Please answer the following questions:

Part I: Multiple Choice (30 pts: 6 @ 5 pts). Please circle the **ONE** best answer:

1. Which one of the following would be most stable?
   a) Co(CO)₄  
   b) Fe(CO)₆  
   c) Fe(CO)₄  
   d) HCo(CO)₄

2. Which of the following compounds is expected to have the greatest IR stretching carbonyl band (wave number, cm⁻¹)?
   a) Fe(CO)₄²⁻  
   b) Cr(CO)₆  
   c) V(CO)₆⁻  
   d) Mn(CO)₆⁺

3. A stable organometallic compound formulated as M(η⁴-C₄H₄)(CO)₃, where C₄H₄ = cyclobutadiene. In this compound M most probably is?
   a) Ru  
   b) Rh  
   c) Mn  
   d) Cr

4. Which of the following complexes would inert towards substitution reactions?
   a) [Co(H₂O)₆]²⁺  
   b) [Cr(H₂O)₆]²⁺  
   c) [Mg(OH₂)₆]²⁺  
   d) [Cr(H₂O)₆]³⁺

5. Which of the following species does not obey the 18-e rule?
   a) H₂Fe(CO)₄  
   b) Ni(PPh₃)₄  
   c) Rh(C₂H₄)(PPh₃)₂Cl  
   d) [(CO)₄Ru-Fe(CO)₄]²⁻

6. Which of the following complexes is expected to exhibit the greatest intensity (largest εₘₐₓ) in the visible region?
   a) [Mn(H₂O)₆]²⁺  
   b) [V(H₂O)₆]²⁺  
   c) [CoCl₄]²⁺  
   d) [Zn(H₂O)₆]²⁺
Part II. (36 pts) Organometallics:

1. (8 pts) Write the formula for
   a) $\text{W}(\eta^3\text{-C}_5\text{H}_5)(\eta^5\text{-C}_5\text{H}_5)(\text{CO})_2$
   b) $\text{[Cr}(\eta^5\text{-C}_5\text{H}_5)(\text{CO})_3\text{]}_2$

2. (9 pts) Describe the bonding (draw structure) and showing the hapticity for $\text{M(C}_7\text{H}_8\text{(CO)}_3$ when $\text{M = Ni, Fe and Cr (C}_7\text{H}_8 = \text{cyclohepta-1,3,5-triene)}$
   a) $\text{Ni(C}_7\text{H}_8\text{(CO)}_3$
   b) $\text{Fe(C}_7\text{H}_8\text{(CO)}_3$
   c) $\text{Cr(C}_7\text{H}_8\text{(CO)}_3$

3. (9 pts) Predict the products of the following reactions:
   a) $[\text{CpFe(CO)}_2\text{]}_2 + \text{Na/Hg}$
   b) $\text{Re}_2\text{(CO)}_{10} + \text{Br}_2$
   c) $\text{Pt(PPh}_3\text{)}_4 + \text{Cl}_2$
4. (10 pts) Give a brief account for the catalytic cycle for the hydrogenation of \( RCH=CH_2 \) using Wilkinson’s catalyst, \( \text{RhCl(PPh}_3)_3 \).

Part III. (34 pts) Reaction Mechanisms of Metal Complexes:

1. (8 pts) The rate constants (at 45ºC) for the anation of \([\text{Co(NH}_3)_5(\text{H}_2\text{O})]^{3+}\) with three anions are shown below.

\[
\begin{align*}
[\text{Co(NH}_3)_5(\text{H}_2\text{O})]^{3+} + \text{L}^{-} & \rightarrow [\text{Co(NH}_3)_5\text{L}^{(3-n)+}] + \text{H}_2\text{O} \\
\text{L}^{-} & \quad \text{k (s}^{-1}\text{)} \\
\text{NCS}^- & \quad 1.6 \times 10^{-5} \\
\text{Cl}^- & \quad 2.1 \times 10^{-5} \\
\text{SO}_4^{2-} & \quad 2.4 \times 10^{-5}
\end{align*}
\]

a) Are these data consistent with a dissociative or associative mechanism?

b) Write an equation for the rate-determining step of these reactions and briefly justify your answer?
2. **(8 pts)** The rate constants (at 45°C) for the anation of \([\text{Cr(H}_2\text{O)}_6]^{3+}\) with three anions are shown below.

\[
\text{[Cr(H}_2\text{O)}_6]^{3+} + L^- \rightarrow \text{[Cr(H}_2\text{O)}_5L]^{2+} + \text{H}_2\text{O}
\]

<table>
<thead>
<tr>
<th>L^-</th>
<th>(k) (M(^{-1})s(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCS^-</td>
<td>1.8 \times 10^{-6}</td>
</tr>
<tr>
<td>Cl^-</td>
<td>2.9 \times 10^{-8}</td>
</tr>
<tr>
<td>I^-</td>
<td>8.0 \times 10^{-10}</td>
</tr>
</tbody>
</table>

a) Are these data consistent with a dissociative or associative mechanism?

b) Write an equation for the rate-determining step of these reactions and briefly justify your answer?

3. **(8 pts)** Activation volumes, \(\Delta V^\circ\) for the acid hydrolysis of \(\text{cis-[Pt(NH}_3)_2\text{Cl}_2]\) and \([\text{PtenCl}_2]\) (displacement of Cl\(^-\) by H\(_2\)O) are -9.5 (at 45°C) and -9.2 (at 42°C) cm\(^3\)/mol, respectively. How are these values consistent with what you know about the mechanism of square-planar substitution?

4. **(10 pts)** Account for the difference in rate constants for the following two reactions.

\[
\text{[Fe(H}_2\text{O)}_6]^{2+} + \text{Cl}^- \rightarrow \text{[FeCl(H}_2\text{O)}_5]^+ + \text{H}_2\text{O} \quad k = 10^6 \text{ M}^{-1}\text{s}^{-1}
\]

\[
\text{[Ru(H}_2\text{O)}_6]^{2+} + \text{Cl}^- \rightarrow \text{[RuCl(H}_2\text{O)}_5]^+ + \text{H}_2\text{O} \quad k = 10^{-2} \text{ M}^{-1}\text{s}^{-1}
\]
You will have 55 minutes to complete this exam.

The exam has 4 pages plus Periodic Table

When you are told to do so, tear off the Periodic Table cover sheet and use as required during exam.