Midterm Examination 1

Multiple Choice Questions

1. If a solution of Hexane (C\textsubscript{6}H\textsubscript{14}) and Methyl Amine (CH\textsubscript{3}NH\textsubscript{2}) were to form, the dominant Intermolecular Force between molecules of Hexane and Methyl Amine would be:
   a) LDF
   b) Dipole-Dipole
   c) H-Bonding
   d) Ion-Dipole

2. A solution prepared by mixing liquid Pentane (C\textsubscript{5}H\textsubscript{12}) and liquid Diethyl Ether (CH\textsubscript{3}CH\textsubscript{2}-O-CH\textsubscript{2}CH\textsubscript{3}) is expected to have an Enthalpy of Solution that is:
   a) large and exothermic \( \Delta H_{\text{soln}} < 0 \)
   b) small and exothermic \( \Delta H_{\text{soln}} < 0 \)
   c) about zero \( \Delta H_{\text{soln}} \approx 0 \)
   d) small and endothermic \( \Delta H_{\text{soln}} > 0 \)
   e) large and endothermic \( \Delta H_{\text{soln}} >> 0 \)

3. The partial pressure of CO\textsubscript{2} gas above the liquid in a bottle of Champagne at 20\textdegree C is 5.5 atm. The Henry’s Law constant is \( k_{\text{CO2}} = 3.7 \times 10^{-2} \) M/atm. What is the Solubility of CO\textsubscript{2} in Champagne?
   a) 1.70 M
   b) 1.05 M
   c) 0.75 M
   d) 0.20 M

4. Caffeine is about 10 times as soluble in hot Water as in cold Water. A hot Water extract of Caffeine is put into an Ice bath and some Caffeine crystallizes. The remaining solution is:
   a) saturated.
   b) unsaturated.
   c) super-saturated.
5. How many grams NaOH is required to prepare 500 mL of a 0.25 M solution?

a) 9.8g  
   b) 5.0g  
   c) 3.7g  
   d) 2.3g

6. Brass is a solution of Copper and Zinc. Red Brass is approximately 20% Zinc. What is the molality of this solid solution?

a) 15.3 m  
   b) 4.7 m  
   c) 3.8 m  
   d) 0.25 m

7. What is the Freezing Point Depression of a 0.001m solution of K₂SO₄ in Water? (K_f = 1.86°C/m for Water)

a) 1.003°C  
   b) 0.1291°C  
   c) 0.0214°C  
   d) 0.0056°C

8. Shaving cream is a colloidal foam, meaning it is a _________ dispersed into a _________ phase.

a) gas; liquid  
   b) liquid; solid  
   c) liquid; liquid  
   d) solid; liquid

9. The light of the beam of a movie projector in a darkened theater is observed to scatter significantly. This demonstrates that the Air in the theater is:

a) a solution.  
   b) a colloidal system.  
   c) a pure substance.  
   d) elemental.
10. At 1000°C, Cyclobutane (C$_4$H$_8$), an explosively unstable hydrocarbon, decomposes to Ethylene:

\[
\text{C}_4\text{H}_8(g) \rightarrow 2 \text{C}_2\text{H}_4(g)
\]

The Rate of Formation of C$_2$H$_4$ is:

a) one quarter that of the Decomposition of C$_4$H$_8$.
b) one half that of the Decomposition of C$_4$H$_8$.
c) twice that of the Decomposition of C$_4$H$_8$.
d) four times that of the Decomposition of C$_4$H$_8$.

11. The dimerization of Cyclopentadiene (C$_5$H$_6$) in Benzene at 25.1°C:

\[
2 \text{C}_5\text{H}_6 \rightarrow \text{C}_{10}\text{H}_{12}
\]

follows Second Order kinetics:

\[
\text{Rate} = k [\text{C}_5\text{H}_6]^2
\]

If the C$_5$H$_6$ concentration is cut in half, the Rate of this reaction will be:

a) cut by one quarter.
b) cut in half.
c) doubled.
d) quadrupled.

12. The following reaction is Second Order:

\[
2 \text{NO}_2(g) \rightarrow 2 \text{NO}(g) + \text{O}_2(g)
\]

with a rate constant k = 0.543M$^{-1}$sec$^{-1}$. If we start with [NO$_2$]$^0$=0.01M, how much will remain after 50 sec?

a) 0.00024 M
b) 0.00097 M
c) 0.0023 M
d) 0.0079 M
13. Again, the following reaction is Second Order:

\[
2 \text{NO}_2(g) \rightarrow 2 \text{NO}(g) + \text{O}_2(g)
\]

with a rate constant \(k = 0.543 \text{M}^{-1} \text{sec}^{-1}\). If we start with \([\text{NO}_2]_0 = 0.01 \text{M}\), how long will it take for the concentration of the reactant to be cut in half?

a) 2892 sec  
   b) 593 sec  
   c) 184 sec  
   d) 34 sec

14. A reaction taking place in an aqueous environment is diluted with additional Water. This should cause the Reaction Rate to:

a) increase.  
   b) remain constant.  
   c) decrease.

15. The Rate Law for the following chemical reaction:

\[
\text{H}_2(g) + 2 \text{ICl}(g) \rightarrow \text{I}_2(g) + 2 \text{HCl}(g)
\]

is:

\[
\text{Rate} = k [\text{H}_2] [\text{ICl}]
\]

The overall Order of this reaction is:

a) 1st  
   b) 2nd  
   c) 3rd  
   d) 4th
1. The nerve gas Phosgene can be produced by mixing Carbon Monoxide and Chlorine gases and exposing the mixture to sunlight. Initial Rate data for this reaction has been obtained:

\[ \text{CO(g) + Cl}_2(g) \rightarrow \text{COCl}_2(g) \]

<table>
<thead>
<tr>
<th>Trial</th>
<th>([\text{CO}]_0 ) (M)</th>
<th>([\text{Cl}_2]_0 ) (M)</th>
<th>Rate(_0 ) (M/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00</td>
<td>0.100</td>
<td>1.29 x 10(^{-29})</td>
</tr>
<tr>
<td>2</td>
<td>0.100</td>
<td>0.100</td>
<td>1.31 x 10(^{-30})</td>
</tr>
<tr>
<td>3</td>
<td>0.100</td>
<td>1.00</td>
<td>1.30 x 10(^{-29})</td>
</tr>
</tbody>
</table>

Determine the Reaction Order with respect to CO and Cl\(_2\) and write the resulting Differential Rate Law for this reaction. (Show your work.)
2. The reaction of Hydrochloric Acid with Methanol:

\[
\text{CH}_3\text{OH(aq)} + \text{HCl(aq)} \rightarrow \text{CH}_3\text{Cl(aq)} + \text{H}_2\text{O}
\]

yields the following data, when a large excess of Methanol is used:

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>[HCl] (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.85</td>
</tr>
<tr>
<td>54</td>
<td>1.58</td>
</tr>
<tr>
<td>107</td>
<td>1.36</td>
</tr>
<tr>
<td>215</td>
<td>1.02</td>
</tr>
<tr>
<td>430</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Determine the initial Reaction Rate. (Show your work.)
3. The rearrangement of Methy Isonitrile has been extensively studied:

\[
\text{CH}_3\text{-NC}(g) \rightarrow \text{CH}_3\text{-CN}(g)
\]

Kinetic data at two different temperatures is plotted below.

At 189.7°C

![Graph](image)

\[y = -0.0015x - 0.0002\]

At 251.2°C

![Graph](image)

\[y = -0.1898x - 6\times10^{-5}\]

Determine the reaction Rate Constants \(k\) for this chemical reaction at the above two temperatures. Determine the Activation Energy \(E_a\) for this reaction. (Space is provided on the next pg.)
4. Zeroth Order reactions seem to be counter-intuitive from a molecular point-of-view. Explain why?

5. Polymers are high molecular weight molecules. 6.053g of poly(Vinyl Alcohol) in a 100.0mL solution has an Osmotic Pressure of 0.272 atm at 25°C.

a) What is the Molarity of this solution?

b) What is the number of mole poly(Vinyl Alcohol) dissolved in this solution?

c) What is the MW of the polymer?
Appendix

Constants

\[ N_A = 6.022045 \times 10^{23} \text{ entities/mole} \]
\[ k_B = 1.380662 \times 10^{-23} \text{ J/K} \]
\[ c = 2.99792458 \times 10^8 \text{ m/sec} \]
\[ h = 6.626176 \times 10^{-34} \text{ J sec} \]
\[ R = 8.314 \text{ J/K mol} \]
\[ = 0.08206 \text{ L atm/K mol} \]
\[ 1 \text{ amu} = 1.6605 \times 10^{-24} \text{ g} \]
The labels on top (1A, 2A, etc.) are common American usage. The labels below these (1, 2, etc.) are those recommended by the International Union of Pure and Applied Chemistry (IUPAC).

The names and symbols for elements 113 and above have not yet been decided.

Atomic weights in brackets are the names of the longest-lived or most important isotope of radioactive elements.

Further information is available at http://www.webelements.com

** Discovered in 2010, element 117 is currently under review by IUPAC.