This print-out should have 29 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

**Strong Acid or Base**

Which of

I) HCl  II) HF  III) LiOH  
IV) HClO₂  V) HNO₃

are strong acids or strong bases in water?

1. All of the compounds
2. I, III, and V only **correct**
3. I, III, IV, and V only
4. I, II, IV, and V only
5. I, II, III, and V only

**Explanation:**

**Buffer NH₃**

What is the pH of a solution containing 0.3 M NH₄Cl and 0.6 M NH₃? The pKₐ of the ammonium ion is 9.25.

1. 5.05
2. 8.95
3. 12.25
4. 4.45
5. 9.55 **correct**

**Explanation:**

**Buffer Prep 01**

Which of the following solutions will produce a buffer?

I) 20 mL of 0.5 M (CH₃)₃NHCl + 50 mL of 0.1 M NH₃  
II) 20 mL of 0.5 M HNO₂ + 50 mL of 0.1 M NaOH

III) 20 mL of 0.5 M HCl + 50 mL of 0.1 M NH₃  
IV) 20 mL of 0.5 M HClO₂ + 50 mL of 0.1 M CH₃COOH  
V) 20 mL of 0.5 M NH₄Cl + 50 mL of 0.1 M NaOH

1. I, II, III, and V only
2. II and IV only
3. I, II, and V only **correct**
4. I, II, IV, and V only
5. II only

**Explanation:**

A buffer contains a weak acid or weak base, plus the salt of that weak acid or base; or, a mixture which will have this composition after any acid-base reactions occur. You may have to calculate the number of moles of each species to determine the composition after any acid-base reaction.

**Msci 18 0412**

Assume that five weak acids, identified only by numbers (1, 2, 3, 4 and 5), have the following ionization constants.

<table>
<thead>
<tr>
<th>Acid</th>
<th>Kₐ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0 × 10⁻³</td>
</tr>
<tr>
<td>2</td>
<td>3.0 × 10⁻⁵</td>
</tr>
<tr>
<td>3</td>
<td>2.6 × 10⁻⁷</td>
</tr>
<tr>
<td>4</td>
<td>4.0 × 10⁻⁹</td>
</tr>
<tr>
<td>5</td>
<td>7.3 × 10⁻¹¹</td>
</tr>
</tbody>
</table>

The anion of which acid is the weakest base?

1. 3
2. 2
3. 1 **correct**
4. 4

5. 5

Explanation:

\[ HA \rightleftharpoons H^+ + A^- \]

\[ K_a = \frac{[H^+][A^-]}{[H][A]} \]

The ‘anion of an acid’ is another way of saying ‘conjugate base,’ and a weak conjugate base corresponds to a strong acid. So really what we’re looking for is which acid is strongest (has the lowest pH).

A low pH means that the \([H^+]\) concentration is low. (Remember that values greater than 7 are basic!) The larger values of \(K_a\) means that there is more \([H^+]\) so you would expect these solutions to be more acidic; i.e., have smaller pH’s. The smaller \(K_a\) values mean less \([H^+]\) in solution, so higher pH’s. The acid with the largest \(K_a\) (#1) will have the lowest pH; i.e., highest \([H^+]\) concentration.

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**Buffer Stress**

006 10.0 points

What is the buffer capacity of 100 mL of 0.1 M HClO\(_2\) and 100 mL of 0.2 M NaClO\(_2\)?

1. 0.1 mol of OH\(^-\) and 0.2 mol of H\(^+\)

2. 10 mol of OH\(^-\) and 20 mol of H\(^+\)

3. 0.02 mol of OH\(^-\) and 0.01 mol of H\(^+\)

4. 0.2 mol of OH\(^-\) and 0.1 mol of H\(^+\)

5. 0.01 mol of OH\(^-\) and 0.02 mol of H\(^+\)

correct

**Explanation:**

\[ \begin{align*} V_1 &= 100 \text{ mL} \quad M_1 = 0.1 \text{ M} \\ V_2 &= 100 \text{ mL} \quad M_2 = 0.2 \text{ M} \end{align*} \]

Adding a strong base will introduce OH\(^-\); the base will react with HA. There is only 0.01 mol of HA so only 0.01 mol of OH\(^-\) can be added before the buffer capacity is exceeded. Adding a strong acid introduces H\(^+\); the acid will react with A\(^-\). There is only 0.02 mol of A\(^-\) so only 0.02 mol of H\(^+\) can be added before exceeding buffer capacity.

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**Titration Curve 02**

007 10.0 points

Consider the titration curve of a weak base with a strong acid.
The pH at point I is equal to the and the pH at point II is pH 7.

1. pK_b of the base, greater than
2. pH of the base, less than
3. pK_b of the base, less than correct
4. pK_b of the base, equal to
5. pH of the base, greater than

Explanation:

**Titration Excess Acid**

What is the pH of a solution containing 50 mL of 0.5 M HNO_3 and 150 mL of 0.1 M NaOH?

1. 1.30 correct
2. 0.30
3. 7.00
4. 2.00
5. 0.70

Explanation:

**Titration End Pt NH3**

What is the pH of a solution containing 100 mL of 0.5 M NH_3 and 200 mL of 0.1 M HCl? The pK_b of ammonia is 4.75.

1. 9.15
2. 9.95
3. 8.72
4. 9.43 correct
5. 9.65

Explanation:

**Titration Partial NH3**

What is the pH of a solution containing 100 mL of 0.3 M HClO_3 and 150 mL of 0.1 M Ba(OH)_2?

1. 9.60
2. 5.39
3. 7.00 correct
4. 13.48
5. 0.52

Explanation:
Arrange the compounds
I) CuS \( K_{sp} = 1.3 \times 10^{-36} \)
II) PbCl\(_2\) \( K_{sp} = 1.6 \times 10^{-5} \)
III) FeS \( K_{sp} = 6.3 \times 10^{-18} \)
IV) Hg\(_2\)Cl\(_2\) \( K_{sp} = 2.6 \times 10^{-18} \)
V) Cu\(_2\)S \( K_{sp} = 2.0 \times 10^{-47} \)
in increasing order of molar solubility.

1. II, IV, III, V, I
2. V, I, IV, III, II
3. I, V, III, IV, II correct
4. I, II, III, IV, V
5. II, III, IV, I, V

Explanation:

Molar Sol Ag\(_2\)S

What is the molar solubility of Ag\(_2\)S? The \( K_{sp} \) is \( 6.3 \times 10^{-51} \).

1. \( 2.82 \times 10^{-13} \)
2. \( 1.16 \times 10^{-17} \) correct
3. \( 6.37 \times 10^{-15} \)
4. \( 7.94 \times 10^{-26} \)
5. \( 5.8 \times 10^{-18} \)

Explanation:

Molar Sol CuBr in NaBr

What is the molar solubility of CuBr in 0.5 M NaBr? The \( K_{sp} \) is \( 4.2 \times 10^{-8} \).

1. \( 3.48 \times 10^{-3} \)
2. \( 2.05 \times 10^{-4} \)
3. \( 4.20 \times 10^{-8} \)
4. \( 4.20 \times 10^{-7} \)

Explanation:

Weak Acid Assumptions

The weak acid equation \( [H^+] = (K_a C_a)^{1/2} \) can be derived from
\[ [H^+]^3 + K_a [H^+]^2 \]
\[ -(K_w + K_a C_a) [H^+] - K_a K_w = 0 \]

1. \( K \) values are far apart, \( K_w \) is negligible and \( C_a \) is significantly smaller than \([H^+]\).
2. \( K_a \) is negligible and \( C_a \) is significantly larger than \([H^+]\).
3. \( K_w \) is negligible and \( C_a \) is significantly smaller than \([H^+]\).
4. \( K \) values are far apart, \( K_w \) is negligible and \( C_a \) is significantly larger than \([H^+]\). correct
5. \( K_w \) is negligible and \( C_a \) is significantly larger than \([H^+]\).

Explanation:

Triprotic pH

What is the pH of a solution containing 0.2 M RbH\(_2\)PO\(_4\)? The pK\(_{a1}\) is 2.12, the pK\(_{a2}\) is 7.21, and the pK\(_{a3}\) is 12.68.

1. 9.95
2. 4.67 correct
3. 7.40
4. 3.95
5. 1.41

Explanation:
NaHCO$_3$, NaCl, and HBr are dissolved in water. How many equations are needed to describe this system?

1. 6
2. 4
3. 8 correct
4. 5
5. 7

**Explanation:**
The species Na$^+$, H$_2$CO$_3$, HCO$_3^-$, CO$_3^{2-}$, Cl$^-$, Br$^-$, H$^+$, and OH$^-$ will be present in the water.

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**Mass Balance Equation**

018 10.0 points

0.5 M of HCOOH is dissolved in water. Which equation describes a possible mass balance equation for this system?

1. $C_{HCOOH} = [HCOO^-] + [H^+]$
2. $C_{HCOOH} = [HCOOH]$
3. $C_{HCOOH} = [HCOOH] + [HCOO^-] + [H^+]$
4. $C_{HCOOH} = [HCOOH] + [HCOO^-]$ correct
5. $C_{HCOOH} = [HCOO^-]$

**Explanation:**

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**Equil Expression**

019 10.0 points

Which of the equilibrium expressions for a triprotic acid H$_3$A would be involved in the calculation to find the pH of a solution found from LiCaA and Na$_2$HA? Assume the $K$ values are far apart and $K_w$ is not involved in the calculation.

1. $K_{a2}$
\[
\begin{align*}
\text{HSO}_4^- & \rightleftharpoons \text{H}^+ + \text{SO}_4^{2-} \\
0.2 & \quad 0.2 \quad 0 \\
-x & \quad +x \quad +x \\
0.2 - x & \quad 0.2 + x \quad x \\
K_{a2} &= \frac{x(0.2 + x)}{0.2 - x}
\end{align*}
\]

**Triprotic pH 01**

**022** 10.0 points

What is the pH of 1 M \(\text{Na}_3\text{A}\) if \(pK_{a1} = 2\), \(pK_{a2} = 6\), and \(pK_{a3} = 10\) for the triprotic acid \(\text{H}_3\text{A}\)?

1. 2
2. 10
3. 12 correct
4. 11
5. 8

**Explanation:**

**Redox Bal 01a**

**023** 10.0 points

When the equation

\[
\text{FeCl}_3 + \text{Au(s)} \rightleftharpoons \text{Fe(s)} + \text{AuCl}
\]

is correctly balanced, what is the coefficient of \(\text{FeCl}_3\)?

1. @@@
2. 2
3. 4
4. 1 correct
5. 5

**Explanation:**

The balanced equation is

\[
\text{FeCl}_3 + 3\text{Au(s)} \rightleftharpoons \text{Fe(s)} + 3\text{AuCl}
\]

**Bal Redox in Acid**

**024** 10.0 points

For a reaction in acid involving the following two half reactions,

\[
\text{Fe}^{3+} + e^- \rightleftharpoons \text{Fe}^{2+}
\]

\[
\text{Cr}_2\text{O}_7^{2-} + 6 e^- \rightleftharpoons 2 \text{Cr}^{3+}
\]

what is the coefficient for \(\text{H}^+\) in the balanced reaction?

1. 6
2. 14 correct
3. 1
4. 7
5. 36

**Explanation:**

The balanced equation is

\[
14\text{H}^+ + 6\text{Fe}^{3+} + \text{Cr}_2\text{O}_7^{2-} \rightleftharpoons 6\text{Fe}^{2+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}
\]

**Ox Agent Order**

**025** 10.0 points

Arrange the agents in increasing order of oxidizing agent strength.

I) \(\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+}\) \(E_{\text{red}}^\circ = +0.77\)
II) \(\text{Cu}^{2+} + e^- \rightarrow \text{Cu}^{+}\) \(E_{\text{red}}^\circ = +0.15\)
III) \(\text{S} + 2e^- \rightarrow \text{S}^{2-}\) \(E_{\text{red}}^\circ = -0.48\)
IV) \(\text{Mn}^{3+} + e^- \rightarrow \text{Mn}^{2+}\) \(E_{\text{red}}^\circ = +1.51\)
V) \(\text{Ca}^{2+} + 2e^- \rightarrow \text{Fe}\) \(E_{\text{red}}^\circ = -2.87\)

1. V, IV, III, II, I
2. I, II, III, IV, V
3. III, V, IV, I, II
4. IV, I, II, III, V
5. V, III, II, I, IV correct

**Explanation:**

Lyon 49740 e5 q20
Consider the standard reduction potentials:

\[
\begin{align*}
Cu^{2+} + 2e^- &\rightarrow Cu \quad E^0 = 0.337 \text{ V} \\
Ag^+ + e^- &\rightarrow Ag \quad E^0 = 0.7994 \text{ V} \\
Au^+ + e^- &\rightarrow Au \quad E^0 = 1.68 \text{ V}
\end{align*}
\]

Which of the following statements about oxidizing strengths of Group IB metal ions is true?

1. Nothing can be predicted about oxidizing strengths from the data given.

2. Cu\(^{2+}\) is a stronger oxidizing agent than Ag\(^+\).

3. Ag\(^+\) is a stronger oxidizing agent than Cu\(^{2+}\). correct

4. Cu\(^{2+}\) is a stronger oxidizing agent than Au\(^+\).

5. Ag\(^+\) is a stronger oxidizing agent than Au\(^+\).

Explanation:

Cell Type 01

What is the cathode in

\[
\begin{align*}
Ag(s) &\mid Ag^{+}(aq) \mid\mid Fe^{2+}(aq) \mid Fe(s) \\
Ag^{+} + e^- &\rightarrow Ag \quad E^\circ_{\text{red}} = +0.80 \\
Fe^{2+} + 2e^- &\rightarrow Fe \quad E^\circ_{\text{red}} = -0.44
\end{align*}
\]

and what type cell is it?

1. Ag\((s) \mid Ag^{+}(aq)\); an electrolysis cell

2. Fe\(^{2+}(aq) \mid Fe(s)\); a battery

3. Ag\((s) \mid Ag^{+}(aq)\); a battery

4. Fe\(^{2+}(aq) \mid Fe(s)\); an electrolysis cell correct

5. Not enough information is provided.

Explanation:

The diagram A \mid B \mid C \mid D is read as follows:

\[
\begin{align*}
A &\rightarrow B + n e^- \quad \text{(oxidation)} \\
C + m e^- &\rightarrow D \quad \text{(reduction)}
\end{align*}
\]

Since reduction occurs at the cathode, the cathode is Fe\(^{2+}(aq) \mid Fe(s)\)

To determine cell type, calculate \(E^\circ\) cell:

\[
\begin{align*}
2 \text{Ag}(s) &\rightarrow 2 \text{Ag}^{+}(aq) + 2e^- \\
E^\circ_{\text{anode}} &= -0.80 \text{ V} \\
\text{Fe}^{2+} + 2e^- &\rightarrow \text{Fe} \\
E^\circ_{\text{cathode}} &= -0.44 \text{ V} \\
2 \text{Ag}(s) + \text{Fe}^{2+} &\rightarrow 2 \text{Ag}^{+}(aq) + \text{Fe} \\
E^\circ_{\text{cell}} &= -1.24 \text{ V}
\end{align*}
\]

Since \(E^\circ\) cell is negative, the reaction is not spontaneous; potential has to be applied to the cell to enable this reaction to occur; i.e., an electrolytic cell.

In this electrochemical cell, what is the reduction half reaction?

1. Zn\(^{2+}(aq) + 2e^- \rightarrow Zn(s)\)

2. Cu\((s) \rightarrow Cu^{2+}(aq) + 2e^-\)

3. Zn\((s) \rightarrow Zn^{2+}(aq) + 2e^-\)

4. Cu\(^{2+}(aq) + 2e^- \rightarrow Cu(s)\) correct

Explanation:

\[
\begin{align*}
\text{Zn}(s) + Cu^{2+}(aq) &\rightarrow Zn^{2+}(aq) + Cu(s)
\end{align*}
\]
Reduction occurs at the cathode. In this cell the reduction half reaction is

\[ \text{Cu}^{2+}(\text{aq}) + 2e^- \rightarrow \text{Cu(s)} \]

\text{Cu}^{2+} cations are attracted to the solid Cu electrode where they are reduced to Cu(s).

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**Std Cell Potential**

029   10.0 points

What is the \( E_{\text{cell}}^\circ \) of

\[ \text{Zn(s)} \mid \text{Zn}^{2+}(\text{aq}) \mid \mid \text{Ce}^{4+}(\text{aq}) \mid \text{Ce}^{3+}(\text{aq}) \]

\[ \text{Zn}^{2+} + 2e^- \rightarrow \text{Zn} \quad E_{\text{red}}^\circ = -0.76 \]

\[ \text{Ce}^{4+} + e^- \rightarrow \text{Ce}^{3+} \quad E_{\text{red}}^\circ = +1.61 \]

1. +2.37 correct
2. +1.61
3. −0.85
4. +0.85
5. −2.37

Explanation: