Questions 1–15 cover material from Exam 1.

1. What state of matter is described as follows?

   On the molecular level, the distances between the molecules are far greater than the sizes of the molecules. Therefore, the density of this state of matter is very low compared to the other states.

   A. Gas
   B. Solid
   C. Liquid
   D. Solid and liquid

2. Consider the following three substances in the liquid state:

   \[
   \begin{array}{ccc}
   \text{ethanol} & \text{dimethyl ether} & \text{ethanal} \\
   \text{H} & \text{H} & \text{H} \\
   \text{H} & \text{C} & \text{C} \\
   \text{O} & \text{H} & \text{C} \\
   \text{H} & \text{H} & \text{H} \\
   \end{array}
   \]

   Which statement is true about these substances?

   A. All three substances can hydrogen bond because all substances contain hydrogen atoms.
   B. Both ethanol and ethanal can hydrogen bond because both substances contain oxygen close to hydrogen.
   C. Ethanol is the only substance of the three that can hydrogen bond.
   D. None of the substances meet the criteria for hydrogen bonding.

3. The surface tension of a liquid ___________________ and the viscosity of a liquid ___________________ with increasing intermolecular forces.

   A. decreases, decreases
   B. increases, increases
   C. decreases, increases
   D. increases, decreases
4. The rate of evaporation of a liquid _____________ as the temperature increases and _____________ as the surface area increases.

A. decreases, decreases
B. increases, increases
C. decreases, increases
D. increases, decreases

5. Methanol has a normal boiling point of 64.7 °C and a heat of vaporization ($\Delta H_{\text{vap}}$) of 35.29 kJ/mol. What is the vapor pressure of methanol at 25.0 °C?

A. 395 torr
B. 4.30 torr
C. 892 torr
D. 143 torr

6. How much heat is required to sublime 2.00 mol I$_2$(s)?

$\Delta H_{\text{fus}} = 7.76$ kJ/mol

$\Delta H_{\text{vap}} = 20.9$ kJ/mol

A. 57.3 kJ
B. 124 kJ
C. 11.6 kJ
D. 30.8 kJ
7. How much heat is required to convert 100. g of water at 75.0 °C to steam at 100. °C?

Specific heat, ice = 2.09 J/g°C
Specific heat, water = 4.18 J/g°C
Specific heat, steam = 2.01 J/g°C
Heat of vaporization, water = 40.7 kJ/mol
Heat of fusion, water = 6.02 kJ/mol
Molar mass H₂O = 18.015 g/mol

A. 1.10 × 10⁴ kJ  
B. 367 kJ  
C. 236 kJ  
D. 10.9 kJ

8. Examine the phase diagram above. Determine which of the following correctly identifies the points.

A. Point 3 is in the liquid region. Point 4 is the triple point.
B. Point 6 is in the solid region. Point 2 is on the liquid-gas phase boundary.
C. Point 3 is in the solid region. Point 5 is on the liquid-gas phase boundary.
D. Point 1 is in the liquid region. Point 4 is the critical point.
9. The following image is the unit cell of a metal chloride. The metal ion (of unknown charge) is at the center of the unit cell and the chloride ions are located on the corners. Determine the empirical formula of the metal chloride.

A. MCl₈
B. MCl₂
C. MCl₄
D. MCl

10. Chromium crystallizes in a body-centered cubic unit cell with a mass of $1.73 \times 10^{-22}$ g. The edge length of the unit cell is $2.89 \times 10^{-8}$ cm. Select the value that is closest to the density of chromium.

A. 0.1 g/cm³
B. 1 g/cm³
C. 10 g/cm³
D. 20 g/cm³

11. Which of the following is the least soluble in benzene (C₆H₆)?

A. CH₃CH₂CH₂CH₂CH₃
B. H₂O
C. CH₃CH₂CH₂CH₂CH₂OH
D. CH₃CH₂CH₂CH₂OH
12. Which statement best describes the unique property of a supersaturated solution?

A. A supersaturated solution must have more solute than solvent.
B. A supersaturated solution can dissolve more solute.
C. A supersaturated solution has more solute dissolved than predicted by the solubility.
D. A supersaturated solution has a precipitated solute in equilibrium with the dissolved solute.

13. A solution is prepared by dissolving 0.025 g O₂(g) in 2.5 kg of water. What is the molality of the solution?

A. 6.9 \times 10^{-4} m 
C. 3.4 \times 10^{-4} m 
B. 1.0 \times 10^{-2} m 
D. 3.1 \times 10^{-4} m 

14. A solution is prepared by dissolving 14.20 g NaCl in enough water to produce 150.0 mL of solution. The density of the solution is 1.008 g/mL. Determine the percent by mass of the solution.

A. 9.489 % 
C. 9.392 % 
B. 9.123 % 
D. 9.266 %
15. A sample of seawater is 0.428 M in NaCl with a density of 1.018 g/mL at 25.0 °C. What is the molality of NaCl in this sample?

A. 0.431 m  C. 0.321 m
B. 0.493 m  D. 0.784 m

16. Which of the following has the correct van’t Hoff factor indicated?

A. Na₃PO₄, i = 4  C. CH₃CH₂CH₃, i = 3
B. KOH, i = 3  D. Mg(C₂H₃O₂)₂, i = 2

17. The osmotic pressure of 250.0 mL of a solution of an unknown nonelectrolyte is 452 torr at 348 K. Determine the molarity of the solution.

A. 0.0633 M  C. 0.0208 M
B. 2.56 M  D. 15.2 M

18. Which solution would you expect to experience the greatest boiling point elevation?

A. 0.05 M Al₂(SO₄)₃  C. 0.05 M K₂SO₄
B. 0.10 Na₂CO₃  D. 0.15 M C₆H₁₂O₆

Questions 16–30 cover material from Exam 2.
19. Use the data in the table provided to determine the rate law of the reaction

\[ 2 \text{A(g) + 2 B(g) \rightarrow 2 C(g) + D(g)} \]

<table>
<thead>
<tr>
<th>Experiment</th>
<th>[A], (M)</th>
<th>[B], (M)</th>
<th>Initial Rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.100</td>
<td>0.100</td>
<td>0.014</td>
</tr>
<tr>
<td>2</td>
<td>0.200</td>
<td>0.100</td>
<td>0.057</td>
</tr>
<tr>
<td>3</td>
<td>0.200</td>
<td>0.200</td>
<td>0.115</td>
</tr>
<tr>
<td>4</td>
<td>0.400</td>
<td>0.400</td>
<td>0.920</td>
</tr>
</tbody>
</table>

A. Rate = \( k[A][B]^2 \)  
B. Rate = \( k[A]^2[B] \)  
C. Rate = \( k[A]^2[B]^2 \)  
D. Rate = \( k[A][B] \)

20. For a certain first-order reaction, the half-life is 2.55 s. What percent of the reactant will remain after 5.95 seconds?

A. 19.8 %  
B. 25.0 %  
C. 22.3 %  
D. 73.2 %

21. Which statement correctly explains what occurs on the molecular level that leads to an increase of reaction rate with temperature?

A. As the temperature increases, the reactants turn into gases and gases have the fastest rates of reactions.
B. As the temperature increases, the kinetic energy of the molecules increases. Therefore, more molecules have the minimum energy necessary to initiate the reaction.
C. As the temperature increases, the distance between molecules decreases. This gives rise to more frequent collisions and more frequent collisions gives rise to a faster rate.
D. There is not an increase in reaction rate with temperature. The rate usually decreases with temperature.
22. A certain chemical reaction has an activation energy of 96.8 kJ/mol and a rate constant of 0.00329 s\(^{-1}\) at 295 K. If the temperature is increased to 350 K, what is the new rate constant?

A. 0.945 s\(^{-1}\)  
B. 2.03 s\(^{-1}\)  
C. 1.62 s\(^{-1}\)  
D. 0.00265 s\(^{-1}\)

23. Initially the following reaction mixture contains 1.0 atm each of SO\(_2\), O\(_2\) and SO\(_3\).

\[
2 \text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2 \text{SO}_3(g) \quad K_p = 6.9 \times 10^6 \text{ (at 298 K)}
\]

What is true about the system at equilibrium?

A. \(2P_{\text{O}_2} = P_{\text{SO}_3}\)  
B. \(P_{\text{SO}_3} > P_{\text{SO}_2}\)  
C. \(2P_{\text{SO}_2} + P_{\text{O}_2} = P_{\text{SO}_3}\)  
D. \(P_{\text{O}_2} > P_{\text{SO}_3}\)

24. Which statement is false about the following reaction mechanism?

\[
\begin{align*}
\text{ClO}^- (aq) + \text{H}_2\text{O}(l) &\rightleftharpoons \text{HClO}(aq) + \text{OH}^- (aq) \quad \text{Fast} \\
\text{I}^- (aq) + \text{HClO}(aq) &\rightleftharpoons \text{HIO}(aq) + \text{Cl}^- (aq) \quad \text{Slow} \\
\text{OH}^- (aq) + \text{HIO}(aq) &\rightleftharpoons \text{H}_2\text{O}(l) + \text{IO}^- (aq) \quad \text{Fast} \\
\text{ClO}^- (aq) + \text{I}^- (aq) &\rightleftharpoons \text{Cl}^- (aq) + \text{IO}^- (aq) \quad \text{Overall}
\end{align*}
\]

A. H\(_2\)O is a catalyst.  
B. I\(^-\) is a reactant.  
C. HClO is an intermediate.  
D. HIO is a catalyst.
25. What is $K_p$ for the overall reaction that converts propane ($C_3H_8$) and steam to carbon dioxide and hydrogen gas ($H_2$) at 1200 K given the following information?

\[
\text{C}_3\text{H}_8(g) + 3 \text{H}_2\text{O}(g) \rightleftharpoons 3 \text{CO}(g) + 7 \text{H}_2(g) \quad K_p = 8.175 \times 10^{15}
\]
\[
\text{CO}(g) + \text{H}_2\text{O}(g) \rightleftharpoons \text{CO}_2(g) + \text{H}_2(g) \quad K_p = 0.6944
\]

A. $3.473 \times 10^{16}$
B. $8.268 \times 10^{15}$
C. $1.229 \times 10^{14}$
D. $2.737 \times 10^{15}$

26. Ethanol can be produced according to the following equation:

\[
\text{C}_2\text{H}_4(g) + \text{H}_2\text{O}(g) \rightleftharpoons \text{C}_2\text{H}_5\text{OH}(g) \quad K_c = ? \text{ at } 250 \text{ K}
\]

When the initial concentrations of $C_2H_4$ and $H_2O$ are both 1.000 M, the equilibrium concentration of $C_2H_4$ is 0.036 M. What is the value of $K_c$?

A. $9.6 \times 10^{-1}$
B. $2.8 \times 10^1$
C. $7.4 \times 10^2$
D. $3.9 \times 10^3$

27. For the following reaction at 298 K, $K_p = 6.70$.

\[
2 \text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g)
\]

At equilibrium, the partial pressure of NO$_2$ is 0.250 atm. Determine the partial pressure of N$_2$O$_4$ at equilibrium.

A. 0.419 atm
B. 1.50 atm
C. 1.22 atm
D. 1.63 atm
28. Given the following reaction, initially at equilibrium, which change will cause the greatest shift in the equilibrium to favor product formation?

\[ 3 \text{C(s)} + 4 \text{H}_2(\text{g}) \rightleftharpoons \text{C}_3\text{H}_8(\text{g}) \quad \Delta \text{H}_{\text{rxn}} = -105 \text{ kJ/mol} \]

A. Double the mass of C  
B. Decrease the pressure of the container  
C. Lower the temperature  
D. Remove H\(_2\)

29. In the following reaction, NH\(_3\) is behaving as a(n) ________________.

\[ \text{H}_2\text{PO}_4^-(aq) + \text{NH}_3(aq) \rightarrow \text{HPO}_4^{2-}(aq) + \text{NH}_4^+(aq) \]

A. Arrhenius base  
B. Arrhenius acid  
C. Brønsted-Lowry base  
D. Brønsted-Lowry acid

30. Calculate [OH\(^-\)] at 25 °C for a solution with [H\(_3\)O\(^+\)] = 3.25 × 10\(^{-4}\) M and indicate whether the solution is acidic, basic, or neutral.

A. [OH\(^-\)] = 3.08 × 10\(^{-11}\) M, acidic  
B. [OH\(^-\)] = 3.08 × 10\(^{-11}\) M, basic  
C. [OH\(^-\)] = 1.28 × 10\(^{-3}\) M, acidic  
D. [OH\(^-\)] = 1.28 × 10\(^{-3}\) M, basic
31. A 0.20 M solution of a monoprotic acid has a percent ionization of 3.9%. Determine $K_a$ of the acid.

A. $3.9 \times 10^{-2}$  
B. $6.5 \times 10^{-4}$  
C. $3.2 \times 10^{-4}$  
D. $1.8 \times 10^{-5}$

32. Calculate the pH of a solution that contains 0.060 M HNO$_3$ and 0.40 M HOCl (hypochlorous acid, $K_a = 2.9 \times 10^{-8}$).

A. 2.45  
B. 6.00  
C. 1.05  
D. 1.22

33. Which salt will be neutralized by the addition of HBr?

A. NaF  
B. LiNO$_3$  
C. CaI$_2$  
D. NH$_4$Cl

34. Select the strongest of these oxyacids.

A. HClO  
B. HClO$_2$  
C. HBrO  
D. HBrO$_2$
35. Which statement is true for the reaction given below?

\[
\begin{align*}
\text{CH}_3\text{N} & \quad + \quad \text{BF}_3 \\
\text{H}_3\text{C} & \quad \text{F} \\
\text{H}_3\text{C} & \quad \text{N} \\
\end{align*}
\]

A. \( (\text{CH}_3)_3\text{N} \) is a Lewis base; it is an electron pair donor.
B. \( (\text{CH}_3)_3\text{N} \) is a Lewis acid; it is an electron pair acceptor.
C. \( \text{BF}_3 \) is a Lewis base; it is an electron pair donor.
D. \( \text{BF}_3 \) is a Lewis base; it is an electron pair acceptor.

36. A buffer made of hypochlorous acid (HClO, \( K_a = 2.9 \times 10^{-8} \)) and sodium hypochlorite (NaClO) has a pH of 8.38. What is true about the ratio of base to acid for this buffer?

A. \( [\text{ClO}^-] = [\text{HClO}] \)  
B. \( [\text{ClO}^-] = 10[\text{HClO}] \)  
C. \( [\text{ClO}^-] > [\text{HClO}] \)  
D. \( [\text{ClO}^-] < [\text{HClO}] \)

37. A few milliliters of 0.10 M NaOH are added to 100 mL of a buffer containing 0.10 M HC\(_2\)H\(_3\)O\(_2\) (acetic acid) and 0.15 M NaC\(_2\)H\(_3\)O\(_2\) (sodium acetate). Which of the following reactions represents the neutralization of the strong base?

A. \( \text{H}_2\text{O}(l) + \text{C}_2\text{H}_3\text{O}_2(aq) \rightarrow \text{C}_2\text{H}_3\text{O}_2^- (aq) + \text{OH}^- (aq) \)
B. \( \text{H}_3\text{O}^+ (aq) + \text{C}_2\text{H}_3\text{O}_2^- (aq) \rightarrow \text{HC}_2\text{H}_3\text{O}_2(aq) + \text{H}_2\text{O}(l) \)
C. \( \text{OH}^- (aq) + \text{HC}_2\text{H}_3\text{O}_2(aq) \rightarrow \text{C}_2\text{H}_3\text{O}_2^- (aq) + \text{H}_2\text{O}(l) \)
D. \( \text{H}_3\text{O}^+ (aq) + \text{OH}^- (aq) \rightarrow 2 \text{H}_2\text{O}(l) \)
38. Calculate the pH of a solution when 10.10 mL of 0.10 M HCl is titrated with 10.10 mL of 0.10 M CH₃NH₂. \( K_b(\text{CH}_3\text{NH}_2) = 4.4 \times 10^{-4} \), \( K_a(\text{CH}_3\text{NH}_3^+) = 2.3 \times 10^{-11} \).

A. 8.23  
B. 5.97  
C. 4.26  
D. 9.77

39. Calculate the pH after 27.5 mL of 0.350 M HNO₃ has been added to 50.0 mL of a 0.160 M codeine solution. \( K_b(\text{codeine}) = 1.6 \times 10^{-6} \).

A. 3.892  
B. 2.739  
C. 1.678  
D. 0.224

40. Calculate the molar solubility of PbBr₂ in pure water. \( K_{sp}(\text{PbBr}_2) = 4.67 \times 10^{-6} \).

A. \( 1.37 \times 10^{-6} \) M  
B. \( 1.39 \times 10^{-2} \) M  
C. \( 2.19 \times 10^{-3} \) M  
D. \( 1.05 \times 10^{-2} \) M

41. A solution is \( 1.50 \times 10^{-3} \) M in \( \text{Ca(NO}_3)_2 \) and \( 3.40 \times 10^{-3} \) M in NaF. \( K_{sp}(\text{CaF}_2) = 1.46 \times 10^{-10} \). Which of the following statements is true?

A. \( Q = 1.73 \times 10^{-8} \) and a precipitate will form.  
B. \( Q = 5.10 \times 10^{-6} \) and a precipitate will form.  
C. \( Q = 1.73 \times 10^{-8} \) and no precipitate will form.  
D. \( Q = 5.10 \times 10^{-6} \) and no precipitate will form.
42. An aqueous solution is 0.100 M in Ca$^{2+}$, Mg$^{2+}$, and Zn$^{2+}$. When sufficient C$_2$O$_4^{2-}$ is added to the solution, CaC$_2$O$_4$ ($K_{sp} = 2.32 \times 10^{-9}$), MgC$_2$O$_4$ ($K_{sp} = 4.83 \times 10^{-6}$), and ZnC$_2$O$_4$ ($K_{sp} = 2.70 \times 10^{-8}$) will precipitate from the solution. What minimum concentration of C$_2$O$_4^{2-}$ is needed to begin precipitation of the salt that precipitates first?

A. $2.32 \times 10^{-8}$  
B. $4.83 \times 10^{-5}$  
C. $2.70 \times 10^{-9}$  
D. $2.08 \times 10^{-3}$

43. Which of the following processes is accompanied by an **increase** in entropy of the system?

A. Freezing of water.  
B. Evaporation of water.  
C. Condensation of methanol vapor.  
D. Crystallization of a supersaturated solution of fructose.

44. Which balanced chemical equation shows the **greatest decrease** in entropy for the reaction?

A. $2 \text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$  
B. $\text{CO}(g) + 2 \text{H}_2(g) \rightarrow \text{CH}_3\text{OH}(g)$  
C. $\text{SnO}_2(s) + \text{H}_2(g) \rightarrow \text{Sn}(s) + \text{H}_2\text{O}(g)$  
D. $2 \text{H}_2\text{S}(g) + 3 \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(l) + 2 \text{SO}_2(g)$

45. What is the change in entropy of the surroundings for the following reaction at 15.0°C?

$$\text{C}_3\text{H}_8(g) + 5 \text{O}_2(g) \rightarrow 3 \text{CO}_2(g) + 4 \text{H}_2\text{O}(g) \quad \Delta H_{\text{rxn}} = -2044 \text{ kJ}$$

A. 7.10 kJ/K  
B. 183 kJ/K  
C. 27.4 kJ/K  
D. 2.63 kJ/K
Questions 46–60 cover material after Exam 3.

46. For a spontaneous process, which of the following must be true?

A. $\Delta S_{\text{rxn}} < 0$  
B. $\Delta S_{\text{rxn}} > 0$

47. Given the table of $\Delta G_f^0$ below, determine the standard Gibbs free energy change of the following reaction.

$$2 \text{CO}(g) + 2 \text{NO}(g) \rightarrow 2 \text{CO}_2(g) + \text{N}_2(g)$$

<table>
<thead>
<tr>
<th>Substance</th>
<th>$\Delta G_f^0$ (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO(g)</td>
<td>-137.2</td>
</tr>
<tr>
<td>CO$_2$(g)</td>
<td>-394.4</td>
</tr>
<tr>
<td>NO(g)</td>
<td>87.6</td>
</tr>
</tbody>
</table>

A. $-689.6$ kJ  
B. $-344.2$ kJ  
C. $-426.1$ kJ  
D. More information is needed.

48. Find $\Delta G_{\text{rxn}}^0$ for $\text{Cu}_2\text{O}(s) + \text{C}(s) \rightarrow 2 \text{Cu}(s) + \text{CO}(g)$ at 375 K, given

$$\text{Cu}_2\text{O}(s) \rightarrow 2 \text{Cu}(s) + \frac{1}{2} \text{O}_2(g) \quad \Delta G_{\text{rxn}}^0 = 140.0 \text{ kJ at 375 K}$$
$$\text{CO}(g) \rightarrow \text{C}(s) + \frac{1}{2} \text{O}_2(g) \quad \Delta G_{\text{rxn}}^0 = 143.8 \text{ kJ at 375 K}.$$

A. 14.1 kJ  
B. 317.2 kJ  
C. $-3.8$ kJ  
D. $-7.2$ kJ
49. Consider the following reaction at 298 K.

\[ 2 \text{H}_2\text{S}(g) + \text{SO}_2(g) \rightarrow 3 \text{S(s, rhombic)} + 2 \text{H}_2\text{O}(g) \quad \Delta G_{\text{rxn}}^0 = -102 \text{ kJ} \]

Calculate \( \Delta G_{\text{rxn}} \) when

\[ P_{\text{H}_2\text{S}} = 1.50 \text{ atm}; \quad P_{\text{SO}_2} = 2.50 \text{ atm}; \quad \text{and} \quad P_{\text{H}_2\text{O}} = 0.0150 \text{ atm}. \]

A. –78 kJ  
B. –102 kJ  
C. –152 kJ  
D. –127 kJ

50. The equilibrium constant, \( K_c = 9.90 \times 10^3 \) at 327 °C for the following reaction:

\[ \text{C}_2\text{H}_4(g) + \text{H}_2\text{O}(g) \rightleftharpoons \text{C}_2\text{H}_5\text{OH}(g) \]

Calculate \( \Delta G_{\text{rxn}}^0 \) at 327 °C.

A. –45.9 kJ  
B. –25.9 kJ  
C. –0.455 kJ  
D. –248 kJ

51. What is the coefficient \( a \) when the equation below is balanced in acid with the smallest possible integers?

\[ a \text{Al(s)} + b \text{MnO}_4^{-}(aq) \rightarrow c \text{Al}^{3+}(aq) + d \text{Mn}^{2+}(aq) \]

A. 2  
B. 3  
C. 5  
D. 12
52. A voltmeter connected to the following cell under standard-state conditions reads 0.34 V. Which statement is true?

\[ \text{Pt} | \text{H}_2(\text{g}, \text{1 atm}) | \text{H}^+(\text{aq}, \text{1.0 M}) \parallel \text{Cu}^{2+}(\text{aq}, \text{1.0 M}) | \text{Cu}(s) \]

A. The reduction half-cell potential of \( \text{Cu}^{2+} + 2 \text{e}^- \rightarrow \text{Cu} \) is \(-0.34 \) V
B. The reduction half-cell potential of \( \text{Cu}^{2+} + 2 \text{e}^- \rightarrow \text{Cu} \) is \(0.34 \) V
C. The reduction half-cell potential of \( \text{Cu}^{2+} + 2 \text{e}^- \rightarrow \text{Cu} \) is \(-0.17 \) V
D. The reduction half-cell potential of \( \text{Cu}^{2+} + 2 \text{e}^- \rightarrow \text{Cu} \) is \(0.17 \) V

53. Calculate \( E^0 \) for the following reaction at 298 K:

\[ \text{Ca}^{2+}(\text{aq}) + 2 \text{Cu}(s) \rightarrow \text{Ca}(s) + 2 \text{Cu}^+(\text{aq}) \]

\[ \text{Ca}^{2+}(\text{aq}) + 2 \text{e}^- \rightarrow \text{Ca}(s) \quad \text{\( E^0 = -2.76 \) V} \]
\[ \text{Cu}^+(\text{aq}) + \text{e}^- \rightarrow \text{Cu}(s) \quad \text{\( E^0 = 0.52 \) V} \]

A. \(-3.80 \) V  C. \(-3.28 \) V
B. \(-2.24 \) V  D. \(3.28 \) V

54. A voltaic cell is constructed that uses the following reaction:

\[ \text{Al}(s) + \text{Au}^{3+}(\text{aq}) \rightarrow \text{Al}^{3+}(\text{aq}) + \text{Au}(s) \]

What is \( E_{\text{cell}} \) when \([\text{Au}^{3+}] = 0.0250 \text{ M} \) and \([\text{Al}^{3+}] = 0.850 \text{ M} \) at 25 °C? The standard cell potential for the reaction is 3.16 V.

A. \(3.13 \) V  C. \(3.98 \) V
B. \(2.65 \) V  D. \(2.02 \) V
55. Which reaction occurs at the anode during the electrolysis of molten Al₂O₃?

A. Al³⁺ is oxidized to Al.  
B. Al³⁺ is reduced to Al.  
C. O²⁻ is oxidized to O₂.  
D. O²⁻ is reduced to O₂.

56. Silver can be plated out of a solution containing Ag⁺ ions according to the half-reaction:

\[ \text{Ag}^+(aq) + e^- \rightarrow \text{Ag}(s). \]

How long would it take to plate 15 g of silver using a current of 2.5 A?

A. 6.0 min  
B. 38 min  
C. \(3.3 \times 10^4\) min  
D. 89 min

57. Which type of radioactive decay emits high-energy electromagnetic waves, often in conjunction with other types of radiation?

A. \(\alpha\) decay  
B. \(\beta\) decay  
C. \(\gamma\) emission  
D. \(\text{e}^+\) emission
58. The elements below lie in the region of the Valley of Stability where $N/Z \approx 1$. Select the nuclide that undergoes positron emission to achieve stability.

A. $^{28}_{12}\text{Mg}$  
B. $^{22}_{12}\text{Mg}$  
C. $^{31}_{10}\text{Ne}$  
D. $^{25}_{10}\text{Ne}$

59. A radioactive sample contains 1.40 g of an isotope that decays with a rate constant of 0.182 day$^{-1}$. What mass of the isotope remains after 6.5 days?

A. 0.25 g  
B. 1.02 g  
C. 0.75 g  
D. 0.43 g

60. How many half-lives must pass for the radioactivity of a technetium-99m sample to decrease to below 5.0% of its initial level?

A. 2 half-lives  
B. 3 half-lives  
C. 5 half-lives  
D. 8 half-lives
Answer Key:
1. A
2. C
3. B
4. B
5. D
6. A
7. C
8. A
9. D
10. C
11. B
12. C
13. D
14. C
15. A
16. A
17. C
18. B
19. B
20. ?
21. B
22. C
23. B
24. D
25. D
26. C
27. A
28. C
29. C
30. A
31. C
32. D
33. A
34. B
35. A
36. C
37. C
38. B
39. C
40. D
41. A
42. A
43. B
44. D
45. A
46. C
47. A
48. C
49. D
50. A
51. C
52. B
53. C
54. A
55. C
56. D
57. C
58. B
59. D
60. C