Chemistry 30 Review Test 3
Redox and Electrochemistry /55

Part I Multiple choice / Numerical Response
Answer the following multiple choice questions on the scantron sheet. Answer the numerical response on your short answer sheet. DO NOT WRITE ON THE TEST PAPER!
(30 marks)

1. When a substance undergoes oxidation, it always:
   a) loses electrons
   b) decreases its oxidation number
   c) becomes positively charged
   d) attains zero charge

2. Which species is reduced in the reaction:
   $Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + 3Sn^{2+}{}_{(aq)} \rightarrow 3Sn^{4+}{}_{(aq)} + 2Cr^{3+}{}_{(aq)} + 7H_2O_{(aq)}$
   a) $Cr_2O_7^{2-}{}_{(aq)}$
   b) $Cr^{3+}{}_{(aq)}$
   c) $Sn^{2+}{}_{(aq)}$
   d) $Sn^{4+}{}_{(aq)}$

3. For the reaction $Sn^{2+}{}_{(aq)} \rightarrow Sn_{(s)} + Sn^{4+}{}_{(aq)}$, a correct statement is that the:
   a) reaction is spontaneous
   b) reaction involves a decrease in potential energy
   c) Sn^{2+} is both the oxidizing and reducing agent
   d) Sn is the oxidizing agent in this nonspontaneous reaction

4. In the compound $Sb_4O_{6(s)}$, antimony has an oxidation state of
   a) 0
   b) +3
   c) +4
   d) +6

5. If the scale for electrode potentials is changed so that the reduction of $Ni^{2+}{}_{(aq)} + 2e^- \rightarrow Ni_{(s)}$ is 0.00 V, the electrode potential for the reduction of $Br_{2(l)}$ will be:
   a) +0.26 V
   b) +0.81 V
   c) +1.07 V
   d) +1.33 V

Use the following information to answer question 6.

Oxidation Potential Table	
$C_{(s)} \rightarrow C^{3+}{}_{(aq)} + 3e^-$	$E° = +1.80$ V
$D_{(l)} \rightarrow D^{2+}{}_{(aq)} + 2e^-$	$E° = +0.35$ V
$A^{2+}{}_{(aq)} \rightarrow A^{4+}{}_{(aq)} + 2e^-$	$E° = -0.25$ V
$2B^-{}_{(aq)} \rightarrow B_{2(g)} + 2e^-$	$E° = -1.25$ V

6. The strongest oxidizing agent in the table is:
   a) $C_{(s)}$
   b) $B_{2(g)}$
   c) $A^{4+}{}_{(aq)}$
   d) $D^{2+}{}_{(aq)}$

7. Which reactants will result in a spontaneous reaction?
   a) $Fe^{2+}{}_{(aq)} + Pb^{2+}{}_{(aq)}$
   b) $Cr^{2+}{}_{(aq)} + Zn^{2+}{}_{(aq)}$
   c) $Sn^{2+}{}_{(aq)} + I_{2(s)}$
   d) $Na^+{}_{(aq)} + Pb_{(s)}$

Use the following information to answer question 8.

An AgO - Cd cell is used in satellite batteries. This cell is very compact and it can supply much energy.

$2AgO_{(s)} + H_2O_{(l)} + 2e^- \rightarrow Ag_2O_{(s)} + 2OH^-_{(aq)}$ $E° = +0.61$ V

$Cd(OH)_{2(s)} + 2e^- \rightarrow Cd_{(s)} + 2OH^-_{(aq)}$ $E° = -0.81$ V

8. The $E°_{net}$ value for this cell is:
   a) -1.42 V
   b) -0.20 V
   c) +0.20 V
   d) +1.42 V

9. In a functioning electrochemical cell,
   a) anions migrate inside the cell from the anode to the cathode
   b) cations migrate inside the cell from the cathode to the anode
   c) electrons move in the external circuit from the anode to the cathode, where reduction occurs
   d) electrons move in the external circuit from the cathode to the anode, where reduction occurs

10. An electrolytic cell contains 2.00 mol/L $NiCl_{2(aq)}$ and operates at 0.500 A. To plate out 5.87 g of $Ni_{(s)}$, how long would this cell have to function?
    a) 1.93×10^4 s
    b) 3.86×10^4 s
    c) 7.72×10^4 s
    d) 1.54×10^5 s

11. Which cell is capable of recharging a 1.25 V battery?
    a) $Ag_{(s)} \mid Ag^+_{(aq)} \parallel Cu^{2+}_{(aq)} \mid Cu_{(s)}$
    b) $Al_{(s)} \mid Al^{3+}_{(aq)} \parallel Sn^{2+}_{(aq)} \mid Sn_{(s)}$
    c) $Co_{(s)} \mid Co^{2+}_{(aq)} \parallel Pb^{2+}_{(aq)} \mid Pb_{(s)}$
    d) $Fe_{(s)} \mid Fe^{2+}_{(aq)} \parallel Ni^{2+}_{(aq)} \mid Ni_{(s)}$

Use the following information to answer numerical response 1.

Cell I	$E°_{net} = 1.33$ V	anode:	$Ni_{(s)} \rightarrow Ni^{2+}_{(aq)} + 2e^-$
		cathode:	$X_{2(s)} + 2e^- \rightarrow 2X^-_{(aq)}$
Cell II	$E°_{net} = 0.23$ V	anode:	$A_{(s)} \rightarrow A^{2+}_{(aq)} + 2e^-$
		cathode:	$Ni^{2+}_{(aq)} + 2e^- \rightarrow Ni_{(s)}$

Numerical response #1

The predicted cell potential for the spontaneous reaction that occurs by combining the half cells $2X^-_{(aq)} \mid X_{2(s)}$ and $A^{2+}_{(aq)} \mid A_{(s)}$ is _____ V (Record your answer to three digits)

12. An oxidation-reduction reaction is:
    a) $H_3O^+_{(aq)} + HS^-_{(aq)} \rightarrow H_2S_{(aq)} + H_2O_{(aq)}$
    b) $F^-_{(aq)} + HF_{(aq)} \rightarrow HF^{2-}_{(aq)}$
    c) $2Br^-_{(aq)} + Cl_{2(aq)} \rightarrow Br_{2(aq)} + 2Cl^-_{(aq)}$
    d) $2OH^-_{(aq)} + SO_{2(g)} \rightarrow SO_3^{2-}{}_{(aq)} + H_2O_{(l)}$

13. When $Fe_{(s)}$ is placed in a solution containing $Cu(NO_3)_{2(aq)}$ and $MgCl_{2(aq)}$, the balanced equation for the most likely redox reaction is:
    a) $3Cu^{2+}_{(aq)} + 2Fe_{(s)} \rightarrow 2Fe^{3+}_{(aq)} + 3Cu_{(s)}$
    b) $Cu^{2+}_{(aq)} + Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + Cu_{(s)}$
    c) $Cu_{(s)} + 2Fe^{3+}_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + 3Cu^{2+}_{(aq)}$
    d) $Mg^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow Mg_{(s)} + Cl_{2(g)}$

14. A strong oxidizing agent is to be titrated using a strong reducing agent. The lease accurate titration technique would be to add the oxidizing agent to the reducing agent by using a
    a) graduated cylinder
    b) medicine dropper
    c) beaker
    d) burette

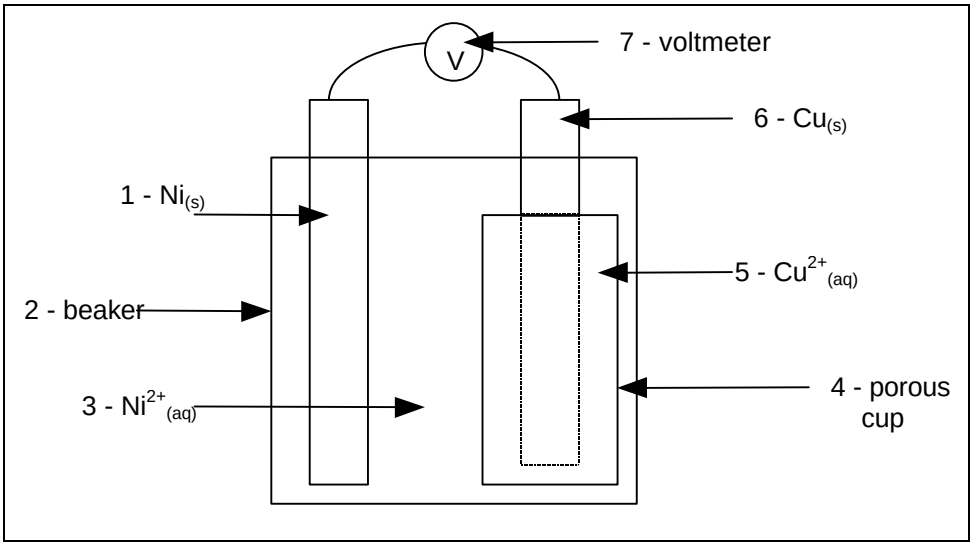
Use the following information to answer numerical response 2.

$$2NO_3^-{}_{(aq)} + 4H^+{}_{(aq)} + Zn_{(s)} \rightarrow 2NO_{2(g)} + 2H_2O_{(l)} + Zn^{2+}{}_{(aq)}$$

Numerical response #2

The $E°_{net}$ for the reaction is _____ V (Record your answer to 3 digits)

Use the following information to answer numerical response 3.



Numerical response #3

When the electrochemical cell is operating, the:
anode is _____ (record in first column)
cathode is _____(record in second column)
reducing agent is _____ (record in third column)
oxidizing agent is _____ (record in fourth column)

15. When acidified $Cr_2O_7^{2-}{}_{(aq)}$ is used in a redox titration to oxidize $Sn^{2+}{}_{(aq)}$ solution, the molar ration of oxidizing agent to reducing agent that must be used to reach the equivalence point will be:
    a) 1:1
    b) 1:3
    c) 1:14
    d) 14:3

16. Using the titration in the previous question and 0.20 mol/L $Cr_2O_7^{2-}{}_{(aq)}$, if 35.0 mL of oxidizing agent were required to react with 43.0 mL of the reducing agent, what was the concentration of $Sn(NO_3)_{2(aq)}$?
    a) 0.17 mol/L
    b) 0.47 mol/L
    c) 0.53 mol/L
    d) 0.76 mol/L

17. The standard reduction potential of a metallic ion is 0.30 V. Which of these metals will be most easily oxidized by this ion?

a) $Cd_{(s)}$
b) $Co_{(s)}$
c) $Pb_{(s)}$
d) $Cu_{(s)}$

Use the following information to answer question 18.

A student observed the reactions between four different metals and the solutions of their ions, and then recorded these "spontaneous" reactions:

I $W_{(s)} + X^+_{(aq)} \rightarrow W^+_{(aq)} + X_{(s)}$
II $X_{(s)} + Y^+_{(aq)} \rightarrow X^+_{(aq)} + Y_{(s)}$
III $Y_{(s)} + Z^+_{(aq)} \rightarrow Y^+_{(aq)} + Z_{(s)}$
IV $Z_{(s)} + W^+_{(aq)} \rightarrow Z^+_{(aq)} + W_{(s)}$
V $X_{(s)} + Z^+_{(aq)} \rightarrow X^+_{(aq)} + Z_{(s)}$

18. If equation I is correct, which equation did the student record incorrectly?
a) II
b) III
c) IV
d) V

19. Which oxidizing agent is the strongest?
a) $Cl_{2(g)}$
b) $Br_{2(l)}$
c) $Cl^-_{(aq)}$
d) $Br^-_{(aq)}$

20. An electrolytic cell is one in which the
a) net potential of the reaction is positive
b) oxidation-reduction reaction is spontaneous
c) energy is converted from electrical to chemical
d) chemical energy is converted to electrical energy

21. Reducing agents are
a) usually positively charged
b) able to react with $Li_{(s)}$
c) able to lose electrons
d) easily reduced

Use the following information to answer question 22.

$ClO_3^-{}_{(aq)} + 6H^+_{(aq)} + 5e^- \rightarrow Cl_{2(g)} + 3H_2O_{(l)}$ $E° = 1.47$ V
$Cl_{2(g)} + 2e^- \rightarrow 2Cl^-_{(aq)}$ $E° = 1.36$ V

22. A student mixes acidified solutions of $KCl_{(aq)}$ and $KClO_{3(aq)}$. Which observation is NOT correct?
a) Chlorine gas is produced
b) A spontaneous reaction occurs
c) The pH of the mixture decreases
d) The concentrations of both $ClO_3^-{}_{(aq)}$ and $Cl^-_{(aq)}$ decrease

23. In the molecules HClO, $HClO_2$, and $HClO_3$, the oxidation number for each chlorine is, respectively,
a) +1, +3, +5
b) +1, +1, +1
c) -1, -3, -5
d) -1, -1, -1

24. Which statement is true of a substance with an oxidation potential of 2.52 V?
    a) It is a strong reducing agent
    b) It is a weak reducing agent
    c) It is a strong oxidizing agent
    d) It has a high electronegativity value

25. If fluorine gas is bubbled through NaI(aq)
    a) $Na^{+}_{(aq)}$ is reduced
    b) $I^{-}_{(aq)}$ is oxidized
    c) $F_{2(aq)}$ is oxidized
    d) $I^{-}_{(aq)}$ is reduced

Use the following information to answer numerical response 4.

1. $Cr_{(s)}$	3. $Sn^{2+}_{(aq)}$
2. $H_2O_{(l)}$	4. $Fe^{2+}_{(aq)}$

Numerical response #4

The order of these reducing agents from strongest to weakest is ____, ____, ____, ____

Use the following information to answer numerical response 5.

In a titration experiment, $K_2Cr_2O_{7(aq)}$ was used to determine the concentration of $Sn^{2+}_{(aq)}$ in an acidified solution of $FeCl_{2(aq)}$. The following data were recorded:

Concentration of $K_2Cr_2O_{7(aq)}$	0.250 mol/L
Volume of $FeCl_{2(aq)}$	10.00 mL
Final burette reading of $K_2Cr_2O_{7(aq)}$	30.2 mL
Initial burette reading of $K_2Cr_2O_{7(aq)}$	0.2 mL

Numerical response #5

The concentration of $Fe^{2+}_{(aq)}$ in the $FeCl_{2(aq)}$ solution in moles per litre, to three digits, is _____ mol/L

Part II - Short Answer Questions

Answer the following questions on a separate piece of paper. Show all of your work for part marks. (25 marks)

Use the following information to answer question 1.

Aluminum is produced by the electrolysis of molten ore. The reaction at the cathode of the electrolytic cell can be simplified and written as: $Al^{3+}_{(l)} + 3e^- \rightarrow Al_{(s)}$

The energy required to produce aluminum by electrolysis is 72 kJ/g

Electrolysis is not required when aluminum is recycled. A major energy expenditure in recycling is the energy required to heat aluminum to its melting point and to melt it. The molar heat of fusion of $Al_{(s)}$ is 10.7 kJ/mol.

1. a) Calculate the amount of energy required to recycle a 16.1 g aluminum pop can. Assume that the aluminum for recycling is at an initial temperature of 20°C.
   b) Give an advantage and a disadvantage of recycling aluminum compared with producing it from electrolysis. Should aluminum be recycled? Justify your answer. (7 marks total)

Use the following information to answer question 2.

A student was given four solutions, labeled A, B, C, and D. One contained $Cl^-_{(aq)}$ ions, one contained $Br^-_{(aq)}$ ions, one contained $Sn2+_{(aq)}$ ions, and one contained $Fe2+_{(aq)}$ ions.

In order to identify each solution, the student selected the following acidified reagents:
$MnO_4^-{}_{(aq)}$, $SO_4^{2-}{}_{(aq)}$, $NO_3^-{}_{(aq)}$, and $Cr_2O_7^{2-}{}_{(aq)}$

The student combined some of each solution with the reagents and recorded these results:

	Unknown Solutions			
Reagents	A	B	C	D
$MnO_4^-{}_{(aq)}$, $H^+_{(aq)}$	√	√	√	√
$SO_4^{2-}{}_{(aq)}$, $H^+_{(aq)}$	x	x	√	x
$NO_3^-{}_{(aq)}$, $H^+_{(aq)}$	x	√	√	x
$Cr_2O_7^{2-}{}_{(aq)}$, $H^+_{(aq)}$	√	√	√	x

2. If "√" indicates a spontaneous reaction and "x" indicates no reaction, identify what each solution contained. Explain how you reached your conclusions. (7 marks)

3. Jane lowered a copper strip into a glass beaker containing 200.0 mL of 0.100 mol/L $AgNO_{3(aq)}$. The beaker was then sealed and left to sit overnight. Next day, she observed that some of the copper strip remained.
   a) assuming that the reaction went to completion, use half reactions to write the net ionic redox reaction that occurred and then calculate the copper (II) ion concentration of the solution.
   b) Give one other observation that Jane could have made (6 marks)

4. A sample of a salt containing Fe^{2+} was dissolved in 50.0 mL of a dilute aid solution and titrated with 0.100 mol/L $Cr_2O_7^{2-}{}_{(aq)}$. The $Fe^{2+}_{(aq)}$ was oxidized to $Fe^{3+}_{(aq)}$ by 40.0 mL of the $Cr_2O_7^{2-}{}_{(aq)}$ solution. Use half-reactions to write the balanced equation for the reaction and determine the mass of iron in the original salt. (5 marks)