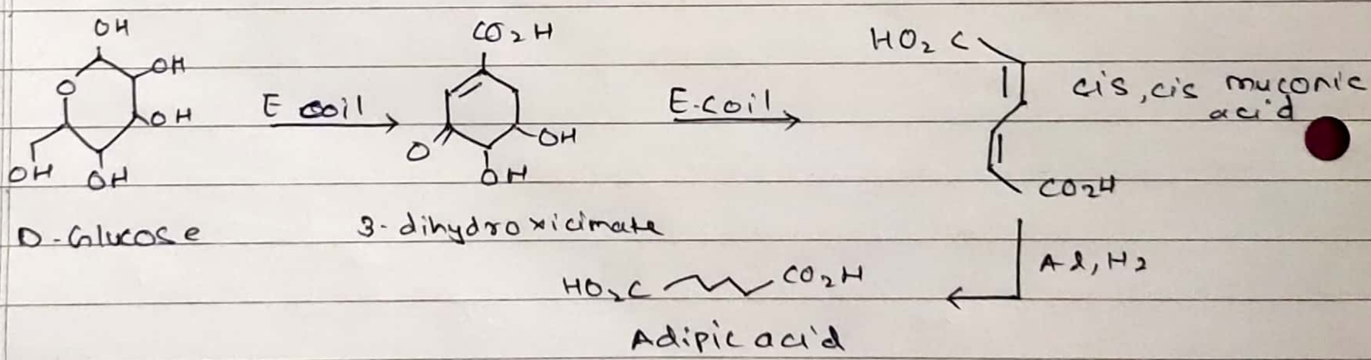
Q. 4 a)

→ i) For the manufacture of adipic acid, catechol and hydroquinone initially the substrate used was benzene which was carcinogenic. The continuse use of benzene affects human health.

2) The traditional synthetic pathway for manufacture of adipic acid is



3) In the new synthetic pathway, traditionally used benzene is substituted by a new substrate glucose. It is non-toxic and safer to use. The alternative grenner pathway is:



4) The green prirciple involved in the above process is use renewable feedstock.

Raw material and feedstock should be renewable ~~forever~~ further than depleting wherever technically and economically possible.

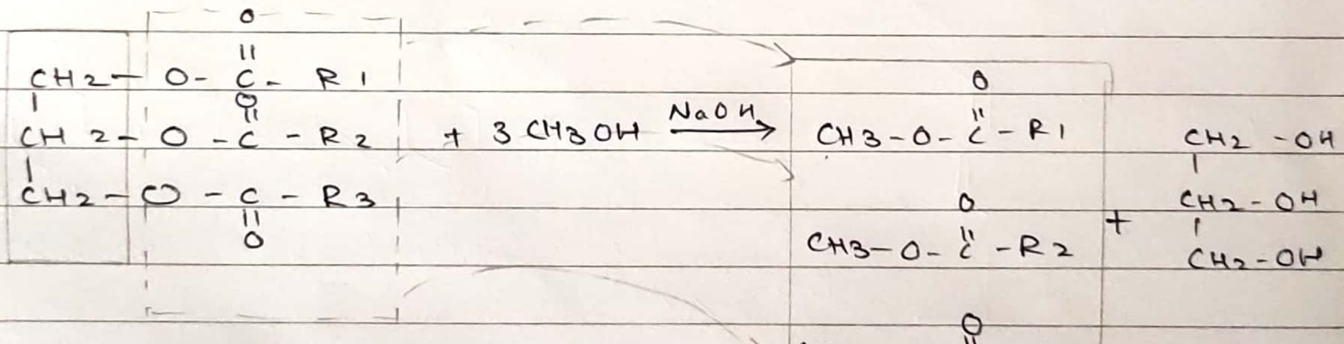
Q. 4 b)

→ i) Transesterification is an organic reaction in which the R group of an alcohol is exchanged with an R group of an ester. This is generally done via the introduction of an acid or base catalyst to the reaction mixture. However, it can also be done using certain enzyme catalyst.

2) <u>Synthesis</u> of <u>Bio diesel</u> :

Biodiesel is derived from vegetable oils which is comprised of 90 - 98 % triglyceride with small quantity of mono and di glyceide, phospholipids, carotene, sulphur compounds, etc.

Tri-glycerides are esters of long chain fatty acids such as eleic acid, laudeic acid, etc.



Triglyceride

glycemin

Mixture of fatty acids

Synthesis of Bio-Diesel.

3) Applications of bio-diesel:

i) Transportation:

- leading application because vehicles require clean, dense, high power fuels in liquid state.
- liquids can be easily pumped and stored.

ii) Power generation

- solid biomass fuel like wood.

iii) Heat

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Q. 5 a)

Octane Number	Cetane Number
1) Octane value is an arbitrary scale which expresses the knocking characteristics of a petrol.	1) The ignition quality of a diesel oil is measured in terms of cetane value.
2) It is defined as the percentage of by volume of iso-octane in a mixture of iso-octane and n-heptane which just matches the knocking characteristics of gasoline under test.	2) It is defined as the percentage by volume of cetane in a mixture of cetane and α-methyl-napthalene which just matches the knocking characteristics of dised oil under test.
3) Oils having least ignition delay are poor gasoline fuels i.e. possesses low octane number.	3) Oils having ignition delay are good diesel fuels ie. possesses high cetane number.
4) The octane number of petrol can be increased by addition of tetraethyl lead or diethyl telluride.	4) It can be increased by addition of additives like ethyl nitrite, ethyl nitrate etc. which are known as accelerators.
5) Petrol containing aromatics have highest octane number.	5) Diesel oils containing n-paraffins have highest cetane number.
6) Oils having high octane number has a low cetane number	6) Oils having high cetane number have a low octane number.

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Q.5 b)

i) Oxidation Corrosion :

This type of corrosion occurs due to attack of atmospheric oxygen on metal surface either at low or high temperature, forming metal oxide as

Metal + O_2 ⟶ Metal Oxide.

Normally, more active metals gets corroded faster than less active metals. For example, alkali metals and alkaline earth metals get oxidized at low temperature as compared to other metals.

2) Alluminum oxidation is a central path of its corrosion resistance. Alluminium has a very high affinity towards oxygen. When a new alluminium surface is exposed in the presence of air or any other oxidizing agent, it quickly develops a thin, hard film of aluminium oxide. The corrosion resistance of alluminum relies on the inactivity of this surface film. Hence, pure alluminum metal exhibits good corrosion resistance in atmospheric oxygen.

Q.5 b)

ii) Zinc is better than tin in protecting iron from corrosion because zinc has more affinity to oxygen than tin. When it is coated on iron layer than it reacts with oxygen of air to form a layer of zinc oxide on iron which prevent the further reaction of iron with oxygen, and thus preventing the process of rusting.