MC, Chem1B, Fall11, Lec Exam3 Name_____

Read questions **carefully** to **understand what is being asked,** before answering. No outside paper is allowed. Use the reverse side of your answer paper as scratch. Use the important equation table and periodic table provided. (Total points = 62 + 39 + 9 = 110).

Show your calculation first with set up equation. Then use the raw data with units in the equation in the equation and then complete the calculation.

1) The following information is available for the reaction at 25°C: 1) _____

	$CaCO_3$ (s) ---->	CaO (s) +	CO_2 (g)
$\Delta G_f°$ (kJ/mol)	-1129.16	-603.42	-394.36
$\Delta H_f°$ (kJ/mol)	-1207.6	-635.09	-393.51
$S_f°$ (J/K.mol)	91.7	38.2	213.74

(a) Calculate the Gibbs free energy change of the reaction (3pts.) .

(b) Calculate the temperature in °C when the reaction will be favorable (5 pts.).

2) The standard entropy of formation of $SiCl_4(g)$, is -134.1 J/K·mol. 2) _____

$Si(s) + 2\ Cl_2\ (g) \rightarrow SiCl_4\ (g)$

Calculate the standard molar entropy of $SiCl_4(g)$ given: S°[Si(s)] = 18.8 J/K·mol-rxn and S°[Cl2(g)] = 223.1 J/K·mol-rxn. (6 pts.)

3) Given: 3) _____

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta G^0 = -394.4$ kJ

$2\,CO(g) + O_2(g) \rightarrow CO_2(g)$ $\Delta G^0 = -514.4$ kJ

Calculate the standard free energy of formation of CO (8 pts.):

$C(s) + 1/2\,O_2(g) \rightarrow CO(g)$

4) A voltaic cell using the reaction below, has a standard cell potential of +1.19 V: 4) _____

$Tl^{3+}(aq) + 2\,Cr^{2+}(aq) \longrightarrow Tl^{+}(aq) + 2\,Cr^{3+}(aq)$

(a) Write the cathode cell reaction (2pt):

(b) Write the anode cell reaction (2pt):

(c) If $Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$ has $E_{red}^0 = -0.43$ V; then calculate the E_{red}^0 for reduction of $Tl^{3+}(aq)$ to $Tl^{+}(aq)$ (4pt):

(d) **Draw** a diagram of the voltaic cell. Make sure to
(a) **label** the **cathode** (1pt)
(b) **label** the **anode** (1pt)
(c) **indicate the direction** of electron flow outside the cell (1pt)
(d) **show** salt bridge (1pt)
(e) **show** direction of flow of cation along the salt bridge (1pt)
(f) **show** direction of flow of anion along the salt bridge (1pt)

5) The standard cell potential (E°) of a voltaic cell constructed using the cell reaction below is 0.76 V: 5) _____

$$Zn\ (s) + 2H^+\ (aq) \rightarrow Zn^{2+}\ (aq) + H_2\ (g)$$

With $P_{H_2} = 1.0$ atm and $[Zn^{2+}] = 1.0$ M, the cell potential is 0.66 V. **Show set up and all your work** to calculate the concentration of H^+ in the cathode compartment (10 pts.).

6) For the cell reaction : 6) _____

$$3\ Ni^{2+}\ (aq) + 2\ Cr(OH)_3(s) + 10\ OH^-(aq) \text{ ---> } 3\ Ni\ (s) + 2\ CrO_4^{2-}\ (aq) + 8\ H_2O\ (l);$$

Given: $CrO_4^{2-}\ (aq) + 4\ H_2O\ (l) + 3\ e^- \text{ ---> } Cr(OH)_3(s) + 5\ OH^-(aq)$ $E^0_{red} = -0.13$ V;

$Ni^{2+}\ (aq) + 2e^- \text{ ---> } Ni\ (s)$ $E^0_{red} = -0.28$ V;

(a) Calculate the E^0 at T = 298 K (4 pts.)

(b) Calculate the standard free energy change ΔG^0 at T = 298 K for the above reaction (6 pts.);

(c) Calculate the equilibrium constant, K at T = 298 K for the above reaction (6 pts.);

MULTIPLE CHOICE. Please answer on your scantron starting at bubble 7. Show your work to select the one response that best completes the statement or answers the question (3 pts each).

7) _____ electrons appear in the following half-reaction when it is balanced. 7) _____

$$S_4O_6^{2-} \rightarrow 2S_2O_3^{2-}$$

A) 2 B) 3 C) 4 D) 1 E) 6

8) What is the oxidation number of nitrogen in the HNO_3? 8) _____

A) +5 B) +7 C) -1 D) +1 E) +3

9) The half-reaction occurring at the anode in the balanced reaction shown below is _____. 9) _____

$$3MnO_4^-(aq) + 24H^+(aq) + 5Fe(s) \rightarrow 3Mn^{2+}(aq) + 5Fe^{3+}(aq) + 12H_2O(l)$$

A) $2MnO_4^-(aq) + 12H^+(aq) + 6e^- \rightarrow 2Mn^{2+}(aq) + 3H_2O(l)$

B) $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$

C) $Fe(s) \rightarrow Fe^{3+}(aq) + 3e^-$

D) $MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

E) $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

10) In a voltaic cell lab experiment the E_{red} of an Al electrode was found to be -0.515 V relative to Cu, which acted as a refenece cell. The E_{cell} is 10) _____

A) - 1.018 V B) + 0.515 V C) + 1.018 V D) - 0.515 V

Table 20.2

Half-reaction	E° (V)
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$	-0.74
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	-0.440
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(s)$	+0.771
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	+0.154

11) Which of the following reactions will occur spontaneously as written? 11) _____

A) $Sn^{4+}(aq) + Fe^{2+}(s) \rightarrow Sn^{2+}(aq) + Fe(s)$

B) $2Cr(s) + 3Fe^{2+}(s) \rightarrow 3Fe(s) + 2Cr^{3+}(aq)$

C) $2Cr^{3+}(aq) + 3Sn^{2+}(aq) \rightarrow 3Sn^{4+}(aq) + 2Cr(s)$

D) $Sn^{2+}(aq) + Fe^{2+}(s) \rightarrow Sn^{4+}(aq) + Fe^{3+}(aq)$

E) $3Fe^{2+}(aq) + Cr^{3+}(aq) \rightarrow Cr(s) + 3Fe^{3+}(aq)$

12) The standard cell potential ($E°_{cell}$) for the voltaic cell based on the reaction below is _____ V. 12) _____

$Sn^{2+}(aq) + 2Fe^{3+}(aq) \rightarrow 2Fe^{2+}(aq) + Sn^{4+}(aq)$

A) +1.21 B) +0.617 C) +0.46 D) +1.39 E) −0.46

13) The reduction half reaction occurring in the standard hydrogen electrode is _____. 13) _____

A) H_2 (g, 1 atm) → $2H^+$ (aq, 1M) + $2e^-$

B) $2H^+$ (aq) + $2OH^-$ → H_2O (l)

C) $2H^+$ (aq, 1M) + Cl_2 (aq) → 2HCl (aq)

D) $2H^+$ (aq, 1M) + $2e^-$ → H_2 (g, 1 atm)

E) O_2 (g) + $4H^+$ (aq) + $4e^-$ → $2H_2O$ (l)

14) The standard cell potential ($E°_{cell}$) for the reaction below is +1.10 V. The cell potential for this reaction is _____ V when the concentration of $[Cu^{2+}] = 1.0 \times 10^{-5}$ M and $[Zn^{2+}] = 1.0$ M. 14) _____

$Zn(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Zn^{2+}(aq)$

A) 0.95 B) 0.80 C) 1.25 D) 1.10 E) 1.40

15) The thermodynamic quantity that expresses the degree of disorder in a system is _____. 15) _____

A) bond energy
B) entropy
C) internal energy
D) enthalpy
E) heat flow

16) The normal boiling point of water is 100.0°C and its molar enthalpy of vaporization is 40.67 kJ/mol. What is the change in entropy in the system in J/K when 39.3 grams of steam at 1 atm condenses to a liquid at the normal boiling point? 16) _____

A) 373 B) 88.8 C) −40.7 D) −88.8 E) −238

17) ΔS is positive for the reaction _____. 17) _____

A) $2NO_2$ (g) → N_2O_4 (g)

B) 2Hg (l) + O_2 (g) → 2HgO (s)

C) BaF_2 (s) → Ba^{2+} (aq) + $2F^-$ (aq)

D) CO_2 (g) → CO_2 (s)

E) $2H_2$ (g) + O_2 (g) → $2H_2O$ (g)

18) Of the following, the entropy of _____ is the largest. 18) _____

A) HCl (s) B) HCl (g) C) HCl (l) D) HBr (g) E) HI (g)

19) The standard Gibbs free energy of formation of _____ is zero. 19) _____

(a) H_2O (l)
(b) Na (s)
(c) H_2 (g)

A) (a) only
B) (b) only
C) (c) only
D) (b) and (c)
E) (a), (b), and (c)

TRUE/FALSE. Select A in the scantron if the statement is TRUE and B if the statement is FALSE (3 pts).

20) The standard reduction potential, E^{o}_{red}, is proportional to the stoichiometric coefficient. T or F

21) The entropy of a pure crystalline substance at 0°C is zero. T or F

22) The more negative ΔG° is for a given reaction, the larger the value of the corresponding equilibrium constant, K. T or F

Show your calculation first with set up equation. Then use the raw data with units in the equation in the equation and then complete the calculation.

23) **Extra Point Question:** 23) _____

Given Cl_2 (g) + 2 e⁻ --> 2 Cl^- (aq) E^0 = + 1.36 V

I_2 (s) + 2 e⁻ --> 2 I^- (aq) E^0 = + 0.54 V

Use above information for the redox reaction Cl_2 (g) + 2 I^- (aq) -> 2 Cl^- (aq) + I_2 (s) and write the

(i) cathode half reaction (2 pts.)

(ii) anode half reaction (2 pts.)

(iii) Show all your quantitave work to decide if the above redox reaction is spontaneous or not. (4 pts):

PERIODIC TABLE OF THE ELEMENTS

	1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 H 1.0079	2 2A																2 He 4.0026
2	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
3	11 Na 22.990	12 Mg 24.305	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
4	19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
5	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
6	55 Cs 132.91	56 Ba 137.33	57 - 71 La-Lu	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)
7	87 Fr (223)	88 Ra (226)	89 -103 Ac-Lr	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Uuu (272)	112 Uub (285)		114 Uuq (289)				

Lanthanide	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 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
Actinide	89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	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 (262)

Some Constants & Conversion Factors:

(**1**) Avogadro number: N = 6.022 x 10^{23}/mole (**2**) Planck's constant: h = 6.626 x 10^{-34} J.sec

(**3**) Gas Constant: R = 0.0821atm L/mol K or R = 8.3145J/mol K; (**4**) Speed of Light: c = 2.997 x 10^{8} m/sec

(**5**) Electronic Charge: e = 1.602 x 10^{-19} Coulomb (**6**) π $\pi = 3.14159$

(**7**) 1 joule = 1 kg. m^2/s^2 = 0.239 calorie = (1 coulomb) x (1 volt); (**8**) 1 calorie = 4.184 joules (**9**) Faraday's Constant: F = 9.648 x 10^{4} coulomb /mol electron; (**10**) 1 pascal = 1 Newton / m^2 = 1 kg/m.s^2; (**11**) 1 atm = 760mm Hg = 760 torr (**12**) K = °C + 273.15 °C; (**13**) °C /5 = (°F – 32) / 9 (**14**) 1 m = 100 cm; (**15**) 1 nm = 10^{-9} m; (**16**) 1 pm = 10^{-12} m; (**17**) 1 L = 1000 cm^3 (**18**) 1 kg = 10^{3} g; (**19**) 1 g = 10^{3} mg; (**20**) 1lb = 453.6g.