Exam3Fall2009thermoelectro

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Thermodynamics can be used to determine all of the following EXCEPT
a. the direction in which a reaction is spontaneous.
b. the extent to which a reaction occurs.
c. the rate of reaction.
d. the temperature at which a reaction is spontaneous.
e. the enthalpy change of a reaction.

____ 2. Which of the following involves a decrease in entropy?
a. the sublimation of carbon dioxide
b. the dissolution of NaCl in water
c. the decomposition of N_2O_4(g) to NO_2(g)
d. the evaporation of ethanol
e. the freezing of liquid water into ice

____ 3. Of the following product-favored processes, which are endothermic?

1. the combustion of methane to produce water and carbon dioxide
2. the expansion of an ideal gas
3. the melting of ice at temperatures greater than 0ºC.

a. 1 only
b. 2 only
c. 3 only
d. 1 and 2
e. 2 and 3

____ 4. Calculate the standard molar entropy change for the combustion of methane.

$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$

Species	Sº (J/K·mol)
CH_4(g)	186.3
O_2(g)	205.1
CO_2(g)	213.7
H_2O(g)	188.8

a. -5.2 J/K
b. -1.0 J/K
c. +1.0 J/K
d. +5.2 J/K
e. +11.1 J/K

____ 5. Predict the signs of ΔH, ΔS, and ΔG for the melting of ice at 50ºC.
a. $\Delta H < 0$, $\Delta S < 0$, $\Delta G < 0$
b. $\Delta H < 0$, $\Delta S > 0$, $\Delta G < 0$
c. $\Delta H < 0$, $\Delta S > 0$, $\Delta G < 0$
d. $\Delta H > 0$, $\Delta S < 0$, $\Delta G < 0$
e. $\Delta H > 0$, $\Delta S > 0$, $\Delta G < 0$

____ 6. Above what temperature would you expect a reaction to become spontaneous if ΔH = +322 kJ and ΔS = +531 J/K?
a. 171 K
b. 209 K
c. 606 K
d. The reaction will be spontaneous at any temperature.
e. The reaction will NOT be spontaneous at any temperature.

____ 7. Calculate ΔG°_{rxn} for the reaction below at 25.0ºC

$2\ H_2S(g) + O_2(g) \rightarrow 2\ H_2O(g) + S(s)$

given ΔH°_{rxn} = -442.4 kJ, and ΔS°_{rxn} = -175.4 J/K.
a. -438.0 kJ
b. -390.1 kJ
c. -321.9 kJ
d. +3943 kJ
e. +5182 kJ

____ 8. Calculate ΔG° for the reaction below at 25.0ºC.

$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$

Species	ΔH°_f(kJ/mol)	S°_f(J/K·mol)
Fe(s)	0	27.78
$O_2(g)$	0	205.14
$Fe_2O_3(s)$	-824.2	87.40

a. -1629 kJ
b. -1484 kJ
c. -780.8 kJ
d. -659.7 kJ
e. +1629 kJ

____ 9. The free energy change for the formation of the complex ion AlF_6^{3-} is -140. kJ at 25ºC. What is the equilibrium constant for the reaction?
a. 2.9×10^{-25}
b. 5.65×10^{1}
c. 3.5×10^{24}
d. 5.2×10^{29}
e. 2.3×10^{56}

____ 10. In the following reaction,

$Fe^{2+}(aq) + Ag^{+}(aq) \rightarrow Fe^{3+}(aq) + Ag(s)$
a. Fe^{2+} is oxidized and Fe^{3+} is reduced.
b. Fe^{2+} is oxidized and Ag^{+} is reduced.
c. Ag^{+} is oxidized and Ag(s) is reduced.
d. Ag^{+} is oxidized and Fe^{2+} is reduced.
e. Ag^{+} is oxidized and Fe^{3+} is reduced.

____ 11. Write a balanced chemical equation for the following reaction in a basic solution.

$H_2O_2(aq) + Cr(OH)_3(s) \rightarrow H_2O(\ell) + CrO_4^{2-}(aq)$

a. $2\ H_2O_2(aq) + 3\ Cr(OH)_3(s) \rightarrow H_2O(\ell) + 3\ CrO_4^{2-}(aq) + 11/2\ H^+(aq)$
b. $2\ H_2O_2(aq) + Cr(OH)_3(s) \rightarrow H_2O(\ell) + CrO_4^{2-}(aq) + 2\ OH^-(aq)$
c. $H_2O_2(aq) + 2\ Cr(OH)_3(s) \rightarrow H_2O(*\ell) + 2\ CrO_4^{2-}(aq) + 4\ H_2O(\ell)$
d. $3\ H_2O_2(aq) + 2\ Cr(OH)_3(s) + 4\ OH^-(aq) \rightarrow 2\ CrO_4^{2-}(aq) + 8\ H_2O(\ell)$
e. $4\ H_2O_2(aq) + 2\ Cr(OH)_3(s) \rightarrow 2\ H_2O(\ell) + 2\ CrO_4^{2-}(aq) + 4\ OH^-(aq)$

____ 12. All of the following statements concerning voltaic cells are true EXCEPT
a. the two half-cells are connected by a salt bridge.
b. electrons flow from the anode to the cathode.
c. oxidation occurs at the cathode.
d. voltaic cells can be used as a source of energy.
e. a voltaic cell consists of two-half cells.

____ 13. What is the correct cell notation for the reaction below?

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

a. $Pb \mid Pb^{2+}(aq) \parallel Cu^{2+}(aq) \mid Cu$
b. $Pb \mid Cu^{2+}(aq) \parallel Pb^{2+}(aq) \mid Cu$
c. $Pb \mid Cu(s) \parallel Pb^{2+}(aq) \mid Cu^{2+}$
d. $Cu \mid Pb^{2+}(aq) \parallel Cu^{2+}(aq) \mid Pb$
e. $Cu \mid Cu^{2+}(aq) \parallel Pb^{2+}(aq) \mid Pb$

____ 14. Write a balanced chemical equation for the overall reaction represented by the cell notation below.
$Pt \mid Sn^{2+}(aq), Sn^{4+}(aq) \parallel Cd^{2+}(aq) \mid Cd(s)$
a. $Cd^{2+}(aq) + Sn^{4+}(aq) \rightarrow Cd(s) + Sn^{2+}(aq)$
b. $Cd^{2+}(aq) + Sn^{2+}(aq) \rightarrow Cd(s) + Sn^{4+}(aq)$
c. $Cd(s) + Sn^{4+}(aq) \rightarrow Cd^{2+}(aq) + Sn^{2+}(aq)$
d. $Cd(s) + Cd^{2+}(aq) \rightarrow Sn^{2+}(aq) + Sn^{4+}(aq)$
e. $Cd(s) + Sn^{2+}(aq) \rightarrow Cd^{2+}(aq) + Sn^{4+}(aq)$

____ 15. Use the standard reduction potentials below to determine which compound or ion is the best oxidizing agent?

$Cl_2(g) + 2\ e^- \rightarrow 2\ Cl^-(aq)$	$E° = +1.36$ V
$Ag^+(aq) + e^- \rightarrow Ag(s)$	$E° = +0.80$ V
$Fe^{2+}(aq) + 2\ e^- \rightarrow Fe(s)$	$E° = -0.44$ V

a. Cl_2
b. Cl^-
c. Ag
d. Fe^{2+}
e. Fe

____ 16. Use the standard reduction potentials below to determine which compound or ion is the best reducing agent?

$Hg^{2+}(aq) + 2\ e^- \rightarrow Hg(\ell)$	$E° = +0.855$ V
$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$	$E° = +0.337$ V
$Cd^{2+}(aq) + 2\ e^- \rightarrow Cd(s)$	$E° = -0.40$ V

a. Hg^{2+}

b. $Hg(\ell)$
c. Cu^{2+}
d. Cd^{2+}
e. Cd

____ 17. Consider the following half-reactions:

$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	$E° = +0.77$ V
$Sn^{2+}(aq) + 2\ e^- \rightarrow Sn(s)$	$E° = -0.14$ V
$Fe^{2+}(aq) + 2\ e^- \rightarrow Fe(s)$	$E° = -0.44$ V
$Al^{3+}(aq) + 3\ e^- \rightarrow Al(s)$	$E° = -1.66$ V
$Mg^{2+}(aq) + 2\ e^- \rightarrow Mg(s)$	$E° = -2.37$ V

Which of the above metals or metal ions are able to oxidize Al(s)?
a. Fe^{3+} and Sn^{2+}
b. Fe^{3+}, Sn^{2+}, and Fe^{2+}
c. Fe^{2+}, Sn, and Fe
d. Mg and Mg^{2+}
e. Mg^{2+} only

____ 18. Given the following two half-reactions, determine which overall reaction is spontaneous and calculate the cell potential.

$Mg^{2+}(aq) + 2\ e^- \rightarrow Mg(s)$	$E° = -2.37$ V
$Ni^{2+}(aq) + 2\ e^- \rightarrow Ni(s)$	$E° = -0.25$ V

a. $Mg^{2+}(aq) + Ni(s) \rightarrow Mg(s) + Ni^{2+}(aq)$ $E^\circ_{cell} = +2.12$ V
b. $Mg^{2+}(aq) + Ni(s) \rightarrow Mg(s) + Ni^{2+}(aq)$ $E^\circ_{cell} = -2.62$ V
c. $Mg^{2+}(aq) + Ni^{2+}(aq) \rightarrow Mg(s) + Ni(s)$ $E^\circ_{cell} = +2.62$ V
d. $Mg(s) + Ni^{2+}(aq) \rightarrow Ni(s) + Mg^{2+}(aq)$ $E^\circ_{cell} = +2.12$ V
e. $Mg^{2+}(aq) + Ni^{2+}(aq) \rightarrow Ni(s) + Mg(s)$ $E^\circ_{cell} = -2.12$ V

____ 19. Calculate E°_{cell} for the following reaction:

$F_2(g) + 2\ Cl^-(aq) \rightarrow 2\ F^-(aq) + Cl_2(g)$

given the following standard reduction potentials.

$F_2(g) + 2\ e^- \rightarrow 2\ F^-(aq)$	$E° = +2.87$ V
$Cl_2(g) + 2\ e^- \rightarrow 2\ Cl^-(aq)$	$E° = +1.36$ V

a. -4.23 V
b. -1.51 V
c. 0.76 V
d. +1.51 V
e. +4.23 V

____ 20. Calculate E for the following electrochemical cell at 25ºC

Ag^+ | Ag(aq, 0.150 M) || Sn^{2+}(aq, 0.500 M), Sn^{4+}(aq, 0.500 M) | Pt given the following standard reduction potentials.

$Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$ $\quad E^{o} = +0.80$ V
$Sn^{4+}(aq) + 2 e^{-} \rightarrow Sn^{2+}(aq)$ $\quad E^{o} = +0.14$ V

a. -0.915 V
b. +0.61 V
c. +0.89 V
d. +0.915 V
e. +0.99 V

____ 21. E°_{cell} for the following redox reaction is +0.236 V.

$2 Fe^{3+}(aq) + 2 I^{-}(aq) \rightarrow 2 Fe^{2+}(aq) + I_2(s)$

What is $\Delta^{o}G$ for this reaction?
a. -91.0 kJ
b. -78.1 kJ
c. -47.2 kJ
d. -45.5 kJ
e. -22.8 kJ

____ 22. Al^{3+} is reduced to Al(s) at an electrode. If a current of 1.00 ampere is passed for 24 hours, what mass of aluminum is deposited at the electrode? Assume 100 % current efficiency.
a. 1.87 g
b. 8.05 g
c. 24.2 g
d. 54.1 g
e. 72.5 g

____ 23. The solubility of $PbCl_2$ is 0.016 mol/L. What is the value of K_{sp} for $PbCl_2$?
a. 4.1×10^{-6}
b. 1.6×10^{-5}
c. 2.6×10^{-4}
d. 5.1×10^{-4}
e. 4.8×10^{-2}

____ 24. The K_{sp} for BaF_2 is 1.7×10^{-6}. What is the concentration of Ba^{2+} in a saturated solution of BaF_2?
a. 5.7×10^{-7} M
b. 1.7×10^{-6} M
c. 1.0×10^{-2} M
d. 1.3×10^{-3} M
e. 7.5×10^{-3} M

____ 25. What is the molar solubility of Ag_2CrO_4 in 0.20 M K_2CrO_4? The value of K_{sp} for Ag_2CrO_4 is 9.0×10^{-12}.
a. 4.5×10^{-11} mol/L
b. 1.3×10^{-10} mol/L
c. 3.6×10^{-8} mol/L
d. 6.7×10^{-6} mol/L
e. 1.3×10^{-4} mol/L

____ 26. What is the molar solubility of Fe^{3+} in a solution that is buffered at a pH of 4.00? The K_{sp} for $Fe(OH)_3$ is 6.3×10^{-38}.
a. 6.3×10^{-23} mol/L

b. 2.3×10^{-9} mol/L
c. 6.3×10^{-8} mol/L
d. 2.3×10^{-6} mol/L
e. 1.4×10^{-4} mol/L

____ 27. The concentration of Ca^{2+} in a solution is 4.7×10^{-4} M. What concentration of CO_3^{2-} is required to just begin precipitating $CaCO_3$? The K_{sp} for $CaCO_3$ is 3.8×10^{-9}.
a. 8.1×10^{-6} M
b. 5.1×10^{-5} M
c. 3.8×10^{-4} M
d. 4.7×10^{-4} M
e. 1.4×10^{-2} M

____ 28. The following anions can be separated by precipitation as silver salts: Cl^-, Br^-, I^-, CrO_4^{2-}. If Ag^+ is added to a solution containing the four anions, each at a concentration of 0.10 M, in what order would they precipitate?

Compound	K_{sp}
AgCl	1.8×10^{-10}
Ag_2CrO_4	9.0×10^{-12}
AgBr	3.3×10^{-13}
AgI	1.5×10^{-16}

a. $AgCl \rightarrow Ag_2CrO_4 \rightarrow AgBr \rightarrow AgI$
b. $AgI \rightarrow AgBr \rightarrow Ag_2CrO_4 \rightarrow AgCl$
c. $Ag_2CrO_4 \rightarrow AgCl$ $AgBr \rightarrow AgI$
d. $Ag_2CrO_4 \rightarrow AgI$ $AgBr \rightarrow AgCl$
e. $AgI \rightarrow AgBr \rightarrow AgCl \rightarrow Ag_2CrO_4$

Essay

29. (6 Pts) Historically, to prevent the oxidation of the iron hulls in ocean vessels, large zinc plates were often affixed to the outside of the hull below the waterline. How does the zinc protect the iron hull?

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30. (6 Pts) Explain the function of a salt bridge in a voltaic cell.

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Answer Section

MULTIPLE CHOICE

1. ANS: C
2. ANS: E
3. ANS: E
4. ANS: A
5. ANS: E
6. ANS: C
7. ANS: B
8. ANS: B
9. ANS: C
10. ANS: B
11. ANS: D
12. ANS: C
13. ANS: A
14. ANS: B
15. ANS: A
16. ANS: E
17. ANS: B
18. ANS: D
19. ANS: D
20. ANS: B
21. ANS: D
22. ANS: B
23. ANS: B
24. ANS: E
25. ANS: D
26. ANS: C
27. ANS: A
28. ANS: E

ESSAY

29. ANS:
    The iron, zinc, and seawater form a voltaic cell. The zinc is more easily oxidized than the iron, so it serves as the anode of the cell. Oxidation occurs at the zinc anode, rather than the iron hull.
30. ANS:
    The salt bridge physically separates the redox couples in an electrochemical cell while enabling electrical conduction through the cell. In addition, the salt bridge helps maintain electroneutrality as reduction and oxidation occur at the cathode and anode. As oxidation occurs, anions flow from the salt bridge toward the anode and cations flow from the anode to the salt bridge. Likewise, cations flow from the salt bridge toward the cathode and anions from the cathode to the salt bridge.