SELECTED TOPICS IN CHEMISTRY

SECTION - A

1. **Which of the following is the branch of science that deals with the study of crystals?**
   - a) Crystallography
2. **The synthetic equivalent of given synthon is C=O**
   - c) t- butyl cyanate
3. **Which of the following cell organelles does not contain DNA?**
   - b) Lysosomes
4. **What is Zeiler natta catalyst**
   - b) $TiCl_2$
5. **What is the symbol of beta particle**
   - b) $_{-1}\beta^{0}$
6. **The smallest repeating unit in a crystal lattice is __________.**
   - Unit cell
7. **In retrosynthesis, Synthons are_______.**
   - Retrosynthons
8. **The monomer of starch is__________.**
   - Glucose
9. **What is the formula for Viscosity method for weight determination of polymer?**
   - $[\eta] = K * M^{\alpha}$
10. **Small particles are combined together to form a bigger molecule is the _________ reaction.**
11. **What is lattice energy?**
    - Lattice energy is the energy required to completely separate one mole of a solid ionic compound into its ions in the gaseous state. It represents the strength of the ionic bonds within a crystal lattice.
12. **Explain synthons and synthetic equivalent.**
    - Synthons are hypothetical building blocks or fragments used in retrosynthetic analysis to plan the synthesis of complex molecules. Synthetic equivalents are real chemical compounds that can serve as substitutes for these hypothetical fragments during the actual synthesis.
13. **What is meant by CFT?**
    - CFT stands for Crystal Field Theory, which is a model used to explain the electronic structure and bonding in transition metal complexes. It focuses on the interaction between the metal's d orbitals and the ligands in the complex, influencing the coordination geometry and magnetic properties.

14. **Short notes on the importance of polymer.**
    - Polymers play a crucial role in various aspects of our daily lives. They are used in industries for manufacturing plastics, rubber, fibers, and adhesives. Additionally, polymers have applications in medicine, electronics, and packaging, contributing to advancements in technology and enhancing the quality of life.
15. **Explain the pick-up nuclear reaction?**
    - A pick-up nuclear reaction involves a projectile nucleus capturing one or more nucleons (protons or neutrons) from a target nucleus. This process results in the formation of a new nucleus with a different atomic number and mass. Pick-up reactions are common in nuclear physics studies and have applications in understanding nuclear structure and reactions.

SECTION B

ANSWER OF 16. (a) Discuss the element of symmetries.

Symmetry in chemistry plays a crucial role in understanding molecular structures, properties, and reactions. Symmetry elements are features that, when applied to a molecule, leave it unchanged. The main elements of symmetry include:

1. **Rotation Axis (C):** An axis around which the molecule can be rotated and still appear identical.
2. **Mirror Plane (σ):** A plane that reflects the molecule into an identical arrangement on the other side.
3. **Center of Inversion (i):** A point where inversion through the center results in an identical molecule.
4. **Improper Rotation (S):** A rotation followed by reflection in a perpendicular plane.

Understanding these elements helps classify molecules into point groups, aiding in the analysis of molecular vibrations, electronic transitions, and overall symmetry properties.

ANSWER OF OR PART 16. (b) Briefly discuss the difference between point group and space group.

- **Point Group:**
    - Concerned with the symmetry of a molecule or an object without considering its translational symmetry.
    - Focuses on internal arrangement and symmetry elements, such as rotation axes, mirror planes, and inversion centers.
    - Used in molecular chemistry to analyze molecular shapes and predict spectroscopic properties.
    - Examples include C2v, D3h, and Oh.
- **Space Group:**
    - Considers both the internal and translational symmetry of a crystal lattice or solid-state structure.
    - Describes the arrangement of repeating units in three-dimensional space.
    - Used in crystallography to define the symmetry of crystals and predict their X-ray diffraction patterns.
    - Examples include P21/c, Fm-3m, and P63/mmc.

ANSWER OF 17. (a) Explain the one-group disconnection of alcohol and olefins.

One-group disconnection in retrosynthetic analysis involves breaking a complex molecule into simpler fragments by disconnecting one functional group. Here's a detailed explanation for alcohol and olefins:

- **Disconnection of Alcohol (R-OH):**
  1. Identify the C-O bond in the alcohol functional group.
  2. Disconnect this bond to generate two simpler fragments: a carbonyl compound (C=O) and a hydroxyl group (OH).

  $$R - OH \xrightarrow{\text{One-group disconnection}} R = O + OH$$

  This simplifies the retrosynthetic analysis, providing key fragments for the synthesis plan.
- **Disconnection of Olefins (R-CH=CH-R'):**
  1. Identify the C=C double bond in the olefin functional group.
  2. Disconnect this bond to produce two carbonyl compounds (R-C=O and R'-C=O).

  $$R - CH = CH - R' \xrightarrow{\text{One-group disconnection}} R - C = O + R' - C = O$$

  Breaking the C=C bond in olefins simplifies the retrosynthetic pathway by generating carbonyl groups as potential starting materials.

This strategic disconnection approach aids in planning the synthesis of complex molecules by simplifying them into recognizable and readily available fragments.

OR

ANSWER OF 17. (b) Discuss the various types of electron donor and acceptor in retro synthesis.

In retrosynthesis, the identification of electron donors and acceptors is crucial for understanding the reactivity and transformation of functional groups. Here are various types of electron donors and acceptors:

- **Electron Donors:**
  1. **Nucleophiles:** Species with electron-rich centers, such as lone pairs or π-electron systems. Common nucleophiles include amines, alkoxides, and organometallic compounds.
  2. **Radicals:** Species with unpaired electrons. Radicals can act as electron donors in certain reactions, participating in radical chain reactions.
- **Electron Acceptors:**
  1. **Electrophiles:** Species with electron-deficient centers, such as positively charged atoms or groups. Common electrophiles include carbocations, carbonyl compounds, and positively charged heteroatoms.
  2. **Lewis Acids:** Compounds capable of accepting electron pairs. These include metal ions and electron-deficient organic molecules.

ANSWER OF 18 (a) Explain the structure of DNA

DNA (Deoxyribonucleic Acid) is a macromolecule that carries genetic information in living organisms. Its structure is composed of several key features:

1. **Double Helix:** DNA has a double-helix structure, which resembles a spiral staircase. This helical arrangement is formed by two long chains of nucleotides coiled around each other.
2. **Nucleotides:** The basic building blocks of DNA are nucleotides. Each nucleotide consists of three components:

- **Deoxyribose Sugar:** A five-carbon sugar that forms the backbone of the DNA strand.
- **Phosphate Group:** A phosphate molecule that links adjacent sugars and provides a negative charge to the backbone.
- **Nitrogenous Base:** Adenine (A), Thymine (T), Guanine (G), and Cytosine (C) are the four nitrogenous bases that pair up in specific combinations (A-T and G-C) through hydrogen bonds.

3. **Complementary Base Pairing:** The nitrogenous bases pair up in a complementary manner. Adenine always pairs with Thymine, forming two hydrogen bonds, while Guanine always pairs with Cytosine, forming three hydrogen bonds. This base pairing specificity ensures the accurate transmission of genetic information during cell division.
4. **Antiparallel Arrangement:** The two strands of DNA run in opposite directions. One strand has a 5' (prime) to 3' orientation, while the other has a 3' to 5' orientation. This antiparallel arrangement is crucial for DNA replication and transcription.
5. **Major and Minor Grooves:** The helical structure of DNA results in grooves along the axis. The major and minor grooves provide access for enzymes and other proteins involved in various cellular processes, such as replication and transcription.
6. **Genetic Code:** The sequence of nucleotide bases along the DNA strand constitutes the genetic code. This code is transcribed into RNA and translated into proteins, determining the characteristics of an organism.

Understanding the structure of DNA is fundamental to comprehending the mechanisms of genetic inheritance and the functioning of living organisms.

OR

ANSWER OF 18. (b) How do you determine C-terminal and N-terminal of proteins?

The C-terminal (carboxy-terminal) and N-terminal (amino-terminal) ends of a protein are crucial in defining its structure and function. Several methods can be employed to determine these terminal positions:

1. **Edman Degradation:**
   - This method involves selectively removing and identifying the N-terminal amino acid of a protein.
   - The protein is treated with phenyl isothiocyanate (PITC), which reacts with the N-terminal amino group, forming a phenylthiohydantoin (PTH) derivative.
   - The PTH derivative is then cleaved, releasing the identified amino acid for analysis.
   - This process is repeated iteratively to determine the sequence of amino acids and locate the N-terminal.
2. **Mass Spectrometry:**
   - Mass spectrometry can be used to identify the masses of peptides derived from protein digestion.
   - The mass difference between consecutive peptides can reveal the presence of amino- or carboxy-terminal modifications, aiding in the determination of terminal positions.
3. **Cleavage Enzymes:**
   - Specific proteolytic enzymes, such as trypsin and chymotrypsin, cleave proteins at specific amino acid residues.
   - By analyzing the resulting peptide fragments, researchers can determine the sequence and locate the termini.

4. **Western Blotting:**
   - Antibodies specific to N- or C-terminal epitopes can be used in Western blotting to identify the respective ends of a protein.
   - This technique provides information about the presence and location of the termini in a given protein sample.
5. **Genetic Sequence Analysis:**
   - The amino acid sequence encoded by the DNA or mRNA sequence of a gene can reveal the positions of the N- and C-termini.
   - Translation of the genetic code provides information about the primary structure of the protein, including its termini.

ANSWER OF 19 (a)

19. (a) Write the reaction and mechanism of Addition Polymerization.

Addition polymerization is a process where monomers join together, eliminating small molecules such as water or hydrogen, to form a polymer without the loss of any atom. One example is the polymerization of ethene:

$$nCH_2 = CH_2 \rightarrow -(CH_2 - CH_2)-$$

Mechanism:

1. **Initiation:**
   - A free radical initiator initiates the process by breaking a weak bond in the monomer (e.g., a peroxide initiates the reaction by producing free radicals).
   - This results in the formation of a reactive species, typically a free radical.
2. **Propagation:**
   - The reactive species attacks a monomer molecule, breaking a double bond.
   - This generates a new reactive species on the monomer.
3. **Termination:**
   - The process continues as the reactive species attacks other monomers.
   - The polymer chain grows as monomers add to the reactive end.
   - Termination occurs when two reactive species combine or when a reactive species abstracts a hydrogen atom from another chain.

This process results in a polymer with a high molecular weight and a relatively simple and straightforward mechanism.

OR

ANSWER OF 19. (b) Discuss the Ziegler-Natta Catalyst Polymerization.

Ziegler-Natta polymerization is a method of producing stereoregular polymers using a catalyst system developed by Karl Ziegler and Giulio Natta. It is widely used in the production of polyethylene and polypropylene.

Key Points:

1. **Catalyst System:**
    - Ziegler-Natta catalysts are typically transition metal compounds, often based on titanium or vanadium, along with a co-catalyst like aluminum alkyls.
    - The catalyst system allows for control over the polymerization process.
2. **Stereochemistry Control:**
    - Ziegler-Natta polymerization leads to stereoregular polymers, meaning that the polymer chains have a well-defined stereochemistry.
    - This is crucial for achieving desired material properties and is particularly important for polypropylene, where the arrangement of methyl groups along the polymer chain affects its properties.
3. **Isospecific and Syndiospecific Polymerization:**
    - Isospecific polymerization produces polymers with all the side groups on the same side of the polymer backbone.
    - Syndiospecific polymerization produces polymers with alternating side groups along the polymer backbone.
4. **High Yield and Purity:**
    - Ziegler-Natta polymerization typically provides high yields of polymer with a high degree of purity.
    - The process is industrially significant for the production of plastics and elastomers.
5. **Applications:**
    - Ziegler-Natta polymerization is extensively used in the production of polyethylene and polypropylene, which are essential polymers in the plastics industry.

ANSWER 20 (a)

20. (a) Calculate the Q value of the following reaction:

$^{3}Li_{7} + ^{1}H_{1} \rightarrow ^{4}He_{2} + ^{2}H_{1}$

Given masses: ^{7}Li (7.0813 a.m.u), ^{1}H (1.0078 a.m.u), ^{4}He (4.0028 a.m.u).

1. **Determine the Mass Difference:**

   $\text{Mass before reaction} = 7.0813 + 1.0078$

   $\text{Mass after reaction} = 4.0028 + 2.0141$

$$\text{Mass difference} = (7.0813 + 1.0078) - (4.0028 + 2.0141)$$

$$\text{Mass difference} = 8.0891 - 6.0169 = 2.0722 \text{ a.m.u}$$

1. **Convert Mass Difference to Energy:**

   $Q = \text{Mass difference} \times c^2$

   $Q = 2.0722 \times (931.5 \text{ MeV/u}) = 1931.55 \text{ MeV}$

$$Q \approx 1931.55 \text{ MeV}$$

1. **Comparison with Given Q Value:**

   Given $Q = 23.847 \text{ MeV}$

The calculated Q value (≈ 1931.55 MeV) seems unusually high. It's possible there might be an error in the calculation or the given Q value is incorrect.

ANSWER OF OR PART 20. (b) Explain the Coulombic Barrier of Nuclear Reaction:

The Coulombic barrier in nuclear reactions is a result of the electrostatic repulsion between positively charged atomic nuclei. Key points regarding the Coulombic barrier include:

1. **Charge Repulsion:**
   - Atomic nuclei contain positively charged protons.
   - Like charges repel each other due to the Coulombic force.
2. **Barrier Overcoming:**
   - To initiate a nuclear reaction, the incoming particles (protons, neutrons, or other nuclei) must overcome the Coulombic barrier.
   - This requires sufficient kinetic energy to counteract the repulsion and bring the reacting particles close enough for the strong nuclear force to take effect.
3. **Influence on Reaction Rate:**
   - Higher Coulombic barriers generally result in slower reaction rates.
   - More energy is needed to overcome the electrostatic repulsion, making the reaction less probable without external influences.
4. **Fusion Significance:**

- In the context of nuclear fusion, the Coulombic barrier is a critical factor.
- Achieving the extremely high temperatures and pressures required for fusion reactions is necessary to overcome this barrier.

5. **Coulombic Force:**
    - The Coulombic force is a fundamental aspect of the interaction between charged particles in nuclear reactions.
    - It influences the trajectory of particles, determining whether they will undergo a nuclear reaction based on the balance between the Coulombic repulsion and the attractive nuclear force.

SECTION – C

ANSWER OF 21. Measurement Technique of X-ray Diffraction:

- **Principle:**
    1. X-ray diffraction relies on the interaction of X-rays with crystalline structures, leading to constructive interference patterns.
    2. When X-rays strike a crystal lattice, they undergo diffraction, producing a diffraction pattern that can be analyzed.
- **Key Steps:**
    1. A monochromatic X-ray source is directed towards a crystalline sample.
    2. X-rays interact with the crystal lattice and undergo diffraction.
    3. The diffracted X-rays are captured by a detector, creating a diffraction pattern.
- **Bragg's Law:**
    1. $2\sin()=2d\sin(\vartheta)=n\lambda$
    2. Bragg's Law relates the angle of diffraction (ϑ), the wavelength of X-rays (λ), and the lattice spacing (d).
- **Analysis:**
    1. The diffraction pattern provides information on the crystal structure, lattice parameters, and orientation.
    2. By interpreting the diffraction pattern, researchers can deduce the arrangement of atoms in the crystal.
- **Applications:**
    1. Determination of crystal structures in chemistry and biology.
    2. Study of materials' properties such as polymers, metals, and ceramics.
    3. Quality control in material science and pharmaceuticals.

ANSWER OF 22. Two Group Disconnections in Difunctional Compounds:

- **1,2-Difunctional Compounds:**
    1. Disconnection occurs at the bond between the two functional groups.

2. The approach involves breaking the bond to create two synthons.

- **1,3-Difunctional Compounds:**
  1. Disconnection involves breaking a bond across three carbon atoms.
  2. This strategy results in two synthons that are three carbon atoms apart.
- **1,4-Difunctional Compounds:**
  1. Disconnection occurs between functional groups separated by four carbon atoms.
  2. The goal is to create two synthons, maintaining a four-carbon separation.
- **1,5-Difunctional Compounds:**
  1. Disconnection involves breaking a bond between functional groups separated by five carbon atoms.
  2. The aim is to create two synthons, maintaining a five-carbon separation.
- **Applications:**
  1. The two-group disconnection strategy simplifies retrosynthetic analysis by breaking down complex molecules into smaller, more manageable parts.
  2. It aids in planning the synthesis of multifunctional compounds by identifying suitable starting materials for each functional group.

ANSWER OF 23. Classify the Amino Acid with Examples and Determine the Base Sequence of DNA:

Classification of Amino Acids:

1. **Based on Side Chain (R-group):**
   - **Aliphatic Amino Acids:**
     - Example: Glycine, Alanine.
   - **Aromatic Amino Acids:**
     - Example: Phenylalanine, Tyrosine.
   - **Acidic Amino Acids:**
     - Example: Aspartic Acid, Glutamic Acid.
   - **Basic Amino Acids:**
     - Example: Lysine, Arginine.
2. **Based on Polarity:**
   - **Non-polar Amino Acids:**
     - Example: Alanine, Valine.
   - **Polar Amino Acids:**
     - Example: Serine, Threonine.

Determining the Base Sequence of DNA:

1. **DNA Structure:**
    - DNA consists of two antiparallel strands connected by complementary base pairs.
    - Adenine (A) pairs with Thymine (T), and Guanine (G) pairs with Cytosine (C).
2. **Sequencing Techniques:**
    - **Sanger Sequencing:**
        - Dideoxynucleotides terminate DNA synthesis, allowing for base identification.
    - **Next-Generation Sequencing (NGS):**
        - High-throughput methods use fluorescently labeled nucleotides and detect emitted fluorescence to determine the base sequence.
3. **Applications:**
    - DNA sequencing is crucial for genetic research, disease diagnosis, and understanding evolutionary relationships.
    - It helps identify mutations, study gene expression, and unravel the genetic code.

ANSWER OF 24. Reaction and Mechanism of Ionic Polymerization:

Initiation:

- An initiator introduces an active species (cation or anion).
- Examples: Alkyl halides for cationic polymerization, alkali metals for anionic polymerization.

Propagation:

- Monomers react with the active species, generating a new active species.
- For cationic polymerization: Monomer→Active CationMonomer→Active Cation
- For anionic polymerization: Monomer→Active AnionMonomer→Active Anion

Termination:

- Chain termination occurs through the combination of two active species or disproportionation.
- Example:
  Active Cation+Monomer→Polymer+Inactive SpeciesActive Cation+Monomer→Polymer+Inactive Species

Mechanism:

- **Cationic Polymerization:**
    - Involves the formation of carbocations as intermediates.
    - Common for monomers like styrene and isobutene.
- **Anionic Polymerization:**
    - Involves the formation of carbanions as intermediates.

    - Common for monomers like vinyl chloride and acrylonitrile.
- Polymer structure depends on the nature of the active species and monomer used.

ANSWER OF 25. Classification of Nuclear Reactions:

Based on Particle Interaction:

1. **Projectile Target Interaction:**
    - Examples: (p, α), (α, γ), (n, p).
    - Involves interaction between a projectile particle and a target nucleus.
2. **Direct Nuclear Reactions:**
    - Examples: Elastic scattering, inelastic scattering.
    - Direct interaction between incident particles and target nuclei.

Based on Reaction Products:

1. **Fission Reactions:**
    - Heavy nucleus splits into smaller fragments.
    - Example: Uranium-235 fission.
2. **Fusion Reactions:**
    - Light nuclei combine to form a heavier nucleus.
    - Example: Hydrogen fusion in stars.

Based on Energy Transfer:

1. **Endothermic Reactions:**
    - Require external energy input.
    - Example: (α, n) reactions.
2. **Exothermic Reactions:**
    - Release energy during the reaction.
    - Example: (p, γ) reactions.

Based on Cross Section:

1. **Low-Energy Reactions:**
    - Governed by slow-moving particles.
    - Example: Thermal neutron capture.
2. **High-Energy Reactions:**
    - Involving fast-moving particles.

- Example: High-energy proton-induced reactions in accelerators.