Biochemistry Unit I Question Bank

Multiple Choice Questions (MCQs)

(10 MCQs, each carrying 1 mark)

1. **Which biomolecule is primarily responsible for energy storage in animals?**
   a) Cellulose
   b) Glycogen
   c) Starch
   d) Chitin
   Answer: b) Glycogen
   Explanation: Glycogen is a polysaccharide stored in animal liver and muscles, serving as a primary energy reserve.

2. **What is the primary function of nucleic acids in cells?**
   a) Energy storage
   b) Structural support
   c) Genetic information storage and transfer
   d) Catalyzing reactions
   Answer: c) Genetic information storage and transfer
   Explanation: Nucleic acids (DNA and RNA) store and transmit genetic information for protein synthesis and cellular functions.

3. **Which of the following is an example of an energy-rich compound?**
   a) Glucose
   b) ATP
   c) Amino acid
   d) Cholesterol
   Answer: b) ATP
   Explanation: ATP (Adenosine Triphosphate) is an energy-rich compound due to its high-energy phosphate bonds.

4. **An exergonic reaction is characterized by:**
   a) Positive free energy change
   b) Negative free energy change
   c) No energy change
   d) High entropy
   Answer: b) Negative free energy change
   Explanation: Exergonic reactions release energy, resulting in a negative Gibbs free energy change ($\Delta G < 0$).

5. **Which functional group is characteristic of amino acids?**
   a) Hydroxyl group
   b) Amino and carboxyl groups

c) Phosphate group
d) Aldehyde group
Answer: b) Amino and carboxyl groups
Explanation: Amino acids contain an amino (-NH2) and a carboxyl (-COOH) group, defining their chemical nature.

6. **What is the role of cyclic AMP (cAMP) in cells?**
   a) Energy currency
   b) Second messenger in signal transduction
   c) Structural component of membranes
   d) Genetic material
   Answer: b) Second messenger in signal transduction
   Explanation: cAMP acts as a second messenger, relaying signals from hormones to regulate cellular processes.

7. **Which lipid type is a major component of cell membranes?**
   a) Triglycerides
   b) Phospholipids
   c) Steroids
   d) Waxes
   Answer: b) Phospholipids
   Explanation: Phospholipids form the bilayer of cell membranes due to their amphipathic nature.

8. **The relationship between free energy (G), enthalpy (H), and entropy (S) is given by:**
   a) $\Delta G = \Delta H + T\Delta S$
   b) $\Delta G = \Delta H - T\Delta S$
   c) $\Delta G = T\Delta H - \Delta S$
   d) $\Delta G = \Delta S - T\Delta H$
   Answer: b) $\Delta G = \Delta H - T\Delta S$
   Explanation: This is the Gibbs free energy equation, where T is the absolute temperature in Kelvin.

9. **Redox potential measures:**
   a) The tendency of a molecule to gain or lose electrons
   b) The energy stored in ATP
   c) The entropy of a system
   d) The enthalpy of a reaction
   Answer: a) The tendency of a molecule to gain or lose electrons
   Explanation: Redox potential indicates a molecule's ability to participate in oxidation-reduction reactions.

10. **Which protein structure level involves the sequence of amino acids?**
    a) Primary
    b) Secondary
    c) Tertiary
    d) Quaternary
    Answer: a) Primary

Explanation: The primary structure of a protein is the linear sequence of amino acids linked by peptide bonds.

Long Answer Questions

(Answer 1 out of 2, 10 marks)

1. **Discuss the classification, chemical nature, and biological roles of lipids in detail.**
   Answer:
   Classification: Lipids are a diverse group of hydrophobic biomolecules classified as:
   - **Fatty acids**: Saturated (e.g., stearic acid) or unsaturated (e.g., oleic acid), serving as energy sources and membrane components.
   - **Triglycerides**: Esters of glycerol and three fatty acids, used for energy storage.
   - **Phospholipids**: Contain a phosphate group (e.g., lecithin), forming cell membranes.
   - **Steroids**: Four-ring structures (e.g., cholesterol), acting as hormones and membrane components.
   - **Waxes**: Esters of long-chain fatty acids and alcohols, providing protective coatings.
     Chemical Nature: Lipids are primarily composed of carbon, hydrogen, and oxygen, with a high proportion of C-H bonds, making them non-polar and insoluble in water but soluble in organic solvents. Phospholipids are amphipathic, with hydrophilic heads and hydrophobic tails.
     Biological Roles:
   - **Energy Storage**: Triglycerides store energy efficiently in adipose tissue.
   - **Membrane Structure**: Phospholipids and cholesterol form the fluid mosaic model of cell membranes.
   - **Signaling**: Steroid hormones (e.g., cortisol) and lipid-derived molecules (e.g., prostaglandins) regulate physiological processes.
   - **Insulation and Protection**: Lipids insulate against cold and cushion organs.
2. **Explain the concept of bioenergetics, including free energy, endergonic and exergonic reactions, and the biological significance of ATP and cyclic AMP.**
   Answer:
   Bioenergetics: Bioenergetics studies energy transformations in living systems, focusing on how cells harness and utilize energy for metabolic processes.
   - **Free Energy (ΔG)**: Gibbs free energy determines a reaction's spontaneity. It is given by $\Delta G = \Delta H - T\Delta S$, where ΔH is enthalpy (heat content), T is temperature, and ΔS is entropy (disorder). A negative ΔG indicates a spontaneous (exergonic) reaction, while a positive ΔG indicates a non-spontaneous (endergonic) reaction.

- **Endergonic Reactions**: Require energy input ($\Delta G > 0$), e.g., biosynthesis of proteins or glucose from CO_2 in photosynthesis.
- **Exergonic Reactions**: Release energy ($\Delta G < 0$), e.g., ATP hydrolysis or glucose oxidation in cellular respiration.
- **Biological Significance of ATP: ATP, with its high-energy phosphate bonds, is the cell's energy currency. Hydrolysis of ATP (ATP → ADP + Pi) releases ~30.5 kJ/mol, driving endergonic reactions like ion transport, muscle contraction, and biosynthesis. ATP is regenerated via cellular respiration and phosphorylation.
- **Biological Significance of cAMP**: Cyclic AMP acts as a second messenger in signal transduction, amplifying signals from hormones like adrenaline. It activates protein kinase A, which phosphorylating targets to regulate metabolism (e.g., glycogen breakdown) and gene expression.

Short Answer Questions

(Answer 2 out of 3, 5 marks each)

1. **Describe the classification and biological role of carbohydrates.**
   Answer:
   Classification: Carbohydrates are classified as:
   - **Monosaccharides**: Simple sugars like glucose and fructose, with 3–6 carbons.
   - **Disaccharides**: Two monosaccharides linked (e.g., sucrose, lactose).
   - **Polysaccharides**: Long chains of monosaccharides (e.g., starch, glycogen, chitin).
     Biological Role:
   - **Energy Source**: Glucose is oxidized in glycolysis to produce ATP.
   - **Storage**: Starch (plants) and glycogen (animals) store energy reserves.
   - **Structural**: Cellulose forms plant cell walls, and chitin provides structural support in fungal and arthropod exoskeletons.
   - **Cell Recognition**: Glycoproteins on cell surfaces mediate signaling and immune responses.
2. **Explain the structure and function of amino acids and proteins.**
   Answer:
   Amino Acids: Amino acids are organic compounds with an amino group (-NH2), carboxyl group (-COOH), and a variable side chain (R group) attached to a central carbon. The 20 standard amino acids differ in their R groups, affecting properties like polarity and charge.
   Proteins: Proteins are polypeptides formed by amino acids linked via peptide bonds. They have four structural levels:
   - **Primary**: Amino acid sequence.

- **Secondary**: Alpha helices or beta sheets due to hydrogen bonding.
- **Tertiary**: 3D folding due to interactions between side chains.
- **Quaternary**: Multiple polypeptide chains (e.g., hemoglobin).
  Functions: Proteins act as enzymes (e.g., catalyzing reactions), structural components (e.g., collagen), transporters (e.g., hemoglobin), antibodies (immune defense), and hormones (e.g., insulin).

3. **What is the significance of redox potential in bioenergetics?**
   Answer:
   Redox potential (E_0) measures a molecule's tendency to gain or lose electrons in oxidation-reduction reactions, critical for bioenergetics. A higher redox potential indicates a greater electron affinity (reduction), while a lower potential favors electron donation (oxidation). In cellular respiration, electrons from nutrients (e.g., NADH) are passed through the electron transport chain, where differences in redox potential drive proton gradient formation, powering ATP synthesis via oxidative phosphorylation. For example, NADH's negative redox potential (-0.32 V) allows it to donate electrons to oxygen (+0.82 V), releasing energy. Redox potential thus governs energy transfer in metabolic pathways.