Name_____*KOL*_____ (print) Name _____(sign)

Please show work for partial credit on the Long Answers and in some of the Short Answer Questions.   Multiple choice questions have no partial credit.   Please write anything you want graded legibly.   If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I   MULTIPLE CHOICE.   Choose the one alternative that best completes the statement or answers the question.   (2 pts per question, 28 pts pts total)

1) Give the term for the amount of solute in moles per liter of solution.   1) ___B___
   A) mole percent
   B) molarity
   C) mole fraction
   D) mass percent
   E) molality

2) Which of the following statements is FALSE? (K = equilibrium constant)   *not related to rate*   2) ___B___
   A) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
   B) K >> 1 implies that the reaction is very fast at producing products.
   C) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
   D) When K >> 1, the forward reaction is favored and essentially goes to completion.
   E) None of the above.

3) Given the following rate law, how does the rate of reaction change if the concentration of Y is   3) ___A___
   doubled?

   $$Rate = k\,[X][Y]$$

   A) The rate of reaction will increase by a factor of 2. — *1st order*
   B) The rate of reaction will decrease by a factor of 2.
   C) The rate of reaction will increase by a factor of 5.
   D) The rate of reaction will increase by a factor of 4.
   E) The rate of reaction will remain unchanged.

   moles = $\dfrac{27.8}{133.8}$ = 0.500

   $500\,mL \times \dfrac{1\,g}{1\,mL} \times \dfrac{Kg}{1000\,g}$ $Kg\ solvent$

4) Calculate the molality of a solution formed by dissolving 27.8 g of LiI (FW = 133.8 g/mol) in 500.0   4) ___D___
   mL of water.
   A) 0.241 *m*   B) 0.556 *m*   C) 0.394 *m*   D) 0.415 *m*   E) 0.254 *m*

5) Calculate the boiling point of a solution of 8.05 moles of ethylene glycol dissolved in 0.500 Kg of   5) ___B___
   water. $\Delta T_b = K_b * m$ CH_4 and $K_b = 0.512°C/m$. Use 100°C as the boiling point of water.
   A) 92°C   B) 108°C   C) 8.3°C   D) 70°C   E) 130°C

   $$\Delta T_b = (0.512)\left(\frac{8.05\,mol}{0.500\,kg}\right) \approx 8$$

   $$BP = 100 + 8$$

6) Identify the rate–determining step.   6) __C__
   A) always the last step
   B) the faster step
   C) the slowest step
   D) the fast step
   E) always the second step

7) Give the term for the amount of solute in moles per kilogram of solvent.   7) __B__
   A) molarity
   B) molality
   C) mass percent
   D) mole fraction
   E) mole percent

8) Identify the solute with the highest van't Hoff factor.   8) __B__
   A) $MgSO_4$ — 2
   B) $FeCl_3$ — 4
   C) $MgCl_2$ — 3
   D) $NaCl$ — 2
   E) nonelectrolyte — 1

9) Give the characteristic of a zero order reaction having only one reactant.   9) __C__
   A) The rate of the reaction is proportional to the square root of the concentration of the reactant.
   B) The rate of the reaction is directly proportional to the concentration of the reactant.
   C) The rate of the reaction is not proportional to the concentration of the reactant.
   D) The rate of the reaction is proportional to the natural logarithm of the concentration of the
      reactant.
   E) The rate of the reaction is proportional to the square of the concentration of the reactant.

10) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)?   10) __B__
   A) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$) ⁴ *like dissolves*
   B) ethylene glycol ($HOCH_2CH_2OH$)   *like "*
   C) trimethylamine ($N(CH_3)_3$)
   D) acetone (CH_3COCH_3)
   E) None of these compounds should be soluble in ethanol.

11) To make a 2.00 m solution, one could take 2.00 moles of solute and add   11) __B__
   A) enough solvent to make 1.00 kg of solution.
   B) 1.00 kg of solvent.
   C) enough solvent to make 1.00 L of solution.
   D) 1.00 L of solvent.

12) Given the following balanced equation, determine the rate of reaction with respect to [NOCl].   12) _A_
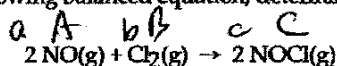
$$a\ A\qquad b\ B\qquad c\ C$$
$$2\ NO(g) + Cl_2(g) \rightarrow 2\ NOCl(g)$$

A) $Rate = +\dfrac{1}{2}\dfrac{\Delta[NOCl]}{\Delta t}$

B) $Rate = -\dfrac{1}{2}\dfrac{\Delta[NO]}{\Delta t}$

C) $Rate = -\dfrac{2\ \Delta[NOCl]}{\Delta t}$

D) $Rate = -\dfrac{1}{2}\dfrac{\Delta[NOCl]}{\Delta t}$
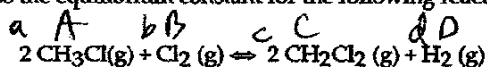
E) It is not possible to determine without more information.

$$rate = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = +\frac{1}{c}\frac{\Delta[C]}{\Delta t}$$

$$rate = +\frac{1}{2}\frac{\Delta[C]}{\Delta t}$$

13) Express the equilibrium constant for the following reaction.   13) _D_

$$a\ A\qquad b\ B\qquad c\ C\qquad d\ D$$
$$2\ CH_3Cl(g) + Cl_2(g) \rightleftharpoons 2\ CH_2Cl_2(g) + H_2(g)$$

A) $K = \dfrac{[CH_3Cl]^{1/2}[Cl_2]}{[CH_2Cl_2]^{1/2}[H_2]}$

B) $K = \dfrac{[CH_2Cl_2][H_2]}{[CH_3Cl][Cl_2]}$

C) $K = \dfrac{[CH_3Cl][Cl_2]}{[CH_2Cl_2][H_2]}$

D) $K = \dfrac{[CH_2Cl_2]^2[H_2]}{[CH_3Cl]^2[Cl_2]}$

E) $K = \dfrac{[CH_3Cl]^2[Cl_2]}{[CH_2Cl_2]^2[H_2]}$

$$K = \frac{[C]^c\ [D]^d}{[A]^a\ [B]^b}$$

14) Consider the following reaction at equilibrium. What effect will removing NO_2 have on the system?   14) _B_

remove

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

A) The reaction will shift in the direction of products.
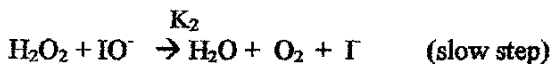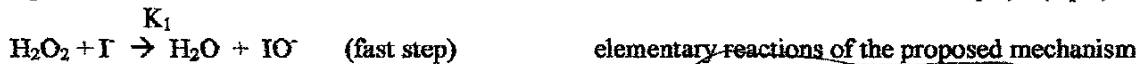B) The reaction will shift in the direction of reactants.
C) The reaction will shift to decrease the pressure.
D) No change will occur since SO_3 is not included in the equilibrium expression.
E) The equilibrium constant will decrease.

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question.   (39 pts)

1. For the following reaction mechanism shown as the elementary reactions given, what is the rate law?
(You do not need to show me only reactants of the overall reaction to complete this problem. You do not need to show me the overall reaction to complete this problem.) (The K shown are not equilibrium constants but the rate constants associated with the reaction mechanism steps.)   (8 pts)

$$H_2O_2 + I^- \xrightarrow{K_1} H_2O + IO^- \quad \text{(fast step)}$$

elementary reactions of the proposed mechanism

$$H_2O_2 + IO^- \xrightarrow{K_2} H_2O + O_2 + I^- \quad \text{(slow step)}$$

$$rate = k_2 [H_2O_2][IO^-]$$

gave fast step rate law -3

added -2

gave k = [H_2O_2][IO^-] -3

bad attempt -5

gave equilibrium constant

2. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (4 pts each, 16 pts total)

really bad -6

extra wrong -3

(c) (d) (b) (a)

Energy

reaction progress

3.   a. For the following **overall reaction** (**not reaction mechanism step**, the overall reaction), Given the concentrations and rates, give the order of the reactant by circling the order for the reagent given. You should assume an irreversible reaction. (note: I made up these reactions to illustrate the point so the reactions as given may not go experimentally as written.) (5 pts each, 10 pts total)

$$NO_2 (g) + O_3 (g) \rightarrow NO_3 (g) + O_2 (g)$$

$[NO_2]$	$[O_3]$	rate
3	1	8
3	2	16
6	1	8

order of the $[NO_2]$ is (zero) (one) (circle one)

order of the $[O_3]$ is (zero) (one) (circle one)

[handwritten:] $[O_3]$ changes - doubles + rate double so first order

[handwritten:] $[NO_2]$ doubles + (rate - no change) so zero order

b. From your results in part (a) write the rate law for the overall reaction shown above. (5 pts)

[handwritten:]
$$rate = k [NO_2]^0 [O_3]^1$$
$$rate = k [O_3]$$

[handwritten annotations:]
order does not match above -1 each

left off k -1

gave $k + y$ for order -1

gave $k = [NO_2]^0 [O_3]$ -1

bad attempt -4

gave $\dfrac{1}{a} \dfrac{\Delta (A)}{\Delta t}$ -2t

Part III. Long Answer Please show work for full credit and to receive partial credit. (33 pts)

1. If you have a 6.0 Molar solution of H_2SO_4 dissolved in water, how many grams of H_2SO_4 (FW = 98.1 g/mol) is in 73.5 mL of this solution. (15 pts)

$$73.5 \, mL \times \frac{6.0 \, moles \, H_2SO_4}{1000 \, mL \, H_2SO_4 \, solution} \times \frac{98.1 \, g \, H_2SO_4}{1 \, mol \, H_2SO_4}$$

(handwritten annotations: 5 pt, 5 pt, 5 pt, upside down −2, bad attempt −10)

$$43.3 \, g \, H_2SO_4 \quad (math -1)$$

2. Equilibrium (18 pts total)

a. For the reaction given, set up the ICE table for a reaction in which the reactant gases are mixed in a constant volume of an inert solvent with **no products present initially**: (6 pts total) (I made up the K_{eq} numbers so these numbers do not match real reaction results.)

$$H_2S(g) + 3/2 \; O_2(g) \rightarrow H_2O(g) + SO_2(g) \qquad K_{eq} = 3.2 \times 10^{-2}$$

If the initial concentration of the H_2S is 0.537 M, and the intial concentration of O_2 is 0.444 M. Show the initial, change and equilibrium concentrations for all reactants and products. You will need to use a variable x to complete this task. (x is usually used for the molecule with the smallest coefficient to make this task easier.)

(handwritten: 1 pt each, ½ pt each)
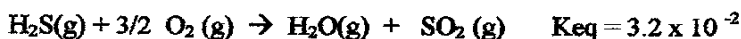
	[H₂S]	[O₂]	[H₂O]	[SO₂]
Initial	0.537	0.444	O	O
Change	− X	− 3/2 X	+ X	+ X
Equilibrium	0.537 − X	0.444 − 3/2 X	X	X

(handwritten annotations: ½ pt each box, ¼ pt each box, Consistent w your wrong Charge OK, ½ pt, ¾ pt)

b.   For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions. To answer this question, you will not be using any of the results from the table in part (a) above. (6 pts)

(1 pt each)

$$K_{eq} = \frac{[H_2O][SO_2]}{[H_2S][O_2]^{1/2}}$$

(gave rate law -4)

(2 pt each)

(added -1)

c.   For the same reaction, set up the K_{eq} to solve for x.   I am not asking you to derive the final actual number for x nor am I asking you to do the algebra to solve for x.   I am just asking you to plug in for your expression in (b) above with your number and x-expressions from the table in part (a) above. (6 pts)

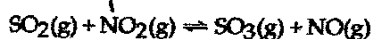$$K_{eq} = \frac{(x)(x)}{(0.557-x)(0.444-^1/_2 x)} = 3.2 \times 10^{-2}$$

(1 pt each)

(½ pt each)

(graded consistent w your @)

(used your table — initial or change -2)

Name_____*Key*_____ (print) Name _____(sign)

Please show work for partial credit on the Long Answers and in some of the Short Answer Questions.   Multiple choice questions have no partial credit.   Please write anything you want graded legibly.   If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I   MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 28 pts pts total)

1) Consider the following reaction at equilibrium. What effect will removing NO_2 have on the system?

remove ↓

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

   A) The reaction will shift to decrease the pressure.
   B) No change will occur since SO_3 is not included in the equilibrium expression.
   C) The reaction will shift in the direction of reactants.
   D) The reaction will shift in the direction of products.
   E) The equilibrium constant will decrease.

1) __C__

2) Given the following balanced equation, determine the rate of reaction with respect to [NOCl].

$$2 NO(g) + Cl_2(g) \rightarrow 2 NOCl(g)$$

$$a A + b B \rightarrow c C + d D$$

$$rate = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} \; ,,,$$

   A) Rate $= -\frac{1}{2}\frac{\Delta[NO]}{\Delta t}$

   B) Rate $= +\frac{1}{2}\frac{\Delta[NOCl]}{\Delta t}$

   C) Rate $= -\frac{1}{2}\frac{\Delta[NOCl]}{\Delta t}$

   D) Rate $= -\frac{2 \Delta[NOCl]}{\Delta t}$

   E) It is not possible to determine without more information.

2) __B__

3) Give the term for the amount of solute in moles per liter of solution.
   A) mass percent
   B) mole fraction
   C) mole percent
   D) molarity
   E) molality

3) __D__

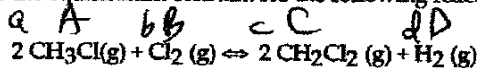4) Identify the solute with the highest van't Hoff factor.
   A) $MgCl_2$ —— 3
   B) $MgSO_4$ —— 2
   C) nonelectrolyte —— 1
   D) $FeCl_3$ —→ 4
   E) NaCl —— 2

4) __D__

5) Calculate the molality of a solution formed by dissolving 27.8 g of LiI (FW = 133.8 g) in 500.0 mL of water. 5) _B_

    A) 0.254 m B) 0.415 m C) 0.556 m D) 0.394 m E) 0.241 m

6) Express the equilibrium constant for the following reaction. 6) _D_

$$2 CH_3Cl(g) + Cl_2(g) \Leftrightarrow 2 CH_2Cl_2(g) + H_2(g)$$

A) $K = \dfrac{[CH_2Cl_2][H_2]}{[CH_3Cl][Cl_2]}$

B) $K = \dfrac{[CH_3Cl][Cl_2]}{[CH_2Cl_2][H_2]}$

C) $K = \dfrac{[CH_3Cl]^{1/2}[Cl_2]}{[CH_2Cl_2]^{1/2}[H_2]}$

D) $K = \dfrac{[CH_2Cl_2]^2[H_2]}{[CH_3Cl]^2[Cl_2]}$

E) $K = \dfrac{[CH_3Cl]^2[Cl_2]}{[CH_2Cl_2]^2[H_2]}$

(handwritten: mole/kg ; $(27.8g/133.8)$; $\left(500 mL \times \frac{1g}{1mL} \times \frac{1kg}{1000g}\right)$; $K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$; # mole/kg solvent)

7) To make a 2.00 m solution, one could take 2.00 moles of solute and add 7) _B_
    A) enough solvent to make 1.00 L of solution.
    B) 1.00 kg of solvent.
    C) 1.00 L of solvent.
    D) enough solvent to make 1.00 kg of solution.

8) Calculate the boiling point of a solution of 8.05 moles of ethylene glycol dissolved in 0.500 Kg of water. $\Delta T_b = K_b * m$ CH4 and $K_b = 0.512°C/m$. Use 100°C as the boiling point of water. 8) _D_
    A) 8.3°C   B) 130°C   C) 92°C   D) 108°C   E) 70°C

(handwritten: $\Delta T_b = \left(\frac{8.05}{0.500}\right)(0.512) \approx 8$; $100 + 8 = 108°$)

9) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)? 9) _A_
    A) ethylene glycol ($HOCH_2CH_2OH$)
    B) trimethylamine ($N(CH_3)_3$)
    C) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)
    D) acetone (CH_3COCH_3)
    E) None of these compounds should be soluble in ethanol.
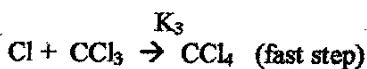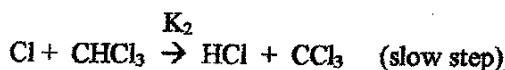
(handwritten: like dissolves like)

10) Give the term for the amount of solute in moles per kilogram of solvent. 10) _D_
    A) mole fraction
    B) mass percent
    C) molarity
    D) molality
    E) mole percent

11) Give the characteristic of a zero order reaction having only one reactant.   11) **B**

    A) The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.

    B) The rate of the reaction is not proportional to the concentration of the reactant.

    C) The rate of the reaction is directly proportional to the concentration of the reactant.

    D) The rate of the reaction is proportional to the square of the concentration of the reactant.

    E) The rate of the reaction is proportional to the square root of the concentration of the reactant.

12) Which of the following statements is FALSE? (K = equilibrium constant) *not related to rate*   12) **B**

    A) When K >> 1, the forward reaction is favored and essentially goes to completion.

    B) K >> 1 implies that the reaction is very fast at producing products.

    C) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.

    D) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.

    E) None of the above.

13) Given the following rate law, how does the rate of reaction change if the concentration of Y is doubled?   13) **B**

$$Rate = k \, [X][Y]$$

first order in Y

    A) The rate of reaction will increase by a factor of 4.

    B) The rate of reaction will increase by a factor of 2.

    C) The rate of reaction will decrease by a factor of 2.

    D) The rate of reaction will increase by a factor of 5.

    E) The rate of reaction will remain unchanged.

14) Identify the rate-determining step.   14) **A**

    A) the slowest step

    B) always the second step

    C) the fast step

    D) always the last step

    E) the faster step

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question.   (39 pts)

1. For the following reaction mechanism shown as the elementary reactions given, what is the rate law? (You do not need to show me only reactants of the overall reaction to complete this problem. You do not need to show me the overall reaction to complete this problem.) (The K shown are not equilibrium constants but the rate constants associated with the reaction mechanism steps.)   (8 pts)

(-3) gave fast step rate law

$$Cl_2 \xrightarrow{K_1} 2\,Cl \qquad \text{(fast step)}$$

elementary reactions of the proposed mechanism

$$Cl + CHCl_3 \xrightarrow{K_2} HCl + CCl_3 \quad \text{(slow step)}$$

added -2

$$Cl + CCl_3 \xrightarrow{K_3} CCl_4 \quad \text{(fast step)}$$

bad attempt -5

gave equilibrium constant

$$rate = K_2\,[Cl][CHCl_3]$$

left off K-1

extra wrong -3

really bad -6
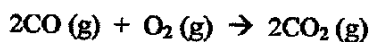
2. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (4 pts each, 16 pts total)

gave
$$K = [Cl][CHCl_3]$$
-3

Energy

reaction progress

3. a. For the following **overall reaction** (**not reaction mechanism step**, the overall reaction), Given the concentrations and rates, give the order of the reactant by circling the order for the reagent given. You should assume an irreversible reaction. (note: I made up these reactions to illustrate the point so the reactions as given may not go experimentally as written.) (5 pts each, 10 pts total)

$2CO \text{ (g)} + O_2 \text{ (g)} \rightarrow 2CO_2 \text{ (g)}$

[CO]	[O$_2$]	rate
5	3	2
10	3	4
5	6	4

order of the [CO] is (zero) (one) (circle one)

order of the [O$_2$] is (zero) (one) (circle one)

[handwritten annotations:] double [CO] & double rate [CO] is first order — hold [O2] constant

double [O2] rate doubles [O2] is first order — hold [CO] constant

gave $k = [CO][O_2]$ —1

b. From your results in part (a) write the rate law for the overall reaction shown above. (5 pts)

$rate = k [CO][O_2]$

[handwritten annotations:]

left off k —1

gave $\frac{1}{a} \frac{\Delta[A]}{\Delta t}$ —2†

gave general $rate = k[A][B]$ —2†

bad attempt —4

gave x & y for order —1

Part III.   Long Answer   Please show work for full credit and to receive partial credit. (33 pts)

1.   If you have a 12.0   Molar solution of KOH dissolved in water, how many grams of KOH (FW = 56.1 g/mol) is in 38.9   mL of this solution. (15 pts)

(5pt)   (5pt)   (5pt)

$$38.9 \, ml \times \frac{12.0 \, mol \, KOH}{1000 \, ml \, KOH \, soln} \times \frac{56.1 \, g \, KOH}{mol \, KOH} =$$

KOH soln

bad attempt −10   math −1

26.2 g KOH   upside down −2½

2.   Equilibrium (18 pts total)

a. For the reaction given, set up the ICE table for a reaction in which the reactant gases are mixed in a constant volume of an inert solvent with **no products present initially**: (6 pts total) (I made up the K_{eq} numbers so these numbers do not match real reaction results.)
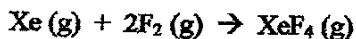
$$Xe \, (g) \; + \; 2F_2 \, (g) \; \rightarrow \; XeF_4 \, (g) \qquad\qquad K_{eq} = 1.78 \times 10^{-8}$$

If the initial concentration of the Xe   is 0.256 M, and the intial concentration of F_2 is 0.311 M. Show the initial, change and equilibrium concentrations for all reactants and products.   You will need to use a variable x to complete this task. (x is usually used for the molecule with the smallest coefficient to make this task easier.)

	[Xe]	[F₂]	[XeF₄]
Initial	0.256	0.311	0
Change	−X	−2X	+X
Equilibrium	0.256 −X	0.311 −2X	X

(3pt)

(3pt)

consistent w your wrong change OK

½ pt bord box

Dr. Hahn   Exam II 9:30 B MWF   page   6

b.   For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions.   To answer this question, you will not be using any of the results from the table in part (a) above. (6 pts)

(handwritten annotation: same rate law –4)

$$k = \frac{[XeF_4]}{[Xe][F_2]^2}$$

(handwritten annotations: added –1 ; 2 pts each ; 1st power)

c.   For the same reaction, set up the K_{eq} to solve for x.   I am not asking you to derive the final actual number for x nor am I asking you to do the algebra to solve for x.   I am just asking you to plug in for your expression in (b) above with your number and x expressions from the table in part (a) above. (6 pts)

$$k = \frac{x}{(0.256-x)(0.311-2x)^2} = 1.18 \times 10^{-8}$$

(handwritten annotation: 1 pt each)

(handwritten annotations: graded consistent w your @ ; used your table initial or change –2)

Name_____ /_____ (print) Name _____(sign)

Please show work for partial credit on the Long Answers and in some of the Short Answer Questions.   Multiple choice questions have no partial credit.   Please write anything you want graded legibly.   If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I   MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 28 pts pts total)

1) Give the characteristic of a zero order reaction having only one reactant.   1) __B__
    A) The rate of the reaction is directly proportional to the concentration of the reactant.
    B) The rate of the reaction is not proportional to the concentration of the reactant.
    C) The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
    D) The rate of the reaction is proportional to the square of the concentration of the reactant.
    E) The rate of the reaction is proportional to the square root of the concentration of the reactant.

2) Give the term for the amount of solute in moles per kilogram of solvent.   2) __E__
    A) mole fraction
    B) mass percent
    C) mole percent
    D) molarity
    E) molality

3) To make a 2.00 m solution, one could take 2.00 moles of solute and add   3) __A__
    A) 1.00 kg of solvent.
    B) enough solvent to make 1.00 kg of solution.
    C) enough solvent to make 1.00 L of solution.
    D) 1.00 L of solvent.

4) Identify the rate–determining step.   4) __E__
    A) the fast step
    B) always the second step
    C) always the last step
    D) the faster step
    E) the slowest step

$$i = 2$$
$$m = \frac{0.067\ mol}{550.0g} \times \frac{1\ kg}{1000\ g} = 0.122$$
$$\Delta T_f = (2)(1.86)(0.122) = 0.45$$

5) Calculate the freezing point of a solution containing 0.067 mol of K Cl and 550.0 grams of water.   5) __E__
The molal–freezing–point–depression constant (K_f) for water is 1.86°C/m. $\Delta T_f = i * K_b * m$. Use
0°C as the freezing point of water and assume complete dissociation of the K Cl.
    A) 1.23 °C   B) –0.23 °C   C) +0.23 °C   D) +0.45 °C   E) –0.45 °C

$$0°C - 0.45 =$$

6) Give the term for the amount of solute in moles per liter of solution.   6) __E__
    A) mole percent
    B) mole fraction
    C) molality
    D) mass percent
    E) molarity

7) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)? 7) __B__

   A) acetone (CH_3COCH_3)

   B) ethylene glycol ($HOCH_2CH_2OH$) "like dissolves like"

   C) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)

   D) trimethylamine ($N(CH_3)_3$)

   E) None of these compounds should be soluble in ethanol.

8) Given the following balanced equation, determine the rate of reaction with respect to [O_2]. 8) __B__

   $$2\ \overset{a\ \text{A}}{O_3(g)} \rightarrow 3\ \overset{b\ \text{B}}{O_2(g)}$$
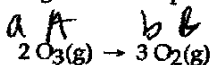
   $$rate = -\frac{1}{a}\frac{\Delta [A]}{\Delta t} = +\frac{1}{b}\frac{\Delta [B]}{\Delta t}$$

   A) Rate $= +\dfrac{3\ \Delta[O_2]}{\Delta t}$

   B) Rate $= +\dfrac{1}{3}\dfrac{\Delta[O_2]}{\Delta t}$

   C) Rate $= -\dfrac{2}{3}\dfrac{\Delta[O_2]}{\Delta t}$

   D) Rate $= -\dfrac{2\ \Delta[O_2]}{\Delta t}$

   E) It is not possible to determine without more information.

   $$m = \frac{(27.8\,g/133.8)}{500.0\ mL \times \frac{1\,g}{1\,mL} \times \frac{1\,Cg}{1000\,g}}$$

9) Calculate the molality of a solution formed by dissolving 27.8 g of LiI (FW = 133.8 g/mol) in 500.0 mL of water. 9) __D__

   A) 0.556 m B) 0.394 m C) 0.254 m D) 0.415 m E) 0.241 m

10) Identify the solute with the lowest van't Hoff factor. 10) __E__

    A) $MgSO_4$ —— 2

    B) $FeCl_3$ —— 4

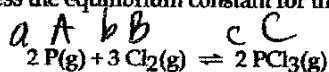   C) NaCl —— 2

    D) $MgCl_2$ —— 3

    E) nonelectrolyte — 1

11) Which of the following statements is FALSE? (K = equilibrium constant) 11) __C__

    A) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.

    B) When K >> 1, the forward reaction is favored and essentially goes to completion.

    C) K >> 1 implies that the reaction is very fast at producing products.

    D) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.

    E) None of the above.

    has nothing to do with rate

12) Express the equilibrium constant for the following reaction.   12) _A_

a A b B c C

$$2 P(g) + 3 Cl_2(g) \rightleftharpoons 2 PCl_3(g)$$

$$K = \frac{[C]^c}{[A]^a[B]^b}$$

A) $K = \dfrac{[PCl_3]^2}{[P]^2[Cl_2]^3}$

B) $K = \dfrac{[P]^2[Cl_2]^3}{[PCl_3]^2}$

C) $K = \dfrac{[P][Cl_2]^{3/2}}{[PCl_3]}$

D) $K = \dfrac{[PCl_3]^{1/2}}{[P]^{1/2}[Cl_2]^{1/3}}$

E) $K = \dfrac{[PCl_3]}{[P][Cl_2]^{3/2}}$

13) Consider the following reaction at equilibrium. What effect will adding more H_2S have on the   13) _C_
system?   added drives Rxn→

$$2 H_2S(g) + 3 O_2(g) \rightleftharpoons 2 H_2O(g) + 2 SO_2(g)$$
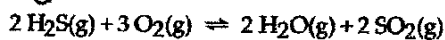
A) The reaction will shift to the left.
B) The equilibrium constant will increase.
C) The reaction will shift in the direction of products.
D) The equilibrium constant will decrease.
E) No change will be observed.

14) Given the following rate law, how does the rate of reaction change if the concentration of Y is   14) _A_
doubled?

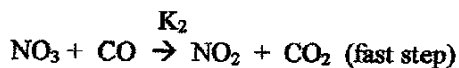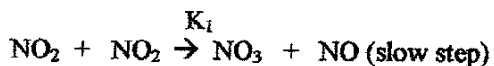Rate = k [X][Y]   1st order with y

A) The rate of reaction will increase by a factor of 2.
B) The rate of reaction will increase by a factor of 5.
C) The rate of reaction will decrease by a factor of 2.
D) The rate of reaction will increase by a factor of 4.
E) The rate of reaction will remain unchanged.

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (39 pts)

1. For the following reaction mechanism shown as the elementary reactions given, what is the rate law? (You do not need to show me only reactants of the overall reaction to complete this problem. You do not need to show me the overall reaction to complete this problem.) (The K shown are not equilibrium constants but the rate constants associated with the reaction mechanism steps.) (8 pts)

$$NO_2 + NO_2 \xrightarrow{K_1} NO_3 + NO \text{ (slow step)}$$

$$NO_3 + CO \xrightarrow{K_2} NO_2 + CO_2 \text{ (fast step)}$$

elementary reactions of the proposed mechanism

$$rate = K_1 [NO_2]^2$$
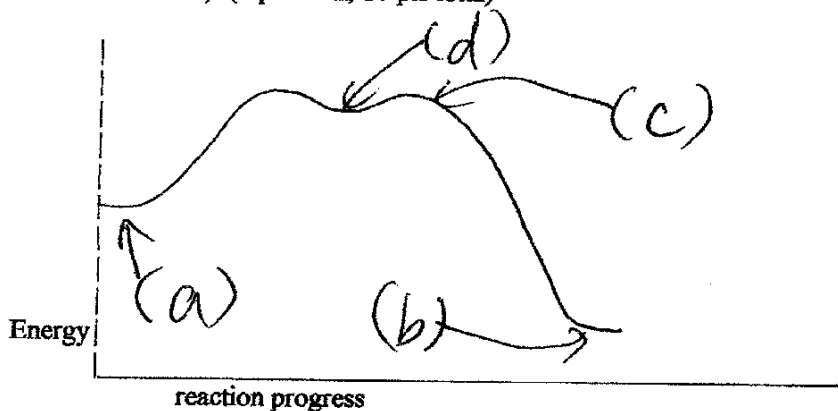
gave $K = [NO_2]^2$) —5

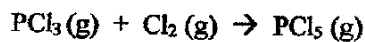bad attempt —5
gave equilibrium constant

really bad —6

extra wrong —3

gave fast step rate law —3

2. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (4 pts each, 16 pts total)

(d)

(c)

(a)

(b)

Energy

reaction progress

3. a. For the following **overall reaction** (**not reaction mechanism step**, the overall reaction), Given the concentrations and rates, give the order of the reactant by circling the order for the reagent given. You should assume an irreversible reaction. (note: I made up these reactions to illustrate the point so the reactions as given may not go experimentally as written.) (5 pts each, 10 pts total)

$PCl_3 (g) + Cl_2 (g) \rightarrow PCl_5 (g)$

[PCl3]	[Cl2]	rate
4	5	8
8	5	8
4	10	8

order of the [PCl3] is (zero) (one) (circle one)

order of the [Cl2] is (zero) (one) (circle one)

$[Cl_2]$ constant
double PCl_3
rate not changed

zero order in PCl_3

keep (PCl_3) constant
double $[Cl_2] - no$
effect on rate

zero order in Cl_2

gave $\frac{1}{a} \frac{\Delta [A]}{\Delta t} - 2\frac{1}{2}$

b. From your results in part (a) write the rate law for the overall reaction shown above. (5 pts)

left off $k - 1$

$rate = k [PCl_3]^0 [Cl_2]^0$

or

$rate = k$

gave $x + y$ for order -1

order does not matth -1 each

gave $k = [PCl_3]^0 [Cl_2]^0$ -1

bad attempt -4

gave general $rate = k[A][B]$ $-2\frac{1}{2}$

Dr. Hahn   Exam II 11:30 A MWF   page   5

Part III. Long Answer Please show work for full credit and to receive partial credit. (33 pts)

1. If you have a 3.0 Molar solution of HCl dissolved in water, how many grams of HCl (FW = 36.5 g/mol) is in 25.0 mL of this solution. (15 pts)

(handwritten) 5 pt

$$25.0 \text{ mL HCl solution} \times \frac{3.0 \text{ mol HCl}}{1000 \text{ mL HCl soln.}} \times \frac{36.5 \text{ g HCl}}{1 \text{ mol HCl}} =$$

(handwritten annotations: "5 pt", "5 pt", "bad attempt −10", "math −1", "upside down −2",)

2.74 g HCl
w sig fig
2.7 g HCl

2. Equilibrium (18 pts total)

a. For the reaction given, set up the ICE table for a reaction in which the reactant gases are mixed in a constant volume of an inert solvent with **no products present initially**: (6 pts total) (I made up the K_{eq} numbers so these numbers do not match real reaction results.)

$$CO_2 (g) + 2H_2O (g) \rightarrow CH_4 (g) + 2 O_2 (g) \qquad K_{eq} = 7.99 \times 10^{-4}$$
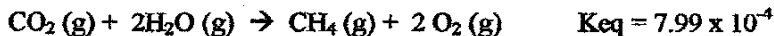
If the initial concentration of the CO_2 is 0.378 M, and the intial concentration of H_2O is 0.428 M. Show the initial, change and equilibrium concentrations for all reactants and products. You will need to use a variable x to complete this task. (x is usually used for the molecule with the smallest coefficient to make this task easier.)

	$[CO_2]$	$[H_2O]$	$[CH_4]$	$[O_2]$
Initial	0.378	0.428	0	0
Change	$-X$	$-2X$	$+X$	$+2X$
Equilibrium	$0.378 - X$	$0.428 - 2X$	X	$2X$

(handwritten annotations: "1 pt each", "2 pt", "½ pt", "3 pt", "3 pt", "Consistent w your change OK", "−½ pt per box", "−¼ pt per box")

b.   For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions.   To answer this question, you will not be using any of the results from the table in part (a) above. (6 pts)

1 pt each

gave rate law -4

$$K_{eq} = \frac{[CH_4][O_2]^2}{[CO_2][H_2O]^2}$$

added -1

2 pt each   *1 pt power*

½ pt each
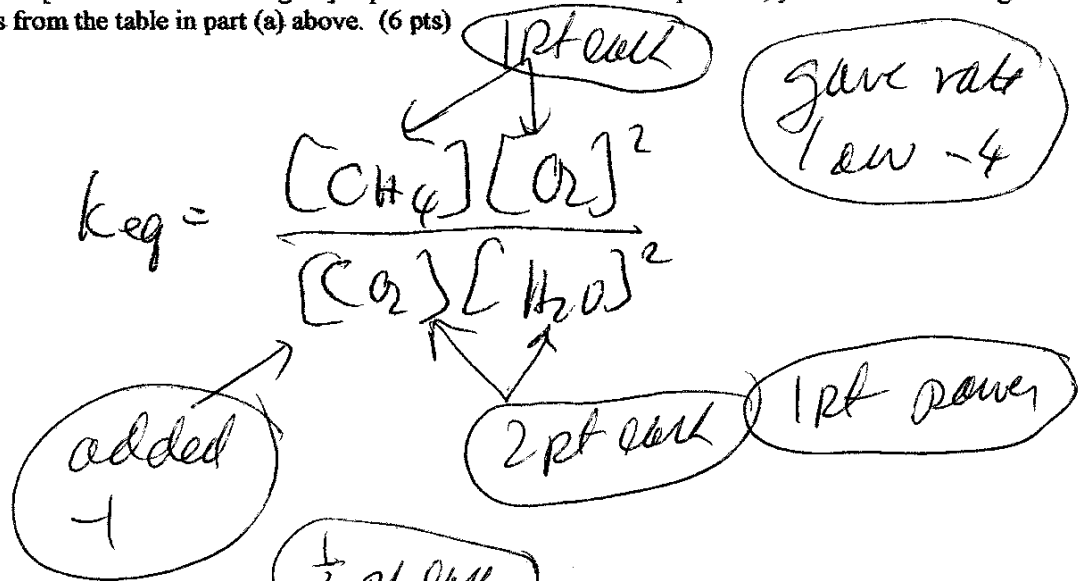
c.   For the same reaction, set up the K_{eq} to solve for x.   I am not asking you to derive the final actual number for x nor am I asking you to do the algebra to solve for x.   I am just asking you to plug in for your expression in (b) above with your number and x expressions from the table in part (a) above. (6 pts)

$$K_{eq} = \frac{(x)(2x)^2}{(0.378-x)(0.428-2x)} = 7.99 \times 10^{-4}$$

no pts off missing

1 pt each

Graded consistent w your (a)

used your table initial or change -2

Name_____*Key*_____ (print) Name _____(sign)

Please show work for partial credit on the Long Answers and in some of the Short Answer Questions.   Multiple choice questions have no partial credit.   Please write anything you want graded legibly.   If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I   MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 28 pts pts total)

1) Given the following rate law, how does the rate of reaction change if the concentration of Y is doubled?

   Rate = k [X][Y]   *First order with y*

   A) The rate of reaction will increase by a factor of 4.
   B) The rate of reaction will increase by a factor of 5.
   C) The rate of reaction will decrease by a factor of 2.
   D) The rate of reaction will increase by a factor of 2.
   E) The rate of reaction will remain unchanged.

1) _D_

2) Identify the solute with the lowest van't Hoff factor.
   A) NaCl —— 2
   B) MgSO₄ ——— 2
   C) nonelectrolyte —— 1
   D) MgCl₂ —— 3
   E) FeCl₃ —— 4

   not related to rate

2) _C_

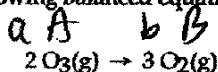3) Which of the following statements is FALSE? (K = equilibrium constant)
   A) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
   B) K >> 1 implies that the reaction is very fast at producing products.
   C) When K >> 1, the forward reaction is favored and essentially goes to completion.
   D) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
   E) None of the above.

3) _B_

4) Give the term for the amount of solute in moles per kilogram of solvent.
   A) mass percent
   B) molality
   C) mole percent
   D) molarity
   E) mole fraction

4) _B_

5) Given the following balanced equation, determine the rate of reaction with respect to $[O_2]$.

$$a\ A \qquad b\ B$$

$$2\ O_3(g) \rightarrow 3\ O_2(g)$$

$$rate = +\frac{1}{b}\frac{\Delta[B]}{\Delta t} = -\frac{1}{a}\frac{\Delta[A]}{\Delta t}$$

A) Rate $= -\dfrac{2}{3}\dfrac{\Delta[O_2]}{\Delta t}$

B) Rate $= +\dfrac{1}{3}\dfrac{\Delta[O_2]}{\Delta t}$
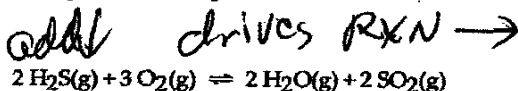
C) Rate $= +\dfrac{3\,\Delta[O_2]}{\Delta t}$

D) Rate $= -\dfrac{2\,\Delta[O_2]}{\Delta t}$

E) It is not possible to determine without more information.

5) __B__

6) Consider the following reaction at equilibrium. What effect will adding more H_2S have on the system?

add drives RXN →

$$2\ H_2S(g) + 3\ O_2(g) \rightleftharpoons 2\ H_2O(g) + 2\ SO_2(g)$$

A) No change will be observed.
B) The reaction will shift in the direction of products.
C) The reaction will shift to the left.
D) The equilibrium constant will increase.
E) The equilibrium constant will decrease.

6) __B__

7) Give the characteristic of a zero order reaction having only one reactant.
A) The rate of the reaction is directly proportional to the concentration of the reactant.
B) The rate of the reaction is not proportional to the concentration of the reactant.
C) The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
D) The rate of the reaction is proportional to the square root of the concentration of the reactant.
E) The rate of the reaction is proportional to the square of the concentration of the reactant.

7) __B__

8) Give the term for the amount of solute in moles per liter of solution.
A) molarity
B) mole percent
C) molality
D) mole fraction
E) mass percent

8) __A__

9) Calculate the molality of a solution formed by dissolving 27.8 g of LiI (FW = 133.8 g/mol) in 500.0 mL of water.
A) 0.556 m B) 0.415 m C) 0.254 m D) 0.241 m E) 0.394 m

9) __B__

$$\left(\frac{27.8\,g}{133.8}\right) \Big/ \left(500.0\ mL \times \frac{1\,g}{1\,mL} \times \frac{kg}{1000\,g}\right) = $$

Dr. Hahn Exam II 11:30 B MWF   page 2

10) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)?
   A) acetone (CH_3COCH_3)
   B) trimethylamine ($N(CH_3)_3$)
   C) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)
   D) ethylene glycol ($HOCH_2CH_2OH$)
   E) None of these compounds should be soluble in ethanol.

10) _D_

u like dissolves like u

(0.122)

11) Identify the rate–determining step.
   A) the fast step
   B) always the last step
   C) the slowest step
   D) the faster step
   E) always the second step

11) _C_

$$m = \left(\frac{0.067 \text{ mol}}{550.0 g} \times \frac{Kg}{1000 g} \right)$$

$c = 2$

12) Calculate the freezing point of a solution containing 0.067 mol of KCl and 550.0 grams of water. The molal–freezing–point–depression constant (K_f) for water is 1.86°C/m. $\Delta T_f = i * K_f * m$. Use 0°C as the freezing point of water and assume complete dissociation of the K Cl.
   A) –0.45 °C   B) 1.23 °C   C) +0.45 °C   D) –0.23 °C   E) +0.23 °C

12) _A_

13) To make a 2.00 m solution, one could take 2.00 moles of solute and add
   A) 1.00 L of solvent.
   B) enough solvent to make 1.00 L of solution.
   C) enough solvent to make 1.00 kg of solution.
   D) 1.00 kg of solvent.
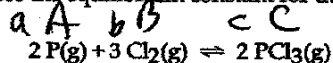
13) _D_

$$\Delta T_f = (2)(1.86)(m)$$

14) Express the equilibrium constant for the following reaction.

$a \, A \quad b \, B \quad c \, C$

$2 P(g) + 3 Cl_2(g) \rightleftharpoons 2 PCl_3(g)$

14) _D_

$$\Delta T_f = 0.455$$

$$0°C - 0.455 =$$

A) $K = \dfrac{[P][Cl_2]^{3/2}}{[PCl_3]}$

B) $K = \dfrac{[P]^2[Cl_2]^3}{[PCl_3]^2}$

C) $K = \dfrac{[PCl_3]}{[P][Cl_2]^{3/2}}$

D) $K = \dfrac{[PCl_3]^2}{[P]^2[Cl_2]^3}$

E) $K = \dfrac{[PCl_3]^{1/2}}{[P]^{1/2}[Cl_2]^{1/3}}$

$$K = \frac{[C]^c}{[A]^a [B]^b}$$

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (39 pts)

1. For the following reaction mechanism shown as the elementary reactions given, what is the rate law? (You do not need to show me only reactants of the overall reaction to complete this problem. You do not need to show me the overall reaction to complete this problem.) (The K shown are not equilibrium constants but the rate constants associated with the reaction mechanism steps.) (8 pts)

gave fast step rate law

$$NO_2 + F_2 \xrightarrow{K_1} NO_2F + F \text{ (fast step)}$$
−4   elementary reactions of the proposed mechanism
added −2

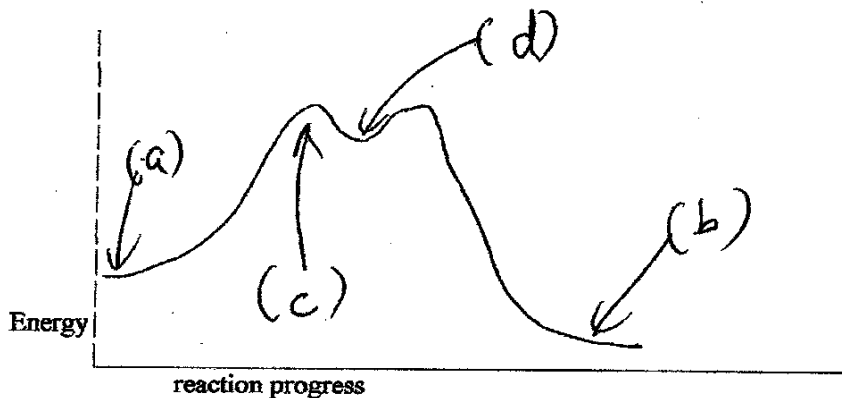$$F + NO_2 \xrightarrow{K_2} NO_2F \text{ (slow step)}$$

$$rate = K_2 [F][NO_2]$$

gave $k = [F][NO_2]$
−3

bad attempt
−5
gave equilibrium constant

extra wrong −3   *really bad −6*

2. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (4 pts each, 16 pts total)

Energy | reaction progress

3.   a. For the following **overall reaction** (**not reaction mechanism step**, the overall reaction), Given the concentrations and rates, give the order of the reactant by circling the order for the reagent given. You should assume an irreversible reaction. (note: I made up these reactions to illustrate the point so the reactions as given may not go experimentally as written.) (5 pts each, 10 pts total)

$CH_4 + 2 O_2 \rightarrow CO_2 + 2 H_2O$

[CH$_4$]	[O$_2$]	rate
7	4	3
7	8	6
14	4	6

keep [CH$_4$] constant
+ double [O$_2$]
|
rate doubles
1st order in [O$_2$]

order of the [CH$_4$] is (zero)(one)(circle one)

order of the [O$_2$] is (zero)(one)(circle one)

keep [O$_2$] constant
+ double [CH$_4$]
|
rate doubles
1st order [CH$_4$]

gave k = [O$_2$][CH$_4$]
+

-2 ½

gave
general
rate = K[A][B]

b. From your results in part (a) write the rate law for the overall reaction shown above. (5 pts)

$$rate = k [O_2][CH_4]$$

order
does not
match
above
+ eou

gave
$\frac{1}{a} \frac{\Delta [A]}{\Delta t}$

-2 ½

left
off
k +

gave
x + y for
order +

Dr. Hahn   Exam II 11:30 B MWF   page   5

bad attempt -4

Part III. Long Answer Please show work for full credit and to receive partial credit. (33 pts)

1. If you have a 4.0 Molar solution of NaOH dissolved in water, how many grams of NaOH (FW = 40.0 g/mol) is in 15.5 mL of this solution. (15 pts)

(handwritten)
5 pt   5 pt   5 pt

$$\frac{15.5 \, mL}{NaOH \, soln.} \times \frac{4.0 \, moles \, NaOH}{1000 \, mL \, NaOH \, solution} \times \frac{40.0 \, g \, NaOH}{1 \, mol \, NaOH} =$$

upside down −2↓

bad attempt −10   math −1

2.48 g NaOH

2. Equilibrium (18 pts total)

a. For the reaction given, set up the ICE table for a reaction in which the reactant gases are mixed in a constant volume of an inert solvent with **no products present initially**: (6 pts total) (I made up the K_{eq} numbers so these numbers do not match real reaction results.)

$$N_2 \, (g) + 2 \, O_2 \, (g) \rightarrow 2 \, NO_2 \, (g) \qquad\qquad K_{eq} = 1.8 \times 10^{-3}$$

If the initial concentration of the N_2 is 0.125 M, and the initial concentration of O_2 is 0.122 M. Show the initial, change and equilibrium concentrations for all reactants and products. You will need to use a variable x to complete this task. (x is usually used for the molecule with the smallest coefficient to make this task easier.)

	$[N_2]$	$[O_2]$	$[NO_2]$	
Initial	0.125	0.122	0	3 pt
Change	−X	−2X	+2X	3 pt
Equilibrium	0.125−X	0.122−2X	2X	

(handwritten)
consistent w your wrong change ok

½ pt per box

Dr. Hahn   Exam II 11:30 B MWF   page   6

b.   For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions.   To answer this question, you will not be using any of the results from the table in part (a) above. (6 pts)

$$K_{eq} = \frac{[NO_2]^2}{[N_2][O_2]^2}$$

(handwritten annotations: "gave rate law -4", "1pt each", "1pt power", "⊕ -1")

c.   For the same reaction, set up the K_{eq} to solve for x.   I am not asking you to derive the final actual number for x nor am I asking you to do the algebra to solve for x.   I am just asking you to plug in for your expression in (b) above with your number and x expressions from the table in part (a) above. (6 pts)

$$K_{eq} = \frac{(2x)^2}{(0.125-x)(0.122-2x)^2} = 1.8 \times 10^{-3}$$

(handwritten annotations: "1pt each", "graded consistent w/ your ⓐ", "used your table initial or change -2")

Exam II   General Chemistry II (CHEM 102)   Form A   3/6/13   9:30 am MWF   Dr. Hahn   Exam # _____

Name_____ (print) Name _____(sign)

Please show work for partial credit on the Long Answers and in some of the Short Answer Questions.   Multiple choice questions have no partial credit.   Please write anything you want graded legibly.   If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)
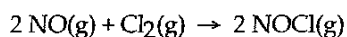
Part I   MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 28 pts pts total)

1) Give the term for the amount of solute in moles per liter of solution.   1) _____
    A) mole percent
    B) molarity
    C) mole fraction
    D) mass percent
    E) molality

2) Which of the following statements is FALSE? (K = equilibrium constant)   2) _____
    A) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
    B) K >> 1 implies that the reaction is very fast at producing products.
    C) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
    D) When K >> 1, the forward reaction is favored and essentially goes to completion.
    E) None of the above.

3) Given the following rate law, how does the rate of reaction change if the concentration of Y is   3) _____
doubled?

       Rate = k [X][Y]

    A) The rate of reaction will increase by a factor of 2.
    B) The rate of reaction will decrease by a factor of 2.
    C) The rate of reaction will increase by a factor of 5.
    D) The rate of reaction will increase by a factor of 4.
    E) The rate of reaction will remain unchanged.

4) Calculate the molality of a solution formed by dissolving 27.8 g of LiI (FW = 133.8 g/mol) in 500.0   4) _____
mL of water.
    A) 0.241 m B) 0.556 m C) 0.394 m D) 0.415 m E) 0.254 m

5) Calculate the boiling point of a solution of 8.05 moles of ethylene glycol dissolved in 0.500 Kg of   5) _____
water. $\Delta T_b = K_b * m$ CH_4 and $K_b = 0.512°C/m$. Use 100°C as the boiling point of water.
    A) 92°C   B) 108°C   C) 8.3°C   D) 70°C   E) 130°C

6) Identify the rate–determining step.

    A) always the last step
    B) the faster step
    C) the slowest step
    D) the fast step
    E) always the second step

6) _____

7) Give the term for the amount of solute in moles per kilogram of solvent.

    A) molarity
    B) molality
    C) mass percent
    D) mole fraction
    E) mole percent

7) _____

8) Identify the solute with the highest van't Hoff factor.

    A) $MgSO_4$
    B) $FeCl_3$
    C) $MgCl_2$
    D) NaCl
    E) nonelectrolyte

8) _____

9) Give the characteristic of a zero order reaction having only one reactant.

    A) The rate of the reaction is proportional to the square root of the concentration of the reactant.
    B) The rate of the reaction is directly proportional to the concentration of the reactant.
    C) The rate of the reaction is not proportional to the concentration of the reactant.
    D) The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
    E) The rate of the reaction is proportional to the square of the concentration of the reactant.

9) _____

10) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)?

    A) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)
    B) ethylene glycol ($HOCH_2CH_2OH$)
    C) trimethylamine ($N(CH_3)_3$)
    D) acetone (CH_3COCH_3)
    E) None of these compounds should be soluble in ethanol.

10) _____

11) To make a 2.00 m solution, one could take 2.00 moles of solute and add

    A) enough solvent to make 1.00 kg of solution.
    B) 1.00 kg of solvent.
    C) enough solvent to make 1.00 L of solution.
    D) 1.00 L of solvent.

11) _____

12) Given the following balanced equation, determine the rate of reaction with respect to [NOCl].   12) _____

$$2 NO(g) + Cl_2(g) \rightarrow 2 NOCl(g)$$

A) $Rate = +\dfrac{1}{2}\dfrac{\Delta[NOCl]}{\Delta t}$

B) $Rate = -\dfrac{1}{2}\dfrac{\Delta[NO]}{\Delta t}$

C) $Rate = -\dfrac{2\,\Delta[NOCl]}{\Delta t}$

D) $Rate = -\dfrac{1}{2}\dfrac{\Delta[NOCl]}{\Delta t}$

E) It is not possible to determine without more information.

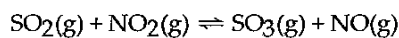13) Express the equilibrium constant for the following reaction.   13) _____

$$2 CH_3Cl(g) + Cl_2(g) \Leftrightarrow 2 CH_2Cl_2(g) + H_2(g)$$

A) $K = \dfrac{[CH_3Cl]^{1/2}[Cl_2]}{[CH_2Cl_2]^{1/2}[H_2]}$

B) $K = \dfrac{[CH_2Cl_2][H_2]}{[CH_3Cl][Cl_2]}$

C) $K = \dfrac{[CH_3Cl][Cl_2]}{[CH_2Cl_2][H_2]}$

D) $K = \dfrac{[CH_2Cl_2]^2[H_2]}{[CH_3Cl]^2[Cl_2]}$

E) $K = \dfrac{[CH_3Cl]^2[Cl_2]}{[CH_2Cl_2]^2[H_2]}$

14) Consider the following reaction at equilibrium. What effect will removing NO_2 have on the   14) _____
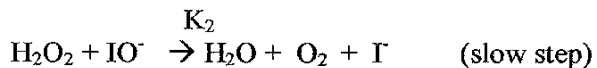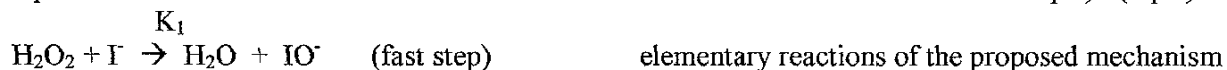system?
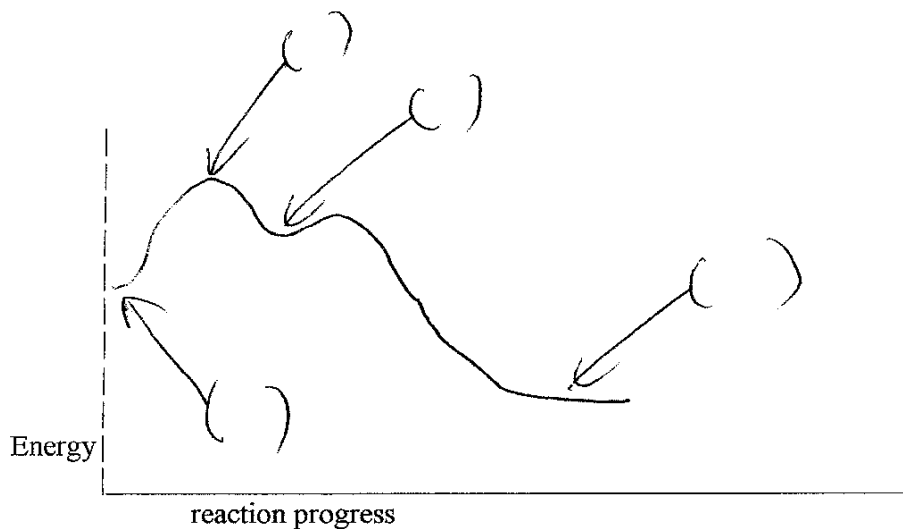
$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

A) The reaction will shift in the direction of products.
B) The reaction will shift in the direction of reactants.
C) The reaction will shift to decrease the pressure.
D) No change will occur since SO_3 is not included in the equilibrium expression.
E) The equilibrium constant will decrease.

Part II   Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question.   (39   pts)
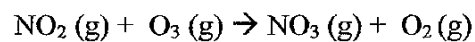
1. For the following reaction mechanism shown as the elementary reactions given, what is the rate law? (You do not need to show me only reactants of the overall reaction to complete this problem. You do not need to show me the overall reaction to complete this problem.) (The K shown are not equilibrium constants but the rate constants associated with the reaction mechanism steps.)   (8 pts)

$$K_1$$
$$H_2O_2 + I^- \rightarrow H_2O + IO^- \quad \text{(fast step)} \qquad \text{elementary reactions of the proposed mechanism}$$

$$K_2$$
$$H_2O_2 + IO^- \rightarrow H_2O + O_2 + I^- \quad \text{(slow step)}$$

2. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (4 pts each, 16 pts total)

Energy |

reaction progress

3.   a. For the following **overall reaction** (**not reaction mechanism step**, the overall reaction), Given the concentrations and rates, give the order of the reactant by circling the order for the reagent given. You should assume an irreversible reaction. (note: I made up these reactions to illustrate the point so the reactions as given may not go experimentally as written.) (5 pts each, 10 pts total)

$NO_2 (g) + O_3 (g) \rightarrow NO_3 (g) + O_2 (g)$

$[NO_2]$	$[O_3]$	rate
3	1	8
3	2	16
6	1	8

order of the $[NO_2]$ is (zero) (one) (circle one)

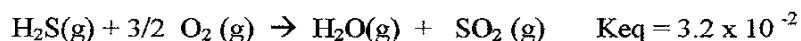order of the [O_3] is (zero)(one) (circle one)

b. From your results in part (a) write the rate law for the overall reaction shown above. (5 pts)

Part III. Long Answer   Please show work for full credit and to receive partial credit. (33 pts)

1.   If you have a 6.0 Molar solution of H_2SO_4 dissolved in water, how many grams of H_2SO_4 (FW = 98.1 g/mol) is in 73.5   mL of this solution. (15 pts)

2.   Equilibrium (18 pts total)

a. For the reaction given, set up the ICE table for a reaction in which the reactant gases are mixed in a constant volume of an inert solvent with **no products present initially**:   (6 pts total) (I made up the K_{eq} numbers so these numbers do not match real reaction results.)

  $H_2S(g) + 3/2 \ O_2 (g) \rightarrow H_2O(g) + \ SO_2 (g)$ $Keq = 3.2 \times 10^{-2}$

 If the initial concentration of the H_2S is 0.537 M, and the intial concentration of O_2 is 0.444 M. Show the initial, change and equilibrium concentrations for all reactants and products.   You will need to use a variable x to complete this task. (x is usually used for the molecule with the smallest coefficient to make this task easier.)

	[H_2S]	[O_2]	[H_2O]	[SO_2]
Initial				
Change				
Equilibrium				

b.   For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions.   To answer this question, you will not be using any of the results from the table in part (a) above. (6 pts)
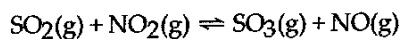
c.   For the same reaction, set up the K_{eq} to solve for x.   I am not asking you to derive the final actual number for x nor am I asking you to do the algebra to solve for x.   I am just asking you to plug in for your expression in (b) above with your number and x expressions from the table in part (a) above. (6 pts)

Name_____ (print) Name _____(sign)

Please show work for partial credit on the Long Answers and in some of the Short Answer Questions.   Multiple choice questions have no partial credit.   Please write anything you want graded legibly.   If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I   MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 28 pts pts total)

1) Consider the following reaction at equilibrium. What effect will removing NO_2 have on the system?   1) _____

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

A) The reaction will shift to decrease the pressure.
B) No change will occur since SO_3 is not included in the equilibrium expression.
C) The reaction will shift in the direction of reactants.
D) The reaction will shift in the direction of products.
E) The equilibrium constant will decrease.

2) Given the following balanced equation, determine the rate of reaction with respect to [NOCl].   2) _____

$$2 NO(g) + Cl_2(g) \rightarrow 2 NOCl(g)$$
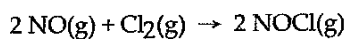
A) $Rate = -\dfrac{1}{2} \dfrac{\Delta[NO]}{\Delta t}$

B) $Rate = +\dfrac{1}{2} \dfrac{\Delta[NOCl]}{\Delta t}$

C) $Rate = -\dfrac{1}{2} \dfrac{\Delta[NOCl]}{\Delta t}$

D) $Rate = -\dfrac{2 \Delta[NOCl]}{\Delta t}$

E) It is not possible to determine without more information.

3) Give the term for the amount of solute in moles per liter of solution.   3) _____
A) mass percent
B) mole fraction
C) mole percent
D) molarity
E) molality

4) Identify the solute with the highest van't Hoff factor.   4) _____
A) $MgCl_2$
B) $MgSO_4$
C) nonelectrolyte
D) $FeCl_3$
E) NaCl

5) Calculate the molality of a solution formed by dissolving 27.8 g of LiI (FW = 133.8 g) in 500.0 mL of water.   5) _____

    A) 0.254 m B) 0.415 m C) 0.556 m D) 0.394 m E) 0.241 m

6) Express the equilibrium constant for the following reaction.   6) _____

$$2\ CH_3Cl(g) + Cl_2\ (g) \rightleftharpoons 2\ CH_2Cl_2\ (g) + H_2\ (g)$$

A) $K = \dfrac{[CH_2Cl_2][H_2]}{[CH_3Cl][Cl_2]}$

B) $K = \dfrac{[CH_3Cl][Cl_2]}{[CH_2Cl_2][H_2]}$

C) $K = \dfrac{[CH_3Cl]^{1/2}[Cl_2]}{[CH_2Cl_2]^{1/2}[H_2]}$

D) $K = \dfrac{[CH_2Cl_2]^2[H_2]}{[CH_3Cl]^2[Cl_2]}$

E) $K = \dfrac{[CH_3Cl]^2[Cl_2]}{[CH_2Cl_2]^2[H_2]}$

7) To make a 2.00 m solution, one could take 2.00 moles of solute and add   7) _____
    A) enough solvent to make 1.00 L of solution.
    B) 1.00 kg of solvent.
    C) 1.00 L of solvent.
    D) enough solvent to make 1.00 kg of solution.

8) Calculate the boiling point of a solution of 8.05 moles of ethylene glycol dissolved in 0.500 Kg of water. $\Delta T_b = K_b * m$ CH_4 and $K_b = 0.512°C/m$. Use 100°C as the boiling point of water.   8) _____

    A) 8.3°C   B) 130°C   C) 92°C   D) 108°C   E) 70°C

9) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)?   9) _____
    A) ethylene glycol ($HOCH_2CH_2OH$)
    B) trimethylamine ($N(CH_3)_3$)
    C) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)
    D) acetone (CH_3COCH_3)
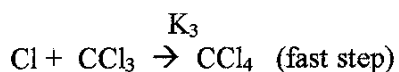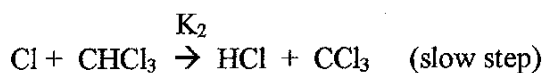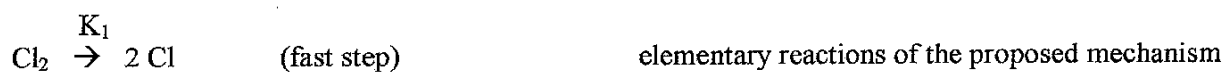   E) None of these compounds should be soluble in ethanol.

10) Give the term for the amount of solute in moles per kilogram of solvent.   10) _____
    A) mole fraction
    B) mass percent
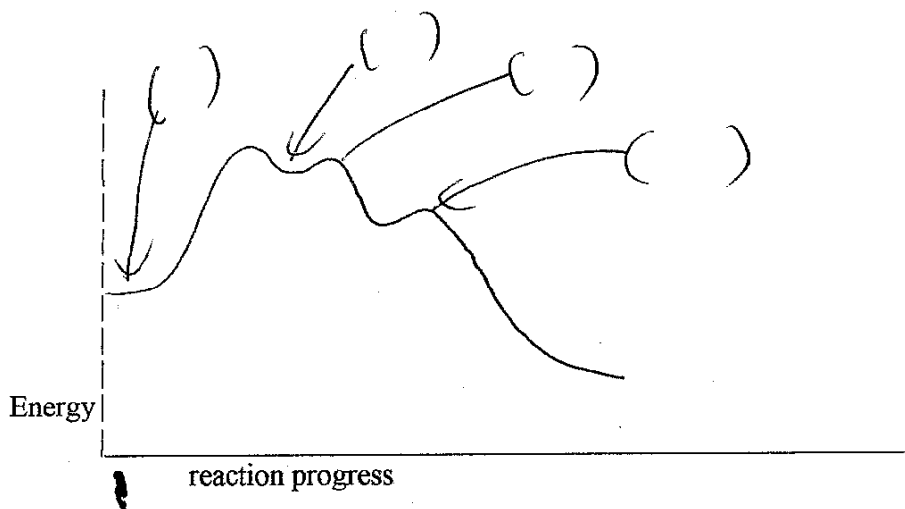   C) molarity
    D) molality
    E) mole percent

11) Give the characteristic of a zero order reaction having only one reactant.   11) _____
   A) The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
   B) The rate of the reaction is not proportional to the concentration of the reactant.
   C) The rate of the reaction is directly proportional to the concentration of the reactant.
   D) The rate of the reaction is proportional to the square of the concentration of the reactant.
   E) The rate of the reaction is proportional to the square root of the concentration of the reactant.

12) Which of the following statements is FALSE? (K = equilibrium constant)   12) _____
   A) When K >> 1, the forward reaction is favored and essentially goes to completion.
   B) K >> 1 implies that the reaction is very fast at producing products.
   C) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
   D) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
   E) None of the above.

13) Given the following rate law, how does the rate of reaction change if the concentration of Y is   13) _____
   doubled?
      Rate = k [X][Y]

   A) The rate of reaction will increase by a factor of 4.
   B) The rate of reaction will increase by a factor of 2.
   C) The rate of reaction will decrease by a factor of 2.
   D) The rate of reaction will increase by a factor of 5.
   E) The rate of reaction will remain unchanged.

14) Identify the rate–determining step.   14) _____
   A) the slowest step
   B) always the second step
   C) the fast step
   D) always the last step
   E) the faster step

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (39 pts)
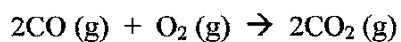
1. For the following reaction mechanism shown as the elementary reactions given, what is the rate law? (You do not need to show me only reactants of the overall reaction to complete this problem. You do not need to show me the overall reaction to complete this problem.) (The K shown are not equilibrium constants but the rate constants associated with the reaction mechanism steps.) (8 pts)

$$Cl_2 \xrightarrow{K_1} 2\,Cl \qquad \text{(fast step)} \qquad \text{elementary reactions of the proposed mechanism}$$

$$Cl + CHCl_3 \xrightarrow{K_2} HCl + CCl_3 \quad \text{(slow step)}$$

$$Cl + CCl_3 \xrightarrow{K_3} CCl_4 \quad \text{(fast step)}$$

2. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (4 pts each, 16 pts total)

Energy |

reaction progress

3. a. For the following **overall reaction** (**not reaction mechanism step**, the overall reaction), Given the concentrations and rates, give the order of the reactant by circling the order for the reagent given.   You should assume an irreversible reaction. (note: I made up these reactions to illustrate the point so the reactions as given may not go experimentally as written.) (5 pts each, 10 pts total)

$2CO (g) + O_2 (g) \rightarrow 2CO_2 (g)$

[CO]	[O_2]	rate
5	3	2
10	3	4
5	6	4

order of the [CO] is (zero) (one) (circle one)

order of the [O_2] is (zero)(one) (circle one)

b. From your results in part (a)   write the rate law for the overall reaction shown above. (5 pts)

Part III.   Long Answer   Please show work for full credit and to receive partial credit. (33 pts)

1.   If you have a   12.0   Molar solution of KOH dissolved in water, how many grams of KOH (FW = 56.1 g/mol) is in 38.9   mL of this solution. (15 pts)

2.   Equilibrium (18 pts total)

a.   For the reaction given, set up the ICE table for a reaction in which the reactant gases are mixed in a constant volume of an inert solvent with **no products present initially**:   (6 pts total)   (I made up the K_{eq} numbers so these numbers do not match real reaction results.)

Xe (g) + 2F$_2$ (g) → XeF$_4$ (g)   Keq = 1.78 x 10^{-8}

If the initial concentration of the Xe   is 0.256 M, and the intial concentration of   F$_2$ is 0.311 M. Show the initial, change and equilibrium concentrations for all reactants and products.   You will need to use a variable x to complete this task. (x is usually used for the molecule with the smallest coefficient to make this task easier.)

	[Xe]	[F$_2$]	[XeF$_4$]
Initial			
Change			
Equilibrium			

b.   For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions.   To answer this question, you will not be using any of the results from the table in part (a) above. (6 pts)

c.   For the same reaction, set up the K_{eq} to solve for x.   I am not asking you to derive the final actual number for x nor am I asking you to do the algebra to solve for x.   I am just asking you to plug in for your expression in (b) above with your number and x expressions from the table in part (a) above. (6 pts)

Name_____ (print) Name _____(sign)

Please show work for partial credit on the Long Answers and in some of the Short Answer Questions.   Multiple choice questions have no partial credit.   Please write anything you want graded legibly.   If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I   MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 28 pts pts total)

1) Give the characteristic of a zero order reaction having only one reactant.   1) _____
    A) The rate of the reaction is directly proportional to the concentration of the reactant.
    B) The rate of the reaction is not proportional to the concentration of the reactant.
    C) The rate of the reaction is proportional to the natural logarithm of the concentration of the
       reactant.
    D) The rate of the reaction is proportional to the square of the concentration of the reactant.
    E) The rate of the reaction is proportional to the square root of the concentration of the reactant.

2) Give the term for the amount of solute in moles per kilogram of solvent.   2) _____
    A) mole fraction
    B) mass percent
    C) mole percent
    D) molarity
    E) molality

3) To make a 2.00 m solution, one could take 2.00 moles of solute and add   3) _____
    A) 1.00 kg of solvent.
    B) enough solvent to make 1.00 kg of solution.
    C) enough solvent to make 1.00 L of solution.
    D) 1.00 L of solvent.

4) Identify the rate–determining step.   4) _____
    A) the fast step
    B) always the second step
    C) always the last step
    D) the faster step
    E) the slowest step

5) Calculate the freezing point of a solution containing 0.067 mol of K Cl and 550.0 grams of water.   5) _____
    The molal–freezing–point–depression constant (K_f) for water is 1.86°C/m. $\Delta T_f = i * K_b * m$. Use
    0°C as the freezing point of water and assume complete dissociation of the K Cl.
    A) 1.23 °C   B) –0.23 °C   C) +0.23 °C   D) +0.45 °C   E) –0.45 °C

6) Give the term for the amount of solute in moles per liter of solution.   6) _____
    A) mole percent
    B) mole fraction
    C) molality
    D) mass percent
    E) molarity

7) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)?　　　　　7) _____

　　　A) acetone (CH_3COCH_3)

　　　B) ethylene glycol ($HOCH_2CH_2OH$)

　　　C) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)

　　　D) trimethylamine ($N(CH_3)_3$)

　　　E) None of these compounds should be soluble in ethanol.

8) Given the following balanced equation, determine the rate of reaction with respect to [O_2].　　　8) _____

$$2\,O_3(g) \rightarrow 3\,O_2(g)$$
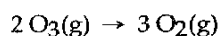
　　　A) $Rate = + \dfrac{3\,\Delta[O_2]}{\Delta t}$

　　　B) $Rate = + \dfrac{1}{3}\dfrac{\Delta[O_2]}{\Delta t}$

　　　C) $Rate = - \dfrac{2}{3}\dfrac{\Delta[O_2]}{\Delta t}$

　　　D) $Rate = - \dfrac{2\,\Delta[O_2]}{\Delta t}$

　　　E) It is not possible to determine without more information.

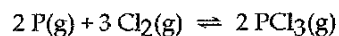9) Calculate the molality of a solution formed by dissolving 27.8 g of LiI (FW = 133.8 g/mol) in 500.0　　9) _____
mL of water.

　　　A) 0.556 m　　　　B) 0.394 m　　　　C) 0.254 m　　　　D) 0.415 m　　　　E) 0.241 m

10) Identify the solute with the lowest van't Hoff factor.　　　　　10) _____

　　　A) $MgSO_4$

　　　B) $FeCl_3$

　　　C) NaCl

　　　D) $MgCl_2$

　　　E) nonelectrolyte

11) Which of the following statements is FALSE? (K = equilibrium constant)　　　　11) _____

　　　A) When $K \approx 1$, neither the forward or reverse reaction is strongly favored, and about the same
　　　　amount of reactants and products exist at equilibrium.

　　　B) When $K \gg 1$, the forward reaction is favored and essentially goes to completion.

　　　C) $K \gg 1$ implies that the reaction is very fast at producing products.

　　　D) When $K \ll 1$, the reverse reaction is favored and the forward reaction does not proceed to a
　　　　great extent.

　　　E) None of the above.

12) Express the equilibrium constant for the following reaction. 12) _____

$$2\ P(g) + 3\ Cl_2(g) \rightleftharpoons 2\ PCl_3(g)$$

A) $K = \dfrac{[PCl_3]^2}{[P]^2[Cl_2]^3}$

B) $K = \dfrac{[P]^2[Cl_2]^3}{[PCl_3]^2}$

C) $K = \dfrac{[P][Cl_2]^{3/2}}{[PCl_3]}$

D) $K = \dfrac{[PCl_3]^{1/2}}{[P]^{1/2}[Cl_2]^{1/3}}$

E) $K = \dfrac{[PCl_3]}{[P][Cl_2]^{3/2}}$

13) Consider the following reaction at equilibrium. What effect will adding more H_2S have on the system? 13) _____
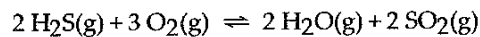
$$2\ H_2S(g) + 3\ O_2(g) \rightleftharpoons 2\ H_2O(g) + 2\ SO_2(g)$$

A) The reaction will shift to the left.
B) The equilibrium constant will increase.
C) The reaction will shift in the direction of products.
D) The equilibrium constant will decrease.
E) No change will be observed.

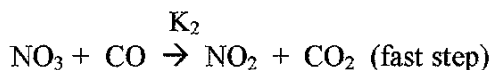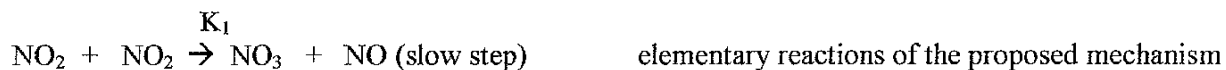14) Given the following rate law, how does the rate of reaction change if the concentration of Y is doubled? 14) _____
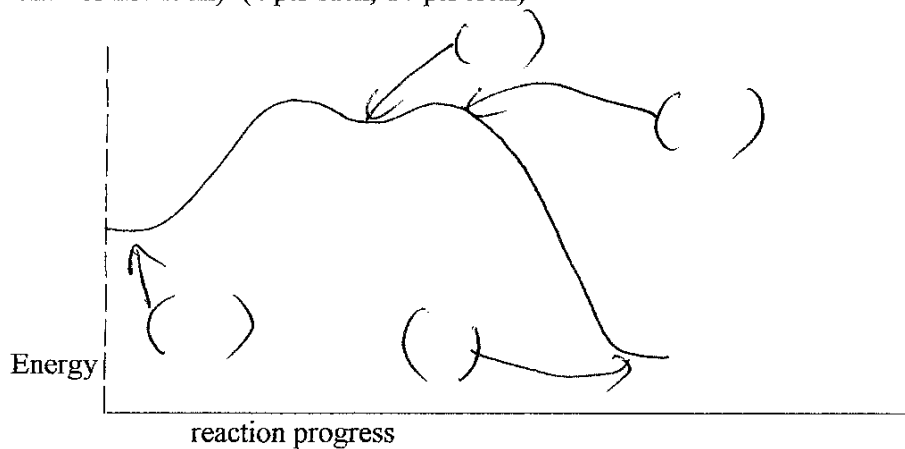
Rate = k [X][Y]

A) The rate of reaction will increase by a factor of 2.
B) The rate of reaction will increase by a factor of 5.
C) The rate of reaction will decrease by a factor of 2.
D) The rate of reaction will increase by a factor of 4.
E) The rate of reaction will remain unchanged.

Part II   Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (39 pts)
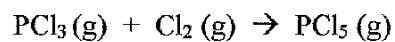
1. For the following reaction mechanism shown as the elementary reactions given, what is the rate law? (You do not need to show me only reactants of the overall reaction to complete this problem. You do not need to show me the overall reaction to complete this problem.) (The K shown are not equilibrium constants but the rate constants associated with the reaction mechanism steps.)   (8 pts)

$$K_1$$
$$NO_2 + NO_2 \rightarrow NO_3 + NO \text{ (slow step)} \qquad \text{elementary reactions of the proposed mechanism}$$

$$K_2$$
$$NO_3 + CO \rightarrow NO_2 + CO_2 \text{ (fast step)}$$

2. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (4 pts each, 16 pts total)

Energy

reaction progress

3.   a. For the following **overall reaction** (**not reaction mechanism step**, the overall reaction), Given the concentrations and rates, give the order of the reactant by circling the order for the reagent given. You should assume an irreversible reaction. (note: I made up these reactions to illustrate the point so the reactions as given may not go experimentally as written.) (5 pts each, 10 pts total)

$PCl_3 (g) + Cl_2 (g) \rightarrow PCl_5 (g)$

$[PCl_3]$	$[Cl_2]$	rate
4	5	8
8	5	8
4	10	8

order of the $[PCl_3]$ is (zero) (one) (circle one)

order of the $[Cl_2]$ is (zero)(one) (circle one)
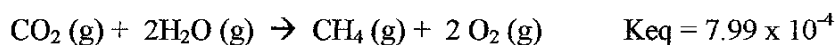
b. From your results in part (a)   write the rate law for the overall reaction shown above. (5 pts)

Part III. Long Answer Please show work for full credit and to receive partial credit. (33 pts)

1.   If you have a 3.0 Molar solution of HCl   dissolved in water, how many grams of HCl (FW = 36.5 g/mol) is in 25.0   mL of this solution. (15 pts)

2.   Equilibrium (18 pts total)

a. For the reaction given, set up the ICE table for a reaction in which the reactant gases are mixed in a constant volume of an inert solvent with **no products present initially**:   (6 pts total) (I made up the K_{eq} numbers so these numbers do not match real reaction results.)

CO_2 (g) + $2H_2O$ (g) $\rightarrow$ CH_4 (g) + $2\,O_2$ (g)   Keq = 7.99 x 10^{-4}

If the initial concentration of the CO_2 is   0.378 M, and the intial concentration of H_2O is 0.428 M. Show the initial, change and equilibrium concentrations for all reactants and products.   You will need to use a variable x to complete this task. (x is usually used for the molecule with the smallest coefficient to make this task easier.)

	$[CO_2]$	$[\ H_2O\ ]$	$[CH_4]$	$[\ O_2]$
Initial				
Change				
Equilibrium				

b.   For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions. To answer this question, you will not be using any of the results from the table in part (a) above. (6 pts)
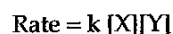
c.   For the same reaction, set up the K_{eq} to solve for x. I am not asking you to derive the final actual number for x nor am I asking you to do the algebra to solve for x. I am just asking you to plug in for your expression in (b) above with your number and x expressions from the table in part (a) above. (6 pts)

Name_____ (print) Name _____(sign)

Please show work for partial credit on the Long Answers and in some of the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 28 pts pts total)

1) Given the following rate law, how does the rate of reaction change if the concentration of Y is doubled?

           Rate = k [X][Y]

1) _____

    A) The rate of reaction will increase by a factor of 4.
    B) The rate of reaction will increase by a factor of 5.
    C) The rate of reaction will decrease by a factor of 2.
    D) The rate of reaction will increase by a factor of 2.
    E) The rate of reaction will remain unchanged.

2) Identify the solute with the lowest van't Hoff factor.

2) _____

    A) NaCl
    B) $MgSO_4$
    C) nonelectrolyte
    D) $MgCl_2$
    E) $FeCl_3$

3) Which of the following statements is FALSE? (K = equilibrium constant)

3) _____

    A) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
    B) K >> 1 implies that the reaction is very fast at producing products.
    C) When K >> 1, the forward reaction is favored and essentially goes to completion.
    D) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
    E) None of the above.

4) Give the term for the amount of solute in moles per kilogram of solvent.

4) _____

    A) mass percent
    B) molality
    C) mole percent
    D) molarity
    E) mole fraction

5) Given the following balanced equation, determine the rate of reaction with respect to $[O_2]$.

5) _____
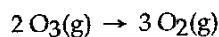
$$2\, O_3(g) \rightarrow 3\, O_2(g)$$

A) $\text{Rate} = -\dfrac{2}{3}\dfrac{\Delta[O_2]}{\Delta t}$

B) $\text{Rate} = +\dfrac{1}{3}\dfrac{\Delta[O_2]}{\Delta t}$
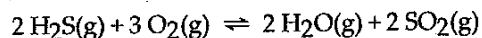
C) $\text{Rate} = +\dfrac{3\,\Delta[O_2]}{\Delta t}$

D) $\text{Rate} = -\dfrac{2\,\Delta[O_2]}{\Delta t}$

E) It is not possible to determine without more information.

6) Consider the following reaction at equilibrium. What effect will adding more H_2S have on the system?

6) _____

$$2\, H_2S(g) + 3\, O_2(g) \rightleftharpoons 2\, H_2O(g) + 2\, SO_2(g)$$

A) No change will be observed.
B) The reaction will shift in the direction of products.
C) The reaction will shift to the left.
D) The equilibrium constant will increase.
E) The equilibrium constant will decrease.

7) Give the characteristic of a zero order reaction having only one reactant.

7) _____

   A) The rate of the reaction is directly proportional to the concentration of the reactant.
   B) The rate of the reaction is not proportional to the concentration of the reactant.
   C) The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
   D) The rate of the reaction is proportional to the square root of the concentration of the reactant.
   E) The rate of the reaction is proportional to the square of the concentration of the reactant.

8) Give the term for the amount of solute in moles per liter of solution.

8) _____

   A) molarity
   B) mole percent
   C) molality
   D) mole fraction
   E) mass percent

9) Calculate the molality of a solution formed by dissolving 27.8 g of LiI (FW = 133.8 g/mol) in 500.0 mL of water.

9) _____

   A) 0.556 m B) 0.415 m C) 0.254 m D) 0.241 m E) 0.394 m

10) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)?   10) _____

    A) acetone (CH_3COCH_3)

    B) trimethylamine ($N(CH_3)_3$)

    C) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)

    D) ethylene glycol ($HOCH_2CH_2OH$)

    E) None of these compounds should be soluble in ethanol.

11) Identify the rate-determining step.   11) _____

    A) the fast step

    B) always the last step

    C) the slowest step

    D) the faster step

    E) always the second step

12) Calculate the freezing point of a solution containing 0.067 mol of KCl and 550.0 grams of water.   12) _____
The molal-freezing-point-depression constant (K_f) for water is $1.86°C/m$. $\Delta T_f = i * K_f * m$. Use $0°C$ as the freezing point of water and assume complete dissociation of the K Cl.

    A) $-0.45\ °C$ B) $1.23\ °C$ C) $+0.45\ °C$ D) $-0.23\ °C$ E) $+0.23\ °C$

13) To make a 2.00 m solution, one could take 2.00 moles of solute and add   13) _____

    A) 1.00 L of solvent.

    B) enough solvent to make 1.00 L of solution.

    C) enough solvent to make 1.00 kg of solution.

    D) 1.00 kg of solvent.

14) Express the equilibrium constant for the following reaction.   14) _____

$$2\,P(g) + 3\,Cl_2(g) \rightleftharpoons 2\,PCl_3(g)$$
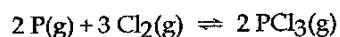
A) $K = \dfrac{[P][Cl_2]^{3/2}}{[PCl_3]}$

B) $K = \dfrac{[P]^2[Cl_2]^3}{[PCl_3]^2}$

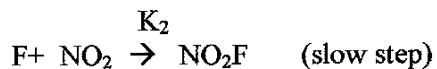C) $K = \dfrac{[PCl_3]}{[P][Cl_2]^{3/2}}$

D) $K = \dfrac{[PCl_3]^2}{[P]^2[Cl_2]^3}$

E) $K = \dfrac{[PCl_3]^{1/2}}{[P]^{1/2}[Cl_2]^{1/3}}$

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (39 pts)
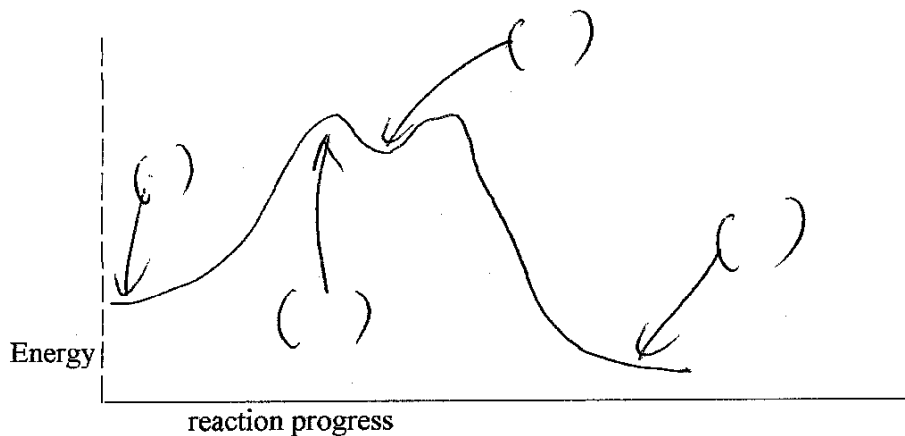
1. For the following reaction mechanism shown as the elementary reactions given, what is the rate law? (You do not need to show me only reactants of the overall reaction to complete this problem. You do not need to show me the overall reaction to complete this problem.) (The K shown are not equilibrium constants but the rate constants associated with the reaction mechanism steps.)   (8 pts)

$$NO_2 + F_2 \xrightarrow{K_1} NO_2F + F \text{ (fast step)}$$ elementary reactions of the proposed mechanism

$$F + NO_2 \xrightarrow{K_2} NO_2F \text{   (slow step)}$$

2. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (4 pts each, 16 pts total)

Energy

reaction progress

3.   a. For the following **overall reaction** (**not reaction mechanism step**, the overall reaction), Given the concentrations and rates, give the order of the reactant by circling the order for the reagent given. You should assume an irreversible reaction. (note: I made up these reactions to illustrate the point so the reactions as given may not go experimentally as written.) (5 pts each, 10 pts total)

$CH_4 + 2 O_2 \rightarrow CO_2 + 2 H_2O$

$[CH_4]$	$[O_2]$	rate
7	4	3
7	8	6
14	4	6

order of the $[CH_4]$ is (zero) (one) (circle one)

order of the $[O_2]$ is (zero)(one) (circle one)

b. From your results in part (a) write the rate law for the overall reaction shown above. (5 pts)

Part III.   Long Answer   Please show work for full credit and to receive partial credit. (33 pts)

1.   If you have a 4.0 Molar solution of NaOH dissolved in water, how many grams of NaOH (FW = 40.0 g/mol) is in 15.5 mL of this solution. (15 pts)

2.   Equilibrium (18 pts total)

a. For the reaction given, set up the ICE table for a reaction in which the reactant gases are mixed in a constant volume of an inert solvent with **no products** **present initially**:   (6 pts total)   (I made up the K_{eq} numbers so these numbers do not match real reaction results.)

$$N_2 (g) + 2 O_2 (g) \rightarrow 2 NO_2 (g) \qquad\qquad K_{eq} = 1.8 \times 10^{-3}$$

If the initial concentration of the N_2 is 0.125 M, and the intial concentration of O_2 is 0.122 M. Show the initial, change and equilibrium concentrations for all reactants and products.   You will need to use a variable x to complete this task.   (x is usually used for the molecule with the smallest coefficient to make this task easier.)

	$[N_2]$	$[\ O_2\ ]$	$[NO_2\ ]$
Initial			
Change			
Equilibrium			

b.   For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions. To answer this question, you will not be using any of the results from the table in part (a) above. (6 pts)

c.   For the same reaction, set up the K_{eq} to solve for x.   I am not asking you to derive the final actual number for x nor am I asking you to do the algebra to solve for x.   I am just asking you to plug in for your expression in (b) above with your number and x expressions from the table in part (a) above. (6 pts)