This print-out should have 30 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

$$K_a = \frac{[H^+] \cdot [A^-]}{[HA]} \quad 10^{-14} = K_w$$

$$[H^+] = (K_a \cdot K_{a_y})^{1/2}$$

$$pK_a = -\log K_a$$

$$\text{pH} = -\log [H^+]$$

$$\text{pOH} = -\log [OH^-]$$

$$pK_a + pK_b = pK_w$$

$$[OH^-] = (K_b \cdot C_b)^{1/2} (K_a \cdot C_a)^{1/2} = [H^+]$$

$$K_{sp} = [C]^c \cdot [A]^a$$

$$E^0_{\text{cell}} = E^0_{\text{cathode}} - E^0_{\text{anode}}$$

$$E_{\text{cell}} = E^0_{\text{cell}} - \left(\frac{0.05916}{n}\right) \cdot \log Q$$

$$Q = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b}$$

$$\Delta G^o = -n \cdot F \cdot E^0_{\text{cell}}$$

$$= -R \cdot T \cdot \ln K$$

$$E^0_{\text{cell}} = \left(\frac{R \cdot T \cdot \ln K}{n \cdot F}\right)$$

$$\left(\frac{I \cdot t}{n \cdot F}\right) = \text{moles of product}$$

$$F = 96,485.3 \text{ C per mole of } e^-$$

Ampere = 1 $\text{ C} \cdot \text{s}^{-1}$

$$R = 8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$$

$$N = 6.022 \times 10^{23}$$

### LDE Simple Buffer Calc 002

#### 001 6.0 points

What would be the pH of a solution prepared from 200 mL of 5 M HOBr and 200 mL of 1 M NaOBr? The $K_a$ of hypobromous acid is $2 \times 10^{-9}$.

1. 6
2. 10
3. 8 correct
4. 4
5. 7

### LDE Identifying Buffers 002

#### 002 6.0 points

Which of the following pairs of solutions would result in a buffer upon mixing?

1. 2 L of 0.1 M C₆H₅NH₂; 3 L of 0.05 M HI correct
2. 5 L of 0.1 M NH₃; 1 L of 0.5 M HCl
3. 100 mL of 0.3 M HCOOH; 50 mL of 0.3 M H₂SO₄
4. 200 mL of 1 M HClO₂; 100 mL of 1 M Ba(OH)₂

### LDE Rank Base Strength by pKb 002

#### 003 6.0 points

Rank following bases from most to least basic:

- hypochlorite (ClO⁻) $pK_b = 12.1$
- nitrite (NO₂⁻) $pK_b = 10.6$
- hypoiodite (IO⁻) $pK_b = 3.3$
- cyanide (CN⁻) $pK_b = 4.8$
1. NO$_2^-$ > ClO$^-$ > IO$^-$ > CN$^-$

2. CN$^-$ > NO$_2^-$ > ClO$^-$ > IO$^-$

3. IO$^-$ > CN$^-$ > NO$_2^-$ > ClO$^-$ correct

4. ClO$^-$ > IO$^-$ > CN$^-$ > NO$_2^-$

**LDE Simple Buffer Capacity 001**

**004  6.0 points**

Consider 4 L of a buffer composed of 2 M HCN and 3 M NaCN? How many moles of strong acid could this buffer withstand?

1. 8

2. 12 correct

3. 3

4. 0

5. 2

**LDE Buffer Neutralization Calc 002**

**005  6.0 points**

If one added 20 mL of 0.04 M Ba(OH)$_2$ to 100 mL of a buffer composed 0.1 M acrylic acid and 0.05 M sodium acrylate, what would be the pH of the resulting solution? Acrylic acid has $K_a$ 5.6 $\times$ 10$^{-5}$.

1. 3.95

2. 4.15 correct

3. 4.37

4. 3.78

5. 4.55

**LDE Understanding Titration Curves 001**

**006  6.0 points**

Consider the titration curve below.

At which point is the pH = $pK_b$?

1. A

2. C

3. none of these correct

4. B

**LDE Titration Excess Calc 001**

**007  6.0 points**

WITHDRAWN

**LDE Titration Equiv Pt Calc 002**

**008  6.0 points**

What will be the pH at the equivalence point of a titration of 0.5 M acrylic acid with an equimolar solution of NaOH? Acrylic acid has a $K_a$ of 5.6 $\times$ 10$^{-5}$.

1. 5.18

2. 8.82 correct

3. 8.97

4. not enough information

5. 11.57

6. 7.00
LDE Molar Solubility Estimation 001
009  6.0 points
Which of the following salts would have the lowest molar solubility?

1. CuCl \( K_{sp} = 1.02 \times 10^{-6} \)
2. CaF\(_2\) \( K_{sp} = 3.95 \times 10^{-11} \)
3. Ag\(_2\)CO\(_3\) \( K_{sp} = 6.15 \times 10^{-12} \) correct
4. Li\(_3\)PO\(_4\) \( K_{sp} = 2.37 \times 10^{-4} \)

LDE Molar Solubility Calculation 003
010  6.0 points
The \( K_{sp} \) of Cd\(_3\)(PO\(_4\))\(_2\) at 18 °C is \( 1.08 \times 10^{-33} \). What is its molar solubility at this temperature?

1. \( 6.5 \times 10^{-11} \) M
2. \( 2.5 \times 10^{-9} \) M
3. \( 3.3 \times 10^{-17} \) M
4. \( 1.0 \times 10^{-7} \) M correct

LDE Common Ion Solubility Calc 001
011  6.0 points
What would be the molar solubility of Cu\(_2\)S \( (K_{sp} = 2 \times 10^{-47}) \) in a \( 2 \times 10^{-3} \) M solution of CuNO\(_3\)?

1. \( 1.7 \times 10^{-16} \)
2. \( 5.0 \times 10^{-42} \) correct
3. \( 1.3 \times 10^{-43} \)
4. \( 1.0 \times 10^{-44} \)

LDE Selective Precipitation 001
012  6.0 points
Consider the \( K_{sp} \) data below and determine which two metal ions would be the most difficult to separate using the oxalate anion (C\(_2\)O\(_4^{2-}\)).

\begin{align*}
\text{FeC}_2\text{O}_4 & \quad K_{sp} = 2.10 \times 10^{-7} \\
\text{PbC}_2\text{O}_4 & \quad K_{sp} = 2.74 \times 10^{-11} \\
\text{MgC}_2\text{O}_4 & \quad K_{sp} = 8.57 \times 10^{-5}
\end{align*}

1. Cu\(^{2+}\) and Pb\(^{2+}\)
2. Cu\(^{2+}\) and Fe\(^{2+}\) correct
3. Fe\(^{2+}\) and Mg\(^{2+}\)
4. Pb\(^{2+}\) and Mg\(^{2+}\)
5. Fe\(^{2+}\) and Pb\(^{2+}\)
6. Cu\(^{2+}\) and Mg\(^{2+}\)

LDE Acid/Base Assumptions 002
013  6.0 points
When using the equation \([H^+] = (K_aC_a)^{1/2}\), why should the value of \( K_a \) be less than \( 10^{-4} \)?

1. To ensure that \([H^+]\) and \([A^-]\) are nearly equal.
2. To ensure that the initial and equilibrium concentrations of HA are nearly equal. correct
3. \( K_a \) doesn’t need to be less than \( 10^{-4} \)
4. To ensure that water’s contribution to \([H^+]\) is negligible.

LDE Polyprotic Acid Equil 002
014  6.0 points
Consider a tetraprotic acid of the form H\(_4\)A. If a buffer is formed by placing Li\(_2\)H\(_2\)A and Li\(_3\)HA in solution, which \( K_a \) is used to solve the buffer equation?

1. not enough information
2. \( K_{a4} \)
3. \( K_{a3} \) correct
4. $K_{a1}$
5. $K_{a0}$
6. $K_{a2}$

**LDE Polyprotic Amphiprotic Calc 003**

Determine the pH of a 0.03 M solution of NaH$_2$PO$_4$. Assume H$_3$PO$_4$ has a $pK_{a1}$ of 2.1 and a $pK_{a2}$ of 7.2 and a $pK_{a3}$ of 12.7.

1. 7.40
2. 7.11
3. 1.81
4. 4.36
5. 4.65 correct
6. 9.95

**LDE Charge Balance 001**

Write the charge balance for a solution that initially contains CsF and CaCO$_3$.

1. $[\text{Cs}^+] + 2[\text{Ca}^{2+}]$
   
   \[= [\text{F}^-] + 2[\text{CO}_3^{2-}] + [\text{HCO}_3^-] \]

2. $[\text{Cs}^+] + [\text{Ca}^{2+}]$

   \[= [\text{F}^-] + [\text{CO}_3^{2-}] + [\text{HCO}_3^-] \]

3. $[\text{Cs}^+] + 2[\text{Ca}^{2+}]$

   \[= [\text{F}^-] + 2[\text{CO}_3^{2-}] \]

4. $[\text{Cs}^+] + 2[\text{Ca}^{2+}] + [\text{H}^+]$

   \[= [\text{OH}^-] + [\text{F}^-] + 2[\text{CO}_3^{2-}] + [\text{HCO}_3^-] \] correct

5. $[\text{Cs}^+] + 2[\text{Ca}^{2+}] + [\text{H}^+]$

   \[= [\text{OH}^-] + [\text{F}^-] + 2[\text{CO}_3^{2-}] \]

6. $[\text{Cs}^+] + [\text{Ca}^{2+}] + [\text{H}^+]$

   \[= [\text{OH}^-] + [\text{F}^-] + [\text{CO}_3^{2-}] + [\text{HCO}_3^-] \]
What would be the pH of a 0.4 M Na$_2$CO$_3$ solution? Carbonic acid has $K_{a1} = 2.5 \times 10^{-4}$, $K_{a2} = 5.6 \times 10^{-11}$.

1. 2.07
2. 8.60
3. 5.40
4. 11.93 **correct**
5. 7.00

What is the sum of the coefficients?

1. 11 **correct**
2. 12
3. 14
4. 5
5. 9

Consider the provided table of standard reduction potentials. Rank the following species from weakest to strongest oxidizing agent: Ni$^{2+}$, Sr$^{2+}$, I$_2$, Au$^{3+}$, Ag$^+$.  

1. Ag$^+ <$ Au$^{3+} <$ I$_2 <$ Ni$^{2+} <$ Sr$^{2+}$
2. Sr$^{2+} <$ I$_2 <$ Au$^{3+} <$ Ag$^+ <$ Ni$^{2+}$
3. Ag$^+ <$ I$_2 <$ Ni$^{2+} <$ Au$^{3+} <$ Sr$^{2+}$
4. Au$^{3+} <$ Sr$^{2+} <$ Ag$^+ <$ I$_2 <$ Ni$^{2+}$
5. Sr$^{2+} <$ Ni$^{2+} <$ I$_2 <$ Ag$^+ <$ Au$^{3+}$ **correct**

If the two half reactions below were used to make an electrolytic cell, what species would be consumed at the anode?

<table>
<thead>
<tr>
<th>Half reaction</th>
<th>$E^\circ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au$^{3+}$ (aq) + 3 e$^-$ $\rightarrow$ Au(s)</td>
<td>+1.50</td>
</tr>
<tr>
<td>I$_2$(s) + 2 e$^-$ $\rightarrow$ 2 I$^-$ (aq)</td>
<td>+0.53</td>
</tr>
</tbody>
</table>

1. Au$^{3+}$ (aq)
2. I$^-$ (aq)
3. I$_2$ (s)
4. Au (s) **correct**
Far a battery, the cathode is the (positive/negative) terminal and the electrons flow through the external circuit from (anode to cathode/cathode to anode).

1. positive, cathode to anode  
2. negative, anode to cathode  
3. negative, cathode to anode  
4. positive, anode to cathode correct

What would be the $E^\circ$ cell of an electrolytic cell made from the following two half reactions?

- $\text{AgCl}(s) + e^- \rightarrow \text{Ag}(s) + \text{Cl}^-(aq)$  
  $E^\circ = +0.22$  
- $\text{Al}^{3+}(aq) + 3 e^- \rightarrow \text{Al}(s)$  
  $E^\circ = -1.66$

1. 1.88  
2. 1.44  
3. −1.44  
4. −1.88 correct

A battery formed from the two half reactions below dies (reaches equilibrium). If $[\text{Fe}^{2+}]$ was 0.24 M in the dead battery, what would $[\text{Cd}^{2+}]$ be in the dead battery?

- $\text{Fe}^{2+} \rightarrow \text{Fe}$  
  $E^\circ = -0.44$  
- $\text{Cd}^{2+} \rightarrow \text{Cd}$  
  $E^\circ = -0.40$

1. 120.3 M  
2. 0.01 M correct  
3. 5.4 M  
4. 0.00005 M