Name: _____ 8 Digit ID Number: _____

Some Useful and Useless Information:

R: 8.314 $J.mol^{-1}.K^{-1}$, 0.08205 $L.atm.mol^{-1}.K^{-1}$	$N = 6.023 \times 10^{23}$
$(1/[R]_t) - (1/[R]_o) = -kt$	$pX = -\log_{10}[X]$
$K_w = 1 \times 10^{-14}$ @ 25°C	$t_{1/2}$: $1/k[R]_o$ $\ln 2/k$ $[R]_o/2k$
$k = Ae^{-E_a/RT}$	$\ln[R]_t - \ln[R]_o = -kt$
$\ln(k_2/k_1) = (-E_a/R)\,[(1/T_2) - (1/T_1)]$	$[R]_o - [R]_t = kt$

Question 1
6 Points

The decomposition of dinitrogen pentoxide in carbon tetrachloride solution at 30 °C

$2\ N_2O_5 = 4\ NO_2 + O_2$

is first order in N_2O_5 with a rate constant of 4.10×10^{-3} min^{-1}.

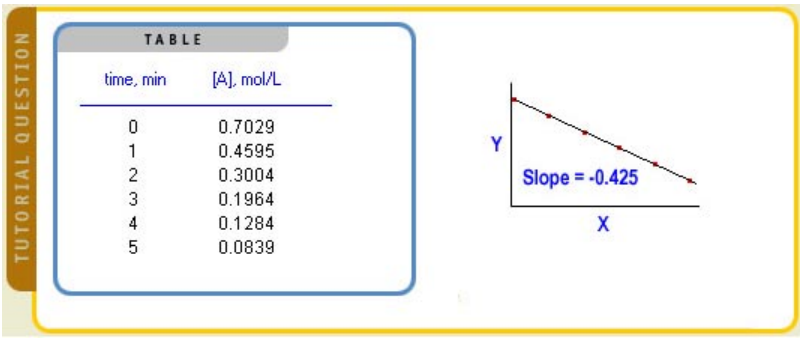
If the initial concentration of N_2O_5 is 0.693 M, how long (in minutes) will it take for the concentration of N_2O_5 to reach 0.148 M. *[For Full Credit You Must Show Work]*

$\ln \{[R]_t/[R]_0\} = -kt$

$\ln \{0.148/0.693\} = -4.10 \times 10^{-3} t$

$t = 375$ min

Question 2
10 Points



Concentration time data for the reaction of A = Products is depicted above. The order of the reaction is either Zero, 1st or 2nd. What labels should appear on the X and Y axis if the reaction is:

Zero Order	X:	t	Y:	[A]
First Order	X:	t	Y:	ln [A]
Second Order	X:	t	Y:	1/[A] Note 1

If the reaction was found to be first order with the slope depicted what is the value for the rate constant k?

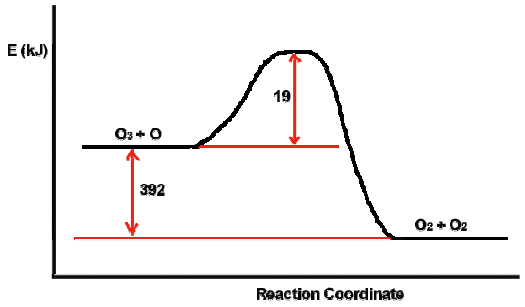
$k = -\text{slope} = 0.425\ min^{-1}$

What would the half life for this reaction be? $t_{\frac{1}{2}} = \{\ln 2/k\} = 1.63$ min

Note 1: A Second order plot has a positive slope, the graph depicted has a negative one thus bonus point for anyone that gave X: t, Y: -1/[A].

Question 3
8 Points

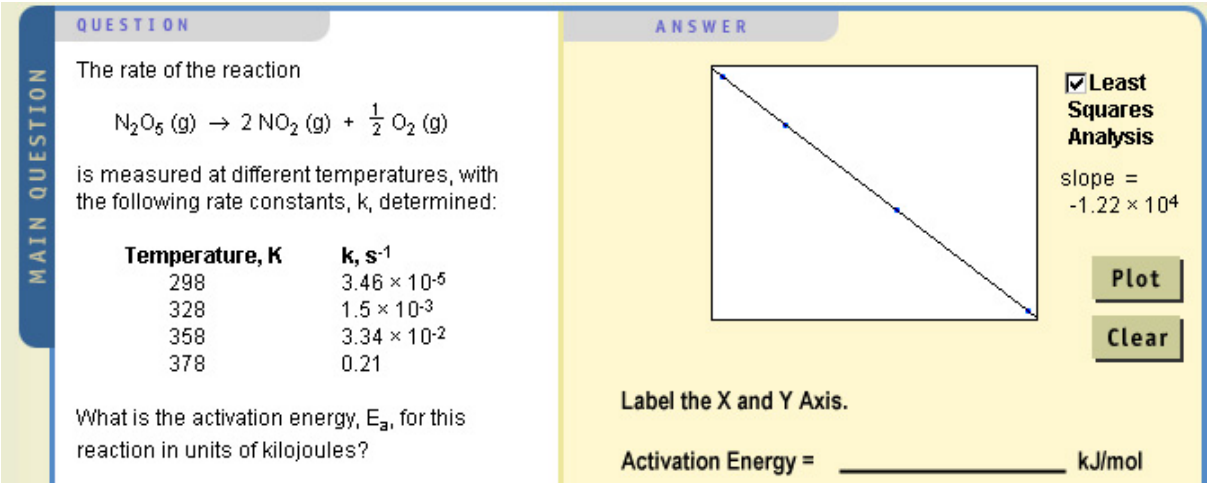
A reaction profile (not to scale!) for the reaction $O_3 + O = 2\ O_2$ is shown below:



Circle those of the following that are false?

1. The magnitude of Ea for the reverse reaction is less than 392.0 kJ.
2. The energy of the products is lower than the energy of the reactants.
3. ΔE is positive.
4. The value of Ea in the presence of a catalyst would be larger than 19.0 kJ.
5. The value of ΔE in the presence of a catalyst would be smaller than -392kJ

Question 4
6 Points



Y Axis: ln k X Axis: 1/T Slope = $-E_a/R$, E_a = 101 kJ.mol^{-1}

Question 5
8 Points

The thermal decomposition of nitryl chloride is proposed to occur by the following mechanism:

slow: $NO_2Cl = NO_2 + Cl$

fast: $Cl + NO_2Cl = NO_2 + Cl_2$

What is the equation for the overall reaction? $2\ NO_2Cl = 2NO_2 + Cl_2$

Which species if any acts as a catalyst? None

Which species if any acts as a reaction intermediate? Cl

Write the rate law for the overall reaction that is consistent with this mechanism.

Rate = $k[NO_2Cl]$

Question 6
6 Points

Write the equilibrium constant expression, K, for the following reaction:

1. $NH_4I(s) \Leftrightarrow NH_3(g) + HI(g)$ $K = [NH_3][HI]$
2. $2NO_2(g) \Leftrightarrow N_2O_4(g)$ $K = [N_2O_4]/[NO_2]^2$
3. $HNO_2(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + NO_2^-(aq)$ $K = [H_3O^+][NO_2^-]/[HNO_2]$

Question 7
4 Points

The equilibrium constant, K, for the following reaction is 8.37 at 736 K:
$2\ NH_3(g) \Leftrightarrow N_2(g) + 3\ H_2(g)$
Calculate K at this temperature for: $1/2\ N_2(g) + 3/2\ H_2(g) \Leftrightarrow NH_3(g)$

Reversed and multiplied by $\frac{1}{2}$
$K_{new} = (1/8.37)^{\frac{1}{2}} = 0.346$

Question 8
7 Points

The equilibrium constant, K, for the following reaction is 77.5 at 600 K:
$CO(g) + Cl_2(g) \Leftrightarrow COCl_2(g)$
Calculate the equilibrium concentrations of reactants and products when 0.470 moles of CO and 0.470 moles of Cl_2 are introduced into a 1.00 L vessel at 600 K.

Help! The two solutions to the quadratic equation associated with this problem are:
x = 0.555 and 0.398

	$[CO]$	$[Cl_2]$	$[COCl_2]$
I	0.47	0.47	0
C	-x	-x	x
E	0.47-x	0.47-x	x

x = 0.398 is the only solution that makes chemical sense

$[CO] = 0.072$ $[Cl_2] = 0.072$ $[COCl_2] = 0.398$

Question 9
10 Points

Consider the following reaction where K = 10.5 at 350 K:
$2\ CH_2Cl_2(g) \Leftrightarrow CH_4(g) + CCl_4(g)$
A reaction mixture was found to contain 1.10×10^{-2} moles of $CH_2Cl_2(g)$, 2.30×10^{-2} moles of $CH_4(g)$, and 4.09×10^{-2} moles of $CCl_4(g)$, in a 1.00 Liter container.

$Q = [CH_4][CCl_4]/[CH_2Cl_2]^2 = (2.3\times10^{-2})(4.09\times10^{-2})/(1.1\times10^{-2})^2 = 7.77 < K$

Indictate True or False:

1. In order to reach equilibrium $CH_2Cl_2(g)$ must be consumed. True
2. In order to reach equilibrium K must decrease. False
3. In order to reach equilibrium CH_4 must be consumed. False
4. Q is greater than K. False
5. The reaction is at equilibrium. No further reaction will occur. False

Question 10
12 points

Consider the following system at equilibrium where $K = 1.80 \times 10^{-2}$ and $\Delta H^\circ = 10.4$ at 698K:
$2\ HI(g) \Leftrightarrow H_2(g) + I_2(g)$

Indictate True or False:

1. The reaction is product favored. False

The production of $H_2(g)$ is favored by:

2. Decreasing the temperature. False
3. Increasing the pressure (by changing the volume). False
4. Increasing the volume. False
5. Removing HI. False
6. Adding I_2. False

Question 11
5 points

The hypothetic reaction, $A \Leftrightarrow B$, after reaching equilibrium at 25°C is heated to 100°C. When equilibrium is reestablished it is found that the concentration of B has decreased. Is this enthalpy change associated with this reaction >0 or <0. Briefly justify your choice.

< 0 , the reaction must be exothermic.

The fact that heating the reaction caused a shift towards products indicates that heat is a product of this reaction, ie it is an exothermic reaction.

Question 12
5 Points

The formula for:

the conjugate base of HF is. F^-

the conjugate acid of NO_2^- is. HNO_2

the conjugate base of $H_2PO_4^-$ is. HPO_4^{2-}

the conjugate acid of HCO_3^- is. H_2CO_3

the conjugate base of NH_4^+ is. NH_3

Question 13
8 Points

The hydronium concentration in an aqueous solution @ 25°C is 4.9×10^{-2} M.

The hydroxide ion concentration is: 2.04×10^{-13} $[H_3O^+][OH^-] = K_w$

The pH of this solution is: 1.31

The pOH is: 12.69

The solution is (acidic/basic) Acidic

Question 14 (5 Points) If instead of $1x10^{-14}$ @ 25°C, the K_w for water was determined to be $1x10^{-16}$ @ 25°C.

1. What would the pH of distilled water be @ 25°C? 8

2. Would water still be considered neutral? Yes
   Briefly Justify your choice?

   $[OH^-] = [H_3O^+] = 1x10^{-8}$, thus water would still be neutral.