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

Martin Larter

Exam 3 May 2015

 Page 1 (24 points)

 Page 2 (19 points)

 Page 3 (23 points)

 Page 4 (18 points)

 Page 5 (16 points)

Total (100 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 |

**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 (2 pts/question)

1. In which of the following is the oxidation number of the underlined element given **incorrectly**?

|  |  |
| --- | --- |
|  | oxidation number |
| 1. K2Cr2O7
 | +6 |
| 1. Al(OH)4-
 | +3 |
| 1. HIO4
 | +5 |
| 1. (NH4)2SO4
 | +6 |
| 1. HSO3-
 | +4 |

1. What statement is **not true** about standard electrode potentials?
2. Eºcell is positive for spontaneous reactions.
3. Electrons will flow from more negative electrode to more positive electrode.
4. The electrode potential of the standard hydrogen electrode is exactly zero.
5. Eºcell is the difference in voltage between the anode and the cathode.
6. The electrode in any half-cell with a greater tendency to undergo reduction is positively charged relative to the SHE and therefore has a positive Eº
7. Consider a "General Chemistry Battery" in which one beaker contains aqueous tin sulfate (SnSO4) and a tin metal electrode and the other beaker contains aqueous lead sulfate (PbSO4) and a lead metal electrode. Which of the following statements is **false**?
8. The mass of the tin electrode will decrease as the process proceeds (true)
9. Sn2+ (aq) is oxidized (false: Sn is being oxidized to Sn2+)
10. Electrons flow from the tin beaker to the lead beaker (true)
11. Sulfate ions flow through the salt bridge from the lead beaker to the tin beaker (true)
12. The concentration of Pb2+ (aq) decreases as the process proceeds (true)



1. The purpose of the salt bridge in an electrochemical cell is to \_\_\_\_\_\_\_\_\_\_.
2. Provide a source of ions to react at the anode and cathode.
3. Provide oxygen to facilitate oxidation at the anode.
4. Provide a means for electrons to travel from the anode to the cathode.
5. Provide a means for electrons to travel from the cathode to the anode.
6. Maintain electrical neutrality in the half-cells via migration of ions.
7. An electrolytic cell is
8. A battery. (voltaic or galvanic cell)
9. A cell in which the cell reaction is spontaneous. (voltaic or galvanic cell)
10. A cell in which an electric current drives a nonspontaneous reaction.
11. A cell in which reactants are continuously supplied to the cell.
12. All of the above
13. For a reaction in a voltaic cell, both Δ*H*° and Δ*S*° are positive. Which of the following statements is true?
14. *E*°cell will increase with an increase in temperature.
15. *E*°cell will decrease with an increase in temperature.
16. *E*°cell will not change when the temperature increases.
17. Δ*G*° > 0 for all temperatures.
18. None of the above statements is true.

Δ*H*° endothertmic, Δ*S*° more random Δ*G*° = Δ*H*° - T Δ*S*° and Δ*G*° =-nFE°

1. The spectrochemical series
2. Relates the oxidation state of a metal to its color.
3. Lists ligands in order of their tendency to split d-orbitals.
4. Lists coordination compounds in order of their color.
5. Lists complex ions in order of their color.
6. Lists ligands in the order of their color.
7. Consider Na+ (aq), Pb2+ (aq), Cl2 (g), Ag+ (aq), and Li+ (aq). The strongest oxidizing agent is:

|  |  |  |
| --- | --- | --- |
| 1. Na+ (aq)
 | 1. Pb2+ (aq)
 | 1. Cl2 (g)
 |
| 1. Ag+ (aq)
 | 1. Li+ (aq)
 |  |

1. The coordination number for Fe in [Fe(ox)3]3- is: oxalate ion bidentate

|  |  |  |
| --- | --- | --- |
| 1. 1
 | 1. 2
 | 1. 3
 |
| 1. 4
 | 1. 6
 |  |

1. Which of the following statements concerning octahedral complexes is incorrect?
2. Strong field ligands produce large crystal field splitting.
3. Weak field ligands produce high spin complexes.
4. Halide ions are strong field ligands.
5. Weak field ligands result in relatively small values for Δº.
6. A relatively large value for Δº causes a complex ion to absorb relatively high energy (shorter wavelength) light.
7. Which ion would you expect to have the largest crystal field splitting Δ,

|  |  |  |
| --- | --- | --- |
| 1. [Fe(CN)6]4-
 | 1. [Fe(CN)6]3-
 | 1. [Fe(H2O)6]2+
 |
| 1. [Fe(H2O)6]3+
 | 1. They all have relatively the same crystal field splitting
 |

1. The complex:

(A) Is cis-[CoCl3F3]3-

(B) Is trans-[CoCl3F3]3-

(C) Is mer-[CoCl3F3]3-

(D) Is fac-[CoCl3F3]3-

(E) Is enantiomer [CoCl3F3]3-

Section 2: Short answer/ essay

1. The following half-reactions that when combined result in a spontaneous reaction conditions

 NO3- (aq) 🡪 NO (g) E° = +0.96 V Hg22+ (aq) 🡪 Hg­ (l) E° = +0.79 V

1. (8 points) Determine the net ionic equation under acidic conditions and the standard cell potential.

Oxidation: (2 Hg­ (l) 🡪 Hg22+ (aq) + 2 e-) x 3 E° = -0.79 V

Reduction: (NO3- (aq) + 4 H+ (aq) + 3 e- 🡪 NO (g) + 2 H2O (l) ) x 2 E° = +0.96 V

2 NO3­- (aq) + 8 H+ (aq) + 6 Hg (l) 🡪 3 Hg22+ (aq) + 2 NO (g) + 4 H2O (l) E° = 0.17 V

1. (4 points)Write the cell notation for the reaction.

Pt (s) **|** Hg (l) | Hg22+ (aq) || NO3- (aq), H+ (aq) | NO (g) | Pt­ (s)

1. (3 points) What would be the effect on the potential of this cell if the size of the electrode were doubled?

 Increasing the size of the electrode would have no effect on the potential. The solid electrode is not part of the Q or K expression thus there is no effect.

1. (4 points) Calculate the ΔG°( in kJ) and K

$$G^{°}=-nFE^{°}=-\left(6 mol e^{-}\right)\left(96485\frac{C}{mol e^{-}}\right)\left(0.17 V\right)\left(\frac{1 J}{1 C V}\right)\left(\frac{1 kJ}{1000 J}\right)=-98 kJ$$

$$K=e^{-\frac{∆G^{°}}{RT}}=e^{- \frac{-98 kJ}{\left(8.314\frac{J}{mol K}\right)(298 K)}×\frac{1000 J}{1 kJ}}=1.5×10^{17}$$

1. (6 points) Determine the potential for the reaction at 298 K when the concentrations of the reactants and products are as follows: [NO3­-] = 0.150 M, [Hg22+] = 0.356 M, PNO= 0.211 atm, and pH 1.00.

$$E\_{cell}=E^{°}-\frac{RT}{nF}lnQ=E^{°}-\frac{RT}{nF}ln\left(\frac{[Hg\_{2}^{2+}]^{3} \left(P\_{NO}\right)^{2}}{[NO\_{3}^{-}]^{2}[H^{+}]^{8}}\right)$$

$$E\_{cell}=0.17 V-\frac{\left(8.3125\frac{J}{mol K}\right)\left(298 K\right)}{\left(6 mol e^{-}\right)\left(96485\frac{C}{mol e^{-}}\right)}ln\left(\frac{(0.356 M)^{3}(0.211 atm)^{2}}{(0.100 M)^{8}(0.150 M)^{2}}\right)$$

$$E\_{cell}=0.17 V-0.068 V=0.10 V$$

1. (3 points) What would be the effect on the potential of this cell if sodium sulfide was added to the Hg22+half-cell and Hg2S were precipitated? Why?

The addition of sulfide would result in the reduction of the concentration of mercury (I) ions. This would cause Q to decrease which would cause ln Q to become negative which would cause E cell to increase (become more positive).

1. (10 points) An unknown metal M is electrolyzed. It took 74.1 s for a current of 2.00 amp to plate out 0.107 g of the metal from a solution containing M(NO3)3. Identify the metal

$$74.1\sec( × \frac{2.00 C}{sec}) × \frac{1mole e^{-} }{96,485 C} × \frac{1mole metal }{3 mole e^{-}}= $$

$$Molar mass= \frac{0.107 g M}{5.10 x10^{–4}mol M}=209.8\frac{g}{mol} ≈210.\frac{g}{mol}$$

$$ $$

$$metal = Bi$$

1. (4 points) Write proper name or formula for each of the following complexes.

|  |  |
| --- | --- |
| [Co(NH3)5Cl](NO3)2 | pentaamminechlorocobalt (III) nitrate |
| K3[Fe(CN)₂(C₂O₄)₂] | potassium dicyanobis(oxalato)ferrate(III) |

1. (8 points) For Mn(en)(NH3)2Br2 complexes, draw clear, 3-dimensional structures of all possible isomers (geometric and/or optical). Also write the term that best describes the structure (i.e., tetrahedral, linear, etc.). (en = ethylenediamine) Points will be deducted if the same structure is drawn more than once

 

1. (6 points) The [Ti(NCS)6]3- ion exhibits a single absorption band at 544 nm.
	1. Calculate the crystal field splitting Δ in kJ/mol.

$$∆=\frac{hc}{λ}=\frac{\left(6.626×10^{-34}J s\right)(3.00 ×10^{8}\frac{m}{s})}{(544 nm ion)}×\frac{10^{9} nm}{1m}×\frac{1 kJ}{1000 J}×\frac{6.022×10^{23} ions}{1 mol}=220\frac{kJ}{mol}$$

* 1. Predict the color of this complex and why.

544 nm is absorbing in the green wavelength, so the compound would be reflecting red wavelength.

Ti+ = [Ar]3d1 and the electron is going to have a large delta transition

1. (4 points) Suggest a chemical test for distinguishing between [Ni(NO3)(en)2]Cl3 and [NiCl3(en)2]NO3. Explain your answer

Add AgNO3, [Ni(NO3)(en)2]Cl3 will precipitate of AgCl, (remember reaction only occur with the counter ion) while NiCl3(en)2]NO3will not.

1. Answer the following for the weak field complex [MnI6]4-, and the strong field complex [Mn(CN)6]4-

 a. (6 points) Sketch the orbital energy level diagrams.

Mn: [Ar] 4s2 3d5

Mn2+: [Ar] 3d5

 \_\_ \_\_

 ↑ ↑

 ↑ ↑ ↑ ↑↓ ↑↓ ↑

 [MnI6]4- [Mn(CN)6]4-

* + 1. (3 points) Are the complex ions paramagnetic or diamagnetic?

[MnI6]4- \_\_\_ paramagnetic \_\_\_ [Mn(CN)6]4-\_\_\_ paramagnetic \_\_\_

* + 1. (3 points) What is the hybridization of [MnI6]4- \_\_sp3d2\_\_\_\_\_
		2. (4 points) Which complex **transmits** the longer wavelengths of incident electromagnetic radiation? Explain your reasoning.

 Strong field ligands absorb shorter wavelength light, therefore [Mn(CN)6]4- transmits longer wavelengths.

**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 | Br2(l) + 2e- -> 2Br-(aq) | 1.07 |
| Fe2+(aq) + 2e- -> Fe(s) | -0.41 | IO3-(aq) + 6H+(aq) + 5e- -> ½ I2(s) + 3H2O(l) | 1.20 |
| Cd2+(aq) + 2e- -> Cd(s) | -0.40 | O2(g) + 4H+(aq) + 4e- -> 2H2O(l) | 1.23 |
| Ni2+(aq) + 2e- -> Ni(s) | -0.23 | Cr2O72-(aq) + 14H+(aq) + 6e- -> 2Cr3+(aq) + 7H2O(l) | 1.33 |
| Sn2+(aq) + 2e- -> Sn(s) | -0.14 | Cl2(g) + 2e- -> 2Cl-(aq) | 1.36 |
| Pb2+(aq) + 2e- -> Pb(s) | -0.13 | Ce4+(aq) + e- -> Ce3+(aq) | 1.44 |
| Fe3+(aq) + 3e- -> Fe(s) | -0.04 | MnO4-(aq) + 8H+(aq) + 5e- -> Mn2+(aq) + 4H2O(l) | 1.49 |
| 2H+(aq) + 2e- -> H2(g) | 0.00 | H2O2(aq) + 2H+(aq) + 2e- -> 2H2O(l) | 1.78 |
| Sn4+(aq) + 2e- -> Sn2+(aq) | 0.15 | Co3+(aq) + e- -> Co2+(aq) | 1.82 |
| Cu2+(aq) + e- -> Cu+(aq) | 0.16 | S2O82-(aq) + 2e- -> 2SO42-(aq) | 2.01 |
| AgCl(s) + e- -> Ag(s) + Cl-(aq) | 0.22 | O3(g) + 2H+(aq) + 2e- -> O2(g) + H2O(l) | 2.07 |
| Cu2+(aq) + 2e- -> Cu(s) | 0.34 | F2(g) + 2e- -> 2F-(aq) | 2.87 |
| ClO3-(aq) + H2O(l) + 2e- -> ClO2-(aq) + 2OH-(aq) | 0.35 |  |  |
| IO-(aq) + H2O(l) + 2e- -> I-(aq) + 2OH-(aq) | 0.49 |  |  |