Chemistry 142 Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Exam 3 May 2009

 Page 1 (24 points)

 Page 2 (26 points)

 Page 3 (26 points)

 Page 4 (23 points)

 Page 5 (14 points)

Total (113 points)

 Percent (100 %)

**All work must be shown to receive credit. Give all answers to the correct number of significant figures**

**Constants**

|  |  |  |
| --- | --- | --- |
| NA = 6.022 x 1023 mol-1 | h=6.626x10-34 J sec | c=3.00x108 m sec-1 |
| R = 8.3145 J/(mol K) = 0.08206 L atm/(mol K) |  | F = 96,485 C/mol |

**Equations**

|  |  |  |
| --- | --- | --- |
| ΔG = ΔH – TΔS | Δ=hc/λ | ΔGo = = – RT Ln Keq |
| ΔG = –nFE |  | *G* = *G*o + RT ln *Q* |
| pH= -Log[H+] | Ln [A] = Ln [A]o – kt | [A] = [A]o e- kt |
| t1/2 = Ln2/ k | 1 = 1 + 2ktA]2 [A]o2 | Kw=Ka\*Kb |
| PT = P1 + P2 + P3 + .............. | sg = kHPg | x=-b ± (b2 – 4ac)½2a |

**The spectrochemical series:**

I- < Br- < S2- < SCN- < Cl- < NO3- < F- < OH- < C2O42- < H2O < NCS- < CH3CN < NH3 < en < bipy < phen < NO2- < PPh3 < CN- < CO



Grossmont College

Periodic Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  IA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | VIIA | NOBLE GASES |
| 1**H**1.008 | IIA |  |  |  |  |  |  |  |  |  |  | IIIA | IVA | VA | VIA | 1**H**1.008 | 2**He**4.002 |
| 3**Li**6.941 | 4**Be**9.012 |  |  |  |  |  |  |  |  |  |  | 5**B**10.81 | 6**C**12.01 | 7**N**14.01 | 8**O**16.00 | 9**F**19.00 | 10**Ne**20.18 |
| 11**Na**23.00 | 12**Mg**24.30 | IIIB | IVB | VB | VIB | VIIB |  VIII VIII VIII | IB | IIB | 13**Al**27.00 | 14**Si**28.09 | 15**P**30.97 | 16**S**32.06 | 17**Cl**35.45 | 18**Ar**39.95 |
| 19**K**39.10 | 20**Ca**40.08 | 21**Sc**44.96 | 22**Ti**47.90 | 23**V**50.94 | 24**Cr**52.00 | 25**Mn**54.94 | 26**Fe**55.85 | 27**Co**58.93 | 28**Ni**58.70 | 29**Cu**63.55 | 30**Zn**65.38 | 31**Ga**69.72 | 32**Ge**72.59 | 33**As**74.92 | 34**Se**78.96 | 35**Br**79.90 | 36**Kr**83.80 |
| 37**Rb**85.47 | 38**Sr**87.62 | 39**Y**88.91 | 40**Zr**91.22 | 41**Nb**92.91 | 42**Mo**95.94 | 43**Tc**(99) | 44**Ru**101.1 | 45**Rh**102.9 | 46**Pd**106.4 | 47**Ag**107.9 | 48**Cd**112.4 | 49**In**114.8 | 50**Sn**118.7 | 51**Sb**121.8 | 52**Te**127.6 | 53**I**126.9 | 54**Xe**131.3 |
| 55**Cs**132.9 | 56**Ba**137.3 | 57**La**138.9 | 72**Hf**178.5 | 73**Ta**180.9 | 74**W**183.9 | 75**Re**186.2 | 76**Os**190.2 | 77**Ir**192.2 | 78**Pt**195.1 | 79**Au**197.0 | 80**Hg**200.6 | 81**Tl**204.4 | 82**Pb**207.2 | 83**Bi**209.0 | 84**Po**(209) | 85**At**(210) | 86**Rn**(222) |
| 87**Fr**(223) | 88**Ra**226.0 | 89**Ac**227.0 | 104**Rf**(261) | 105**Db**(262) | 106**Sg**(263) | 107**Bh**(262) | 108**Hs**(265) | 109**Mt**(266) | 110**??**(269) |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 58**Ce**140.1 | 59**Pr**140.9 | 60**Nd**144.2 | 61**Pm**(147) | 62**Sm**150.4 | 63**Eu**152.0 | 64**Gd**157.3 | 65**Tb**158.9 | 66**Dy**162.5 | 67**Ho**164.9 | 68**Er**167.3 | 69**Tm**168.9 | 70**Yb**173.0 | 71**Lu**175.0 |
| 90**Th**232.0 | 91**Pa**231.0 | 92**U**238.0 | 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) | 103**Lr**(260) |

Section 1: Multiple Choice (3 pts/question)

1. Molten PbCl2 is subjected to electrolysis in order to form elemental lead and chlorine. Which of the following is true?
2. Elemental chlorine gas is formed at the cathode and bubbles away
3. Elemental lead metal is formed and deposited at the anode
4. Electrons flow from the cathode to the anode
5. Chloride ions are the reducing agents in the reaction
6. none of the above
7. A metal can be protected from corrosion by making it:
8. Either electrode in an electrochemical cell.
9. The electrolyte in an electrochemical cell.
10. The cathode in an electrochemical cell.
11. The anode in an electrochemical cell.
12. none of the above
13. Use Eo value to calculate Ksp of Ni(OH)2 at 25oC (hint one of the electrodes is Ni (s))
14. 2 x10-16 b) 6x1010 c) 30 d) 1 x10-9 e) 4x10-13

1. Rank Sn2+ (aq), I- (aq) and Cu (s) in order of strongest to weakest reducing agent
2. I- (aq) > Sn2+ (aq) > Cu (s) b) Sn2+ (aq) > Cu (s) > I- (aq) c) Cu (s) > I- (aq) > Sn2+ (aq)
3. I- (aq) > Cu (s) > Sn2+ (aq) e) Cu (s) > Sn2+ (aq) > I- (aq)
4. The tetrahedral complex ion [Cu(H2O)4]2+ has magnetic properties that correspond to how many unpaired electrons?

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

1. A bidentate ligand always
2. Has bonds formed to two metal ions
3. Has two donar atoms
4. Has a charge of 2+ or 2-.
5. Forms complex ions with a charge of 2+ or 2-.
6. Has medical uses.
7. A particular complex ion is observed to have a orange red color at approximate wavelength of 630 nm. What is the value of the crystal field splitting energy for this complex

a) 188.5 kJ/mol b) 171 kJ/mol c) 213.8 kJ/mol

d) 278.4 kJ/mol e) 249.3 kJ/mol

1. In the qualitative analysis schemes, initial separation of the metal cations into various groups is based on\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Difference in acid/base properties of the metal cations
3. Amphoteric properties
4. Difference in Ksp values
5. Ability to form ammonia complexes
6. Hydrolysis of the metal cation

Section 2: Short answer/ essay

1. Consider a voltaic cell based on the following unbalanced reaction

Pb (s) + IO3- (aq) 🡪 Pb2+ (s) + I2(s)

1. Write the balanced oxidation and reduction half reactions under acidic conditions (label which is oxidation and which is reduction), the overall reaction equation and calculate Eocell. (9 pts)

Oxidation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Reduction: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Overall Reaction: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Write the line notation for the cell \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (3 pts)
2. Draw a fully labeled Free energy diagram for this reaction at 298 K. Indicate and clearly label on the diagram (i) a point where the reaction is spontaneous, and (ii) the equilibrium point. Explain your logic behind your graph (calculations are not necessary). (6 pts)

Explain:

Free

Energy

Products

Reactants

1. Draw a picture of the cell. Indicate the composition of all parts of the cell, the direction of electron flow, and the direction of ion movements within each compartment. (8 pt)

1. Give the IUPAC name or formula, oxidation state, coordination number and electron configuration (8 pts)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Formula** | **Oxidation #** | **Coordination #** | **Electron Config** |
|  | [Co(en)2(NH3)(CN)] 2+ |  |  |  |
| potassium trichlorosulfatoplatinate(II) |  |  |  |  |

1. How does Crystal Field theory account for the following observations? In each part, ***show* and *explain***the relative positions of the orbital’s and the number of electrons in each.(18 pts)
	1. [Ru(H2O)6]2+ is found to be paramagnetic whereas [Ru(CN)6]4─ is found to be diamagnetic.
	2. The color of a solution of [V(CN)6]4─ ions appears yellow whereas a solution of [V(H2O)6]2+ appears blue.
	3. A solution of [Cd(H2O)6]2+ is colorless.
2. A Zn/Cu ***battery*** is constructed based on the following electrochemical cell in which the volume of solution in each half-cell is 250 mL.

Zn(s) **|** Zn2+ (0.100 M) **||** Cu2+ (1.50 M) **|** Cu(s)

1. This battery is pronounced "dead" when 99 % of its chemical capacity is used up (i.e., when the concentration of Cu2+ has dropped to 1.00 % of its initial value). Calculate the cell potential (in volts) of the battery at this point. (8 pts)
2. Determine the length of time (in hours) that this battery could supply a current of 1.50 amps until it dies (based on the same 99 % definition of "dead"). (6 pts)
3. The following cations Hg22+, Pb2+ and Ag+ are present in solution. List the ions or compounds that would be found from the following observations. (9 pts)
	1. Forms a chloride precipitate that is soluble in or reacts with NaOH solution
	2. Forms a chloride precipitate that is soluble in aqueous ammonia (NH3) solution
	3. Forms a white chloride precipitate, when treated with excess aqueous ammonia (NH3) solution a black precipitate forms
4. Define the following
	1. *geometric isomerism* and *optical isomerism (4pts)*

*geometric isomerism:*

*optical isomerism:*

* 1. Give an example of each using [Pd(C2O4)2Br2]2+. Make sure to give specific labels to each according to the type of isomerism. (6pts)
1. Explain why potassium metal cannot be electroplated from an aqueous solution. (4pts)

**Standard Electrode Potentials in Aqueous Solution at 25°C**

|  |  |  |  |
| --- | --- | --- | --- |
| Cathode (Reduction)Half-Reaction | E° (volts) | Cathode (Reduction)Half-Reaction | E° (volts) |
| Li+(aq) + e- -> Li(s) | -3.04 | Cu+(aq) + e- -> Cu(s) | 0.52 |
| K+(aq) + e- -> K(s) | -2.92 | I2(s) + 2e- -> 2I-(aq) | 0.54 |
| Ca2+(aq) + 2e- -> Ca(s) | -2.76 | ClO2-(aq) + H2O(l) + 2e- -> ClO-(aq) + 2OH-(aq) | 0.59 |
| Mg2+(aq) + 2e- -> Mg(s) | -2.38 | Fe3+(aq) + e- -> Fe2+(aq) | 0.77 |
| Al3+(aq) + 3e- -> Al(s) | -1.66 | Hg22+(aq) + 2e- -> 2Hg(l) | 0.80 |
| 2H2O(l) + 2e- -> H2(g) + 2OH-(aq) | -0.83 | Ag+(aq) + e- -> Ag(s) | 0.80 |
| Zn2+(aq) + 2e- -> Zn(s) | -0.76 | Hg2+(aq) + 2e- -> Hg(l) | 0.85 |
| Cr3+(aq) + 3e- -> Cr(s) | -0.74 | ClO-(aq) + H2O(l) + 2e- -> Cl-(aq) + 2OH-(aq) | 0.90 |
| Ni(OH)2 (s) + 2e- -> Ni(s) + 2OH-(aq) | -0.72 | 2Hg2+(aq) + 2e- -> Hg22+(aq) | 0.90 |
| Fe2+(aq) + 2e- -> Fe(s) | -0.41 | NO3-(aq) + 4H+(aq) + 3e- -> NO(g) + 2H2O(l) | 0.96 |
| Cd2+(aq) + 2e- -> Cd(s) | -0.40 | Br2(l) + 2e- -> 2Br-(aq) | 1.07 |
| Ni2+(aq) + 2e- -> Ni(s) | -0.23 | IO3-(aq) + 6H+(aq) + 5e- -> ½ I2(s) + 3H2O(l) | 1.20 |
| Sn2+(aq) + 2e- -> Sn(s) | -0.14 | O2(g) + 4H+(aq) + 4e- -> 2H2O(l) | 1.23 |
| Pb2+(aq) + 2e- -> Pb(s) | -0.13 | Cr2O72-(aq) + 14H+(aq) + 6e- -> 2Cr3+(aq) + 7H2O(l) | 1.33 |
| Fe3+(aq) + 3e- -> Fe(s) | -0.04 | Cl2(g) + 2e- -> 2Cl-(aq) | 1.36 |
| 2H+(aq) + 2e- -> H2(g) | 0.00 | Ce4+(aq) + e- -> Ce3+(aq) | 1.44 |
| Sn4+(aq) + 2e- -> Sn2+(aq) | 0.15 | MnO4-(aq) + 8H+(aq) + 5e- -> Mn2+(aq) + 4H2O(l) | 1.49 |
| Cu2+(aq) + e- -> Cu+(aq) | 0.16 | H2O2(aq) + 2H+(aq) + 2e- -> 2H2O(l) | 1.78 |
| AgCl(s) + e- -> Ag(s) + Cl-(aq) | 0.22 | Co3+(aq) + e- -> Co2+(aq) | 1.82 |
| Cu2+(aq) + 2e- -> Cu(s) | 0.34 | S2O82-(aq) + 2e- -> 2SO42-(aq) | 2.01 |
| ClO3-(aq) + H2O(l) + 2e- -> ClO2-(aq) + 2OH-(aq) | 0.35 | O3(g) + 2H+(aq) + 2e- -> O2(g) + H2O(l) | 2.07 |
| IO-(aq) + H2O(l) + 2e- -> I-(aq) + 2OH-(aq) | 0.49 | F2(g) + 2e- -> 2F-(aq) | 2.87 |

**Solubility Constants at 25****C**

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Ksp | Name | Ksp |
| Silver chloride | 1.77×10-10 | Manganese (II) hydroxide | 1.6 x 10-13 |
| Barium fluoride | 1.7 x 10-6 | Lead (II) hydroxide | 2.8 x 10-16 |
| Barium phosphate | 6 x 10-39 | Lead (II) phosphate | 3.0 x 10-44 |
| Barium sulfate | 1.1 x 10-10 | Lead (II) Sulfide | 3.2 x 10-28 |
| Cadmium carbonate | 1.0×10-12 | Lead (II) Sulfate | 1.8 x 10-8 |
| Cadmium hydroxide | 7.2×10-15 | Nickel(II) carbonate | 6.6 x 10-9 |
| Cadmium phosphate | 2.53×10-33 | Nickel(II) hydroxide | 2.8 x 10-16 |
| Cadmium sulfide | 1×10-27 | Nickel(II) phosphate | 4.74×10-32 |
| Iron (II) carbonate | 2.1 x 10-11 | Nickel(II) sulfide | 4×10-20 |
| Iron (II) hydroxide | 7.9 x 10-16 | Tin(II) hydroxide | 5.45×10-27 |
| Mercury(I) carbonate | 3.6×10-17 | Tin(II) sulfide | 1×10–70 |
| Mercury(I) chloride | 1.43×10-18 |  |  |

## Formation Constants for Complex Ions at 25 oC.

|  |  |  |  |
| --- | --- | --- | --- |
| Complex Ion | Kf | Complex Ion | Kf |
| [Ag(NH3)2]+ | 1.6×107 | [PbI4]2– | 3.0×104 |
| [Cd(en)3]2+ | 1.2×1012 | [Pb(OH)4]2– | 3.8×1014 |
| [Cd(NH3)4]2+ | 1.3×107 | [Pb(ox)2]2– | 3.5×106 |
| [Ni(CN)4]2– | 2×1031 | [HgCl4]2 |  5.0 x 1015 |
| [Ni(EDTA)]2– | 3.6×1018 | [Hg(NH3)4]2+ 1.8 x 1019 | 1.8 x 1019 |
| [Ni(en)3]2+ | 2.1×1018 | [SnF6]2- | 1.0 x 1025 |
| [Ni(NH3)6]2+ | 5.5×108 | SnS32- | 2.1×1018 |
| [PbCl3]– | 2.4×101 | SnCl62- | 6.8×1029 |
| [Pb(EDTA)]2– | 2×1018 |  |  |