Exam 2a
Chem 1142
Spring 2011

Name: KEY

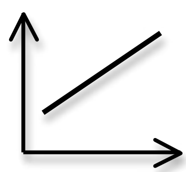
MULTIPLE CHOICE. [2 pts ea.] Choose the best response on the scantron sheet. [**36 pts total.**]

Q1. For the reaction: $A \longrightarrow 2B + C$, the rate could be expressed as $-\Delta[A]/\Delta t$. An equivalent expression is:

a) $-\frac{1}{2}\frac{\Delta[B]^2}{\Delta t}$ b) $-\frac{1}{2}\frac{\Delta[B]}{\Delta t}$ c) $+\frac{1}{2}\frac{\Delta[B]}{\Delta t}$ d) $+\frac{\Delta[B]^2}{\Delta t}$ e) $+\frac{\Delta[B][C]}{\Delta t}$

Q2.A student analyzed a second-order reaction and obtained the graph at the right, but forgot to label the axes. What should the labels be for the X and the Y coordinates respectively?

a) time, ln [A]
b) time, [A]
c) temperature, [A]
d) temperature, ln [A]
e) time, 1/[A]



Q3. For the overall reaction: $2A \longrightarrow B$, the reaction order is:

a) zero order b) first order c) second order
d) impossible to predict without experimental rates at various concentrations of A
e) impossible to predict without knowing the heat of reaction

Q4. What are the units for k, the rate constant, in a first order reaction?

a) $M \cdot s^{-1}$ b) M c) s^{-1} d) $M^{-1} \cdot s^{-1}$ e) $s^{-1} \cdot M$

Q5. What is the rate law for the reaction: $A + B \longrightarrow 2C$, based on the following kinetic data?

Experiment #	Initial Conc of [A] / M	Initial Conc. of [B] / M	Initial rate of reaction / M/s
1	0.40	0.10	3.6×10^3
2	0.20	0.10	1.8×10^3
3	0.20	0.50	4.5×10^4

a) rate = $k[A][B]^2$ b) rate = $k[A]^{1/2}[B]^5$ c) rate = $k[A]^2[B]$
d) rate = $k[A][B]^{1/5}$ e) rate = $k[A]^{1/2}[B]^2$

Q6. What is unique about the half-life of any first-order reaction at 25 °C?

a) The units are always s^{-1} b) The value only depends on the rate constant, k
c) The value only depends on the initial concentration of reactant
d) $\Delta[A]/\Delta t = 1$ e) $\Delta[A]/\Delta t = ½$

Q7. The Arrhenius equation, $k = Ae^{-Ea/RT}$, may be used to calculate the activation energy from the slope of a line plotted with what parameters?

a) ln k vs. 1/Temperature   b) ln k vs. 1/time   c) 1/k vs. Temperature
d) 1/k vs. 1/time   e) ln k vs. e^{-T}

Q8. In general, as the temperature increases, the rate of a chemical reaction

a) increases due to an increased activation energy
b) increases only for an endothermic reaction
c) increases due to a greater number of effective collisions
d) increases because bonds are weakened
e) is not changed

Q9. In basic solution, $(CH_3)_3CCl$ reacts according to the equation:

$$(CH_3)_3CCl + OH^- \longrightarrow (CH_3)_3COH + Cl^-$$

The accepted mechanism for this reaction is:

$(CH_3)_3CCl \longrightarrow (CH_3)C^+ + Cl^-$ (SLOW)
$(CH_3)_3C^+ + OH^- \longrightarrow (CH_3)_3COH$ (FAST)

What is the rate law expression for the reaction?

a) rate = $k[(CH_3)_3C^+]^2[OH^-]$ b) rate = $k[(CH_3)_3C^+][OH^-]^2$ c) rate = $k[Cl^-]$
d) rate = $k[(CH_3)_3CCl]$ e) rate = $k[(CH_3)_3CCl][OH^-]$

Q10. What name would be used to describe an elementary reaction such as:

a) $NO(aq) + 2Cl^-(aq) \longrightarrow NOCl_2^{2-}(aq)$
a) bimolecular   b) unimolecular   c) termolecular
d) dimolecular   e) termolecular

Q11. The equilibrium constant, K_c for the reaction:

$$CaSO_3(s) \rightleftharpoons CaO(s) + SO_2(g)$$

is:

a) $\dfrac{[CaO][SO_2]}{[CaSO_3]}$ b) $[CaO][SO_2]$ c) $[SO_2]$

d) $\dfrac{1}{[SO_2]}$ e) $\dfrac{[CaSO_3]}{[CaO][SO_2]}$

Q12. For which of the following values of the equilibrium constant does the reaction mixture consist mainly of reactants at equilibrium?

a) 10^5 b) 10^3 c) 10^0 d) 10^{-3} e) 10^{-5}

Q13. Which expression correctly describes the equilibrium constant for the following reaction?

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

a) $K_c = \dfrac{4[NH_3]+5[O_2]}{6[H_2O]+4[NO]}$ b) $K_c = \dfrac{6[H_2O]+4[NO]}{4[NH_3]+5[O_2]}$

c) $K_c = \dfrac{[H_2O][NO]}{[NH_3][O_2]}$ d) $K_c = \dfrac{[H_2O]^6[NO]^4}{[NH_3]^4[O_2]^5}$ e) $K_c = \dfrac{[NH_3]^4[O_2]^5}{[H_2O]^6[NO]^4}$

Q14. For which of the following equilibria would $K_c = K_p$?

a) $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$

b) $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

c) $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

d) $CO(g) + \frac{1}{2} O_2(g) \rightleftharpoons CO_2(g)$

e) $2NO_2(g) \rightleftharpoons N_2O_4(g)$

Q15. At 25 °C, the reaction

$2ICl(g) \rightleftharpoons I_2(g) + Cl_2(g)$; ΔH =+27.0 kJ/mol

has an equilibrium constant of 6.2×10^{-6}. Which of the following would be true if the temperature were increased to 100 °C?

1. The equilibrium constant would be larger.
2. The concentration of ICl(g) would be increased.
3. The partial pressure of I_2 would increase.

a) 1 only b) 2 only c) 3 only d) 1 and 2 only e) 1 and 3 only

Q16. For the reaction system $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ at equilibrium, ΔH = –92 kJ/mol. In order to both shift the equilibrium and increase the yield of ammonia, we should

1. increase the temperature
2. decrease the temperature
3. increase the pressure
4. decrease the pressure

a) 1 only b) 2 only c) 1 and 3 only d) 2 and 3 only e) 1 and 4 only

Q17. Addition of a catalyst to a reaction at equilibrium does not alter the value of the equilibrium constant.

a) TRUE b) FALSE

Q18. A chemical reaction has an equilibrium constant of 0.49 at a particular temperature. If the reaction quotient is equal to 0.53, then…

a) The reaction shifts to the right to make more products

b) The reaction is at equilibrium, and no shift will occur

c) The reaction shifts to the left to make more reactants

d) The reaction shifts to the left and causes a temperature decrease

e) The reaction shifts to the right and causes a temperature increase

Short Response. Show all work.

Q19. [7 pts.] The rate law for the reaction

$$NH_4^+(aq) + NO_2^-(aq) \longrightarrow N_2(g) + 2H_2O(l)$$

is given by rate=$k[NH_4^+][NO_2^-]$. At 25 °C, the rate constant is $3.0 \times 10^{-4}\ M^{-1} \cdot s^{-1}$. Calculate the rate of the reaction at this temperature if $[NH_4^+] = 0.26$ M, and $[NO_2^-] = 0.080$ M.

$$Rate = 3.0\times10^{-4}\ M^{-1}\cdot s^{-1} \times 0.26M \times 0.080M$$
$$= 6.2\times10^{-6}\frac{M}{s}$$

300.K

278K

Q20. [15 pts.] The rate at which tree crickets chirp is 2.0×10^2 per minute at 27 °C, but only 39.6 per minute at 5 °C. From these data, calculate the "energy of activation" for the chirping process. (*Hint:* The ratio of rates is equal to the ratio of rate constants.)

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

$$\Rightarrow E_A = \frac{\ln\left(k_2/k_1\right)\cdot R}{\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

$$= \frac{\ln\left(\frac{2.0\times10^2/min}{39.6/min}\right)\times 8.3145\ J/mol\,K}{\left(\frac{1}{278K} - \frac{1}{300.K}\right)}$$

$$= 51{,}000\ J/mol \quad \text{or} \quad 51\ kJ/mol$$

Q21. [5 pts.] How does a catalyst increase the rate of a reaction?

It lowers the activation energy by providing an alternate mechanism.

Q22. [6 pts.] Write equilibrium constant expressions for K_c and K_p for the following reactions:

a) $2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$

$$K_c = \frac{[CO]^2[O_2]}{[CO_2]^2} \quad , \quad K_p = \frac{P_{CO}^2 \cdot P_{O_2}}{P_{CO_2}^2}$$

b) $2HgO(s) \rightleftharpoons 2Hg(l) + O_2(g)$

$$K_c = [O_2] \quad , \quad K_p = P_{O_2}$$

Q23. [10 pts.] Write out electron configurations for the following ATOMS or IONS:

a) Li $1s^2 2s^1$

b) Ca^{2+} [Ar]

c) Cu $[Ar]\,4s^1 3d^{10}$ (Auf bau exception!)

d) Fe^{2+} $[Ar]\,3d^6$

e) Br^- [Kr]

Q24. [11 pts.] The equilibrium constant K_c for the reaction

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

is 4.2 at 1650 °C. Initially 0.80 mol H_2 and 0.80 mol CO_2 are injected into a 5.0-L flask. Calculate the concentration of each species at equilibrium.

$[H_2]_i = [CO_2]_i = \frac{0.80\,mol}{5.0\,L} = 0.16\,M$

$H_2 + CO_2 \rightleftharpoons H_2O + CO$

	H_2	CO_2	H_2O	CO
I	0.16	0.16	0	0
C	$-x$	$-x$	$+x$	$+x$
E	$(0.16-x)$	$(0.16-x)$	(x)	(x)

$K_c = \frac{[H_2O][CO]}{[H_2][CO_2]_{eq}}$

$\Rightarrow \sqrt{4.2} = \sqrt{\frac{(x)(x)}{(0.16-x)(0.16-x)}}$

$\Rightarrow 2.05 = \frac{x}{0.16-x}$

$\Rightarrow 2.05(0.16-x) = x$

$\Rightarrow 0.328 - 2.05x = x$

$\Rightarrow 0.328 = 3.05x$

$\Rightarrow x = \frac{0.328}{3.05}$

$= 0.108$

$\Rightarrow [H_2O]_{eq} = [CO]_{eq} = 0.108\,M$

$\Rightarrow [H_2]_{eq} = [CO_2]_{eq} = 0.052\,M$

Q25. [10 pts.] Write formulas for the following compounds:

a) ammonium sulfate $(NH_4)_2SO_4$ $NH_4^+ \; SO_4^{2-}$

b) copper(I) acetate $CuC_2H_3O_2$ $Cu^+ \; C_2H_3O_2^-$

c) iron(III) nitride FeN $Fe^{3+} \; N^{3-}$

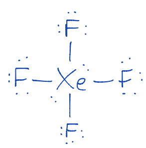
d) heptanitrogen disulfide N_7S_2 hepta=7, di=2

e) nitric acid HNO_3 recall.

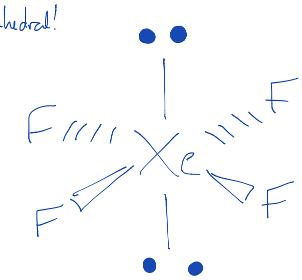
BONUS QUESTIONS

Predict the molecular geometry of XeF_4.

$8+7\times4=36e^-$



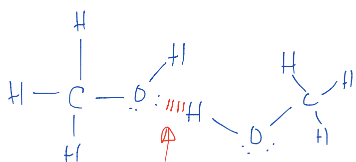
6 repulsions ⇒ octahedral!



SQUARE PLANAR

lp → opposite sides to minimize lp-lp repulsions!

Draw a diagram showing the formation of hydrogen bonds between molecules of CH_3OH. Clearly label the location of the hydrogen bonds in your diagram!



Hydrogen Bond!

Useful Information

Periodic Table of the Elements

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

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

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

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

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

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

<u>•2-order</u>: $1/[A]_t = kt + 1/[A]_0$ $\qquad$ $t_{1/2} = 1 / ([A]_0 \cdot k)$

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

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