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version | last name | first name | signature

McCord CH302

unique: 49175 and 49190

Exam 4

May 8, 2019

Wednesday 7:30 - 9:00 PM

A-L in HMA

M-Z In BUR 106

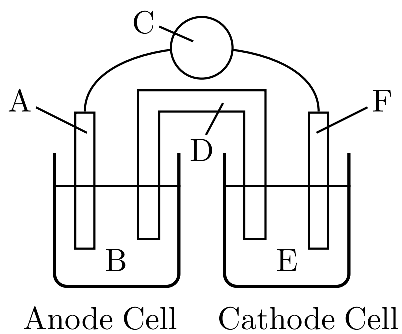
Remember to refer to the Periodic Table handout that is separate from this exam copy.

NOTE: Please keep this exam copy intact (all pages still stapled - including this cover page). You must turn in ALL the materials that were distributed. This means that you turn in your exam copy (name and signature included), bubble sheet, periodic table handout, and all scratch paper. Please also have your UT ID card ready to show as well.

This print-out should have 25 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 (part 1 of 2) 4.0 points

The following two questions refer to this diagram for a voltaic cell. Neither of the two electrodes are an inert electrode.



Where would you find the species that is being oxidized?

1. A **correct**

2. C

3. E

4. B

5. D

Explanation:
A is the electrode in the anode cell. Oxidation always occurs at the anode.

002 (part 2 of 2) 4.0 points

If the half-reaction for the anode involves Fe^{2+} and Fe, which of these redox pairs could be in the cell on the right?

1. None of these can give a voltaic cell

2. H^+ and H_2

3. Cr^{3+} and Cr

4. Mn^{2+} and Mn

5. Sn^{2+} and Sn **correct**

Explanation:
Because the Fe^{2+}/Fe half-reaction is the anode and this is a galvanic cell, the other half-reaction must have a standard reduction potential that is more positive (higher up on the standard reduction potential table) than that of Fe^{2+}/Fe. Only two answer choices have a more positive reduction potential: Sn^{2+}/Sn, and H^+/H2. But the H^+/H2 half-reaction has no solid component to serve as an electrode and therefore requires a platinum electrode, and the problem specifies that there are no platinum electrodes. That leaves Sn^{2+}/Sn as the only option.

003 4.0 points

When direct heat is applied to potassium chlorate, $KClO_3$, it decomposes to form KCl and other byproducts. Was chlorine oxidized or reduced? How many electrons were transferred during the process?

1. oxidized, 3 electrons

2. reduced, 3 electrons

3. oxidized, 6 electrons

4. reduced, 6 electrons **correct**

5. reduced, 9 electrons

6. oxidized, 4 electrons

Explanation:
For the conversion of $KClO_3$ to KCl, the Cl atom is going from a +5 to a -1 oxidation state. This is a reduction reaction that involves the gain of 6 electrons.

004 4.0 points

Consider the lead-acid battery and the chemical reaction that drives it forward during use (discharge). Which of the following substances is *reduced* as the battery discharges and what electrode is it?

1. Pb, anode

2. Pb, cathode

3. $PbSO_4$, anode

4. $PbSO_4$, cathode

5. PbO_2, anode

6. PbO_2, cathode **correct**

Explanation:
PbO_2 has lead in the +4 oxidation state. This will accept 2 electrons and thus be reduced to $PbSO_4$ as the battery discharges. Reduction is always at the cathode. Another way to state this is to say that PbO_2 is the oxidizing agent for this reaction.

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005 4.0 points

Consider the following cell:

$$\mathrm{Pd} \,|\, \mathrm{Pd}^{2+} \,||\, \mathrm{Ru}^{3+} \,|\, \mathrm{Ru}$$

What is ΔG° for the overall cell reaction that is represented here? Balance the reaction using the lowest possible integer values.

1. +91.2 kJ

2. −91.2 kJ

3. −877 kJ

4. +877 kJ

5. +182 kJ **correct**

6. −182 kJ

Explanation:

$Pd^{2+}/Pd = +0.915$ V

$Ru^{3+}/Ru = +0.60$ V

$E^\circ = 0.60 - 0.915 = -0.315$ V

$$\begin{aligned}\Delta G^\circ &= -nFE^\circ \\ &= -6(96485)(-0.315) = +182356\,\mathrm{J} \\ &= +182\,\mathrm{kJ}\end{aligned}$$

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006 4.0 points

The following cell

$$\mathrm{Zn} \,|\, \mathrm{Zn}^{2+}\,(1\,\mathrm{M}) \,||\, \mathrm{H}^{+}\,(?\,\mathrm{M}) \,|\, \mathrm{H}_2\,(1\,\mathrm{atm}) \,|\, \mathrm{Pt}$$

is found to have a potential of 0.540 V. Find the missing concentration of the H^+ and use it to determine the pH of that solution.

1. 5.50

2. 2.25

3. 7.50

4. 3.75 **correct**

5. 1.69

6. 1.88

Explanation:

$E^\circ = 0 - (-0.762) = +0.762$ V

Overall reaction: $Zn + 2H^+ \rightarrow H_2\,(g) + Zn^{2+}$

Using Nernst:

$$0.540 = 0.762 - \frac{0.05916}{2}\log\frac{(1\,\mathrm{atm})(1\,\mathrm{M})}{[\mathrm{H}^+]^2}$$

$[H^+] = 1.77 \times 10^{-4}$ M

$\mathrm{pH} = -\log(1.77 \times 10^{-4}) = 3.75$

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007 4.0 points

What is the Faraday constant?

1. The average voltage carried by the cell flowing in the opposite direction of the electrons

2. The charge of one mole of electrons **correct**

3. The potential difference between half-reactions measured in volts

4. The metallic conductor that makes contact with an electrolyte in a galvanic cell

5. The rate of charge transferred per unit time

Explanation:

F = 96485 c/mol e = The charge of one mole of electrons.

008 4.0 points

If a scientist wants to plate out the largest mass of metal possible in the shortest period of time using his 5 amp electroplating system, which of these solutions should he choose as his plating solution?

1. $Cu(NO_3)_2$

2. $Al(NO_3)_3$

3. $Co(NO_3)_3$

4. $Mg(NO_3)_2$

5. $Cd(NO_3)_2$ **correct**

Explanation:
Cd^{2+} has the largest molar mass of all the metal choices (resulting in the largest mass of metal per mole plated), and it also requires only 2 electrons per atom plated, compared with 3 for Al^{3+} and Co^{3+}.

009 (part 1 of 2) 4.0 points

Consider the following reaction. How many electrons are transferred when the reaction is performed in basic conditions?

$$MnO_4^- + S^{2-} \longrightarrow SO_3^{2-} + MnO_2$$

1. 4 e^-

2. 8 e^-

3. 12 e^-

4. 6 e^- **correct**

5. 3 e^-

Explanation:
The correctly balanced equation is:

$$H_2O + 2MnO_4^- + S^{2-} \longrightarrow SO_3^{2-} + 2MnO_2 + 2OH^-$$

This reaction transfers a total of 6 electrons

010 (part 2 of 2) 4.0 points

In the balanced equation from the previous problem, what is the coefficient for the hydroxide ion? Is it a reactant or a product?

1. 8; product

2. 2; product **correct**

3. 2; reactant

4. 4; product

5. 6; product

6. 6; reactant

7. 1; reactant

Explanation:
See explanation 1 for balanced reaction.

011 4.0 points

Use half-reactions from the standard reduction table to calculate the K_{sp} for $Zn(IO_3)_2$.

1. 3.9×10^{-6} **correct**

2. 7.3×10^{-19}

3. 6.8×10^{-32}

4. 1.7×10^{-26}

5. 4.8×10^{-12}

Explanation:
$Zn(IO_3)_2 + 2e^- \rightarrow Zn + 2IO_3^-$

$$E^\circ = -0.922\ \text{V}$$

$Zn \rightarrow Zn^{2+} + 2e^-$ (shown as oxidation)

$$E^\circ = +0.762\ \text{V}$$

Adding the half-reactions together, we get the solubility reaction for $Zn(IO_3)_2$:

$$Zn(IO_3)_2 \rightarrow Zn^{2+} + 2IO_3^-$$

$$E^\circ = -0.922 + 0.762 = -0.160\ \text{V}$$

K for this reaction then will be K_{sp} for $Zn(IO_3)_2$.

$$K_{sp} = 10^{\frac{nE^\circ}{0.05916}}$$

$= 10^{\frac{(2)(-0.16)}{0.05916}} = 3.9 \times 10^{-6}$

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012 4.0 points

On board the space shuttles, hydrogen fuel cells provided electrical energy, and astronauts drank the water that was produced. If the overall reaction is $2H_2 + O_2 \rightarrow 2H_2O$, what will be the standard potential (E°) for this fuel cell under acidic conditions?

1. 1.23 V **correct**

2. 0.00 V

3. 0.615 V

4. 1.78 V

5. 0.830 V

Explanation:
The reduction half reactions are:

$2H^+ + 2\ e^- \rightarrow H_2$ (E = 0.00 V)

$O_2 + 4H^+ + 4\ e^- \rightarrow 2H_2O$ (E = +1.23 V)

O_2 / H_2O will be the reduction and H^+ / H_2 will be the oxidation, so 1.23 - 0.00 = 1.23 V

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013 4.0 points

What is the potential for the following cell?

$\mathrm{In}\,|\,\mathrm{In}^{3+}\,(0.010\,\mathrm{M})\,||$
$\mathrm{Ce}^{4+}\,(0.50\,\mathrm{M}), \mathrm{Ce}^{3+}\,(0.010\,\mathrm{M})\,|\,\mathrm{Pt}$

1. 1.88 V

2. 2.09 V **correct**

3. 1.81 V

4. 1.95 V

5. 2.02 V

6. 2.37 V

Explanation:
Rxn: $3Ce^{4+} + In \rightarrow In^{3+} + 3Ce^{3+}$

$E^\circ = 1.61 - (-0.34) = 1.95\,\mathrm{V}$

$Q = \frac{[Ce^{3+}]^3[In^{3+}]}{[Ce^{4+}]^3} = \frac{(0.01)^3(0.01)}{(0.5)^3}$

$= 8.0 \times 10^{-8}$

$E = 1.95 - \frac{0.05916}{3}\log(8.0 \times 10^{-8}) = 2.09$ V

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014 4.0 points

A group of scientists have landed on a new planet in an alternate universe. On this planet, they have decided to use the Zn/Zn^{2+} half-reaction as their standard reference electrode. What is the new standard reduction potential for F_2?

1. + 2.11 V

2. + 3.63 V **correct**

3. + 2.87 V

4. 0 V

5. - 2.87 V

Explanation:
By using zinc instead of the standard hydrogen electron, the electrical potential difference between F_2 and the standard is 0.76 V more. This results in a reduction potential of 3.63 V.

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015 4.0 points

Using an electroplating system operating at 7.35 amps, it take 1.50 hours to plate out 5.00 grams of an unknown metal from its molten chloride salt, MCl_2. Identify the metal M.

1. Mg **correct**

2. Cd

3. Cu

4. Zn

5. Fe

Explanation:
$\frac{I \cdot t}{n \cdot F}$ = moles of metal

$\frac{7.35\,(1.5\times60\times60)}{2\cdot96485}$ = .206 mol metal

molar mass = 5 g / .206 mol = 24.3 g

This matches the molar mass of Mg.

016 (part 1 of 2) 4.0 points

What is the shorthand notation for the following electrochemical cell?

$2Cr^{2+}(aq) + Co^{2+}(aq) \longrightarrow 2Cr^{3+}(aq) + Co(s)$

1. Co^{2+} | Co || Cr^{2+} , Cr^{3+}

2. Pt | Cr^{2+} , Cr^{3+} || Co^{2+} | Co **correct**

3. Cr^{2+} | Cr^{3+} || Co^{2+} | Co

4. Co | Co^{2+} || Cr^{2+} , Cr^{3+} | Pt

5. Cr^{2+} , Cr^{3+} || Co^{2+} | Co

Explanation:

You must use an inert electrode in the chromium solution compartment because you do not have a solid metal anode. Otherwise, follow your convention of: anode—anodic solution—— cathodic solution— cathode

017 (part 2 of 2) 4.0 points

What is the oxidizing agent in the previous problem?

1. Co

2. Cr^{2+}

3. Pt

4. Co^{2+} **correct**

5. Cr^{3+}

Explanation:

The oxidizing agent is the species being reduced. This is Co^{2+}.

018 4.0 points

Determine the potential for the following cell:

$Mn \,|\, Mn^{2+}\,(0.025\,M) \,||\, Cd^{2+}\,(0.025\,M) \,|\, Cd$

1. -0.78 V

2. -0.84 V

3. +0.78 V **correct**

4. +0.84 V

5. +0.72 V

6. -0.72 V

Explanation:

E° = -0.4 V + 1.18 V = +0.78 V

$Q = [Mn^{2+}]/[Cd^{2+}] = 0.025/0.025 = 1$

Since $Q = 1$, the log$Q$ term in the Nernst equation will zero out. This means $E = E^\circ =$ +0.78 V.

019 4.0 points

Consider a standard voltaic cell at equilibrium. Which of the following is true?

1. E > 0, $\Delta G > 0$, $K > 1$

2. E < 0, $\Delta G > 0$, $K < 0$

3. E = 0, $\Delta G = 0$, $K > 1$ **correct**

4. E = 0, $\Delta G = 0$, $K = 1$

5. E < 0, $\Delta G > 0$, $K < 1$

Explanation:

For a voltaic cell at equilibrium:

E = 0, $\Delta G = 0$, $K > 1$

It is important to realize here that E and ΔG are not standard values, so at equilibrium they are equal to zero (think of this voltaic cell as a dead battery).

020 4.0 points

An electrolytic cell is set up with two inert electrodes labeled J and K both placed into a single beaker of molten calcium chloride. You observe bubbles of pale green chlorine gas at electrode J and metallic calcium forming at electrode K. Which is true of electrode J?

1. It is the cathode and chloride is being reduced.

2. It is the anode and chloride is being reduced.

3. It is the cathode and chloride is being oxidized.

4. It is the anode and chloride is being oxidized. **correct**

Explanation:
Chloride is being oxidized at electrode J, so it is the anode. Calcium is being reduced at electrode K, so it is the cathode.

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021 4.0 points

For the given cell:

$$\text{Mn}\,|\,\text{Mn}^{2+}\,(0.20\,\text{M})\,||\,\text{Mn}^{2+}\,(?\,\text{M})\,|\,\text{Mn}$$

Find the missing concentration of Mn^{2+} given that the cell potential is found to be 8.9 mV.

1. 0.40 M **correct**

2. 0.10 M

3. 0.28 M

4. 2.5 M

5. 0.20 M

6. 3.5 M

7. 0.14 M

Explanation:
$E^\circ = 0$

$0.0089\text{ V} = 0 - \frac{0.05916}{2}\log\frac{0.2}{x}$

$x = 0.40$ M

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022 4.0 points

You are examining a non-rechargeable D-cell battery that you are about to put in a flashlight. You see that one end is labeled '+' and the other is labeled '–'. Now that you have studied batteries in general chemistry you know that the '+' indicates the end that is the:

1. cathode **correct**

2. Pt electrode

3. anode

4. inert electrode

Explanation:
In a battery (a voltaic cell), '+' denotes the cathode.

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023 4.0 points

What are the oxidation states of Na, Cl, and O in $NaClO_4$?

1. Na = +1, Cl = +7, O = −8

2. Na = +1, Cl = +1, O = −2

3. Na = +9, Cl = −1, O = −8

4. Na = +3, Cl = −1, O = −2

5. Na = +1, Cl = +7, O = −2 **correct**

Explanation:
$NaClO_4$ is an ionic compound made up of Na^+ (so Na has an oxidation state of +1) and ClO_4^-. In a molecule with other atoms, oxygen has an oxidation state of -2 (unless it is a peroxide, which it is not in this case). The addition of all the oxidation states have to add up to the overall charge of the molecule. Since ClO_4^- has an overall charge of -1, Cl must have an oxidation state of +7 [7+4(-2) = -1].

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024 4.0 points

The following reaction occurs in acidic conditions. What is the coefficient of water in the overall balanced equation? Is it a reactant or a product?

$$As_2O_3 + NO_3^- \longrightarrow H_3AsO_4 + NO$$

1. 2; product

2. 3; reactant

3. 3; product

4. 2; reactant

5. 7; reactant **correct**

6. 4; reactant

Explanation:
The correctly balanced equation is:

$$7H_2O + 4H^+ + 3As_2O_3 + 4NO_3^- \longrightarrow 6H_3AsO_4 + 4NO$$

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025 4.0 points

Consider the following short-hand notation for a concentration cell at standard conditions:

$$Pt(s)\,|\,H_2(g)\,|\,H^+(aq)\,||\,H^+(aq)\,|\,H_2(g)\,|\,Pt(s)$$

Which of the following will result in a positive cell potential?

1. This cell can only have a cell potential equal to 0 V

2. Increasing the pressure of H_2 in the cathode compartment

3. Decreasing the pH of the cathode compartment **correct**

4. Decreasing the pressure of H_2 in the anode compartment

5. Increasing the H^+ concentration in the anode compartment

Explanation:
The cell potential for this concentration cell is equal to 0. You can increase the cell potential by decreasing the value of Q, given below:

$$Q = \frac{[H^+]_a^2 P_{H_2,c}}{[H^+]_c^2 P_{H_2,a}}$$

Using this equation, you can determine that decreasing the pH of the cathode compartment (increasing $[H^+]$) will decrease Q and increase E.