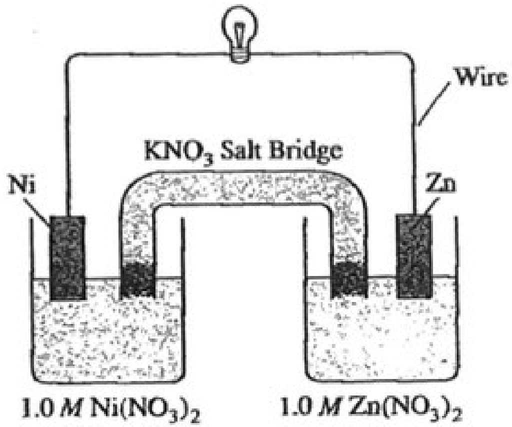
Answer EITHER Question 7 below OR Question 8 printed on page 13. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.



7. Answer the following questions that refer to the galvanic cell shown in the diagram above. (A table of standard reduction potentials is printed on the green insert and on page 4 of the booklet with the pink cover.)

(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.

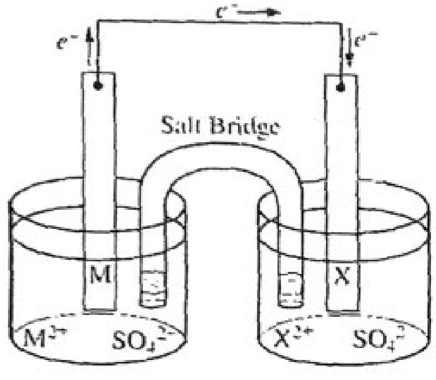
(d) Specify whether the value of K_{eq} for the cell reaction is less than 1, greater than 1, or equal to 1. Justify your answer.

GO ON TO THE NEXT PAGE.

Answer EITHER Question 7 below OR Question 8 printed on page 13. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.

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.

3.

Answer EITHER Question 2 below OR Question 3 printed on page 8. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 20 percent.

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, $E°$, 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.

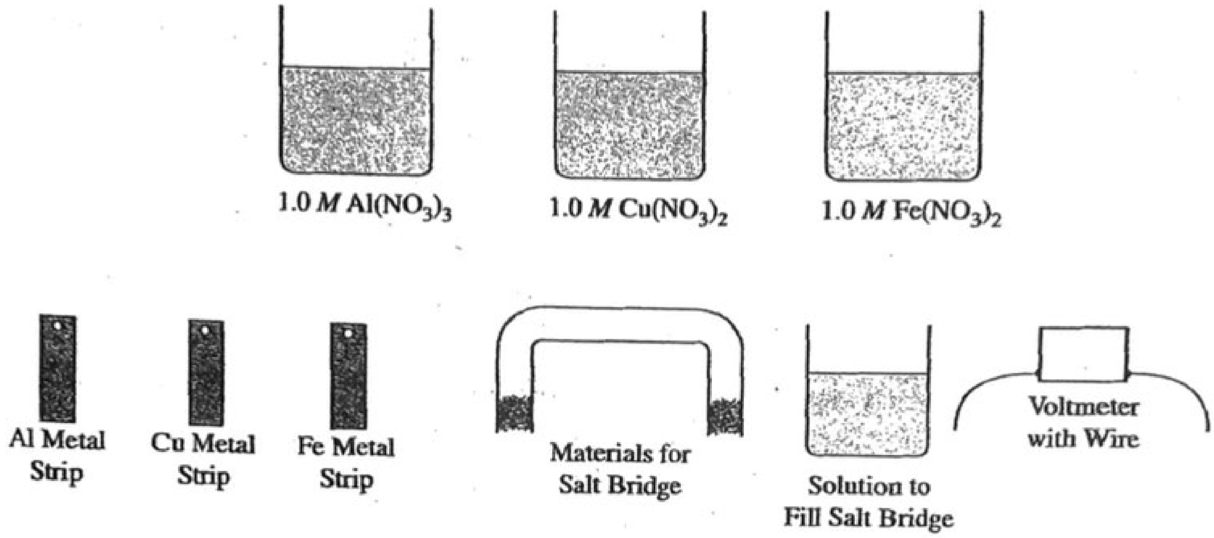
(e) Under the conditions specified in part (d), is the reaction in the cell spontaneous? Justify your answer.

GO ON TO THE NEXT PAGE.

4.

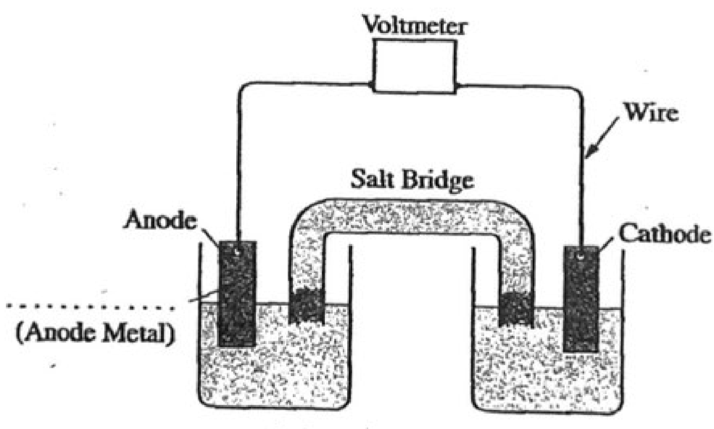
6. Answer the following questions about electrochemistry.

(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}.



(b) Calculate the standard cell potential, E°_{cell}, 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.



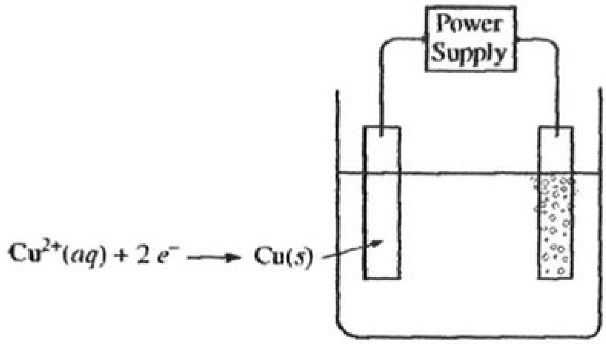
(d) Of the compounds NaOH, CuS, and $NaNO_3$, which one is appropriate to use in a salt bridge? Briefly explain your answer, and for each of the other compounds, include a reason why it is not appropriate.

(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.

5.



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)
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+1.23
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+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.

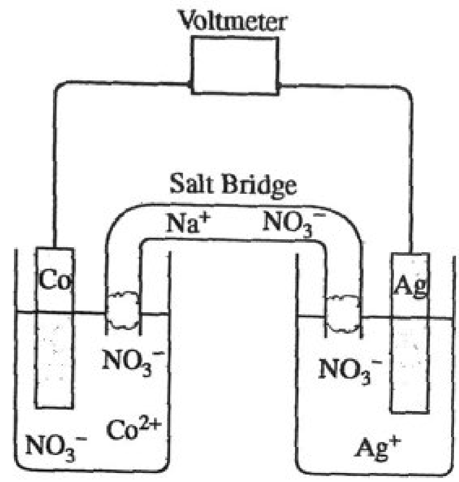
(f) Calculate the dry volume, in liters measured at 25°C and 1.16 atm, of the $O_2(g)$ that is produced.

STOP

If you finish before time is called, you may check your work on this part only.
Do not turn to the other part of the test until you are told to do so.

Answer Question 5 and Question 6. The Section II score weighting for these questions is 15 percent each.

Your responses to these questions will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.



1.00 *M* $Co(NO_3)_2$ 1.00 *M* $AgNO_3$

5. Answer the following questions relating to the galvanic cell shown in the diagram above.

(a) Write the balanced equation for the overall cell reaction.

(b) Calculate the value of $E°$ for the cell.

(c) Is the value of $\Delta G°$ for the overall cell reaction positive, negative, or 0 ? Justify your answer.

(d) Consider the cell as it is operating.

(i) Does E_{cell} increase, decrease, or remain the same? Explain.

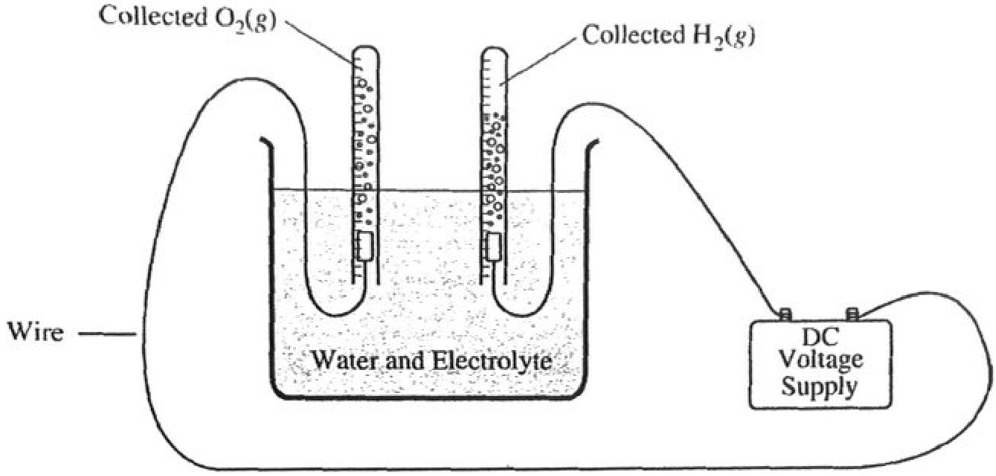
(ii) Does ΔG of the overall cell reaction increase, decrease, or remain the same? Explain.

(iii) What would happen if the $NaNO_3$ solution in the salt bridge was replaced with distilled water? Explain.

(e) After a certain amount of time, the mass of the Ag electrode changes by *x* grams. Given that the molar mass of Ag is 108 g mol^{-1} and the molar mass of Co is 59 g mol^{-1}, write the expression for the change in the mass of the Co electrode in terms of *x*.

GO ON TO THE NEXT PAGE

Answer EITHER Question 2 below OR Question 3 printed on pages 8 and 9. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 20 percent.



2. Water was electrolyzed, as shown in the diagram above, for 5.61 minutes using a constant current of 0.513 ampere. A small amount of nonreactive 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.

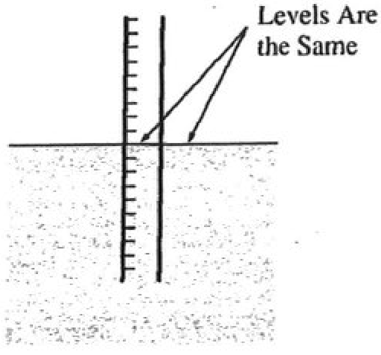
(b) Calculate the amount of electric charge, in coulombs, that passed through the solution.

(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.



37. Chlorine dioxide (ClO_2), which is produced by the reaction

$$2NaClO_2(aq) + Cl_2(g) \longrightarrow 2ClO_2(g) + 2NaCl(aq)$$

has been tested as a disinfectant for municipal water treatment. Using data from Table 17.1, calculate $\mathscr{E}°$ and $\Delta G°$ at 25°C for the production of ClO_2.

$ClO_2 + e^- \rightarrow ClO_2^-$ $\mathscr{E}° = .954V$

$Cl_2 + 2e^- \rightarrow 2Cl^-$ $\mathscr{E}° = 1.36V$

51. A galvanic cell is based on the following half-reactions at 25°C:

$$Ag^+ + e^- \longrightarrow Ag$$

$$H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$$

Predict whether $\mathscr{E}_{cell}$ is larger or smaller than $\mathscr{E}°_{cell}$ for the following cases.

a. $[Ag^+] = 1.0\ M, [H_2O_2] = 2.0\ M, [H^+] = 2.0\ M$

b. $[Ag^+] = 2.0\ M, [H_2O_2] = 1.0\ M, [H^+] = 1.0 \times 10^{-7}\ M$

71. Consider the galvanic cell based on the following half-reactions:

$$Au^{3+} + 3e^- \longrightarrow Au \quad \mathscr{E}° = 1.50\ V$$

$$Tl^+ + e^- \longrightarrow Tl \quad \mathscr{E}° = -0.34\ V$$

a. Determine the overall cell reaction and calculate $\mathscr{E}°_{cell}$.

b. Calculate $\Delta G°$ and K for the cell reaction at 25°C.

c. Calculate $\mathscr{E}_{cell}$ at 25°C when $[Au^{3+}] = 1.0 \times 10^{-2}\ M$ and $[Tl^+] = 1.0 \times 10^{-4}\ M$.