Exam 2A
Chem 1142
Spring 2015

Name:_____

MULTIPLE CHOICE. [4 pts ea.] Choose the best response on the scantron sheet. [**60 pts total.**]

Q1. For the chemical reaction:

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

which of the following expressions would correspond to the **rate** of the reaction?

a) $\frac{\Delta[CH_4]}{\Delta t}$ b) $\frac{\Delta[O_2]}{\Delta t}$ c) $\frac{\Delta[H_2O]}{\Delta t}$ d) $\frac{\Delta[CO_2]}{\Delta t}$

Q2. A set of experiments reveals that when the initial concentration of a reactant A is increased by a factor of 4, the initial rate of the reaction is unaffected. From this information we can determine that the reaction order with respect to A is:

a) Zero b) One c) Two d) Three e) Four

Q3. The units for a second-order rate constant are:

a) s^{-1} b) M/s c) M^2/s d) $M^{-1}s^{-1}$ e) M^3s^{-2}

Q4. For the reaction: $A \rightarrow 2B$, a plot of $[A]^{-1}$ vs. t is linear. This allows us to determine:

a) The reaction must be zero-order with respect to A
b) The reaction must be first-order with respect to A
c) The reaction must be second-order with respect to B
d) The activation energy is equal to the slope of the graph × –R
e) The reaction is an elementary reaction

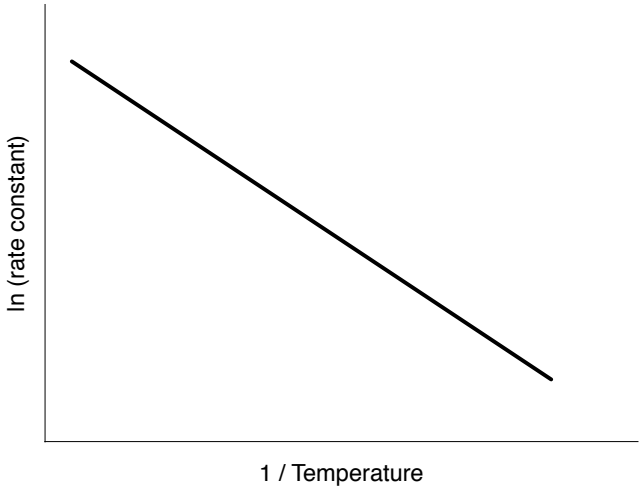
Q5. In which equilibrium reaction below will $K_p = K_c$?

a) $H_2(g) + I_2(g) \rightleftharpoons 2HI(l)$ b) $HCl(g) + CaCO_3(s) \rightleftharpoons CaCl_2(s) + CO_2(g)$
c) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ d) $H_2O(l) \rightleftharpoons H_2O(g)$
e) $CH_3OH(l) + ½\ O_2(g) \rightleftharpoons CH_2O(l) + H_2(g)$

Q6. If K_c for the reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is 12.0 at 25 ºC, then predict the equilibrium constant for the reaction: $4NH_3(g) \rightleftharpoons 2N_2(g) + 6H_2(g)$ at the same temperature.

a) 12.0 b) 24.0 c) –0.0908 d) –24.0 e) 0.00694

Q7. The slope of the following graph provides information about:



a) The value of ΔH^o b) The rate constant, assuming a first-order reaction
c) The rate constant, assuming a second-order reaction
d) The activation energy e) The molecularity of the elementary reaction

Q8. The reaction $H_2(g) + I_2(g) \rightarrow 2HI(g)$ is thought to proceed via the mechanism:

$I_2 \rightarrow 2I$ (slow)
$I + H_2 \rightarrow HI + H$ (fast)
$H + I_2 \rightarrow HI + I$ (fast)

Predict the rate law for this reaction.

a) rate = $k[H_2][I_2]$ b) rate = $k[HI]^2$ c) rate = $k[H_2]$
d) rate = $k[I_2]$ e) rate = $k[I][H_2]$

Q9. Given the reaction: $2N_2O(g) \rightleftharpoons 2NO(g) + N_2(g)$; $\Delta H^o = -130$ kJ/mol at 25 ºC, predict in which direction the equilibrium will shift after the temperature is decreased.
a) To the left b) No change c) To the right d) Not enough information to predict

Q10. If the reaction quotient is equal to the equilibrium constant, then:
a) The reaction will proceed to make more reactants, until it reaches equilibrium
b) The reaction is at equilibrium
c) The reaction will proceed to make more products, until it reaches equilibrium
d) If the reaction is exothermic, it will proceed to make more products
e) If the reaction is endothermic, it will proceed to make more products

Short Response.

Show ALL work to receive credit.

Q11. [20 pts.] The chemical equilibrium:

$$2CH_4(g) \rightleftharpoons C_2H_6(g) + H_2(g)$$

has a equilibrium constant, K_p, equal to 0.092 at 120 ºC. Imagine you started with a mixture of gases where the partial pressure of CH_4 is 0.10 atm and the partial pressures of C_2H_6 and H_2 are both 1.0 atm.

a) Calculate the reaction quotient, and explain which direction the reaction will shift in order to come to equilibrium.

b) Calculate the equilibrium partial pressures of all three gases, as well as the total pressure.

Q12. [20 pts.] Given the following information, deduce the rate law and the value of the rate constant for the following reaction: $A + 2B \rightarrow 3C$

Be sure to show *all* work. If you adopt the inspection method, be sure to explain how you determine the reaction orders using complete sentences.

Experiment	$[A]_0$ / M	$[B]_0$ / M	Initial rate / $M \cdot s^{-1}$
#1	0.50	0.25	3.7×10^{-3}
#2	0.50	0.35	5.18×10^{-3}
#3	1.0	0.25	1.48×10^{-2}

rate law:_____

rate constant:_____ (include units)

Q13. [10 pts.] a) K_c for the reaction: $2NO_2(g) \rightleftharpoons N_2O_4(g)$ is equal to 13.9 at 45 ºC. Calculate K_p at this same temperature.

[10 pts.] b) Using complete sentences, *explain* how it is possible to tell whether a reaction is exothermic or endothermic by measuring how the equilibrium constant changes as the reaction temperature is increased.

Bonus Question: Given a chemical reaction, A → P, what would you have to plot to determine whether the reaction was *second order* with respect to A? Sketch this graph, and explain how you would use it to determine the second order rate constant.

"This is a lovely old song that tells of a young woman who leaves her cottage, and goes off to work. She arrives at her destination, and places some solid NH_4HS in a flask containing 0.50 atm of ammonia, and attempts to determine the pressures of ammonia and hydrogen sulfide when equilibrium is reached."

Useful Information

Periodic Table of the Elements

IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1																	2
H																	He
1.01	2											13	14	15	16	17	4.00
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
6.94	9.01											10.81	12.01	14.01	16.00	19.00	20.18
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
22.99	24.31	3	4	5	6	7	8	9	10	11	12	26.98	28.09	30.97	32.07	35.45	39.95
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.10	40.08	44.96	47.87	50.94	52.00	54.94	55.85	58.93	58.69	63.55	65.39	69.72	72.61	74.92160	78.96	79.90	83.80
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
85.47	87.62	88.91	91.22	92.91	95.94	[98]	101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.60	126.90	131.29
55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
132.91	137.33	174.97	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.20	208.98	[210]	[210]	[222]
87	88	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr	Ra**	Lr	Rf	Db	Sg	Bh	Hs	Mt									
[223]	[226]	[262]	[261]	[262]	[266]	[264]	[265]	[268]	[269]	[272]	[277]		[285]		[289]		[293]

*	57	58	59	60	61	62	63	64	65	66	67	68	69	70
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
	138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
**	89	90	91	92	93	94	95	96	97	98	99	100	101	102
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
	[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

$$R = 8.3145\frac{\text{J}}{\text{mol}\cdot\text{K}} = 0.08206\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}}$$

$$k = Ae^{-\frac{E_A}{RT}} \qquad \ln k = -\frac{E_A}{R}\cdot\frac{1}{T} + \ln A \qquad \ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

• 0-order: $[\text{A}]_t = -kt + [\text{A}]_0$ $\qquad t_{1/2} = \dfrac{[\text{A}]_0}{2k}$

• 1-order: $\ln[\text{A}]_t = -kt + \ln[\text{A}]_0$ $\qquad \ln\left(\dfrac{[A]_t}{[A]_0}\right) = -kt$ $\qquad t_{1/2} = \dfrac{0.693}{k}$

• 2-order: $\dfrac{1}{[\text{A}]_t} = kt + \dfrac{1}{[\text{A}]_0}$ $\qquad t_{1/2} = \dfrac{1}{[\text{A}]_0 k}$

$K_p = K_c(RT)^{\Delta n_g}$

Given: $ax^2 + bx + c = 0$, then $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$