### Chem 112 - Exam 2 - 2017

**Average**: Avg = 60.7

**Median**: Med = 64

**Standard Deviation**: \( \sigma = 20 \)
DO NOT OPEN THIS EXAM UNTIL YOU ARE INSTRUCTED TO DO SO

- Please print your name on the scantron
  - Last Name, First Name
  - That’s all that’s needed

- Sit in odd numbered seats.

- Books & Bags in the front of the room.

- No text entry calculators.

- Use the exams as scratch paper.

- Keep the exams when you are done.

- Turn in the scantrons.

100 total points. Questions 1-16 worth 6 points each. Question 17 worth 4 points.
### Constants

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>$8.314 \text{ J/K-mol}$</td>
</tr>
<tr>
<td></td>
<td>$0.0821 \text{ l-atm/K-mol}$</td>
</tr>
<tr>
<td>1 mole</td>
<td>$6.022 \times 10^{23}$</td>
</tr>
<tr>
<td>Faraday</td>
<td>$96,500 \text{ coulombs}$</td>
</tr>
</tbody>
</table>

### Chem 111 Equations

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$q = m \Delta H$</td>
<td>Gas Equations</td>
</tr>
<tr>
<td>$u = \frac{3RT}{M}$</td>
<td>(P+(n²a/V²))(V-nb)=nRT</td>
</tr>
<tr>
<td>$\Delta x^2 + y^2 = c^2$</td>
<td>Volume of a cube: $V = l^3$</td>
</tr>
<tr>
<td>$S = kT$</td>
<td>Henry’s Law</td>
</tr>
<tr>
<td>$\ln P = -\frac{\Delta H_{\text{vap}}}{RT} + b$</td>
<td>Clausius-Clapeyron Equation</td>
</tr>
<tr>
<td>$P_A = P_a X_A$</td>
<td>Colligative Properties</td>
</tr>
<tr>
<td>$\Delta P = P_a X_B$</td>
<td>$\Delta T_b = K_b c_m$</td>
</tr>
<tr>
<td>$\Delta T_f = K_f c_m$</td>
<td>$K_p = K_c (RT)^{\Delta n}$</td>
</tr>
<tr>
<td>$\ln [A]_t = -kt + \ln [A]_0$</td>
<td>Chemical Kinetics</td>
</tr>
<tr>
<td>$\ln \frac{P_2}{P_1} = \frac{\Delta H_{\text{vap}}}{RT} \left( \frac{1}{T_1} - \frac{1}{T_2} \right)$</td>
<td>Arrhenius Equation</td>
</tr>
<tr>
<td>$aA + bB = cC + dD$</td>
<td>Chemical Equilibrium</td>
</tr>
<tr>
<td>$K_C = \frac{[C]^c[D]^d}{[A]^a[B]^b}$</td>
<td>$K_p = K_c (RT)^{\Delta n}$</td>
</tr>
<tr>
<td>$pH = -\log [H^+]$</td>
<td>pH</td>
</tr>
<tr>
<td>$\text{antilog}(x) = 10^x$</td>
<td>$K_b K_w = K_w$</td>
</tr>
<tr>
<td>$pX = -\log X$</td>
<td>Henderson-Hasselbach Eqn</td>
</tr>
<tr>
<td>$aX^2 + bX + c = 0$</td>
<td>Quadratic formula</td>
</tr>
<tr>
<td>$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$</td>
<td>$\Delta G = \Delta H - T\Delta S$</td>
</tr>
<tr>
<td>$\Delta U = q + w$</td>
<td>Chemical Thermodynamics</td>
</tr>
<tr>
<td>$w = -P\Delta V$</td>
<td>$\Delta G = \Delta G^0 + RT \ln Q$</td>
</tr>
<tr>
<td>$\Delta G^0 = -RT \ln K$</td>
<td>$\Delta G^0 = -nFE_{\text{cell}}$</td>
</tr>
<tr>
<td>$E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}}$</td>
<td>Nernst Equation</td>
</tr>
<tr>
<td>$E_{\text{cell}} = E^0_{\text{cell}} - \frac{RT}{nF} \ln Q$</td>
<td>At 298K</td>
</tr>
<tr>
<td>$E^0_{\text{cell}} = E^0_{\text{cell}} - \frac{0.0592}{n} \log Q$</td>
<td></td>
</tr>
</tbody>
</table>
1) The presence of a non-volatile solute will do which of the following to the boiling point of a solvent? 
   a) increase BP 
   b) decrease BP 
   c) may increase or decrease BP 
   d) does not effect BP 

2) At the melting point of a solid which of the following statements is true about its vapor pressure? 
   a) the VP of the liquid is 1 atm 
   b) the VP of the solid is 1 atm 
   c) the VP of the liquid is less than the solid’s VP 
   d) the VP of the liquid is equal to the solid’s VP 
   e) the VP of gas is greater than 1 atm 

3) A 2.50 molal solution of glycerine (MW = 92.11) in water has a density of 1.23 g/mL. Calculate the mass percentage of glycerine in this solution. 
   a) 15.8% 
   b) 16.8% 
   c) 18.7% 
   d) 20.0% 
   e) 21.1% 

4) The solubility of CO₂ in water at 20 °C is 8.67 x 10⁻³ M when the partial pressure of CO₂ is 0.50 atm. What is the solubility of CO₂ when the partial pressure above the solution is 5.2 atm? 
   a) 0.00012 M 
   b) 0.00083 M 
   c) 0.044 M 
   d) 0.090 M 
   e) 0.0121 M 

5) Given the data in the table below, determine the rate law for the following reaction. 
   \[2\text{Hg}^{2+}(aq) + \text{C}_2\text{O}_4^{2-}(aq) \rightarrow 2\text{CO}_2^{2-}(aq) + \text{Hg}_2^{2+}(aq)\] 

<table>
<thead>
<tr>
<th>[Hg²⁺]</th>
<th>[C₂O₄²⁻]</th>
<th>Initial rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.10</td>
<td>1.2 x 10⁻⁷</td>
</tr>
<tr>
<td>0.10</td>
<td>0.20</td>
<td>4.8 x 10⁻⁷</td>
</tr>
<tr>
<td>0.20</td>
<td>0.20</td>
<td>9.6 x 10⁻⁷</td>
</tr>
</tbody>
</table>

   a) rate = k [Hg²⁺][C₂O₄²⁻] 
   b) rate = k [Hg²⁺]²[C₂O₄²⁻] 
   c) rate = k [Hg²⁺][C₂O₄²⁻]³ 
   d) rate = k [Hg²⁺]³²/[C₂O₄²⁻]² 
   e) rate = k [Hg²⁺][C₂O₄²⁻]²
6) The following reaction mechanism would indicate which of the following rate law?  

\[ \text{NO} + \text{O}_2 = \text{NO}_3 \text{ fast equilibrium} \]
\[ \text{NO}_3 + \text{NO} \rightarrow 2\text{NO}_2 \text{ slow} \]

a) rate = \( k [\text{NO}]^2[\text{O}_2] \)
b) rate = \( k [\text{NO}][\text{O}_2] \)
c) rate = \( k [\text{NO}]^{1/2}[\text{O}_2] \)
d) rate = \( k [\text{NO}]^2 \)
e) rate = \( k [\text{O}_2] \)

7) A first order reaction expected to be a linear relationship if the following is plotted.  

a) \( 1/[A]t \) vs. \( t \)
b) \( [A]t \) vs. \( t \)
c) \( 1/[A]^2t \) vs. \( t \)
d) \( \ln[A]t \) vs. \( t \)
e) \( 1/[A]t \) vs. \( 1/t \)

8) The half-life of a second order reaction is  

a) \( \ln(k) \)
b) \( \ln2/k \)
c) \( 1/[A]_0k \)
d) \( 1/k \)
e) \( [A]_0k \)

9) Calculate the freezing point of a solution that is made by mixing equal volumes of antifreeze (ethylene glycol, \( \text{C}_2\text{H}_6\text{O}_2 \)) and water.  

Ethylene Glycol: density = 1.12 \( g/cm^3 \), MW = 62 \( g/mol \)
Water: density = 1.00 \( g/cm^3 \)
\( K_f (\text{H}_2\text{O}) = 1.86 \text{ } ^0\text{C}/\text{m} \)

a) \(-10.6 \text{ } ^0\text{C} \)
b) \(-33.7 \text{ } ^0\text{C} \)
c) \(-14.5 \text{ } ^0\text{C} \)
d) \(-2.1 \text{ } ^0\text{C} \)
e) \(-42.5 \text{ } ^0\text{C} \)
10) Diamond crystallizes in a cubic lattice with an edge length of 357 pm. If there are a total of 8 carbon atoms in the unit cell, what is the density of diamond? 

   a) 12.9 g/cm$^3$
   b) 3.54 g/cm$^3$
   c) 8.26 g/cm$^3$
   d) 2.26 g/cm$^3$
   e) 6.20 g/cm$^3$

11) Which type of bonding does Ca form upon solidification? 

   a) covalent network
   b) ionic
   c) metallic
   d) molecular
   e) ion-dipole

12) Which of the following compounds will be most soluble in ethanol (CH$_3$CH$_2$OH)?

   a) trimethylamine (N(CH$_3$)$_3$)
   b) acetone (CH$_3$COCH$_3$)
   c) ethylene glycol (HOCH$_2$CH$_2$OH)
   d) hexane (CH$_3$CH$_2$CH$_2$CH$_2$CH$_3$)
   e) chloroform (CHCl$_3$)

13) Which of the following statements is true?

   a) In general, the solubility of a solid in water decreases with increasing temperature.
   b) In general, the solubility of a gas in water decreases with increasing temperature.
   c) The solubility of a gas in water usually increases with decreasing pressure.
   d) The solubility of an ionic solid in water decreases with increasing temperature.
   e) None of the above statements are true.

14) Which of the following concentration units are temperature dependent?

   a) mole fraction
   b) molality
   c) mass percent
   d) molarity
   e) none of the above.
15] Which of the following diagrams would best describe the phase diagram of carbon dioxide?  

![diagrams]

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

16] A change in temperature from 10 °C to 20 °C is found to double the rate of a given chemical reaction. How did this change affect the reacting molecules?  

a) It doubled their average velocity.  
b) It doubled their average energy.  
c) It doubled the number of collisions per second.  
d) It doubled the pressure inside the reaction vessel.  
e) It doubled the proportion of molecules possessing at least the minimum energy required for the reaction.  

17] My recitation meets at  

a) 12:30 pm on Thursdays  
b) blank  
c) blank  
d) 2:30 pm on Thursdays  

Answers

1 a)  

2 d
3 c) for 1 kg of solution: 2.50 mol/kg x 92.11g/mol gly. = 230.3 g gly.
Mass% = \[\frac{230.3 \text{ g}}{230.3 + 1000 \text{ g}}\] x 100 = 18.7%

4 d) \[S = kP \ k = 8.67 \times 10^{-3} \text{ M/0.50 atm} = 1.734 \times 10^{-2} \text{ M/atm} \ S = 1.734 \times 10^{-2}(5.2 \text{ atm}) = 0.090 \text{ atm}\]

5 e)

6 a)
7 d)
8 c)
9 b) assume 1 L of water and 1 L E.G.  
\[
\begin{array}{ccc}
\text{H}_2\text{O} & \text{EG} \\
\text{vol} & 1 \text{ L} & 1 \text{ L} \\
\text{mass} & 1000 \text{ g} & 1120 \text{ g} \\
\text{mol} & 55.5 \text{ mol} & 18.1 \text{ mol}
\end{array}
\]

\[
\text{molality EG} = 18.1 \text{ mol/kg water} \quad \Delta T = -k_m = -1.86 \text{ C/m} \quad 18.1 \ m = -33.7 \text{ C}
\]