This print-out should have 15 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001  10.0 points
Which of the following is not a correct statement about a popular battery used in our daily lives?

1. Lithium ion batteries, which are used in cell phones, are considered by some to be a safety risk because of explosion or fire.

2. Sulfuric acid is the acid most commonly found in lead acid storage batteries.

3. Calcium oxide is the base most commonly found in alkaline batteries. correct

4. Nickel cadmium batteries are decreasingly popular because memory effects reduce the lifetime of the battery.

5. “Hybrid” automobiles most often employ a nickel metal hydride battery as their electrical power source.

Explanation:
The base most commonly found in alkaline batteries is MnO$_2$ (manganese(II) oxide).

002  10.0 points
Consider the reaction
\[ \text{CrO}_2^- + \text{ClO}^- \rightarrow \text{CrO}_4^{2-} + \text{Cl}^- \]
in basic aqueous solution. In the balanced stoichiometric equation, what is the coefficient of Cl$^-$?

1. 4

2. 2

3. 3 correct

4. 1

Explanation:

003  10.0 points
If the two half reactions below were used to make a battery, what species would be produced at the anode?

<table>
<thead>
<tr>
<th>Half reaction</th>
<th>$E^\circ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu$^{2+}$(aq) + 2e$^-$ $\rightarrow$ Cu(s)</td>
<td>+0.34</td>
</tr>
<tr>
<td>Fe$^{3+}$(aq) + e$^-$ $\rightarrow$ 2Fe$^{2+}$(aq)</td>
<td>+0.77</td>
</tr>
</tbody>
</table>

1. Fe$^{3+}$(aq)

2. Fe$^{2+}$(aq)

3. Cu(s)

4. Cu$^{2+}$(aq) correct

Explanation:
A battery must have a negative positive cell potential and therefore the anodic reaction must produce Cu$^{2+}$(aq).

004  10.0 points
Using the standard potential tables, what is the largest approximate $E^\circ$ value that can be achieved when two half cell reactions are combined to form a battery?

1. 3 V

2. 6 V correct

3. −6 V

4. −3 V

Explanation:
Using the tables, the largest values of $E^\circ_{\text{red}}$ are about + 3 V and - 3 V.
The species with the positive value would be reduced, the other would be oxidised so:
$E^\circ_{\text{cell}} = + 3 \text{ V} - (- 3 \text{ V}) = + 6 \text{ V}$

005  10.0 points
For an electrolytic cell, which of the following must be negative?

I) $E^\circ_{\text{cell}}$

II) anode

III) cathode

1. I, II, III
2. II

3. I, II

4. II, III

5. I, III correct

6. I

7. III

Explanation:
By definition and by convention, the standard cell potential of an electrolytic cell is less than zero, and the cathode is attributed a negative sign.

006 10.0 points

How long would a current of 10 mA take to produce 0.096 g of Mo(s) from Mo^{5+}(aq)?

1. 964,850 s
2. 9,648,500 s
3. 48,242.5 s correct
4. 4,824,250 s
5. 9,648.5 s
6. 48,242,500 s

Explanation:
This is a 4 electron process.

\[(0.096 \text{ g Mo(s)}) \left( \frac{1 \text{ mol}}{96 \text{ g}} \right) = 0.001 \text{ mol Mo(s)}\]

10 mA = 0.01 A

\[
\frac{It}{N_eF} = n_p
\]

\[
t = \frac{n_pN_eF}{I} = \frac{0.001 \cdot 5 \cdot 96,485}{0.01} = 48,242.5 \text{ s}
\]

007 10.0 points

The reaction

\[2\text{Ag}^+(aq) + \text{Fe(s)} \rightarrow \text{Fe}^{2+}(aq) + 2\text{Ag(s)}\]

taking place in a battery generates a current of 2 amp. How much Fe(s) is consumed in 1 hour?

1. 1.04 g
2. 3.46 g
3. 8.32 g
4. 4.16 g
5. 2.08 g correct

Explanation:

\[i = 2 \text{ A} \quad t = 1 \text{ h}\]

The half equation of interest is

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

and the total charge is

\[
q = (2 \text{ A}) (1 \text{ h}) \frac{60 \text{ min}}{1 \text{ h}} \frac{60 \text{ sec}}{1 \text{ min}} = 7200 \text{ C}.
\]

We can then convert this charge to number of electrons and finally the amount of Fe consumed:

\[
(7200 \text{ C}) \frac{1 \text{ mol } e^-}{96485 \text{ C}} \times \frac{1 \text{ mol Fe}}{2 \text{ mol } e^-} \times \frac{55.847 \text{ g Fe}}{1 \text{ mol Fe}} = 2.08374 \text{ g Fe}
\]

008 10.0 points

The figure represents a reaction at 298 K.

Based on the figure, the standard voltage is

1. positive. correct
2. negative.
Explanation:
$\Delta G^o$ is negative (point E is lower free energy than point A), so the standard voltage is positive.

Which type of widely used battery is NOT rechargeable?

1. lead-acid (storage batteries)  
2. alkaline correct  
3. nickel-cadmium (NiCad)  
4. lithium-ion

Explanation:
Alkaline batteries were not designed to be rechargeable and do not do so efficiently, although there are some websites that disagree.

When the equation 
$\text{FeCl}_3 + \text{Au(s)} \rightleftharpoons \text{Fe(s)} + \text{AuCl}$
is correctly balanced, what is the coefficient of Fe(s)?

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

Explanation:
The balanced equation is
$\text{FeCl}_3 + 3 \text{Au(s)} \rightleftharpoons \text{Fe(s)} + 3 \text{AuCl}$

Cr$_2$O$_7^{2-}$ + 6 $e^-$ $\rightleftharpoons$ 2 Cr$^{3+}$

What is the coefficient for H$^+$ in the balanced reaction?

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

Explanation:
The balanced equation is
$14 \text{H}^+ + 6 \text{Fe}^{3+} + \text{Cr}_2\text{O}_7^{2-} \rightleftharpoons 6 \text{Fe}^{2+} + 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$

Consider the standard reduction potentials
$\text{Cu}^{2+} + 2 \text{e}^- \rightarrow \text{Cu} \quad E^0 = 0.337 \text{ V}$  
$\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag} \quad E^0 = 0.7994 \text{ V}$  
$\text{Au}^+ + \text{e}^- \rightarrow \text{Au} \quad E^0 = 1.68 \text{ V}$

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

1. Ag$^+$ is a stronger oxidizing agent than Au$^+$.  
2. Cu$^{2+}$ is a stronger oxidizing agent than Au$^+$.  
3. Ag$^+$ is a stronger oxidizing agent than Cu$^{2+}$. correct  
4. Nothing can be predicted about oxidizing strengths from the data given.  
5. Cu$^{2+}$ is a stronger oxidizing agent than Ag$^+$.  

Explanation:

For a reaction in acid involving the following two half reactions,
$\text{Fe}^{3+} + \text{e}^- \rightleftharpoons \text{Fe}^{2+}$

What is the cathode in
$\text{Ag(s)} | \text{Ag}^+(aq) \ || \ \text{Fe}^{2+}(aq) | \ \text{Fe(s)}$
Ag$^+ + e^- \rightarrow Ag$ $\quad \mathcal{E}_{\text{red}}^\circ = +0.80$
Fe$^{2+} + 2e^- \rightarrow Fe$ $\quad \mathcal{E}_{\text{red}}^\circ = -0.44$
and what type cell is it?

1. Ag(s) | Ag$^+(aq)$; an electrolytic cell
2. Not enough information is provided.
3. Fe$^{2+}(aq)$ | Fe(s); an electrolytic cell correct
4. Fe$^{2+}(aq)$ | Fe(s); a battery
5. Ag(s) | Ag$^+(aq)$; a battery

Explanation:
The diagram A | B || C | D is read as follows:
A $\rightarrow$ B + n e$^-$ (oxidation)
C + m e$^-$ $\rightarrow$ D (reduction)
Since reduction occurs at the cathode, the cathode is Fe$^{2+}(aq)$ | Fe(s).
To determine the cell type, calculate $\mathcal{E}^\circ$ cell:

2 Ag(s) $\rightarrow$ 2 Ag$^+(aq)$ + 2 e$^-$ $\quad \mathcal{E}_{\text{anode}}^\circ = -0.80$ V

Fe$^{2+}$ + 2 e$^- \rightarrow Fe$ $\quad \mathcal{E}_{\text{cathode}}^\circ = -0.44$ V

2 Ag(s) + Fe$^{2+}$ $\rightarrow$ 2 Ag$^+(aq)$ + Fe $\quad \mathcal{E}_{\text{cell}}^\circ = -1.24$ V

Since $\mathcal{E}^\circ$ 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.

| 014 | 10.0 points |

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

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

Explanation:

Zn(s) + Cu$^{2+}(aq)$ $\rightarrow$ Zn$^{2+}(aq)$ + Cu(s)

Reduction occurs at the cathode. In this cell the reduction half reaction is

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

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

| 015 | 10.0 points |

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

Zn(s) | Zn$^{2+}(aq)$ || Ce$^{4+}(aq)$ | Ce$^{3+}(aq)$
Zn$^{2+}$ + 2 e$^- \rightarrow$ Zn $\quad E_{\text{red}}^\circ = -0.76$
Ce$^{4+}$ + e$^- \rightarrow$ Ce$^{3+}$ $\quad E_{\text{red}}^\circ = +1.61$
1. +1.61
2. -0.85
3. -2.37
4. +0.85

5. +2.37 correct

Explanation: