ELECTROCHEMISTRY – Sample Midterm Questions

Voltaic Cells

1 Balance using the half-reaction method. Identify the oxidizing and reducing agents.

a) $H_5IO_6 + I^- \rightarrow I_2$ (acidic solution) b) $H_2S + CrO_4^{2-} \rightarrow Cr^{3+} + S_8$ (acidic solution)
c) $Cr(OH)_3 + BrO^- \rightarrow CrO_4^{2-} + Br^-$(basic solution) d) $MnO_4^- + N_2H_4 \rightarrow MnO_2 + N_2$ (basic solution)

2. For each of the following cells write the anode, cathode and overall cell reaction and calculate the standard cell voltage. a) $Pt/Fe(CN)_6^{3-}$, $Fe(CN)_6^{4-}$ // Mg^{2+}/Mg b) $Pt / Cl_2 / KCl // Hg_2Cl_2 / Hg/Pt$

3. For the voltaic cell Zn/Zn^{2+} // In^{3+}/In, the standard cell voltage is 0.420 V. Using the standard potential for the zinc couple, calculate the standard potential for the In^{3+}/In couple.

4. a) Arrange the following species in order of decreasing strength as reducing agents at standard conditions:
Cr^{3+}, Cu, Mg, H_2, Br^-, Fe^{2+}

b) Arrange the following in order of decreasing strength as oxidizing agents at standard conditions:
Cl_2, Fe^{2+}, Zn^{2+}, I_2, Pb^{2+}, AgCl

5. Which of the following reagents will oxidize Br^- to Br_2 at standard conditions? Write an equation for the reaction.
$Cl_{2(aq)}$, $Fe_2(SO_4)_2$, $Ce(SO_4)_2$

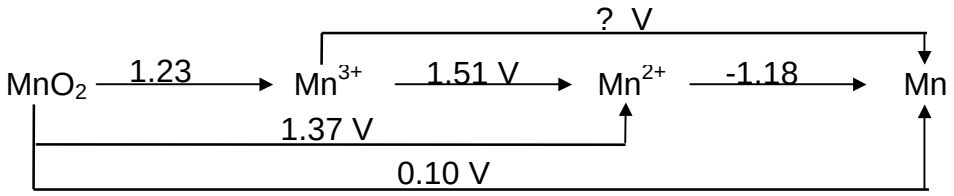
6. Select from the Data sheet a reducing agent capable of reducing Fe^{3+} to Fe^{2+} but not Fe^{2+} to Fe.

7. A Ni/Ni^{2+} // Ag^+/Ag voltaic cell is constructed in which the standard cell voltage is 1.03 V. Calculate the free energy change at 25°C when 1.00 gram of silver plates out, if all concentrations remain at their standard value of 1 M throughout the process. What is the maximum electrical work done by the cell on its surroundings during the experiment?

8. Calculate the standard voltage of a fuel cell in which the reaction is

$$CH_3OH_{(l)} + \frac{3}{2} O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(l)}$$ Use $\Delta G°_f$ data from the Data Sheet.

9 Given the following reduction potentials for some of the various oxidation states of manganese in acid solution.



a) Calculate the standard reduction potential for the couple indicated as (?).

b) Show that manganese(III) ion will disproportionate in aqueous solution. Write the equation for the reaction.

NERNST EQUATION

10. Calculate the cell voltage at 25°C for the following cells:

    a) Zn/Zn^{2+}(1 M) // Pb^{2+}(0.01 M)/Pb b) Al/Al^{3+}(0.02 M) // Sn^{2+}(0.10 M)/Sn c) Cu/Cu^{2+}(0.10 M) // Cu^{2+}(1.0 M)/Cu

11. A voltaic cell consists of Cu electrode dipping in 1.0 M Cu^{2+} solution and a hydrogen gas electrode (H_2 pressure = 1.0 atm) in a solution of unknown pH. The copper electrode is positive and the cell voltage is 0.573 V. Calculate the pH of the hydrogen half-cell.

12. Given that the initial voltage of the following cell is 1.410 V at 25°C, calculate $[Ag^+]$ in the silver half-cell: Zn/Zn^{2+}(0.10 M) // Ag^+(? M)/Ag

13. The voltage of the following cell is 0.986 V. Calculate the reduction potential of the U^{3+}/U couple.
    U/U^{3+}(0.001 M) // Zn^{2+}(0.10 M)/Zn

14. A galvanic cell consists of a Pb electrode in a 1.0 M Pb^{2+} solution and another Pb electrode in a saturated solution of $PbSO_4$. The cell voltage is 0.114 V with the electrode in the $PbSO_4$ solution negative. Calculate the K_{sp} of $PbSO_4$.

15. Calculate the equilibrium constant at 25°C for the cell reaction in the cell
    Pt/Sn^{2+}, Sn^{4+} // Cu^{2+}/Cu.

16. Calculate the equilibrium constant at 25°C for the reaction: $Cu^{2+} + Cu \rightleftharpoons 2\ Cu^+$

17. Using data given in the Data Sheet, calculate K_{sp} of $Ag_2C_2O_{4(s)}$

18. Using the half-reaction $Ag(S_2O_3)_2^{3-} + e^- \rightleftharpoons Ag + 2S_2O_3^{2-}$ $E° = 0.017$ V
    and additional data from the Data Sheet calculate the formation constant for $Ag(S_2O_3)_2^{3-}$ complex ion.

19. The cell voltage E is 0.168 V at 25°C of a cell in which the reaction is: $Co + Sn^{2+}$ (0.18 M) $\rightleftharpoons$ $Sn + Co^{2+}$ (0.020 M)
    Calculate E° and the equilibrium constant for the reaction.

Electrolysis

20. Chlorine is produced commercially by the electrolysis of aqueous sodium chloride. How long will it take to produce 1.18 kg of chlorine, if the current is 5.00×10^2 A assuming 100% current efficiency.

21. An electric current is passed through an aqueous solution of $AgNO_3$ How many grams of silver will be deposited by a 1.00 A current flowing for 1.00 hour?

22. A hydrogen/oxygen fuel cell is based on the reaction $2\ H_2 + O_2 \rightarrow 2\ H_2O$. If the cell produces 1.5 amps of current and if the $H_{2(g)}$ fuel is contained in a 1.0 L tank at 100 atm. pressure at 25°C, how long can the fuel cell operate before the hydrogen is consumed, assuming an unlimited supply of oxygen?

23. In the Hall process, aluminum is produced by the electrolysis of molten Al_2O_3. The electrode reactions are:
    $C + 2\ O^{2-} \rightarrow CO_2 + 4\ e^-$ $Al^{3+} + 3\ e^- \rightarrow Al$
    In the process the carbon of which the anode is composed is gradually consumed by the anode reaction. How many grams of carbon are lost from the anode in the time that it takes to produce 1.00 kg of aluminum?

24. A current of 0.0100 A was passed through a solution of iridium bromide. The only reaction at the cathode was the deposition of iridium (Ir). After 3.00 hours, 0.0720 g of Ir had been deposited. Determine the charge of the iridium ion Ir^{x+}.

25. A voltaic cell consisting of $Cu_{(s)}/Cu^{2+}_{(aq)}$ and $Sn_{(s)}/Sn^{2+}_{(aq)}$ half-cells. If the cell initially at standard conditions delivers a current of 0.400 A for 48.0 hours, what are the concentrations of each of the ions and the cell voltage at this point? Assume each half-cell volume is 1.0 L