R = 0.08206 L amt/mol K = 8.314 J/mol K
 c = 2.99792 \times 10^8 \text{ m/s}
F = 96,485 \text{ J/V (C/mol e^-)}

1. List the four things that effect chemical reactivity (8 pt)
   a. TEMP
   b. CONC
   c. STATE OF SUBDIVISION
   d. CATALYST

2. Consider the reaction:
   \[
   \text{X} + \text{Y} \rightarrow \text{Z}
   \]

The following initial rates of reaction have been observed for certain reactant concentrations:

<table>
<thead>
<tr>
<th>[X]</th>
<th>[Y]</th>
<th>Rate, mol, L^{-1} h^{-1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.50</td>
<td>0.053</td>
</tr>
<tr>
<td>0.20</td>
<td>0.30</td>
<td>0.127</td>
</tr>
<tr>
<td>0.40</td>
<td>0.60</td>
<td>1.02</td>
</tr>
<tr>
<td>0.20</td>
<td>0.60</td>
<td>0.254</td>
</tr>
<tr>
<td>0.40</td>
<td>0.30</td>
<td>0.509</td>
</tr>
</tbody>
</table>

a. What is the rate equation for the reaction? (5 pt)

\[
\text{rate} = k [X]^2 [Y]
\]

b. What is the value of the rate constant? (3 pt)

\[
k = \frac{\text{rate}}{[X]^2 [Y]} = \frac{0.053}{(0.10)^2(0.50)} = 10.6
\]

c. What is the order of the reaction in each reactant and the overall order of the reaction? (3 pt)

2nd order in [X]  \quad 1^{st} \text{ order in [Y]}

3rd order overall
3. Use the following diagram for questions a-e, (10 pt)

![Reaction pathway diagram]

a. Which is the transition state?  
   A  B  C  D  E  
   \(\bigcirc\)

b. Which is the activation energy?  
   A  B  C  D  E  
   \(\bigcirc\)

c. Is the activation energy positive or negative?  positive  negative  

4. For the following reaction between gases at equilibrium, determine the effect on the equilibrium (circle one of the following: shift left, no change, shift right) when the following changes take place. (10 pt)

\[
\text{CH}_4(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + 2 \text{H}_2(\text{g}) \quad \Delta H = 206 \text{ kJ}
\]

a. Increase the temperature  
   shift left  no change  shift right  

b. Increase the volume  
   shift left  no change  shift right  

c. Increase the pressure  
   shift left  no change  shift right  

d. Remove H\(_2\)(g) from the reaction  
   shift left  no change  shift right  

e. Add a catalyst  
   shift left  no change  shift right
5. Circle the **acid** in each of the following pairs that is **stronger**. (10 pt)

a. HCl and HBr

b. HBrO₄ and HClO₄

c. HBrO and HBrO₂

d. HNO₂ and HNO₃

e. CH₃OOH \( (K_a = 1.8 \times 10^{-5}) \) and HCOOH \( (K_a = 1.7 \times 10^{-4}) \)

6. Consider a 1.00-L buffer made by adding 0.30 mol formic acid, HCOOH, and 0.52 mol potassium formate, HCOOK, to sufficient water. Calculate the pH of the buffer.

For formic acid, \( K_a = 1.7 \times 10^{-4} \). (6 pt)

\[
\begin{align*}
\text{HA} & \rightleftharpoons \text{H}^+ + \text{A}^- \\
K_a & = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} \\
\therefore \quad \text{pH} & = -\log(K_a \frac{[\text{HA}]}{[\text{A}^-]}) = -\log(1.7 \times 10^{-4} \frac{0.30}{0.52}) \\
& = 4.01
\end{align*}
\]
7. In the following reaction, identify the **acid** (A), **conjugate acid** (CA), **base** (B), and **conjugate base** (CB). (4 pt)

\[
\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-
\]

\[
\begin{array}{c}
\text{B} \\
\text{A} \\
\text{CA} \\
\text{CB}
\end{array}
\]

8. Identify the **Lewis acid** (LA) and **Lewis base** (LB) in each of the reactions below. (4 pt)

a. \(\text{Cl}^- + \text{BCl}_3 \rightarrow \text{BCl}_4^-\)

\[
\begin{array}{c}
\text{LB} \\
\text{LA}
\end{array}
\]

b. \(\text{AlCl}_3 + \text{NH}_3 \rightarrow \text{Al}_3\text{NH}_3\)

\[
\begin{array}{c}
\text{LA} \\
\text{LB}
\end{array}
\]

9. What is the pH of a 0.076 M solution of \(\text{C}_2\text{H}_5\text{NH}_2\)? For of \(\text{C}_2\text{H}_5\text{NH}_2\), \(K_b = 5.6 \times 10^{-4}\). (5 pt)

\[
\text{B} + \text{H}_2\text{O} \rightleftharpoons \text{BN}^+ + \text{OH}^-
\]

\[
K_b = \frac{[\text{BN}^+][\text{OH}^-]}{[\text{B}]} = x
\]

\[
x^2 = K_b [\text{B}]
\]

\[
x = \sqrt{K_b [\text{B}]} = 6.5 \times 10^{-3} = [\text{OH}^-]
\]

\[
\text{pOH} = 2.18
\]

\[
\text{pH} = 14 - 2.18 = 11.82
\]
10. What order is the radioactive decay process? (3 pt)

Skip

11. For Mercury, Hg, (a) write the equilibrium equation for the boiling point, (b) calculate $\Delta G^\circ$, and (c) estimate the boiling temperature, $T_{bp}$. (10 pt)

for $\text{Hg (l)}$ $\Delta H_f^\circ = 0$ (by definition), $S^\circ = 77.4 \text{ J/K} \cdot \text{mol}$; 

$\text{Hg (g)}$ $\Delta H_f^\circ = 60.78 \text{ kJ/mol}$, $S^\circ = 174.7 \text{ J/K} \cdot \text{mol}$

\(\text{a) } \text{Hg (l)} \rightleftharpoons \text{Hg (g)}\)

\(\text{b) } K = P_{\text{Hg}} = 1 \text{ atm}\)

\(\Delta G^\circ = -RT \ln K = 0\)

\(\text{c) } T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{60.78 \text{ kJ}}{(174.7 - 77.4) \text{ J/K}} = 0.25 \text{ K} \)
12. List the hybridization and geometry about the carbon atoms below each of the following molecules (6 pt)

a. 

Hybridization: 
Geometry: 

b. 

Hybridization: 
Geometry: 

c. 

Hybridization: 
Geometry: 

14. Given the following two half-reactions and their potentials, write the balanced equation for the reaction that is spontaneous and give the $E^\circ$ of the cell. (6 pt)

\[
\begin{align*}
Cr^{3+}(aq) + 3e^- &\rightarrow Cr(s) & E^\circ = -0.74 \text{ V} \\
Ag^+(aq) + e^- &\rightarrow Ag(s) & E^\circ = +0.80 \text{ V}
\end{align*}
\]

\[
\begin{align*}
E_{cell} &= E_{red} - E_{ox} \\
E_{cell} &= +0.80 \text{ V} - +0.74 \text{ V} \\
E_{cell} &= +0.06 \text{ V}
\end{align*}
\]

15. Calculate $\Delta G^\circ$ for the cell in problem 14. (3 pt)

\[
\Delta G^\circ = -nFE^\circ \\
= -(3)(96483 \text{ J/mol e}^-)(1.54 \text{ V}) = -445760 \text{ J}
\]

\[
\text{Chemical Principles II Final Exam 6}
\]