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

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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).

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002 10.0 points

Consider the reaction

$$CrO_2^- + ClO^- \rightarrow CrO_4^{-2} + Cl^-$$

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:

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003 10.0 points

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

Half reaction	E°
$Cu^{2+}(aq) + 2\,e^- \longrightarrow Cu(s)$	+0.34
$Fe^{3+}(aq) + e^- \longrightarrow 2\,Fe^{2+}(aq)$	+0.77

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

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004 10.0 points

Using the standard potential tables, what is the largest approximate E^0 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°_{red} are about + 3 V and - 3 V.

The species with the positive value would be reduced, the other would be oxidised so:

E°_{cell} = + 3 V - (- 3 V) = + 6 V

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005 10.0 points

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

I) E^o_{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.

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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

$$\frac{It}{N_e F} = n_p$$

$$t = \frac{n_p N_e F}{I} = \frac{0.001 \cdot 5 \cdot 96,485}{0.01} = 48,242.5 \text{ s}$$

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007 10.0 points

The reaction

$$2\,Ag^+(aq) + Fe(s) \rightarrow Fe^{2+}(aq) + 2\,Ag(s)$$

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:

$i = 2$ A $\quad t = 1$ h

The half equation of interest is

$$Fe(s) \rightarrow Fe^{2+} + 2\,e^-$$

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:

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

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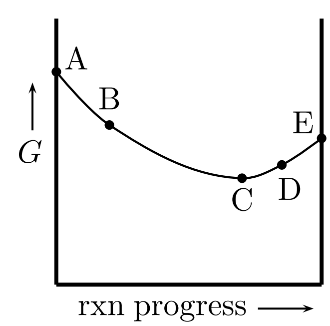
008 10.0 points

The figure represents a reaction at 298 K.



Based on the figure, the standard voltage is

1. positive. **correct**

2. negative.

Explanation:
ΔG° is negative (point E is lower free energy than point A), so the standard voltage is positive.

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009 10.0 points
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.

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010 10.0 points
When the equation

$$FeCl_3 + Au(s) \rightleftharpoons Fe(s) + AuCl$$

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

$$FeCl_3 + 3\,Au(s) \rightleftharpoons Fe(s) + 3\,AuCl$$

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011 10.0 points
For a reaction in acid involving the following two half reactions,

$$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$$

$$Cr_2O_7^{2-} + 6\,e^- \rightleftharpoons 2\,Cr^{3+}$$

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
$$14\,H^+ + 6\,Fe^{3+} + Cr_2O_7 \rightleftharpoons 6\,Fe^{2+} + 2\,Cr^{3+} + 7\,H_2O$$

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012 10.0 points
Consider the standard reduction potentials

$Cu^{2+} + 2\,e^- \rightarrow Cu$ $\quad E^0 = 0.337$ V
$Ag^+ + 1\,e^- \rightarrow Ag$ $\quad E^0 = 0.7994$ V
$Au^+ + 1\,e^- \rightarrow Au$ $\quad E^0 = 1.68$ 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:

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013 10.0 points
What is the cathode in

$$Ag(s) \mid Ag^+(aq) \mid\mid Fe^{2+}(aq) \mid Fe(s)$$

$Ag^+ + e^- \to Ag$ $\mathcal{E}^\circ_{red} = +0.80$
$Fe^{2+} + 2\,e^- \to Fe$ $\mathcal{E}^\circ_{red} = -0.44$
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

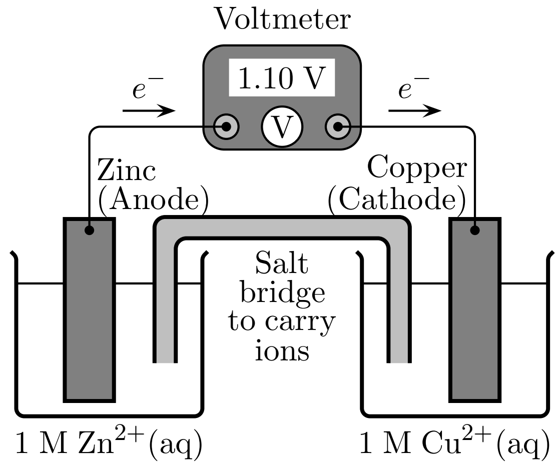
5. Ag(s) | Ag^+(aq); a battery

Explanation:
The diagram A | B || C | D is read as follows:
$A \to B + n\,e^-$ (oxidation)
$C + m\,e^- \to D$ (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:

$$2\,Ag(s) \to 2\,Ag^+(aq) + 2\,e^-$$
$$\mathcal{E}^\circ_{anode} = -0.80\text{ V}$$
$$Fe^{2+} + 2\,e^- \to Fe$$
$$\mathcal{E}^\circ_{cathode} = -0.44\text{ V}$$
$$2\,Ag(s) + Fe^{2+} \to 2\,Ag^+(aq) + Fe$$
$$\mathcal{E}^\circ_{cell} = -1.24\text{ V}$$

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. $Zn(s) \to Zn^{2+}(aq) + 2\,e^-$

2. $Cu^{2+}(aq) + 2\,e^- \to Cu(s)$ **correct**

3. $Zn^{2+}(aq) + 2\,e^- \to Zn(s)$

4. $Cu(s) \to Cu^{2+}(aq) + 2\,e^-$

Explanation:

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

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

$$Cu^{2+}(aq) + 2\,e \to Cu(s)$$

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°_{cell} of

$$Zn(s) \mid Zn^{2+}(aq) \,||\, Ce^{4+}(aq) \mid Ce^{3+}(aq)$$

$Zn^{2+} + 2\,e^- \to Zn$ $E^\circ_{red} = -0.76$
$Ce^{4+} + e^- \to Ce^{3+}$ $E^\circ_{red} = +1.61$

1. +1.61

2. −0.85

3. −2.37

4. +0.85

5. +2.37 **correct**

Explanation: