There are a total of four pages (15 problems) in the exam. All work must be shown on the exam. Show your method of calculation clearly. Correct answers not showing the work will not receive credit.

Notes written on one 8.5 X 11 inch page may be used. All other notes and books are not allowed.

<table>
<thead>
<tr>
<th>Pg 1</th>
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<tbody>
<tr>
<td>(30)</td>
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<td>(26)</td>
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<td>Pg 3</td>
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<td>(20)</td>
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<td>Total</td>
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<td>(100)</td>
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</table>

This is last year's midterm. You must also work all the homework problems to do well on this year's midterm.

Enjoy the long weekend!
1. Oxidation of a primary alcohol produces an aldehyde, which oxidizes further to produce a carboxylic acid. Oxidation of a secondary alcohol produces a ketone. No reaction is observed for the oxidation of a tertiary alcohol. Draw the structure of the alcohol and the structures of the product(s) formed from the oxidation of each of the following alcohols.

a) (4 pts) 2-propanol

\[
\text{CH}_3 \text{CH}_2 \text{OH} \quad \text{oxid.} \quad \text{CH}_3 \text{CHO} \quad \text{oxid.} \quad \text{CH}_3 \text{C} = \text{O}
\]

b) (4 pts) cyclohexanol

\[
\text{oxid.} \quad \text{O} \quad \text{cyclohexane}
\]

c) (4 pts) ethanol

\[
\text{CH}_3 \text{CH}_2 \text{OH} \quad \text{oxid.} \quad \text{CH}_3 \text{CHO} \quad \text{oxid.} \quad \text{CH}_3 \text{C} \quad \text{O}
\]

d) (4 pts) 2-methyl-2-propanol

\[
\text{CH}_3 \text{C} \quad \text{CH}_3 \quad \text{oxid.} \quad \text{NO}_x \text{ RN}
\]

2. (6 pts) Polyvinyl chloride is an addition polymer of chloroethene, CH\textsubscript{2}=CHCl (commonly called vinyl chloride). Draw the repeating unit for polyvinyl chloride.

\[
\left[ \text{CH}_2 = \text{CHCl} \right]_n
\]

3. (8 pts) Draw the repeating unit of the condensation polymer produced using the following monomer.

\[
\text{CH}_3 \quad \text{HO-CH-COOH}
\]

\[
\text{HCOCH}_3 \quad \text{O} \quad \text{CH}_3 \quad \text{C} \quad \text{OH}
\]

\[
\left[ \text{O} - \text{CH} - \text{C} \right]_n
\]

\[
\text{repeating unit}
\]
4. (4 pts) Based on the colors of the aqueous solutions of the following coordination compounds, which complex has the largest crystal field splitting? Circle the answer.

\[
\begin{align*}
&[\text{Co(NH}_3\text{)}_6\text{Cl}_3] \quad \text{orange-yellow} \quad \text{absorbs violet-blue} \quad \frac{\lambda}{400-450} \quad \Delta = \frac{hc}{\lambda} \\
&[\text{Co(NH}_3\text{)}_3\text{Cl}_3] \quad \text{green} \quad \text{red} \quad 700 \quad \text{largest } \Delta \\
&[\text{Co(NH}_3\text{)}_3\text{Cl}]\text{Cl}_2 \quad \text{purple} \quad \text{yellow} \quad 600 \quad \text{smallest } \Delta
\end{align*}
\]

5. (2 pts) Which complex will absorb light of longer wavelength? Circle the answer.

\[
\begin{align*}
&K_3[\text{Fe(CN)}_6] \quad \text{K}_3[\text{FeF}_6] \quad \Delta = \frac{hc}{\lambda} \\
&\text{CN}^- \text{ stronger field ligand } \Rightarrow \text{ longer } \Delta \Rightarrow \text{ larger } \lambda \\
&\text{CN}^- \text{ smaller field ligand } \Rightarrow \text{ smaller } \Delta
\end{align*}
\]

6. (4 pts) Draw the d-orbital diagram for the low-spin tetrahedral complex \(K_3[\text{Fe(CN)}_4] \). \(\text{Fe} \quad 3d^6 \quad \text{tetrahedral} \quad \frac{1}{1} \quad \frac{1}{1} \quad \frac{1}{1} \quad \frac{1}{1} \quad \frac{1}{1} \quad \frac{1}{1}
\]

7. The color of an aqueous solution of the octahedral ion hexaaqua nickel(II) is observed to be green.

a) (4 pts) Estimate the wavelength of absorption.

\[\text{absorbs red} \quad \lambda = 700 \text{ nm}\]

b) (4 pts) Estimate the crystal field splitting energy, \( \Delta \), in kJ.

\[
\Delta = \frac{hc}{\lambda} = \left(6.626 \times 10^{-34} \text{ Js}\right) \left(3.0 \times 10^8 \text{ m/s}\right) \frac{1}{700 \times 10^{-9} \text{ m}} = 2.84 \times 10^{-19} \text{ J} \quad \text{or} \quad 2.84 \times 10^{-22} \text{ kJ}
\]

8. (8 pts) Consider a compound where a transition metal ion is coordinated to six NH\(_3\) ligands and chloride is the counter ion. Addition of AgNO\(_3\) to an aqueous solution of the coordination compound results in a cloudy white precipitate, presumably AgCl(s). You dissolve 0.100 g of the compound in water and titrate the solution with 0.0500 M AgNO\(_3\). The endpoint was reached after 9.00 mL of titrant was added. How many grams of chloride ion were present in the 0.100 g sample?

\[
\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl(s)}
\]

\[
(0.05 \text{ mol} / \text{L}) \times 0.009 \text{ L}
\]

\[
0.0045 \text{ mol Ag}^+ \left( \frac{1 \text{ mol Cl}^-}{1 \text{ mol Ag}^+} \right) = 0.00045 \text{ mol Cl}^-
\]

\[
35.45 \text{ g/mol}
\]

\[
0.016 \text{ g Cl}^-
\]
9. (4 pts) Give the systematic name for the following compounds.

\[ \text{Pt(NH}_3\text{)}_4\text{Br}_2\text{Cl}_2 \quad \text{tetraamine dibromoplatinum (IV) chloride} \]

\[ \text{K}_2(\text{Fe(CN)}_4) \quad \text{potassium tetra cyanoferrate (II)} \]

10. (6 pts) Give the oxidation state of the central metal atom in each of the following coordination compounds and the coordination number.

<table>
<thead>
<tr>
<th>Oxidation State</th>
<th>Coordination Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{K}_2(\text{Zn(CN)}_4) ]</td>
<td>+2</td>
</tr>
<tr>
<td>[ \text{[Cr(en)(H}_2\text{O})_2\text{F}_2\text{]Cl} ]</td>
<td>+3</td>
</tr>
<tr>
<td>[ \text{[Cr(NH}_3\text{)}_4\text{Cl}_2\text{]Br} ]</td>
<td>+3</td>
</tr>
</tbody>
</table>

11. (4 pts) Write the chemical formulas for the following compounds.

a) Tetraamineaquachlorocobalt(III)bromide

\[ \text{[Co(NH}_3\text{)}_4(\text{H}_2\text{O})\text{Cl}\text{]}\text{Br}_2 \]

b) Sodium hexafluorovanadate(III)

\[ \text{Na}_3\text{[VF}_6\text{]} \]

12. (6 pts) Draw the optical isomers of the octahedral complex \([\text{Co(NH}_3\text{)}_2(\text{H}_2\text{O})_2\text{Cl}_2]^+\).

\[ \text{all duplicate ligands must be cis} \]
13. (8 pts) Draw the structural and geometric isomers of chloropropene. There are a total of four isomers. If you draw more than four, you must cross out the ones that are incorrect.

\[ \begin{align*}
\text{Cl} & \quad \text{H} \\
\text{O} & \quad \text{C} \quad \text{CH}_3 \\
\text{H} & \quad \text{C} \quad \text{H} \\
\text{H} & \quad \text{C} \quad \text{CH}_3 \\
\text{Cl} & \quad \text{H}
\end{align*} \]

14. (8 pts) Calculate the molality of $\text{C}_2\text{H}_5\text{OH}$ in an aqueous solution prepared by mixing 40.0 mL of $\text{C}_2\text{H}_5\text{OH}$ with 120.0 mL of $\text{H}_2\text{O}$ at 20°C. The density of $\text{C}_2\text{H}_5\text{OH}$ is 0.789 g/mL at 20°C.

\[ m = \frac{\text{moles} \ \text{C}_2\text{H}_5\text{OH}}{\text{kg} \ \text{H}_2\text{O}} \]

\[ 40 \ \text{mL} \ \text{C}_2\text{H}_5\text{OH} \left(0.789 \frac{\text{g}}{\text{mL}}\right) \frac{1\text{mol}}{46 \text{g}} = 0.686 \text{ mol C}_2\text{H}_5\text{OH} \]

\[ 120.0 \ \text{mL} \ \text{H}_2\text{O} \left(1 \frac{\text{g}}{\text{mL}}\right) = 120.0 \ \text{g} \]

\[ \frac{0.686 \text{ mol}}{0.120 \text{ kg}} = 5.7 \text{ m} \]

15. (8 pts) Ice cream is made by freezing a liquid mixture that, as a first approximation, can be considered a solution of sucrose ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) in water. Estimate the temperature at which the first ice crystals begin to appear in a mix that consists of 34% (by mass) sucrose in water. $K_f = 1.86 \ ^\circ \text{C kg/mol}$

\[ 34 \text{ g C}_{12}\text{H}_{22}\text{O}_{11} \left(\frac{1000 \text{ g}}{\text{kg}}\right) \left(\frac{1\text{ mol}}{342 \text{ g}}\right) = 1.51 \ \frac{\text{mol}}{\text{kg}} \]

\[ \Delta T = -iK_f m \quad i = 1 \]

\[ \Delta T = -\left(1.86 \ ^\circ \text{C kg/mol}\right) \left(1.51 \ \frac{\text{mol}}{\text{kg}}\right) \]

\[ \Delta T = -2.8^\circ \text{C} \]

\[ T_f = 0^\circ \text{C} = -2.8^\circ \text{C} \]

\[ T_f = -2.8^\circ \text{C} \]
**INFORMATION, EQUATIONS AND CONSTANTS**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
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<tbody>
<tr>
<td>Δ = h/c/λ</td>
<td>h = 6.626 x 10⁻³⁴ J s</td>
</tr>
<tr>
<td>π = iMRT</td>
<td>c = 3.0 x 10⁸ m/s</td>
</tr>
<tr>
<td>ΔT = iKb m_{solute}</td>
<td>1 nm = 1 x 10⁻⁹ m</td>
</tr>
<tr>
<td>ΔT = -iKf m_{solute}</td>
<td>R = 8.3145 J mol⁻¹ K⁻¹</td>
</tr>
<tr>
<td>P = kH X</td>
<td>R = 0.08206 L atm mol⁻¹ K⁻¹</td>
</tr>
</tbody>
</table>

P_{sol} = X_{solvent}P_{solvent}  
1 atm = 760 torr

The visible region of the electromagnetic spectrum:

<table>
<thead>
<tr>
<th>Color</th>
<th>λ (nm)</th>
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<tbody>
<tr>
<td>violet</td>
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<tr>
<td>blue</td>
<td>500</td>
</tr>
<tr>
<td>green</td>
<td>600</td>
</tr>
<tr>
<td>yellow</td>
<td>700</td>
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</tbody>
</table>

Γ < Br⁻ < Cl⁻ < F, OH⁻ < H₂O < :NCS⁻ < NH₃ < en < NO₂⁻ < CO, CN⁻

weak field ligands

strong field ligands

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**周期表**

<table>
<thead>
<tr>
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<tbody>
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**unsupported**

<table>
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**Period**

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**s block**

- lanthanides
- actinides

**p block**

<table>
<thead>
<tr>
<th>18</th>
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<th>20</th>
<th>21</th>
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<td>NCS⁻</td>
<td>NH₃</td>
<td>en</td>
<td>NO₂⁻</td>
</tr>
</tbody>
</table>

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**Color Cycle**

- Orange
- Red
- Yellow
- Green
- Blue

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