

Key

Name (please print)

**CHEMISTRY 128
HOUR TEST I
13 June 2009**

USEFUL INFORMATION:

$$\Delta S_{\text{surroundings}} = -\Delta H/T$$

$$\Delta S^{\circ}_{\text{system}} = \Sigma S^{\circ}_{\text{prod}} - \Sigma S^{\circ}_{\text{react}}$$

$$\Delta H^{\circ}_{\text{reaction}} = \Sigma H^{\circ}_{\text{prod}} - \Sigma H^{\circ}_{\text{react}}$$

$$\Delta G^{\circ}_{\text{reaction}} = \Sigma G^{\circ}_{\text{prod}} - \Sigma G^{\circ}_{\text{react}}$$

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

$$\Delta G_{\text{system}} = \Delta G^{\circ}_{\text{system}} - RT \ln Q$$

$$\Delta G^{\circ}_{\text{system}} = -RT \ln K$$

$$N = 6.022 \times 10^{23}$$

$$c_{\text{H}_2\text{O}} = 4.184 \text{ J/gC}$$

$$R = 8.314 \text{ J/mol.K}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{0.693}{k}$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

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

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$T(\text{K}) = T(\text{C}^{\circ}) + 273.15$$

$$\ln[A] = -kt + \ln[A]_0$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$\ln k = -\frac{E_a}{R} \cdot \frac{1}{T} + \ln A$$

$$K = ^{\circ}\text{C} + 273.15$$

$$K_p = K_c (RT)^{\Delta n}$$

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

1																	18
IA																	VIIIA
1 H 1.008	2 IIA											13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	2 He 4.00
3 Li 6.94	4 Be 9.01											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 22.99	12 Mg 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 -	9 VIII B	10 -	11 IB	12 IIB	13 Al 26.98	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 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.30
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 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.34	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po 210	85 At 210	86 Rn 222
87 Fr 223	88 Ra 226.03	103 Lr 262.1	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt									

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04
89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu 239.05	95 Am 241.06	96 Cm 247.07	97 Bk 249.08	98 Cf 251.08	99 Es 254.09	100 Fm 257.10	101 Md 258.10	102 No 255

**There Are 7 Pages On This Test Including This Cover Page.
The Test Contains 100 Points.**

I. (44 points) Short Answers

1. (4 pts) When water vapor condenses on a cold glass of iced tea, heat is transferred from the (Circle one: system, surroundings) to the (Circle one: system, surroundings).

2. For each of the following processes, give the sign of ΔH° , ΔS° , ΔG° (at room temperature). $\Delta G = \Delta H - T\Delta S$

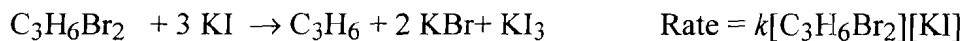


3. The fact that the disorder of the universe is increasing is a restatement of the (Circle one: 1st, 2nd, 3rd) law of thermodynamics.

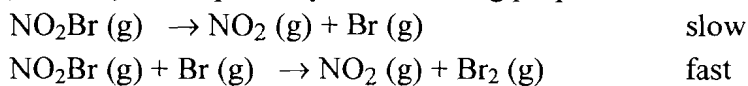
4. (3pts) The value of the ΔG°_f for Hg(l) is _____ and the value of S° for Hg(l) is _____.

- a. not zero, not zero
- b. zero, zero
- c. not zero, zero
- d. zero, not zero
- e. none of the above

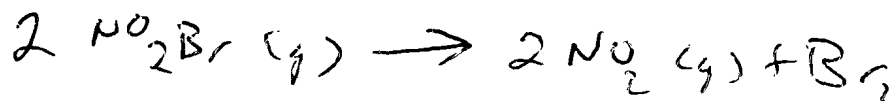
5. (4 points) The following reaction is (zero, first second) order overall and (first, second, third) with respect to [KI].



6. Nitryl bromide, NO_2Br , decomposes by the following proposed mechanism.



a. (3 pts) Write the overall, balanced chemical equation for this process.



b. (3 pts) Mathematically give the relative rate of appearance of Br_2 to the relative disappearance of NO_2Br .

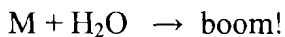
$$\text{rate} = -\frac{1}{2} \frac{\Delta [\text{NO}_2\text{Br}]}{\Delta t} = + \frac{\Delta [\text{Br}_2]}{\Delta t}$$

c. (4 pts) The reaction is (Circle one: zero, first, second) order with respect to $[\text{NO}_2\text{Br}]$ and (Circle one: zero, first, second) with respect to $[\text{Br}]$.

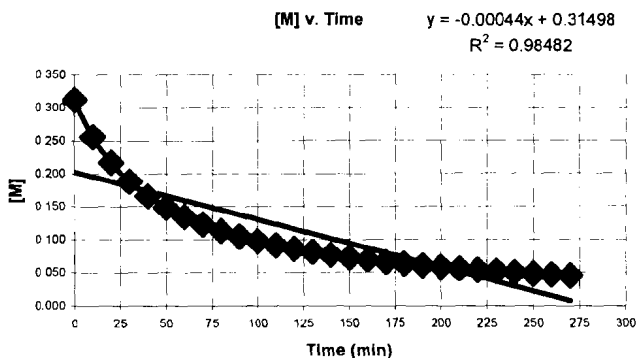
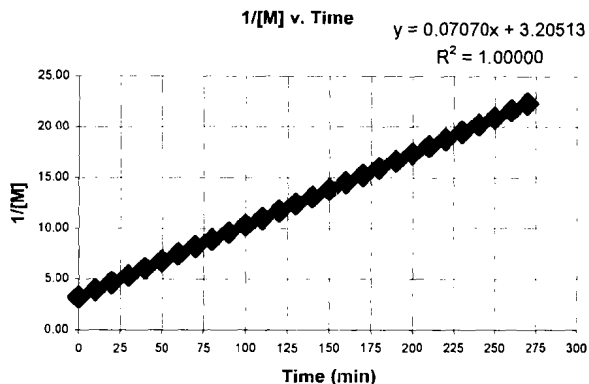
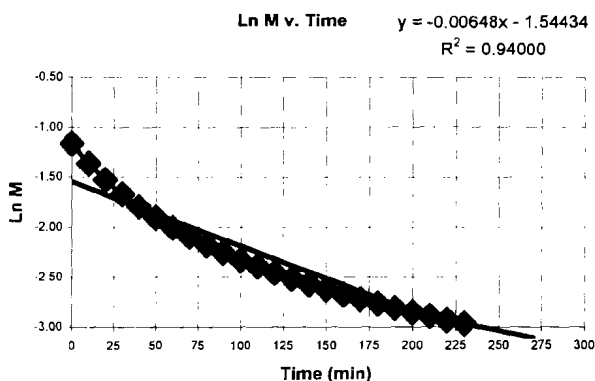
d. (2 pts) Identify all intermediates involved in this process. Br

7. (6 points) A plot of $\frac{1}{T}$ (x-axis) vs. $\ln k$ (y-axis) would yield a straight line with the slope equal to $-\frac{E_a}{R}$ and the y-intercept equal to $\ln A$.

8. The newly discovered element, Motherinlawium (M), was found to react violently with water.



The kinetics of the reaction with respect to Motherinlawium (M) were studied, and the data was plotted.



a) (3 pts) Determine the order of the reaction with respect to [M] 2nd order

b) (4 pts) Determine the value and units of the rate constant, k for this process.
 Rate Constant, k, 0.07070 l
M.min

II. Calculations. Show clear, complete setup for full credit.

9. (11 points) A 15.0 g sample of nickel metal is heated to 95.0°C and dropped into a calorimeter containing 55.0 g of 23.0°C water. Assuming that the calorimeter absorbs a negligible amount of heat (in other words it is a perfect calorimeter), calculate the final temperature (in °C) of the nickel and the water. (Note: The specific heat of nickel is 0.444 J/°C·g).

$$0 = \Delta H_{\text{metal}} + \Delta H_{\text{H}_2\text{O}} + \Delta H_{\text{calorimeter}} \rightarrow 0$$

Final Temperature 25.0°C

$$0 = C_{\text{Ni}} \cdot m_{\text{Ni}} \cdot \Delta T_{\text{Ni}} + C_{\text{H}_2\text{O}} \cdot m_{\text{H}_2\text{O}} \cdot \Delta T_{\text{H}_2\text{O}}$$

$$0 = (0.444 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}})(15.0 \text{g})(T_f - 95.0^\circ\text{C}) + (4.184 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}})(55.0 \text{g})(T_f - 23.0^\circ\text{C})$$

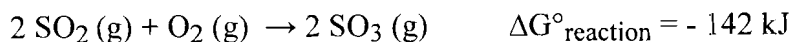
$$0 = 6.66 T_f - 632.7 + 230.12 T_f - 5292.76$$

$$0 = 236.78 T_f - 5925.46$$

$$5925.46 = 236.78 T_f$$

$$T_f = 25.0^\circ\text{C}$$

10. (10 points) Consider the following reaction:



Given that ΔH°_f for SO_2 is -297 kJ/mol and that ΔH°_f for SO_3 is -396 kJ/mol, calculate $S^\circ_{\text{reaction}}$ (in J/K) at 25°C.

$$\Delta H^\circ_{\text{reaction}} = 2 \Delta H^\circ_f(\text{SO}_3) - [2 \Delta H^\circ_f(\text{SO}_2) + \Delta H^\circ_f(\text{O}_2)] \quad S^\circ_{\text{reaction}} \underline{-188 \frac{\text{J}}{\text{K}}}$$

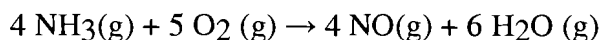
$$\Delta H^\circ_{\text{reaction}} = [2(-396 \frac{\text{kJ}}{\text{mol}})] - [2(-297 \frac{\text{kJ}}{\text{mol}}) + 0]$$

$$\Delta H^\circ_{\text{reaction}} = -792 \text{ kJ} + 594 \text{ kJ} = -198 \text{ kJ}$$

$$\Delta G^\circ = \Delta H^\circ - T \Delta S^\circ \Rightarrow \Delta S^\circ = \frac{\Delta H^\circ - \Delta G^\circ}{T}$$

$$= \frac{(-198 \text{ kJ}) - (-142 \text{ kJ})}{(298 \text{ K})} \times \frac{1000 \text{ J}}{1 \text{ kJ}} = -188 \frac{\text{J}}{\text{K}}$$

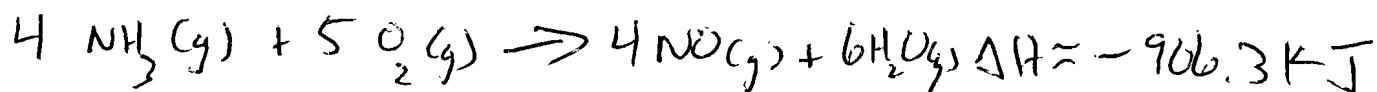
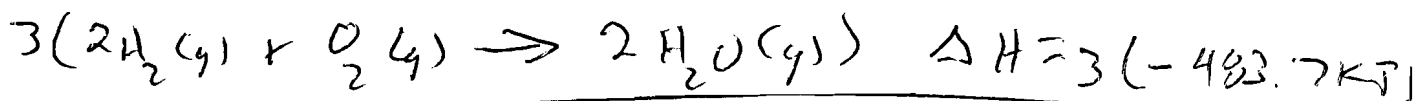
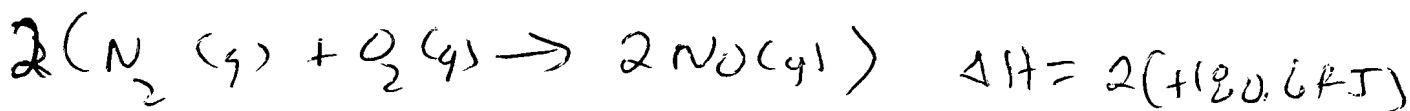
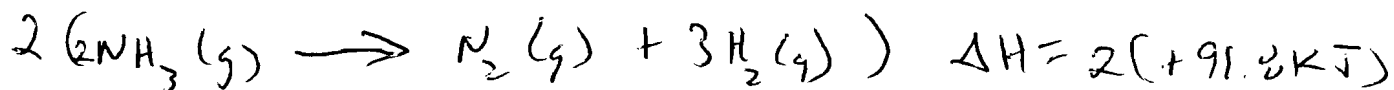
11. Ammonia reacts with O_2 in the presence of a platinum catalyst to produce nitric oxide, NO , and water.



a. (6 pts) Calculate the heat of this reaction at constant pressure using the following data:



$$\Delta H = \underline{-906.3 \text{ kJ}}$$



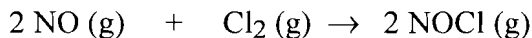
b. (3 pts) The reaction of NH_3 with O_2 is an (Circle one: **endothermic**, **exothermic**) process.

c. (4 pts) What quantity of heat is evolved or absorbed in the oxidation of 10.0 g of NH_3 ?

$$\text{Heat (in J)} \quad \underline{1.33 \times 10^5 \text{ J}}$$

$$10.0 \text{ g } NH_3 \times \frac{1 \text{ mol } NH_3}{17.0 \text{ g } NH_3} \times \frac{-906.3 \text{ kJ}}{4 \text{ mol } NH_3} = -133 \text{ kJ} \times \frac{1000 \text{ J}}{1 \text{ kJ}} =$$

12. (12 points) The following reaction was studied at -10°C :



and the corresponding data were collected.

experiment	$[\text{NO}]_0 (\text{M})$	$[\text{Cl}_2]_0 (\text{M})$	initial rate ($\text{mol L}^{-1} \text{s}^{-1}$)
1	0.10	0.10	0.18
2	0.10	0.20	0.36
3	0.20	0.20	1.45

a. (3 points) Determine the order of the reaction with respect to $[\text{NO}]$.

Order of $[\text{NO}]$ 2

$$\frac{\text{Rate 3}}{\text{Rate 2}} = \frac{1.45}{0.36} = \frac{k [0.20]^m [0.20]^n}{k [0.10]^m [0.20]^n}$$

$$4.0 = (2.0)^m \Rightarrow m = 2$$

b. (3 points) Determine the order of the reaction with respect to $[\text{Cl}_2]$.

Order of $[\text{Cl}_2]$ 1

$$\frac{\text{Rate 2}}{\text{Rate 1}} = \frac{0.36}{0.18} = \frac{k [0.10]^m [0.20]^n}{k [0.10]^m [0.10]^n}$$

$$2.0 = (2.0)^n \Rightarrow n = 1$$

c. (1 point) Write the rate law expression.

$$\text{rate} = k [\text{NO}]^2 [\text{Cl}_2]^1$$

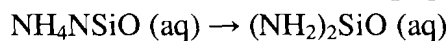
d. (2 points) Calculate the overall order.

Overall Order 3

e. (3 points) Determine the value and units of the rate constant, k

$$k = \frac{\text{rate}}{[\text{NO}]^2 [\text{Cl}_2]^1} = \frac{0.18 \frac{\text{mol}}{\text{L s}}}{\left[0.10 \frac{\text{mol}}{\text{L}}\right]^2 \left[0.10 \frac{\text{mol}}{\text{L}}\right]} = 180 \frac{\text{L}^2}{\text{mol}^3 \text{s}}$$

13. (11 pts) NH_4NSiO rearranges in water to give $(\text{NH}_2)_2\text{SiO}$, and the rate law for the reaction was experimentally determined to be: $\text{rate} = k[\text{NH}_4\text{NSiO}]^2$.



2nd Order!

A 0.476 M solution of NH_4NSiO was prepared in the lab. After 50.00 minutes, the concentration was 0.270 M.

a. What is the half-life (in minutes) of NH_4NSiO ?

Half-life of NH_4NSiO 65.6 min

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0} \Rightarrow k = \frac{\frac{1}{[A]_t} - \frac{1}{[A]_0}}{t} = \frac{\frac{1}{[0.270\text{M}]} - \frac{1}{[0.476\text{M}]}}{50.00\text{ min}} = \frac{3.70 \frac{1}{\text{M}} - 2.10 \frac{1}{\text{M}}}{50.00\text{ min}}$$

$$k = 0.0320 \frac{\text{L}}{\text{mol}\cdot\text{min}}$$

$$t_{1/2} = \frac{1}{k[A]_0} = \frac{1}{(0.0320 \frac{\text{L}}{\text{mol}\cdot\text{min}})(0.476 \frac{\text{mol}}{\text{L}})} = 65.6\text{ min}$$

b. What will the NH_4NSiO concentration be after 3.67 hours?

$[\text{NH}_4\text{NSiO}]$ 0.109 M

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$$

$$\frac{1}{[A]_t} = (0.0320 \frac{\text{L}}{\text{mol}\cdot\text{min}})(3.67\text{ hr})(\frac{60\text{ minutes}}{1\text{ hr}}) + \frac{1}{[0.476\text{M}]}$$

$$\frac{1}{[A]_t} = 7.05 \frac{1}{\text{M}} + 2.10 = 9.15 \frac{1}{\text{M}}$$

$$[A]_t = \frac{1}{9.15 \frac{1}{\text{M}}} = 0.109\text{ M}$$