Midterm Examination 1

Multiple Choice Questions

1. If a solution of Water (H\textsubscript{2}O) and Methyl Amine (CH\textsubscript{3}NH\textsubscript{2}) were to form, the dominant Intermolecular Force between molecules of Water 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 Octane (C\textsubscript{8}H\textsubscript{18}) is expected to have an Enthalpy of Solution that is:
   a) large and exothermic (\(\Delta H_{\text{soln}} << 0\)) \(\Delta H_{\text{pent}} \sim \) small (LDF)
   b) small and exothermic (\(\Delta H_{\text{soln}} < 0\)) \(\Delta H_{\text{octan}} \sim \) small (LDF)
   c) about zero (\(\Delta H_{\text{soln}} \sim 0\)) ***** \(\Delta H_{\text{mix}} \sim \) small (LDF)
   d) small and endothermic (\(\Delta H_{\text{soln}} > 0\))
   e) large and endothermic (\(\Delta H_{\text{soln}} >> 0\)) \(\Delta H_{\text{soln}} \sim \) small + small - small \sim 0

3. The Henry's Law Constant for O\textsubscript{2} in Water is \(k_{O_2} = 0.00128 \text{ M/atm}\). How many grams of O\textsubscript{2} can dissolve in 2.00L Water if the partial pressure of O\textsubscript{2} over the Water is 0.20 atm? (Hint: First calculate the solubility of the O\textsubscript{2} in the Water.)
   a) 0.123g \(S_{O_2} = k_{O_2} P_{O_2} = (0.00128 \text{ M/atm})(0.20 \text{ atm}) = 2.56 \times 10^{-4} \text{ M}\)
   b) 0.105g
   c) 0.063g
   d) 0.016g ***** \#g = (2.56 \times 10^{-4} \text{ M})(2.00 \text{ L})(32 \text{ g/mol}) = 0.016g

4. When a diver dives to great depths, an excess of gaseous Nitrogen will dissolve in his blood. If he surfaces too rapidly, he can suffer from the Bends. This is because his blood is ________________ with respect to Nitrogen.
   a) saturated
   b) unsaturated
   c) super-saturated *****
5. A solution is prepared by mixing 3.50g Naphthalene (moth-balls, C_{10}H_{11}) into 29.0g of Benzene (a hydrocarbon liquid, C_{6}H_{6}). What is the mole fraction of Benzene in this solution?

   a) 0.978  
   b) 0.933  
   c) 0.871  
   d) 0.711

   \# mol Nap = (3.50 \text{ g}) \times \left( \frac{1 \text{ mol Nap}}{131 \text{ g}} \right) = 0.0267 \text{ mol Nap}

   \# mol Ben = (29.0 \text{ g}) \times \left( \frac{1 \text{ mol Ben}}{78 \text{ g}} \right) = 0.3718 \text{ mol Ben}

   x_{\text{Ben}} = \frac{0.3718}{0.3718 + 0.0267} = 0.933

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

   Assume 100 g Soln: 20g Zn & 80g Cu

   \# mol = \frac{20g}{65.4 \text{ g/mol}} = 0.306 \text{ mol}

   \text{molality} = \frac{0.306 \text{ mol}}{0.80 \text{ kg}} = 3.8 \text{ m}

7. While cooking, you add a "pinch" of Table Salt, NaCl, to a quart of water simmering in a sauce pan. Take the "pinch" of salt to be about 0.1 gram and the amount of water to be close to 1 L; ~1 kg. What is the elevation in the boiling point of this solution? For water, \(K_b = 0.521 \degree C/m\).

   a) 1.003\degree C  
   b) 0.1291\degree C  
   c) 0.0214\degree C  
   d) 0.0018\degree C

   \Delta T_b = K_b m = (2)(0.521 \degree C/m)(0.00171 \text{ m}) = 0.0018\degree C

8. Milk is a colloidal emulsion, meaning it is a ____________ dispersed into a ____________ phase.

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

   Liquid Fat globules dispersed in an Aqueous Sol'n

9. As a pan of water is heated, the concentration of the dissolved gases will:

   a) increase.  
   b) decrease.  
   c) remain fairly constant.
10. Hydrogen reacts explosively with Oxygen to produce Water

\[ 2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(g) \]

The Rate of Consumption of O\textsubscript{2} is:

a) one quarter that of H\textsubscript{2}.

\[ \text{Rate} = - (1/2) \Delta[\text{H}_2] / \Delta t = - \Delta[\text{O}_2] / \Delta t \]

b) one half that of H\textsubscript{2}. ******

c) twice that of H\textsubscript{2}.

d) four times that of H\textsubscript{2}.

11. Chloroform reacts with Chlorine to form Carbon Tetrachloride:

\[ \text{CHCl}_3 + \text{Cl}_2 \rightarrow \text{CCl}_4 + \text{HCl} \]

The rate law for this reaction is:

\[ \text{Rate} = k [\text{CHCl}_3] [\text{Cl}_2]^{1/2} \]

If the concentration of the Chlorine is increased by a factor of four, the reaction rate will increase by a factor of:

a) 2. ******

\[ \text{Rate} \sim 4^{1/2} x = 2 x \]

b) 4.

c) 8.

d) 16.

12. The decomposition of Nitramide occurs according to first-order kinetics with a rate constant of 0.00563 min\textsuperscript{-1}:

\[ \text{NH}_4\text{NO}_2\text{aq}) \rightarrow \text{N}_2\text{O}(g) + \text{H}_2\text{O}(l) \]

How long will it take for a solution that is 0.105M Nitramide to decompose to 0.041M?

a) 23.4 min  
\[ [\text{Nit}] = [\text{Nit}]_0 \exp(-kt) \]

b) 97.1 min

c) 167 min ******  
\[ (0.041 \text{ M}) = (0.105 \text{ M}) \exp( - (0.00563 \text{ min}^{-1}) t) \]

d) 245 min  
\[ t = 167 \text{ min} \]
13. 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?

\[ \frac{1}{[\text{N}_2\text{O}_5]} = \frac{1}{[\text{N}_2\text{O}_5]_0} - kt \]

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

14. 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 189.7°C is plotted below.

The Rate Constant \( k \) for this reaction is:

a) 0.0002 min\(^{-1}\)  
   b) **0.0015 min\(^{-1}\)**  
   c) 0.1133 min\(^{-1}\)  
   d) 0.3341 min\(^{-1}\)
15. The bromination of nitric oxide:

\[ 2 \text{NO} + \text{Br}_2 \rightarrow 2 \text{NOBr} \]

occurs according to the following rate law:

\[ \text{Rate} = k [\text{NO}]^2 [\text{Br}_2] \]

The overall Order of this reaction is:

a) 1\text{st}
b) 2\text{nd}
c) 3\text{rd} \quad \text{order} = 2 + 1 = 3
d) 4\text{th}
**Short Answer**

1. Initial rate data is provided for the following reaction:

$$2 \text{NO} + \text{H}_2 \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$$

<table>
<thead>
<tr>
<th>Trial #</th>
<th>[NO]₀ (M)</th>
<th>[H₂]₀ (M)</th>
<th>rate₀ (M/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial #1</td>
<td>6.4 x 10⁻³</td>
<td>2.2 x 10⁻³</td>
<td>2.60 x 10⁻⁵</td>
</tr>
<tr>
<td>Trial #2</td>
<td>12.8 x 10⁻³</td>
<td>2.2 x 10⁻³</td>
<td>10.4 x 10⁻⁵</td>
</tr>
<tr>
<td>Trial #3</td>
<td>6.4 x 10⁻³</td>
<td>4.4 x 10⁻³</td>
<td>5.20 x 10⁻⁵</td>
</tr>
</tbody>
</table>

Determine the Reaction Order with respect to NO and H₂. Write the resulting Rate Law for this reaction. (Show your work.)

Assume

$$\text{Rate} = k [\text{NO}]^m [\text{H}_2]^n$$

Then

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \left(\frac{[\text{NO}]_2}{[\text{NO}]_1}\right)^m$$

$$(10.4 / 2.60) = (12.8 / 6.4)^m$$

$$4 = 2^m$$

$$m = 2$$

$$\frac{\text{Rate}_3}{\text{Rate}_1} = \left(\frac{[\text{H}_2]_3}{[\text{H}_2]_1}\right)^n$$

$$(5.20 / 2.60) = (4.4 / 2.2)^n$$

$$2 = 2^n$$

$$n = 1$$

Finally,

$$\text{Rate} = k [\text{NO}]^2 [\text{H}_2]$$
2. For the decomposition of N\(_2\)O\(_5\), we have:

\[
2 \text{N}_2\text{O}_5 \rightarrow 4 \text{NO}_2 + \text{O}_2
\]

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>[N(_2)O(_5)] (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.65 x 10(^{-2})</td>
</tr>
<tr>
<td>600</td>
<td>1.24 x 10(^{-2})</td>
</tr>
<tr>
<td>1200</td>
<td>0.93 x 10(^{-2})</td>
</tr>
<tr>
<td>1800</td>
<td>0.71 x 10(^{-2})</td>
</tr>
</tbody>
</table>

Calculate the reaction rate during the first and last time intervals. Comment on your results.

\[
\text{Rate} = - \frac{1}{2} \frac{\Delta [\text{N}_2\text{O}_5]}{\Delta t}
\]

\[1^{st} \text{ Interval}\]

\[
\text{Rate} = - \frac{1}{2} \frac{(1.24 - 1.65) \times 10^{-2} \text{ M}}{(600 - 0 \text{ sec})} = 3.42 \times 10^{-6} \text{ M/sec}
\]

\[\text{Last Interval}\]

\[
\text{Rate} = - \frac{1}{2} \frac{(0.71 - 0.93) \times 10^{-2} \text{ M}}{(1800 - 1200 \text{ sec})} = 1.83 \times 10^{-6} \text{ M/sec}
\]

The rate has decreased as expected when the concentration of the reactants decreases.

3. Amnesic Shellfish Poisoning is a result of eating shell which contain high levels of Domoic Acid. How were the harvesters of Blue Muscles on Prince Edward Island advised to avoid raising shellfish with high levels of Domoic Acid and why does this remedy work?

**Sol'n:** Wait a sufficient amount of time after a Red Tide before harvesting the shellfish.

Domoic Acid is very hydrophillic. So it will not absorb into the fleshy parts of the muscle. It will instead be expelled from the digestive tract of the muscle with the water.
4. 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?

\[ C = \frac{\pi}{RT} = \frac{0.272 \text{ atm}}{0.08206 \text{ L atm/K mol}} \times (298.15 \text{ K}) \]

\[ = 0.011 \text{ M} \]

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

\[ \# \text{ mol} = (0.0111 \text{ M})(0.1000 \text{ L}) = 0.00111 \text{ mol} \]

c) What is the MW of the polymer?

\[ \text{MW} = \frac{6.053 \text{ g}}{0.00111 \text{ mol}} = 5.4 \times 10^3 \text{ g/mol} \]

5. Why do we expect the Rate of a chemical reaction to decrease as the reaction proceeds? Why might this not happen?

As the molecules get further apart, because they are more dilute, they collide less frequently and therefore should react more slowly.

This may not happen if the reaction relies on some hidden variable or if the molecules collide and react in a way not explained by the overall reaction stoichiometry.
Appendix

Constants

\[ N_A = 6.022045 \times 10^{23} \text{ entities/mole} \]
\[ k_B = 1.380662 \times 10^{-23} \text{ J/K} \]
\[ c = 2.99792458 \times 10^8 \text{ m/sec} \]
\[ h = 6.626176 \times 10^{-34} \text{ J sec} \]
\[ R = 8.314 \text{ J/K mol} \]
\[ = 0.08206 \text{ L atm/K mol} \]
\[ 1 \text{ amu} = 1.6605 \times 10^{-24} \text{ g} \]
# Periodic Table of the Elements

**Main Group Elements**

<table>
<thead>
<tr>
<th>Representative Elements</th>
<th>1A (^a)</th>
<th>2A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
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</tr>
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</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Li</th>
<th>Be</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Na</td>
<td>Mg</td>
</tr>
</tbody>
</table>

| 3                       | K          | Ca  | Sc  | Ti  | V   | Cr  | Mn  | Fe  | Co  | Ni  | Cu  | Zn  | Rb  | Sr  | Y   | Zr  | Nb  | Mo  | Tc  | Ru  | Rh  | Pd  | Ag  | Cd  |
|-------------------------|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 4                       | Rb         | Sr  | Y   | Zr  | Nb  | Mo  | Tc  | Ru  | Rh  | Pd  | Ag  | Cd  | In  | Sn  | Sb  | Te  | I   | Xe  |
|-------------------------|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 5                       | Cs         | Ba  | Lu  | Hf  | Ta  | W   | Re  | Os  | Ir  | Pt  | Au  | Hg  | In  | Sn  | Sb  | Te  | I   | Xe  | 54  |
|-------------------------|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 6                       | Fr         | Ra  | Lr  | Rf  | Db  | Sg  | Bh  | Hs  | Mt  | Ds  | Rg  | Cn  | 88  | 89  | 90  | 91  | 92  | 93  | 94  | 95  | 96  | 97  | 98  | 99  | 100 |

**Lanthanide series**

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<th>La</th>
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<th>Nd</th>
<th>Sm</th>
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<th>Gd</th>
<th>Dy</th>
<th>Ho</th>
<th>Er</th>
<th>Tm</th>
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**Actinide series**

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<th>Pu</th>
<th>Am</th>
<th>Cm</th>
<th>Bk</th>
<th>Cf</th>
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\(^a\) 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.**