1. A certain nonvolatile nonelectrolyte has a molar mass of 120 g/mol. What is the vapor pressure, in torr, of a solution obtained by adding 20.0 g of this compound to 60.0 g of benzene (C<sub>6</sub>H<sub>6</sub>, molar mass = 78.1 g/mol) at 20°C? The vapor pressure of pure benzene at 20°C is 75 torr.
   a) 37 torr  d) 67 torr
   b) 56 torr  e) 62 torr
   c) 49 torr

2. Propylene glycol, C<sub>3</sub>H<sub>6</sub>(OH)<sub>2</sub> (molar mass = 76.09 g/mol) is sometimes used in automobile antifreeze solutions. Suppose that a certain aqueous solution of propylene glycol has a mole fraction X<sub>C<sub>3</sub>H<sub>6</sub>(OH)<sub>2</sub></sub> = 0.100. (The solvent, H<sub>2</sub>O, has a molar mass of 18.02 g/mol.) What is the molality of propylene glycol in the solution?
   a) 0.131 m  d) 1.62 m
   b) 5.55 m  e) 0.162 m
   c) 6.17 m

3. If the process of dissolving a solute in a solvent is considered to be three steps as defined below for purposes of understanding the ΔH<sub>soln</sub>, what is the correct set of signs of the various ΔH terms?
   \[ \Delta H_1 \text{ – separation of solute particles from each other} \]
   \[ \Delta H_2 \text{ – separation of solvent molecules from each other} \]
   \[ \Delta H_3 \text{ – combination of solute particles with solvent molecules} \]
   a) +  +  –
   b)  –  –  +
   c)  +  –  +
   d)  –  +  +
   e)  +  –  –

4. The equilibrium concentration of oxygen in water at 25°C which is in contact with air at 1.00 atm pressure is 8.5 x 10^-3 g/L. What will happen to the oxygen concentration if this water is moved to an elevation such as Denver where the air pressure is 0.90 atm?
   a) Oxygen will escape from water until its concentration reaches 7.7 x 10^-3 g/L.
   b) More oxygen will dissolve until the concentration reaches 9.5 x 10^-3 g/L.
   c) No change will occur so long as the percent oxygen in the air remains constant.
   d) The only variable which matters is the temperature, so assuming the temperature does not change, the concentration of oxygen will not change.

5. What is the direction of net flow of water in osmosis, if both sides of the semipermeable membrane are under the same pressure? Assume that the solute is sugar, a nonelectrolyte, dissolved in water.
   a) from the dilute solution (or pure water) into the concentrated solution
   b) from the concentrated solution into the dilute solution (or pure water)
   c) although the osmotic pressure is different in the dilute solution (or pure water) from that of the concentrated solution, no actual flow occurs
   d) the direction of flow depends upon the material constituting the membrane

6. A solution is prepared by dissolving 6.00 g of an unknown nonelectrolyte in enough water to make 1.00 L of solution. The osmotic pressure of this solution is 0.750 atm at 25.0°C. What is the molar mass of this unknown solute?
   a) 16.4 g/mol  d) 30.6 g/mol
   b) 196 g/mol  e) 5.12 x 10^-3 g/mol
   c) 110 g/mol

7. Which of the aqueous solutions below has the lowest freezing point?
   a) 0.050 m glucose (glucose is a nonelectrolyte)
   b) 0.040 m NaNO<sub>3</sub>
   c) 0.030 m MgCl<sub>2</sub>
   d) 0.020 m AlCl<sub>3</sub>
   e) 0.010 m K<sub>3</sub>PO<sub>4</sub>

8. The freezing point of pure CCl<sub>4</sub> is -22.3°C and its K<sub>f</sub> is 29.8°C/m. What is the freezing point of a solution containing 5.00 g of naphthalene (C<sub>10</sub>H<sub>8</sub>, a nonelectrolyte) dissolved in 60.0 g of CCl<sub>4</sub>?
   a) -32.7°C  d) -24.7°C
   b) -41.7°C  e) -24.7°C
   c) 10.4°C

9. The oxidation of ammonia produces nitrogen and water via the reaction
   \[ 4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l) \]
   If ammonia is being consumed at a rate of 0.72 M/s, how fast is oxygen being consumed?
   a) 0.24 M/s  d) 0.63 M/s
   b) 0.48 M/s  e) 0.96 M/s
   c) 0.54 M/s

10. Consider the hypothetical reaction:
    \[ A + B + C \rightarrow \text{products} \]
    The following initial concentrations and initial rates were obtained for the reaction at 25°C:
    | [A]<sub>0</sub> | [B]<sub>0</sub> | [C]<sub>0</sub> | Initial Rate (M/s) |
    | (M) | (M) | (M) |
    | 0.100 | 0.200 | 0.300 | 4.20 x 10^-3 |
    | 0.100 | 0.200 | 0.600 | 1.68 x 10^-2 |
    | 0.100 | 0.400 | 0.300 | 4.20 x 10^-3 |
    | 0.300 | 0.200 | 0.300 | 1.26 x 10^-2 |
    What is the correct rate law for this reaction?
    a) rate = k [A]<sup>2</sup> [B] [C]<sup>4</sup>
    b) rate = k [A] [B] [C]<sup>2</sup>
    c) rate = k [A] [B] [C]
    d) rate = k [A] [C]<sup>2</sup>
    e) rate = k [A]<sup>3</sup> [C]<sup>4</sup>

11. The rate law for the reaction
    \[ 5Br^- (aq) + BrO_3^- (aq) + H^+ (aq) \rightarrow 3Br_2 (l) + 3H_2O(l) \]
has been experimentally determined to be
rate = k[Br\textsuperscript{-}][BrO\textsubscript{3}\textsuperscript{-}][H\textsuperscript{+}]

What is the overall order for this reaction?
a) 1  c) 3
b) 2  d) 4
e) The order of the reaction cannot be determined from
the information provided.

12. A chemical reaction that is first-order in A is observed to
have a rate constant of 1.2 x 10\textsuperscript{-2} s\textsuperscript{-1}. If the initial
concentration of A is 2.0 M, what is the concentration of
A after 200 s?
a) 0.18 M  d) 6.0 x 10\textsuperscript{-3} M
b) 0.55 M  e) 1.7 M
c) 1.0 M

13. A first-order reaction is observed to have a rate constant
of 0.0154 min\textsuperscript{-1}. What is the half-life of this reaction?
a) 4.87 min  d) 64.9 min
b) 2.11 min  e) 19.5 min
c) 45.0 min

14. Suppose that the reaction A \rightarrow \text{products} obeys first-order
kinetics. If the half-life of this reaction is 30.0 minutes,
how long does it take for 62.5% of A to react?
a) 37.5 min  d) 20.3 min
b) 47.5 min  e) 42.5 min
c) 45.0 min

15. Suppose that the reaction A \rightarrow \text{products} is a second-order
reaction. Which of the following, when drawn on a
graph, would be a straight line?
a) [A] vs. time
b) [A]\textsuperscript{2} vs. time
c) [A]\textsuperscript{1/2} vs. time
d) ln [A] vs time
e) \frac{1}{[A]} vs. time

16. What are the units of the rate constant for a second-order
reaction?
a) M\textsuperscript{-1}s\textsuperscript{-1}  d) M\textsuperscript{2}s\textsuperscript{-1}
b) s\textsuperscript{-1}  e) M\textsuperscript{1/2}s\textsuperscript{-1}
c) M\textsuperscript{-1}s\textsuperscript{-1}

17. A certain first-order reaction has a rate constant k = 2.1 x
10\textsuperscript{8} s\textsuperscript{-1} at 355 K. If the activation energy for this reaction
is 135 kJ/mol, calculate the rate constant at 550 K.
a) 3.3 x 10\textsuperscript{9}  d) 4.9 x 10\textsuperscript{9}
b) 2.3 x 10\textsuperscript{12}  e) 7.2 x 10\textsuperscript{9}
c) 2.1 x 10\textsuperscript{9}

Questions 18 and 19 refer to the information below:
Consider the reaction
2H\textsubscript{2}O\textsubscript{2}(aq) \rightarrow 2H\textsubscript{2}O(l) + O\textsubscript{2}(g)
The mechanism for this reaction is believed to be the two-step
mechanism below:

\begin{align*}
\text{step 1} & \quad \text{H}_2\text{O}_2(aq) + \Gamma(aq) \rightarrow \text{H}_2\text{O}(l) + \text{IO}^-(aq) \quad \text{(slow)} \\
\text{step 2} & \quad \text{H}_2\text{O}_2(aq) + \text{IO}^-(aq) \rightarrow \text{H}_2\text{O}(l) + \text{O}_2(g) + \Gamma(aq) \quad \text{(fast)}
\end{align*}

18. What rate law is consistent with this mechanism?
a) rate = k [H\textsubscript{2}O\textsubscript{2}]\textsuperscript{2}  d) rate = k [H\textsubscript{2}O\textsubscript{2}][\Gamma]
b) rate = k [H\textsubscript{2}O\textsubscript{2}][\text{IO}^-]  e) rate = k [H\textsubscript{2}O\textsubscript{2}]

19. What is the catalyst, and what is the reactive intermediate
in the reaction above?
a) \Gamma(aq) is the catalyst, and IO\textsuperscript{-}(aq) is the reactive
intermediate.
b) IO\textsuperscript{-}(aq) is the reactive intermediate, and \Gamma\textsuperscript{-} is the
catalyst.
c) \Gamma(aq) is the catalyst, and there is no reactive
intermediate.
d) IO\textsuperscript{-}(aq) is the catalyst, and there is no reactive
intermediate.
e) IO\textsuperscript{-}(aq) is the catalyst, and H\textsubscript{2}O\textsubscript{2} is the reactive
intermediate.

20. Which of the following statements below is/are true
concerning the activation energy for a reaction?
I. \( E_a \) is the difference in energy between reactants and
activated complex.
II. \( E_a \) decreases with increasing temperature.
III. The greater the activation energy, the faster the reaction.
IV. Catalysts generally work by lowering the \( E_a \) for a
reaction.
a) III and IV  d) I and IV
b) I, II, and IV  e) I, II, III, and IV
c) II, III, and IV

21. The density of a 3.54 M solution of NH\textsubscript{4}Cl in water is
1.0512 g/mL. What is the molality of the solution? (The
molar mass of NH\textsubscript{4}Cl is 53.45 g/mol.)
a) 18.7 m  d) 6.29 m
b) 3.37 m  e) 2.98 m
c) 4.11 m

22. Which is more likely to be soluble in water, CCl\textsubscript{4} or
CaCl\textsubscript{2}?
a) CCl\textsubscript{4}  c) Neither is likely to be soluble in water.
b) CaCl\textsubscript{2}  d) Both are likely to be very soluble in water.

Answers