Chem 121 **Name** ____________________________________

Exam 4 –May 3, 2006 **Form A -- 100 points**

Multiple Choice: Complete the following, clearly circle the correct answer. (4 pts ea.)

1. Fluoride ion ranks low in the spectrochemical series and produces a weak crystal field in complex ions. Based on this, predict the number of unpaired electrons in CoF_6^{3-}.

   a) 0 b) 1 c) 2 d) 3 e) 4

2. Breeder reactors are used to convert the nonfissionable $^{238}_{92}U$ to a fissionable product. Neutron capture of the $^{238}_{92}U$ is followed by two successive beta decays. What is the final fissionable product?

   a) $^{239}_{94}Pu$ b) $^{235}_{88}Ra$ c) $^{235}_{92}U$ d) $^{238}_{94}Pu$ e) $^{239}_{93}Np$

3. The acids $HC_2H_3O_2$ and HF are both weak but HF is a stronger acid than $HC_2H_3O_2$. HCl is a strong acid. Order the following according to base strength.

   a) $C_2H_3O_2^- > F^- > Cl^- > H_2O$
   b) $Cl^- > F^- > C_2H_3O_2^- > H_2O$
   c) $F^- > C_2H_3O_2^- > H_2O > Cl^-$
   d) $C_2H_3O_2^- > F^- > H_2O > Cl^-$
   e) none of these

4. Calculate the $[H^+]$ in a 0.010 M solution of HCN, $K_a = 6.2 \times 10^{-10}$.

   a) 1.0×10^{-7} M b) 3.6×10^{-3} M c) 6.2×10^{-10} M
   d) 2.5×10^{-6} M e) none of these

5. Which is the correct order for increasing pHs for 0.10 M solutions of HNO_3, KCl, NH_4Cl, KOH, and $NaC_2H_3O_2$? (K_a for $HC_2H_3O_2$ is 1.80×10^{-5}, K_a for NH_4^+ is 5.56×10^{-10}).

   a) KCl, NH_4Cl, HNO_3, KOH, $NaC_2H_3O_2$
   b) HNO_3, KCl, NH_4Cl, KOH, $NaC_2H_3O_2$
   c) NH_4Cl, HNO_3, KCl, KOH, $NaC_2H_3O_2$
   d) HNO_3, NH_4Cl, KCl, $NaC_2H_3O_2$, KOH
   e) none of these

6. A solution contains 0.450 M HA ($K_a = 2.0 \times 10^{-7}$) and 0.250 M NaA. Calculate the pH after 0.050 mole of NaOH is added to 1.00 L of this solution.

   a) 6.83 b) 6.44 c) 6.57 d) 6.70 e) none of these

7. Which of the following compounds has the lowest solubility in mol/L in water?

   a) $Al(OH)_3$, $K_{sp} = 2 \times 10^{-32}$
   b) $PbSO_4$, $K_{sp} = 1.3 \times 10^{-8}$
   c) CdS, $K_{sp} = 1.0 \times 10^{-28}$
   d) $Sn(OH)_2$, $K_{sp} = 3 \times 10^{-27}$

8. If 30 mL of 5.0 x 10^{-4} M $Ca(NO_3)_2$ are added to 70 mL of 2.0 x 10^{-4} M NaF, will a precipitate occur? (K_{sp} of CaF_2 = 4.0 x 10^{-11})

   a) No, because the ion product (Q) is greater than K_{sp}.

   b) Yes, because the ion product (Q) is less than K_{sp}.

   c) No, because the ion product (Q) is less than K_{sp}.

   d) Yes, because the ion product (Q) is greater than K_{sp}.

   e) Not enough information is given.

9. Use the following initial rate data to determine the rate law for the reaction below.

$$CH_3COCH_3 + Br_2 \xrightarrow{H^+} CH_3COCH_2Br + H^+ + Br^-$$

$[CH_3COCH_3]_0$	$[Br_2]_0$	$[H^+]_0$	$\frac{\Delta[Br_2]}{\Delta t}$ (M/s)
1.00	1.00	1.00	4.0 x 10^{-3}
2.00	1.00	1.00	8.0 x 10^{-3}
2.00	2.00	1.00	8.0 x 10^{-3}
1.00	2.00	2.00	8.0 x 10^{-3}

   a) Rate = k$[Br_2][H^+]$

   b) Rate = k$[CH_3COCH_3][H^+]$

   c) Rate = k$[CH_3COCH_3][Br_2][H^+]^2$

   d) Rate = k$[CH_3COCH_3][Br_2]$

   e) Rate = k$[CH_3COCH_3][Br_2][H^+]$

10. If the reaction 2HI → H_2 + I_2 is second order, which of the following will yield a linear plot?

   a) log [HI] vs time   b) 1/[HI] vs time   c) [HI] vs time   d) ln [HI] vs time

11. The reaction: 2A + B → C has the following proposed mechanism:

   Step 1: A + B ⇌ D (fast equilibrium)

   Step 2: D + B → E

   Step 3: E + A → C + B

   If step 2 is the rate-determining step, then the rate of formation of C should equal:

   a) k[A]   b) $k[A]^2[B]^2$ c) $k[A][B]^2$ d) $k[A]^2[B]$ e) k[A][B]

12. The rate constant for a reaction increases from 10.0 s^{-1} to 100. s^{-1} when the temperature is increased from 300° K to 400° K. What is the activation energy for the reaction in kJ/mol?

   a) 23.0   b) 12.7   c) 5.00   d) 18.3   e) 45.6

Transition Metals and Coordination Chemistry. Complete two (2) of problems 13-15. Clearly mark the problem you do not want graded. (14 points each)

13. Briefly compare and contrast each of the terms in the following pairs:

    a. weak-field ligand vs. strong field ligand

    b. low-spin complex vs. high-spin complex

14. Consider the salt $Na[Cr(en)(NH_3)_2I_2]$

    a. Name the anion in this salt.

    b. What is the oxidation state for chromium in this ion? What is the electron configuration for the chromium in this complex ion?

    c. What is the geometry around the chromium ion? What is the coordination number?

15. Consider the two complexes: $[MnCl_6]^{4-}$ and $[Mn(CN)_6]^{4-}$.

a. Given that CN^- is a strong-field ligand and Cl^- is a weak-field ligand, sketch the orbital-energy level diagram for each ion. How many unpaired electrons are in each ion?

b. One of the compounds absorbs red light at 650 nm while the other absorbs blue light at about 450 nm. Which of the ions absorbs red and which absorbs blue? Justify your answer.

Nuclear Chemistry. Complete two (2) of problems 16-18. Clearly mark the problem you do not want graded. (14 points each)

16. Tritium (^3H) decays with a half-life of 12.1 years. The age of a bottle of wine was determined by monitoring the tritium level in the wine. The activity of tritium was found to be 8.3% of that of a sample of fresh grape juice from the same region from which the wine was bottled. How old is the wine?

17. Sketch a diagram of a nuclear power plant and describe the importance of each of the components. What key component is a safety feature whose primary job is to keep the reaction from getting out of control? How does this safety feature do its job?

18. Identify at least two types of processes that are likely to occur when the neutron-to-proton ratio in a nucleus is too low? Justify your response.

Possibly Useful Information

$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

$R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$

$^{o}C = K - 273.15$

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

$\Delta G = \Delta G^{o} - RT\ln Q$

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

$pH + pOH = 14$

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

$K_a K_b = K_w$

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

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

$[R]_t = -kt + [R]_0$

$\ln[R]_t = -kt + \ln[R]_0$

$$\frac{1}{[R]_t} = kt + \frac{1}{[R]_0}$$

$\ln[R]_0 - \ln[R]_t = kt$

$$\frac{1}{[R]_t} - \frac{1}{[R]_0} = kt$$

$$\ln\left(\frac{N}{N_0}\right) = -kt$$

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES
1 H 1.00797																1 H 1.00797	2 He 4.0026
3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183
11 Na 22.9898	12 Mg 24.312											13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	†89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 ? (271)	111 ? (272)	112 ? (277)						

Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

* Lanthanide Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97

† Actinide Series

90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)