**Electrochemistry Practice Problems**

**Multiple Choice**

*Identify the letter of the choice that best completes the statement or answers the question.*

\_\_\_\_ 1. Which of the following best accounts for the fact that a galvanic cell based on the reaction represented below will generate electricity?

Cl2(g) + 2 I-(aq)  2 Cl- (aq) + I2(aq)

|  |  |
| --- | --- |
| a. | Cl2 can easily lose two electrons. |
| b. | Cl2 is a stronger oxidizing agent than I2. |
| c. | I atoms have more electrons than do atoms of Cl. |
| d. | I- is a more stable species than I2. |
| e. | I2(s) is more soluble than Cl2(g). |

\_\_\_\_ 2.

H2Se*(g)* + 4 O2F2*(g)*  SeF6*(g)* + 2 HF*(g)* + 4 O2*(g)*

Which of the following is true regarding the reaction represented above?

|  |  |
| --- | --- |
| a. | The oxidation number of O does not change. |
| b. | The oxidation number of H changes from -1 to +1. |
| c. | The oxidation number of F changes from +1 to -1. |
| d. | The oxidation number of Se changes from -2 to +6. |

\_\_\_\_ 3. M*(s)* + 3 Ag+*(aq)*  3 Ag*(s)* + M3+*(aq)* *E*o = + 2.46 V

Ag+*(aq)* + *e-*  Ag*(s)* *E*o = + 0.80 V

According to the information above, what is the standard reduction potential for the half-reaction M3+*(aq)* + 3 *e-*  M*(s)* ?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | –1.66 V | d. | 1.66 V |
| b. | –0.06 V | e. | 3.26 V |
| c. | 0.06 V |

\_\_\_\_ 4. Which of the following statements correctly describes the movement of particles through an electrochemical cell?

|  |  |
| --- | --- |
| a. | Anions enter the anode compartment through the salt bridge and electrons travel through the external wire from the anode to the cathode. |
| b. | Cations enter the cathode compartment through the salt bridge and electrons travel through the external wire from the cathode to the anode. |
| c. | Anions enter the anode compartment through the salt bridge and electrons travel through the salt bridge from the anode to the cathode.  |
| d. | Cations enter the cathode compartment through the salt bridge and electrons travel through the salt bridge from the cathode to the anode. |

Consider an electrolytic cell that involves the following half-reaction.

AlF63– + 3 *e-*  Al + 6 F–

\_\_\_\_ 5. Which of the following occurs in the reaction?

|  |  |
| --- | --- |
| a. | AlF63– is reduced at the cathode. |
| b. | Al is oxidized at the anode. |
| c. | Aluminum is converted from the -3 oxidation state to the 0 oxidation state. |
| d. | F– acts as a reducing agent. |
| e. | F– is reduced at the cathode. |

\_\_\_\_ 6. A steady current of 10 amperes is passed through an aluminum-production cell for 15 minutes. Which of the following is the correct expression for calculating the number of grams of aluminum produced? (1 faraday = 96,500 coulombs)

|  |  |  |  |
| --- | --- | --- | --- |
| a. | (10\*15\*96,500)/(27 \*60) g | d. | (96,500\*27)/(10\*15\*60\*3) g |
| b. | (10\*15\*27)/(60\*96,500) g | e. | (27\*3)/(96,500\*10\*15\*60) g |
| c. | (10\*15\*60\*27)/(96,500\*3) g |

**Problem**

 7. **2001 D**



Answer the following questions that refer to the galvanic cell shown in the diagram above. (Refer to a [table of standard reduction potentials](https://docs.google.com/presentation/d/1fPhxS-cVjLNnAoS3aXFsDqPKa5EH-3mLpxZ8u9M6_Cw/edit?usp=sharing).)

(a) Identify the anode of the cell and write the half reaction that occurs there.

(b) Write the net ionic equation for the overall reaction that occurs as the cell operates and calculate the value of the standard cell potential, *Ecell* .

(c) Indicate how the value of *Ecell*  would be affected if the concentration of Ni(NO3)2*(aq)* was changed from 1.0 *M* to 0.10 *M* and the concentration of Zn(NO3)2*(aq)* remained at 1.0 *M*. Justify your answer.

(d) Specify whether the value of *Keq* for the cell reaction is less than 1, greater than 1, or equal to 1. Justify your answer.

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 8. Answer the following questions that relate to electrochemical reactions. (2000B)

(a) Under standard conditions at 25C, Zn*(s)* reacts with Co2+*(aq)* to produce Co*(s)*.

(i) Write the balanced equation for the oxidation half reaction.

(ii) Write the balanced net-ionic equation for the overall reaction.

(iii) Calculate the standard potential, *E*, for the overall reaction at 25C.

(b) At 25C, H2O2 decomposes according to the following equation.

2 H2O2*(aq)*  2 H2O*(l)* + O2*(g)* *E* = 0.55 V

(i) Determine the value of the standard free energy change, *G*, for the reaction at 25C.

(ii) Determine the value of the equilibrium constant, *K*eq, for the reaction at 25C.

(iii) The standard reduction potential, *E*, for the half reaction O2*(g)* + 4 H+*(aq)* + 4 *e*-  2 H2O*(l)* has a value of 1.23 V. Using this information in addition to the information given above, determine the value of the standard reduction potential, *E* for the half reaction below.

O2*(g)* + 2 H+*(aq)* + 2 *e*-  H2O2*(aq)*

(c) In an electrolytic cell, Cu*(s)* is produced by the electrolysis of CuSO4*(aq)*. Calculate the maximum mass of Cu*(s)* that can be deposited by a direct current of 100. amperes passed through 5.00 L of 2.00 *M* CuSO4*(aq)* for a period of 1.00 hour.

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 9. 2011A

 A fuel cell is an electrochemical cell that converts the chemical energy stored in a fuel into electrical energy. A cell that uses H2 as the fuel can be constructed based on the following half-reactions.

|  |  |
| --- | --- |
| **Half-reaction** | **Eo (298 K)** |
| 2 H2O(l) + O2(g) + 3 e- → 4 OH-(aq) | 0.40 V |
| 2 H2O(l) + 2 e- → H2(g) + 2 OH-(aq) | -0.83V |

a) Write the equation for the overall cell reaction. (1 pt)

b) Calculate the standard potential for the cell at 298 K. (1 pt)

Assume that 0.93 mol of H2(g) is consumed as the cell operates for 600. seconds.

c) Calculate the number of moles of electrons that pass through the cell. (1 pt)

d) Calculate the average current, in amperes, that passes through the cell. (2 pts)

e) Some fuel cells use butane gas, C4H10, rather than hydrogen gas. The overall reaction that occurs in a butane fuel cell is: 2C4H10(g) + 13 O2(g) → 8CO2(g) + 10 H2O(*l*)

What is one environmental advantage of using fuel cells that are based on hydrogen rather than on hydrocarbons such as butane? (1 pt)

**Electrochemistry Practice Problems**

**Answer Section**

**MULTIPLE CHOICE**

 1. ANS: B PTS: 1

 2. ANS: D PTS: 1

 3. ANS: A PTS: 1

 4. ANS: A PTS: 1

 5. ANS: A PTS: 1

 6. ANS: C PTS: 1

**PROBLEM**

 7. ANS:

(a) zinc; Zn*(s)* Zn2+*(aq)* + 2 *e*–

(b) Zn*(s)* + Ni2+*(aq)*  Zn2+*(aq)* + Ni*(s)*

 *Ecell*  = +0.76 + (-0.25) V = +0.51 V

(c) decrease *Ecell* ; *Ecell*  = *Ecell* – log *Q*, *Q* = , when the value of Q becomes larger than 1 then the log Q > 1 and is subtracted from the standard potential of the cell.

(d) greater than 1. All spontaneous reactions (this reaction is spontaneous because the cell potential is larger than 0) have a *Keq* that are larger than 1, which favors the formation of products.

PTS: 1

 8. ANS:

(a) (i) Zn*(s)*  Zn2+*(aq)* + 2 *e*-

 (ii) Zn*(s)* + Co2+*(aq)*  Zn2+*(aq)* + Co*(s)*

 (iii) oxid: Zn*(s)*  Zn2+*(aq)* + 2 *e*- *E* = +0.76V

 red: Co2+*(aq)*+ 2 *e*-  Co*(s)* *E* = –0.28V

 +0.48V

(b) (i) *G* = –n*E* = –(2)(96500)(0.55) = –106 kJ

 (ii) *K*eq = e–*G*/RT = e–(–106150/(8.31)(298)) = 4.131018

 (iii) ~~2 H2O~~*~~(l)~~* + O2*(g)*  2 H2O2*(aq)* *E* = –0.55 V

 O2*(g)* + 4 H+*(aq)* + 4 *e*-  ~~2 H2O~~*~~(l)~~* *E* = 1.23 V

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 2 O2*(g)* + 4 H+*(aq)* + 4 *e*-  2 H2O2*(aq)* *E* = 0.68 V

 divide the equation by 2 but keep the *E* the same.

(d) 119 g Cu

PTS: 1

 9. ANS:

a) 1 pt for correct equation

b)  1 pt for correct value

c) 1 pt for correct answer

d)  1 pt for coulombs, 1 pt for amps

e) no CO2 released...no greenhouse gas emissions

PTS: 1