# Exam 4
# Chem 1142
# Fall 2008

Name:_____

**MULTIPLE CHOICE**. [4 pts ea.]

Q1. $6I^-(aq) + 2MnO_4^-(aq) + 4H_2O(l) \rightarrow 3I_2(s) + 2MnO_2(s) + OH^-(aq)$

Which of the following statements regarding the reaction represented by the equation above is correct?

a) Iodide ion is oxidized by hydroxide ion.
b) $MnO_4^-$ is oxidized by iodide ion.
c) The oxidation number of manganese changes from +7 to +2.
d) The oxidation number of manganese remains the same.
e) The oxidation number of iodine changes from –1 to 0.

Q2. __ $Cr_2O_7^{2-}$ + __ $e^-$ + __ $H^+ \rightarrow$ __ $Cr^{3+}$ + __ $H_2O(l)$

When the equation for the half reaction above is balanced with the lowest whole-number coefficients, the coefficient for $H_2O$ is

a) 2 b) 4 c) 6 d) 7 e) 14

Q3. Which of the following must be true for a reaction that proceeds spontaneously from initial standard state conditions?

a) $\Delta G° > 0$ and $K_{eq} > 1$ b) $\Delta G° > 0$ and $K_{eq} < 1$ c) $\Delta S° < 0$ and $K_{eq} > 1$
d) $\Delta G° < 0$ and $K_{eq} > 1$ e) $\Delta G° = 0$ and $K_{eq} = 1$

Q4. Which of the following produces an INCREASE in entropy of the system?

a) $H_2O(l) \rightarrow H_2O(s)$ b) $2O_2(g) + 2SO(g) \rightarrow 2SO_3(g)$
c) $2CH_3OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$ d) $I_2(s) \rightarrow I_2(l)$
e) None of the above.

Q5. When a reaction is at equilibrium, which of the following statements is TRUE?

a) $\Delta G = \Delta G^o$ b) $\ln K_{eq} = 0$ c) $\Delta G^o = 0$ d) $Q = 0$ e) $\Delta G = 0$

Q6. Which of the following statements about a salt bridge in a voltaic cell is TRUE?

a) Free electrons flow through the salt bridge to maintain electrical neutrality in the two half-cells.
b) The salt bridge allows the ions present in the two half-cells to mix extensively.
c) The wire must be connected directly to the salt bridge in order for the salt bridge to be able to maintain electrical neutrality in the two half-cells.
d) In some cases, a salt bridge functions as the anode.
e) Ions from the electrolyte in the salt bridge flow into each half-cell to maintain

Q7. [10 pts.] Balance the following redox reaction in acidic solution using the half-reaction method:

$Fe_3O_4(s) + ClO_3^-(aq) \rightarrow Fe^{3+}(aq) + Cl^-(aq)$

Q8. [10 pts.] Balance the following redox reaction in basic solution using the half-reaction method:

$Cr_2O_7^{2-}(aq) + SO_3^{2-}(aq) \rightarrow Cr^{3+}(aq) + SO_4^{2-}(aq)$

Q9. [10 pts.] Molten NaCl is electrolysed for 3.0 hours using an electrical current of 120 A. How many moles of $Cl_2(g)$ are formed?

Q10. [6 pts.] Calculate $E^\circ$ for the following cell: $Mg(s)\,|\,Mg^{2+}(aq)\,||\,Ag^{+}(aq)\,|\,Ag(s)$

Q11. [10 pts.] Write the cell reaction for the following cell:
$Mg(s)\,|\,Mg^{2+}(aq)\,|\,|\,Ag^{+}(aq)\,|\,Ag(s)$

Q12. [10 pts.] A reaction has $\Delta H^{o} = +30.3$ kJ/mol and $\Delta S^{o} = +320$ J/mol·K. Calculate $\Delta G^{o}$ at 25°C, and 75 °C. At what temperature will the reaction become spontaneous?

Q13. [10 pts.] Predict the sign of $\Delta S^{o}$ (+ve, –ve, ≈0) for the following chemical reactions:

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

b) $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g)$

c) $CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$

Q14. [10 pts.] Determine the cell voltage produced by the following cell *(where the reactants and products are not in their standard states!)* at 298 K:
**Useful Information**: $E^{o}_{Cr^{3+},Cr} = -0.74$ V, $E^{o}_{Cu^{2+},Cu} = +0.34$ V

$Cr(s) \,|\, Cr^{3+}(aq, 0.045\ M) \;\|\; Cu^{2+}(aq, 0.85\ M) \,|\, Cu(s)$

**BONUS QUESTION**: A chemical reaction has $\Delta G^{o} = -3.4$ kJ/mol at 25 °C. What is its equilibrium constant?

## *Useful information*

$\Delta G = -nFE_{cell}$ $\quad \Delta G^{o} = -nFE^{o}_{cell}$ $\quad E^{o}_{cell} = \dfrac{RT}{nF}\ln K$

$E_{cell} = E^{o}_{cell} - \dfrac{RT}{nF}\ln Q$ $\quad E^{o}_{cell} = E^{o}_{cathode} - E^{o}_{anode}$ $\quad F = 96{,}500\ \text{C/mol e}^{-}$

$h = 6.626 \times 10^{-34}\ \text{J}\cdot\text{s}$ $\quad R = 8.3145\ \text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$ $\quad Q\ (\text{charge}) = I \cdot t$

$E = h\nu$ $\quad c = \nu\lambda$ $\quad c = 2.998 \times 10^{8}\ \text{m}\cdot\text{s}^{-1}$ $\quad N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

Periodic Table of the Elements

| 1 | | | | | | | | | | | | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H 1.00794 | 2 | | | | | | | | | | | | | | | | 2 He 4.002602 |
| 3 Li 6.941 | 4 Be 9.012182 | | | | | | | | | | | 5 B 10.811 | 6 C 12.0107 | 7 N 14.00674 | 8 O 15.9994 | 9 F 18.998403 | 10 Ne 20.1797 |
| 11 Na 22.989770 | 12 Mg 24.3050 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 Al 26.981538 | 14 Si 28.0855 | 15 P 30.973762 | 16 S 32.066 | 17 Cl 35.4527 | 18 Ar 39.948 |
| 19 K 39.0983 | 20 Ca 40.078 | 21 Sc 44.95591 | 22 Ti 47.867 | 23 V 50.9415 | 24 Cr 51.9961 | 25 Mn 54.938049 | 26 Fe 55.845 | 27 Co 58.9332 | 28 Ni 58.6934 | 29 Cu 63.546 | 30 Zn 65.39 | 31 Ga 69.723 | 32 Ge 72.61 | 33 As 74.92160 | 34 Se 78.96 | 35 Br 79.904 | 36 Kr 83.80 |
| 37 Rb 85.4678 | 38 Sr 87.62 | 39 Y 88.90585 | 40 Zr 91.224 | 41 Nb 92.90638 | 42 Mo 95.94 | 43 Tc [98] | 44 Ru 101.07 | 45 Rh 102.9055 | 46 Pd 106.42 | 47 Ag 107.8682 | 48 Cd 112.411 | 49 In 114.818 | 50 Sn 118.71 | 51 Sb 121.76 | 52 Te 127.60 | 53 I 126.90447 | 54 Xe 131.29 |
| 55 Cs 132.90545 | 56 Ba* 137.327 | 71 Lu 174.967 | 72 Hf 178.49 | 73 Ta 180.9479 | 74 W 183.84 | 75 Re 186.207 | 76 Os 190.23 | 77 Ir 192.217 | 78 Pt 195.078 | 79 Au 196.96655 | 80 Hg 200.59 | 81 Tl 204.3833 | 82 Pb 207.2 | 83 Bi 208.98038 | 84 Po [210] | 85 At [210] | 86 Rn [222] |
| 87 Fr [223] | 88 Ra** [226] | 103 Lr [262] | 104 Rf [261] | 105 Db [262] | 106 Sg [266] | 107 Bh [264] | 108 Hs [265] | 109 Mt [268] | 110 [269] | 111 [272] | 112 [277] | 113 | 114 [285] | 115 | 116 [289] | 117 | 118 [293] |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | 57 La 138.9055 | 58 Ce 140.116 | 59 Pr 140.90765 | 60 Nd 144.24 | 61 Pm [145] | 62 Sm 150.36 | 63 Eu 151.964 | 64 Gd 157.25 | 65 Tb 158.92534 | 66 Dy 162.50 | 67 Ho 164.93032 | 68 Er 167.26 | 69 Tm 168.93421 | 70 Yb 173.04 |
| ** | 89 Ac [227] | 90 Th 232.0381 | 91 Pa 231.03588 | 92 U 238.0289 | 93 Np [237] | 94 Pu [244] | 95 Am [243] | 96 Cm [247] | 97 Bk [247] | 98 Cf [251] | 99 Es [252] | 100 Fm [257] | 101 Md [258] | 102 No [259] |