

INFORMATION, SCRAP, AND COVER PAGE

This page contains information which may or may not be needed. This page can also be used for scrap paper or for cover paper. THIS PAGE WILL NOT BE COLLECTED. TEAR THIS PAGE OFF THE EXAM. DO NOT TURN IN THIS PAGE.

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

$$T(\text{K}) = T(^{\circ}\text{C}) + 273$$

Free energy

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

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

First order kinetics

$$\ln \frac{[A]_0}{[A]_t} = akt \quad t_{1/2} = \frac{\ln 2}{ak}$$

Second order kinetics

$$\frac{1}{[A]_t} - \frac{1}{[A]_0} = akt \quad t_{1/2} = \frac{1}{ak [A]_0}$$

Arrhenius

$$k = A e^{-E_a/RT}$$

	ΔH_f° kJ/mol	S° J/K·mol	ΔG_f° kJ/mol		ΔH_f° kJ/mol	S° J/K·mol	ΔG_f° kJ/mol
Bromine				Oxygen			
$\text{Br}_2(l)$	0	152.21	0	$\text{O}_2(g)$	0	205.15	0
$\text{Br}_2(g)$	30.91	245.39	3.13	$\text{O}_2(aq)$	-11.7	110.9	16.4
$\text{Br}_2(aq)$	-2.59	130.5	3.93	$\text{O}_3(g)$	142.67	238.93	163.18
$\text{Br}^-(aq)$	-121.55	82.4	-103.96	$\text{H}_2\text{O}(l)$	-285.83	69.95	-237.14
				$\text{H}_2\text{O}(g)$	-241.83	188.83	-228.58
				$\text{OH}^-(aq)$	-229.99	-10.75	-157.24
Chlorine				Sodium			
$\text{Cl}_2(g)$	0	223.08	0	$\text{Na}(s)$	0	51.46	0
$\text{Cl}^-(aq)$	-167.16	56.5	-131.23	$\text{Na}^+(aq)$	-240.12	59.0	-261.90
$\text{ClO}_2(g)$	97.00	256.84	114.84	$\text{NaCl}(s)$	-411.12	72.12	-384.02
$\text{HClO}(aq)$	-120.9	142	-79.9	$\text{NaBr}(s)$	-361.41	86.82	-349.27
$\text{ClO}^-(aq)$	-107.1	42	-36.8	$\text{NaOH}(s)$	-425.93	64.44	-379.74

PRINT NAME _____

SIGN NAME _____

CIRCLE your recitation section in the list below.

15: M	9:00	DA 103	16: M	10:00	CB 16
17: T	11:00	CB 329	18: W	8:00	CB 16
19: W	12:00	CB 329			

SCORED GRADE: _____

All answers should be with the correct significant figures.

The Periodic Table and the Information Page will not be collected. They can be used as scratch paper or as cover paper. Do not turn them in.

Be certain your answers are clear. If an answer is not clear, it can be considered wrong.

Problems marked with ** in the margin are directly from the assigned homework. These total 30 points.

Place your name in the space provided at the top of each question page. This helps to identify the pages if they are accidentally separated during grading and processing.

Work promptly. Use your time effectively.

****KEEP YOUR WORK AND ANSWERS COVERED.****

1. (30 pts) Indicate whether each statement is true (T) or false (F). Be certain T or F is clearly indicated.

- _____ An exothermic process increases the entropy of the surroundings.
- _____ At standard conditions, every exothermic reaction with a positive ΔS° is exergonic.
- _____ S° for $N_2(g)$ is zero.
- _____ The activity of every gas phase compound at standard conditions is one.
- _____ As ΔG° increases (less negative or more positive), K increases.
- _____ ΔG_f° for $I_2(g)$ is negative.
- _____ The elementary step given by $Br_2(g) \rightarrow 2 Br(g)$ is unimolecular.
- _____ The reaction given by $P_4(s) + 6 H_2(g) \rightarrow 4 PH_3(g)$ cannot be elementary.
- _____ Chlorine atoms catalyze the decomposition of ozone in the atmosphere.
- _____ The exergonic direction for any process is that direction which leads to equilibrium.

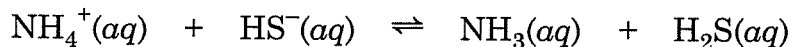
- ** 2. (5 pts) Consider each of the following balanced equations.

1. $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$
2. $Na_2CO_3(s) \rightarrow Na_2O(s) + CO_2(g)$
3. $C_3H_8(g) + 5 O_2(g) \rightarrow 3 CO_2(g) + 4 H_2O(l)$
4. $H_2(g) + Cl_2(g) \rightarrow 2 HCl(g)$
5. $2 SO_2(g) + O_2(g) \rightarrow 2 SO_3(g)$

Which one will have the most positive ΔS° ? _____

Which one will have the most negative ΔS° ? _____

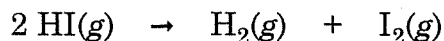
3. (6 pts) Ammonium hydrogen sulfide dissolves in water, giving an equilibrium with $NH_3(aq)$ and $H_2S(aq)$.



At 298 K, $K = 182$. For a solution at equilibrium which contains 0.0020 M each of $NH_3(aq)$ and $H_2S(aq)$, circle the concentration (in M) of ammonium ion.

- 3.8×10^{-6} 5.3×10^{-6} 7.8×10^{-6} 1.1×10^{-5} 4.0×10^{-5} 9.7×10^{-5}
 1.5×10^{-4} 4.1×10^{-4} 8.3×10^{-4} 2.3×10^{-3} 6.0×10^{-3} 9.8×10^{-3}

4. (8 pts) The following reaction is second order in HI, with $k = 0.0285$ (L/mol)/s at 800 K.



The reaction starts with 0.250 mol/L of HI. Circle the amount (in mol/L) of HI remaining after 1.50 minutes.

0.0661	0.0807	0.0954	0.110	0.126	0.147
0.152	0.170	0.187	0.202	0.216	0.231

Circle the percent completion. (Above answer must be correct for credit here.)

7.60%	13.6%	19.2%	25.2%	32.0%	37.4%
41.2%	49.6%	56.0%	61.8%	67.7%	73.6%

5. (8 pts) Consider the reaction energy diagram at right for a composite mechanism.



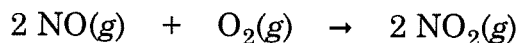
How many elementary steps are involved? _____

Which elementary step has the largest E_a ? _____

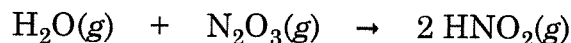
How many elementary steps are endothermic? _____

Is the overall reaction exothermic or endothermic? _____

- ** 6. (7 pts) Write the speed relationships between reactant and products for the following.



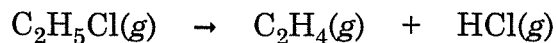
- ** 7. (5 pts) For the following reaction, $E_a = 37.17$ kJ and $A = 3.78 \times 10^{10}$ (L/mol)/s.



Circle the value of k (in (L/mol)/s) at a temperature of 325 K.

10,800	13,600	23,300	27,400	30,300	33,600
40,100	48,200	52,900	54,100	60,500	65,800

- ** 8. (7 pts) The following reaction is first order in $\text{C}_2\text{H}_5\text{Cl}$; $k = 4.7 \text{ s}^{-1}$ at 960 K.



Write the rate equation. _____

Circle the rate of the reaction (in (mol/L)/s) when $[\text{C}_2\text{H}_5\text{Cl}] = 0.068 \text{ mol/L}$.

0.32	0.35	0.39	0.40	0.43	0.47
0.52	0.56	0.59	0.61	0.64	0.68

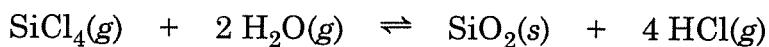
9. (6 pts) The reaction of elemental chlorine gas with an aqueous solution of sodium hydroxide produces sodium chloride, sodium hypochlorite and $\text{H}_2\text{O}(l)$. (The salts are soluble.) Circle the value of ΔG° (in kJ) for this reaction at 25 °C.

-73.0	-90.7	-106.3	-129.5	-140.6	-163.8
-187.9	-205.5	-226.1	-247.9	-266.7	-283.3

10. (6 pts) Circle the EVP (in atm) at 273.15 K for the vaporization of $\text{Br}_2(l)$.

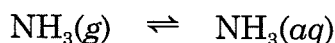
0.0122	0.0270	0.0418	0.0577	0.0738	0.0903
0.106	0.148	0.193	0.227	0.252	0.289

11. (6 pts) Consider the following reaction at 200 °C.



Write the Q expression.

- ** 12. (6 pts) Consider the solubility equilibrium of $\text{NH}_3(g)$ in water at 298 K.



For this process, $K = 59.7$. A container is partly filled with an $\text{NH}_3(aq)$ solution which initially contains 0.0936 mol NH_3 . At equilibrium, the solution volume was 400. mL and the gas space volume was 2.00 L. Circle the pressure (in atm) of $\text{NH}_3(g)$ at equilibrium.

0.00113	0.00164	0.00226	0.00279	0.00332	0.00390
0.00422	0.00468	0.00507	0.00538	0.00641	0.00692