CHEM 130 Name _ Quiz 9 – November 18, 2016

Complete the following problems. Write your final answers in the blanks provided.

For problems 1 and 2, consider the mechanism below that has been proposed for the spontaneous gas phase reaction of chlorine gas with chloroform (CHCl₃) to produce carbon tetrachloride (CCl₄) and hydrogen chloride (HCl).

Cl ₂ (g)	k₁ ₹ k-₁	2CI(g)	Fast equilibrium
$CI(g) + CHCI_3$	$k_2 \rightarrow$	$HCI(g) + CCI_3(g)$	Slow
$CCI_3(g) + CI(g)$	k₃ →	CCl ₄ (g)	Fast

If the experimentally-determined rate law is: Rate = k[Cl₂]^{1/2}[CHCl₃], is this an acceptable mechanism? (9 points)

Your first step would be to check that the stoichiometry for the sum of the elementary steps matches that for the overall reaction. In this case, it does.

Then, determine the rate law for this mechanism, starting with the rate law for the slow step, which is the rate-determining step.

Rate =
$$k_2[CI][CHCI_3]$$

Since CI is an intermediate, we need to find an expression for it in terms of reactants. Because step 1 is an equilibrium, the rate of the forward and reverse reactions are equal $k_1[CI_2] = k_{-1}[CI]^2$

Solving for [CI]:

Inserting this into the original rate law gives us

Rate =
$$k_2(k[Cl_2]^{1/2})[CHCl_3]$$

Rate = $k[Cl_2]^{1/2}[CHCl_3]$

This does match the experimental rate law, indicating that the mechanism is reasonable, assuming the experimentally-determined rate law is valid.

Note that since the third step is fast, it does not contribute to the overall rate law for the reaction because the kinetics are dominated by the rate-determining step.

2. Regardless of your answer for part 1, draw a reaction coordinate diagram corresponding to the proposed mechanism. Label the axes of your diagram, as well as reactants, products, transition states, and intermediates. Identify the activation energies for each step. (9 points)



3. In no more than four sentences, explain how a catalyst increases the rate of a chemical reaction while not changing the enthalpy of the reaction. (7 points)

The catalyst provides an alternate, lower activation energy mechanism for the reaction that allows the reaction to proceed more rapidly. The identities of the reactants and products, as well as the stoichiometry remains the same, to the thermodynamics of the reaction are unchanged.

Possibly Useful Information

$rate = k[A]^0$	$[A]_t = -kt + [A]_0$	$t_{1/2} = [A]_0/2k$
$rate = k[A]^1$	$ln[A]_t = -kt + ln[A]_0$	$t_{1/2} = 0.693/k$
rate = $k[A]^2$	$\frac{1}{\left[A\right]_{t}} = kt + \frac{1}{\left[A\right]_{0}}$	$t_{1/2} = 1/(k[A]_0)$

18 8A He 4.00260	10 Ne 20.1797	18 Ar 39.948	36 Kr 83.80	54 Xe 131.29	86 Rn (222)		71 Lu 174.967	103 Lr (262)	
17 7A	9 F 18.9984	17 CI 35.4527	35 Br 79.904	53 I 126.904	85 At (210)		70 Yb 173.04	102 No (259)	
16 6A	8 0 15.9994	16 S 32.066	34 Se 78.96	52 Te 127.60	84 Po (209)		69 Tm 168.934	101 Md (258)	
15 5A	7 N 14.0067	15 P 30.9738	33 As 74.9216	51 Sb 121.757	83 Bi 208.980		68 Er 167.26	100 Fm (257)	
14 4A	6 C 12.011	14 Si 28.0855	32 Ge 72.61	50 Sn 118.710	82 Pb 207.2		67 Ho 164.930	99 Es (252)	
13 3A	5 B 10.811	13 Al 26.9815	31 Ga 69.723	49 In 114.818	81 TI 204.383		66 Dy 162.50	98 Cf (251)	ø
		12 2B	30 Zn 65.39	48 Cd 112.411	80 Hg 200.59		65 Tb 158.925	97 Bk (247)	Hall, In
		11 1B	29 Cu 63.546	47 Ag 107.868	79 Au 196.967	111 Rg (272)	64 Gd 157.25	96 Cm (247)	entice
		10	28 Ni 58.693	46 Pd 106.42	78 Pt 195.08	110 Ds (271)	63 Eu 151.965	95 Am (243)	rson Pr
		-8B-	27 Co 58.9332	45 Rh 102.906	77 Ir 192.22	109 Mt (268)	62 Sm 150.36	94 Pu (244)	07 Pea
		∞ (26 Fe 55.847	44 Ru 101.07	76 Os 190.23	108 Hs (277)	61 Pm (145)	93 Np 237.048	nt © 20
		7B 7B	25 Mn 54.9381	43 Tc (98)	75 Re 186.207	107 Bh (264)	60 Nd 144.24	92 U 238.029	opyrigł
		6 6B	24 Cr 51.9961	42 Mo 95.94	74 W 183.84	106 Sg (266)	59 Pr 140.908	91 Pa 231.036	0
		5 5B	23 V 50.9415	41 Nb 92.9064	73 Ta 180.948	105 Db (262)	58 Ce 140.115	90 Th 232.038	
		4 4B	22 Ti 47.88	40 Zr 91.224	72 Hf 178.49	104 Rf (261)			
		3B 3B	21 Sc 44.9559	39 Y 88.9059	57 *La 138.906	⁸⁹ †Ac 227.028	e series	eries	
2 2A	4 Be 9.01218	12 Mg 24.3050	20 Ca 40.078	38 Sr 87.62	56 Ba 137.327	88 Ra 226.025	thanid	inide st	
1 1A H 1.00794	3 Li 6.941	11 Na 22.9898	19 K 39.0983	37 Rb 85.4678	55 Cs 132.905	87 Fr (223)	*Lan	[†] Act	