Chemistry 125/126
Hourly 1 Review Notes and Questions to check your understanding.

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Experiment 3: Redox: Transferring Electrons

Major Concepts

A. Substances can be ranked as oxidizing or reducing agents from experimental data.
   • The stronger reducing and oxidizing agents are the reactants.
   • The weaker reducing and oxidizing agents are the products.
   • There is an inverse relationship between reducing and oxidizing agent strength of the species.

   Example 1: Observation: \( \text{Cu(s)} + 2\text{Ag}^+_{\text{aq}} \rightarrow \text{Cu}^{2+}_{\text{aq}} + 2\text{Ag (s)} \)
               reducing agent strength: Cu > Ag
               oxidizing agent strength: \( \text{Ag}^+ > \text{Cu}^{2+} \)

   Example 2: Observation: \( \text{Cl}_2_{\text{aq}} + 2\text{I}^-_{\text{aq}} \rightarrow 2\text{Cl}^-_{\text{aq}} + \text{I}_2_{\text{aq}} \)
               reducing agent strength: I^- > Cl-
               oxidizing agent strength: \( \text{Cl}_2 > \text{I}_2 \)

B. Reaction vs. no reaction combos can be predicted from a given reaction or non-reaction.
   • The products of a spontaneous rxn. will not react.

   Example 1: \( \text{Cu(s)} + 2\text{Ag}^+_{\text{aq}} \rightarrow \text{Cu}^{2+}_{\text{aq}} + 2\text{Ag (s)} \)
               \( \therefore \text{Cu}^{2+}_{\text{aq}} + \text{Ag (s)} \rightarrow \text{no reaction} \)

   Example 2: \( \text{Cl}_2_{\text{aq}} + 2\text{I}^-_{\text{aq}} \rightarrow 2\text{Cl}^-_{\text{aq}} + \text{I}_2_{\text{aq}} \)
               \( \therefore \text{Cl}^-_{\text{aq}} + \text{I}_2_{\text{aq}} \rightarrow \text{no reaction} \)
   • Non-reactants are the stable products of a spontaneous rxn.

   Example: \( \text{Cl}^-_{\text{aq}} + \text{I}_2_{\text{aq}} \rightarrow \text{no reaction} \)
               \( \therefore \text{Cl}_2_{\text{aq}} + 2\text{I}^-_{\text{aq}} \rightarrow \text{reaction} \)
               (note: The latter rxn would constitute experimental proof of no rxn between Cl- and I2)

C. Reaction vs. no reaction can be predicted from relative strength.

   Example 1: Given the reducing agent strength: \( \text{Zn} > \text{Cu} > \text{Ag} \)
               You can predict that Zn will react with metals ions of both Cu and Ag; Cu will only react
               with the metal ions of Ag; Ag will not react with the metals ions of either Zn or Cu.

   Example 2: Given the Oxidizing agent strength: \( \text{Cl}_2 > \text{Br}_2 > \text{I}_2 \)
               You can predict that Cl2 will react with the halide ions Br- and I-; Br2 will only react
               with the halide ion I-; I2 will not react with either Br- or Cl-

D. The halides (e.g., Cl-, I-, Br-)
   • are ionic species
   • are colorless, soluble in water (due to polarity of water) and insoluble in hexane (nonpolar).
E. The halogens (e.g., Cl₂, I₂, Br₂)

- are nonpolar
- have distinctive colors (yellow green, pink-violet, or yellow-orange) in hexane but are different to distinguish from one another in water (light yellow or yellow-green, brown, or brown)
- are more soluble in hexane than water.
- By tracking colors in hexane, it is possible to determine the identity of any halogen products.

Example: \[ \text{Cl}_2(\text{aq}) + 2\text{I}^- (\text{aq}) \rightarrow 2\text{Cl}^- (\text{aq}) + \text{I}_2(\text{aq}) \]

Color changes occur as the yellow-green color of chlorine (Cl₂) disappears from the hexane phase upon reaction and the violet-pink color of iodine (I₂) appears in the hexane phase

Example: \[ \text{NaCl} (\text{aq}) + \text{I}_2(\text{aq}) \rightarrow \text{no reaction} \]

The hexane phase remains violet-pink indicating no reaction (i.e. if reaction occurred, the color would disappear since colorless I⁻ would form).
EXPERIMENT 3 (Redox: Transferring Electrons)

Part 1 Reactivity of Metals and Predicting Metal Reactivity

1. This question deals with a study of redox reactions involving metals and aqueous solutions (0.1M nitrates) of the metal cations. Below are your recorded (incomplete) observations:

<table>
<thead>
<tr>
<th></th>
<th>Pb(NO$_3$)$_2$</th>
<th>Cd(NO$_3$)$_2$</th>
<th>Mn(NO$_3$)$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>no reaction</td>
<td>reaction</td>
<td>Reaction</td>
</tr>
<tr>
<td>Cd</td>
<td>no reaction</td>
<td>no reaction</td>
<td>no reaction</td>
</tr>
<tr>
<td>Mn</td>
<td>no reaction</td>
<td>no reaction</td>
<td>no reaction</td>
</tr>
</tbody>
</table>

A. Complete a net equation (do not include spectator ions) describing the reaction between Cd metal and Pb(NO$_3$)$_2$(aq). Make sure you indicate correct charge and state of all products. Identify the oxidizing and reducing agent.

Completed Net Reaction for Cd(s) + Pb(NO$_3$)$_2$(aq)

\[
\text{Cd (s)} + \text{Pb}^{2+} \text{(aq)} \rightarrow \text{_______} + \text{_______}
\]

Oxidizing agent = ___________
Reducing agent = ___________

B. Based on the observations (above table) and your knowledge of redox reactions, will a reaction occur if manganese metal is added to 0.10 M Cd(NO$_3$)$_2$?

Circle "yes" or "no" to indicate if a Mn will react with 0.10 M Cd(NO$_3$)$_2$:

Yes. a reaction will occur
No reaction will occur.

C. Based on the observations for reactions of Pb and Cd, it is possible to determine the relative strengths of three oxidizing agents: Mn$^{2+}$, Cd$^{2+}$, and Pb$^{2+}$. What are the relative strengths?

Strongest oxidizing agent: ____________
Weakest oxidizing agent: ____________

Part 2 Halogens and Halides

2. This question involves a study of redox reactions where the observations given below were made. Hexane was added to all product mixtures:

A. CrCl$_2$ (aq) + I$_2$ (aq) → Product?
   colored brown aqueous layer is colored; hexane layer is colorless

B. NaCl (aq) + I$_2$(aq) → Product?
   colorless brown aqueous layer is colorless; hexane layer is pink

Based on test reaction B, what do you know about reaction A?
Conclusions regarding reaction A?

Based on the results, what are the relative strengths of Cr\(^{3+}\) and I\(_2\) as oxidizing agents?

<table>
<thead>
<tr>
<th>Strongest oxidizing agent</th>
<th>Weakest oxidizing agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>________________________</td>
<td>________________________</td>
</tr>
</tbody>
</table>

(now try Nov. 07, 7; March’07, 1A(2-3); Nov.’06, 5C; March’06, 3D; March’05, 1D, 3C)

**Part 3 Analysis of Reactions**

3. This questions deals with an investigation of redox reactions.

   Information:
   Cl\(_2\), Br\(_2\), Fe\(^{3+}\), I\(_2\), Sn\(^{4+}\), & K\(^+\) are oxidizing agents (giving Cl\(^-\), Br\(^-\), Fe\(^{2+}\), I\(^-\), Sn\(^{2+}\), & K).

   Best oxidizing agent  Cl\(_2\) > Br\(_2\) > Fe\(^{3+}\) > I\(_2\) > Sn\(^{4+}\) > K\(^+\)  Worst oxidizing agent

You add a few crystals of FeCl\(_3\) to a test tube (A) with water and a few KBr crystals to another test tube (B). The crystals dissolve. Write a balanced equation for the dissociation of FeCl\(_3\)(s).

Balanced equation for the dissociation of FeCl\(_3\) into ions when placed in water:

\[
\text{FeCl}_3(s) \rightarrow \text{___________} + \text{__________}
\]

You now mix the contents of test tube A with the contents of test tube B and add hexane to the resulting mixture. Based on the oxidizing agent strengths (above), determine if a redox reaction occurs. Identify (circle) any species present in the hexane phase or indicate (circle) NONE.

<table>
<thead>
<tr>
<th>NONE</th>
<th>Cl(_2)</th>
<th>Cl(^-)</th>
<th>Br(_2)</th>
<th>Br(^-)</th>
<th>Fe(^{3+})</th>
<th>Fe(^{2+})</th>
</tr>
</thead>
</table>

Based solely on the relative oxidizing agent strengths indicated above, which reactions (below), if any, should occur? Put an X in the appropriate box.

<table>
<thead>
<tr>
<th>Will Occur</th>
<th>Won't occur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Br(_2) + Sn(^{2+}) → 2 Br(^-) + Sn(^{4+})</td>
<td></td>
</tr>
<tr>
<td>Fe(^{3+}) + 2 I(^-) → Fe(^{2+}) + I(_2)</td>
<td></td>
</tr>
</tbody>
</table>

(now try March ’08, 4; Nov.’07, 7; March’07, 3D; Nov.’06, 5; March’06, 6; Nov.’05, 4)