# Chemistry 210 Exam 4

Be sure to put your name on each page. This page can be removed from your exam so that you will have a Periodic Table handy throughout the exam, it does not need to be turned in. Show all your work for problems which require any sort of calculation, no credit will be given for answers without work shown. If you have shown a significant amount of work or multiple drawings for a problem, draw a box around what you consider your final answer.

Avogadro's Number = $6.022 \times 10^{23}$ $^{\text{units}}/_{\text{mol}}$
$32.00^{\circ}F = 0.000^{\circ}C = 273.15K$
Density of Water = $1.000\ ^{g}/_{mL}$
$R = 0.08206\ ^{L \cdot atm}/_{mol \cdot K} = 8.314\ ^{J}/_{mol \cdot K}$
1atm = 760torr = 760mmHg = 101.325kPa
PV=nRT
$\Delta T_{fp/bp} = k_{fp/bp} \bullet m \bullet i$
For water: $k_{fp} = -1.86\ ^{^{\circ}C}/_{m}$
$k_{bp} = 0.512\ ^{^{\circ}C}/_{m}$
$P_1 = X_1 P_1^{\circ}$
$\Pi = MRTi$
$C_1V_1 = C_2V_2$
Quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Integrated Rate Laws:

| | |
|---|---|
| $0^{th}$ | $[A]_t = -kt + [A]_o$ |
| $1^{st}$ | $\ln[A]_t = -kt + \ln[A]_o$ |
| $2^{nd}$ | $1/[A]_t = kt + 1/[A]_o$ |

$k = Ae^{-Ea/RT}$

$$\ln(k) = \left(\frac{-E_a}{R}\right)\left(\frac{1}{T}\right) + \ln(A)$$

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$pH = pK_a + \log\left(\frac{[\text{conjugate base}]}{[\text{conjugate acid}]}\right)$$

If you use $C_1V_1 = C_2V_2$ to calculate a titration, you will receive zero points for that problem.

$E_{cell} = E^{\circ}_{cell} - {}^{RT}/_{nF}\ ln Q$
$E^{\circ}_{cell} = {}^{RT}/_{nF}\ ln K^{\circ}$
$K^{\circ} = e\text{^}(\ {}^{nF}/_{RT}\ E^{\circ}_{cell})$
$F = 96485\ ^{J}/_{V \bullet mol\ of\ electrons}$
$\Delta G^{\circ} = \Delta H^{\circ}_{system} - T\Delta S^{\circ}_{system}$
$\Delta G^{\circ} = -nFE^{\circ}_{cell} = -RT ln K^{\circ}$
$\Delta G = \Delta G^{\circ} + RT ln Q$
$F = 96485\ ^{C}/_{mol\ electrons}$
1A = 1 C / sec

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 **H** 1.0079 | | | | | | | | | | | | | | | | | 2 **He** 4.0026 |
| 3 **Li** 6.941 | 4 **Be** 9.0122 | | | | | | | | | | | 5 **B** 10.811 | 6 **C** 12.011 | 7 **N** 14.007 | 8 **O** 15.999 | 9 **F** 18.998 | 10 **Ne** 20.180 |
| 11 **Na** 22.990 | 12 **Mg** 24.305 | | | | | | | | | | | 13 **Al** 26.982 | 14 **Si** 28.086 | 15 **P** 30.974 | 16 **S** 32.066 | 17 **Cl** 35.453 | 18 **Ar** 39.948 |
| 19 **K** 39.098 | 20 **Ca** 40.078 | 21 **Sc** 44.956 | 22 **Ti** 47.88 | 23 **V** 50.942 | 24 **Cr** 51.996 | 25 **Mn** 54.938 | 26 **Fe** 55.847 | 27 **Co** 58.933 | 28 **Ni** 58.69 | 29 **Cu** 63.546 | 30 **Zn** 65.39 | 31 **Ga** 69.723 | 32 **Ge** 72.61 | 33 **As** 74.922 | 34 **Se** 78.96 | 35 **Br** 79.904 | 36 **Kr** 83.80 |
| 37 **Rb** 85.468 | 38 **Sr** 87.62 | 39 **Y** 88.906 | 40 **Zr** 91.224 | 41 **Nb** 92.906 | 42 **Mo** 95.94 | 43 **Tc** (98) | 44 **Ru** 101.07 | 45 **Rh** 102.91 | 46 **Pd** 106.42 | 47 **Ag** 107.87 | 48 **Cd** 112.41 | 49 **In** 114.82 | 50 **Sn** 118.71 | 51 **Sb** 121.76 | 52 **Te** 127.60 | 53 **I** 126.90 | 54 **Xe** 131.29 |
| 55 **Cs** 132.91 | 56 **Ba** 137.33 | 71 **Lu** 174.97 | 72 **Hf** 178.49 | 73 **Ta** 180.95 | 74 **W** 183.84 | 75 **Re** 186.21 | 76 **Os** 190.23 | 77 **Ir** 192.22 | 78 **Pt** 195.08 | 79 **Au** 196.97 | 80 **Hg** 200.59 | 81 **Tl** 204.38 | 82 **Pb** 207.2 | 83 **Bi** 208.98 | 84 **Po** (209) | 85 **At** (210) | 86 **Rn** (222) |
| 87 **Fr** (223) | 88 **Ra** 226.03 | 103 **Lr** (260) | 104 **Rf** (261) | 105 **Db** (262) | 106 **Sg** (263) | 107 **Bh** (262) | 108 **Hs** (265) | 109 **Mt** (266) | 110 **Ds** (269) | 111 **Rg** (272) | 112 **Cn** (277) | 113 | 114 **Fl** | 115 | 116 **Lv** | 117 | 118 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 **La** 138.91 | 58 **Ce** 140.12 | 59 **Pr** 140.91 | 60 **Nd** 144.24 | 61 **Pm** (145) | 62 **Sm** 150.36 | 63 **Eu** 151.97 | 64 **Gd** 157.25 | 65 **Tb** 158.93 | 66 **Dy** 162.50 | 67 **Ho** 164.93 | 68 **Er** 167.26 | 69 **Tm** 168.94 | 70 **Yb** 173.04 |
| 89 **Ac** 227.03 | 90 **Th** 232.04 | 91 **Pa** 231.04 | 92 **U** 238.03 | 93 **Np** 237.05 | 94 **Pu** (244) | 95 **Am** (243) | 96 **Cm** (247) | 97 **Bk** (247) | 98 **Cf** (251) | 99 **Es** (252) | 100 **Fm** (258) | 101 **Md** (258) | 102 **No** (259) |



*Score*

**Multiple Choice (5pts each):** Circle the letter of the most correct response.

1. According to the Lewis definitions of acids and bases:
   a. A base is a source of hydroxide ions
   b. A base accepts electrons
   c. An acid donates $H^+$
   d. An acid accepts electron pairs
   e. A base accepts $H^+$

2. A reaction will be product-favored/spontaneous if:
   a. $\Delta G^o < 0$
   b. $K_{eq} < 1$
   c. $\Delta H > 0$
   d. $\Delta S^o < 0$
   e. $E°_{cell} < 0$

3. In a spontaneous electrochemical voltaic cell, which of the following is ***true***?
   a. The cell potential is zero
   b. Oxidation occurs at the cathode
   c. Electrons flow from the cathode to the anode
   d. Cations flow through the salt bridge from the cathode to the anode
   e. The metal cathode gains mass as the cell reaction proceeds

4. For a spontaneous redox reaction, which of the following is ***false***?
   a. Oxidation is the process of losing electrons
   b. Gaining electrons is reduction
   c. Electrons appear on the left side of the oxidation half reaction
   d. Water molecules are added to balance any extra oxygen atoms
   e. $\Delta G$ is negative.

5. How are the change in Gibb's Free Energy and the equilibrium constant for a reaction related?
   a. As K approaches zero, $\Delta G$ approaches zero
   b. They're not.
   c. The value of $\Delta G$ is equal to (-logK)
   d. As $\Delta G$ gets more positive, K approaches 1
   e. As $\Delta G$ gets more negative, K gets very large

**Problems:**

6. The solubility product constant ($K_{sp}$) for barium nitrate is $4.64 \times 10^{-3}$ at 25°C. What is the concentration of nitrate ions in a saturated solution of barium nitrate at 25°C? (10pts)



*Score*

7. Give the oxidation number for each atom in the following formulas. (10pts each formula)

$K_2SO_3$ $HOCH_2CH_2NH_2$

8. For each of the following pairs of half reactions, predict which would have the more positive standard reduction potential (easier to reduce, harder to oxidize). Explain your prediction. (10pts each)

$S|S^{-2}$ vs $Se|Se^{-2}$

$Cs^{+1}|Cs$ vs $K^{+1}|K$

9. You have combined 50.00mL of 0.794M potassium chloride solution and 50.00mL of 0.837M sodium perchlorate solution. A precipitate forms. What is the precipitate and what is the theoretical yield of the precipitate? (12pts)

$K_{sp}(KClO_4) = 1.05x10^{-2}$; $K_{sp}(NaCl) = 36$

10. You would like to plate some ruthenium (Atomic # = 44) onto a small piece of jewelry. If you submerge the jewelry in 0.582M $Ru(NO_3)_3(aq)$ and pass 1.692amperes through the solution for 1.73 minutes, how many grams of Ru will have plated onto the piece of jewelry? (12 pts)



*Score*

11. For each of the following pairs of half-reactions/half-cells, determine the voltage of the spontaneous reaction/cell and write a balanced equation for the spontaneous reaction, identifying the oxidation and reduction half-reactions. (12pts each)

$Au^{3+}(aq)|Au(s)$ and $Sn^{+2}(aq)|Sn(s)$

$Cr^{3+}(aq)|Cr(s)$ and $Br_2(aq)|Br^{-1}(aq)$

$IO_3^{-1}(aq)|I_2(s)$ and $NiO_2(s)|Ni^{+2}(aq)$

12. What is the expected cell potential of the spontaneous voltaic cell constructed from a 0.882M $Co^{+3}(aq)|Co(s)$ half cell and a 1.518M $Ag^{+}(aq)|Ag(s)$ half cell at 25°C? (15pts)

**Standard Reduction Potentials at 25ºC:**

| **Half cell** | **$E^o_{red}$ (volts)** |
|---|---|
| $Au^{+3}\|Au$ | +1.50 |
| $Sn^{+2}\|Sn$ | -0.136 |
| $Cr^{+3}\|Cr$ | -0.743 |
| $Br_2\|Br^{-1}$ | +1.065 |
| $Ru^{+3}\|Ru$ | +1.052 |

| **Half cell** | **$E^o_{red}$ (volts)** |
|---|---|
| $IO_3^{-1}\|I_2$ | +1.195 |
| $NiO_2\|Ni^{+2}$ | +1.678 |
| $Co^{+3}\|Co$ | +1.632 |
| $Ag^{+1}\|Ag$ | +0.7996 |
| | |



*Score*