Exam II   General Chemistry II (CHEM 102)   Summer I   Dr. Hahn   Exam # _____

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

Please show work for partial credit and full credit on the Long Answers and in some of the Short Answer Questions.   Multip
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)   If you run out of space, please continue on the back page of the
exam and clearly tell me where the remaining answer can be found.

NA = not attempted   NW = no work

Part I   MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2
pts per question, 26 pts pts total)

1) Given the following balanced equation, determine the rate of reaction with respect to [NH3].   1) __B__
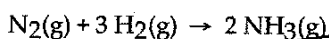
$$N_2(g) + 3 H_2(g) \rightarrow 2 NH_3(g)$$

A) Rate $= -\dfrac{2\Delta[NH_3]}{\Delta t}$

B) Rate $= +\dfrac{1}{2}\dfrac{\Delta[NH_3]}{\Delta t}$
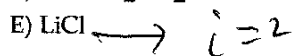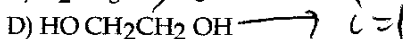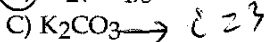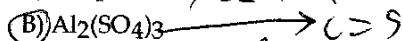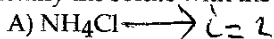
C) Rate $= -\dfrac{1}{2}\dfrac{\Delta[NH_3]}{\Delta t}$

D) Rate $= +\dfrac{2\,\Delta[NH_3]}{\Delta t}$

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

rate $= -\dfrac{\Delta[N_2]}{\Delta t} = -\dfrac{1}{3}\dfrac{\Delta[H_2]}{\Delta t}$

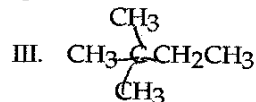*$= \dfrac{1}{2}\dfrac{\Delta[NH_3]}{\Delta t}$ reactant = negative   products = positive*

2) Identify the solute with the highest van't Hoff factor.   2) __B__
   A) NH4Cl $\longrightarrow$ i = 2
   B) Al2(SO4)3 $\longrightarrow$ i = 5
   C) K2CO3 $\longrightarrow$ i = 3
   D) HO CH2CH2 OH $\longrightarrow$ i = 1
   E) LiCl $\longrightarrow$ i = 2

3) Place the following compounds in order of **increasing** strength of intermolecular forces.   3) __E__

I. CH3CH2CH2CH2CH2CH3   II. CH3-C-CH3 (with CH3 top and CH3 bottom)   III. CH3-C-CH2CH3 (with CH3 top and CH3 bottom)
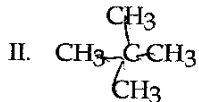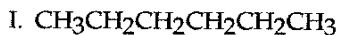
   A) III < I < II
   B) III < II < I
   C) I < III < II
   D) I < II < III
   E) II < III < I

C_6H_{14} greatest mw C_5H_{12} smallest mw C_6H_{14} less surface area

mw = 2(19)   *mw = 2(127)*   *mw = 2(75.5)*

4) Place the following compounds in order of **increasing** strength of intermolecular forces.   4) __C__
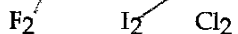
F_2 I_2 Cl_2

smallest mw has smallest
dispersion force - all 3
molecule has dispersion

A) $F_2 < I_2 < Cl_2$
B) $Cl_2 < F_2 < I_2$
C) $F_2 < Cl_2 < I_2$
D) $I_2 < F_2 < Cl_2$
E) $I_2 < Cl_2 < F_2$

5) Identify triple point.   5) __A__
  A) The temperature and pressure where liquid, solid, and gas are equally stable and are in equilibrium.
  B) The temperature that is unique for a substance.
  C) The temperature, pressure, and density for a gas.
  D) The temperature at which the solid and liquid co-exist.
  E) The temperature at which the boiling point equals the melting point.

6) What is the molality of a glucose solution prepared by dissolving 18.0 g of glucose, $C_6H_{12}O_6$, in 125.9 g of water? [FW (glucose) = 180.18 g/mol]   6) __C__
  A) 0.143 m B) 0.695 m C) 0.793 m D) 7.94 × 10^{-4} m

solvent

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

$$m = \frac{(18.0/180.18)}{(125.9 \times \frac{kg}{g})}$$

8) Which of the following compounds exhibits hydrogen bonding?   8) __C__
  A) CH_3OCH_3 B) HI   C) NH_3 D) CH_3Cl

H directly attached to F, O, N

9) Parts per billion requires a multiplication factor of _____.   9) __C__
  A) 10^{-3} B) 10^3 C) 10^9 D) 10^6 E) 10^{-6}

10) Define freezing.   10) __E__
  A) the phase transition from gas to solid
  B) the phase transition from liquid to gas
  C) the phase transition from solid to gas
  D) the phase transition from gas to liquid
  E) the phase transition from liquid to solid

11) Choose the pair of substances that are most likely to form a miscible solution.   11) _B_

    A) C_6H_{14} and H_2O " like dissolves like "
    B) C_6H_{14} and $C_{10}H_{20}$
    C) N_2O_4 and NH_4Cl both have dispersion force only
    D) LiBr and C_5H_{12}
    E) None of the pairs above will form a homogeneous solution.

12) The rate–determining elementary reaction step in a reaction mechanism.   12) _E_

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

13) Place the following compounds in order of **increasing** strength of intermolecular forces.   13) _E_

    CO_2 F_2 NH_2CH_3 ← H bonding

    A) $NH_2CH_3 < F_2 < CO_2$
    B) $NH_2CH_3 < CO_2 < F_2$
    C) $CO_2 < NH_2CH_3 < F_2$
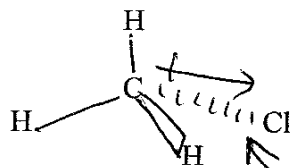   D) $F_2 < NH_2CH_3 < CO_2$
    E) $F_2 < CO_2 < NH_2CH_3$

both are dispersion

$F_2 = mw = 2(19) = 38$

$CO_2 = mw = 12 + 2(16) = 44$

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. Some questions may require that you show work. If you do not show work, you may lose points. (40 pts)

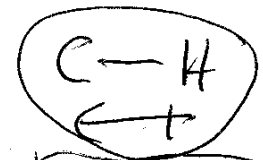1. Intermolecular forces question: (9 pts total, 3 pts each letter)
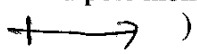
assume C&H has same EN

VSEPRT molecular shape = tetrahedral

2 pts

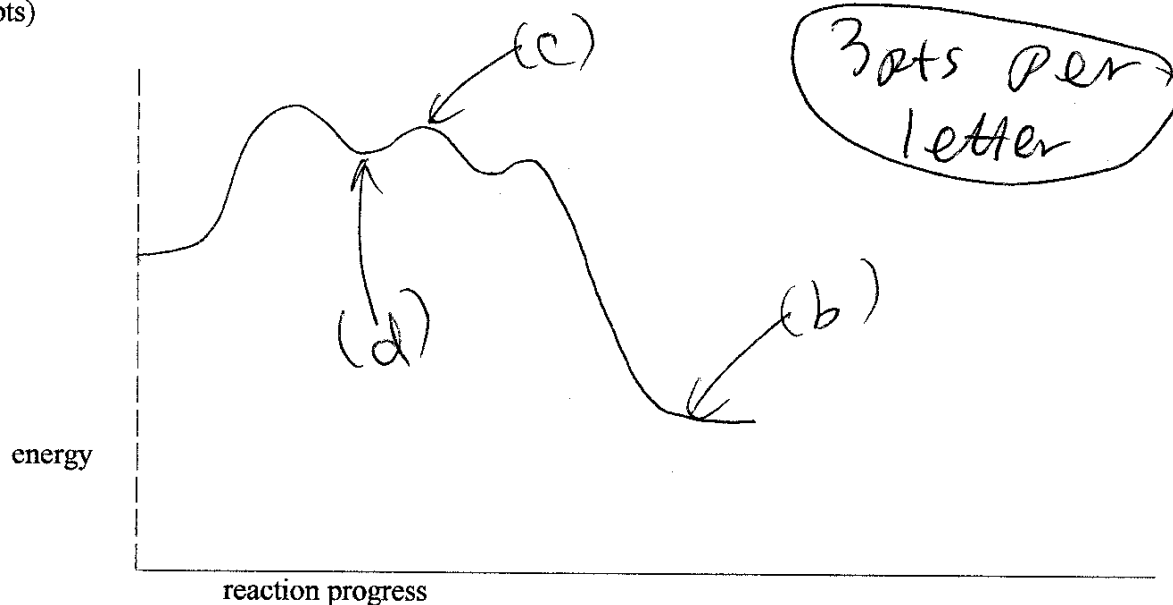*1 pt all 3 C—H arrows*

C—H
←—←
but ok to have no arrow

(a) For the molecule shown, draw a dipole moment arrow for each bond in the molecule. (The dipole moment arrow should look like (—+——>))

(b) The dipole moment for the molecule as a whole is [(zero) or (not zero)] (circle one)

(c) The intermolecular force for this molecule is [(London force) or (dipole-dipole) or (hydrogen bonding)] (circle one)

2. For a reaction illustrated below, label (a) reactant (b) product (c) transition state (d) intermediate by filling in the blank with the appropriate letters. You may use each letter one time, many times or not at all. (9 pts)

(c)

3 pts per letter

(d)

(b)

energy

reaction progress

3. For the following reaction mechanism and the overall reaction, give the expression for the rate law. You do not need to have the expression in only reagents given in the overall reaction. Assume all reactions including the overall reactions are irreversible. I am using letters A,B,C,... etc. to represent some molecule in the reaction mechanism and overall reaction. (8 pts)

$2A + 3B \xrightarrow{k_1} 2D$ elementary reaction mechanism step (1)   slow

$2D + 2E \xrightarrow{k_2} F + 2G$ elementary reaction mechanism step (2)   fast

___

$2A + 3B + 2E \rightarrow F + 2G$ overall reaction

gave equilibrium not rate

$-4 \quad = \dfrac{[D]^2}{[A]^2[B]^3}$

left off -3 ③

Rate = $k_1[A]^2[B]^3$ ③

4. For the overall reaction given, show the rate expression using $\Delta\,[O_3\,(g)]$ and change in time. (6 pts)

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

$rate = -\dfrac{1}{2}\dfrac{\Delta[O_3]}{\Delta t} = +\dfrac{1}{3}\dfrac{\Delta[O_2]}{\Delta t}$

wrong # -2   *sign -1 pt*

gave $\dfrac{[O_2]^3}{[O_3]^2}$ -6

extra wrong -2

5. 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 reaction rate and concentrations to illustrate the point so the rate will not experimentally fit the date shown below.) (4 pts each, 8 pts total)

$2NO_2\,(g) + Cl_2\,(g) \rightarrow 2ClNO_2\,(g)$
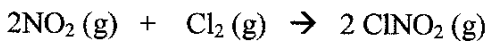
[NO₂]	[Cl₂]	rate
3	2	9
2	3	16
6	2	9
2	6	32

keep Cl_2 constant, double $[NO_2]$ no change rate - zero order
keep $[NO_2]$ constant, double $[Cl_2]$ - rate doubles 1st order

$rate = k_1[NO_2]^0[Cl_2]^1$

order of the [NO₂] is (zero) (one) (circle one)
order of the [Cl₂] is (zero) (one) (circle one)

No partial credit

Part III. Long Answer Please show work for full credit and to receive partial credit. (35 pts)
**** Please attempt every problem for partial credit. You will get no partial credit if you just rewrite the question with no change in anything.****

1. If you want to heat 36.7 grams of liquid water from 75.2 °C to 100.0 °C, what is the heat required, q ?
$(q = m C \Delta T, C_{water} = 4.184 J/g°C)$ (10 pts)

$$\Delta T = 100.0°C - 75.2°C = 24.8°C$$

$$q = (36.7g)(4.184 \frac{J}{g°C})(24.8°C)$$

$$q = 3808 J$$

$$q = 3808 J \times \frac{kJ}{1000 J} = 3.81 \Longleftarrow$$ did not need to convert to kJ

2. (a) For a 0.125 molal aqueous $Fe_2(SO_4)_3$ solution, what is the boiling point elevation ? $(\Delta T_b = i$ x m x K_b $K_b = 0.512$ °C /m, You should assume complete dissociation of the $Fe_2(SO_4)_3$ in water. (9 pts)

$$i = 5$$

$$\Delta T_b = (5)(0.125 m)(0.512°C/m) = 0.32 °C$$

2pt

6pts

1pt math

(b) What is the boiling point of the solution in part (a). (boiling point of water is 100.0 °C) (2 pts)

$$BP (solution) = 100.0°C + 0.32°C = 100.32°C$$

3   You have 23.7 grams of Li Br (molar mass = 86.84 g/mol) and dissolve it in 500.0 mL of water which results in a 520.2 mL of total solution (density of pure water = 1.00 g / mL).   (I made up these numbers so these numbers do not fit experimental data.) (12 pts, 6 pts each)

(a) What is the molarity (M) of the solution ? (show work) $M = \dfrac{\#\ moles\ Li\ Br}{liter-solution}$ (6pt)

$\#\ moles\ Li\ Br = 23.7g \times \dfrac{mol\ LiBr}{86.84g\ LiBr} = 0.273\ mol\ LiBr$ (2pt)

$\#\ liters = 520.2\ mL \times \dfrac{1\ liter}{1000mL} = 0.5202\ L$ (2pt)

$M = \dfrac{0.273\ mol\ LiBr}{0.5202\ L} = 0.5248\ M$ (molarity) (2pt)

(b) What is the molality (m) of the solution ? (show work) (6pt)

$m = \dfrac{\#\ moles\ solute}{kg\ solvent}$

$\#\ moles = 0.273\ mol\ LiBr$ (2pt)

$kg\ solvent = 500.0\ mL\ H_2O \times \dfrac{1.00g\ H_2O}{mL\ H_2O} \times \dfrac{1\ kg}{1000\ g} =$

$kg\ solvent = 0.5000\ kg$ (2pt)

$m = \dfrac{0.273\ mol\ LiBr}{0.5000\ kg} = 0.546\ m$ (molality) (2pt)

Exam II   General Chemistry II (CHEM 102)   Summer I   Dr. Hahn   Exam # _____

Name_____ (print) Name _____(sign)

Please show work for partial credit and full credit on the Long Answers and in some of the Short Answer Questions.   Multip
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)   If you run out of space, please continue on the back page of the
exam and clearly tell me where the remaining answer can be found.

**Part I   MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2
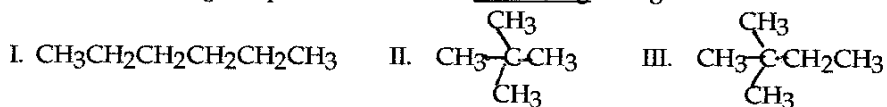pts per question, 26 pts pts total)**

1) Given the following balanced equation, determine the rate of reaction with respect to [NH3].   1) _____

$$N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3(g)$$
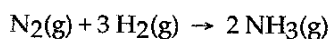
A) $\text{Rate} = -\dfrac{2\Delta[NH_3]}{\Delta t}$

B) $\text{Rate} = +\dfrac{1}{2}\dfrac{\Delta[NH_3]}{\Delta t}$

C) $\text{Rate} = -\dfrac{1}{2}\dfrac{\Delta[NH_3]}{\Delta t}$

D) $\text{Rate} = +\dfrac{2\,\Delta[NH_3]}{\Delta t}$

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

2) Identify the solute with the highest van't Hoff factor.   2) _____
   A) NH_4Cl
   B) $Al_2(SO_4)_3$
   C) K_2CO_3
   D) $HO\,CH_2CH_2\,OH$
   E) $LiCl$

3) Place the following compounds in order of **increasing** strength of intermolecular forces.   3) _____

   I. $CH_3CH_2CH_2CH_2CH_2CH_3$ II. $CH_3-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}}-CH_3$ III. $CH_3-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}}-CH_2CH_3$

   A) III < I < II
   B) III < II < I
   C) I < III < II
   D) I < II < III
   E) II < III < I

4) Place the following compounds in order of **increasing** strength of intermolecular forces.   4) _____

F_2 I_2 Cl_2

A) $F_2 < I_2 < Cl_2$
B) $Cl_2 < F_2 < I_2$
C) $F_2 < Cl_2 < I_2$
D) $I_2 < F_2 < Cl_2$
E) $I_2 < Cl_2 < F_2$

5) Identify triple point.   5) _____
   A) The temperature and pressure where liquid, solid, and gas are equally stable and are in equilibrium.
   B) The temperature that is unique for a substance.
   C) The temperature, pressure, and density for a gas.
   D) The temperature at which the solid and liquid co-exist.
   E) The temperature at which the boiling point equals the melting point.

6) What is the molality of a glucose solution prepared by dissolving 18.0 g of glucose, $C_6H_{12}O_6$, in   6) _____
   125.9 g of water? [FW (glucose) = 180.18 g/mol), density water = 1 g/ 1 mL]
   A) 0.143 m B) 0.695 m C) 0.793 m D) 7.94×10^{-4} m

7) Give the term for the amount of solute in moles per Kg of ~~sol vent~~   7) _____
   A) molarity
   B) mole fraction
   C) mass percent
   D) mole percent
   E) molality

8) Which of the following compounds exhibits hydrogen bonding?   8) _____
   A) CH_3OCH_3 B) HI   C) NH_3 D) CH_3Cl

9) Parts per billion requires a multiplication factor of _____.   9) _____
   A) 10^{-3} B) 10^3 C) 10^9 D) 10^6 E) 10^{-6}

10) Define freezing.   10) _____
    A) the phase transition from gas to solid
    B) the phase transition from liquid to gas
    C) the phase transition from solid to gas
    D) the phase transition from gas to liquid
    E) the phase transition from liquid to solid

11) Choose the pair of substances that are most likely to form a miscible solution.

    A) C_6H_{14} and H_2O

    B) C_6H_{14} and $C_{10}H_{20}$

    C) N_2O_4 and NH_4Cl

    D) LiBr and C_5H_{12}

    E) None of the pairs above will form a homogeneous solution.

11) _____

12) The rate–determining elementary reaction step in a reaction mechanism.

    A) always the last step

    B) the fast step

    C) always the second step
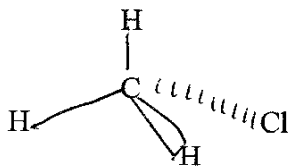
    D) the faster step

    E) the slowest step

12) _____

13) Place the following compounds in order of **increasing** strength of intermolecular forces.

        CO_2 F_2 NH_2CH_3

    A) $NH_2CH_3 < F_2 < CO_2$

    B) $NH_2CH_3 < CO_2 < F_2$

    C) $CO_2 < NH_2CH_3 < F_2$

    D) $F_2 < NH_2CH_3 < CO_2$

    E) $F_2 < CO_2 < NH_2CH_3$

13) _____

Part II **Short Answer:** Write the word or phrase or circle the choice that best completes each statement or answers the question. Some questions may require that you show work. If you do not show work, you may lose points. (40 pts)
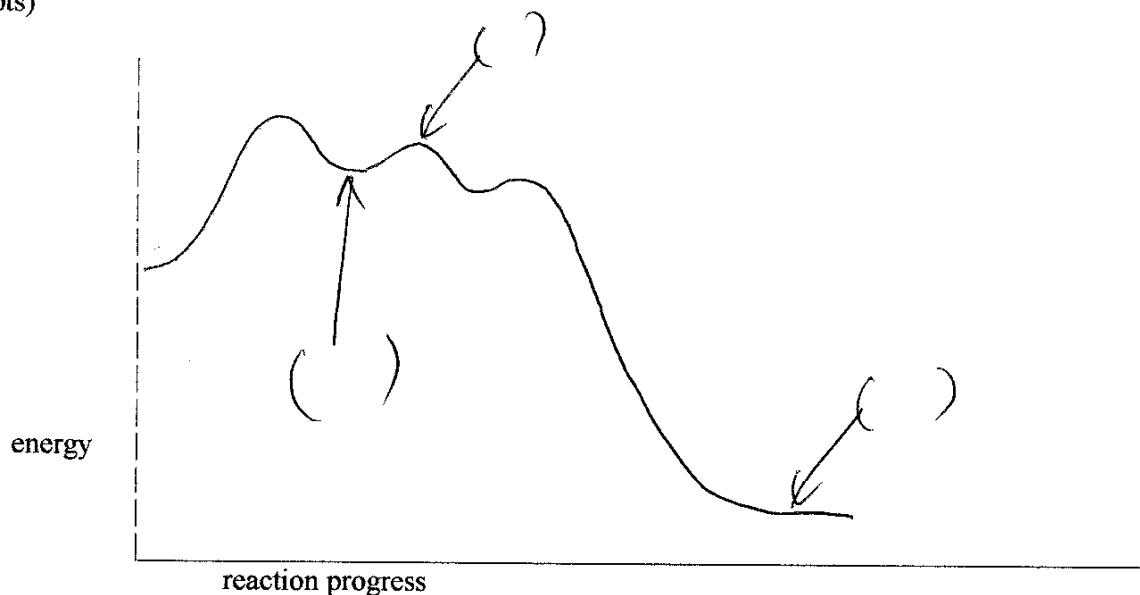
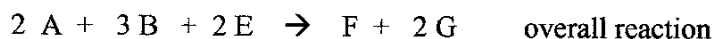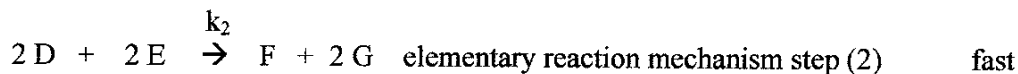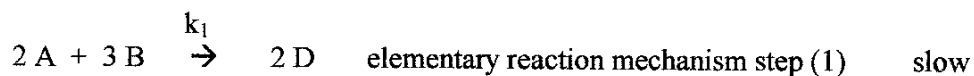1.   Intermolecular forces question: (9 pts total, 3 pts each letter)

VSEPRT molecular shape = tetrahedral

(a)   For the molecule shown, draw a dipole moment arrow for each bond in the molecule.   (The dipole moment arrow should look like (⊢——→   )

(b)   The dipole moment for the molecule as a whole is [(zero) or (not zero)] (circle one)

(c)   The intermolecular force for this molecule is [(London force) or (dipole-dipole) or (hydrogen bonding)] (circle one)

2.   For a reaction illustrated below, label (a) reactant (b) product (c) transition state (d) intermediate by filling in the blank with the appropriate letters. You may use each letter one time, many times or not at all. (9 pts)
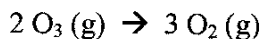

energy

reaction progress

3. For the following reaction mechanism and the overall reaction, give the expression for the rate law. You do not need to have the expression in only reagents given in the overall reaction. Assume all reactions including the overall reactions are irreversible. I am using letters A,B,C,... etc. to represent some molecule in the reaction mechanism and overall reaction. (8 pts)
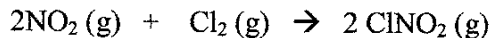
$$2A + 3B \xrightarrow{k_1} 2D \quad \text{elementary reaction mechanism step (1)} \quad \text{slow}$$

$$2D + 2E \xrightarrow{k_2} F + 2G \quad \text{elementary reaction mechanism step (2)} \quad \text{fast}$$

$$2A + 3B + 2E \rightarrow F + 2G \quad \text{overall reaction}$$

Rate = _____

4. For the overall reaction given, show the rate expression using $\Delta [O_3 (g)]$ and change in time. (6 pts)

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

5. 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 reaction rate and concentrations to illustrate the point so the rate will not experimentally fit the date shown below.) (4 pts each, 8 pts total)

$$2NO_2 (g) + Cl_2 (g) \rightarrow 2 ClNO_2 (g)$$

[NO$_2$]	[Cl$_2$]	rate
3	2	9
2	3	16
6	2	9
2	6	32

order of the [NO$_2$] is (zero) (one) (circle one)
order of the [Cl$_2$] is (zero)(one) (circle one)

**Part III.   Long Answer   Please show work for full credit and to receive partial credit. (35 pts)
**** Please attempt every problem for partial credit.   You will get no partial credit if you just rewrite
the question with no change in anything.******

1.   If you want to heat 36.7 grams of liquid water from 75.2 °C to 100.0 °C, what is the heat required, q ?
(q = m C ΔT, C $_{water}$ = 4.184 J/g °C) (10 pts)

2.   (a)   For a 0.125 molal aqueous $Fe_2(SO_4)_3$ solution, what is the boiling point elevation ?   ($\Delta T_b = i$
x m x K$_b$ K$_b$ = 0.512 °C /m,   You should assume complete dissociation of the $Fe_2(SO_4)_3$ in water. (9 pts)

(b)   What is the boiling point of the solution in part (a). (boiling point of water is 100.0 °C) (2 pts)

3   You have 23.7 grams of Li Br (molar mass = 86.84 g/mol) and dissolve it in 500.0 mL of water which results in a 520.2 mL of total solution (density of pure water = 1.00 g / mL).   (I made up these numbers so these numbers do not fit experimental data.) (12 pts, 6 pts each)

(a) What is the molarity (M) of the solution ?   (show work)

(b) What is the molality (m) of the solution ? (show work)