MCAT Chemical and Physical Foundations of Biological Systems Practice Exam (Sample)

Study Guide

BY EXAMZIFY

Everything you need from our exam experts!

Table of Contents

Introduction

Preparing for a certification exam can feel overwhelming, but with the right tools, it becomes an opportunity to build confidence, sharpen your skills, and move one step closer to your goals. At Examzify, we believe that effective exam preparation isn't just about memorization, it's about understanding the material, identifying knowledge gaps, and building the test-taking strategies that lead to success.

This guide was designed to help you do exactly that.

Whether you're preparing for a licensing exam, professional certification, or entry-level qualification, this book offers structured practice to reinforce key concepts. You'll find a wide range of multiple-choice questions, each followed by clear explanations to help you understand not just the right answer, but why it's correct.

The content in this guide is based on real-world exam objectives and aligned with the types of questions and topics commonly found on official tests. It's ideal for learners who want to:

- **Practice answering questions under realistic conditions,**
- **Improve accuracy and speed,**
- **Review explanations to strengthen weak areas, and**
- **Approach the exam with greater confidence.**

We recommend using this book not as a stand-alone study tool, but alongside other resources like flashcards, textbooks, or hands-on training. For best results, we recommend working through each question, reflecting on the explanation provided, and revisiting the topics that challenge you most.

Remember: successful test preparation isn't about getting every question right the first time, it's about learning from your mistakes and improving over time. Stay focused, trust the process, and know that every page you turn brings you closer to success.

Let's begin.

How to Use This Guide

This guide is designed to help you study more effectively and approach your exam with confidence. Whether you're reviewing for the first time or doing a final refresh, here's how to get the most out of your Examzify study guide:

1. Start with a Diagnostic Review

Skim through the questions to get a sense of what you know and what you need to focus on. Don't worry about getting everything right, your goal is to identify knowledge gaps early.

2. Study in Short, Focused Sessions

Break your study time into manageable blocks (e.g. 30 – 45 minutes). Review a handful of questions, reflect on the explanations, and take breaks to retain information better.

3. Learn from the Explanations

After answering a question, always read the explanation, even if you got it right. It reinforces key points, corrects misunderstandings, and teaches subtle distinctions between similar answers.

4. Track Your Progress

Use bookmarks or notes (if reading digitally) to mark difficult questions. Revisit these regularly and track improvements over time.

5. Simulate the Real Exam

Once you're comfortable, try taking a full set of questions without pausing. Set a timer and simulate test-day conditions to build confidence and time management skills.

6. Repeat and Review

Don't just study once, repetition builds retention. Re-attempt questions after a few days and revisit explanations to reinforce learning.

7. Use Other Tools

Pair this guide with other Examzify tools like flashcards, and digital practice tests to strengthen your preparation across formats.

There’s no single right way to study, but consistent, thoughtful effort always wins. Use this guide flexibly — adapt the tips above to fit your pace and learning style. You've got this!

Questions

1. **In which type of solvent does nucleophilicity generally increase up the periodic table?**
   - **A. Protic solvents**
   - **B. Aprotic solvents**
   - **C. Non-polar solvents**
   - **D. Polar solvents**

2. **How is spring potential energy calculated?**
   - **A. PE = 1/2kx^2**
   - **B. PE = mgh**
   - **C. PE = rgh**
   - **D. PE = nRT**

3. **Which is NOT a characteristic of carboxylic acids?**
   - **A. Contains hydroxyl group**
   - **B. Always has a carbonyl group**
   - **C. Always has nitrogen atom attached**
   - **D. Can participate in hydrogen bonding**

4. **What does combining Bohr and Planck's equations illustrate regarding photon energy?**
   - **A. It is dependent solely on wavelength**
   - **B. It is influenced by the electron's location**
   - **C. It is proportional to frequency only**
   - **D. It represents the total energy of an atom**

5. **How many orbitals are present in the f subshell?**
   - **A. 5**
   - **B. 6**
   - **C. 7**
   - **D. 8**

6. To determine whether a compound is chiral or to classify it as cis or trans, what is the primary consideration?

- **A. Count the number of double bonds**
- **B. Count down the substituents based on atomic number**
- **C. Evaluate molecular shape**
- **D. Analyze the bond angles**

7. In the context of acid strength, bases typically have which kind of pKa values?

- **A. Low pKa values**
- **B. High pKa values**
- **C. Negative pKa values**
- **D. Zero pKa values**

8. What is the relationship between the energy (E) of a photon and its frequency (f)?

- **A. E increases as f decreases**
- **B. E is independent of f**
- **C. E is directly proportional to f**
- **D. E is inversely proportional to f**

9. What type of agent is LiAlH4 in organic chemistry?

- **A. Oxidizing agent**
- **B. Reducing agent**
- **C. Catalytic agent**
- **D. Solvent**

10. What are the two types of configurational isomers?

- **A. Geometric and structural isomers**
- **B. Enantiomers and diastereomers**
- **C. Conformational and meso isomers**
- **D. Chiral and achiral isomers**

Answers

1. **B**
2. **A**
3. **C**
4. **B**
5. **C**
6. **B**
7. **B**
8. **C**
9. **B**
10. **B**

Explanations

1. In which type of solvent does nucleophilicity generally increase up the periodic table?

- A. Protic solvents
- **B. Aprotic solvents**
- C. Non-polar solvents
- D. Polar solvents

Nucleophilicity, the ability of a species to donate electrons to form a chemical bond, generally increases up the periodic table in aprotic solvents due to the nature of these solvents and their interactions with nucleophiles. Aprotic solvents do not have hydrogen atoms attached to electronegative atoms, which means they do not participate in hydrogen bonding. This absence of hydrogen bonding allows nucleophiles to remain more "free" and reactive, as their electron density is not heavily shielded. In the case of aprotic solvents, nucleophilicity is influenced primarily by the charge density and size of the nucleophile. As one moves up the periodic table, for example from iodide to fluoride, larger atoms tend to hold onto their electrons more loosely, making them more effective nucleophiles in a medium that does not interfere with their reactivity. In contrast, protic solvents stabilize nucleophiles through hydrogen bonding, particularly for larger anions. This stabilization can impede their nucleophilicity because the solvent creates a solvation shell around the nucleophile that can hinder its ability to approach the electrophile and share its electrons. Non-polar solvents do not facilitate nucleophilic reactions well because they lack polarity, which is necessary for sol

2. How is spring potential energy calculated?

- **A. PE = 1/2kx^2**
- B. PE = mgh
- C. PE = rgh
- D. PE = nRT

Spring potential energy is calculated using the formula $PE = \frac{1}{2} k x^2$, where PE represents the potential energy stored in the spring, k is the spring constant, and x is the displacement of the spring from its equilibrium position. This formula derives from Hooke's Law, which states that the force exerted by a spring is proportional to its extension or compression, defined mathematically as $F = -kx$. The factor of $\frac{1}{2}$ arises because as a spring is compressed or stretched, the force increases linearly from zero at the rest position up to kx at maximum displacement. To find the work done in stretching or compressing the spring, one must integrate this force over the distance x, leading to the formula for potential energy. The $\frac{1}{2} k x^2$ thus represents the total work done on the spring to displace it from its equilibrium position. In contrast, the other formulas represent different types of potential energy. The formula $PE = mgh$ is used to calculate gravitational potential energy, where m is mass,

3. Which is NOT a characteristic of carboxylic acids?

A. Contains hydroxyl group

B. Always has a carbonyl group

C. Always has nitrogen atom attached

D. Can participate in hydrogen bonding

Carboxylic acids are defined by the presence of a functional group that consists of both a carbonyl group (C=O) and a hydroxyl group (–OH) bonded to the same carbon atom, which gives rise to their unique properties. The characteristic of containing a hydroxyl group is fundamental to carboxylic acids because this functional group, when combined with the carbonyl group, defines them structurally. Likewise, carboxylic acids indeed always have a carbonyl group, as this is integral to their identity. In terms of hydrogen bonding, carboxylic acids are particularly capable of this due to their hydroxyl group. The ability to form hydrogen bonds significantly influences their boiling points and solubility in water. The assertion that carboxylic acids always have a nitrogen atom attached is incorrect because nitrogen is not a requisite component of these compounds. Carboxylic acids can exist without any nitrogen atoms present. Thus, this lack of requirement for nitrogen is what distinguishes option C as the correct answer, as it does not align with the defining features of carboxylic acids.

4. What does combining Bohr and Planck's equations illustrate regarding photon energy?

A. It is dependent solely on wavelength

B. It is influenced by the electron's location

C. It is proportional to frequency only

D. It represents the total energy of an atom

Combining Bohr's and Planck's equations illustrates that photon energy is influenced by the electron's location within an atom, which directly relates to the quantum energy levels defined by the Bohr model. In the Bohr model, electrons occupy discrete energy levels, and when an electron transitions between these levels, it emits or absorbs a photon whose energy corresponds to the difference between the two levels. Planck's equation, $E = h\nu$, describes the energy of a photon in terms of its frequency, where h is Planck's constant and ν is the frequency of the emitted or absorbed photon. The specific frequencies (and thus the energies) of the photons emitted or absorbed by an atom depend on the energy levels established by the electron configurations within that atom. Therefore, the energy of the emitted or absorbed photon is contingent upon the initial and final energy states of the electron, emphasizing the impact of the electron's location. The other options do not effectively capture the relationship between photon energy and the electron's quantum state. While it is true that photon energy is related to wavelength (as expressed in $E = \frac{hc}{\lambda}$), it is not solely dependent on wavelength because that relationship

5. How many orbitals are present in the f subshell?

A. 5

B. 6

C. 7

D. 8

The f subshell is associated with the angular momentum quantum number $l = 3$. The number of orbitals within a given subshell can be determined by the formula $2l + 1$. For the f subshell, substituting the value of l: $$2(3) + 1 = 6 + 1 = 7$$ Thus, the f subshell contains 7 orbitals. Each of these orbitals can hold a maximum of 2 electrons, meaning that the f subshell can accommodate a total of 14 electrons. Understanding the structure of the subshells and their corresponding orbitals, including the fact that there are types of subshells designated by letters (s, p, d, f), helps clarify the organization of electrons in atoms and their behavior during chemical bonding.

6. To determine whether a compound is chiral or to classify it as cis or trans, what is the primary consideration?

A. Count the number of double bonds

B. Count down the substituents based on atomic number

C. Evaluate molecular shape

D. Analyze the bond angles

When determining whether a compound is chiral or classifying it as cis or trans, the primary consideration involves analyzing the substituents attached to a double bond or a chiral center based on their atomic number. For chirality, a carbon atom must have four different substituents for it to be considered a chiral center. By comparing the atomic numbers of the atoms attached to the stereocenter, one can establish priority. The highest atomic number receives the highest priority, which helps in determining the configuration of the molecule (R or S). In the case of alkenes, cis and trans configurations depend on the substituents around the double bond. If the two highest-priority substituents on each end of the double bond are on the same side, the configuration is 'cis'. If they are on opposite sides, it's 'trans'. The ranking of substituents based on atomic number is essential for making these determinations correctly. While factors such as molecular shape and bond angles can influence the overall geometry of a molecule, they are secondary considerations compared to the identification of substituent priority when defining chirality or cis/trans configuration. Counting double bonds provides context for structural classification but does not directly inform chirality or configurational designation

7. In the context of acid strength, bases typically have which kind of pKa values?

A. Low pKa values

B. High pKa values

C. Negative pKa values

D. Zero pKa values

In the context of acid strength, bases typically have high pKa values. The pKa value is a measure of the strength of an acid; specifically, it indicates the tendency of an acid to donate a proton. A higher pKa value means that the acid is weaker, which implies that its conjugate base is relatively strong. For bases, a high pKa value suggests that the base is not prone to accepting protons easily, reflecting a more stable state when compared to stronger acids. Essentially, when a base reacts with an acid, it tends to hold onto its protons more tightly, leading to higher pKa values. This is crucial because the relationship between acids and bases is often discussed in terms of their conjugate pairs—where the strength of an acid is inversely related to the strength of its conjugate base. Thus, when identifying the characteristics of bases through their pKa values, high pKa values signify that the substance behaves as a weaker acid, indicating that its corresponding base is more stable and less likely to donate protons.

8. What is the relationship between the energy (E) of a photon and its frequency (f)?

A. E increases as f decreases

B. E is independent of f

C. E is directly proportional to f

D. E is inversely proportional to f

The relationship between the energy of a photon and its frequency is described by the equation $E = hf$, where E represents the energy of the photon, h is Planck's constant, and f is the frequency of the photon. This equation shows that energy is directly proportional to frequency: as the frequency increases, the energy of the photon also increases. This direct proportionality means that if you were to increase the frequency of the photon, you would correspondingly increase its energy. Conversely, a decrease in frequency would lead to a decrease in energy. Therefore, the correct answer illustrates that energy and frequency have a linear relationship where a higher frequency results in higher energy levels for photons.

9. What type of agent is $LiAlH_4$ in organic chemistry?

A. Oxidizing agent

B. Reducing agent

C. Catalytic agent

D. Solvent

Lithium aluminum hydride, commonly represented as LiAlH4, functions as a reducing agent in organic chemistry. It is a strong reducing agent that donates hydride ions (H-) to electrophilic centers, facilitating the reduction of various functional groups such as carbonyl compounds (aldehydes and ketones), nitriles, esters, and carboxylic acids to their corresponding alcohols or amines. In the reduction process, the hydride ions reduce the oxidation state of the functional groups involved, effectively adding hydrogen to the molecules and removing oxygen or other substituents. This ability to donate hydride ions is what distinguishes LiAlH4 as a reducing agent rather than an oxidizing agent, which would instead accept electrons and cause a decrease in the oxidation state of another species. LiAlH4 is also not a catalytic agent, since it participates directly in the chemical reaction and is consumed in the process, nor is it a solvent, as it does not serve to dissolve other substances without chemically changing. Its role is clear in the context of reduction, affirming its classification as a reducing agent.

10. What are the two types of configurational isomers?

A. Geometric and structural isomers

B. Enantiomers and diastereomers

C. Conformational and meso isomers

D. Chiral and achiral isomers

The two types of configurational isomers are indeed enantiomers and diastereomers. Configurational isomers are compounds that have the same molecular formula and connectivity but differ in the arrangement of their atoms in space, which cannot be converted into one another through simple rotations about single bonds. Enantiomers are a type of configurational isomer that are non-superimposable mirror images of each other. They exhibit different optical activities, meaning that they rotate plane-polarized light in opposite directions. This property is critical, particularly in biological systems, where one enantiomer may be biologically active while the other is not, leading to different physiological effects. Diastereomers, on the other hand, are configurational isomers that are not mirror images of each other. They typically have multiple chiral centers, and their properties can differ significantly, including boiling points, melting points, and solubilities. Because they are not mirror images, they do not have the same optical activity, which adds to their complexity in comparison to enantiomers. Understanding these distinctions is crucial for fields like pharmacology, organic chemistry, and biochemistry, where the three-dimensional arrangement of molecules plays a key role in their function and interactions. Other provided options do

Next Steps

Congratulations on reaching the final section of this guide. You've taken a meaningful step toward passing your certification exam and advancing your career.

As you continue preparing, remember that consistent practice, review, and self-reflection are key to success. Make time to revisit difficult topics, simulate exam conditions, and track your progress along the way.

If you need help, have suggestions, or want to share feedback, we'd love to hear from you. Reach out to our team at hello@examzify.com.

Or visit your dedicated course page for more study tools and resources:

https://mcat-chemphysicalfoundationsofbiosystems.examzify.com

We wish you the very best on your exam journey. You've got this!