Set 4. Exercises and Problems

Multiple Choice Questions

1. $MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$ E=+1.51V

   $Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$ E=+1.60V

   Given the listed standard electrode potentials above, what is the E^0 for the cell below, in volts:

   $Mn^{2+}(aq) + 5Ce^{4+}(aq) + 4H_2O(l) \rightarrow MnO_4^-(aq) + 5Ce^{3+}(aq) + 8H^+(aq)$?

   (a) +3.12 (b) +2.16 (c) +0.50 (d) +1.21 (e) +0.09

2. $N_2(g) + 5H^+(aq) + 4e^- \rightarrow N_2H_5^+(aq)$ $E^o = -0.23V$

   $BiO^+(aq) + 2H^+(aq) + 3e^- \rightarrow Bi(s) + H_2O(l)$ $E^o = +0.32V$

   Given the listed standard electrode potentials above, what is the E^o for the cell below.

   $4BiO^+(aq) + 3N_2H^{5+}(aq) \rightarrow 4Bi(s) + 3N_2(g) + 4H_2O(l) + 7H^+(aq)$?

   (a) +1.88V (b) +0.34 (c) -0.09 (d) +0.09 (e) +0.55

3. Based on the cell notation for a spontaneous reaction, the reaction at the anode is:

   $Mg(s)/Mg^{2+}(aq)//Sn^{2+}(aq)/Sn(s)$

   (a) Mg is oxidised (b) Sn^{2+} is oxidised

   (c) Mg^{2+} is reduced (d) Sn is reduced

4. Based on the cell notation for a spontaneous reaction,

   $Mg(s)/Mg^{2+}(aq)//H^+(aq)/H_2(g)/Pt$

   (a) Electrons flow in the external circuit toward the platinum electrode

   (b) H_2 is oxidised

   (c) Mg is the anode

   (d) Mg^{2+} is reduced

   (e) None of the above is correct

5. $I_2(s) + 2e^- \rightarrow 2I^-(aq)$ $E^o = +0.536$ V

   $Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$ $E^o = +1.36$ V

   From the listed standard electrode potentials above, what would be the E^o for the cell:

   $I^-/I_2//Cl_2/Cl^-$?

   (a) +0.948 (b) -0.824 (c) +1.896 (d) +0.824 (e) -1.896

6. $Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$ $E^o = -0.74$ V

$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$ $E^o = -0.44$ V

From the listed standard electrode potentials above, what is the E^o for the cell:

$Cr(s)/Cr^{3+}(aq)\ //\ Cd^{2+}(aq)/Cd(s)$?

(a) +1.80 (b) -1.18 (c) + 1.34 (d) +0.30 (e) -0.16

7. In a copper/zinc electrochemical cell, which uses copper sulfate and zinc sulfate electrolytes (the copper half cell is called Y and the zinc half cell is X) which of the following can be used as the solution in the salt bridge?

1) 1 mol L^{-1} NaCl 2) 1 mol L^{-1} KNO_3 3) 1 mol L^{-1} Na_2SO_4

(a) 1 only (b) 2 only (c) 3 only (d) 1 and 2 only (e) all three

8. In the cell referred to in question 7, cell X is zinc sulfate solution and cell Y is copper (II) sulfate solution. In this cell, what is the function of the salt bridge?

(a) To complete the circuit by allowing electrons to move from cell Y to cell X.

(b) To complete circuit by allowing ions to move between the two solutions.

(c) To complete the circuit by allowing electrons to move from cell X to cell Y.

(d) To complete the circuit by allowing electric current to flow from cell Y to cell X.

(e) To complete the circuit by allowing electric current to flow from cell X to cell Y.

9. Referring to the cell indicated in question 7, what happens when the zinc rod and zinc sulfate in cell X are replaced by magnesium rod and magnesium sulfate?

(a) A lamp connected to the external circuit will go out.

(b) A lamp connected to the external circuit will become brighter.

(c) A lamp connected to the external circuit will become dimmer.

(d) The cell gives smaller emf.

(e) The current flow reverses its direction.

10. Two clean metal foils are connected by means of wires to a small lamp and then dipped into dilute sulfuric acid as shown.

Which of the following metals in dilute sulfuric acid makes the lamp brightest?

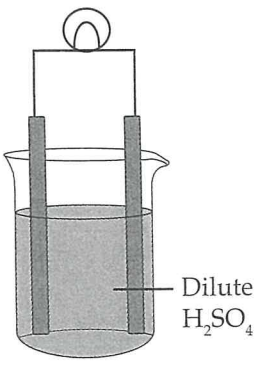
(a) magnesium/zinc.

(b) magnesium/copper.

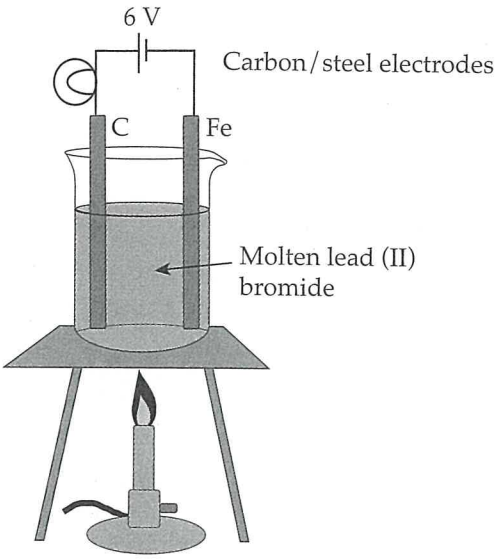
(c) zinc/copper.

(d) silver/copper.

(e) copper/copper.



Questions 11, 12 and 13 are based on the sketch of the circuit shown below



11. The lead (II) bromide in the beaker is kept molten by using the Bunsen flame. During the experiment, which of the following can be observed?

    1) The lamp lights up.

    2) Reddish brown fumes are evolved near the carbon electrode.

    3) A silvery solid is coated on steel electrode.

    (a) 1 only (b) 2 only (c) 3 only (d) 2 and 3 only (e) 1, 2 and 3.

12. The experiment should be performed in a fume cupboard because:

    (a) the reaction takes place at high temperatures.

    (b) poisonous bromine vapours are evolved.

    (c) carbon electrode reacts with the cations.

    (d) steel electrode reacts with the cations.

    (e) molten lead (II) bromide evaporates to give poisonous vapours.

13. The molten compound lead (II) bromide conducts electricity because:

    (a) molten lead (II) bromide contains delocalised electrons.

    (b) lead is a metal which conducts.

    (c) lead (II) bromide is very unstable.

    (d) bromine is ionic.

    (e) The liquid contains ions.

Longer Questions

1. Study the Standard Reduction Potentials on the Data Sheet and answer the following questions:

   (a) Which species is the strongest oxidant?

   _____

   (b) Which species is the strongest reductant?

   _____

   (c) Which species is weakest reductant?

   _____

   (d) Which species is the weakest oxidant?

   _____

   (e) What is the cell emf of the galvanic reaction, $Zn/Zn^{2+}//Fe^{2+}/Fe$?

   _____

   (f) Identify a reaction that has a galvanic voltage of 1.14 V. (There could be several)

   _____

   (g) Identify a galvanic cell reaction which occurs in the rusting of iron in moist air.

   _____

2. Will a reaction occur in the following cases? Justify your answer.

   (a) Water and calcium metal

   _____

   _____

   (b) Aqueous acidified solution of potassium permanganate and tin (II) nitrate

   _____

   _____

   (c) Potassium metal and an aqueous solution of sodium nitrate

   _____

   _____

3. Using the Standard Reduction Potential, predict the theoretical emf for the following reactions:

   (a) $Ni / Ni^{2+} // Ag^{+} / Ag$

   _____

   _____

   (b) $Cr^{3+}/Cr_2O_7^{2-}//H_2O_2/H^{+}/H_2O$

   _____

   _____

(c) $Zn/Zn^{2+}//Ni^{2+}/Ni$

4. Standard electrode potentials for the following two metals are given below:

$Cu^{2+} + 2e^- \rightarrow Cu$ $E^0 = 0.34V$ $Zn^{2+} + 2e^- \rightarrow Zn$ $E^o = -0.76$ V

(a) Why is the copper reaction assigned a positive potential?

(b) Why is zinc reaction assigned a negative potential?

(c) For a galvanic cell using the above reactions, what will be the cell potential?

(d) Which one will be the oxidant?

(e) If the half-reaction $Zn^{2+} \rightarrow Zn$ is assigned an arbitrary value of 0 V, what will be the electrode potential for the half reaction with copper?

(f) What will be the new cell potential for the Cu^{2+}/Zn cell?

5. Assuming that the electrode potential for the half-reaction $K^+(aq) + e^- \rightarrow K(s)$ is assigned a E^0 value of 0.00V, how will the electrode potential values assigned to all the other half-reactions change?

6. Note the following information:

$AuBr_4^-(aq) + 3e^- \rightarrow Au(s) + 4Br^-(aq)$	$E^0 = -0.858$ V
$Eu^{3+}(aq) + e^- \rightarrow Eu^{2+}(aq)$	$E^0 = -0.43$ V
$IO^-(aq) + H_2O(l) + 2e^- \rightarrow I^-(aq) + 2OH^-(aq)$	$E^0 = 0.49$
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	$E^0 = -0.14$ V

(a) Write the cell reaction that would give the largest cell emf.

(b) Write the cell reaction that would give the smallest cell emf.

7. A galvanic cell that uses the reaction, $Fe^{2+}(aq) + Mg \rightarrow Fe + Mg^{2+}(aq)$ has a cell emf of 1.93 V under standard conditions.

   (a) What is meant by "under standard conditions"?

   _____

   _____

   _____

   (b) What are the E^{o} values for each of the two half reactions?

   _____

   _____

   _____

8. (a) Arrange the following species in order of increasing strength as oxidants:

   $Cr_2O_7^{2-}$, H_2O_2, Cu^{2+}, Cl_2, O_2

   _____

   (b) Arrange the following species in order of increasing strength as reducing agents:

   Zn, I^-, Sn^{2+}, H_2O_2, Al

   _____

9. Indicate which of the following reactions are spontaneous under standard conditions:

   (a) $H_2S(aq) + Cl_2(aq) \rightarrow S(s) + 2Cl^-(aq) + 2H^+(aq)$

   _____

   (b) $5H_2O_2(l) + Cl_2(aq) \rightarrow 4H_2O(l) + 2H^+(aq) + 2ClO_3^-(aq)$

   _____

   (c) $2Cl^-(aq) + Cu^{2+}(aq) \rightarrow Cu(s) + Cl_2(g)$

   _____

   (d) $10NO_3^-(aq) + 3I_2(s) + 4H^+(aq) \rightarrow 10NO(g) + 6IO_3^-(aq) + 2H_2O(l)$

   _____

10. The net cell reaction in a galvanic cell is $Sn(s) + Br_2(aq) \rightarrow Sn^{2+}(aq) + 2Br^-(aq)$

    What is the effect on the cell emf of each of the following changes?

    (a) The anode surface area is doubled?

    _____

    (b) The platinum electrode is replaced by a graphite electrode?

    _____

    (c) Tin (II) sulfate salt is dissolved in the anode half-cell?

    _____

    (d) Sodium bromide solution is added to the cathode half-cell?

    _____

11. In writing the notation for an electrochemical cell, what do the following mean:

(a) An oblique line

_____

(b) The formula of a substance in parentheses

_____

(c) A double oblique line

_____

12. Using the Standard Reduction Potential Table, identify an oxidising agent which will, under standard conditions, oxidise:

(a) I^- to I_2, but not Cl^- to Cl_2

_____

(b) $Fe_{(s)}$ to Fe^{2+}, but not $Pb_{(s)}$ to Pb^{2+}

_____

(c) $Zn_{(s)}$ to Zn^{2+}, but not $Cd_{(s)}$ to Cd^{2+}

_____

13. Use sketches to show the experimental arrangement by which the following galvanic half cells could be coupled together to produce a potential difference. Label the parts. Give the standard cell potentials for each of the cells.

(a) $Sn/Sn^{2+}//Ag^+/Ag$

(b) $Cl_2/Cl^-(Pt)//I^-/I_2(Pt)$

(c) $Fe/Fe^{2+}//Sn^{4+}/Sn^{2+}(Pt)$

14. Two common galvanic cells are the rechargeable nickel oxide-cadmium alkaline cell and the silver oxide-zinc button alkaline cell. Identify the anode and cathode reactions in the cells mentioned.

(a) $2NiO(OH)_{(s)} + Cd_{(s)} + 2H_2O_{(l)} \rightarrow Cd(OH)_{2(s)} + 2Ni(OH)_2$

(b) $Ag_2O_{(s)} + Zn_{(s)} + H_2O_{(l)} \rightarrow 2Ag_{(s)} + Zn(OH)_{2(s)}$

15. A cell is represented by $Fe_{(s)}/Fe^{2+}_{(aq)}//H^+_{(aq)}/H_{2(g)}(Pt)$

(a) Identify the anode and write the anode half equation.

(b) Identify the cathode and write the cathode half equation.

(c) Draw a diagram to show the design of the galvanic cell below. Label the parts including all the chemicals and the direction of flow of electrons and ions.

16. A galvanic cell is represented by the equation: (Pt) $Fe^{2+}_{(aq)}/Fe^{3+}_{(aq)}//Br_{2(aq)}/Br^-_{(aq)}$ (Pt).

(a) What is the anode half-reaction?

(b) What is the cathode half-reaction?

(c) Which electrode is to be labelled positive? Why?

(d) Which electrode is to be labelled negative? Why?

(e) What is the direction of the flow of bromide ions?

(f) What is the direction of the flow of electrons?

(g) What is the cell emf?

(h) If you place a mixture of $Fe(NO_3)_2$ solution and bromine water in a container, will a reaction occur? How will you know?

17. (a) Explain why hydrochloric acid reacts with zinc but not with copper:

(b) Why is it necessary to regularly check the density of the electrolyte in the car battery?

18. (a) Why are $NaNO_3$ or KNO_3 or NH_4NO_3 commonly used in salt bridges but not NaCl?

(b) What is the purpose of a salt bridge in an electrochemical cell?

(c) Why is sodium chloride unsuitable for a salt bridge for a cell which uses zinc and silver electrodes?

19. Ethanol and methane are fuels suitable for fuel cells.

Fuel cells can operate either in an acidic environment or in an alkaline environment.

(a) Derive the anode and cathode reactions in a fuel cell which uses ethanol in an acidic environment?

(b) What are the anode and cathode reactions in a fuel cell which uses methane in an acidic environment?

20. Electrolysis is used to purify impure copper, either from blister copper extracted from copper ore, or from scrap metal that contains copper.

(a) Draw a labelled diagram of an electrolytic cell used for purifying copper.

(b) Give the anode and cathode half equations for the purification of copper in the above cell.

Anode:

Cathode:

(c) Impure copper may contain reactive metal impurities such as zinc, iron and nickel, which are below copper on the standard reduction potential table. To prevent these impurities frombeing reduced at the cathode a small voltage is used in the electrolytic cell. Using iron as an example explain why a small voltage is used. Include equations and E^{o}s in your answer.

(d) Impurities like gold, silver and platinum may also be present in impure copper. What happens to these impurities during the purification of the copper?