

Chem 130
Exam 3, Ch 7, 19, and a little 14
100 Points

Name _____
November 11, 2011

Please follow the instructions for each section of the exam. Show your work on all mathematical problems. Provide answers with the correct units and significant figures. Be concise in your answers to discussion questions.

Part 0: Warmup. 4 points each

1. A spontaneous process:
 - a. will happen quickly.
 - b. releases large amounts of energy.
 - c. will continue on its own once begun.
 - d. is never endothermic.Answer _____
2. Reactions with a positive ΔH° and a negative ΔS° are:
 - a. spontaneous at all temperatures.
 - b. non-spontaneous at all temperatures.
 - c. spontaneous at low temperatures but non-spontaneous at high temperatures.
 - d. non-spontaneous at low temperatures but spontaneous at high temperatures.Answer _____
3. The reaction $A + B \rightarrow C + D$ is second order in A and zero order in B. The value of k is $0.012 \text{ M}^{-1}\text{min}^{-1}$. What is the rate of this reaction when $[A] = 0.235 \text{ M}$ and $[B] = 0.125 \text{ M}$?
 - a. $6.6 \times 10^{-4} \text{ M min}^{-1}$
 - b. $2.8 \times 10^{-3} \text{ M min}^{-1}$
 - c. $1.9 \times 10^{-4} \text{ M min}^{-1}$
 - d. $1.5 \times 10^{-3} \text{ M min}^{-1}$Answer _____

Part I: Complete all of problems 3-8. 12 points each.

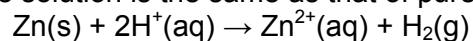
4. For each of the statements below, indicate whether the statement is CORRECT or INCORRECT and justify your choice in no more than two sentences for each item.
 - a. As temperature in a gas decreases, ΔS is positive.
 - b. As two gases mix, ΔS is positive.
 - c. Molecules in a liquid state have higher entropy than molecules in the gaseous state.

Form B

5. Determine ΔH° for the reaction $\text{N}_2\text{H}_4(\text{l}) + 2\text{H}_2\text{O}_2(\text{l}) \rightarrow \text{N}_2(\text{g}) + 4\text{H}_2\text{O}(\text{l})$ from these data:

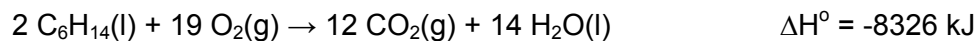
Reaction	ΔH°
$\text{N}_2\text{H}_4(\text{l}) + \text{O}_2(\text{g}) \rightarrow \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$	-622.2 kJ
$\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$	-285.8 kJ
$\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}_2(\text{l})$	-187.8 kJ

6. A coffee-cup calorimeter contains 100.0 mL of 0.300 M HCl at 20.3°C. When 1.82 g zinc metal also at 20.3°C is added and is allowed to react, the temperature rises to 30.5°C. What is the heat of reaction per mole of Zn? Assume no heat is lost during the course of the reaction and that the heat capacity and the density of the solution is the same as that of pure water.



Form B

7. Determine the standard enthalpy of formation of hexane, $\text{C}_6\text{H}_{14}(\text{l})$, from the information below. Report your result in units of kJ per mole of hexane.



Species	$\Delta H^\circ_f, \text{kJ mol}^{-1}$	$S^\circ, \text{J mol}^{-1} \text{K}^{-1}$	$\Delta G^\circ_f, \text{kJ mol}^{-1}$
$\text{O}_2(\text{g})$	0	205.1	0
$\text{H}_2(\text{g})$	0	130.7	0
$\text{C}(\text{s, graphite})$	0	5.74	0
$\text{CO}_2(\text{g})$	-393.5	213.7	-394.4
$\text{H}_2\text{O}(\text{l})$	-285.8	69.91	-237.1
$\text{H}_2\text{O}(\text{g})$	-241.8	188.8	-228.6

8. For the reaction, $2 \text{NO}(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2 \text{NOCl}(\text{g})$, $\Delta H^\circ = -40.9 \text{ kJ}$. At what temperatures do you expect the reaction to be spontaneous: high, low, all, or none? Justify your answer.

Part II. Answer two (2) of problems 9-11. Clearly mark the problems you do not want graded. 15 points each.

9. The initial rate of the reaction $A + B \rightarrow C + D$ is determined for different initial conditions, with the results listed in the table below. Determine the rate law and the rate constant for the reaction.

Experiment	[A], M	[B], M	Initial Rate (Ms^{-1})
1	0.0133	0.0185	3.35×10^{-4}
2	0.0133	0.0370	6.75×10^{-4}
3	0.0266	0.0370	2.70×10^{-3}
4	0.0266	0.0185	1.35×10^{-3}

Form B

10. Sketch two reaction coordinate diagrams below. For the first diagram, illustrate a generic reaction that is non-spontaneous and fast in the forward direction. For the second, illustrate a generic reaction that is spontaneous and slow in the forward direction. Clearly label your plots. For each diagram, include a brief description of how it satisfies the spontaneity and speed of the reaction requirements.

Form B

11. Consider the reaction $\text{N}_2\text{O}(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{NH}_4\text{NO}_3(\text{s})$ at 298K.

Species	ΔH°_f , kJ mol ⁻¹	S° , J mol ⁻¹ K ⁻¹	ΔG°_f , kJ mol ⁻¹
O ₂ (g)	0	205.1	0
H ₂ (g)	0	130.7	0
NH ₄ NO ₃ (s)	-365.6	151.1	-183.9
N ₂ O(g)	82.05	219.9	104.2
H ₂ O(l)	-285.8	69.91	-237.1
H ₂ O(g)	-241.8	188.8	-228.6

- Is the forward reaction exothermic or endothermic?
- What is the value of ΔG° at 298 K?
- Does the reaction occur spontaneously at temperatures above 298 K, below 298 K, both, or neither? Justify your answer.

Form B
Possibly Useful Information

$\Delta G = \Delta H - T\Delta S$	$^{\circ}\text{C} = \text{K} - 273.15$
$q_{\text{rxn}} = n\Delta H_{\text{rxn}}$	$q = mc\Delta T$
Don't eat the yellow snow!	$q_{\text{released}} = -q_{\text{absorbed}}$

Compound	Molar Mass (g/mol)	Compound	Molar Mass (g/mol)
H ₂ O	18.0153	C ₆ H ₁₄	86.177
H ₂ O ₂	34.0147	CO ₂	44.010
HCl	36.4606	N ₂ H ₄	32.0452
H ₂	2.01588	NH ₄ NO ₃	80.0434
N ₂	28.0135	N ₂ O	44.0129
O ₂	31.9988	NO	30.0061
Cl ₂	70.9054	NOCl	65.4588

Material	Specific Heat Capacity (J/gK)
H ₂ O (s)	2.050
H ₂ O (l)	4.184
H ₂ O (g)	2.080
Zn(s)	0.390

1																	18
1A																	8A
<div><div>1</div><div>H</div><div>1.00794</div></div>	2											13	14	15	16	17	<div><div>2</div><div>He</div><div>4.00260</div></div>
2A											3A	4A	5A	6A	7A		
<div><div>3</div><div>Li</div><div>6.941</div></div>	<div><div>4</div><div>Be</div><div>9.01218</div></div>											<div><div>5</div><div>B</div><div>10.811</div></div>	<div><div>6</div><div>C</div><div>12.011</div></div>	<div><div>7</div><div>N</div><div>14.0067</div></div>	<div><div>8</div><div>O</div><div>15.9994</div></div>	<div><div>9</div><div>F</div><div>18.9984</div></div>	<div><div>10</div><div>Ne</div><div>20.1797</div></div>
<div><div>11</div><div>Na</div><div>22.9898</div></div>	<div><div>12</div><div>Mg</div><div>24.3050</div></div>	3	4	5	6	7	8	9	10	11	12	<div><div>13</div><div>Al</div><div>26.9815</div></div>	<div><div>14</div><div>Si</div><div>28.0855</div></div>	<div><div>15</div><div>P</div><div>30.9738</div></div>	<div><div>16</div><div>S</div><div>32.066</div></div>	<div><div>17</div><div>Cl</div><div>35.4527</div></div>	<div><div>18</div><div>Ar</div><div>39.948</div></div>
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.0983	40.078	44.9559	47.88	50.9415	51.9961	54.9381	55.847	58.9332	58.693	63.546	65.39	69.723	72.61	74.9216	78.96	79.904	83.80
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
85.4678	87.62	88.9059	91.224	92.9064	95.94	(98)	101.07	102.906	106.42	107.868	112.411	114.818	118.710	121.757	127.60	126.904	131.29
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
132.905	137.327	138.906	178.49	180.948	183.84	186.207	190.23	192.22	195.08	196.967	200.59	204.383	207.2	208.980	(209)	(210)	(222)
87	88	89	104	105	106	107	108	109	110	111							
Fr	Ra	†Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							
(223)	226.025	227.028	(261)	(262)	(266)	(264)	(277)	(268)	(271)	(272)							

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	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)