CHM 152 Exam 3 100 Pts Spring 2007 Name: Key ID: B

Exam3C152S07

Be sure the person sitting on either side of you has a different colored exam. You may write on the exam, but be sure to put your *name and exam color* on your Green Scantron. *Identify the letter of the choice that best completes the statement or answers the question.*

____ 1. In the following reaction,

$Fe^{2+}(aq) + Ag^{+}(aq) \rightarrow Fe^{3+}(aq) + Ag(s)$

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

____ 2. Write a balanced chemical equation for the following reaction in an acidic solution.

$Cr_2O_7^{2-}(aq) + Fe^{2+}(aq) \rightarrow Cr^{3+}(aq) + Fe^{3+}(aq)$

a. $Cr_2O_7^{2-}(aq) + 6\ Fe^{2+}(aq) + 7\ H^{+}(aq) \rightarrow 2\ Cr^{3+}(aq) + 6\ Fe^{3+}(aq) + 7\ OH^{-}(aq)$
b. $Cr_2O_7^{2-}(aq) + Fe^{2+}(aq) + 14\ H^{+}(aq) \rightarrow 2\ Cr^{3+}(aq) + Fe^{3+}(aq) + 7\ H_2O(\ell)$
c. $Cr_2O_7^{2-}(aq) + Fe^{2+}(aq) \rightarrow 2\ Cr^{3+}(aq) + Fe^{3+}(aq)$
d. $Cr_2O_7^{2-}(aq) + Fe^{2+}(aq) + 7\ H^{+}(aq) \rightarrow 2\ Cr^{3+}(aq) + Fe^{3+}(aq) + 7\ OH^{-}(aq)$
e. $Cr_2O_7^{2-}(aq) + 6\ Fe^{2+}(aq) + 14\ H^{+}(aq) \rightarrow 6\ Fe^{3+}(aq) + 2\ Cr^{3+}(aq) + 7\ H_2O(\ell)$

____ 3. What is the correct cell notation for the reaction below?

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

ox → red or Anode → Cathode

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

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

____ 4. Use the standard reduction potentials below to determine which compound or ion is the best oxidizing agent?

Gains e^{-}s

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

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

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____ 5. Use the standard reduction potentials below to determine which compound or ion is the best reducing agent?

Loses e^-s

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

$Cd(s) \rightarrow Cd^{2+}(aq) + 2e^-$ $+0.40$ V

Spon.

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

____ 6. Consider the following half-reactions:

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

$Al(s) \rightarrow Al^{3+} + 3e^-$ $+1.66$ V

Which of the above metals or metal ions are able to oxidize Al(s)?

GAIN e^-s from Al

a. Fe^{3+} and Sn^{2+}
b. Mg and Mg^{2+}
c. Mg^{2+} only
d. Fe^{2+}, Sn, and Fe
e. Fe^{3+}, Sn^{2+}, and Fe^{2+}

____ 7. Given the following two half-reactions, determine which overall reaction is spontaneous and calculate the cell potential.

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

$Mg(s) \rightarrow Mg^{2+} + 2e^-$ $+2.37$ V
$Ni^{2+} + 2e^- \rightarrow Ni(s)$ -0.25 V
$Ni^{2+} + Mg \rightarrow Ni(s) + Mg^{2+}$ $+2.12$ V

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

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____ 8. Calculate E for the following electrochemical cell at 25ºC

ox

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.

1st

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

$2Ag \rightarrow 2Ag^{+} + 2e$

$E° = -0.6$ V

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

2nd

$E = -0.66\ V - \frac{0.0591}{2} \log\left(\frac{0.5}{(0.15)^2(0.5)}\right)$

$= -0.61\ V$

____ 9. Calculate ΔG° for the disproportionation of Cu^{+},

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

given the following standard reduction potentials.

$\Delta G = -nFE$

$Cu^{+}(aq) + e^{-} \rightarrow Cu(s)$	$E° = +0.518$ V
$Cu^{2+}(aq) + 2\ e^{-} \rightarrow Cu(s)$	$E° = +0.337$ V

$\Delta G = -2(9.65 \times 10^{4}\ C)(0.181\ V)$

$2\ Cu^{+} + 2e^{-} \rightarrow 2Cu(s)$ 0.518 V

$Cu(s) \rightarrow Cu^{2+} + 2e^{-}$ -0.337 V

0.181 V

$\Delta G = -34933\ J$

$J = C \cdot V$

a. -165 kJ
b. -175 kJ
c. -34.9 kJ
d. -56.8 kJ
e. -1180 kJ

____ 10. 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.

$Al^{3+} + 3e^{-} \rightarrow Al$?g

$\frac{24\ hrs}{} \cdot \frac{3600\ sec}{1\ hr} \cdot \frac{1.00\ C}{sec} \cdot \frac{mole\ e^{-}}{9.65 \times 10^{4}\ C} \cdot \frac{1\ mol\ Al}{3\ mole\ e^{-}} \cdot \frac{27.0\ g}{mol} =$

a. 1.87 g
b. 54.1 g
c. 24.2 g
d. 72.5 g
e. 8.05 g

____ 11. Thermodynamics can be used to determine all of the following EXCEPT
a. the direction in which a reaction is spontaneous.
b. the enthalpy change of a reaction.
c. the rate of reaction.
d. the extent to which a reaction occurs.
e. the temperature at which a reaction is spontaneous.

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____ 12. 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	S° (J/K·mol)
$CH_4(g)$	186.3
$O_2(g)$	205.1
$CO_2(g)$	213.7
$H_2O(g)$	188.8

591.3 − 596.5

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

____ 13. Predict the signs of ΔH, ΔS, and ΔG for the combustion of hydrogen gas at 25°C.

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(\ell)$

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. $\Delta H < 0, \Delta S < 0, \Delta G < 0$

____ 14. Predict the signs of ΔH, ΔS, and ΔG for the melting of ice at 50°C.

ΔH +, ΔS +, ΔG −

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. $\Delta H < 0, \Delta S > 0, \Delta G < 0$

____ 15. Above what temperature would you expect a reaction to become spontaneous if ΔH = +322 kJ and ΔS = +531 J/K?

$\Delta G = \Delta H - T\Delta S$

$\Delta G = 0$ @ Eq so: $0 = \Delta H - T\Delta S$

$T = \frac{\Delta H}{\Delta S} = \frac{+322 \times 10^3\ J}{531\ J/K}$

a. The reaction will NOT be spontaneous at any temperature.
b. 171 K
c. 606 K
d. 209 K
e. The reaction will be spontaneous at any temperature.

____ 16. At what temperature would you expect a reaction to become spontaneous if ΔH = +67.0 kJ and ΔS = -131 J/K?

$\Delta G = \Delta H - T\Delta S$

non spon. non spon

a. The reaction will NOT be spontaneous at any temperature.
b. $T > 511$ K
c. $T < -511$ K
d. The reaction will be spontaneous at any temperature.
e. $T > 238$ K

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____ 17. Calculate ΔG°_{rxn} for the reaction below at 25.0°C

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

$\Delta G = \Delta H - T\Delta S$

given ΔH°_{rxn} = -442.4 kJ, and ΔS°_{rxn} = -175.4 J/K.

a. -438.0 kJ
b. +3943 kJ
c. -390.1 kJ
d. -321.9 kJ
e. +5182 kJ

____ 18. Calculate ΔG° for the reaction below at 25.0°C.

$C_2H_5OH(\ell) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(\ell)$

Species	ΔH°_f(kJ/mol)	S°_f(J/Kmol)
$C_2H_5OH(\ell)$	-277.7	160.7
$O_2(g)$	0	205.1
$CO_2(g)$	-393.5	213.7
$H_2O(\ell)$	-285.8	69.1

$\Delta S = 634.7 - 776. = -141.3\ J/K$

$\Delta H = -1644.4 - {}^-277.7 = -1366.7\ kJ$

$\Delta G = -1366.7 - 298\,(-0.1413)$

$\Delta G = -1325$

a. +2435 kJ
b. 141.3 kJ
c. +1038 kJ
d. 1325 kJ
e. 365.1 kJ

____ 19. We have a solution of benzoic acid, $C_6H_5CO_2H$. What is the effect of adding sodium hydroxide to this solution?

1. The pH increases.
2. The concentration of $C_6H_5CO_2H$ decreases.
3. The concentration of H_3O^+ increases.

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

____ 20. What is the pH of a mixture containing 0.30 M HNO_2 and 0.15 M $NaNO_2$? (K_a for $HNO_2 = 4.5 \times 10^{-4}$)

a. 3.05
b. 4.35
c. 4.65
d. 5.01
e. 4.05

$pH = -\log K_a + \log \frac{0.15}{0.30}$

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____ 21. What is the pH of the solution that results from adding 15 mL of 0.50 M NaOH to 25 mL of 0.50 M HF? (K_a for HF = 7.2×10^{-4})

a. 3.32
b. 10.86
c. 3.49
d. 4.61
e. 7.53

$pH = -\log K_a + \log \frac{0.0075}{0.0125 - 0.0075}$

$NaOH + HF \rightarrow NaF + H_2O + XS$

____ 22. Which of the following combinations would be the best to buffer the pH to 9.0?

a. CH_3CO_2H and CH_3COO^-, $K_a = 18 \times 10^{-5}$
b. H_3PO_4 and $H_2PO_4^-$, $K_a = 7.5 \times 10^{-3}$
c. HNO_2 and NO_2^-, $K_a = 4.5 \times 10^{-4}$
d. $H_2PO_4^-$ and HPO_4^{2-}, $K_a = 6.2 \times 10^{-8}$
e. NH_4^+ and NH_3, $K_a = 5.7 \times 10^{-10}$ $pK_a = 9.2$

____ 23. Which of the following equations is the solubility product for $Ca(IO_3)_2$?

a. $K_{sp} = [Ca^{2+}][I^-]^2[3O^{2-}]^2$
b. $K_{sp} = [Ca^{2+}]^2[IO_3^-]$
c. $K_{sp} = [Ca^{2+}][IO_3^-]^2$
d. $K_{sp} = [Ca^{2+}][I^-]^2[O^{2-}]^6$
e. $K_{sp} = [Ca^{2+}][IO_3^-]$

____ 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. 1.0×10^{-2} M
b. 5.7×10^{-7} M
c. 1.3×10^{-3} M
d. 7.5×10^{-3} M
e. 1.7×10^{-6} M

$BaF_2(s) \rightleftharpoons Ba^{2+} + 2F^-$ $K_{sp} = [\ ][\ ]^2$

0 0

x 2x $1.7 \times 10^{-6} = [x][2x]^2$

$x =$

____ 25. At what pH will a solution 0.150 M Cu^{2+} begin to precipitate as $Cu(OH)_2$? The K_{sp} for $Cu(OH)_2$ is 1.6×10^{-19}.

a. 1.80
b. 7.23
c. 5.01
d. 8.99
e. 13.18

$Cu(OH)_2(s) \rightleftharpoons Cu^{2+} + 2OH^-$

$K_{sp} = [Cu^{2+}][OH^-]^2$

$1.6 \times 10^{-19} = [0.150][OH]^2$

$[OH^-] = 1.03 \times 10^{-9}$

$pOH = 8.99$

$pH = 5.01$