
2. Which one of the following acids is a strong acid? [A. Oxalic acid. B. Citric acid. C. Aspirin. D. Perchloric acid.]

3. Which one of the following molecules can behave as an amphiprotic species? [A. H₂O. B. PH₃. C. N₂H₄. D. NO.] 


5. What is the concentration of a solution that has molar absorptivity (ε) and absorbance (A) of 6,600 cm⁻¹M⁻¹ and 0.75, respectively, assuming that the path length in a UV spectrometer is 1 cm? [A. 5. B. 0.114. C. 3.73. D. 2.45. mm. [Hint: Beer's law, A = εbc]]

6. Which one of the following thermodynamic quantities is a state function that does not depend on the path taken to go from the initial state to the final state? [A. Heat, q. B. Work, w. C. Enthalpy, ΔH or q_p. D. All of the above.]

7. What is the thermodynamic quantity that can be directly measured in a bomb calorimeter? [A. Work, w. B. Enthalpy, ΔH or q_p. C. Gibb's free energy, ΔG. D. Internal energy, ΔE or q_v.]

8. What is the constant that is proposed to show that energy is quantized during blackbody radiation? [A. Avogadro number, N. B. Planck constant, h. C. Boltzmann constant, k. D. Rydberg constant, R.]

9. For the photoelectric effect, electrons are ejected when light strikes the surface of a metal, but only if the [A. Intensity. B. Angle. C. Radiation. D. Frequency. of the light reaches a certain threshold.]

10. The potential energy of an electron in the nth level = Eₙ = -Rhc/n², where R, h, c, and n are Rydberg constant, Planck constant, speed of light, and principal quantum number, respectively. The principal quantum number, n, defines [A. The energy. B. The distance of the electron from the nucleus. C. All of the above. D. None of the above.]

11. Which one of the following statements is correct concerning the equation, λ = h/mv, proposed by de Broglie, where mv = p (momentum)? [A. This is the particle-wave duality of electrons or anything. B. The electronic configuration of Fe³⁺. C. The light intensity of blackbody radiation. D. The threshold of photon having the ability to eject electrons from a metal plate.]

12. An electron at a given point in space can be described by a wave function, ψ. The square of the wavelength, ψ², defines the [A. Altitude. B. Depth. C. Area. D. Probability. of finding the electron. Scientists refer to this quantity as the electron density.]

13. What is the magnetic quantum number, m, related to the orbitals within a subshell? [A. Energy. B. Distance to the nucleus. C. Shape. D. Orientation.]

14. Elements and compounds that have unpaired electrons (↑) are attracted to a magnet. These species are referred to as [A. Ferromagnetism. B. Paramagnetism. C. Diamagnetism. D. All of the above.
15. Which one of the following species is isoelectronic with CO? A. CN\(^-\) B. OH\(^-\) C. Br\(_2\) D. Cl\(_2\). [Hint: Molecules and ions having the same number of valence electrons and the same Lewis structures are said to be isoelectronic.]

16. Which is most likely the structure that represents the resonance structure of molecular ozone, O\(_3\)? A. O=O=O B. O=O=O C. O=O=O D. All of the above.

17. What is the formal charge on N in NO\(_3\)? A. -1 B. 0 C. +1 D. +2.

18. The basis or valence bond theory (VBT) is the A. Cross-linking B. Orthogonality C. Substitution D. Overlap of atomic orbitals.


20. The MO configuration of NO, nitric oxide, is [core electrons] \((\sigma_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi_{2p})^2(\sigma_{2p})^1\). What is the bond order between N and O? A. 2.5 B. 2.0 C. 1.5 D. 1.

21. For the hydration of potassium (K\(^+\)) and lithium (Li\(^+\)) ions, they can be expressed as K\(^+\)...KOH\(_2\) and Li\(^+\)...KOH\(_2\). Which type of hydration exhibits a more exothermic value? A. K\(^+\)...KOH\(_2\) B. Li\(^+\)...KOH\(_2\) C. K\(^+\)...KOH\(_2\)...Li\(^+\) D. Li\(^+\)...KOH\(_2\)...K\(^+\).

22. For polar compounds and non-polar compounds of approximately the same molecular weights, which is expected to exhibit a higher value for their enthalpy of vaporization? A. Polar compounds B. Non-polar compounds. C. It depends on the atmosphere. D. Molecular recognition needs to be taken into consideration.

23. When \(n\)-C\(_8\)H\(_{18}\) and CCl\(_4\) are mixed, which one of the following statements is correct? A. The energy of the system is more dispersed than in the two. B. Entropy, \(\Delta S\), of the system is increased. C. Induced-dipole/induced dipole forces occur between these two molecules. D. All of the above.

24. For the colligative properties of solution, which one of the following statements is INCORRECT for freezing point depression? A. Solution containing the solutes can solidify B. Due to the presence of solutes, solvent molecules are farther apart, making it difficult for them (solvent molecules) to approach. C. Temperature needs to be lowered for pure solvent molecules to get closer. D. None of the above.

25. For the reaction, NO\(_2\)(g) \(+\) CO(g) \<\> NO(g) \(+\) CO\(_2\)(g), how does the activated complex look like at the transition state? A. ONO\(_2\)NO B. O=NO\(_2\)O\(_2\)C\(_{\equiv}\)O=C=O. C. O\(_2\)C\(_{\equiv}\)O=C=O D. ON\(_2\)O\(_2\)C\(_{\equiv}\)O=C=O, where “\(^{\equiv}\)” indicates a partial bond.

26. In the Arrhenius equation, \(k = \text{rate constant} = Ae^{-Ea/RT}\), which term is related to the number of collisions, and to the fraction of collisions that have the correct geometry? A. k B. A. C. Ea. D. R.

27. For a chemical reaction, aA + bB \<\> cC + dD, which one of the following statements is INCORRECT? A. The reaction quotient, \(Q\), is equal to \([C]^c[D]^d/[A]^a[B]^b\). B. The equilibrium constant, \(K\), is also equal to \([C]^c[D]^d/[A]^a[B]^b\). C. When \(Q < K\), the reaction is moving forward (\(<\)\). D. When \(Q < K\), the reaction is moving backward (\(\geq\)).

28. The \(K_a\) of C\(_2\)H\(_5\)CO\(_2\)H, CH\(_3\)CO\(_2\)H, and HCO\(_2\)H is 1.3x10\(^{-5}\), 1.8x10\(^{-5}\), and 1.8x10\(^{-4}\), respectively. This is because A. C\(_2\)H\(_5\)OH has the highest molecular weight. B. CH\(_3\)CO\(_2\)H is naturally found. C. Alkyl group, C\(_2\)H\(_5\), is an electron-donating group. D. HCO\(_2\)H has the lowest molecular weight.\(^*\)
29. Which one of the following statements is INCORRECT?  
A. Cl, Na, Mg, NO₃, ..., has no measurable effect on solution pH.  
B. The conjugate acidic cation of basic cation [Al(H₂O)₆(OH)]²⁺ is [Al(H₂O)₆]³⁺.  
C. CO₃²⁻ is amphiprotic.  
D. All metal cations, M⁺⁺, are hydrated in water, i.e., [M(H₂O)₆]²⁺.

30. The acidic strength of H-X, where X = F, Cl, Br, and I, is determined by two factors, H-X bond breaking enthalpy and electron affinity of X. HI is far more acidic than HF. Therefore, A. H-X bond strength is smaller for HI.  
B. The radius of I is larger than F.  
C. HF has a smaller molecular weight.  
D. HI is more electromagnetic, compared to I, explaining the high acidity of HI.

31. Which one of the following statements is INCORRECT concerning the dissociation of CH₃CO₂H → CH₃CO²⁻ + H⁺?  
A. This is because the H on –CO₂H is more positive.  
B. CH₃CO₂⁻ has resonance structures.  
C. H⁺ + CH₃CO₂H does not occur because C atom of CH₃ group is not sufficiently electronegative to accommodate the negative charge.  
D. CH₃CO₂⁻ will have a much larger positive partial charge than the O-H hydrogen atom.

32. The molecules or ions that bind to metal ions, such as H₂O in [Fe(H₂O)₆]³⁺, are called A. Ligands.  
B. Atoms.  
C. Alloys.  
D. Multimers.

33. In the reaction, PbS(s) ↔ Pb²⁺(aq) + S²⁻(aq), when PbS is dissolved in water, the lead ion concentration is greater than expected. This is because A. PbS has a high Ksp value.  
B. S²⁻ undergoes extensive hydrolysis.  
C. [Pb²⁺] cannot be affected by temperature.  
D. PbS needs to be heated.

34. Which one of the following criterion is important for a buffer solution to work efficiently?  
A. The right pH range, where it buffers.  
B. The concentrations of a buffer solution.  
C. The ratio between [conjugate base]/[acid].  
D. All of the above.

35. For gases, Ar and CO₂, which has a larger entropy, ΔS, value?  
A. Ar.  
B. CO₂.  
C. Ar.  
D. CO.

36. For the reaction, 2H₂(g) + O₂(g) → 2H₂O(g), ΔrH° = -483.6 kJ/mol, ΔrS° = -88.8 J/mol, ΔrG° = -457.2 kJ/mol (ΔG = ΔH - TΔS). Which one of the following statements is correct?  
A. The reaction is endothermic.  
B. Entropy is increased.  
C. The reaction is non-spontaneous.  
D. Some heat released is used to reverse energy dispersal.

37. Ludwig Boltzmann proposed that the entropy of a system results from the number of microstates available. That is, S = klnW. Which one of the following phenomenon is consistent with this equation?  
A. The expansion of gases.  
B. Ethanol can be dissolved in water.  
C. Br₂ is dissolved in CCl₄.  
D. All of the above.

38. Ligands can be listed in order of their ability to split the d orbitals. This list is called A. Periodic table.  
B. Chemical analysis.  
C. Spectrochemical series.  
D. Term symbols.

39. Which one of the following compounds is likely to be stable? [Hint: Effective atomic number (EAN) or 18-electron rule]  
A. CuCl₂.  
B. ZnCl₂.  
C. TiCl₂.  
D. Fe(CO)₅.

40. For various multiple bonds in compounds, such as carbon monoxide, C≡O and in Ni(C≡O)₄, which triple bond is longer?  
A. C≡O.  
B. Ni(C≡O)₄.  
C. It depends on the oxidation state of Ni.  
D. All of the above.
1. What is the concentration of CO₂ in water at 25°C when the partial pressure is 0.33 bar? [Hint: Henry’s law: $S_\text{H} = k_\text{H}P_\text{g}$, and $k_\text{H} = 0.034 \text{ mol/kg-bar for CO}_2$] (Although CO₂ reacts with water to give traces of $\text{H}^+$ and $\text{HCO}_3^-$, the reaction occurs to such a small extent that Henry’s law is obeyed at low CO₂ partial pressures.)

2. Why cannot NF₅ exist, whereas PF₅ can?

3. Sketch the Lewis structures for [ClF₂⁺]. What are the electron-pair and molecular geometry of this ionic species?

4. Could the cation, $\text{H}_2^+$, exist? What is the ion’s bond order?

5. Calculate the enthalpy of vaporization of diethyl ether (C₂H₅)₂O. This compound has vapor pressures of 57.0 mm Hg and 534 mm Hg at -22.8 °C and 25.0 °C, respectively. [Hint: $\ln(P_2/P_1) = (-\Delta_vapH^\circ/R) \times (1/T_2 - 1/T_1)$, where $R = 8.314 \text{ J/mol-K}$]

6. Assume you dissolve 10.0 g of sucrose (C₁₂H₂₂O₁₁) in 225 ml (225 g) of water and warm the water to 60°C. What is the vapor pressure of the water over this solution? [Hint: $P_\text{solvent} = X_\text{solvent}P_\text{H₂O}^\circ$, $P_\text{H₂O}^\circ = 149.4 \text{ mm Hg at 60°C}$]

7. The colorless N₂O₄ decomposes to the brown gas NO₂ in a first-order reaction, N₂O₄(g) → 2 NO₂(g). The rate constant $k = 4.5 \times 10^3 \text{ sec}^{-1}$ at 274 K and $k = 1.00 \times 10^9 \text{ sec}^{-1}$ at 283 K. What is the activation energy, $E_a$? [Hint: $\ln(k_2/k_1) = (-E_a/R) \times (1/T_2 - 1/T_1)$; $R = 8.314 \text{ J/mol-K}$]

8. Equilibrium exists between butane and isobutene when [butane] = 0.20 M and [isobutene] = 0.50 M. An additional 2.00 mol/L of isobutene is added to the mixture. What are the concentrations of butane and isobutene after equilibrium has again been attained? [Butane ↔ Isobutene, $K_{eq} = 2.5$]

9. What is the pH of the solution that results from adding 30.0 ml of 0.100 M NaOH to 45.0 ml of 0.100M acetic acid, CH₃CO₂H? [Hint: $K_a$ of acetic acid = $1.8 \times 10^{-5}$, Henderson–Hasselbalch equation: pH = pKa + log([Salt]/[Acid])]

10. Use the Henderson–Hasselbalch equation to calculate the pH of 1.00 L of a buffer solution containing 15.0 g of NaHCO₃ and 18.0 g of Na₂CO₃. (Consider this buffer as a solution of the weak acid HCO₃⁻ with CO₃²⁻ as its conjugate base.) [Hint: For CO₃²⁻ + H⁺ ↔ HCO₃⁻ + OH⁻, $K_b$ = $2.1 \times 10^{-4}$, and $K_a \times K_b = K_w = 1 \times 10^{-14}$]