

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.

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

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

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

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

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

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

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
$\text{CO}_2(g)$	-393.52	213.80	-394.39	$\text{H}_2\text{O}(l)$	-285.83	69.95	-237.14
$\text{CO}_2(aq)$	-413.80	117.6	-385.98	$\text{H}_2\text{O}(g)$	-241.83	188.83	-228.58
$\text{HCO}_3^-(aq)$	-691.99	91.2	-586.77	$\text{OH}^-(aq)$	-229.99	-10.75	-157.24
$\text{CO}_3^{2-}(aq)$	-677.14	-56.9	-527.81				
$\text{C}_2\text{H}_5\text{OH}(l)$	-277.69	160.7	-174.78	$\text{Na}^+(aq)$	-240.12	59.0	-261.90
$\text{C}_2\text{H}_5\text{OH}(g)$	-235.10	282.70	-168.49	$\text{NaCl}(s)$	-411.12	72.12	-384.02
$\text{C}_2\text{H}_5\text{OH}(aq)$	-288.3	148.5	-181.64	$\text{NaHCO}_3(s)$	-950.81	101.7	-851.0
$\text{Cl}_2(g)$	0	223.08	0				
$\text{Cl}^-(aq)$	-167.16	56.5	-131.23	$\text{H}_2\text{S}(g)$	-20.50	205.76	-33.33
$\text{HCl}(g)$	-92.31	186.90	-95.30	$\text{H}_2\text{S}(aq)$	-39.7	121	-27.83
$\text{HI}(g)$	26.36	206.59	1.56				

PRINT NAME _____

SIGN NAME _____

CIRCLE your recitation section in the list below.

A: M 9:00 HM 210

B: M 10:00 DA 208B

C: T 11:00 NS 317

D: W 8:00 LF 130

E: W 12:00 SK 209

F: Th 4:00 HM 108

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 from the assigned homework. These total 32 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.

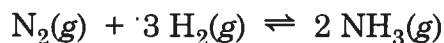
Work promptly. Use your time effectively.

****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.

- _____ The formation reaction of magnesium oxide has a positive ΔS° .
- _____ Every reaction is spontaneous if the entropy of the system increases.
- _____ $H^+(aq)$ is the only ion with a zero free energy of formation.
- _____ $\Delta G^\circ_{\text{soln}}$ of $O_2(g)$ is negative.
- _____ At typical pressures, the activity of a solid is zero.
- _____ At standard conditions, $Q = 1$.
- _____ All first order elementary reactions are unimolecular.
- _____ An intermediate in a composite mechanism does not appear in the balanced equation for the overall process.
- _____ In exothermic reactions, the forward E_a is greater than the reverse E_a .
- _____ After two half-lives, a reaction is done.

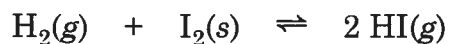
2. (5 pts) Consider the following equilibrium in a container at 400. K and a gas volume of 86.1 L.



$K = 36.6$ at this temperature. Upon reaching equilibrium during one run, the pressure of nitrogen was found to be 0.217 atm and the pressure of ammonia was found to be 0.361 atm. Circle the pressure (in atm) of hydrogen.

0.152	0.176	0.197	0.218	0.236	0.254
0.279	0.290	0.311	0.331	0.357	0.372

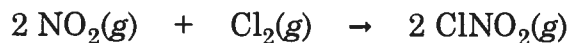
- **** 3. (6 pts) The following equation is balanced.



For the following conditions at 298.15 K, circle ΔG (in kJ).

0.221 atm H_2	0.440 mol I_2	0.937 atm HI			
4.57	4.78	4.90	5.18	5.36	5.57
5.71	5.92	6.18	6.33	6.54	6.70

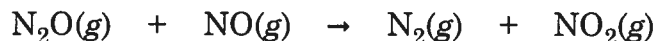
- ** 4. (9 pts) Consider the following balanced equation.



The rate law for this reaction is the following: $\text{rate} = k [\text{Cl}_2] [\text{NO}_2]^2$. Indicate whether each statement below is true (T) or false (F).

- _____ The reaction is third order overall.
- _____ The rate will be slower by a factor of two if the concentration of Cl_2 is doubled.
- _____ The rate will be faster by a factor of four if the concentration of NO_2 is doubled.

5. (6 pts) The following reaction is first order in each reactant and second order

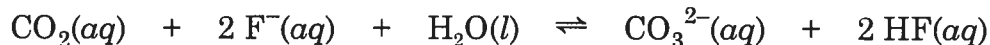


overall; $k = 18.6 \text{ L/mol/s}$ at 1100 K. The system starts with $2.52 \times 10^{-4} \text{ mol/L}$ of N_2O and $2.52 \times 10^{-4} \text{ mol/L}$ of NO . Circle the concentration (in mol/L) of N_2O remaining after 60.0 min.

- | | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1.41×10^{-5} | 3.38×10^{-5} | 5.63×10^{-5} | 7.98×10^{-5} | 9.20×10^{-5} |
| 1.33×10^{-4} | 1.51×10^{-4} | 1.77×10^{-4} | 1.96×10^{-4} | 2.13×10^{-4} |

6. (2 pts) If $Q = K$, which direction is exergonic? _____
- (2 pts) If Q increases, does the driving force increase or decrease? _____
- (2 pts) For a process which is exothermic and endergonic, does an increase in temperature increase or decrease ΔG° ? _____
- (2 pts) For a process which is endothermic and exergonic, what is the sign of ΔS ? _____

- ** 7. (6 pts) Consider the following equilibrium system, for which $K = 4.2 \times 10^{-11}$.



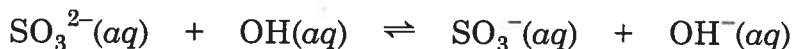
The process begins with 0.054 M CO_2 and 0.022 M F^- . Circle the concentration (in M) of CO_3^{2-} at equilibrium.

- | | | | | | |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| 1.0×10^{-6} | 2.6×10^{-6} | 5.3×10^{-6} | 6.5×10^{-6} | 7.7×10^{-6} | 8.2×10^{-6} |
| 2.8×10^{-5} | 4.1×10^{-5} | 5.4×10^{-5} | 6.7×10^{-5} | 8.0×10^{-5} | 9.3×10^{-5} |

- ** 8. (5 pts) Using ΔH° and S° values, calculate (and circle) the normal boiling point (in K) for ethanol, $C_2H_5OH(l)$.

333.6	335.7	337.1	339.0	341.2	343.8
345.5	347.3	349.1	351.6	353.8	355.9

9. (8 pts) The following is an elementary step.



Write the reverse rate equation. _____

List any free radicals that are present (on either side). _____

Will increasing the temperature increase the rate(s) in the forward, reverse, both, or neither directions? _____

10. (6 pts) Consider the gas-forming reaction between an aqueous solution of sodium bicarbonate and an aqueous solution of hydrochloric acid, which produces carbon dioxide gas, water and aqueous sodium chloride. Circle the ΔG° (in kJ) for this reaction.

-12.31	-28.06	-32.54	-44.76	-50.07	-66.15
-74.06	-88.23	-91.80	-103.72	-110.33	-127.83

- ** 11. (6 pts) In each of lines a and b below, circle the entry which has the largest S° .

a.	$PF_3(g)$	$PF_5(g)$	$N_2(g)$	$NF_3(g)$
b.	$NH_3(g)$	$AsH_3(g)$	$H_2O(g)$	$H_2S(g)$

12. (5 pts) Calculate (and circle) the solubility (in M) of $H_2S(g)$ in water at 298.15 K when the pressure of $H_2S(g)$ is one atm.

0.0281	0.0320	0.0409	0.0588	0.0663	0.0780
0.0866	0.0997	0.109	0.218	0.305	0.467