Name _____ AP CHEM ___/___/___

Collected Essays Chapter 17

1980 - #2

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

For the reaction above, E° = 0.740 volt at 25 °C.

(a) Determine the standard electrode potential for the reaction half-reaction $M^{2+}(aq) + 2\ e^- \rightarrow M(s)$.

(b) A cell is constructed in which the reaction above occurs. All substances are initially in their standard states, and equal volumes of the solutions are used. The cell is then discharged. Calculate the value of the cell potential, E, when $[Cu^{2+}]$ has dropped to 0.20 molar.

(c) Find the ratio $[M^{2+}]aq / [Cu^{2+}]aq$ when the cell reaction above reaches equilibrium.

1981 - #5

A solution of $CuSO_4$ was electrolyzed using platinum electrodes by passing a current through the solution. As a result, there was a decrease in both $[Cu^{2+}]$ and the solution pH; one electrode gained in weight and a gas was evolved at the other electrode.

(a) Write the cathode half-reaction that is consistent with the observation above.

(b) Write the anode half-reaction that is consistent with the observations above.

(c) Sketch an apparatus that can be used for such an experiment and label its necessary components.

(d) List the experimental measurement that would be needed in order to determine from such an experiment the value of the faraday.

1982 - #2

When a dilute solution of H_2SO_4 is electrolyzed, $O_2(g)$ is produced at the anode and $H_2(g)$ is produced at the cathode.

(a) Write the balanced equations for the anode, cathode, and overall reaction that occur in this cell.

(b) Compute the coulombs of charge passed through the cell in 100.0 minutes at 10.0 amperes.

(c) What number of moles of O_2 is produces by the cell when it is operated for 100. minutes at 10.0 amperes?

(d) The standard enthalpy of formation of $H_2O(g)$ is -242 kilojoules per mole. How much heat is liberated by the complete combustion, at 298 K and 1.00 atmosphere, of the hydrogen produced by the cell operated as in (c)?

1983 - #8

$Ti^{3+} + HOBr <===> TiO^{2+} + Br^-$ (in acid solution)

(a) Write the correctly balanced half-reaction and net ionic equation for the skeletal equation shown above.

(b) Identify the oxidizing agent and the reducing agent in this reaction.

(c) A galvanic cell is constructed that utilizes the reaction above. The concentration of each species is 0.10-molar. Compare the cell voltage that will be observed with the standard cell potential. Explain your reasoning.

(d) Give one example of a property of this reaction, other than the cell voltage, that can be calculated from the standard cell potential, E°. State the relationship between E° and the property you have specified.

1985 - #2

(a) Titanium can be reduced in acid solution from TiO^{2+} to Ti^{3+} with zinc metal. Write a balanced equation for the reaction of TiO^{2+} with zinc in acid solution.

(b) What mass of zinc metal is required for the reduction of a 50.00-milliliter sample of a 0.115-molar solution of TiO^{2+}?

(c) Alternatively, the reduction of TiO^{2+} to Ti^{3+} can be carried out electrochemically. What is the minimum time, in seconds, required to reduce another 50.00-milliliter sample of the 0.115-molar TiO^{2+} solution with a direct current of 1.06 amperes?

(d) The standard reduction potential, E°, for TiO^{2+} to Ti^{3+} is +0.06 volt. The standard reduction potential, E°, for Zn^{2+} to Zn(s) is -0.763 volt. Calculate the standard cell potential, E°, and the standard free energy change, ΔG°, for the reaction described in part(a).

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1986 - #2
A direct current of 0.125 ampere was passed through 200 milliliters of a 0.25-molar solution of $Fe_2(SO_4)_3$ between platinum electrodes for a period of 1.100 hours. Oxygen gas was produced at the anode.
The only change at the cathodes was a slight change in the color of the solution. At the end of the electrolysis, the electrolyte was acidified with sulfuric acid and was titrated with an aqueous solution of potassium permanganate. The volume of the $KMnO_4$ solution required to reach the end point was 24.65 milliliters.
(a) How many faradays were passed through the solution?
(b) Write a balanced half-reaction for the process that occurred at the cathode during the electrolysis.
(c) Write a balanced net ionic equation for the reaction that occurred during the titration with potassium permanganate.
(d) Calculate the molarity of the $KMnO_4$ solution.

1987 - #6
A dilute solution of sodium sulfate, Na_2SO_4, was electrolyzed using inert platinum electrodes. In a separate experiment, a concentrated solution of sodium chloride, NaCl, was electrolyzed also using inert platinum electrodes. In each experiment, gas formation was observed at both electrodes.
(a) Explain why metallic sodium is not formed in either experiment.
(b) Write balanced equations for the half-reactions that occur at the electrodes during electrolysis of the dilute sodium sulfate solution. Clearly indicate which half-reaction occurs at each electrode.
(c) Write balanced equations for the half-reactions that occur at the electrodes during the electrolysis of the concentrated sodium chloride solution. Clearly indicate which half-reaction occurs at each electrode.
(d) Select two of the gases obtained in these experiments, and for each gas, indicate one experimental procedure that can be used to identify it.

1988 - #3
An electrochemical cell consists of a tin electrode in an acidic solution of 1.00-molar Sn^{2+} connected by a salt bridge to a second compartment with a silver electrode in an acidic solution of 1.00-molar Ag^+.
(a) Write the equation for the half-cell reaction occurring at each electrode. Indicate which half-reaction occurs at the anode.
(b) Write the balanced chemical equation for the overall spontaneous cell reaction that occurs when the circuit is complete. Calculate the standard voltage, E°, for this cell reaction.
(c) Calculate the equilibrium constant for this cell reaction at 298 K.
(d) A cell similar to the one described above is constructed with solutions that have initial concentrations of 1.00 molar Sn^{2+} and 0.0200-molar Ag^+. Calculate the initial voltage, E, of this cell.

1989 - #2
The electrolysis of an aqueous solution of potassium iodide, KI, results in the formation of hydrogen gas at the cathode and iodine at the anode. A sample of 80.00 milliliters of a 0.150-molar solution of KI was electrolyzed for 3.00 minutes, using a constant current. At the end of this time, the I_2 produced was titrated against a 0.225-molar solution of sodium thiosulfate, which reacts with iodine according to the equation below. The end point of the titration was reached when 37.2 milliliters of the $Na_2S_2O_3$ solution had been added.

$$I_2 + 2\ S_2O_3^{2-} \rightarrow 2\ I^- + S_4O_6^{2-}$$

(a) How many moles of I_2 was produced during the electrolysis?
(b) The hydrogen gas produced at the cathode during the electrolysis was collected over water at 25 °C at a total pressure of 752 millimeters of mercury. Determine the volume of hydrogen collected. (The vapor pressure of water at 25 °C is 24 millimeters of mercury.)
(c) Write the equations for the half reaction that occurs at the anode during the electrolysis.
(d) Calculate the current used during the electrolysis.

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1991 - #7

Explain each of the following.

(a) When an aqueous solution of NaCl is electrolyzed, $Cl_2(g)$ is produced at the anode, but no Na(s) is produced at the cathode.

(b) The mass of Fe(s) produced when 1 faraday is used to reduce a solution of $FeSO_4$ is 1.5 times the mass of Fe(s) produced when 1 faraday is used to reduce a solution of $FeCl_3$.

$Zn + Pb^{2+}$ (1-molar) → Zn^{2+} (1-molar) + Pb

(c) The cell that utilized the reaction above has a higher potential when $[Zn^{2+}]$ is decreased and $[Pb^{2+}]$ held constant, but a lower potential when $[Pb^{2+}]$ is decreased and $[Zn^{2+}]$ is held constant.

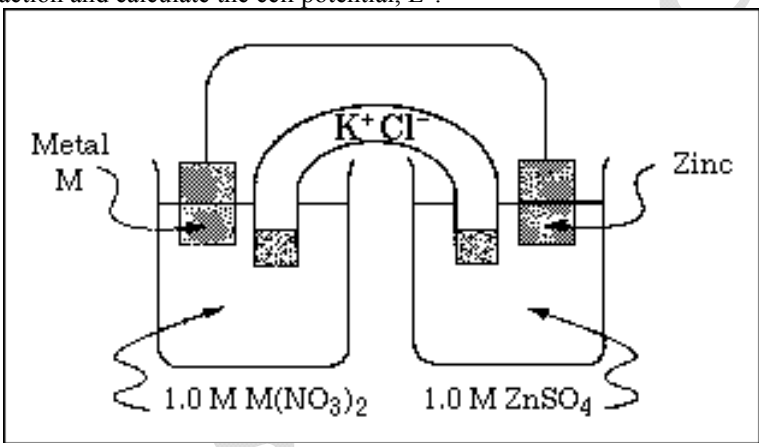
(d) The cell that utilizes the reaction given in (c) has the same cell potential as another cell in which $[Zn^{2+}]$ and $[Pb^{2+}]$ are each 0.1-molar.

1992 - #2

An unknown metal M forms a soluble compound $M(NO_3)_2$.

(a) A solution of $M(NO_3)_2$ is electrolyzed. When a constant current of 2.50 amperes is applied for 35.0 minutes, 3.06 grams of the metal M is deposited. Calculate the molar mass of M and identify the metal.

(b) The metal identified in (a) is used with zinc to construct a galvanic cell, as shown below. Write the net ionic equation for the cell reaction and calculate the cell potential, E°.



(c) Calculate the value of the standard free energy change, ΔG°, at 25 °C for the reaction in (b)

(d) Calculate the potential, E, for the cell shown in (b) if the initial concentration of $ZnSO_4$ is 0.10-molar, but the concentration of the $M(NO_3)_2$ solution remains unchanged.

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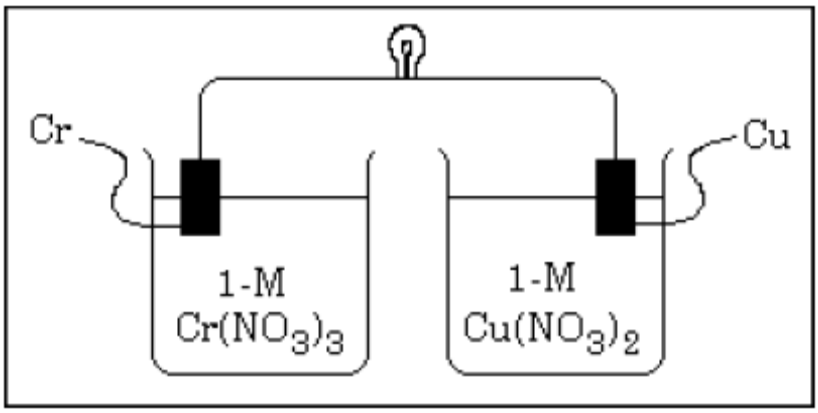
1993 – #7

A galvanic cell is constructed using a chromium electrode in a 1.00 molar solution of $Cr(NO_3)_3$ and a copper electrode in a 1.00 molar solution of $Cu(NO_3)_2$. Both solutions are at 25°C.

(a) Write a balanced net ionic equation for the spontaneous reaction that occurs as the cell operates. Identify the oxidizing agent and the reducing agent.

(b) A partial diagram of the cell is shown below.



(i) Which metal is the cathode?

(ii) What additional component is necessary to make the cell operate?

(iii) What function does the component in (ii) serve?

(c) How does the potential of this cell change if the concentration of $Cr(NO_3)_3$ is changed to 3.00 molar at 25 °C? Explain.

1996 - #7

$Sr(s) + Mg^{2+} <===> Sr^{2+} + Mg(s)$

Consider the reaction represented above that occurs at 25°C. All reactants and products are in their standard states. The value of the equilibrium constant, K_{eq}, for the reaction is 4.2×10^{17} at 25°C.

(a) Predict the sign of the standard cell potential, E°, for a cell based on the reaction. Explain your prediction.

(b) Identify the oxidizing agent for the spontaneous reaction.

(c) If the reaction were carried out at 60°C instead of 25°C, how would the cell potential change? Justify your answer.

(d) How would the cell potential change if the reaction were carried out at 25°C with a 1.0-molar solution of $Mg(NO_3)_2$ and a 0.10-molar solution of $Sr(NO_3)_2$? Explain.

(e) When the cell reaction in (d) reaches equilibrium, what is the cell potential?

1997 - #3

In an electrolytic cell, a current of 0.250 ampere is passed through a solution of a chloride of iron, producing Fe(s) and $Cl_2(g)$.

(a) Write the equation for the reaction that occurs at the anode.

(b) When the cell operates for 2.00 hours, 0.521 gram of iron is deposited at one electrode. Determine the formula of the chloride of iron in the original solution.

(c) Write the balanced equation for the overall reaction that occurs in the cell.

(d) How many liters of $Cl_2(g)$, measured at 25°C and 750 mmHg, are produced when the cell operates as described in part (b)?

(e) Calculate the current that would produce chlorine gas at a rate of 3.00 grams per hour.

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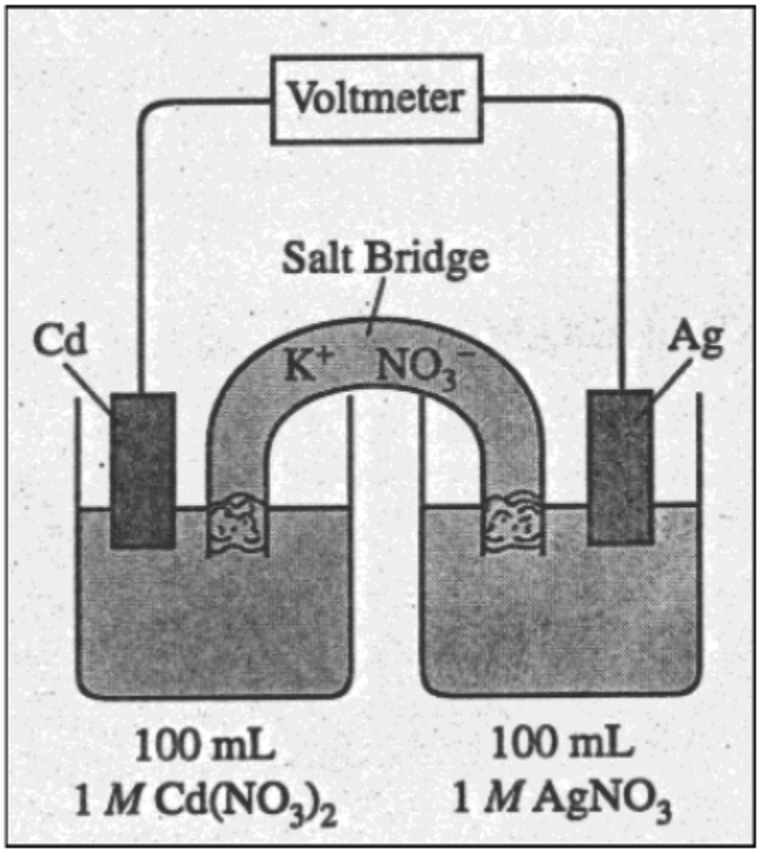
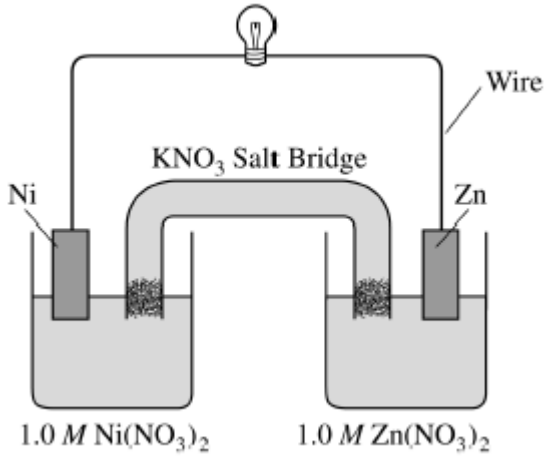
1998 - #8



Answer the following questions regarding the electrochemical cell shown above.
(a) Write the balanced net-ionic equation for the spontaneous reaction that occurs as the cell operates, and determine the cell voltage.
(b) In which direction do anions flow in the salt bridge as the cell operates? Justify your answer.
(c) If 10.0 mL of 3.0-molar $AgNO_3$ solution is added to the half-cell on the right, what will happen to the cell voltage? Explain.
(d) If 1.0 grams of solid NaCl is added to each half-cell, what will happen to the cell voltage? Explain.
(e) If 20.0 mL of distilled water is added to both half-cells, the cell voltage decreases. Explain.

2000 - #2
Answer the following questions that relate to electrochemical reactions.
(a) Under standard conditions at 25°C, Zn(*s*) reacts with $Co^{2+}(aq)$ 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, H_2O_2 decomposes according to the following equation.
$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)\ E° = 0.55$ V
(i) Determine the value of the standard free energy change, $\Delta G°$, 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 $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ 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.
$O_2(g) + 2H^+(aq) + 2\ e^- \rightarrow H_2O_2(aq)$
(c) In an electrolytic cell, Cu(*s*) is produced by the electrolysis of $CuSO_4(aq)$. 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* $CuSO_4(aq)$ for a period of 1.00 hour.

2001 - #7



Answer the following questions that refer to the galvanic cell shown in the diagram above. (Use the table of standard reduction potentials provided to you.)
(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 E_{cell} would be affected if the concentration of $Ni(NO_3)_2(aq)$ was changed from 1.0 *M* to 0.10 *M* and the concentration of $Zn(NO_3)_2(aq)$ remained at 1.0 *M*. Justify your answer.
(d) Specify whether the value of K_{eq} for the cell reaction is less than 1, greater than 1, or equal to 1. Justify your answer.

2002 - #2
Answer parts (a) through (e) below, which relate to reactions involving silver ion, Ag^+.
The reaction between silver ion and solid zinc is represented by the following equation.

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

(a) A 1.50 g sample of Zn is combined with 250. mL of 0.110 *M* $AgNO_3$ at 25°C.
(i) Identify the limiting reactant. Show calculations to support your answer.
(ii) On the basis of the limiting reactant that you identified in part (i), determine the value of $[Zn^{2+}]$ after the reaction is complete. Assume that volume change is negligible.
(b) Determine the value of the standard potential, $E°$ for a galvanic cell based on the reaction between $AgNO_3(aq)$ and solid Zn at 25°C.

Another galvanic cell is based on the reaction between $Ag^+(aq)$ and $Cu(s)$, represented by the equation below.
At 25°C, the standard potential, E_{cell} , for the cell is 0.46 V.

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

(c) Determine the value of the standard free-energy change, $\Delta G°$, for the reaction between $Ag^+(aq)$ and $Cu(s)$ at 25°C.
(d) The cell is constructed so that $[Cu^{2+}]$ is 0.045 *M* and $[Ag^+]$ is 0.010 *M*. Calculate the value of the potential, *E* for the cell.
(e) Under the conditions specified in part (d), is the reaction in the cell spontaneous? Justify your answer.

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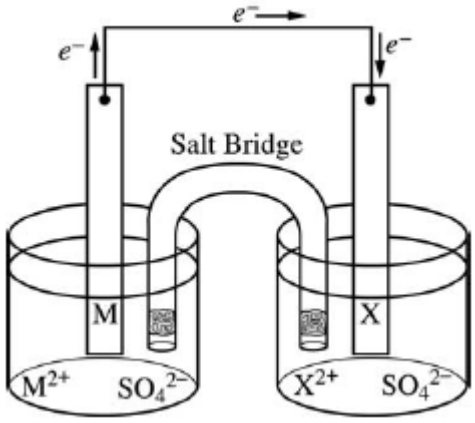
2002B - #7

The diagram below shows the experimental setup for a typical electrochemical cell that contains two standard half-cells. The cell operates according to the reaction represented by the following equation.

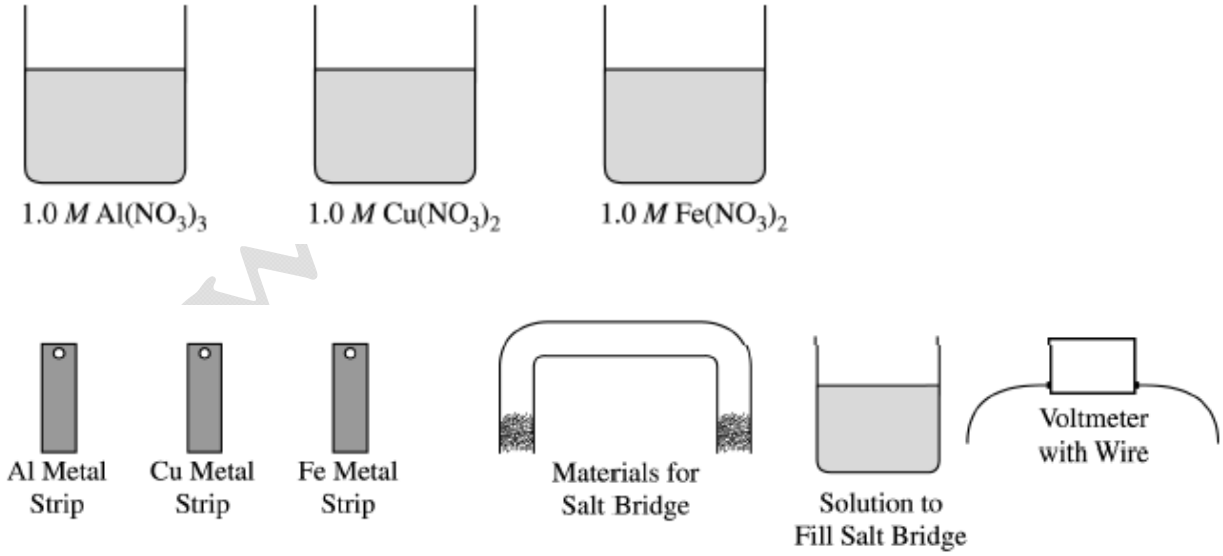
$$Zn(s) + Ni^{2+}(aq) \rightarrow Ni(s) + Zn^{2+}(aq)$$



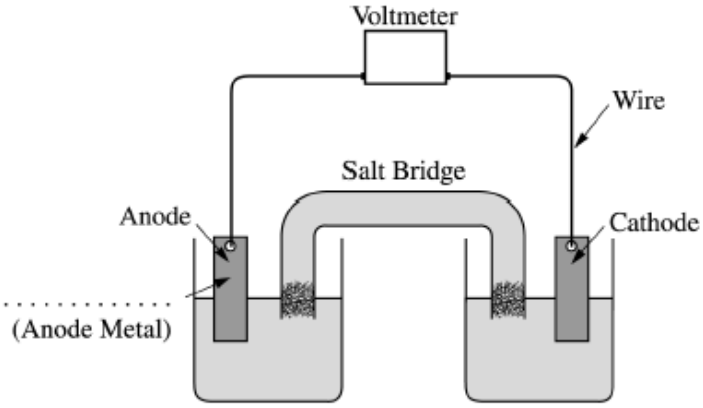
(a) Identify M and M^{2+} in the diagram and specify the initial concentration for M^{2+} in solution.
(b) Indicate which of the metal electrodes is the cathode. Write the balanced equation for the reaction that occurs in the half-cell containing the cathode.
(c) What would be the effect on the cell voltage if the concentration of Zn^{2+} was reduced to 0.100 *M* in the half-cell containing the Zn electrode?
(d) Describe what would happen to the cell voltage if the salt bridge was removed. Explain.

2003B - #6

Answer the following questions about electrochemistry.
(a) Several different electrochemical cells can be constructed using the materials shown below. Write the balanced net-ionic equation for the reaction that occurs in the cell that would have the greatest positive value of E_{cell}^{o}.



(b) Calculate the standard cell potential, E_{cell}^{o}, for the reaction written in part (a).
(c) A cell is constructed based on the reaction in part (a) above. Label the metal used for the anode on the cell shown in the figure below.

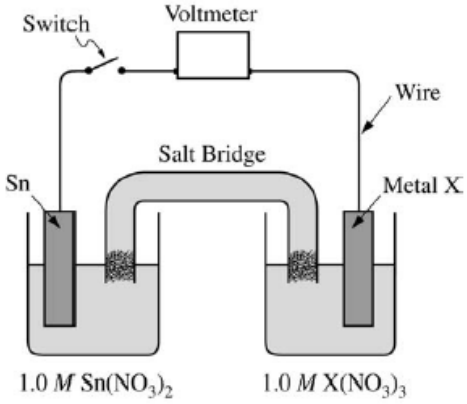


(d) Of the compounds NaOH, CuS, and $NaNO_3$, which one is appropriate to use in a salt bridge? Briefly explain your answer, and for each of the other compounds, include a reason why it is not appropriate.
(e) Another standard cell is based on the following reaction.

$Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$

If the concentration of Zn^{2+} is decreased from 1.0 *M* to 0.25 *M,* what effect does this have on the cell potential? Justify your answer.

2004 - #6



An electrochemical cell is constructed with an open switch, as shown in the diagram above. A strip of Sn and a strip of an unknown metal, X, are used as electrodes. When the switch is closed, the mass of the Sn electrode increases. The half-reactions are shown below.

$Sn^{2+}(aq) + 2\ e^- \rightarrow Sn(s)$ $\quad E° = -0.14$ V
$X^{3+}(aq) + 3\ e^- \rightarrow X(s)$ $\quad E° = ?$

(a) In the diagram above, label the electrode that is the cathode. Justify your answer.
(b) In the diagram above, draw an arrow indicating the direction of the electron flow in the external circuit when the switch is closed.
(c) If the standard cell potential, E_{cell}, is +0.60 V, what is the standard reduction potential, in volts, for the X^{3+}/X electrode?
(d) Identify metal X.
(e) Write a balanced net-ionic equation for the overall chemical reaction occurring in the cell.
(f) In the cell, the concentration of Sn^{2+} is changed from 1.0 *M* to 0.50 *M*, and the concentration of X^{3+} is changed from 1.0 *M* to 0.10 *M*.

(i) Substitute all the appropriate values for determining the cell potential, E_{cell}, into the Nernst equation. (Do not do any calculations.)
(ii) On the basis of your response in part (f) (i), will the cell potential, E_{cell}, be greater than, less than, or equal to the original E_{cell}? Justify your answer.

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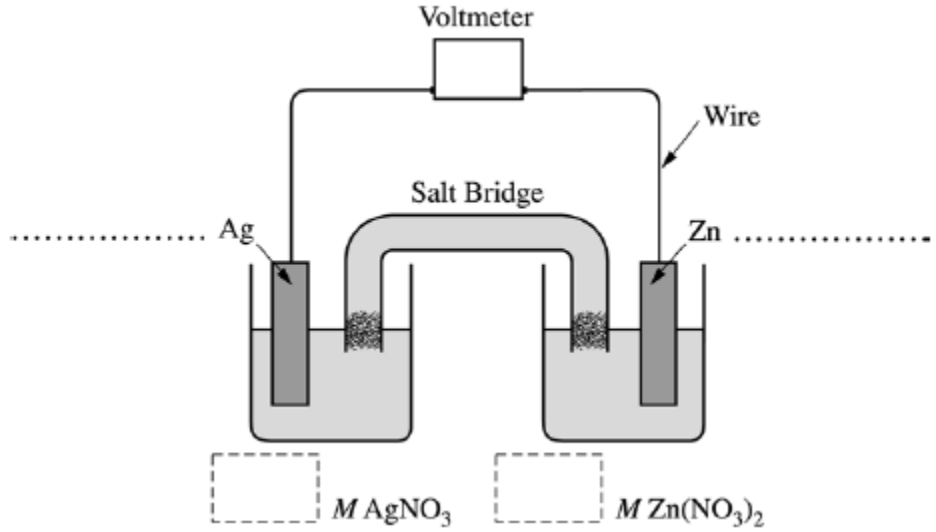
2004B - #6



The following questions refer to the electrochemical cell shown in the diagram above.
(a) Write a balanced net ionic equation for the spontaneous reaction that takes place in the cell.
(b) Calculate the standard cell potential, $E°$, for the reaction in part (a).
(c) In the diagram above,
(i) label the anode and the cathode on the dotted lines provided, and
(ii) indicate in the boxes below the half-cells, the concentration of $AgNO_3$ and the concentration of $Zn(NO_3)_2$ that are needed to generate $E°$.
(d) How will the cell potential be affected if KI is added to the silver half-cell? Justify your answer.

2005 – #8d

The compound NaI dissolves in pure water according to the equation $NaI(s) \rightarrow Na^+(aq) + I^-(aq)$. Some of the information in the table of standard reduction potentials given below may be useful in answering the questions that follow.

Half-reaction E°	(V)
$O_2(g) + 4H^+ + 4\ e^- \rightarrow 2\ H_2O(l)$	1.23
$I_2(s) + 2\ e^- \rightarrow 2\ I^-$	0.53
$2H_2O(l) + 2\ e^- \rightarrow H_2(g) + 2OH^-$	−0.83
$Na^+ + e^- \rightarrow Na(s)$	−2.71

(d) An electric current is applied to a 1.0 M NaI solution.
(i) Write the balanced oxidation half-reaction for the reaction that takes place.
(ii) Write the balanced reduction half-reaction for the reaction that takes place.
(iii) Which reaction takes place at the anode, the oxidation reaction or the reduction reaction?
(iv) All electrolysis reactions have the same sign for $\Delta G°$. Is the sign positive or negative? Justify your answer.

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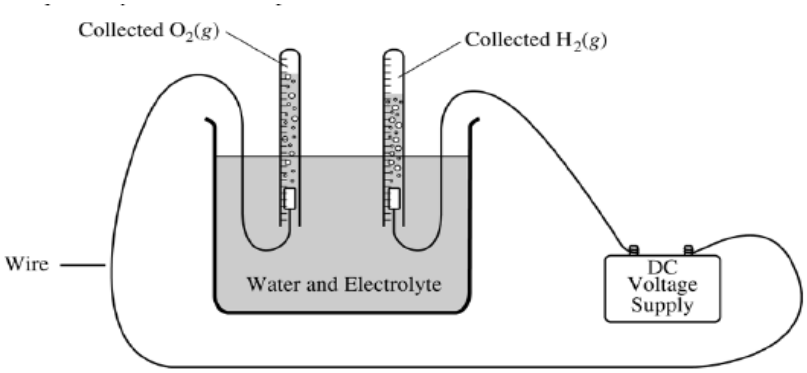
2005B - #2



Water was electrolyzed, as shown in the diagram to the right, for 5.61 minutes using a constant current of 0.513 ampere. A small amount of non-reactive electrolyte was added to the container before the electrolysis began. The temperature was 298 K and the atmospheric pressure was 1.00 atm.

(a) Write the balanced equation for the half reaction that took place at the anode.

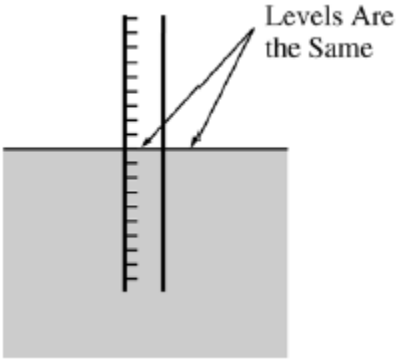
(b) Calculate the amount of electric charge, in coulombs, that passed through the solution.

(c) Why is the volume of $O_2(g)$ collected different from the volume of $H_2(g)$ collected, as shown in the diagram?

(d) Calculate the number of moles of $H_2(g)$ produced during the electrolysis.

(e) Calculate the volume, in liters, at 298 K and 1.00 atm of dry $H_2(g)$ produced during the electrolysis.

(f) After the hydrolysis reaction was over, the vertical position of the tube containing the collected $H_2(g)$ was adjusted until the water levels inside and outside the tube were the same, as shown in the diagram below. The volume of gas in the tube was measured under these conditions of 298 K and 1.00 atm, and its volume was greater than the volume calculated in part (e). Explain.



2006B - #2

Answer the following questions about voltaic cells.

(a) A voltaic cell is set up using Al /Al^{3+} as one half-cell and Sn /Sn^{2+} as the other half-cell. The half-cells contain equal volumes of solutions and are at standard conditions.

(i) Write the balanced net-ionic equation for the spontaneous cell reaction.

(ii) Determine the value, in volts, of the standard potential, $E°$, for the spontaneous cell reaction.

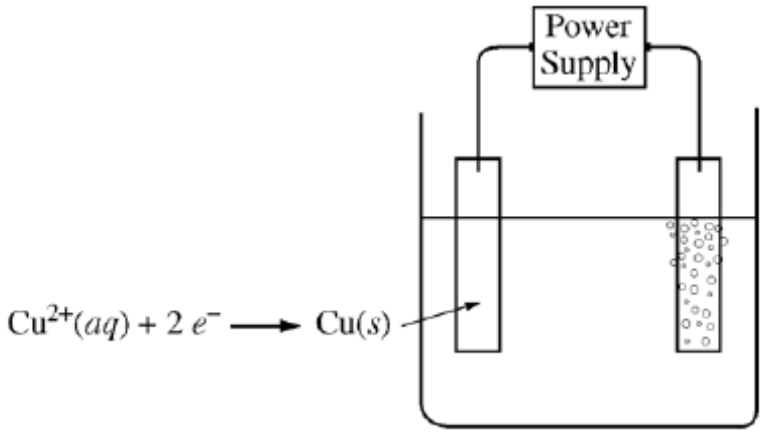
(iii) Calculate the value of the standard free-energy change, $\Delta G°$, for the spontaneous cell reaction. Include units with your answer.

(iv) If the cell operates until [Al^{3+}] is 1.08 *M* in the Al /Al^{3+} half-cell, what is [Sn^{2+}] in the Sn /Sn^{2+} half-cell?

(b) In another voltaic cell with Al /Al^{3+} and Sn /Sn^{2+} half-cells, [Sn^{2+}] is 0.010 *M* and [Al^{3+}] is 1.00 *M*. Calculate the value, in volts, of the cell potential, E_{cell} , at 25°C.

2007 #3

An external direct-current power supply is connected to two platinum electrodes immersed in a beaker containing 1.0 *M* $CuSO_4(aq)$ at 25°C, as shown in the diagram above. As the cell operates, copper metal is deposited onto one electrode and $O_2(g)$ is produced at the other electrode. The two reduction half-reactions for the overall reaction that occurs in the cell are shown in the table below.



Half-Reaction	$E°$(V)
$O_2(g) + 4\ H^+(aq) + 4\ e^- \rightarrow 2\ H_2O(l)$	+1.23
$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$	+0.34

(a) On the diagram, indicate the direction of electron flow in the wire.
(b) Write a balanced net ionic equation for the electrolysis reaction that occurs in the cell.
(c) Predict the algebraic sign of $\Delta G°$ for the reaction. Justify your prediction.
(d) Calculate the value of $\Delta G°$ for the reaction.
An electric current of 1.50 amps passes through the cell for 40.0 minutes.
(e) Calculate the mass, in grams, of the Cu(*s*) that is deposited on the electrode.
(f) Calculate the dry volume, in liters measured at 25°C and 1.16 atm, of the $O_2(g)$ that is produced.

2007B - #3

$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$$

In a hydrogen-oxygen fuel cell, energy is produced by the overall reaction represented above.
(a) When the fuel cell operates at 25°C and 1.00 atm for 78.0 minutes, 0.0746 mol of $O_2(g)$ is consumed. Calculate the volume of $H_2(g)$ consumed during the same time period. Express your answer in liters measured at 25°C and 1.00 atm.
(b) Given that the fuel cell reaction takes place in an acidic medium,
(i) write the two half reactions that occur as the cell operates,
(ii) identify the half reaction that takes place at the cathode, and
(iii) determine the value of the standard potential, $E°$, of the cell.
(c) Calculate the charge, in coulombs, that passes through the cell during the 78.0 minutes of operation as described in part (a).

2008 - #3a-c

Answer the following questions related to chemical reactions involving nitrogen monoxide, NO(g).
The reaction between solid copper and nitric acid to form copper(II) ion, nitrogen monoxide gas, and water is represented by the following equation.

$$3\ Cu(s) + 2\ NO_3^-(aq) + 8\ H^+(aq) \rightarrow 3\ Cu^{2+}(aq) + 2\ NO(g) + 4\ H_2O(l) \quad E° = +0.62\ V$$

(a) Using the information above and in the table below, calculate the standard reduction potential, E °, for the reduction of NO_3^- in acidic solution.

Half-Reaction	Standard Reduction Potential, E °
$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$	+0.34 V
$NO_3^-(aq) + 4\ H^+(aq) + 3\ e^- \rightarrow NO(g) + 2\ H_2O(l)$	?

(b) Calculate the value of the standard free energy change, ΔG °, for the overall reaction between solid copper and nitric acid.
(c) Predict whether the value of the standard entropy change, ΔS °, for the overall reaction is greater than 0, less than 0, or equal to 0. Justify your prediction.

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