Q.P CODE:-10024928

MUMBAI UNIVERSITY CBCGS SEM 2
ENGINEERING CHEMISTRY – ll Dec 2023 SOLUTIONS

Q1. Attempt any Five of the following:

a. Give the principle of cathodic protection? What are the two types of cathodic protection? [5]

Ans:- Cathodic protection is a corrosion control technique used in engineering chemistry to prevent the corrosion of metal structures. The principle is based on the electrochemical reactions that occur when metals corrode in the presence of an electrolyte (usually soil or water). The goal is to shift the metal structure to be protected into a cathodic (reduced) state, thereby preventing its corrosion. The two main types of cathodic protection are:

1. Galvanic Cathodic Protection (GCP): This method utilizes the principle of a galvanic cell, where a more reactive (less noble) metal is coupled with the structure to be protected. The sacrificial anode, typically made of zinc, magnesium, or aluminum, corrodes preferentially instead of the protected metal. As the sacrificial anode corrodes, it releases electrons, providing cathodic protection to the structure.

2.Impressed Current Cathodic Protection (ICCP): In this method, an external power source, often a rectifier, is used to impress a direct current onto the structure to be protected. The external current counteracts the natural corrosion process by forcing the structure to act as the cathode. This external current effectively polarizes the structure and prevents the corrosion reaction from occurring.

b. Define Spectroscopy and Electromagnetic spectrum. [5]

Ans:- Spectroscopy: Spectroscopy is a technique used to study the interaction between matter and electromagnetic radiation. It involves the analysis of the absorption, emission, or scattering of light by matter to obtain information about its composition, structure, and properties. Spectroscopy is widely used in various scientific and engineering fields, including chemistry, physics, and materials science. Different types of spectroscopy techniques, such as infrared spectroscopy, ultraviolet-visible spectroscopy, and nuclear magnetic resonance spectroscopy, provide valuable insights into the characteristics of molecules and materials. Electromagnetic Spectrum: The electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation, extending from the lowest frequencies (long-wavelength radio waves) to the highest frequencies (short-wavelength gamma rays). It encompasses a wide range of electromagnetic waves, including radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. Each region of the spectrum has specific characteristics and interactions with matter. Engineers and scientists use different parts of the

electromagnetic spectrum for various applications, such as communication, imaging, and material analysis.

c. A cell is constructed from Ni / Ni+2 and Cu+2/Cu half cells. Given E0Ni = -0.257 V and E0Cu = 0.337 V. Find out the standard potential of the cell. [5]

Ans:- The standard cell potential (E*cell) can be calculated using the standard reduction potentials of the half-cells. The standard reduction potential (Ered) is related to the standard cell potential by the equation:

$E^{*}_{cell} = E^{*}_{red,cathode} - E^{*}_{red,anode}$.

The half-cell with the higher standard reduction potential acts as the cathode, and the other half-cell acts as the anode. Given the standard reduction potentials:

$E^{*}_{red,Ni^{\circ}} = -0.257\ V$ $E^{*}_{red,Ni^{\circ}} = -0.257V$

$E^{*}_{red,Cu^{\circ}} = 0.337\ V$ $E^{*}_{red,Cu^{\circ}} = 0.337V$

Now, identify the cathode and anode: Cathode (where reduction occurs): Cu^{2+2+} / Cu with $E^{*}_{red,cathode^{\circ}} = 0.337\ V$ Anode (where oxidation occurs): Ni / Ni^{2+2+} with $E^{*}_{red,anode^{\circ}} = -0.257\ V$. Now substitute these values into the formula:

$E^{*}_{cell^{\circ}} = E_{red,cathode^{\circ}} - E_{red,anode^{\circ}}$

$E^{*}_{cell^{\circ}} = 0.337\ V - (-0.257\ V)$

$E^{*}_{cell^{\circ}} = 0.337\ V + 0.257\ V$

$E^{*}_{cell^{\circ}} = 0.594\ V$

Therefore, the standard potential of the cell is 0.594 V

d. How does position of metal in galvanic series affect corrosion. [5]

Ans:- The position of a metal in the galvanic series is directly related to its corrosion susceptibility. Here's how the position of a metal in the galvanic series affects corrosion:

1. Anodic and Cathodic Reactions:

Metals higher in the galvanic series (more active) tend to act as anodes and undergo oxidation reactions. Metals lower in the galvanic series (less active) tend to act as cathodes and undergo reduction reactions.

2. Corrosion of Anodic Metals:

Metals at the top of the galvanic series are more likely to corrode because they have a higher tendency to lose electrons (undergo oxidation). These metals are more easily oxidized and are more susceptible to corrosion when exposed to an electrolyte.

3.Protection of Cathodic Metals:

Metals at the bottom of the galvanic series are less likely to corrode as they have a lower tendency to lose electrons (they are more noble).

These metals often act as cathodes and can provide a form of protection for the anodic metals by accepting electrons and preventing their corrosion.

4.Galvanic Corrosion:

When two dissimilar metals are in contact in the presence of an electrolyte, galvanic corrosion may occur. The metal higher in the galvanic series (anodic metal) corrodes more rapidly, while the metal lower in the series (cathodic metal) may be protected or corrode at a slower rate.

e. Explain 'Prevention of waste' principle in green chemistry. [5]

Ans:- The "Prevention of waste" principle in green chemistry mphasizes the importance of designing chemical processes in a way that minimizes the generation of waste. The goal is to prevent the creation of hazardous substances and reduce the overall environmental impact of chemical processes. The principle encourages the use of efficient and sustainable methods to achieve chemical transformations, with a focus on resource conservation.

1.Source Reduction: Instead of focusing solely on waste treatment or disposal, the "Prevention of waste" principle advocates for designing processes that inherently produce less waste. This involves considering the entire life cycle of a chemical product and minimizing waste at each stage, from raw material extraction to manufacturing, use, and disposal.

2.Atom Economy: Green chemistry encourages high atom economy, meaning that a significant portion of the reactants becomes part of the final product, reducing the generation of by-products.

3.Efficient Catalysis: The use of catalysts is promoted to enhance the efficiency of chemical reactions, allowing them to proceed under milder conditions and reducing the need for excessive reagents.

4.Renewable Feedstocks: Green chemistry encourages the use of renewable raw materials instead of fossil-based resources. By utilizing sustainable feedstocks, chemical processes can be designed to be more environmentally friendly and reduce the overall environmental impact.

f. What are fuels? Give the characteristics of good fuel. [5]

Ans:- Fuels are substances that release energy when undergoing a combustion reaction. They are essential for various applications, such as generating heat, powering engines, and producing electricity. Fuels can be solid, liquid, or gaseous, and they are used in a wide range of industries and everyday activities.

Characteristics of a Good Fuel:

- High Energy Content: A good fuel should have a high calorific value, meaning it can release a large amount of energy per unit mass or volume when burned. This ensures efficiency in energy production.
- Ease of Storage and Transport: Ideal fuels are easy to store and transport. This involves considerations of density, stability, and ease of handling. Liquid and gaseous fuels are often preferred for their ease of transportation.
- Readily Combustible: A good fuel should have a low ignition temperature, allowing it to combust easily. This ensures that energy can be released efficiently when needed.
- Stable and Safe: Fuels should be chemically stable and safe to handle. Stability prevents spontaneous combustion, and safety is crucial in storage, transportation, and usage.
- Availability: An ideal fuel should be readily available in large quantities. Accessibility and abundance contribute to the economic viability of a fuel source.

g. A sample of coal has the following composition by mass: C = 85%, H = 6%, O = 8%, S = 0.5% and Ash = 0.5%. Calculate HCV using Dulong's Formula. [5]

Ans:- Dulong's formula is a rule of thumb used to estimate the Higher Heating Value (HHV) or Higher Calorific Value (HCV) of a fuel based on its elemental composition. The formula is given by:

$$HCV=337C+1442(H-O/8)+93S$$

where: C,H,O And S are the percentages of carbon, hydrogen, oxygen, and sulfur in the fuel, respectively. Let's calculate the HCV for the given sample of coal:

Given:
C=85% H=6% O=8% S=0.5%

$$HCV =337(85)+1442(6-88)+93(0.5)$$

$$HCV=28645+8652-46$$

$$HCV=37350.5$$

Therefore, the Higher Calorific Value (HCV) of the given coal sample, calculated using Dulong's formula, is approximately 37350.5 kJ/ kg.

Q2. a. What is Electrochemical corrosion? Explain Hydrogen evolution mechanism with the help of Diagram. [6]

Ans:- Electrochemical corrosion is a process in which a metal undergoes corrosion due to electrochemical reactions occurring at its surface when it is exposed to an electrolyte (usually a liquid such as water). This process involves both oxidation and

reduction reactions, typically occurring at different locations on the metal surface. In electrochemical corrosion, the metal serves as an anode and a cathode simultaneously. At the anode, metal atoms lose electrons and go into the electrolyte as metal ions (oxidation), while at the cathode, another reaction occurs where reduction takes place, and electrons are consumed.

Hydrogen Evolution Mechanism:

The hydrogen evolution mechanism is a common type of corrosion reaction that can occur during electrochemical corrosion, especially in acidic environments. It involves the reduction of protons (H^+) to produce hydrogen gas (H_2).

Here is a simplified representation of the hydrogen evolution mechanism:

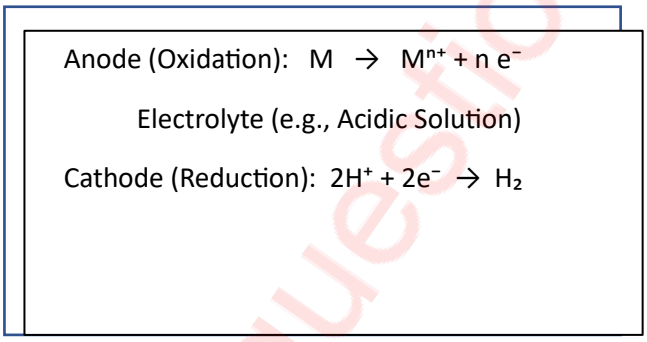
- Anodic Reaction (Oxidation): M→Mn+ne−

  This is the oxidation of the metal (M) at the anode. Metal atoms lose electrons and go into the electrolyte as metal ions (Mn+).

- Cathodic Reaction (Reduction): 2H++2e−→H2
  This is the reduction of protons (H+H+) at the cathode. Protons gain electrons and combine to form hydrogen gas (H2H2).

Overall Reaction: M+2H+→Mn++H2

The overall electrochemical corrosion reaction involves the oxidation of the metal and the reduction of protons, resulting in the production of metal ions and hydrogen gas.



(6) b. Define Green chemistry. Calculate the % atom economy for the following synthesis process of propene [5]

Ans:- Green Chemistry, also known as sustainable chemistry, is an area of chemistry and chemical engineering focused on designing products and processes that minimize the use and generation of hazardous substances. The aim is to reduce the environmental impact of chemical processes, making them more sustainable, economically viable, and safer. Green Chemistry involves the application of principles that promote the efficient use of resources,

the reduction of waste, and the development of environmentally friendly products and technologies.

Atom economy is a measure of the efficiency of a chemical reaction in utilizing the atoms of the reactants to form the desired products. It is calculated using the formula:

Atom Economy= Molecular mass of desired product*100
/Sum of molecular masses of all reactants

For the given synthesis process of propene:

CH3-CH2-CH2-OH+HCl→CH3-CH=CH2+H2O

The reactants are propanol and HCl, and the desired product is propene.

Molecular mass of propanol (C3H8O) = 3×Atomic mass of C+8×Atomic mass of H+ Atomic mass of O3×Atomic mass of C+8×Atomic mass of H+ Atomic mass of O

Molecular mass of HCl (HCl) =
Atomic mass of H+Atomic mass of ClAtomic mass of H+Atomic mass of Cl

Molecular mass of propene (C3H6) =
3×Atomic mass of C+6×Atomic mass of H3×Atomic mass of C+6×Atomic mass of H

Substitute these values into the formula:

Atom Economy

=Molecular mass of propene *100
Molecular mass of propanol + Molecular mass of HCl

Now, calculate the values and find the percentage.

Molecular Masses:

Molecular mass of propanol (C3H8O) = 3×12+8×1+16=60g/mol

Molecular mass of HCl (HCl) = 1+35.5=36.5g/mol

Molecular mass of propene (C3H6) =3×12+6×1=42g/mol

Atom Economy Calculation: Atom Economy=4260+36.5×100

Atom Economy=96.542×100

Atom Economy≈43.56%

Therefore, the atom economy of the synthesis process for propene is approximately 43.56%

c. What is knocking. Explain the role of anti-knocking agents. [4]

Ans:- Knocking, also known as engine knock or detonation, is an undesirable phenomenon in internal combustion engines where the fuel-air mixture in the combustion chamber ignites spontaneously and unpredictably before the normal

ignition event. This uncontrolled ignition can result in a sharp, metallic knocking or pinging sound, and it can lead to engine damage over time. Knocking occurs when the pressure and temperature in the combustion chamber cause the air-fuel mixture to ignite spontaneously, often causing pressure waves that collide and create the characteristic knocking noise.

Anti-knocking agents, also known as knock inhibitors or octane enhancers, are substances added to fuels to reduce or eliminate knocking in internal combustion engines. These agents work by altering the combustion characteristics of the fuel, making it less prone to premature ignition.

The role of anti-knocking agents includes the following:

- Increasing Octane Rating: Anti-knocking agents increase the octane rating of fuels. Higher octane ratings indicate a greater resistance to knocking.
- Cooling Effect: Some anti-knocking agents have a cooling effect on the combustion process, reducing the temperature in the combustion chamber and minimizing the likelihood of premature ignition.
- Improving Combustion Stability: By modifying the combustion characteristics of the fuel, anti-knocking agents contribute to more stable and controlled combustion, preventing the disruptive pressure waves associated with knocking.
- It's important to note that the development and use of anti-knocking agents are influenced by environmental and health considerations, and regulations may restrict or ban certain compounds based on their impact on air quality and human health.

Q3. a. What is oxidation corrosion. Name the different types of oxide layer formed and state which oxide layers are non-protective in nature. Explain with suitable examples. [6]

Ans:- Oxidation corrosion is a type of corrosion that occurs when a metal reacts with oxygen in the presence of moisture, forming metal oxides. This reaction leads to the deterioration of the metal surface, and the extent of corrosion depends on factors such as the type of metal, the environment, and the presence of impurities.

Types of Oxide Layers:

1. Protective Oxide Layers:

Some metal oxides act as protective layers, preventing further corrosion by acting as a barrier between the metal and the corrosive environment.

Examples of metals forming protective oxide layers include:

Aluminum (Al): Forms a thin and transparent layer of aluminum oxide (Al_2O_3) that protects against further corrosion.

Chromium (Cr): Forms a protective layer of chromium oxide (Cr_2O_3) on stainless steel, enhancing corrosion resistance.

2. Non-Protective Oxide Layers:

Some oxide layers are porous, easily cracked, or water-permeable, providing little or no protection to the underlying metal. This leads to continued corrosion and degradation.

Examples of metals forming non-protective oxide layers include:

Iron (Fe): Forms rust, primarily iron oxide (Fe_2O_3 or Fe_3O_4), which is porous and allows water and oxygen to reach the underlying metal. Rust is an example of a non-protective oxide layer.

Zinc (Zn): Forms a white and powdery layer of zinc oxide (ZnO) that may not effectively protect the metal underneath.

Explanation with Examples:

1. Protective Oxide Layer Example - Aluminum:

Aluminum reacts with oxygen to form aluminum oxide (Al_2O_3), a protective layer.

- $4Al+3O_2 \rightarrow 2Al_2O_3$

The aluminum oxide layer is adherent, transparent, and provides a protective barrier against further corrosion.

2. Non-Protective Oxide Layer Example - Iron (Rust):

Iron reacts with oxygen and moisture to form rust, primarily iron oxide (Fe_2O_3 or Fe_3O_4).

- $4Fe+3O_2+6H_2O \rightarrow 4Fe(OH)_3$

Rust is a non-protective oxide layer because it is porous, allowing water and oxygen to reach the underlying iron, leading to continued corrosion.

It's crucial to understand the nature of the oxide layers formed, as protective layers contribute to the longevity and corrosion resistance of metals, while non-protective layers accelerate corrosion and degradation.

b. 3.2 gm of coal in Kjeldahl's experiment evolved NH_3 gas was absorbed in 40 ml of 0.5 N H_2SO_4. After absorption the excess acid required 16 ml of 0.5N NaOH for complete neutralization. 2.5 gmsof coal sample in quantitative analysis gave 0.42 gm $BaSO_4$. Calculate the % N and S. [5]

Ans:- The given information includes the weights of coal, the volume and concentration of the acid used, and the volume and concentration of the base used for titration.

Let's break down the steps to calculate the percentage of nitrogen (% N) and sulfur (% S) in the coal sample:

1. Calculation of % Nitrogen (% N):

Equivalent weight of NH_3=
Number of moles of electrons exchanged in the reaction/Molecular weight of NH_3

Number of moles of NH_3=Volume of H_2SO_4 used/1000 ×Normality of H_2SO_4

Volume of H_2SO_4 used=Total volume of H_2SO_4−Volume of NaOH used

Molecular weight of NH_3=17 g/mol

Number of moles of electrons exchanged in the reaction=6

Normality of H_2SO_4=0.5 N

Total volume of H_2SO_4=40 ml

Volume of NaOH used=16 ml

Weight of coal sample=3.2 g

Calculate the weight of nitrogen in the coal sample:

Weight of nitrogen=Equivalent weight of NH_3×Volume of NaOH used×1000Weight of coal sample

Weight of nitrogen=Equivalent weight of NH_3×Volume of NaOH used×Weight of coal sample1000

Weight of nitrogen=2.83×16×10003.2=355.625 mg Weight of nitrogen=2.83×16×3.21000 =355.625mg

%N=Weight of coal sample /Weight of nitrogen ×100
%N=355.625/3200×100=11.114%%

2.Calculation of % Sulfur (% S):

Equivalent weight of $BaSO_4$=Number of moles of electrons exchanged in the reactio n/ Molecular weight of $BaSO_4$

Number of moles of electrons exchanged in the reaction=8

Molecular weight of $BaSO_4$=Molecular weight of Ba+2(Molecular weight of S)+4(Mol ecular weight of O)

Molecular weight of Ba=137.33 g/mol

Molecular weight of S=32.07 g/mol

Molecular weight of O=16 g/mol

Weight of $BaSO_4$=0.42 g

Weight of coal sample=2.5 g

Calculate the weight of sulfur in the coal sample:

Weight of sulfur=Equivalent weight of $BaSO_4$×Weight of $BaSO_4$×1000/Weight of coal sample

Weight of sulfur=29.18375×0.42×2.51000 =4674.84mg

Calculate the percentage of sulfur:

%S=Weight of sulfur/Weight of coal sample×100

%S=4674.84/2500×100=186.9936%

%S=25004674.84 ×100=186.9936%

c. What is Electrochemistry? Differentiate between Electrolytic cell and Galvanic cell. [4]

Ans:- Electrochemistry:

Electrochemistry is a branch of chemistry that deals with the study of the relationship between electrical energy and chemical reactions. It involves the conversion of chemical energy into electrical energy (as in batteries or galvanic cells) and vice versa (as in electrolysis). Electrochemical processes occur at the interface between an electrode and an electrolyte, which is a medium that allows ions to move.

Differentiation between Electrolytic Cell and Galvanic Cell:

1. Nature of the Cell:
- Galvanic Cell: Also known as a voltaic cell or a primary cell, a galvanic cell spontaneously converts chemical energy into electrical energy. It produces an electric current as a result of spontaneous redox reactions.
- Electrolytic Cell: An electrolytic cell requires an external source of electrical energy to drive a non-spontaneous chemical reaction. It converts electrical energy into chemical energy.
2. Energy Change:
- Galvanic Cell: The overall reaction is exothermic, releasing energy. It has a negative standard cell potential (E◦), and the electrons flow from the anode to the cathode.
- Electrolytic Cell: The overall reaction is endothermic, requiring an external source of electrical energy. It has a positive standard cell potential (E◦), and the electrons flow from the cathode to the anode.
3. Spontaneity:
- Galvanic Cell: Spontaneous redox reactions occur without the need for an external electrical source. The cell generates electrical energy as a result of the spontaneous reaction.
- Electrolytic Cell: Non-spontaneous reactions are driven by an external electrical source. Electrical energy is used to force a chemical change that would not occur spontaneously.
4. Electrode Polarity:

- Galvanic Cell: The anode is negative, and the cathode is positive. Electrons flow from the anode to the cathode in the external circuit.
- Electrolytic Cell: The anode is positive, and the cathode is negative. Electrons flow from the cathode to the anode in the external circuit.

5. Cell Potential:
- Galvanic Cell: Has a positive cell potential (E∘) due to the spontaneous nature of the redox reaction.
- Electrolytic Cell: Has a negative cell potential (E∘) because the reaction is non-spontaneous.

6. Applications:
- Galvanic Cell: Commonly used in batteries to provide electrical power for portable devices.
- Electrolytic Cell: Used in processes such as electroplating, electrolysis for metal extraction, and various industrial applications.

Q.4]

a. Calculate the weight of air required for complete combustion of 1Kg coal containing C=65%, H=4%, O=5%, S=2%, N=4%, moisture=10% and remaining ash. [6]

Ans:- To calculate the weight of air required for the complete combustion of 1 kg of coal, we need to consider the stoichiometry of the combustion reaction and the composition of the coal. The combustion of coal involves the reaction with oxygen in the air to produce carbon dioxide (CO_2), water (H_2O), sulfur dioxide (SO_2), and nitrogen oxides (NO_x). The balanced reaction for the combustion of carbon (C) is as follows:

$2C+O_2 \rightarrow CO_2$

To calculate the weight of air required, we need to determine the moles of each element in the coal and the stoichiometric coefficients in the combustion reaction.

Given composition of coal (per kg):

Carbon (C): 65%

Hydrogen (H): 4%

Oxygen (O): 5%

Sulfur (S): 2%

Nitrogen (N): 4%

Moisture: 10% (water content)

Calculate the weight of each element in 1 kg of coal:

Weight of C=0.65kg Weight of H=0.04 kg
Weight of O=0.05kg Weight of S=0.02 kg
Weight of N=0.04 kg Weight of moisture=0.1 kg

- Step 1: Calculation of Combustion Stoichiometry:

Moles of each element in 1 kg of coal:

Carbon (C): 65121265 = 5.42 moles

Hydrogen (H): 4114 = 4 moles

Oxygen (O): 516165 = 0.3125 moles

Sulfur (S): 232322 = 0.0625 moles

Nitrogen (N): 428284 = 0.1429 moles

Moles of oxygen required for combustion:

From carbon: 5.42×2=10.845.42×2=10.84 moles

From hydrogen: 4×12=24×21 =2 moles

From sulfur: 0.0625×2=0.1250.0625×2=0.125 moles

Total moles of oxygen required: 10.84+2+0.125=12.965

Total moles of air required (assuming 21% oxygen in air):

Moles of oxygen in air = 21% of total moles of air

Moles of air = 12.965/0.21=61.785 moles

- Step 2: Calculation of Weight of Air:

Molar mass of air (approximately): 28.97 g/mol

Weight of air required = 61.785×28.97=1787.4561.785×28.97=1787.45 grams

Therefore, the weight of air required for complete combustion of 1 kg of coal is approx.

B. Give conventional and green chemistry route of production of Indigo. Highlight the green chemistry principles in this case. [5]

Ans:- Conventional Route for Indigo Production:

The conventional method for producing indigo involves a series of chemical reactions that utilize various reagents and generate by-products. The key steps in

the conventional synthesis include the synthesis of phenylglycine, its oxidation to isatin, and the subsequent conversion of isatin to indigo. The overall process typically involves the use of hazardous chemicals and may generate waste products.

Green Chemistry Route for Indigo Production:

A more environmentally friendly and sustainable approach to indigo production aligns with the principles of green chemistry. The green synthesis of indigo aims to minimize the use of hazardous chemicals, reduce waste, and improve the overall environmental impact of the process. Here are some aspects of a potential green chemistry route for indigo production:

- Renewable Feedstocks:

Utilizing renewable and sustainable feedstocks as starting materials. For example, using bio-based starting materials derived from plant sources.

- Catalysis:

Incorporating catalytic processes to enhance reaction efficiency and selectivity. Green catalysts, such as enzymes or benign metal catalysts, can be employed to minimize the need for harsh and toxic reagents.

- Solvent Selection:

Choosing environmentally benign solvents, such as water or bio-based solvents, to replace traditional organic solvents. This reduces the environmental impact associated with solvent use.

- Energy Efficiency:

Implementing energy-efficient processes to reduce the overall energy consumption during synthesis. Utilizing microwave or ultrasound-assisted reactions, for instance, can lead to faster reactions and lower energy requirements.

- Waste Minimization:

Designing the synthesis to minimize the generation of by-products and waste. This involves optimizing reaction conditions to maximize product yield and reduce the formation of unwanted side products.

c. How is the rate of corrosion influenced by: (i) pH of the medium (ii) Relative areas of cathode and anode parts. [4]

Ans:- Rate of Corrosion and its Influencing Factors:

The rate of corrosion, the process by which metals degrade due to chemical reactions with their environment, is influenced by several factors. Two key factors that significantly impact the rate of corrosion are the pH of the medium and the relative areas of the cathode and anode parts.

1. pH of the Medium:

- Effect on Corrosion:
- The pH of the corrosive environment plays a crucial role in determining the rate of corrosion.
- In an aqueous environment, the presence of hydrogen ions (H+) can accelerate the corrosion process, especially for metals like iron.
- Low pH (acidic conditions) can lead to more aggressive corrosion, as it enhances the dissolution of metal ions from the anode.
- High pH (alkaline conditions) can also influence corrosion, particularly for metals susceptible to alkaline attack.

2. Relative Areas of Cathode and Anode Parts:

- Effect on Corrosion:
- The relative areas of the cathode and anode parts affect the corrosion rate according to the Galvanic Series. The Galvanic Series is a list of metals arranged in order of their corrosion potentials.
- When two dissimilar metals are in contact, the metal with a higher position in the Galvanic Series becomes the cathode, and the one with a lower position becomes the anode. The anode corrodes more rapidly than it would on its own.
- Larger cathode area and smaller anode area lead to a higher rate of corrosion. Conversely, a larger anode area and smaller cathode area result in reduced corrosion.

In both cases, understanding and controlling these factors are essential for preventing or minimizing corrosion. Strategies such as proper material selection, use of corrosion inhibitors, and environmental monitoring can be employed to address corrosion issues and align with principles of green and sustainable chemistry.

Q.5 A. Give in tabular form the relation between electromagnetic spectrum, types of spectroscopy and corresponding energy changes. [6]

Ans:-

Here's a tabular representation of the relation between the electromagnetic spectrum, types of spectroscopy, and corresponding energy changes:

Electromagnetic Spectrum	Types of Spectroscopy	Corresponding Energy Changes
Radio Waves	Radiofrequency Spectroscopy	Low energy transitions
Microwaves	Microwave Spectroscopy	Rotational transitions
Infrared	Infrared Spectroscopy	Vibrational transitions
Visible and UV	UV-Visible Spectroscopy	Electronic transitions
X-rays	X-ray Spectroscopy	Inner-shell electronic transitions
Gamma Rays	Gamma-ray Spectroscopy	Nuclear transitions (nuclear energy levels)

Each region of the electromagnetic spectrum corresponds to different types of spectroscopy, and the energy changes associated with these spectroscopies are

related to the transitions that occur within the molecules or atoms being studied. The transitions can involve changes in rotational energy, vibrational energy, electronic energy, or nuclear energy levels, depending on the specific type of spectroscopy and the region of the spectrum.

b. Explain trans-esterification method for synthesis of bio- diesel. Mention advantages of Bio-diesel. [5]

Ans:- Transesterification is a chemical process used for the synthesis of biodiesel from triglycerides (fats and oils) and alcohol. The reaction involves the replacement of the glycerol moiety in triglycerides with alcohol, typically methanol or ethanol, to form biodiesel (fatty acid methyl or ethyl esters) and glycerol as a by-product. The reaction is catalyzed by a base or an acid.

The general transesterification reaction is represented as follows:

Triglyceride+Alcohol→Catalyst Biodiesel+Glycerol

The biodiesel produced through transesterification has properties similar to those of conventional diesel fuel and can be used in existing diesel engines without modification.

Advantages of Biodiesel:

- Renewable Source:

Biodiesel is derived from renewable resources such as vegetable oils, animal fats, or algae. This contrasts with fossil diesel, which is derived from finite and non-renewable fossil fuels.

- Reduced Greenhouse Gas Emissions:

Biodiesel generally has lower greenhouse gas emissions compared to conventional diesel. The carbon dioxide released during biodiesel combustion is offset by the carbon dioxide absorbed during the growth of the biodiesel feedstock.

- Biodegradability:

Biodiesel is more biodegradable than traditional diesel fuel, which can reduce environmental impact in case of spills or leaks.

- Domestic Production:

Biodiesel can be produced locally, reducing dependence on imported fossil fuels and enhancing energy security.

- Compatibility with Existing Infrastructure:

Biodiesel can be used in existing diesel engines and infrastructure without major modifications. It can be blended with conventional diesel in various proportions.

C .What are metallic coatings? Distinguish between galvanizing and tinning. [4]

Ans:- Metallic coatings involve the application of a layer of metal onto the surface of another material for various purposes, such as corrosion protection, aesthetics, conductivity, or improved mechanical properties. These coatings are typically applied through processes like electroplating, hot-dipping, cladding, or other deposition methods.
Two common metallic coatings are galvanizing and tinning:

Galvanizing:

Process: Galvanizing is a process in which a layer of zinc is applied to the surface of iron or steel to protect it from corrosion. It can be achieved through either hot-dip galvanizing or electro-galvanizing.

Tinning:

Process: Tinning is a process in which a thin layer of tin is applied to the surface of a metal, typically copper or steel. It is commonly done through hot-dipping or electroplating.

Distinguishing Between Galvanizing and Tinning:

1.Base Metal:

- Galvanizing: Typically applied to iron or steel.
- Tinning: Applied to various metals, with common applications on copper and steel.

2.Coating Metal:

- Galvanizing: Involves coating with zinc.
- Tinning: Involves coating with tin.

3.Process:

- Galvanizing: Can be achieved through hot-dip galvanizing or electro-galvanizing.
- Tinning: Can be done through hot-dip tinning or electroplating.

4.Purpose:

- Galvanizing: Primarily for corrosion protection by providing a sacrificial layer.
- Tinning: For corrosion resistance, improved solderability, and appearance.

5.Applications:

- Galvanizing: Commonly used in construction, outdoor structures, automotive parts, etc.
- Tinning: Used in tinplate production, kitchenware, electronic components, and food packaging.

Q.6 a. What are reference electrodes? Give construction and working of any one secondary reference electrode. [6]

Ans:-

Reference electrodes are electrodes with a known and stable electrochemical potential used as a reference point in electrochemical measurements. They provide a stable potential against which the potential of other electrodes can be measured. Reference electrodes are crucial in various electrochemical applications, including corrosion studies, electroanalytical chemistry, and cell potential measurements.

One example of a secondary reference electrode is the Saturated Calomel Electrode (SCE).

Working of the SCE:

The construction and working of the SCE involve the following steps:

1.Formation of Ag/AgCl Electrode:

- The silver wire coated with silver chloride (AgCl) acts as the working electrode. It forms a reversible half-cell by establishing equilibrium with the silver-silver chloride (Ag/AgCl) couple.

2.Formation of Calomel Electrode:

- The silver-silver chloride electrode is connected to the mercury(I) chloride (calomel) electrode. The junction between the Ag/AgCl and calomel electrodes is immersed in the KCl solution.

3.Electrochemical Equilibrium:

- The Ag/AgCl electrode and the calomel electrode reach electrochemical equilibrium in the saturated KCl solution. The potential of the Ag/AgCl electrode is stabilized by the formation of a stable chloride layer on its surface.

4.Stable Potential:

- The presence of mercury(I) chloride helps maintain a stable and known potential for the reference electrode. The potential of the SCE is well-defined and remains constant under standard conditions.

5.Reference for Electrochemical Measurements:

- The SCE provides a stable reference potential against which the potential of other electrodes can be measured.

B. What is meant by knocking in internal combustion engine? Define octane number and name any two anti-knock agents. [5]

Ans:- Knocking in Internal Combustion Engine: Knocking (also known as detonation or engine knock) in an internal combustion engine refers to the undesirable phenomenon where the air-fuel mixture ignites spontaneously or prematurely in the combustion chamber, causing a sharp and uncontrolled increase in pressure. This rapid pressure rise can result in a distinctive knocking or pinging sound. Knocking can lead to engine damage and reduced efficiency.
Octane Number: The octane number is a measure of a fuel's resistance to knocking in a spark-ignition internal combustion engine. It indicates the ability of a fuel to withstand premature ignition and resist knocking during combustion. The octane number is crucial for assessing the performance and safety of gasoline (petrol) used in automotive engines.

There are two types of octane numbers:

- **Research Octane Number (RON):**

The Research Octane Number is determined under mild operating conditions in a laboratory setting. It represents the fuel's ability to resist knocking during low-speed, part-throttle driving conditions.

- **Motor Octane Number (MON):**

The Motor Octane Number is determined under more severe conditions, including higher speeds and higher temperatures. It reflects the fuel's resistance to knocking under high-speed, high-load conditions.

Anti-knock agents, also known as anti-knock additives, are substances added to gasoline to improve its octane rating and reduce the likelihood of knocking. Two common anti-knock agents are:

1. Tetraethyl Lead (TEL):

Tetraethyl lead was historically one of the most widely used anti-knock agents. It effectively increased the octane rating of gasoline and reduced knocking. However, due to environmental and health concerns associated with lead emissions, the use of TEL in gasoline has been largely phased out.

2. Methyl Tertiary Butyl Ether (MTBE):

MTBE is an oxygenate that was added to gasoline to increase its octane number and enhance combustion efficiency. It contains oxygen, which promotes more complete combustion. However, MTBE faced environmental concerns due to its potential groundwater contamination, and its use has decreased in recent years.

C. What are selection rules? Explain any two selection rules. [4]

Ans:- Selection Rules in Spectroscopy:

Selection rules are conditions or criteria that dictate whether a particular transition between quantum states is allowed or forbidden. These rules are fundamental in

quantum mechanics and help determine the probability of transitions between energy levels in atoms or molecules. Two commonly discussed selection rules are the $\Delta l = \pm 1$ rule and the $\Delta m = 0, \pm 1$ rule:

1. **$\Delta l = \pm 1$ Rule:**

This selection rule pertains to transitions in angular momentum quantum number (l). It states that a change in the azimuthal quantum number (l) between initial and final states must be $\Delta l = \pm 1$ for the transition to be allowed.
For example, if an electron is transitioning from an initial state with $l = 1$ to a final state with $l = 2$, or vice versa, the transition is allowed. However, a transition from $l = 1$ to $l = 3$ is forbidden.

2. **$\Delta m = 0, \pm 1$ Rule:**

This selection rule is associated with transitions in the magnetic quantum number (m).
It states that the change in the magnetic quantum number (m) between the initial and final states must be $\Delta m = 0, \pm 1$ for the transition to be allowed.
The magnetic quantum number describes the orientation of the orbital in space. For example, if an electron is in an orbital with $m = 0$, it can transition to an orbital with $m = -1, 0$, or 1, but not to $m = \pm 2$.
These selection rules are essential in understanding the allowed transitions in the emission or absorption of electromagnetic radiation (such as light) by atoms. They help predict and explain the spectral lines observed in atomic and molecular spectra, providing valuable insights into the behavior of particles at the quantum level.