CHEMISTRY 212, Lect. Sect. 002  
Dr. G. L. Roberts  
Exam #1/Spring 2000  
Thursday, February 24, 2000

CLOSED BOOK EXAM—No notes or books allowed. Calculators may be used. Atomic masses of interest are included on the last page. Periodic tables are not allowed for this exam. CIRCLE ALL OF YOUR ANSWERS TO THE PROBLEMS BELOW. For problems that do not involve multiple choices write your final answer in the answer box. SHOW ALL WORK FOR CREDIT on non-multiple choice problems. Answers given with no work shown will receive zero credit.

(3 points each)

1. Most gases become less soluble in water as the temperature increases. What can be concluded about the signs of $\Delta H_{\text{soln}}$ and $\Delta S_{\text{soln}}$ in this case?
   (a) $\Delta H_{\text{soln}} < 0$ and $\Delta S_{\text{soln}} < 0$  
   (b) $\Delta H_{\text{soln}} < 0$ and $\Delta S_{\text{soln}} > 0$  
   (c) $\Delta H_{\text{soln}} > 0$ and $\Delta S_{\text{soln}} < 0$  
   (d) $\Delta H_{\text{soln}} > 0$ and $\Delta S_{\text{soln}} > 0$

2. A solution is prepared by dissolving 17.75 g sulfuric acid, $\text{H}_2\text{SO}_4$, in enough water to make 100.0 mL of solution. If the density of the solution is 1.1094 g/mL, what is the molality?
   (a) 0.1775 m  
   (b) 0.1810 m  
   (c) 1.810 m  
   (d) 1.940 m

3. The solubility of gaseous solutes in liquid solvents is greater when the
   (a) external pressure over the solution is increased  
   (b) external pressure is decreased  
   (c) partial pressure of the gas above the solution is increased  
   (d) partial pressure of the solvent is increased

4. All of the following factors affect reaction rates: concentration of reactants, concentration of catalyst, reaction temperature, surface area of a solid reactant or catalyst.
   (a) true  
   (b) false

5. Colligative properties depend on the concentration of solvent molecules or ions in solution but not on the chemical identity of the solute.
   (a) true  
   (b) false

6. For relatively dilute aqueous solutions the molality and molarity are approximately equal.
   (a) true  
   (b) false

7. According to Raoult’s Law, the equilibrium vapor pressure of a pure liquid is always decreased when a substance is dissolved in the liquid.
   (a) true  
   (b) false

8. The solubility of argon in water at 25°C is 0.0150 M. What is the Henry’s Law constant for argon if the partial pressure of argon in air is 0.00934 atm?.
   (a) 1.40 x 10\(^{-4}\)  
   (b) 0.623  
   (c) 1.61  
   (d) 4.10

9. If one mole of each is dissolved in 1.00 liter of water, which will lower the vapor pressure the most?
   (a) $\text{C}_12\text{H}_{22}\text{O}_{11}$  
   (b) $\text{NaNO}_3$  
   (c) $\text{C}_3\text{H}_7\text{OH}$  
   (d) $\text{MgCl}_2$

10. Assuming that sea water is a 3.5 wt% solution of NaCl in water, calculate its osmotic pressure at 20°C. The density of a 3.5% NaCl solution at 20°C is 1.023 g/mL.
    (a) 1.0 atm  
    (b) 15 atm  
    (c) 29 atm  
    (d) 100 atm

11. A solution of 62.4 g of insulin in enough water to make 1.00 L of solution has an osmotic pressure of 0.305 atm at 25°C. Based on these data, what is the molar mass of insulin?
    (a) 621 g/mol  
    (b) 5000 g/mol  
    (c) 7570 g/mol  
    (d) 71,900 g/mol

12. At 80°C, pure liquid A has an equilibrium vapor pressure of 700 mmHg and pure liquid B has an equilibrium vapor pressure of 940 mmHg. What is the mole fraction of A in the vapor for a $X_A$ = $X_B$ = 0.500 solution?
    (a) 0.25  
    (b) 0.57  
    (c) 0.75  
    (d) 0.43
13. Which statement is true for the general rate law: \( \text{Rate} = k[A]^m[B]^n \)?
   (a) It can be written from the stoichiometry of the overall reaction.
   (b) The overall order of the reaction is equal to \( m \times n \).
   (c) The values for the exponents must be determined by experiment.
   (d) The exponents in the rate law must be positive integers.

14. The reaction that takes place in a Breathalyzer for determining the alcohol level in a person’s bloodstream is given below. If the rate of appearance of \( \text{Cr}_2(\text{SO}_4)_3 \) is \( 1.24 \text{ mol/min} \), what is the rate of disappearance of \( \text{C}_2\text{H}_6\text{O} \)?

   \[
   2\text{K}_2\text{Cr}_2\text{O}_7 + 8\text{H}_2\text{SO}_4 + 3\text{C}_2\text{H}_6\text{O} \rightarrow 2\text{Cr}_2(\text{SO}_4)_3 + 2\text{K}_2\text{SO}_4 + 3\text{C}_2\text{H}_4\text{O}_2 + 11\text{H}_2\text{O}
   \]

   (a) 0.413 mol/min   (b) 0.826 mol/min   (c) 1.86 mol/min   (d) 3.72 mol/min

15. For the general rate law, \( \text{Rate} = k[A]^m[B]^n \), what will happen to the rate of reaction if the concentration of \( A \) is tripled?
   (a) The rate will be halved.   (b) The rate will be doubled.
   (c) The rate will be tripled.   (d) The rate will remain the same.

16. Which of the following statements are true about reaction mechanisms?
   I. A rate law can be written from the molecularity of the slowest elementary step.
   II. The final rate law can include intermediates.
   III. The rate of the reaction is dependent on the fastest step in the mechanism.
   IV. A mechanism can never be proven to be the correct pathway for the reaction.

   (a) I, II, III   (b) II, IV   (c) I, III   (d) I, IV

17. Which of the following statements are true about reaction order?
   I. A plot of \( \ln[A] \) vs. \( t \) is linear for a first-order process.
   II. A plot of \( 1/[A] \) vs. \( \log t \) is linear for a second-order process.
   III. A plot of \( \log[A] \) vs. \( t \) is linear for a first-order process.
   IV. A plot of \( 1/[A] \) vs. \( t \) is linear for a second-order process.

   (a) I, II, III   (b) II, III, IV   (c) I, III, IV   (d) I, II, IV   (e) None of the above

18. According to Collision Theory, a chemical reaction takes place if the energy of the collision between two molecules is sufficient to break chemical bonds, thereby providing a sound explanation of the role of \( E_a \).
   (a) true   (b) false

19. Which of the following statements does not describe the equilibrium state?
   (a) Equilibrium is dynamic and there is no net conversion to reactants and products
   (b) The concentration of the reactants is equal to the concentration of the products.
   (c) The concentration of the reactants and products reach a constant level.
   (d) The rate of the forward reaction is equal to the rate of the reverse reaction.

20. Which of the following statements is false regarding the equilibrium constant, \( K \)?
   (a) \( K \) for a reaction at a particular temperature always has the same value.
   (b) \( K \) for the reverse reaction is the negative of \( K \) for the forward reaction.
   (c) The numerical value of \( K \) depends on the form of the balanced equation.
   (d) When quoting \( K \), it is customary to omit units.

21. When 0.494 g of \( \text{K}_3\text{Fe(CN)}_6 \) is dissolved in 100.0 g of water, the freezing point is found to be \(-0.093^\circ\text{C}\). How many ions are present for each formula unit of \( \text{K}_3\text{Fe(CN)}_6 \) dissolved? (The value of "i" may or may not be a whole # integer.)

   \[ i = \_ \]
22. The initial rate of a reaction \( A + B \rightarrow C \) was measured for several different starting concentrations of \( A \) and \( B \), with the results given below. Using these data determine (a) the rate law for the reaction; (b) the magnitude of the rate constant; (c) the rate of the reaction when \( [A] = 0.50 \text{ M} \) and \( [B] = 0.250 \text{ M} \).

<table>
<thead>
<tr>
<th>Run #</th>
<th>([A]/ \text{M})</th>
<th>([B]/ \text{M})</th>
<th>(rate)/(M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00 \times 10^{-4}</td>
</tr>
<tr>
<td>2</td>
<td>2.00</td>
<td>1.00</td>
<td>2.00 \times 10^{-4}</td>
</tr>
<tr>
<td>3</td>
<td>1.00</td>
<td>2.00</td>
<td>2.00 \times 10^{-4}</td>
</tr>
<tr>
<td>4</td>
<td>2.00</td>
<td>2.00</td>
<td>4.00 \times 10^{-4}</td>
</tr>
</tbody>
</table>

(a) rate=_______________

(b) \( k = \)_______________

(c) rate=_______________

23. Assuming that the loss of ability to recall learned material is a first-order process with a half-life of 70 days, compute the number of days required to forget 70% of the material that you have learned in preparation for this exam. (Assume constant temperature and no further reference to the learned material during the decay period.)

\[ t = \]_______________

24. A compound of cobalt, carbon, and oxygen contains 28.10% oxygen and 34.47% cobalt. When 0.147g of this compound is dissolved in 6.72g of cyclohexane, the solution freezes at 5.23°C. What is the molecular formula of the compound?

Molecular formula

25. Write the equilibrium equation for the reverse reaction: \( 2 \text{CH}_4(g) + 3 \text{O}_2(g) \leftrightarrow 2 \text{CO}_2(g) + 4 \text{H}_2\text{O}(g) \)
Potentially useful/useless information.

f.p. cyclohexane = 6.55°C
k_f (cyclohexane) = 20.2°C/m
k_f (H_2O) = 1.858°C/m
m_c = 9.11 x 10^{-3} kg
m_b = 1.673 x 10^{-3} kg
m_m = 1.675 x 10^{-3} kg
J = N•m
N = m_P•kgs^{-2}
N_A = 6.02 x 10^{23} units/mol
R = 0.0821 L•atm/mol•K
R = 8.314 J/mol•K
1 L•atm = 101 J = 0.101 kJ
1 Pa = 1 kg/(m•s^2) = 1 N/m

\begin{align*}
\Delta H^\text{rxn} &= \Delta H_f^\text{products} - \Delta H_f^\text{reactants} \\
\Delta H &= n_c \Delta T \\
q &= ms\Delta T \\
x_i &= \frac{n_i}{n_{total}} = \left( \frac{P_i}{P_{total}} \right) \\
P_1 = x_i P_T \\
P_T = \Sigma P_i \\
\log \left( \frac{P_2}{P_1} \right) &= \left( \frac{\Delta H_{298}}{2.303 R} \right) \left( \frac{1}{T_1} - \frac{1}{T_2} \right) \\
F.C. &= (\#ve) - (\#lpe) - \frac{1}{2} (\#se) \\
S &= k_0 P \\
P_A = P_a \Delta x_A \\
\Delta P = P_a \Delta x_B \\
\Delta T_h &= k_a \Delta x_m \\
\Delta T_l &= k_b \Delta x_m \\
\Pi &= MRT \\
\ln \left( \frac{[A]_x}{[A]_0} \right) &= -kt \\
\log \left( \frac{[A]_x}{[A]_0} \right) &= -kt/2.303 \\
\log \left( \frac{k_x}{k_i} \right) &= \frac{E_x}{2.303 R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right) \\
t_{1/2} &= 0.693/k \\
k &= pfZ \\
f &= e^{E_a/RT} \\
\text{r.m.s.} &= \sqrt{\frac{3RT}{M_m}} \\
K_p &= \frac{[C]^a[D]^d}{[A]^b[B]^c} \\
Q_p &= \frac{[C]^a[D]^d}{[A]^b[B]^c} \\
K_p &= K_a(RT)^{n_c} \\
K_w &= [H^+] [OH^-] = 1.0 \times 10^{-14} \text{ at } 25°C \\
pH &= -\log [H^+] \\
pH + pOH &= 14.00 \\
K_a &= \frac{[H^+] [A^-]}{[HA]} \\
K_b &= \frac{[HB^-] [OH^-]}{[B]} \\
K_a K_b &= K_w