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TUTOR STEM PRACTICE MCAT GENERAL CHEMISTRY QUESTIONS

MCAT Section: Chemical and Physical Foundations of Biological Systems

MCAT General Chemistry Question 1

Which of the following is the best explanation for the high boiling point of water compared to other molecules of similar size?

- A) Ionic bonds
- B) London dispersion forces
- C) Hydrogen bonding
- D) Dipole-dipole interactions

Correct Answer: C) Hydrogen bonding

Reasoning: Water has a high boiling point relative to other molecules of similar size primarily due to hydrogen bonding. Hydrogen bonds are strong intermolecular forces that occur when hydrogen atoms bonded to highly electronegative atoms like oxygen interact with lone pairs of electrons on other electronegative atoms. Electronegativity is a measure of the tendency of an atom to attract electrons towards itself when it forms a chemical bond. These bonds significantly increase the energy required to break the liquid structure, subsequently turning the liquid structure into a gaseous structure, resulting in a higher boiling point.

MCAT General Chemistry Question 2

What is the hybridization of the central carbon atom in acetone (CH_3COCH_3)?

- A) sp
- B) sp^2
- C) sp^3
- D) s

Correct Answer: B) sp^2

Reasoning: In acetone (CH_3COCH_3), the central carbon atom is bonded to three other atoms (two methyl groups and one oxygen atom) and has no lone pairs, resulting in three regions of electron density around the central carbon. This configuration corresponds to sp^2 hybridization, where one s orbital and two p orbitals hybridize to form three sp^2 hybrid orbitals.

MCAT General Chemistry Question 3

Which of the following statements correctly describes the effect of a catalyst on a chemical reaction?

- A) It increases the activation energy.
- B) It decreases the activation energy.

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- C) It shifts the equilibrium position.
D) It is consumed during the reaction.

Correct Answer: B) It decreases the activation energy.

Reasoning: A catalyst speeds up a chemical reaction by providing an alternative reaction pathway with a lower activation energy. This allows more reactant molecules to have enough energy to react, increasing the reaction rate. Catalysts do not alter the equilibrium position of the reaction and are not consumed during the reaction; they remain unchanged and can be used repeatedly.

MCAT General Chemistry Question 4

Which of the following best describes the molecular geometry of sulfur hexafluoride (SF₆)?

- A) Tetrahedral
B) Square planar
C) Octahedral
D) Trigonal bipyramidal

Correct Answer: C) Octahedral

Reasoning: Sulfur hexafluoride (SF₆) has six fluorine atoms symmetrically arranged around a central sulfur atom, with each sulfur-fluorine bond pointing towards the corners of an octahedron. This gives SF₆ an octahedral molecular geometry, which corresponds to sp³d² hybridization of the central sulfur atom.

MCAT General Chemistry Question 5

Which of the following is true about the solubility product constant (K_{sp})?

- A) It is dependent on the concentration of reactants.
B) It is dependent on the concentration of products.
C) It is constant for a given solute at a specific temperature.
D) It is the same for all temperatures.

Correct Answer: C) It is constant for a given solute at a specific temperature.

Reasoning: The solubility product constant (K_{sp}) is a specific type of equilibrium constant that applies to the dissolution of a sparingly soluble ionic compound in water. K_{sp} is constant for a given solute at a specific temperature, reflecting the degree to which the compound dissociates into its ions in solution. While K_{sp} values can vary with temperature, they are independent of the concentrations of the solute and solvent.

MCAT General Chemistry Question 6

What is the oxidation state of sulfur in the compound H₂SO₄?

- A) +2
B) +4
C) +6
D) -2

Correct Answer: C) +6

Reasoning: In H₂SO₄ (sulfuric acid), hydrogen has an oxidation state of +1 and oxygen has an oxidation state of -2. To determine the oxidation state of sulfur, we set up the equation: 2(+1) + S + 4(-2) = 0. Solving for S gives: 2 + S - 8 = 0, so S = +6. Therefore, the oxidation state of sulfur in H₂SO₄ is +6.

MCAT General Chemistry Question 7

Which of the following statements correctly describes alpha decay in radioactive elements?

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- A) Alpha decay involves the emission of an electron from the nucleus, decreasing the atomic number by one.
B) Alpha decay involves the emission of two protons and two neutrons, decreasing the atomic number by two and the mass number by four.
C) Alpha decay involves the emission of a neutron from the nucleus, decreasing the mass number by one.
D) Alpha decay involves the emission of a positron from the nucleus, increasing the atomic number by one.

Correct Answer: B) Alpha decay involves the emission of two protons and two neutrons, decreasing the atomic number by two and the mass number by four.

Reasoning: In alpha decay, an unstable nucleus emits an alpha particle, which consists of two protons and two neutrons. This process results in a decrease in the atomic number by two (since two protons are lost) and a decrease in the mass number by four (since both two protons and two neutrons are lost). The emitted alpha particle is identical to a helium-4 nucleus. This type of radioactive decay commonly occurs in heavy elements, such as uranium-238 and radium-226, as they seek to become more stable by reducing their size.

MCAT General Chemistry Question 8

Which of the following is the best description of an endothermic reaction?

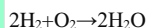
- A) It releases heat to the surroundings.
B) It absorbs heat from the surroundings.
C) It has a negative change in enthalpy (ΔH).
D) It has a negative change in entropy (ΔS).

Correct Answer: B) It absorbs heat from the surroundings.

Reasoning: An endothermic reaction is one that absorbs heat from its surroundings, resulting in a positive change in enthalpy ($\Delta H > 0$). This means that the products of the reaction have higher enthalpy than the reactants, and heat is taken in to facilitate the reaction.

MCAT General Chemistry Question 9

Given the balanced chemical equation:



How many moles of water (H_2O) are produced when 3 moles of hydrogen gas (H_2) react completely with oxygen gas (O_2)?

- A) 1.5 moles
B) 2 moles
C) 3 moles
D) 4.5 moles

Correct Answer: C) 3 moles

Reasoning: According to the balanced chemical equation, 2 moles of hydrogen gas (H_2) react with 1 mole of oxygen gas (O_2) to produce 2 moles of water (H_2O). This means that the molar ratio of H_2 to H_2O is 1:1. Therefore, the number of moles of water produced is equal to the number of moles of hydrogen gas reacted, assuming oxygen is in excess. Given 3 moles of hydrogen gas, the reaction will produce:

$$3 \text{ moles } \text{H}_2 \times [(2 \text{ moles } \text{H}_2\text{O}) / (2 \text{ moles } \text{H}_2)] = 3 \text{ moles } \text{H}_2\text{O}$$

Thus, 3 moles of water are produced when 3 moles of hydrogen gas react completely with oxygen gas.

MCAT General Chemistry Question 10

Which of the following best describes the concept of lattice energy?

- A) The energy required to convert a solid to a liquid.
B) The energy released when one mole of an ionic crystalline compound is formed from its gaseous ions.
C) The energy required to remove an electron from an atom.
D) The energy absorbed when a covalent bond is broken.

Correct Answer: B) The energy released when one mole of an ionic crystalline compound is formed from its gaseous ions.

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Reasoning: Lattice energy is the energy released when one mole of an ionic crystalline compound forms from its gaseous ions. It is a measure of the strength of the bonds in the ionic solid, reflecting the electrostatic interactions between the oppositely charged ions in the crystal lattice.

MCAT General Chemistry Question 11

Which of the following accurately describes the relationship between the rate constant (k) and the activation energy (E_a) in the Arrhenius equation?

- A) As E_a increases, k increases.
- B) As E_a increases, k decreases.
- C) As temperature increases, E_a increases.
- D) As temperature increases, k decreases.

Correct Answer: B) As E_a increases, k decreases.

Reasoning: According to the Arrhenius equation, $k = A \cdot e^{(-E_a/RT)}$, the rate constant (k) is inversely related to the activation energy (E_a). As the activation energy increases, the exponent becomes more negative, leading to a smaller value of k . Therefore, higher activation energy results in a lower rate constant, meaning the reaction proceeds more slowly.

MCAT General Chemistry Question 12

Which of the following statements is true regarding the periodic trend of ionization energy?

- A) Ionization energy increases down a group and decreases across a period.
- B) Ionization energy decreases down a group and increases across a period.
- C) Ionization energy decreases down a group and decreases across a period.
- D) Ionization energy remains constant across a period.

Correct Answer: B) Ionization energy decreases down a group and increases across a period.

Reasoning: Ionization energy is the energy required to remove an electron from an atom. It decreases down a group because the valence electrons are farther from the nucleus and experience less electrostatic attraction. It increases across a period due to increasing nuclear charge, which holds the valence electrons more tightly.

MCAT General Chemistry Question 13

Which of the following compounds exhibits both ionic and covalent bonding?

- A) NaCl
- B) H_2O
- C) KNO_3
- D) CH_4

Correct Answer: C) KNO_3

Reasoning: KNO_3 (potassium nitrate) exhibits both ionic and covalent bonding. The compound consists of potassium ions (K^+) and nitrate ions (NO_3^-). The nitrate ion has covalent bonds between nitrogen and oxygen atoms, while the bond between K^+ and NO_3^- is ionic.

MCAT General Chemistry Question 14

Which of the following best explains why the equilibrium constant (K) is temperature-dependent?

- A) The concentrations of reactants and products vary with temperature.
- B) The activation energy of the reaction changes with temperature.
- C) The enthalpy change (ΔH) of the reaction changes with temperature.
- D) The rate of the forward and reverse reactions changes with temperature.

Correct Answer: D) The rate of the forward and reverse reactions changes with temperature.

Reasoning: The equilibrium constant (K) is temperature-dependent because the rates of the forward and reverse reactions are influenced by temperature. As temperature changes, the rate constants for both reactions change, altering the ratio of products to reactants at equilibrium.

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Which of the following species is the conjugate base of H_2PO_4^- ?

- A) H_3PO_4
- B) HPO_4^{2-}
- C) PO_4^{3-}
- D) H_2O

Correct Answer: B) HPO_4^{2-} **Reasoning:** The conjugate base of an acid is formed by removing a proton (H^+) from the acid. When H_2PO_4^- loses a proton, it forms HPO_4^{2-} . Therefore, HPO_4^{2-} is the conjugate base of H_2PO_4^- .**MCAT General Chemistry Question 16**

Which of the following correctly describes the principle behind a buffer solution?

- A) It resists changes in pH by neutralizing added acids or bases.
- B) It maintains a constant pH regardless of added substances.
- C) It enhances the conductivity of a solution.
- D) It catalyzes acid-base reactions.

Correct Answer: A) It resists changes in pH by neutralizing added acids or bases.**Reasoning:** A buffer solution consists of a weak acid and its conjugate base or a weak base and its conjugate acid. It resists changes in pH by neutralizing added acids or bases through reactions with the buffer components, thus maintaining a relatively stable pH.**MCAT General Chemistry Question 17**

Which of the following statements is true about a first-order reaction?

- A) The rate of the reaction is directly proportional to the concentration of one reactant.
- B) The rate of the reaction is independent of the concentration of the reactants.
- C) The rate of the reaction is proportional to the square of the concentration of one reactant.
- D) The rate of the reaction is proportional to the product of the concentrations of two reactants.

Correct Answer: A) The rate of the reaction is directly proportional to the concentration of one reactant.**Reasoning:** In a first-order reaction, the rate is directly proportional to the concentration of one reactant. This means that if the concentration of the reactant doubles, the reaction rate also doubles. The rate law for a first-order reaction is typically expressed as $\text{rate} = k[\text{A}]$, where $[\text{A}]$ is the concentration of the reactant and k is the rate constant.**MCAT General Chemistry Question 18**

Which of the following best explains the trend in atomic size across a period in the periodic table?

- A) Atomic size increases due to additional electron shells.
- B) Atomic size decreases due to increasing nuclear charge.
- C) Atomic size increases due to decreasing nuclear charge.
- D) Atomic size remains constant due to shielding effect.

Correct Answer: B) Atomic size decreases due to increasing nuclear charge.**Reasoning:** Across a period, the atomic size decreases because the number of protons in the nucleus increases, leading to a stronger electrostatic attraction between the nucleus and the valence electrons. This increased nuclear charge pulls the electrons closer to the nucleus, resulting in a smaller atomic radius.**MCAT General Chemistry Question 19**

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Which of the following correctly describes the process of entropy (ΔS) in a spontaneous reaction?

- A) Entropy always decreases in a spontaneous reaction.
- B) Entropy always increases in a spontaneous reaction.
- C) The entropy change can be positive or negative in a spontaneous reaction, but the overall Gibbs free energy change (ΔG) must be negative.
- D) Entropy remains constant in a spontaneous reaction.

Correct Answer: C) The entropy change can be positive or negative in a spontaneous reaction, but the overall Gibbs free energy change (ΔG) must be negative.

Reasoning: In a spontaneous reaction, the overall Gibbs free energy change (ΔG) must be negative. While an increase in entropy ($\Delta S > 0$) generally favors spontaneity, it is possible for a reaction to be spontaneous with a decrease in entropy ($\Delta S < 0$) if the enthalpy change (ΔH) is sufficiently negative. The relationship is described by the Gibbs free energy equation: $\Delta G = \Delta H - T\Delta S$.

MCAT General Chemistry Question 20

Which of the following best describes the concept of resonance energy?

- A) The energy required to form a covalent bond.
- B) The energy difference between the most stable resonance structure and the actual molecule.
- C) The energy released when an ionic bond is formed.
- D) The energy required to break a hydrogen bond.

Correct Answer: B) The energy difference between the most stable resonance structure and the actual molecule.

Reasoning: Resonance energy is the difference in energy between the most stable resonance structure (if it existed as a single entity) and the actual molecule, which is a hybrid of all possible resonance structures. This energy represents the stabilization gained through delocalization of electrons.

MCAT General Chemistry Question 21

Which of the following explains why benzene (C_6H_6) is more stable than expected based on its structure?

- A) It contains alternating single and double bonds.
- B) It forms hydrogen bonds between its molecules.
- C) It exhibits resonance, allowing electron delocalization.
- D) It has a high molecular weight.

Correct Answer: C) It exhibits resonance, allowing electron delocalization.

Reasoning: Benzene (C_6H_6) is more stable than expected due to resonance. The electrons in the π -bonds are delocalized over the entire ring, creating a resonance-stabilized structure. This delocalization lowers the overall energy of the molecule, making it more stable than if it had distinct alternating single and double bonds.

MCAT General Chemistry Question 22

Which of the following best describes a coordination complex?

- A) A molecule that has hydrogen bonds between its atoms.
- B) A compound consisting of a central metal atom or ion bonded to surrounding molecules or anions.
- C) A substance that dissociates completely in water.
- D) A mixture of two or more substances.

Correct Answer: B) A compound consisting of a central metal atom or ion bonded to surrounding molecules or anions.

Reasoning: A coordination complex consists of a central metal atom or ion surrounded by ligands, which are molecules or anions that donate electron pairs to form coordinate covalent bonds. These complexes play significant roles in various biological and chemical processes.

MCAT General Chemistry Question 23

Which of the following best describes the principle behind Le Chatelier's principle?

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- A) A change in concentration, pressure, or temperature will shift the equilibrium position to oppose the change.
B) The total pressure of a gas mixture is equal to the sum of the partial pressures of its components.
C) The energy required to break a bond is equal to the energy released when the bond is formed.
D) The entropy of the universe always increases in a spontaneous process.

Correct Answer: A) A change in concentration, pressure, or temperature will shift the equilibrium position to oppose the change.

Reasoning: Le Chatelier's principle states that if a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium will shift to counteract the change and restore a new equilibrium state. This principle helps predict the direction of the shift in response to changes in concentration, pressure, or temperature.

MCAT General Chemistry Question 24

Which of the following correctly describes the bond order in molecular orbital theory?

- A) The number of valence electrons in a molecule.
B) The difference between the number of bonding and antibonding electrons divided by two.
C) The total number of bonds in a molecule.
D) The number of lone pairs of electrons in a molecule.

Correct Answer: B) The difference between the number of bonding and antibonding electrons divided by two.

Reasoning: In molecular orbital theory, the bond order is calculated as the difference between the number of bonding electrons and antibonding electrons, divided by two. A higher bond order indicates a stronger, more stable bond.

MCAT General Chemistry Question 25

Which of the following best explains the concept of a limiting reactant in a chemical reaction?

- A) The reactant that is present in the smallest quantity.
B) The reactant that determines the maximum amount of product formed.
C) The reactant that has the highest molar mass.
D) The reactant that reacts fastest in the reaction.

Correct Answer: B) The reactant that determines the maximum amount of product formed.

Reasoning: The limiting reactant is the reactant that is completely consumed first in a chemical reaction, thereby limiting the amount of product that can be formed. It determines the maximum yield of the reaction because once it is used up, the reaction cannot proceed further.

MCAT General Chemistry Question 26

Which of the following statements correctly describes an exergonic reaction?

- A) It has a positive change in free energy (ΔG).
B) It has a negative change in free energy (ΔG).
C) It requires an input of energy to proceed.
D) It results in the absorption of heat.

Correct Answer: B) It has a negative change in free energy (ΔG).

Reasoning: An exergonic reaction is characterized by a negative change in free energy ($\Delta G < 0$), indicating that the reaction releases energy and is spontaneous. These reactions proceed without the need for an external input of energy.

MCAT General Chemistry Question 27

Which of the following is the correct expression for the equilibrium constant (K_c) for the reaction: $2 \text{NO(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2 \text{NO}_2\text{(g)}$?

- A) $[\text{NO}_2] / ([\text{NO}] * [\text{O}_2])$
B) $[\text{NO}_2]^2 / ([\text{NO}]^2 * [\text{O}_2])$

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Website : www.tutorSTEM.caMCAT Page : www.tutorSTEM.ca/mcatPhone Number for Tutor STEM's Medical School MCAT Department : [416-795-5000](tel:416-795-5000)C) $[\text{NO}_2]^2 / ([\text{NO}] * [\text{O}_2]^2)$ D) $[\text{NO}]^2 * [\text{O}_2] / [\text{NO}_2]^2$ **Correct Answer: B) $[\text{NO}_2]^2 / ([\text{NO}]^2 * [\text{O}_2])$**

Reasoning: The equilibrium constant expression (K_c) for a reaction is written as the concentration of the products raised to their stoichiometric coefficients divided by the concentration of the reactants raised to their stoichiometric coefficients. For the reaction $2 \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{NO}_2(\text{g})$, the expression is $K_c = [\text{NO}_2]^2 / ([\text{NO}]^2 * [\text{O}_2])$.

MCAT General Chemistry Question 28

Which of the following best describes a sigma bond (σ bond)?

A) A bond formed by the sideways overlap of p orbitals.

B) A bond formed by the end-to-end overlap of orbitals.

C) A bond that results from the attraction between ions.

D) A bond formed by the overlap of d orbitals.

Correct Answer: B) A bond formed by the end-to-end overlap of orbitals.

Reasoning: A sigma bond (σ bond) is formed by the end-to-end overlap of atomic orbitals, such as s orbitals or p orbitals along the internuclear axis. This type of bond is the strongest form of covalent bond and allows for free rotation around the bond axis.

MCAT General Chemistry Question 29

Which of the following explains why noble gases are chemically inert?

A) They have incomplete valence electron shells.

B) They have high ionization energies and low electron affinities.

C) They form stable covalent bonds with other elements.

D) They readily lose or gain electrons to achieve a stable configuration.

Correct Answer: B) They have high ionization energies and low electron affinities.

Reasoning: Noble gases are chemically inert because they have a complete valence electron shell, resulting in high ionization energies and low electron affinities. This stable electron configuration makes them unlikely to form bonds with other elements.

MCAT General Chemistry Question 30

Which of the following describes the process of sublimation?

A) The transition from solid to liquid.

B) The transition from liquid to gas.

C) The transition from solid to gas.

D) The transition from gas to solid.

Correct Answer: C) The transition from solid to gas.

Reasoning: Sublimation is the process where a solid changes directly into a gas without passing through the liquid state. This phase transition occurs under specific temperature and pressure conditions.

MCAT General Chemistry Question 31

Which of the following correctly describes the concept of an azeotrope?

A) A mixture of two liquids that has a constant boiling point and composition throughout distillation.

B) A compound that forms crystals with a high degree of symmetry.

C) A solution that exhibits a maximum boiling point.

D) A mixture that cannot be separated by filtration.

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Website : www.tutorSTEM.caMCAT Page : www.tutorSTEM.ca/mcatPhone Number for Tutor STEM's Medical School MCAT Department : [416-795-5000](tel:416-795-5000)**Correct Answer: A) A mixture of two liquids that has a constant boiling point and composition throughout distillation.**

Reasoning: An azeotrope is a mixture of two or more liquids that has a constant boiling point and retains the same composition of components in both the liquid and vapor phase during distillation. This occurs because the components interact in such a way that they cannot be separated by simple distillation.

MCAT General Chemistry Question 32

Which of the following best describes the principle of Hund's Rule?

- A) Electrons fill orbitals starting with the lowest energy level.
- B) Electrons fill orbitals in pairs with opposite spins.
- C) Electrons fill degenerate orbitals singly before pairing up.
- D) The total number of electrons in an atom is equal to its atomic number.

Correct Answer: C) Electrons fill degenerate orbitals singly before pairing up.

Reasoning: Hund's Rule states that electrons will fill degenerate (equal energy) orbitals singly, with parallel spins, before pairing up. This minimizes electron-electron repulsion and results in a more stable electron configuration.

MCAT General Chemistry Question 33

Which of the following best describes the process of titration?

- A) The separation of a mixture into its components.
- B) The measurement of the concentration of a solution by reaction with a standard solution.
- C) The formation of a precipitate from a solution.
- D) The vaporization of a liquid into a gas.

Correct Answer: B) The measurement of the concentration of a solution by reaction with a standard solution.

Reasoning: Titration is a quantitative analytical technique used to determine the concentration of a solution by reacting it with a standard solution of known concentration. The point at which the reaction is complete is typically indicated by a color change (endpoint).

MCAT General Chemistry Question 34

Which of the following correctly describes the relationship between pH and pK_a ?

- A) When $pH < pK_a$, the acidic form predominates.
- B) When $pH > pK_a$, the acidic form predominates.
- C) When $pH = pK_a$, the basic form predominates.
- D) When $pH = pK_a$, the solution is neutral.

Correct Answer: A) When $pH < pK_a$, the acidic form predominates.

Reasoning: When the pH of a solution is less than the pK_a of an acidic group, the protonated (acidic) form of the group predominates. Conversely, when the pH is greater than the pK_a , the deprotonated (basic) form predominates. When $pH = pK_a$, the concentrations of the protonated and deprotonated forms are equal.

MCAT General Chemistry Question 35

Which of the following best explains why transition metals often form colored compounds?

- A) They have incomplete s orbitals.
- B) They can form covalent bonds with nonmetals.
- C) They have partially filled d orbitals that allow d-d electronic transitions.
- D) They are highly reactive and readily form compounds.

Correct Answer: C) They have partially filled d orbitals that allow d-d electronic transitions.

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Reasoning: Transition metals often form colored compounds due to the presence of partially filled d orbitals. When light is absorbed, electrons can be excited from one d orbital to another (d-d transitions), resulting in the characteristic colors of these compounds.

MCAT General Chemistry Question 36

Which of the following best describes the concept of molality (m)?

- A) Moles of solute per liter of solution.
- B) Moles of solute per kilogram of solvent.
- C) Grams of solute per liter of solution.
- D) Grams of solute per kilogram of solvent.

Correct Answer: B) Moles of solute per kilogram of solvent.

Reasoning: Molality (m) is defined as the number of moles of solute per kilogram of solvent. It is a concentration unit that, unlike molarity, does not change with temperature because it depends on the mass of the solvent rather than the volume of the solution.

MCAT General Chemistry Question 37

Which of the following is the correct name for the compound with the formula KClO_3 ?

- A) Potassium chloride
- B) Potassium chlorate
- C) Potassium perchlorate
- D) Potassium hypochlorite

Correct Answer: B) Potassium chlorate

Reasoning: The compound KClO_3 is named potassium chlorate. It consists of potassium (K^+) cations and chlorate (ClO_3^-) anions. The name reflects the oxidation state of chlorine in the chlorate ion, which is +5.

MCAT General Chemistry Question 38

Which of the following correctly describes the relationship between pressure and volume in Boyle's Law?

- A) Pressure and volume are directly proportional.
- B) Pressure and volume are inversely proportional.
- C) Pressure and volume are not related.
- D) Pressure and volume are equal at all temperatures.

Correct Answer: B) Pressure and volume are inversely proportional.

Reasoning: Boyle's Law states that for a given amount of gas at constant temperature, the pressure and volume are inversely proportional. This means that as the volume of the gas decreases, the pressure increases, and vice versa, as described by the equation $P_1V_1 = P_2V_2$.

MCAT General Chemistry Question 39

Which of the following best explains why acids are able to donate protons?

- A) They have a high concentration of electrons.
- B) They have lone pairs of electrons available for donation.
- C) They have hydrogen atoms bonded to electronegative elements, making the hydrogen atom partially positive and thus easier to donate as a proton.
- D) They form strong ionic bonds with bases.

Correct Answer: C) They have hydrogen atoms bonded to electronegative elements, making the hydrogen atom partially positive and thus easier to donate as a proton.

Reasoning: Acids are able to donate protons (H^+) because they have hydrogen atoms bonded to electronegative elements such as oxygen or chlorine. These electronegative elements pull electron density away from the hydrogen atom, making it partially positive and more easily released as a proton.

Website : www.tutorSTEM.caMCAT Page : www.tutorSTEM.ca/mcatPhone Number for Tutor STEM's Medical School MCAT Department : [416-795-5000](tel:416-795-5000)**MCAT General Chemistry Question 40**

Which of the following is true about the boiling point of a solution compared to the boiling point of the pure solvent?

- A) The boiling point of the solution is lower than that of the pure solvent.
- B) The boiling point of the solution is higher than that of the pure solvent.
- C) The boiling point of the solution is the same as that of the pure solvent.
- D) The boiling point of the solution varies depending on the solute concentration but is not necessarily higher or lower than that of the pure solvent.

Correct Answer: B) The boiling point of the solution is higher than that of the pure solvent.

Reasoning: The boiling point of a solution is higher than that of the pure solvent due to boiling point elevation, a colligative property. The presence of a non-volatile solute lowers the vapor pressure of the solvent, requiring a higher temperature to reach the boiling point.

MCAT General Chemistry Question 41

Which of the following statements is true regarding the relationship between the rate of a reaction and the activation energy?

- A) The rate of a reaction is independent of the activation energy.
- B) The rate of a reaction decreases as the activation energy increases.
- C) The rate of a reaction increases as the activation energy increases.
- D) The rate of a reaction is only dependent on the concentration of reactants, not activation energy.

Correct Answer: B) The rate of a reaction decreases as the activation energy increases.

Reasoning: The rate of a reaction decreases as the activation energy increases because higher activation energy means that fewer reactant molecules have sufficient energy to overcome the energy barrier and form products. The Arrhenius equation shows this inverse relationship between the rate constant (k) and activation energy (E_a).

MCAT General Chemistry Question 42

Which of the following best describes a voltaic (galvanic) cell?

- A) A device that converts electrical energy into chemical energy.
- B) A device that converts chemical energy into electrical energy.
- C) A device that converts mechanical energy into electrical energy.
- D) A device that converts light energy into electrical energy.

Correct Answer: B) A device that converts chemical energy into electrical energy.

Reasoning: A voltaic (galvanic) cell is an electrochemical cell that converts chemical energy into electrical energy through spontaneous redox reactions. The flow of electrons generated by the redox reactions creates an electric current that can be used to do work.

MCAT General Chemistry Question 43

Which of the following describes the concept of vapor pressure?

- A) The pressure exerted by a liquid at its boiling point.
- B) The pressure exerted by a vapor in equilibrium with its liquid or solid phase at a given temperature.
- C) The pressure exerted by a gas at room temperature.
- D) The pressure exerted by a gas during condensation.

Correct Answer: B) The pressure exerted by a vapor in equilibrium with its liquid or solid phase at a given temperature.

Reasoning: Vapor pressure is the pressure exerted by a vapor in equilibrium with its liquid or solid phase at a given temperature. It reflects the tendency of molecules to escape from the liquid or solid phase into the vapor phase. Vapor pressure increases with temperature.

MCAT General Chemistry Question 44

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Which of the following correctly explains the behavior of a gas according to the kinetic molecular theory?

- A) Gas particles are in constant, random motion and collisions between them are perfectly elastic.
- B) Gas particles are in constant, random motion and collisions between them are inelastic.
- C) Gas particles are at rest and only move when energy is added.
- D) Gas particles are in constant, random motion and collisions between them are perfectly inelastic.

Correct Answer: A) Gas particles are in constant, random motion and collisions between them are perfectly elastic.

Reasoning: According to the kinetic molecular theory, gas particles are in constant, random motion, and collisions between them and with the walls of the container are perfectly elastic. This means that there is no net loss of kinetic energy during collisions, and the average kinetic energy of gas particles is proportional to the temperature.

MCAT General Chemistry Question 45

Which of the following best describes the relationship between the number of protons in an atom and its chemical properties?

- A) The number of protons determines the atomic mass of the atom.
- B) The number of protons determines the chemical properties of the atom.
- C) The number of protons determines the number of neutrons in the atom.
- D) The number of protons determines the physical state of the atom.

Correct Answer: B) The number of protons determines the chemical properties of the atom.

Reasoning: The number of protons in an atom, also known as the atomic number, determines the element's identity and its chemical properties. The chemical behavior of an element is largely influenced by its electron configuration, which is directly related to the number of protons in the nucleus.

MCAT General Chemistry Question 46

Which of the following correctly describes a Bronsted-Lowry acid?

- A) A substance that donates a proton (H^+).
- B) A substance that accepts a proton (H^+).
- C) A substance that donates an electron pair.
- D) A substance that accepts an electron pair.

Correct Answer: A) A substance that donates a proton (H^+).

Reasoning: A Bronsted-Lowry acid is defined as a substance that donates a proton (H^+) to another substance. In contrast, a Bronsted-Lowry base is a substance that accepts a proton.

MCAT General Chemistry Question 47

Which of the following correctly explains why metallic solids are good conductors of electricity?

- A) Their electrons are tightly bound to the nuclei.
- B) Their electrons are free to move throughout the lattice.
- C) Their atoms are held together by ionic bonds.
- D) Their atoms are held together by covalent bonds.

Correct Answer: B) Their electrons are free to move throughout the lattice.

Reasoning: Metallic solids are good conductors of electricity because they have a "sea of electrons" that are free to move throughout the metal lattice. These delocalized electrons can carry an electric current through the material.

MCAT General Chemistry Question 48

Which of the following best describes the concept of half-life in the context of radioactive decay?

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- A) The time required for half of the atoms in a sample to decay.
B) The time required for all of the atoms in a sample to decay.
C) The time required for half of the sample to change its phase.
D) The time required for a radioactive substance to become stable.

Correct Answer: A) The time required for half of the atoms in a sample to decay.

Reasoning: The half-life of a radioactive substance is the time required for half of the atoms in a sample to undergo radioactive decay. It is a measure of the rate at which a radioactive substance decays and is specific to each isotope.

MCAT General Chemistry Question 49

Which of the following describes the primary intermolecular force present in liquid ammonia (NH_3)?

- A) London dispersion forces
B) Dipole-dipole interactions
C) Hydrogen bonding
D) Ionic bonding

Correct Answer: C) Hydrogen bonding

Reasoning: Liquid ammonia (NH_3) exhibits hydrogen bonding as its primary intermolecular force. Hydrogen bonds form between the hydrogen atom of one ammonia molecule and the lone pair of electrons on the nitrogen atom of another ammonia molecule, resulting in strong intermolecular attractions.

MCAT General Chemistry Question 50

Which of the following best explains the principle of Hess's Law?

- A) The total enthalpy change of a reaction is independent of the pathway taken.
B) The entropy of a system always increases in a spontaneous process.
C) The rate of a reaction is proportional to the concentration of reactants.
D) The equilibrium constant of a reaction is dependent on temperature.

Correct Answer: A) The total enthalpy change of a reaction is independent of the pathway taken.

Reasoning: Hess's Law states that the total enthalpy change of a chemical reaction is the same, regardless of the pathway taken from reactants to products. This principle allows for the calculation of enthalpy changes for complex reactions by summing the enthalpy changes of individual steps.

MCAT General Chemistry Question 51

Which of the following best describes the relationship between the solubility of a gas in a liquid and the temperature?

- A) Solubility increases with increasing temperature.
B) Solubility decreases with increasing temperature.
C) Solubility remains constant with temperature changes.
D) Solubility is not affected by temperature.

Correct Answer: B) Solubility decreases with increasing temperature.

Reasoning: The solubility of a gas in a liquid typically decreases with increasing temperature. As temperature rises, the kinetic energy of gas molecules increases, making it easier for them to escape from the liquid into the gas phase, thus reducing solubility.

MCAT General Chemistry Question 52

Which of the following correctly explains the concept of bond dissociation energy?

- A) The energy required to form a covalent bond.
B) The energy required to break a covalent bond.

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- C) The energy released when an ionic bond is formed.
D) The energy required to separate a molecule into its ions.

Correct Answer: B) The energy required to break a covalent bond.

Reasoning: Bond dissociation energy is the energy required to break a covalent bond in a molecule, resulting in the separation of the bonded atoms. It is a measure of the strength of the bond, with higher dissociation energies indicating stronger bonds.

MCAT General Chemistry Question 53

Which of the following best describes the concept of formal charge in a molecule?

- A) The total number of valence electrons in the molecule.
B) The difference between the number of valence electrons in an atom and the number of electrons assigned to it in a Lewis structure.
C) The number of electrons gained or lost by an atom to form a stable ion.
D) The overall charge of a molecule.

Correct Answer: B) The difference between the number of valence electrons in an atom and the number of electrons assigned to it in a Lewis structure.

Reasoning: Formal charge is calculated by taking the number of valence electrons in a free atom and subtracting the number of non-bonding electrons and half the number of bonding electrons assigned to the atom in a Lewis structure. It helps in determining the most stable Lewis structure for a molecule.

MCAT General Chemistry Question 54

Which of the following best describes the relationship between the number of electrons in a given orbital and the Pauli exclusion principle?

- A) Only one electron can occupy an orbital.
B) Two electrons can occupy an orbital, but they must have opposite spins.
C) Two electrons can occupy an orbital, and they can have the same spin.
D) An unlimited number of electrons can occupy an orbital.

Correct Answer: B) Two electrons can occupy an orbital, but they must have opposite spins.

Reasoning: The Pauli exclusion principle states that no two electrons in an atom can have the same set of four quantum numbers. Therefore, two electrons can occupy the same orbital only if they have opposite spins, ensuring that their quantum numbers differ.

MCAT General Chemistry Question 55

Which of the following best describes the concept of electronegativity?

- A) The ability of an atom to donate electrons.
B) The ability of an atom to attract electrons in a chemical bond.
C) The energy required to remove an electron from an atom.
D) The energy released when an electron is added to an atom.

Correct Answer: B) The ability of an atom to attract electrons in a chemical bond.

Reasoning: Electronegativity is a measure of the tendency of an atom to attract electrons towards itself when it forms a chemical bond. Higher electronegativity indicates a greater ability to attract electrons.

MCAT General Chemistry Question 56

Which of the following best describes the process of nuclear fission?

- A) The splitting of a heavy nucleus into lighter nuclei, accompanied by the release of energy.
B) The combining of light nuclei to form a heavier nucleus, accompanied by the release of energy.
C) The decay of an unstable nucleus into a stable nucleus.
D) The absorption of a neutron by a nucleus.

Website : www.tutorSTEM.caMCAT Page : www.tutorSTEM.ca/mcatPhone Number for Tutor STEM's Medical School MCAT Department : [416-795-5000](tel:416-795-5000)**Correct Answer: A) The splitting of a heavy nucleus into lighter nuclei, accompanied by the release of energy.**

Reasoning: Nuclear fission is the process in which a heavy nucleus splits into two or more lighter nuclei, releasing a significant amount of energy. This process is used in nuclear reactors and atomic bombs.

MCAT General Chemistry Question 57

Which of the following best describes the principle of colligative properties?

- A) They depend on the identity of the solute particles.
- B) They depend on the number of solute particles in a solution.
- C) They depend on the chemical nature of the solvent.
- D) They depend on the volume of the solution.

Correct Answer: B) They depend on the number of solute particles in a solution.

Reasoning: Colligative properties are properties of a solution that depend on the number of solute particles present, not their identity. Examples include boiling point elevation, freezing point depression, vapor pressure lowering, and osmotic pressure.

MCAT General Chemistry Question 58

Which of the following correctly describes the relationship between enthalpy (ΔH) and internal energy (ΔU) in a chemical reaction at constant pressure?

- A) $\Delta H = \Delta U - P\Delta V$
- B) $\Delta H = \Delta U + P\Delta V$
- C) $\Delta H = \Delta U - V\Delta P$
- D) $\Delta H = \Delta U + V\Delta P$

Correct Answer: B) $\Delta H = \Delta U + P\Delta V$

Reasoning: At constant pressure, the change in enthalpy (ΔH) is related to the change in internal energy (ΔU) by the equation $\Delta H = \Delta U + P\Delta V$, where P is pressure and ΔV is the change in volume. This equation accounts for the work done by the system during expansion or compression.

MCAT General Chemistry Question 59

Which of the following describes the main feature of a polar covalent bond?

- A) Electrons are shared equally between atoms.
- B) Electrons are transferred completely from one atom to another.
- C) Electrons are shared unequally between atoms, resulting in partial charges.
- D) Electrons are delocalized over multiple atoms.

Correct Answer: C) Electrons are shared unequally between atoms, resulting in partial charges.

Reasoning: In a polar covalent bond, electrons are shared unequally between atoms due to differences in electronegativity. This unequal sharing creates partial positive and negative charges on the bonded atoms, leading to a dipole moment.

MCAT General Chemistry Question 60

Which of the following best describes the different forms of heat transfer and their mechanisms?

- A) Conduction involves the transfer of heat through fluid motion, convection involves the transfer of heat through direct contact, and radiation involves the transfer of heat through electromagnetic waves.
- B) Conduction involves the transfer of heat through direct contact, convection involves the transfer of heat through fluid motion, and radiation involves the transfer of heat through electromagnetic waves.
- C) Conduction involves the transfer of heat through electromagnetic waves, convection involves the transfer of heat through fluid motion, and radiation involves the transfer of heat through direct contact.
- D) Conduction involves the transfer of heat through direct contact, convection involves the transfer of heat through electromagnetic waves, and radiation involves the transfer of heat through fluid motion.

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Correct Answer: B) Conduction involves the transfer of heat through direct contact, convection involves the transfer of heat through fluid motion, and radiation involves the transfer of heat through electromagnetic waves.

Reasoning: Heat transfer can occur through three primary mechanisms: conduction, convection, and radiation.

- **Conduction** is the transfer of heat through direct contact between molecules. It occurs in solids, liquids, and gases but is most effective in solids where molecules are closely packed. Heat is transferred from the hotter part of the object to the cooler part through molecular collisions and vibrations. For example, a metal rod becoming hot when one end is placed in a flame.
- **Convection** is the transfer of heat through the movement of fluids (liquids or gases). It involves the bulk movement of the fluid, carrying heat energy with it. This can occur naturally due to density differences caused by temperature variations (natural convection) or can be forced by external means such as a pump or fan (forced convection). For example, boiling water, where hot water rises and cooler water descends.
- **Radiation** is the transfer of heat through electromagnetic waves, such as infrared radiation. It does not require a medium and can occur in a vacuum. All objects emit and absorb radiant energy, and the amount of radiation emitted increases with temperature. For example, the heat felt from the Sun or a glowing incandescent bulb.

Each form of heat transfer operates through distinct mechanisms and is relevant in various physical contexts, from everyday experiences to industrial applications and natural phenomena.

MCAT General Chemistry Question 61

Which of the following best describes the principle behind chromatography?

- A) The separation of compounds based on their boiling points.
- B) The separation of compounds based on their solubility in a solvent.
- C) The separation of compounds based on their distribution between a stationary phase and a mobile phase.
- D) The separation of compounds based on their ability to form ionic bonds.

Correct Answer: C) The separation of compounds based on their distribution between a stationary phase and a mobile phase.

Reasoning: Chromatography separates compounds based on their differential distribution between a stationary phase (solid or liquid) and a mobile phase (liquid or gas). Compounds that interact more strongly with the stationary phase move more slowly, while those that interact less move more quickly.

MCAT General Chemistry Question 62

Which of the following best describes the process of adsorption?

- A) The uptake of molecules into the interior of a solid or liquid.
- B) The separation of a mixture into its components.
- C) The adherence of molecules to the surface of a solid or liquid.
- D) The formation of a homogeneous mixture.

Correct Answer: C) The adherence of molecules to the surface of a solid or liquid.

Reasoning: Adsorption is the process in which molecules adhere to the surface of a solid or liquid. This is different from absorption, where molecules are taken up into the interior of the solid or liquid. Adsorption is a surface phenomenon and is important in various chemical and industrial processes.

MCAT General Chemistry Question 63

Which of the following best describes the role of a salt bridge in a galvanic cell?

- A) It provides a path for the flow of electrons.
- B) It maintains electrical neutrality by allowing the flow of ions.
- C) It separates the anode and cathode compartments.
- D) It increases the cell voltage by storing charge.

Correct Answer: B) It maintains electrical neutrality by allowing the flow of ions.

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Reasoning: In a galvanic cell, the salt bridge allows ions to flow between the anode and cathode compartments to maintain electrical neutrality. Without a salt bridge, the build-up of charge would stop the flow of electrons and the reaction would cease.

MCAT General Chemistry Question 64

Which of the following correctly describes the principle behind a calorimeter?

- A) It measures the heat transfer associated with chemical reactions.
- B) It measures the electrical conductivity of solutions.
- C) It measures the rate of chemical reactions.
- D) It measures the pressure changes in a system.

Correct Answer: A) It measures the heat transfer associated with chemical reactions.

Reasoning: A calorimeter is an instrument used to measure the amount of heat transferred to or from a substance during a chemical or physical process. This measurement allows for the determination of enthalpy changes and specific heats.

MCAT General Chemistry Question 65

Which of the following best explains the concept of effective nuclear charge (Z_{eff})?

- A) The total number of protons in an atom.
- B) The net positive charge experienced by valence electrons.
- C) The number of neutrons in the nucleus.
- D) The attraction between protons and neutrons in the nucleus.

Correct Answer: B) The net positive charge experienced by valence electrons.

Reasoning: Effective nuclear charge (Z_{eff}) is the net positive charge felt by valence electrons after accounting for the shielding effect of inner-shell electrons. It is calculated as $Z_{\text{eff}} = Z - S$, where Z is the atomic number and S is the shielding constant.

MCAT General Chemistry Question 66

Which of the following best describes the concept of an equilibrium constant (K_{eq})?

- A) The rate at which reactants are converted to products.
- B) The ratio of the concentration of products to reactants at equilibrium.
- C) The energy required to reach the transition state.
- D) The speed at which equilibrium is reached.

Correct Answer: B) The ratio of the concentration of products to reactants at equilibrium.

Reasoning: The equilibrium constant (K_{eq}) is the ratio of the concentration of the products to the concentration of the reactants, each raised to the power of their stoichiometric coefficients, at equilibrium. It provides a measure of the extent of a reaction.

MCAT General Chemistry Question 67

Which of the following statements best describes the criteria for a spontaneous reaction in terms of Gibbs free energy (ΔG)?

- A) A reaction is spontaneous if ΔG is positive, indicating that energy is absorbed by the system.
- B) A reaction is spontaneous if ΔG is negative, indicating that energy is released by the system.
- C) A reaction is non-spontaneous if ΔG is negative, indicating that energy is absorbed by the system.
- D) A reaction is non-spontaneous if ΔG is zero, indicating that the system is at equilibrium.

Correct Answer: B) A reaction is spontaneous if ΔG is negative, indicating that energy is released by the system.

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Reasoning: The spontaneity of a chemical reaction is determined by the Gibbs free energy change (ΔG) of the system. Gibbs free energy is a thermodynamic potential that combines enthalpy, entropy, and temperature to predict the direction of chemical processes.

- **Spontaneous reactions** occur without the need for an external energy input and are characterized by a negative ΔG ($\Delta G < 0$). This negative value indicates that the reaction releases free energy, making the process thermodynamically favorable.
- **Non-spontaneous reactions** require an input of energy to proceed and are characterized by a positive ΔG ($\Delta G > 0$). This positive value indicates that the reaction absorbs free energy, making the process thermodynamically unfavorable without external energy input.
- When ΔG is zero ($\Delta G = 0$), the system is at equilibrium, meaning there is no net change in the concentrations of reactants and products, and the forward and reverse reactions occur at the same rate.

Therefore, a reaction is considered spontaneous if it has a negative ΔG , indicating that the process releases energy and is thermodynamically favorable.

MCAT General Chemistry Question 68

Which of the following best describes the process of oxidation in a redox reaction?

- A) The gain of electrons and a decrease in oxidation number.
- B) The loss of electrons and an increase in oxidation number.
- C) The gain of protons and an increase in oxidation number.
- D) The loss of protons and a decrease in oxidation number.

Correct Answer: B) The loss of electrons and an increase in oxidation number.

Reasoning: Oxidation is the process in which an atom, ion, or molecule loses electrons, resulting in an increase in its oxidation number. This process is a key component of redox (reduction-oxidation) reactions, where the substance that is oxidized donates electrons to the substance that is reduced.

MCAT General Chemistry Question 69

Which of the following best describes the difference between a galvanic cell and an electrolytic cell?

- A) A galvanic cell requires an external power source to drive the reaction, while an electrolytic cell generates electrical energy spontaneously.
- B) A galvanic cell generates electrical energy from spontaneous redox reactions, while an electrolytic cell uses electrical energy to drive non-spontaneous redox reactions.
- C) In a galvanic cell, oxidation occurs at the cathode, while in an electrolytic cell, oxidation occurs at the anode.
- D) Both galvanic and electrolytic cells operate only in aqueous solutions.

Correct Answer: B) A galvanic cell generates electrical energy from spontaneous redox reactions, while an electrolytic cell uses electrical energy to drive non-spontaneous redox reactions.

Reasoning: A galvanic (or voltaic) cell converts chemical energy into electrical energy through spontaneous redox reactions, producing a flow of electrons and generating an electric current. In contrast, an electrolytic cell uses an external power source to provide the energy needed to drive non-spontaneous redox reactions, thereby consuming electrical energy to induce chemical changes.

MCAT General Chemistry Question 70

Which of the following best describes the relationship between bond energy and bond length?

- A) Bond energy increases as bond length increases.
- B) Bond energy decreases as bond length increases.
- C) Bond energy and bond length are not related.
- D) Bond energy and bond length are directly proportional.

Correct Answer: B) Bond energy decreases as bond length increases.

Reasoning: Bond energy is the amount of energy required to break a bond between two atoms. Generally, as bond length increases, the bond energy decreases because longer bonds are typically weaker and easier to break.

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MCAT General Chemistry Question 71

Which of the following best describes the principle of Dalton's Law of Partial Pressures?

- A) The total pressure exerted by a gas mixture is equal to the sum of the partial pressures of each individual gas.
- B) The volume of a gas is directly proportional to its temperature at constant pressure.
- C) The pressure of a gas is inversely proportional to its volume at constant temperature.
- D) The rate of effusion of a gas is inversely proportional to the square root of its molar mass.

Correct Answer: A) The total pressure exerted by a gas mixture is equal to the sum of the partial pressures of each individual gas.

Reasoning: Dalton's Law of Partial Pressures states that in a mixture of non-reacting gases, the total pressure is equal to the sum of the partial pressures of the individual gases. Each gas exerts a pressure independent of the others.

MCAT General Chemistry Question 72

Which of the following best describes the concept of a Lewis acid?

- A) A substance that donates a proton (H^+).
- B) A substance that accepts a pair of electrons.
- C) A substance that donates a pair of electrons.
- D) A substance that accepts a proton (H^+).

Correct Answer: B) A substance that accepts a pair of electrons.

Reasoning: A Lewis acid is defined as a substance that accepts a pair of electrons to form a covalent bond. This concept broadens the definition of acids and bases beyond proton transfer to include electron pair transfer.

MCAT General Chemistry Question 73

Which of the following molecules has a trigonal bipyramidal molecular geometry according to VSEPR theory?

- A) Methane (CH_4)
- B) Phosphorus pentachloride (PCl_5)
- C) Sulfur hexafluoride (SF_6)
- D) Ammonia (NH_3)

Correct Answer: B) Phosphorus pentachloride (PCl_5)

Reasoning: According to VSEPR theory, the shape of a molecule is determined by the repulsion between electron pairs around the central atom.

- **Methane (CH_4)** has four bonding pairs and no lone pairs around the central carbon atom, resulting in a tetrahedral geometry.
- **Phosphorus pentachloride (PCl_5)** has five bonding pairs and no lone pairs around the central phosphorus atom, resulting in a trigonal bipyramidal geometry. The five pairs of bonding electrons are arranged to minimize repulsion, with three pairs in the equatorial plane and two pairs in the axial positions.
- **Sulfur hexafluoride (SF_6)** has six bonding pairs and no lone pairs around the central sulfur atom, resulting in an octahedral geometry.
- **Ammonia (NH_3)** has three bonding pairs and one lone pair around the central nitrogen atom, resulting in a trigonal pyramidal geometry.

Therefore, among the given options, only phosphorus pentachloride (PCl_5) exhibits a trigonal bipyramidal molecular geometry.

MCAT General Chemistry Question 74

Which of the following best describes the difference between ionic compounds and covalent compounds?

- A) Ionic compounds are formed by the sharing of electrons, while covalent compounds are formed by the transfer of electrons.
- B) Ionic compounds typically have lower melting and boiling points than covalent compounds.
- C) Ionic compounds are formed by the transfer of electrons, resulting in the formation of ions, while covalent compounds are formed by the sharing of electrons between atoms.
- D) Ionic compounds are generally insoluble in water, whereas covalent compounds are usually soluble in water.

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Correct Answer: C) Ionic compounds are formed by the transfer of electrons, resulting in the formation of ions, while covalent compounds are formed by the sharing of electrons between atoms.

Reasoning: Ionic compounds are formed when electrons are transferred from one atom to another, leading to the creation of positively and negatively charged ions that are held together by electrostatic forces. Covalent compounds, on the other hand, are formed when atoms share electrons to achieve stable electron configurations, resulting in molecules held together by covalent bonds.

MCAT General Chemistry Question 75

Which of the following best describes the concept of a conjugate acid-base pair?

- A) A pair of compounds that differ by one proton.
- B) A pair of compounds that differ by one electron.
- C) A pair of compounds that differ by one neutron.
- D) A pair of compounds that have the same number of protons.

Correct Answer: A) A pair of compounds that differ by one proton.

Reasoning: A conjugate acid-base pair consists of two species that differ by a single proton (H^+). The acid donates a proton to form its conjugate base, while the base accepts a proton to form its conjugate acid.

MCAT General Chemistry Question 76

Which of the following best describes the nature of dipole-dipole interactions in molecular compounds?

- A) Dipole-dipole interactions occur between nonpolar molecules due to temporary dipoles.
- B) Dipole-dipole interactions occur between molecules with permanent dipoles, aligning positive and negative ends.
- C) Dipole-dipole interactions are the strongest type of intermolecular forces.
- D) Dipole-dipole interactions only occur in ionic compounds.

Correct Answer: B) Dipole-dipole interactions occur between molecules with permanent dipoles, aligning positive and negative ends.

Reasoning: Dipole-dipole interactions are intermolecular forces that occur between polar molecules, which have permanent dipoles due to differences in electronegativity between atoms within the molecules. These interactions arise because the positive end of one dipole is attracted to the negative end of another dipole, leading to an overall attractive force between the molecules. For example, in a sample of hydrogen chloride (HCl) molecules, the partially positive hydrogen atoms are attracted to the partially negative chlorine atoms of neighboring molecules, creating dipole-dipole attractions.

Unlike London dispersion forces, which are temporary and occur in all molecules, dipole-dipole interactions are specific to molecules with permanent dipoles. They are generally stronger than dispersion forces but weaker than hydrogen bonds and ionic interactions. These interactions play a significant role in determining the physical properties, such as boiling and melting points, of polar compounds.

MCAT General Chemistry Question 77

Which of the following best describes the principle of the conservation of energy?

- A) Energy can be created or destroyed but not transferred.
- B) Energy can be transferred or transformed but not created or destroyed.
- C) Energy is always conserved in open systems but not in closed systems.
- D) Energy is conserved only in exothermic reactions.

Correct Answer: B) Energy can be transferred or transformed but not created or destroyed.

Reasoning: The principle of the conservation of energy states that energy cannot be created or destroyed; it can only be transferred or transformed from one form to another. This principle is fundamental to all physical and chemical processes.

MCAT General Chemistry Question 78

Which of the following correctly describes the trend in atomic radius across a period in the periodic table?

- A) Atomic radius increases from left to right across a period.
- B) Atomic radius decreases from left to right across a period.

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- C) Atomic radius remains constant across a period.
D) Atomic radius increases, then decreases across a period.

Correct Answer: B) Atomic radius decreases from left to right across a period.

Reasoning: As you move from left to right across a period in the periodic table, the number of protons in the nucleus increases, resulting in a greater positive charge. This increased nuclear charge pulls the electrons closer to the nucleus, thereby decreasing the atomic radius. Additionally, electrons are being added to the same principal energy level, so the effect of increased nuclear charge is not offset by increased shielding, leading to a smaller atomic size.

MCAT General Chemistry Question 79

Which of the following best describes the behavior of gases according to the ideal gas law?

- A) Gases behave ideally at high pressures and low temperatures.
B) Gases behave ideally at low pressures and high temperatures.
C) Gases behave ideally at low pressures and low temperatures.
D) Gases behave ideally at high pressures and high temperatures.

Correct Answer: B) Gases behave ideally at low pressures and high temperatures.

Reasoning: Gases behave most ideally under conditions of low pressure and high temperature. Under these conditions, intermolecular forces and the volume of gas molecules become negligible, allowing the gas to follow the ideal gas law more closely.

MCAT General Chemistry Question 80

Which of the following statements correctly describes the Zeroth, First, and Second Laws of Thermodynamics?

- A) The Zeroth Law states that energy cannot be created or destroyed, the First Law states that the entropy of an isolated system always increases, and the Second Law states that if two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other.
B) The Zeroth Law states that if two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other, the First Law states that energy cannot be created or destroyed, and the Second Law states that the entropy of an isolated system always increases.
C) The Zeroth Law states that if two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other, the First Law states that the entropy of an isolated system always increases, and the Second Law states that energy cannot be created or destroyed.
D) The Zeroth Law states that energy cannot be created or destroyed, the First Law states that if two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other, and the Second Law states that the entropy of an isolated system always increases.

Correct Answer: B) The Zeroth Law states that if two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other, the First Law states that energy cannot be created or destroyed, and the Second Law states that the entropy of an isolated system always increases.

Reasoning: The laws of thermodynamics describe the principles governing energy transfer and the behavior of thermodynamic systems:

- **Zeroth Law of Thermodynamics:** This law establishes the concept of temperature and thermal equilibrium. It states that if two systems are each in thermal equilibrium with a third system, then they are in thermal equilibrium with each other. This principle allows the definition of temperature as a measurable and comparable property.
- **First Law of Thermodynamics:** Also known as the Law of Energy Conservation, it states that energy cannot be created or destroyed, only transferred or transformed from one form to another. Mathematically, it is expressed as: $\Delta U = Q - W$ where ΔU is the change in internal energy of a system, Q is the heat added to the system, and W is the work done by the system.
- **Second Law of Thermodynamics:** This law introduces the concept of entropy, a measure of disorder or randomness. It states that the total entropy of an isolated system can never decrease over time; it can only increase or remain constant in ideal cases. This implies that natural processes tend to move towards a state of greater disorder and that energy transformations are not 100% efficient, as some energy is always dissipated as heat.

These fundamental laws are essential for understanding thermodynamic processes, energy transfer, and the behavior of systems in thermal, mechanical, and chemical contexts.

MCAT General Chemistry Question 81

Which of the following best describes an isothermal process in the context of thermodynamics?

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- A) An isothermal process occurs at constant pressure, with no change in temperature.
B) An isothermal process occurs at constant volume, with no change in temperature.
C) An isothermal process occurs at constant temperature, where the internal energy of the system changes.
D) An isothermal process occurs at constant temperature, with no change in the internal energy of the system.

Correct Answer: D) An isothermal process occurs at constant temperature, with no change in the internal energy of the system.

Reasoning: In thermodynamics, an isothermal process is one that occurs at a constant temperature. During an isothermal process, the temperature of the system remains unchanged. Because the internal energy of an ideal gas depends solely on its temperature, if the temperature remains constant, the internal energy also remains constant.

In an isothermal process involving an ideal gas, any heat (q) added to the system is used to do work (W) by the system, or conversely, any work done on the system results in the transfer of an equivalent amount of heat out of the system. The relationship can be described by the first law of thermodynamics:

$$\Delta U = q - W$$

For an isothermal process:

$$\Delta U = 0$$

Thus:

$$q = W$$

This means that all the heat added to the system is converted into work done by the system, or all the work done on the system is balanced by the heat removed from it, maintaining the constant temperature.

Isothermal processes are idealized and occur slowly enough to allow the system to remain in thermal equilibrium with its surroundings, ensuring the temperature stays constant. These processes are significant in understanding the behavior of gases and the work done during thermodynamic cycles, such as in the Carnot cycle.

MCAT General Chemistry Question 82

Which of the following best describes the concept of ionization energy?

- A) The energy required to add an electron to an atom.
B) The energy released when an electron is added to an atom.
C) The energy required to remove an electron from an atom.
D) The energy released when a proton is removed from an atom.

Correct Answer: C) The energy required to remove an electron from an atom.

Reasoning: Ionization energy is the amount of energy required to remove an electron from a gaseous atom or ion. It reflects the attraction between the nucleus and the electrons; higher ionization energy indicates a stronger attraction.

MCAT General Chemistry Question 83

Which of the following best describes the concept of molarity?

- A) Moles of solute per liter of solution.
B) Moles of solute per kilogram of solvent.
C) Grams of solute per liter of solution.
D) Grams of solute per kilogram of solvent.

Correct Answer: A) Moles of solute per liter of solution.

Reasoning: Molarity (M) is a measure of concentration, defined as the number of moles of solute dissolved in one liter of solution. It is commonly used to express the concentration of solutions in chemistry.

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Website : www.tutorSTEM.caMCAT Page : www.tutorSTEM.ca/mcatPhone Number for Tutor STEM's Medical School MCAT Department : [416-795-5000](tel:416-795-5000)**MCAT General Chemistry Question 84**

Which of the following statements correctly describes the nature of hydrogen bonds in molecular compounds?

- A) Hydrogen bonds occur between any hydrogen atom and a nearby atom.
- B) Hydrogen bonds occur only between hydrogen atoms and oxygen atoms within the same molecule.
- C) Hydrogen bonds occur between a hydrogen atom covalently bonded to a highly electronegative atom and a nearby electronegative atom with a lone pair of electrons.
- D) Hydrogen bonds are the strongest type of intramolecular forces.

Correct Answer: C) Hydrogen bonds occur between a hydrogen atom covalently bonded to a highly electronegative atom and a nearby electronegative atom with a lone pair of electrons.

Reasoning: Hydrogen bonds are a special type of dipole-dipole interaction that occur specifically when a hydrogen atom is covalently bonded to a highly electronegative atom, such as nitrogen (N), oxygen (O), or fluorine (F). The high electronegativity of these atoms results in a significant partial positive charge on the hydrogen atom and a partial negative charge on the electronegative atom.

The hydrogen bond forms between this partially positive hydrogen atom and a nearby electronegative atom (N, O, or F) with a lone pair of electrons. For example, in water (H_2O), hydrogen bonds form between the hydrogen atom of one water molecule and the oxygen atom of another water molecule.

Hydrogen bonds are stronger than typical dipole-dipole interactions and London dispersion forces but weaker than covalent and ionic bonds. They play a crucial role in determining the properties of many substances, including the high boiling and melting points of water, the secondary and tertiary structures of proteins, and the stability of nucleic acid structures like DNA.

MCAT General Chemistry Question 85

Which of the following statements accurately describes a fundamental aspect of atomic structure?

- A) Protons and neutrons have nearly the same mass and are found in the electron cloud surrounding the nucleus.
- B) Electrons are much lighter than protons and neutrons and are found in the nucleus.
- C) Protons have a positive charge, neutrons have no charge, and electrons have a negative charge, with protons and neutrons located in the nucleus and electrons in the electron cloud.
- D) The number of protons in an atom is always equal to the number of neutrons.

Correct Answer: C) Protons have a positive charge, neutrons have no charge, and electrons have a negative charge, with protons and neutrons located in the nucleus and electrons in the electron cloud.

Reasoning: The atomic structure consists of three primary subatomic particles: protons, neutrons, and electrons.

- **Protons:** These subatomic particles are found in the nucleus of the atom and carry a positive charge (+1). The number of protons in the nucleus determines the atomic number and defines the element.
- **Neutrons:** Neutrons are also located in the nucleus of the atom and have no electrical charge (neutral). Neutrons have a mass similar to that of protons and contribute to the overall mass of the atom. The number of neutrons can vary among atoms of the same element, resulting in different isotopes.
- **Electrons:** Electrons are much lighter than protons and neutrons and carry a negative charge (-1). They are found in the electron cloud, which surrounds the nucleus. Electrons occupy various energy levels or orbitals around the nucleus.

The correct and fundamental aspect of atomic structure is that protons and neutrons are located in the nucleus of the atom, while electrons are found in the electron cloud surrounding the nucleus. Protons have a positive charge, neutrons are neutral, and electrons have a negative charge. The mass of protons and neutrons is nearly the same, while electrons are significantly lighter.

Therefore, the statement that accurately describes a fundamental aspect of atomic structure is option C: Protons have a positive charge, neutrons have no charge, and electrons have a negative charge, with protons and neutrons located in the nucleus and electrons in the electron cloud.

MCAT General Chemistry Question 86

A buffer solution is made using ammonia (NH_3) and ammonium chloride (NH_4Cl). Which of the following best describes how the buffer solution responds to the addition of a strong base like NaOH?

- A) The pH of the buffer will significantly increase because NaOH will increase the concentration of OH^- ions without any neutralization.
- B) The ammonium ions (NH_4^+) will react with the added OH^- ions from NaOH, forming more ammonia (NH_3) and water, thereby minimizing the change in pH.
- C) The ammonia (NH_3) will react with the added OH^- ions from NaOH, forming more ammonium ions (NH_4^+), thereby minimizing the change in pH.
- D) The pH of the buffer will significantly decrease because NaOH will decrease the concentration of OH^- ions.

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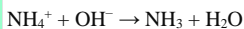
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Website : www.tutorSTEM.caMCAT Page : www.tutorSTEM.ca/mcatPhone Number for Tutor STEM's Medical School MCAT Department : [416-795-5000](tel:416-795-5000)**Correct Answer: B) The ammonium ions (NH_4^+) will react with the added OH^- ions from NaOH, forming more ammonia (NH_3) and water, thereby minimizing the change in pH.**

Reasoning: A buffer solution containing ammonia (NH_3) and its conjugate acid, ammonium chloride (NH_4Cl), resists changes in pH upon the addition of small amounts of a strong acid or base. When NaOH, a strong base, is added to the buffer, the OH^- ions from NaOH will react with the ammonium ions (NH_4^+). This reaction forms more ammonia (NH_3) and water, reducing the concentration of free OH^- ions and thereby minimizing the change in pH:



This conversion of ammonium ions to ammonia helps maintain the pH of the buffer solution within a narrow range, illustrating the buffer's capacity to neutralize added bases. If the buffer were not present, the addition of NaOH would lead to a significant increase in OH^- ion concentration, resulting in a large increase in pH. The buffering action is crucial for maintaining pH stability in various chemical and biological systems.

MCAT General Chemistry Question 87

Which of the following best describes the principle of entropy (ΔS)?

- A) Entropy always decreases in a spontaneous reaction.
- B) Entropy always increases in a spontaneous reaction.
- C) The entropy change can be positive or negative in a spontaneous reaction, but the overall Gibbs free energy change (ΔG) must be negative.
- D) Entropy remains constant in a spontaneous reaction.

Correct Answer: C) The entropy change can be positive or negative in a spontaneous reaction, but the overall Gibbs free energy change (ΔG) must be negative.

Reasoning: In a spontaneous reaction, the overall Gibbs free energy change (ΔG) must be negative. While an increase in entropy ($\Delta S > 0$) generally favors spontaneity, it is possible for a reaction to be spontaneous with a decrease in entropy ($\Delta S < 0$) if the enthalpy change (ΔH) is sufficiently negative. The relationship is described by the Gibbs free energy equation: $\Delta G = \Delta H - T\Delta S$.

MCAT General Chemistry Question 88

Which of the following best describes the process of electron emission in the context of the photoelectric effect?

- A) Electrons are emitted from a metal surface when it is heated to a high temperature.
- B) Electrons are emitted from a metal surface when it is bombarded with high-energy neutrons.
- C) Electrons are emitted from a metal surface when it absorbs photons of sufficient energy.
- D) Electrons are emitted from a metal surface when it is exposed to a magnetic field.

Correct Answer: C) Electrons are emitted from a metal surface when it absorbs photons of sufficient energy.

Reasoning: The photoelectric effect is the phenomenon where electrons are emitted from a metal surface when it absorbs photons with energy equal to or greater than the metal's work function (the minimum energy needed to remove an electron from the surface of the metal). According to the quantum theory, if the energy of the incoming photons ($h\nu$, where h is Planck's constant and ν is the frequency of the light) is greater than the work function, electrons are ejected from the surface. This process demonstrates the particle-like behavior of light and was a key experiment leading to the development of quantum mechanics.

MCAT General Chemistry Question 89

Which of the following best describes the information that can be obtained from a phase change (phase diagram) of a substance?

- A) The phase diagram shows the variation of pressure with volume at constant temperature.
- B) The phase diagram indicates the conditions of temperature and pressure at which distinct phases of a substance coexist in equilibrium.
- C) The phase diagram depicts the energy changes during a chemical reaction.
- D) The phase diagram provides the specific heat capacities of different phases of a substance.

Correct Answer: B) The phase diagram indicates the conditions of temperature and pressure at which distinct phases of a substance coexist in equilibrium.

Reasoning: A phase diagram is a graphical representation that shows the conditions of temperature and pressure under which different phases of a substance (solid, liquid, and gas) coexist in equilibrium. Key features of a phase diagram include:

- **Phase Boundaries:** These lines or curves on the diagram separate different phases and indicate the conditions under which two phases coexist in equilibrium. For example, the line between the solid and liquid regions indicates the melting/freezing points at various pressures.

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- **Triple Point:** This point on the phase diagram represents the unique set of conditions (specific temperature and pressure) at which all three phases (solid, liquid, and gas) coexist in equilibrium.
- **Critical Point:** This point marks the end of the liquid-gas boundary. Beyond this point, the substance exists as a supercritical fluid, where distinct liquid and gas phases do not exist.
- **Regions:** The areas on the phase diagram represent the conditions under which the substance exists solely as a solid, liquid, or gas.

Understanding phase diagrams is crucial for predicting the phase behavior of a substance under various temperature and pressure conditions. For example, a phase diagram can be used to determine the boiling point of a liquid at a given pressure or to understand the conditions necessary to sublime a solid directly into a gas.

Therefore, a phase diagram provides essential information about the equilibrium conditions of different phases of a substance, helping in the analysis of phase transitions and the effects of temperature and pressure on the state of matter.

MCAT General Chemistry Question 90

Which of the following correctly describes the concept of isoelectronic species?

- A) Atoms or ions with the same number of protons.
- B) Atoms or ions with the same number of electrons.
- C) Atoms or ions with the same atomic number.
- D) Atoms or ions with the same mass number.

Correct Answer: B) Atoms or ions with the same number of electrons.

Reasoning: Isoelectronic species are atoms or ions that have the same number of electrons. This means they have the same electronic configuration and often exhibit similar chemical properties.

MCAT General Chemistry Question 91

Which of the following best describes the role of a reducing agent in a redox reaction?

- A) It gains electrons and is reduced.
- B) It loses electrons and is oxidized.
- C) It neither gains nor loses electrons.
- D) It increases the oxidation number of another substance.

Correct Answer: B) It loses electrons and is oxidized.

Reasoning: In a redox reaction, a reducing agent donates electrons to another substance and is itself oxidized in the process. By losing electrons, the reducing agent increases the oxidation number of another substance, facilitating its reduction. Conversely, the substance that gains the electrons and is reduced is called the oxidizing agent.

MCAT General Chemistry Question 92

Which of the following molecules has a tetrahedral molecular geometry according to VSEPR theory?

- A) Carbon dioxide (CO_2)
- B) Boron trifluoride (BF_3)
- C) Methane (CH_4)
- D) Xenon tetrafluoride (XeF_4)

Correct Answer: C) Methane (CH_4)

Reasoning: According to VSEPR theory, the shape of a molecule is determined by the repulsion between electron pairs around the central atom.

- **Carbon dioxide (CO_2)** has two double bonds around the central carbon atom with no lone pairs, resulting in a linear geometry.
- **Boron trifluoride (BF_3)** has three bonding pairs and no lone pairs around the central boron atom, resulting in a trigonal planar geometry.

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- **Methane (CH₄)** has four bonding pairs and no lone pairs around the central carbon atom, resulting in a tetrahedral geometry. The four pairs of bonding electrons arrange themselves as far apart as possible, forming a tetrahedral shape with bond angles of approximately 109.5 degrees.
- **Xenon tetrafluoride (XeF₄)** has four bonding pairs and two lone pairs around the central xenon atom, resulting in a square planar geometry.

Therefore, among the given options, only methane (CH₄) exhibits a tetrahedral molecular geometry.

MCAT General Chemistry Question 93

Which of the following best describes the difference in electrical conductivity between ionic compounds and covalent compounds in their respective states?

- A) Ionic compounds conduct electricity in solid form, while covalent compounds conduct electricity when dissolved in water.
- B) Ionic compounds conduct electricity when dissolved in water or melted, while covalent compounds generally do not conduct electricity in any state.
- C) Ionic compounds do not conduct electricity in any state, while covalent compounds conduct electricity in solid form.
- D) Both ionic and covalent compounds conduct electricity in solid form.

Correct Answer: B) Ionic compounds conduct electricity when dissolved in water or melted, while covalent compounds generally do not conduct electricity in any state.

Reasoning: Ionic compounds conduct electricity when dissolved in water or melted because their ions are free to move and carry electric charge. In solid form, ionic compounds do not conduct electricity because the ions are fixed in place within the crystal lattice. Covalent compounds typically do not conduct electricity in any state because they do not have free ions or charged particles to carry the current.

MCAT General Chemistry Question 94

Which of the following best describes a key aspect of the quantum mechanical model of the atom?

- A) Electrons move in fixed orbits around the nucleus.
- B) Electrons have precise positions and momenta at any given time.
- C) Electrons exist in orbitals, which are regions of space where there is a high probability of finding an electron.
- D) Electrons orbit the nucleus in paths determined by classical mechanics.

Correct Answer: C) Electrons exist in orbitals, which are regions of space where there is a high probability of finding an electron.

Reasoning: The quantum mechanical model of the atom, developed through the contributions of several physicists including Schrödinger, Heisenberg, and Dirac, provides a more accurate description of electron behavior compared to earlier models such as the Bohr model. Key aspects of the quantum mechanical model include:

- **Orbitals:** Unlike fixed orbits in the Bohr model, electrons in the quantum mechanical model exist in orbitals. Orbitals are regions of space around the nucleus where there is a high probability (usually 90-95%) of finding an electron. These regions are described by wave functions, which are solutions to Schrödinger's equation.
- **Heisenberg Uncertainty Principle:** This principle states that it is impossible to simultaneously know both the exact position and exact momentum of an electron. This intrinsic uncertainty means that electrons do not follow precise paths but rather exist in regions of probability.
- **Quantum Numbers:** Electrons are described by a set of four quantum numbers (n , l , m_l , and m_s) that specify their energy level, shape, orientation of the orbital, and spin, respectively. These quantum numbers determine the distribution and arrangement of electrons in an atom.
- **Electron Clouds:** The probability distribution of electrons around the nucleus forms electron clouds. These clouds represent areas where electrons are likely to be found rather than fixed paths.

Therefore, the key aspect of the quantum mechanical model is the concept of orbitals—regions of space where there is a high probability of finding an electron. This model provides a more accurate and comprehensive understanding of electron behavior, atomic structure, and chemical bonding.

MCAT General Chemistry Question 95

Which of the following correctly represents the electron configuration of a ground-state sulfur atom (S)?

- A) $1s^2 2s^2 2p^6 3s^2 3p^4$
- B) $1s^2 2s^2 2p^6 3s^2 3p^3 4s^1$

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- C) $1s^2 2s^2 2p^6 3s^2 3p^6$
D) $1s^2 2s^2 2p^6 3s^2 3d^4$

Correct Answer: A) $1s^2 2s^2 2p^6 3s^2 3p^4$

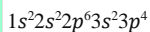
Reasoning: The electron configuration of an atom describes the distribution of its electrons among the various atomic orbitals. The rules for determining electron configuration include the Aufbau principle, the Pauli exclusion principle, and Hund's rule.

- **Aufbau Principle:** Electrons fill atomic orbitals in order of increasing energy levels, starting with the lowest energy level.
- **Pauli Exclusion Principle:** Each orbital can hold a maximum of two electrons with opposite spins.
- **Hund's Rule:** Electrons will fill degenerate orbitals (orbitals with the same energy) singly before pairing up.

Sulfur (S) has an atomic number of 16, meaning it has 16 electrons. The electron configuration for sulfur is determined as follows:

1. Fill the 1s orbital: $1s^2$ (2 electrons)
2. Fill the 2s orbital: $2s^2$ (2 electrons)
3. Fill the 2p orbitals: $2p^6$ (6 electrons)
4. Fill the 3s orbital: $3s^2$ (2 electrons)
5. Fill the 3p orbitals: $3p^4$ (4 electrons)

Combining these, the electron configuration for a ground-state sulfur atom is:



Therefore, the correct electron configuration of a ground-state sulfur atom (S) is option A) $1s^2 2s^2 2p^6 3s^2 3p^4$.

MCAT General Chemistry Question 96

Which of the following statements best distinguishes covalent bonds from ionic bonds?

- A) Covalent bonds involve the complete transfer of electrons from one atom to another, while ionic bonds involve the sharing of electrons between atoms.
B) Covalent bonds typically form between metals and nonmetals, while ionic bonds form between nonmetals only.
C) Covalent bonds involve the sharing of electron pairs between atoms, while ionic bonds involve the electrostatic attraction between oppositely charged ions.
D) Covalent bonds result in the formation of crystal lattice structures, while ionic bonds result in the formation of discrete molecules.

Correct Answer: C) Covalent bonds involve the sharing of electron pairs between atoms, while ionic bonds involve the electrostatic attraction between oppositely charged ions.

Reasoning: Covalent bonds and ionic bonds are two fundamental types of chemical bonds that differ in their mechanisms of formation:

- **Covalent Bonds:** These bonds involve the sharing of one or more pairs of electrons between atoms, usually nonmetals, to achieve stable electron configurations (typically resembling the electron configuration of noble gases). The shared electrons allow each atom to attain a full valence shell. Molecules like H_2 , O_2 , and CH_4 are examples of compounds with covalent bonds.
- **Ionic Bonds:** These bonds form through the complete transfer of one or more electrons from one atom (typically a metal) to another atom (typically a nonmetal), resulting in the formation of positively charged cations and negatively charged anions. The electrostatic attraction between these oppositely charged ions holds them together in a lattice structure. Examples of ionic compounds include NaCl (sodium chloride) and MgO (magnesium oxide).

The key distinction is that covalent bonds involve shared electron pairs between atoms, leading to the formation of molecules, whereas ionic bonds involve the electrostatic attraction between ions resulting from the transfer of electrons. This fundamental difference gives rise to distinct physical properties, such as melting points, boiling points, electrical conductivity, and solubility in various solvents.

MCAT General Chemistry Question 97

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Which of the following best describes the significance of electron spin in atomic structure and chemistry?

- A) Electron spin determines the size of the electron cloud around an atom.
- B) Electron spin is responsible for the magnetic properties of atoms and the Pauli exclusion principle, which states that no two electrons in an atom can have the same set of four quantum numbers.
- C) Electron spin determines the energy levels of electrons in an atom.
- D) Electron spin has no impact on the chemical behavior of atoms.

Correct Answer: B) Electron spin is responsible for the magnetic properties of atoms and the Pauli exclusion principle, which states that no two electrons in an atom can have the same set of four quantum numbers.

Reasoning: Electron spin is a fundamental property of electrons that describes their intrinsic angular momentum. It is denoted by the quantum number S , which can have values of $+\frac{1}{2}$ or $-\frac{1}{2}$. This property has several significant implications in atomic structure and chemistry:

- **Magnetic Properties:** The spin of electrons contributes to the magnetic moment of an atom. Atoms with unpaired electrons exhibit paramagnetic behavior, meaning they are attracted to external magnetic fields. Conversely, atoms with all paired electrons exhibit diamagnetic behavior, meaning they are weakly repelled by magnetic fields.
- **Pauli Exclusion Principle:** This principle states that no two electrons in the same atom can have the same set of four quantum numbers (n , l , m_l , and m_s), meaning that each orbital can hold a maximum of two electrons, and they must have opposite spins. This principle explains the electron cloud's structure around an atom and the arrangement of electrons in atomic orbitals.
- **Chemical Behavior:** The spin of electrons affects the way atoms interact and bond with each other. For example, the pairing of electrons with opposite spins in chemical bonds is essential for the formation of stable molecules.

Therefore, electron spin is crucial for understanding the magnetic properties of atoms, the arrangement of electrons in orbitals, and the overall chemical behavior of atoms and molecules.

MCAT General Chemistry Question 98

Which of the following statements correctly describes a characteristic of the halogens (Group 17) in the periodic table?

- A) Halogens are highly reactive metals that readily lose electrons to form cations.
- B) Halogens have high electronegativities and readily gain electrons to form anions.
- C) Halogens are inert gases that do not react with other elements.
- D) Halogens have low electronegativities and low ionization energies.

Correct Answer: B) Halogens have high electronegativities and readily gain electrons to form anions.

Reasoning: Halogens, which are found in Group 17 of the periodic table, include elements such as fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At). These elements have several key characteristics:

- **High Electronegativity:** Halogens have high electronegativities, meaning they have a strong tendency to attract electrons in chemical bonds.
- **Reactivity:** Halogens are highly reactive nonmetals, especially with alkali metals and alkaline earth metals, to form salts.
- **Electron Gain:** Halogens readily gain one electron to achieve a noble gas electron configuration, forming anions with a -1 charge (e.g., Cl^-).
- **Diatomic Molecules:** In their elemental form, halogens exist as diatomic molecules (e.g., F_2 , Cl_2).

Therefore, the correct characteristic of halogens is that they have high electronegativities and readily gain electrons to form anions, making them highly reactive nonmetals.

MCAT General Chemistry Question 99

Which of the following best describes the formation of a coordinate covalent bond?

- A) A bond formed by the equal sharing of electrons between two atoms.
- B) A bond formed when both electrons in the bond are donated by the same atom.
- C) A bond formed by the transfer of electrons from one atom to another.
- D) A bond formed when two atoms share electrons unequally, creating a dipole.

Correct Answer: B) A bond formed when both electrons in the bond are donated by the same atom.

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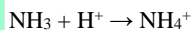
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Reasoning: A coordinate covalent bond, also known as a dative bond, is a type of covalent bond in which both electrons in the bond are donated by the same atom. This typically occurs when a Lewis base (an electron pair donor) donates a lone pair of electrons to a Lewis acid (an electron pair acceptor).

An example of a coordinate covalent bond can be seen in the formation of the ammonium ion (NH_4^+). In this case, a lone pair of electrons from the nitrogen atom in an ammonia molecule (NH_3) is donated to a proton (H^+), forming a coordinate covalent bond and resulting in the ammonium ion:



In this bond, the nitrogen atom provides both electrons for the bond with the hydrogen ion.

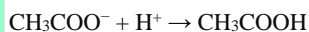
MCAT General Chemistry Question 100

A buffer solution contains acetic acid (CH_3COOH) and its conjugate base, acetate (CH_3COO^-). Which of the following statements correctly describes how the buffer solution responds to the addition of a strong acid like HCl?

- A) The pH of the buffer will significantly decrease because HCl will increase the concentration of H^+ ions without any neutralization.
- B) The acetate ions (CH_3COO^-) will react with the added H^+ ions from HCl, forming more acetic acid (CH_3COOH), thereby minimizing the change in pH.
- C) The acetic acid (CH_3COOH) will react with the added H^+ ions from HCl, forming more acetate ions (CH_3COO^-), thereby minimizing the change in pH.
- D) The pH of the buffer will significantly increase because HCl will decrease the concentration of H^+ ions.

Correct Answer: B) The acetate ions (CH_3COO^-) will react with the added H^+ ions from HCl, forming more acetic acid (CH_3COOH), thereby minimizing the change in pH.

Reasoning: A buffer solution containing acetic acid (CH_3COOH) and its conjugate base, acetate (CH_3COO^-), resists changes in pH upon the addition of small amounts of a strong acid or base. When HCl, a strong acid, is added to the buffer, the H^+ ions from HCl will react with the acetate ions (CH_3COO^-). This reaction forms more acetic acid (CH_3COOH) and reduces the concentration of free H^+ ions, thereby minimizing the change in pH:



This conversion of acetate ions to acetic acid helps maintain the pH of the buffer solution within a narrow range, illustrating the buffer's capacity to neutralize added acids. In contrast, if the buffer were not present, the addition of HCl would lead to a significant increase in H^+ ion concentration, resulting in a large decrease in pH. Thus, the buffering action is crucial for maintaining pH stability in various chemical and biological systems.

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