NAME: **SECTION:**

General Chemistry II - CHEM 112

Instructions: This test is closed book and closed notes. Calculators are also allowed, although pre-prepared programs, integration and equation solving routines are not. Credit is dependent on showing all steps in the calculation on this test. Clearly state any assumptions or approximations you use to solve the problems. (6 problems, 100 pts)

R = 8.31441 J/K*mol

R = 0.08206 L*atm/K*mol

1 atm = 760 Torr

0 ^{o}C = 273.15 K

N_A = 6.022x10^{23} mol

1 m = 100 cm = 1000 mm = 10^6 mm = 10^9 nm = 10^{10} Å

density of water: ρ = 1.00 g/ml = 1.00 kg/L

1 L• atm = 101.3 J

$w = -P\Delta V$

$q_{surr} = C\Delta T$ $q_{surr} = -q_{system}$

$\Delta E = q + w$ $\Delta H = \Delta E + P\Delta V$

$\Delta G = \Delta H - T\Delta S$ $\Delta G = \Delta G° + RT\ln Q$

$\Delta G° = -RT\ln K_{eq}$ $K_{eq} = e^{-\Delta G°/RT}$

$$\ln K_{eq} = \frac{\Delta S^o}{R} - \frac{\Delta H^o}{RT}$$

aA + bB ⇌ cC + dD $\text{rate} = -\frac{\Delta A}{a\Delta t} = -\frac{\Delta B}{b\Delta t} = \frac{\Delta C}{c\Delta t} = \frac{\Delta D}{d\Delta t}$

rate = k[A]^x[B]^y

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rate = k[R]^0 $[R] = [R]_0 - kt$

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rate = k[R]^1

$\ln[R] = \ln[R]_0 - kt$ $t_{1/2} = 0.693/k$

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rate = k[R]^2 $\frac{1}{[R_t]} = kt + \frac{1}{[R_o]}$

$k = Ae^{(-Ea/RT)}$ $\ln(k) = \ln(A) - E_a/R\ (1/T)$

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

$$\ln\left(\frac{K_1}{K_2}\right) = \frac{\Delta H^o}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

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1.) For the mechanism below answer the following questions:

$$2NO \rightleftharpoons N_2O_2$$
$$N_2O_2 + O_2 \rightarrow 2NO_2$$
$$2NO + O_2 \rightarrow 2NO_2$$

a.) What is the intermediate of the elementary steps? (Hint: what gets crossed out while adding the chemical equations together) (3 points)

b.) For the second elementary step, $rate_1 = 2.5x10^{-3}[O_2]^y$, what is the value for y? (3 points)

c.) If the rate of disappearance of O_2 is 7.0 M s^{-1}, what is the rate of NO_2 appearance? (4 points)

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2.) For the reaction and data below, answer the following quesitons:

$$H_2O + CO_2 \rightarrow H_2CO_3$$

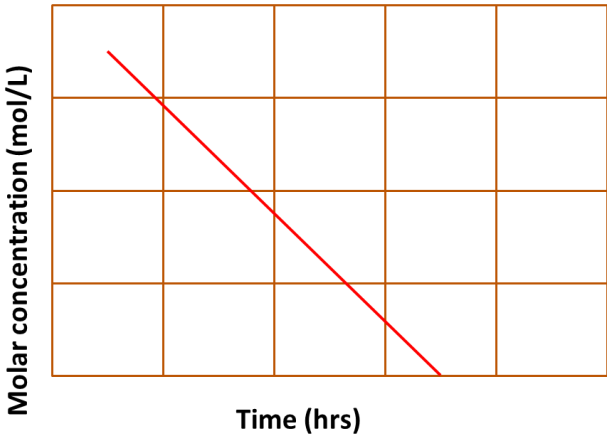
Exp.	**H_2O (M)**	**Rel. conc.**	**CO_2 (M)**	**Rel. conc.**	**Rate (Ms^{-1})**	**Rate change**
1	0.1		0.01		$1.5x10^{-3}$	
2	0.1		0.01		$1.5x10^{-3}$	
3	0.2		0.01		$3.0x10^{-3}$	
4	0.2		0.02		$6.0x10^{-3}$	

a.) What is the order with respect to H_2O? (5 points)

b.) What is the order with respect to CO_2? (5 points)

c.) Write the full rate law, with the value for *k*, for the reaction? (5 points)

3.) After a set of experiments in a lab on the reaction R → P, you plot your data and get the plot below:



Use the correct integrated rate equation to determine how long it takes for 0.2 M R to decrease to 20% of its original concentration if the rate constant $k = 7.5 \times 10^{-3}$ M s^{-1}. (15 points)

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4.) For the following reaction, calculate ΔG^o at 25 ^oC. (20 pts)

$$2CH_4(g) + 4O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$$

Substance	S^o**, J/mol-K**	H^o**, kJ/mol**
$CH_4(g)$	186.15	-74.81
$CO_2(g)$	213.63	-393.51
$H_2O(g)$	188.72	-241.82
$O_2(g)$	205.03	0
$H_2O(l)$	69.91	-285.83

5.) At equilibrium the following reaction has a ΔG^o value of -11.9 kJ/mol. You go into the lab and find the reaction NOT at equilibrium and instead find the concentrations are $[NO_2]$ = 0.025 M, $[O_3]$ = 0.0010 M, $[NO_3]$ = 0.030 M, and $[O_2]$ = 0.10 M.

$$NO_{2(g)} + O_{3(g)} \rightleftharpoons NO_{3(g)} + O_{2(g)}$$

Find ΔG for the above non-equilibrium reaction at 125 ^oC (20 points)

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6.) Circle the correct answer: (4 points each)

a.) A reaction has a positive value of ΔH^o, the reaction is:

endothermic spontaneous exothermic

b.) A car engine gives off heat while doing work, therefore the value for q is:

positive negative zero

c.) A reaction has a negative value of ΔG^o, the reaction is:

disordered spontaneous non-spontaneous

d.) For the reaction $CO + 2O_2 \rightarrow CO_2 + O_3$, the disorder, ΔS^o:

increases decreases is zero

e.) A reaction has a positive ΔH^o and a negative ΔS^o, the reaction is:

spontaneous non-spontaneous make believe