1. Which intermolecular attraction should be the most important in a solution containing benzene, C_6H_6, dissolved in toluene, C_7H_8?

   a) ion-dipole
   b) dipole-dipole
   c) ion-ion
   d) hydrogen bonding
   e) London dispersion forces

2. Calculate the molality of an aqueous solution of sucrose, $C_{12}H_{22}O_{11}$ (molar mass = 507.2 g/mol), if the mole fraction of sucrose is 0.0677.

   a) 4.03 m
   b) 1.68 m
   c) 1.31 m
   d) 0.776 m
   e) 0.252 m

3. The vapor pressure of pure methanol, CH_3OH, is 94.0 mm Hg at 20°C; the vapor pressure of pure ethanol, C_2H_5OH, is 44.0 mm Hg at the same temperature. What is the vapor pressure of a solution consisting of 1.50 mol methanol and 3.25 mol ethanol at 20°C?

   a) 59.8 mm Hg
   b) 73.5 mm Hg
   c) 78.2 mm Hg
   d) 69.0 mm Hg
   e) 28.4 mm Hg

4. What is the boiling point of a solution containing 30.0 g of K_2SO_4 (molar mass = 174.3 g/mol) dissolved in 100.0 g of water? (K_b for H_2O is 0.51 °C kg/mol.) (Assume complete dissociation.)

   a) 101.8°C
   b) 102.6°C
   c) 106.1°C
   d) 103.5°C
   e) 100.8°C

5. 100.0 mL of an aqueous solution containing 0.120 g of an unknown molecular compound generates an osmotic pressure of 18.0 mm Hg at 20.0°C. What is the molar mass of the unknown compound?

   a) 86 g/mol
   b) 122 g/mol
   c) 164 g/mol
   d) 860 g/mol
   e) 1220 g/mol

6. Arrange the following solutions in decreasing order of their freezing points:

   I.   0.10 m Na_3PO_4
   II.   0.25 m CH_3CH_2OH (ethanol, a nonelectrolyte)
   III. 0.15 m NaCl
   IV.   0.20 m $CaCl_2$

   a) II > III > I > IV
   b) I > III > IV > II
   c) II > IV > III > I
   d) IV > I > III > II
   e) I > II > III > IV

7. For which case would ΔH_{soln} be expected to be negative?

   a) If solute-solute interactions are much greater than solvent-solvent and solute-solvent interactions.
   b) If solvent-solvent interactions are much greater than solute-solvent and solute-solute interactions.
   c) If solute-solvent interactions are much greater than solvent-solvent and solute-solute interactions.
   d) If solute-solvent interactions are much less than solvent-solvent and solute-solute interactions.
   e) choices (a) and (b) are both correct.

8. The decomposition of hydrogen iodide, $2HI(g) \rightarrow H_2(g) + I_2(g)$, has rate constants of 9.51×10^{-9} $M^{-1}s^{-1}$ at 500 K and 1.10×10^{-5} $M^{-1}s^{-1}$ at 600 K. What is the activation energy for this reaction?

   a) 27.2 kJ/mol
   b) 176 kJ/mol
   c) 14.9 kJ/mol
   d) 45.3 kJ/mol
   e) 112 kJ/mol

9. Consider the hypothetical reaction below:

   $A + B \rightarrow C + D$

   It is found that doubling the initial concentration of A causes the initial reaction rate to be four times as great but that doubling the initial concentration of B has no effect on the initial reaction rate. What is the rate law for this reaction?

   a) rate = $k[A][B]$
   b) rate = $k[A]^2[B]$
   c) rate = $k[A]^2$
   d) rate = $k[A]^4[B]$
   e) rate = $k[A]^4$

10. The reaction between nitric oxide and ozone is represented by this equation:

$$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$$
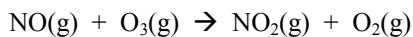
If the reaction is first order with respect to NO and first order with respect to O_3, what are the units of the rate constant?

a) $M^2 s^{-1}$
b) $M^{-2} s^{-1}$
c) $M s^{-1}$
d) $M^{-1} s^{-1}$
e) s^{-1}

11. Cyclopropane decomposes to propane at 450°C. The decomposition is a first-order reaction with a rate constant at 450° of 0.0560 min^{-1}. What is the half-life of cyclopropane at 450°C?

a) 1.22 min
b) 2.33 min
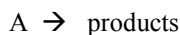c) 4.66 min
d) 8.26 min
e) 12.4 min

12. The thermal decomposition of N_2O_5 proceeds as follows:

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$
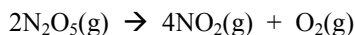
This is a first-order reaction with a rate constant of 5.10 x $10^{-4} s^{-1}$ at 318 K. How long would it take 20.0% of N_2O_5 to decompose at 318 K?

a) 5.97 s
b) 7.36 s
c) 438 s
d) 3160 s
e) 1360 s

13. Consider the reaction

A → products

If a plot of 1/[A] versus time is a straight line, what can be said about this reaction?

a) The reaction is zero-order.
b) The reaction is first-order.
c) The reaction is second-order.
d) The reaction order is –1.
e) None of these statements is true.

14. Consider the reaction energy profile for a certain reaction shown on the right. How would this profile change if the temperature of the reaction system was increased by 50°?

a) ΔE would increase.
b) ΔE would decrease.
c) E_a would increase.
d) E_a would decrease.
e) The profile would not change.

15. Increasing the temperature of a reaction causes the rate of the reaction to increase because:

a) The activation energy, E_a, is increased.
b) The activation energy, E_a, is decreased.
c) The frequency factor, also called the pre-exponential term, A, is increased.
d) The fraction of collisions with sufficient energy to react is increased.
e) The pressure exerted by the gas molecules increases.

16. The reaction below occurs in one elementary bimolecular step. What is the rate law for this reaction?

$$2NO_2(g) \rightarrow O_2(g) + N_2O_2(g)$$
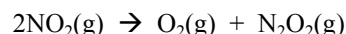
a) rate = $k[NO_2]$
b) rate = $k[NO_2]^2$
c) rate = $k\dfrac{[NO_2]^2}{[O_2][N_2O_2]}$
d) rate = $k\dfrac{[O_2][N_2O_2]}{[NO_2]^2}$
e) rate = $k[NO_2]^{-2}$

17. Consider the reaction below:

$$H_2(g) + 2ICl(g) \rightarrow 2HCl(g) + I_2(g)$$
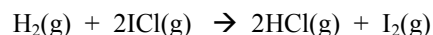
The experimentally-determined rate law for this reaction is: rate = $k[H_2][ICl]$. Which of the following mechanisms is consistent with the observed rate law?

a) $H_2(g) + ICl(g) \rightarrow HI(g) + HCl(g)$ (slow)
   $HI(g) + ICl(g) \rightarrow HCl(g) + I_2(g)$ (fast)

b) $H_2(g) + ICl(g) \rightarrow HI(g) + HCl(g)$ (fast)
   $HI(g) + ICl(g) \rightarrow HCl(g) + I_2(g)$ (slow)

c) $H_2(g) + 2ICl(g) \rightarrow 2HCl(g) + I_2(g)$

d) $H_2(g) + ICl(g) \rightarrow HCl(g) + I(g)$ (slow)
   $I(g) + ICl(g) \rightarrow I_2(g) + Cl(g)$ (fast)

e) $H_2(g) + 2ICl(g) \rightarrow 2HCl(g) + 2\ I(g)$ (slow)
   $2I(g) \rightarrow I_2(g)$ (fast)

18. Sulfuric acid is a very strong inorganic used in commercial and non-commercial laboratories. What is the molarity of a 70.00 wt % solution of sulfuric acid in water? The density of the solution is 1.6503 g/mL.

   a)   0.7137 M
   b)   7.141 M
   c)   11.78 M
   d)   4.328 M
   e)   0.01178 M

19. The solubility of CO_2 gas in water is 3.45×10^{-2} mol/L at 25°C and 1.00 atm pressure. What is the solubility (mol/L) of the dissolved CO_2 in a carbonated soft drink pressurized with 2.0 atm of CO_2 gas at 25°C?

   a.   0.069
   b.   2.0
   c.   0.017
   d.   0.138
   e. 8.6×10^{-3}

20. What is the vapor pressure of a solution formed by dissolving 25.0 g of glucose ($C_6H_{12}O_6$, molar mass = 180.2 g/mol) in 75.0 g of water at 50.0°C? (The vapor pressure of pure water at 50.0°C is 92.5 torr.)

   a)   2.98 torr
   b)   23.1 torr
   c)   69.4 torr
   d)   79.7 torr
   e)   89.5 torr

21. When a nonvolatile solute is dissolved to make a solution, how will the solution compare to the pure solvent in each of the following colligative properties?

	vapor pressure	boiling point	freezing point
a.	same	higher	lower
b.	lower	lower	higher
c.	higher	higher	lower
d.	lower	higher	same
e.	lower	higher	lower

22. In an experiment, pure water was separated from an aqueous sugar solution by a semipermeable membrane which allows water to pass freely but not sugar. After some time has passed, the concentration of the sugar solution…
   a)   will have increased.
   b)   will have decreased.
   c)   will not have changed.
   d)   might have increased or decreased depending on other factors.
   e)   will be the same on both sides of the membrane.

23   Consider the following reaction:

   $N_2(g + 3H_2(g) \rightarrow 2NH_3(g)$
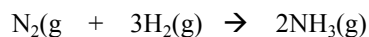
   If H_2 is being consumed at a rate of 1.50 M/s, how fast is NH_3 being formed?

   a)   0.750 M/s
   b)   2.25 M/s
   c)   4.50 M/s
   d)   1.00 M/s
   e)   0.500 M/s

24.   Given the initial rate data for the reaction A + B → C, determine the rate equation for the reaction.

[A] (mol/L)	[B] (mol/L)	rate
0.033	0.015	0.010
0.033	0.030	0.020
0.099	0.015	0.090

   a.   rate = k $[A]^2$ [B]
   b.   rate = k [A] [B]
   c.   rate = k $[A]^3$ $[B]^2$
   d.   rate = k $[A]^2$ $[B]^2$
   e.   rate = k $[A]^3[B]$