

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 = 6.022×10^{23} units/mol

$32.00^\circ\text{F} = 0.000^\circ\text{C} = 273.15\text{K}$

Density of Water = 1.000 g/mL

$R = 0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K} = 8.314 \text{ J}/\text{mol}\cdot\text{K}$

$PV = nRT$

$\Delta T_{\text{fp/bp}} = k_{\text{fp/bp}} \cdot m \cdot i$

For water, $k_{\text{fp}} = -1.86^\circ\text{C}/m$; $k_{\text{bp}} =$

$0.52^\circ\text{C}/m$

$P_1 = X_1 P_1^\circ$

$P = cRT$

$C_1 V_1 = C_2 V_2$

Quadratic formula:

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

Integrated Rate Laws:

$$\ln[A]_t = -kt + \ln[A]_o$$

$$1/[A]_t = kt + 1/[A]_o$$

$$[A]_t = -kt + [A]_o$$

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

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

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

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

$$E_{\text{cell}} = E_{\text{cell}}^\circ - \frac{RT}{nF} \ln Q$$

$$E_{\text{cell}}^\circ = \frac{RT}{nF} \ln K^\circ$$

$$K^\circ = e^{(nF/RT) E_{\text{cell}}^\circ}$$

$$F = 96485 \text{ J}/\text{V}\cdot\text{mol of electrons}$$

$$\Delta G^\circ = \Delta H^\circ_{\text{system}} - T\Delta S^\circ_{\text{system}}$$

$$\Delta G^\circ = -nFE_{\text{cell}}^\circ = -RT \ln K^\circ$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$$F = 96485 \text{ C}/\text{mol electrons}$$

$$1A = 1 \text{ C} / \text{sec}$$

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	57 La 138.91	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	89 Ac 227.03	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)			114			116				

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	71 Lu 174.97
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)	103 Lr (260)

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Multiple Choice (5pts each)

1. The symbol ΔS represents:
 - a. Change in entropy
 - b. Change in solubility
 - c. Change in enthalpy
 - d. Change in free energy
 - e. Change in time

2. A small positive change in free energy means:
 - a. The reaction is very slow
 - b. The reaction is endothermic
 - c. The reaction is not spontaneous
 - d. The system is becoming more disordered
 - e. The reaction is spontaneous

3. For a reaction with a large negative ΔS :
 - a. Heat is required to make the reaction proceed
 - b. The system is becoming much more ordered
 - c. The reaction is not spontaneous
 - d. The disorder of the system is increasing
 - e. The reaction proceeds very slowly

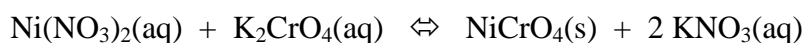
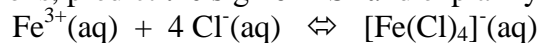
4. A reaction will be product-favored/spontaneous/naturally occurring if:
 - a. $\Delta G^\circ < 0$
 - b. $K_{eq} < 1$
 - c. $\Delta H > 0$
 - d. $\Delta S^\circ < 0$
 - e. $K_{eq} < 0$

5. A reaction will be spontaneous at all temperature if:
 - a. $\Delta H^\circ_{system} > 0$ and $\Delta S^\circ_{system} > 0$
 - b. $\Delta H^\circ_{system} = 0$ and $\Delta S^\circ_{system} > 0$
 - c. $\Delta H^\circ_{system} > 0$ and $\Delta S^\circ_{system} = 0$
 - d. $\Delta H^\circ_{system} > 0$ and $\Delta S^\circ_{system} < 0$
 - e. $\Delta H^\circ_{system} < 0$ and $\Delta S^\circ_{system} < 0$

6. If the change in enthalpy for a reaction is positive and the change in entropy is negative:
 - a. The reaction releases heat
 - b. The reaction will never be spontaneous
 - c. The system is becoming more disordered
 - d. The reaction will always be spontaneous
 - e. The reaction will be spontaneous only at low temperatures

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

8. For each of the following reactions, predict the sign of ΔS° and explain your answer (6pts each):



9. You are studying the reaction of aspirin $\{\text{C}_9\text{H}_8\text{O}_4(\text{s})\}$ with caffeine $\{\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2(\text{s})\}$ to produce aspeine $\{\text{C}_9\text{H}_{10}\text{N}_2\text{O}_3(\text{s})\}$ and caffirin $\{\text{C}_8\text{H}_8\text{N}_2\text{O}_3(\text{s})\}$. The temperature in your laboratory is 18.57°C and you find that ΔG for this reaction is -9.451 kJ/mol . You have also determined that for this reaction $\Delta S = +87.38 \text{ J/mol}\cdot\text{K}$ (20pts)
- a. Is the reaction endothermic or exothermic? (*Explain your answer with explicit calculations.*)

b. Over what temperature range is this reaction spontaneous?

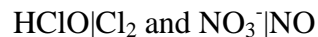
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10. Propane { $C_3H_8(g)$ } reacts with oxygen gas in gas grills to produce carbon dioxide gas, water gas and heat. How much energy is released by burning 54.938g of propane in an unlimited supply of oxygen? If all of this energy is used to decompose silver chloride solid to chlorine gas and silver metal, how many grams of silver metal can be produced? (25pts)

11. You would like to plate 2.18g of platinum (atomic # = 78) using an electrolytic cell containing a solution of platinum(II) nitrate and operating at 5.16A. How long will you have to run the cell? (15pts)

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12. 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 reaction that occurs, identifying the oxidation and reduction half-reactions. (20pts each)


Thermodynamic Values at 25°C:

Substance	ΔH°_f (kJ/mol)	S° (J/mol·K)	ΔG°_f (kJ/mol)
$\text{C}_3\text{H}_8(\text{g})$	-103.85	270.3	-23.4
$\text{O}_2(\text{g})$	0	205.138	0
$\text{CO}_2(\text{g})$	-393.509	213.74	-394.359
$\text{H}_2\text{O}(\text{g})$	-241.8	188.8	-228.6
$\text{AgCl}(\text{s})$	-127.0	96.3	-109.8
$\text{Cl}_2(\text{g})$	0	223.1	0
$\text{Ag}(\text{s})$	0	42.6	0

Standard Reduction Potentials at 25°C:

Half cell	E°_{red} (volts)	Half cell	E°_{red} (volts)
$\text{Pt}^{2+}(\text{aq}) \text{Pt}(\text{s})$	+0.76	$\text{HClO}(\text{aq}) \text{Cl}_2(\text{g})$	+1.61
$\text{La}^{3+}(\text{aq}) \text{La}(\text{s})$	-2.38	$\text{NO}_3^-(\text{aq}) \text{NO}(\text{g})$	+0.96
$\text{Sn}^{4+}(\text{aq}) \text{Sn}^{2+}(\text{aq})$	+0.15		