Final General Chemistry II (CHEM 102) Form A 4/26/13 9:30 am MWF Dr. Hahn Exam # orange

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) (200 pt exam, worth only 180 pts, does not have 20 pt EC)

$q = m\,C\,\Delta T$, $pH + pOH = 14$ $pKa + pKb = 14$ $K_a \times K_b = 1.0 \times 10^{-14}$ $[H_3O^+][OH^-] = 1.0 \times 10^{-14} = k_W$

p (anything) = - log (anything) $pH = pK_a + \log \{ [base] / [acid] \}$ M = molarity = moles / liter

$\Delta H^o_{rxn} = \{ \Sigma\ n\,\Delta H^o_f(products)\} - \{ \Sigma\ n\,\Delta H^o_f(products) \}$ $\Delta G^o_{rxn} = \{ \Sigma\ n\,\Delta G^o_f(products)\} - \{ \Sigma\ n\,\Delta G^o_f(products) \}$ $\Delta S^o_{rxn} = \{ \Sigma\ n\ S^o(products)\} - \{ \Sigma\ n\ S^o(products) \}$

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (24 questions, 2 pts per question, 48 pts total)

1) Which of the following statements is TRUE? 1) E
A) State functions do not depend on the path taken to arrive at a particular state.
B) ΔH_{rxn} can be determined using a coffee cup calorimeter.
C) q system = - q surrounding
D) Energy is neither created nor destroyed, excluding nuclear reactions.
(E) All of the above are true.

2) What is the ground-state electron configuration for the element chromium (Z = 24)? 2) B
A) [Ne] $4s^2\ 3d^4$ (B) [Ar] $4s^1\ 3d^5$ C) [Ar] $3d^6$ D) [Ar] $4s^2\ 3d^4$

3) Which of the following solutions is a good buffer system? 3) B
A) A solution that is 0.10 M H Cl and 0.10 M NH_4^+
(B) A solution that is 0.10 M H $C_2H_3O_2$ and 0.10 M Li $C_2H_3O_2$
C) A solution that is 0.10 M Na OH and 0.10 M K OH
D) A solution that is 0.10 M H F and 0.10 M Na $C_2H_3O_2$
E) None of the above are buffer systems.

4) Define sublimation. 4) D
A) the phase transition from liquid to gas
B) the phase transition from liquid to solid
C) the phase transition from gas to liquid
(D) the phase transition from solid to gas
E) the phase transition from gas to solid

5) Give the term for the amount of solute in moles per liter of solution. 5) B
A) molality
(B) molarity
C) mole fraction
D) mole percent
E) mass percent

6) Identify the diprotic acid. 6) E

A) CH_3COOH
B) HCl
C) $HClO_4$
D) HNO_3
E) H_2SO_4

7) Given the following rate law, how does the rate of reaction change if the concentration of Y is doubled? 7) A

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 4.
D) The rate of reaction will increase by a factor of 5.
E) The rate of reaction will remain unchanged.

8) 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. (m = moles / kg solvent) 8) E

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

9) Consider the following reaction at equilibrium. What effect will removing NO_2 have on the system? 9) D

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

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 equilibrium constant will decrease.
D) The reaction will shift in the direction of reactants.
E) The reaction will shift in the direction of products.

10) The specific heat capacity of liquid mercury is 0.14 J/g °C. How many joules of heat are needed to raise the temperature of 5.00 g of mercury from 15.0°C to 36.5°C? ($q = m\ C\ \Delta T$) 10) C

A) 36 J
B) 1.7 J
C) 15 J
D) 7.7×10^2 J
E) 0.0013 J

11) Identify the solute with the highest van't Hoff factor. 11) E

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

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

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

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

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

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

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

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

13) Calculate $\Delta S°_{rxn}$ for the following reaction. The S° for each species is shown below the reaction. 13) E

$\Delta\, S°_{rxn} = \{\ \Sigma\ n\ S°\,(products)\} - \{\ \Sigma\ n\ S°\,(products)\ \}$

	$N_2H_4(l) + H_2(g)$	$\rightarrow$	$2\,NH_3(g)$
S° (J/mol•K)	121.2	130.7	192.8

A) -59.1 J/K B) +118.2 J/K C) +178.9 J/K D) -202.3 J/K (E) +133.7 J/K

14) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)? 14) B

A) trimethylamine ($N(CH_3)_3$)

(B) ethylene glycol ($HOCH_2CH_2OH$)

C) acetone (CH_3COCH_3)

D) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)

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

15) Which one of the following has a low density? 15) A

(A) gas

B) solid

C) liquid

D) none of the above

E) all of the above

16) Define boiling. 16) E

A) A solid becomes a liquid.

B) A gas becomes a solid.

C) A solid becomes a gas.

D) A gas becomes a liquid.

(E) A liquid becomes a gas.

17) Express the equilibrium constant for the following reaction. 17) B

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

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

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

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

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

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

18) Calculate the concentration of H_3O^+ in a solution that contains 5.5×10^{-5} M OH^- at 25°C. 18) E

$\{[H_3O^+][OH^-] = 1.0 \times 10^{-14}\}$

A) 9.2×10^{-1} M

B) 1.8×10^{-12} M

C) 9.2×10^{-2} M

D) 5.5×10^{-10} M

(E) 1.8×10^{-10} M

19) 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. 19) A

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

20) Identify the rate-determining step. 20) E

A) always the second step

B) the fast step

C) the faster step

D) always the last step

(E) the slowest step

21) Calculate the pOH in an aqueous solution with a pH of 9.85 at 25°C. $(pH + pOH = 14)$ 21) D

A) 5.15 B) 2.15 C) 4.00 (D) 4.15 E) 3.15

22) Place the following compounds in order of **increasing** strength of intermolecular forces. 22) E

CH_4 $CH_3CH_2CH_3$ CH_3CH_3

A) $CH_3CH_2CH_3 < CH_3CH_3 < CH_4$
B) $CH_3CH_2CH_3 < CH_4 < CH_3CH_3$
C) $CH_3CH_3 < CH_4 < CH_3CH_2CH_3$
D) $CH_4 < CH_3CH_2CH_3 < CH_3CH_3$
E) $CH_4 < CH_3CH_3 < CH_3CH_2CH_3$

23) Give the term for the amount of solute in moles per kilogram of solvent. 23) D

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

24) What is the conjugate **acid** of HCO_3^- ? 24) B

A) CO_3^{2-} B) H_2CO_3 C) OH^- D) H_2O E) H_3O^+

II. Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (93 points)

1. For the element As (atomic number = 33) (3 pts each, 15 pts)

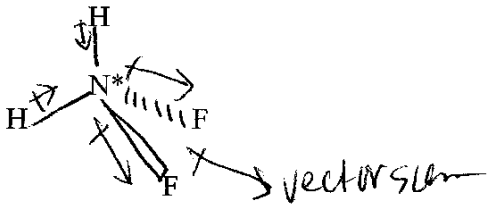
The group number is V the charge for an ion (if one exists) is 5-8 = -3

The number of valence electrons (for a neutral atom) is 5

The electron configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^3$ or $[Ar]\ 4s^2 3d^{10} 4p^3$ (use notation $1s^2$, etc)

The valence electron configuration is $4s^2, 4p^3$ (use notation $1s^2$, etc)

2. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPRT shape of the molecule at the * is tetrahedral (3 pts each, 12 pts)



a. Draw in the individual bond dipole vectors on the molecule shown.
(vectors should look like +--------->)

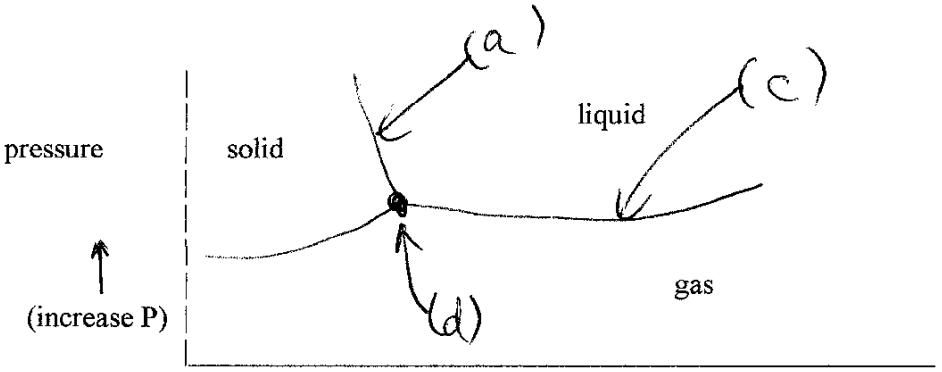
b. The vector sum of the dipole moment for the molecule is (zero) or (not zero) (circle one)

c. The molecule as a whole is (polar) or (nonpolar) (circle one)

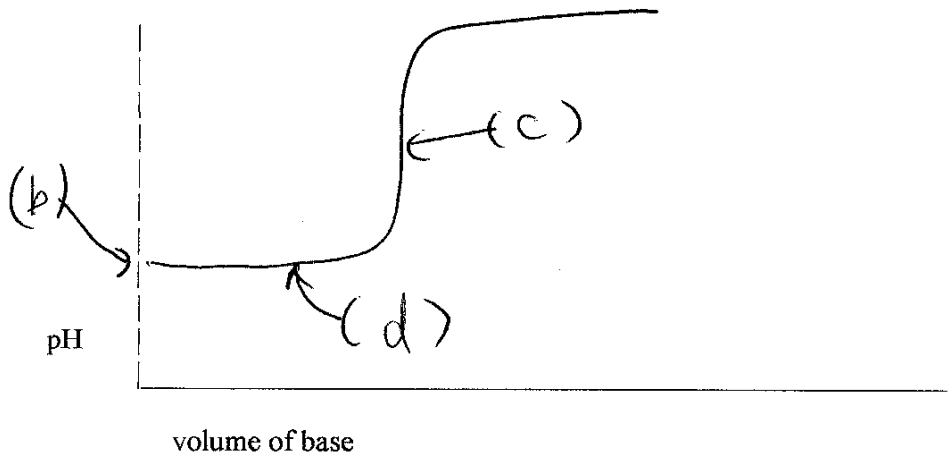
d. The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)

3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (4 pts each, 12 pts)

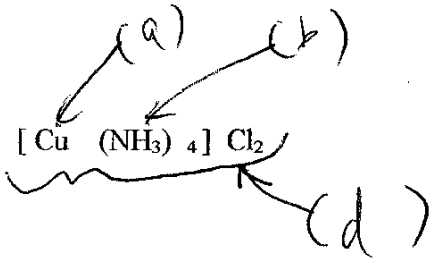
(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to ~~liquid~~ solid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point You may use each letter once, many times or not at all.



4. Match the titration curve for a strong acid being titrated by adding a strong base with the statements below. You may use the letters one time, no time or many times. (a) M = (# moles base - # moles acid) / total volume (b) $[H^+] = [H_3O^+] = [HA]$ (HA is a generic strong acid) (c) pH = 7 (d) M = (# moles acid - # moles base) / total volume (5 pts each, 15 pts total)

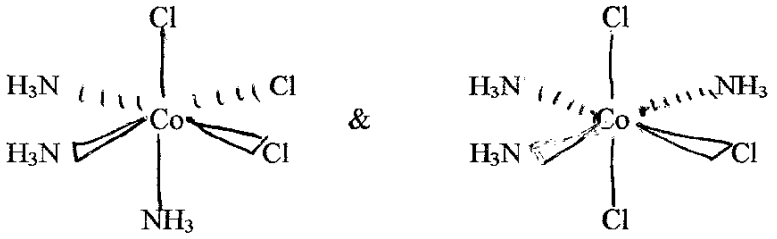


5. For the coordination compound given, label each parenthesis with the correct letter. You may use each letter one time, many times or not at all. (a) metal (b) ligand (c) coordination complex (d) coordination compound (3 pts each, 9 pt total)



6. Given the isomer pairs shown, match the kind of isomer by using the letters given. Each blank may have one to as many as four of the possible isomer names. (a) fac- mer isomer type of geometric isomer (b) coordination isomer type of structural isomer (c) linkage isomer type of structural isomer (d) cis/trans isomer type of geometric isomer (12 pts total, 6 pts per blank)

$[Co(NH_3)_5Br]Cl$ & $[Co(NH_3)_5Cl]Br$ b



a

7. For the reaction $2\ NH_3(g) \rightarrow N_2H_4(g) + H_2(g)$ set up the formula to calculate ΔG°_{RXN} by filling in the blanks above. It is possible that you may **not** use all blanks and / or that some of the blanks may have the **number one** in the blank. (Since I am not giving you any numbers or a chart to look up the numbers, you do not need to attempt to actually calculate the final number. Actually it is impossible for you to actually calculate the final numbers because I am not giving you enough information to come up with the final number.) (2 pts each, 18 pts total)

ΔG°_{RXN} = { 1 ΔG°_f [$N_2H_4(g)$] + 1 ΔG°_f [$H_2(g)$] } -

{ 2 ΔG°_f [$NH_3(g)$] + { / ΔG°_f [/]}

Part III Long Answer: Show all work for full credit and for partial credit. (70 pts)

1. a. If you have a 0.010 M 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. (14 pts)

$$25.0\,mL \times \frac{0.010\,mol\,HCl}{1000\,mL} \times \frac{36.5\,g}{1\,mol\,HCl} = 9.13 \times 10^{-3}\,g$$

b. What is the pH of your solution above ? Show work.(8 pts)

$$pH = -\log(0.010) = 2.00$$

8. 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.) (12 pts total)

$H_2\,(g) + I_2\,(g) \rightarrow 2\,H\,I\,(g)$

$[H_2]$	$[I_2]$	rate
3	1	8
3	2	16
6	1	16

double I_2, double rate

double H_2 - double rate

a.order of the $[H_2]$ is (zero) (one) (circle one) (4 pts each, 8 pts total)
order of the $[I_2]$ is (zero) (one) (circle one)

b Write the final experimentally (from the data which I gave you in the chart above) determined rate law in terms of the concentration of the reactants with the correct order using a rate constant = k (4 pts)

$$rate = k[H_2][I_2]$$

3 Equilibrium (36 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 product present initially**: (2pts per blank 18 pts total) (I made up some of the K_{eq} numbers so these numbers do not match real reaction results.)

$N_2(g) + 3\ H_2(g) \rightarrow 2NH_3\ (g)$ $\quad K_{eq} = 3.7 \times 10^{8}$

If the initial concentration of the N_2(g is 0.375 M, and the initial concentration of H_2(g) is 0.115 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.)

	$[N_2]$	$[H_2]$	$[NH_3]$
Initial	0.375	0.115	0
Change	$-x$	$-3x$	$+2x$
Equilibrium	$0.375 - x$	$0.115 - 3x$	$2x$

b. For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions. (expression mean you show me the equation for Keq in terms of the concentrations (ex: $[H_3O^+]$) To answer this question, you will not be using the results from the table in part (a) above. (9 pts)

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

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. (9 pts)

$$K_{eq} = \frac{(2x)^2}{(0.375 - x)(0.115 - 3x)^3} = 3.7 \times 10^{8}$$

Final General Chemistry II (CHEM 102) Form B 4/26/13 9:30 am MWF Dr. Hahn Exam # white

Name Key (print) Name _____ (sign)

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$q = m\,C\,\Delta T$, $pH + pOH = 14$ $pKa + pKb = 14$ $K_a \times K_b = 1.0 \times 10^{-14}$ $[H_3O^+][OH^-] = 1.0 \times 10^{-14} = k_W$

p (anything) = - log (anything) $pH = pK_a + \log \{ [base] / [acid] \}$ M = molarity = moles / liter

$\Delta H^o_{rxn} = \{ \Sigma\ n \Delta H^o_f(products)\} - \{ \Sigma\ n \Delta H^o_f(products) \}$ $\Delta G^o_{rxn} = \{ \Sigma\ n \Delta G^o_f(products)\} - \{ \Sigma\ n \Delta G^o_f(products) \}$ $\Delta S^o_{rxn} = \{ \Sigma\ n\ S^o(products)\} - \{ \Sigma\ n\ S^o(products) \}$

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (24 questions, 2 pts per question, 48 pts total)

1) Calculate the concentration of H_3O^+ in a solution that contains 5.5×10^{-5} M OH^- at 25°C. 1) B

$\{[H_3O^+][OH^-] = 1.0 \times 10^{-14}\}$

A) 1.8×10^{-12} M
(B) 1.8×10^{-10} M
C) 9.2×10^{-1} M
D) 5.5×10^{-10} M
E) 9.2×10^{-2} M

2) Which of the following statements is TRUE? 2) E

A) ΔH_{rxn} can be determined using a coffee cup calorimeter.
B) Energy is neither created nor destroyed, excluding nuclear reactions.
C) $q_{system} = -q_{surrounding}$
D) State functions do not depend on the path taken to arrive at a particular state.
(E) All of the above are true.

3) 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. (m = moles / kg solvent) 3) D

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

4) Identify the diprotic acid. 4) B

A) HCl
(B) H_2SO_4
C) HNO_3
D) $HClO_4$
E) CH_3COOH

5) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)? 5) C

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

6) Consider the following reaction at equilibrium. What effect will removing NO_2 have on the system? 6) B

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

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

7) 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. 7) B

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

8) Identify the rate-determining step. 8) D

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

9) What is the conjugate **acid** of HCO_3^- ? 9) D

A) CO_3^{2-} B) H_2O C) OH^- D) H_2CO_3 E) H_3O^+

10) Which one of the following has a low density? 10) B

A) liquid
B) gas
C) solid
D) none of the above
E) all of the above

11) What is the ground-state electron configuration for the element chromium (Z = 24)? 11) A

A) [Ar] $4s^1\ 3d^5$ B) [Ne] $4s^2\ 3d^4$ C) [Ar] $4s^2\ 3d^4$ D) [Ar] $3d^6$

12) Calculate $\Delta S°_{rxn}$ for the following reaction. The S° for each species is shown below the reaction. 12) B

$\Delta S°_{rxn} = \{ \Sigma \text{ n } S°(\text{products})\} - \{ \Sigma \text{ n } S°(\text{products}) \}$

	$N_2H_4(l) + H_2(g) \rightarrow 2\,NH_3(g)$		
S° (J/mol·K)	121.2	130.7	192.8

A) −202.3 J/K (B) +133.7 J/K C) +118.2 J/K D) +178.9 J/K E) −59.1 J/K

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

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

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

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

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

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

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

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

$$\text{Rate} = k\,[X][Y]$$

(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 4.
D) The rate of reaction will increase by a factor of 5.
E) The rate of reaction will remain unchanged.

15) Which of the following solutions is a good buffer system? 15) C

A) A solution that is 0.10 M Na OH and 0.10 M K OH
B) A solution that is 0.10 M H Cl and 0.10 M NH_4^+
(C) A solution that is 0.10 M H $C_2H_3O_2$ and 0.10 M Li $C_2H_3O_2$
D) A solution that is 0.10 M H F and 0.10 M Na $C_2H_3O_2$
E) None of the above are buffer systems.

16) Place the following compounds in order of **increasing** strength of intermolecular forces. 16) B

CH_4 $CH_3CH_2CH_3$ CH_3CH_3

A) $CH_4 < CH_3CH_2CH_3 < CH_3CH_3$
B) $CH_4 < CH_3CH_3 < CH_3CH_2CH_3$
C) $CH_3CH_3 < CH_4 < CH_3CH_2CH_3$
D) $CH_3CH_2CH_3 < CH_3CH_3 < CH_4$
E) $CH_3CH_2CH_3 < CH_4 < CH_3CH_3$

17) The specific heat capacity of liquid mercury is 0.14 J/g °C . How many joules of heat are needed to raise the temperature of 5.00 g of mercury from 15.0°C to 36.5°C? ($q = m\ C\ \Delta\ T$) 17) B

A) 0.0013 J
B) 15 J
C) 1.7 J
D) 7.7×10^2 J
E) 36 J

18) Define sublimation. 18) B

A) the phase transition from gas to liquid
B) the phase transition from solid to gas
C) the phase transition from liquid to gas
D) the phase transition from gas to solid
E) the phase transition from liquid to solid

19) Identify the solute with the highest van't Hoff factor. 19) A

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

20) Give the term for the amount of solute in moles per kilogram of solvent. 20) C

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

21) Give the term for the amount of solute in moles per liter of solution. 21) D

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

22) Calculate the pOH in an aqueous solution with a pH of 9.85 at 25°C. (pH + pOH = 14) 22) E

A) 2.15 B) 3.15 C) 4.00 D) 5.15 E) 4.15

23) Define boiling. 23) C

A) A solid becomes a liquid.
B) A gas becomes a liquid.
C) A liquid becomes a gas.
D) A solid becomes a gas.
E) A gas becomes a solid.

24) Given the following balanced equation, determine the rate of reaction with respect to [NOCl]. 24) D

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

A) $\text{Rate} = -\frac{2\,\Delta[NOCl]}{\Delta t}$

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

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

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

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

II. Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (93 points)

1. For the element Se (atomic number = 34) (3 pts each, 15 pts)

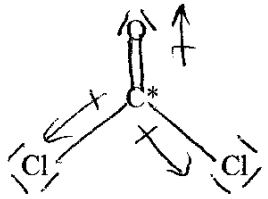
The group number is VIA the charge for an ion (if one exists) is 6-8 = -2

The number of valence electrons (for a neutral atom) is 6

The electron configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}4p^4$ or $[Ar]4s^2, 3d^{10}4p^4$ (use notation $1s^2$, etc)

The valence electron configuration is $4s^2, 4p^4$ (use notation $1s^2$, etc)

2. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPRT shape of the molecule at the * is trigonal planar (3 pts each, 12 pts)



a. Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like +---------->)

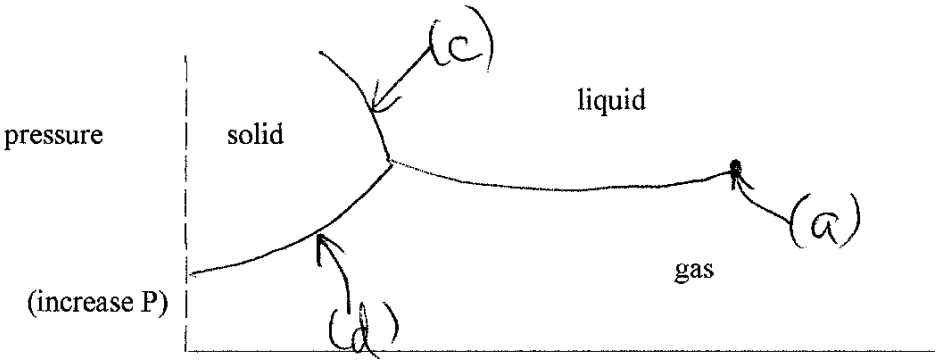
b. The vector sum of the dipole moment for the molecule is (zero) or (not zero) (circle one)

c. The molecule as a whole is (polar) or (nonpolar) (circle one)

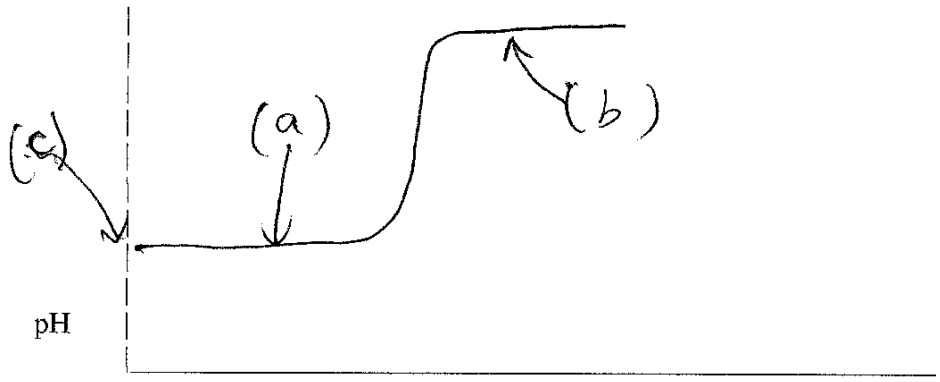
d. The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)

3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (4 pts each, 12 pts)

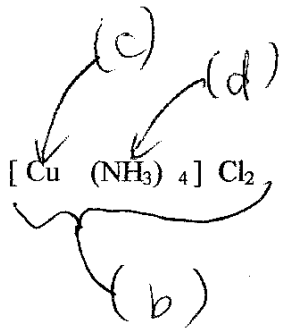
(a) the critical point (b) a line for the conversion of gas to liquid (c) a line for the conversion of solid to liquid (d) a line for the conversion of liquid to gas (e) the triple point You may use each letter once, many times or not at all.



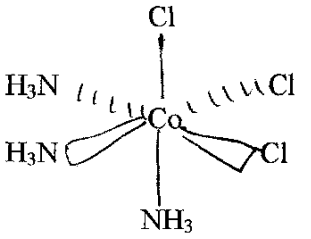
4. Match the titration curve for a strong acid being titrated by adding a strong base with the statements below. You may use the letters one time, no time or many times. (a) M = (# moles acid - # moles base) / total volume (b) M = (# moles base - # moles acid) / total volume (c) $[H^+] = [H_3O^+] = [HA]$ (HA is a generic strong acid) (d) pH = 7 (5 pts each, 15 pts total)



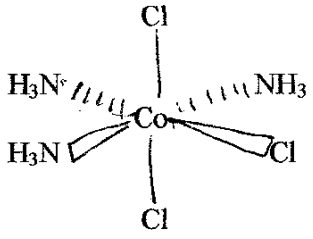
5. For the coordination compound given, label each parenthesis with the correct letter. You may use each letter one time, many times or not at all. (a) coordination complex (b) coordination compound (c) metal (d) ligand (3 pts each, 9 pt total)



6. Given the isomer pairs shown, match the kind of isomer by using the letters given. Each blank may have one to as many as four of the possible isomer names. (a) cis/trans isomer type of geometric isomer (b) fac- mer isomer type of geometric isomer (c) coordination isomer type of structural isomer (d) linkage isomer type of structural isomer (12 pts total, 6 pts per blank)



&



b

[Co(NH3)5Br]Cl & [Co(NH3)5Cl]Br

c

7. For the reaction Fe_2O_3 (s) + 3 CO (g) → 2 Fe (s) + 3 CO_2(g) set up the formula to calculate ΔG°_{RXN} by filling in the blanks above. It is possible that you may **not** use all blanks and / or that some of the blanks may have the **number one** in the blank. (Since I am not giving you any numbers or a chart to look up the numbers, you do not need to attempt to actually calculate the final number. Actually it is impossible for you to actually calculate the final numbers because I am not giving you enough information to come up with the final number.) (2 pts each, 18 pts total)

ΔG°_{RXN} = { 2 ΔG°_f [Fe(s)] + 3 ΔG°_f [$CO_2(g)$] } -

zero

{ 1 ΔG°_f [$Fe_2O_3(s)$] + { 3 ΔG°_f [CO(g)] }

Part III Long Answer: Show all work for full credit and for partial credit. (70 pts)

1. a. If you have a 0.050 Molar solution of HNO_3 dissolved in water, how many grams of HNO_3 (FW = 63.02 g/mol) is in 15.5 mL of this solution. (14 pts)

$$15.5\,mL\ soln. \times \frac{0.050\,mol\,HNO_3}{1000\,mL\ soln.} \times \frac{63.02\,g\,HNO_3}{1\,mol\,HNO_3} = 0.0488\,g\ HNO_3$$

b. What is the pH of your solution above ? Show work.(8 pts)

$$pH = -\log(0.050) = 1.30$$

2. 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.) (12 pts total)

$CO(g) + 2\,H_2(g) \rightarrow CH_3OH\,(g)$

[CO]	[H_2]	rate
1	1	1
2	1	2
1	2	1

double [CO], rate doubles

double H_2, rate no change

a. order of the [CO] is (zero) (one) (circle one) (4 pts each)
order of the [H_2] is (zero) (one) (circle one)

b Write the final experimentally (from the data which I gave you in the chart above) determined rate law in terms of the concentration of the reactants with the correct order using a rate constant = k (4 pts)

$$rate = k[CO]^0[H_2]^1 = k[H_2]$$

3. Equilibrium (36 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 product present initially**: (2pts per blank 18 pts total) (I made up some of the K_{eq} numbers so these numbers do not match real reaction results.)

$H_2\,(g) + I_2\,(g) \rightarrow 2\,HI\,(g) \quad K_{eq} = 6.2 \times 10^{-2}$

If the initial concentration of the H_2 (g) is 0.178 M, and the initial concentration of I_2 (g) is 0.711 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_2]	[I_2]	[HI]
Initial	0.178	0.711	0
Change	$-x$	$-x$	$+2x$
Equilibrium	$0.178 - x$	$0.711 - x$	$2x$

b. For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions. (expression mean you show me the equation for Keq in terms of the concentrations (ex: $[H_3O^+]$) To answer this question, you will not be using the results from the table in part (a) above. (9 pts)

$$K = \frac{[HI]^2}{[H_2][I_2]}$$

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. (9 pts)

$$\frac{(2x)^2}{(0.178 - x)(0.711 - x)} = 6.2 \times 10^{-2}$$

Final General Chemistry II (CHEM 102) Form A 4/26/13 11:30 am MWF Dr. Hahn Exam # Orange

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) (200 pt exam, worth only 180 pts, does not have 20 pt EC)

$q = m\,C\,\Delta T$, $pH + pOH = 14$ $pKa + pKb = 14$ $K_a \times K_b = 1.0 \times 10^{-14}$ $[H_3O^+][OH^-] = 1.0 \times 10^{-14} = k_W$

p (anything) = - log (anything) $pH = pK_a + \log \{ [base] / [acid] \}$ M = molarity = moles / liter

$\Delta H^o_{rxn} = \{ \Sigma\ n \Delta H^o_f(products)\} - \{ \Sigma\ n \Delta H^o_f(products) \}$ $\Delta G^o_{rxn} = \{ \Sigma\ n \Delta G^o_f(products)\} - \{ \Sigma\ n \Delta G^o_f(products) \}$ $\Delta S^o_{rxn} = \{ \Sigma\ n\ S^o(products)\} - \{ \Sigma\ n\ S^o(products) \}$

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (24 questions, 2 pts per question, 48 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 proportional to the square 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 proportional to the square root of 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 directly proportional to the concentration of the reactant.

2) Which of the following solutions is a good buffer system? 2) C
   A) A solution that is 0.10 M H Cl and 0.10 M NH_4^+
   B) A solution that is 0.10 M H F and 0.10 M Na $C_2H_3O_2$
   (C) A solution that is 0.10 M H $C_2H_3O_2$ and 0.10 M Li $C_2H_3O_2$
   D) A solution that is 0.10 M Na OH and 0.10 M K OH
   E) None of the above are buffer systems.

3) Identify a substance that is not in its standard state. 3) C
   A) Ca B) Ne (C) CO D) O_2 E) H_2

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

5) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)? 5) A
   (A) ethylene glycol ($HOCH_2CH_2OH$)
   B) acetone (CH_3COCH_3)
   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.

6) Place the following compounds in order of **decreasing** strength of intermolecular forces. 6) A

I. $CH_3CH_2CH_2CH_2CH_2CH_3$ II. $CH_3C(CH_3)_2CH_3$ III. $CH_3C(CH_3)_2CH_2CH_3$

(A) I > III > II
B) III > II > I
C) II > III > I
D) III > I > II
E) I > II > III

7) Which of the following statements is TRUE? 7) E

A) Energy is neither created nor destroyed, excluding nuclear reactions.
B) State functions do not depend on the path taken to arrive at a particular state.
C) $q_{system} = -q_{surrounding}$
D) ΔH_{rxn} can be determined using a coffee cup calorimeter.
(E) All of the above are true.

8) Calculate the freezing point of a solution containing 0.067 mol of K Cl and 550.0 grams of water. The molal-freezing-point-depression constant (K_f) for water is 1.86°C/*m*. $\Delta T_f = i * K_b * m$. Use 0°C as the freezing point of water and assume complete dissociation of the K Cl. 8) D

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

9) What is the ground-state electron configuration for the element chromium (Z = 24)? 9) A

(A) [Ar] $4s^1\ 3d^5$ B) [Ar] $4s^2\ 3d^4$ C) [Ne] $4s^2\ 3d^4$ D) [Ar] $3d^6$

10) Give the term for the amount of solute in moles per kilogram of solvent. 10) B

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

11) Calculate the concentration of OH^- in a solution that contains 3.9×10^{-4} M H_3O^+ at 25°C. 11) E

$\{[H_3O^+][OH^-] = 1.0 \times 10^{-14}\}$

A) 2.7×10^{-2} M
B) 2.7×10^{-3} M
C) 3.9×10^{-4} M
D) 2.6×10^{-12} M
(E) 2.6×10^{-11} M

12) Calculate the amount of heat (in kJ) necessary to raise the temperature of 47.8 g benzene by 57.0 °C. The specific heat capacity of benzene is 1.05 J/g°C $q = m\,C\,\Delta T$ 12) A

(A) 2.86 kJ B) 16.6 kJ C) 1.61 kJ D) 2.59 kJ E) 3.85 kJ

13) Use the information provided to determine $\Delta H°_{rxn}$ for the following reaction: 13) E

$\Delta H°_{rxn} = \{ \Sigma\ n \Delta H°_f(\text{products}) \} - \{ \Sigma\ n \Delta H°_f(\text{products}) \}$

	$\Delta H°_f$ (kJ/mol)
$CH_4(g)$	–75
$CCl_4(g)$	–96
$HCl(g)$	–92

$CH_4(g) + 4\ Cl_2(g) \rightarrow CCl_4(g) + 4\ HCl(g)$ $\quad \Delta H°_{rxn} = ?$

A) –71 kJ B) +79 kJ C) +113 kJ D) –113 kJ (E) –389 kJ

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

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

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

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

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

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

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

15) Consider the following reaction at equilibrium. What effect will adding more H_2S have on the system? 15) E

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

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

16) Give the term for the amount of solute in moles per liter of solution. 16) E

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

17) Identify the solute with the lowest van't Hoff factor. 17) B

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

18) Given the following rate law, how does the rate of reaction change if the concentration of Y is doubled? 18) C

$$\text{Rate} = k\,[X][Y]$$

A) The rate of reaction will increase by a factor of 4.
B) The rate of reaction will decrease by a factor of 2.
C) The rate of reaction will increase 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.

19) Given the following balanced equation, determine the rate of reaction with respect to $[O_2]$. 19) C

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

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

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

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

D) $\text{Rate} = +\frac{3\,\Delta[O_2]}{\Delta t}$

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

20) Identify the triprotic acid. 20) B

A) H_2SO_3 B) H_3PO_4 C) $HClO_4$ D) H_2SO_4 E) HNO_3

21) Determine the K_b for CN^- at 25°C. The K_a for HCN is 4.9×10^{-10}. $\{K_a \times K_b = 1.0 \times 10^{-14}\}$ 21) D

A) 4.9×10^{-14}
B) 2.3×10^{-9}
C) 1.4×10^{-5}
D) 2.0×10^{-5}
E) 3.7×10^{-7}

22) Calculate the $\Delta G°_{rxn}$ using the following information. $\Delta G°_{rxn} = \{ \Sigma\ n \Delta G°_f(\text{products})\} - \{ \Sigma\ n \Delta G°_f(\text{products}) \}$ 22) C

$$2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ SO_2(g) + 2\ H_2O(g) \qquad \Delta G°_{rxn} = ?$$

$\Delta G°_f$ (kJ/mol)	−33.4	−300.1	−228.6

A) −495.3 kJ B) +112.4 kJ (C) −990.6 kJ D) +66.8 kJ E) −528.7 kJ

23) Which one of the following has a definite shape and volume? 23) A

(A) solid
B) gas
C) liquid
D) none of the above
E) all of the above

24) What is the conjugate base of $H_2PO_4^-$? 24) D

A) PO_4^{3-} B) OH^- C) H_3O^+ (D) HPO_4^{2-} E) H_3PO_4

II. Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (93 points)

1. For the element Ga (atomic number = 31) (3 pts each, 15 pts)

The group number is III the charge for an ion (if one exists) is +3

The number of valence electrons (for a neutral atom) is 3

The electron configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^1$ or [Ne] $3s^2, 3p^1$ (use notation $1s^2$, etc)

The valence electron configuration is $3s^2, 3p^1$ (use notation $1s^2$, etc)

2.. For the molecule given: NO_3^{-1} (12 pts total)

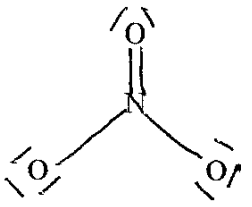
a. What is the total number of valence electrons (hint: anything with a negative charge has that many more electrons, anything with a positive charge has that many fewer electrons) ? You should show work for partial credit and for full credit. (6 pts)

# of valence electrons in the molecule given 24 $\bar{e}$

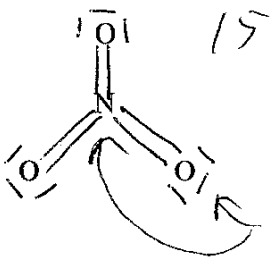
$\# \bar{e} = 5 + 3(6) + 1 = 24\bar{e}$

N O ↑Charge

b. Circle the number of the correct Lewis Dot structure (6 pts)



(1)



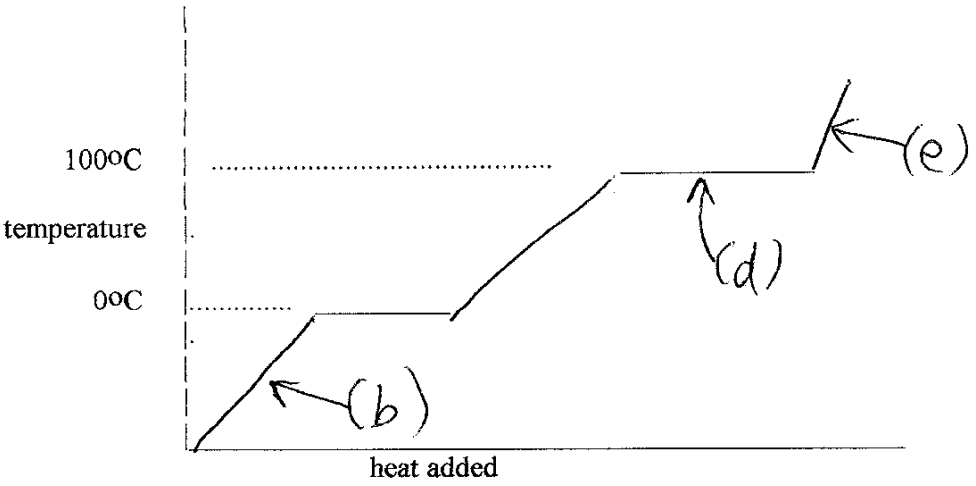
(2)

15 x 2 = 30 too many $\bar{e}$

more than octet in elements without d orbitals

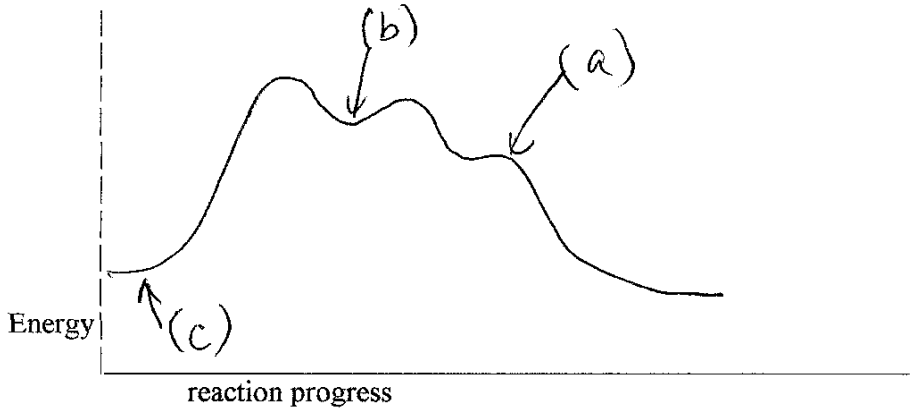
12 x 2 = 24

3. For the following chart for the interconversion of water under Pressure = 1.00 atm,(4 pts, 12 pts total)

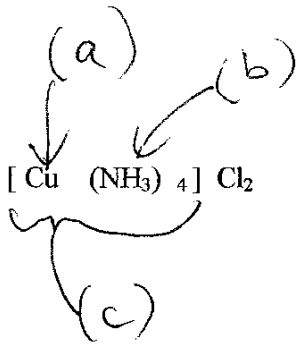


Label the graph above by filling in the parenthesis with the letters shown (a) melting ice (b) heating ice (c) heating liquid water (d) boiling liquid water (e) heating gaseous water (You may use each letter one time, many times or not at all.)

4. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms. (a) transition state (b) intermediate (c) reactant (d) product (Each term may be used once, more than once or not at all) (5 pts each, 15 pts total)

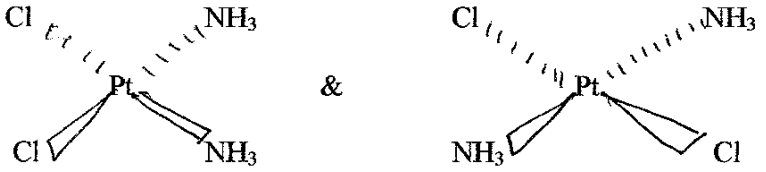


4. For the coordination compound given, label each parenthesis with the correct letter. You may use each letter one time, many times or not at all. (a) metal (b) ligand (c) coordination complex (d) coordination compound (3 pts each, 9 pt total)



5. Given the isomer pairs shown, match the kind of isomer by using the letters given. Each blank may have one to as many as four of the possible isomer names. (a) cis/trans isomer type of geometric isomer (b) fac- mer isomer type of geometric isomer (c) coordination isomer type of structural isomer (d) linkage isomer type of structural isomer (12 pts total, 6 pts per blank)

d



a

6. For the reaction $I_2(g) + Cl_2(g) \rightarrow 2\,ICl(g)$ set up the formula to calculate ΔS°_{RXN} by filling in the blanks above. It is possible that you may **not** use all blanks and / or that some of the blanks may have the **number one** in the blank. (Since I am not giving you any numbers or a chart to look up the numbers, you do not need to attempt to actually calculate the final number. Actually it is impossible for you to actually calculate the final numbers because I am not giving you enough information to come up with the final number.) (2 pts each, 18 pts total)

ΔS°_{RXN} = { 2 S°[ICl(g)] + / S°[/] } -

{ 1 S°[$I_2(g)$] + { 1 S°[$Cl_2(g)$] }

Part III Long Answer: Show all work for full credit and for partial credit. (70 pts)

1. Calculate the pH of a buffer solution with a concentration of 0.15 M CH_3COOH and 0.25 M CH_3COO Na.

a. What is the pK_a of CH_3COOH if Ka is 1.8×10^{-5} . (8 pts)

$pKa = -\log(1.8 \times 10^{-5}) = 4.74$

b. Use the Henderson Hasselbalch to calculate the pH $pH = pK_a + \log \{ [base] / [acid] \}$ (14 pts)

$pH = 4.74 + \log \frac{[CH_3COONa]}{[CH_3COOH]} = pH = 4.74 + 0.22$

$pH = 4.74 + \log \left(\frac{0.25}{0.15}\right) 1.67 \quad pH = 4.96$

2. 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.) (12 pts total)

$N_2(g) + O_2(g) \rightarrow 2\,NO(g)$

$[N_2]$	$[O_2]$	rate
2	1	8
2	2	16
4	1	16

double O_2, double rate

double N_2, double rate

a. order of the $[N_2]$ is (zero) (one) (circle one)
order of the $[O_2]$ is (zero) (one) (circle one)

b Write the final experimentally (from the data which I gave you in the chart above) determined rate law in terms of the concentration of the reactants with the correct order using a rate constant = k (4 pts)

$rate = K[N_2][O_2]$

3. Equilibrium (36 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 product present initially**: (2pts per blank 18 pts total) (I made up some of the K_{eq} numbers so these numbers do not match real reaction results.)

$CO(g) + 2\,H_2(g) \rightarrow CH_3OH\,(g) \quad K_{eq} = 1.5 \times 10^3$

If the initial concentration of the CO(g) is 0.178 M, and the initial concentration of $H_2(g)$ is 0.938 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]	[H_2]	[CH_3OH]
Initial	0.178	0.938	0
Change	$-x$	$-2x$	$+x$
Equilibrium	$0.178 - x$	$0.938 - 2x$	x

b. For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions. (expression mean you show me the equation for Keq in terms of the concentrations (ex: $[H_3O^+]$) To answer this question, you will not be using the results from the table in part (a) above. (9 pts)

$$K = \frac{[CH_3OH]}{[CO][H_2]^2}$$

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. (9 pts)

$$K = \frac{x}{(0.178 - x)(0.938 - 2x)^2} = 1.5 \times 10^3$$

Final General Chemistry II (CHEM 102) Form B 4/26/13 11:30 am MWF Dr. Hahn Exam # _____

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) (200 pt exam, worth only 180 pts, does not have 20 pt EC)

$q = m\,C\,\Delta T$, $pH + pOH = 14$ $pKa + pKb = 14$ $K_a \times K_b = 1.0 \times 10^{-14}$ $[H_3O^+][OH^-] = 1.0 \times 10^{-14} = k_W$

p (anything) = - log (anything) $pH = pK_a + \log \{ [base] / [acid] \}$ M = molarity = moles / liter

$\Delta H^o_{rxn} = \{ \Sigma\ n\ \Delta H^o_f(products)\} - \{ \Sigma\ n\ \Delta H^o_f(products) \}$ $\Delta G^o_{rxn} = \{ \Sigma\ n\ \Delta G^o_f(products)\} - \{ \Sigma\ n\ \Delta G^o_f(products) \}$ $\Delta S^o_{rxn} = \{ \Sigma\ n\ S^o(products)\} - \{ \Sigma\ n\ S^o(products) \}$

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (24 questions, 2 pts per question, 48 pts pts total)

1) Identify the rate-determining step. 1) B
A) the fast step
B) the slowest step
C) always the last step
D) always the second step
E) the faster step

2) Determine the K_b for CN^- at 25°C. The K_a for HCN is 4.9×10^{-10}. $\{K_a \times K_b = 1.0 \times 10^{-14}\}$ 2) A
A) 2.0×10^{-5}
B) 4.9×10^{-14}
C) 3.7×10^{-7}
D) 1.4×10^{-5}
E) 2.3×10^{-9}

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

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

4) Identify a substance that is not in its standard state. 4) D
A) Ca B) O_2 C) Ne D) CO E) H_2

5) Calculate the $\Delta G°_{rxn}$ using the following information. $\Delta G°_{rxn} = \{ \Sigma\ n \Delta G°_f(products)\} - \{ \Sigma\ n \Delta G°_f(products) \}$ 5) B

$$2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ SO_2(g) + 2\ H_2O(g) \qquad \Delta G°_{rxn} = ?$$

$\Delta G°_f$ (kJ/mol)	-33.4	-300.1	-228.6

A) -528.7 kJ (B) -990.6 kJ C) -495.3 kJ D) +66.8 kJ E) +112.4 kJ

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

7) What is the ground-state electron configuration for the element chromium (Z = 24)? 7) C
A) [Ne] $4s^2\ 3d^4$ B) [Ar] $4s^2\ 3d^4$ (C) [Ar] $4s^1\ 3d^5$ D) [Ar] $3d^6$

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

9) What is the conjugate base of $H_2PO_4^-$? 9) A
(A) HPO_4^{2-} B) PO_4^{3-} C) H_3PO_4 D) OH^- E) H_3O^+

10) Identify the solute with the lowest van't Hoff factor. 10) C
A) $FeCl_3$
B) NaCl
(C) nonelectrolyte
D) $MgCl_2$
E) $MgSO_4$

11) Calculate the concentration of OH^- in a solution that contains 3.9×10^{-4} M H_3O^+ at 25°C. 11) E
$\{[H_3O^+][OH^-] = 1.0 \times 10^{-14}\}$
A) 2.6×10^{-12} M
B) 2.7×10^{-3} M
C) 2.7×10^{-2} M
D) 3.9×10^{-4} M
(E) 2.6×10^{-11} M

12) Which of the following solutions is a good buffer system? 12) A

A) A solution that is 0.10 M H $C_2H_3O_2$ and 0.10 M Li $C_2H_3O_2$
B) A solution that is 0.10 M Na OH and 0.10 M K OH
C) A solution that is 0.10 M H F and 0.10 M Na $C_2H_3O_2$
D) A solution that is 0.10 M H Cl and 0.10 M NH_4^+
E) None of the above are buffer systems.

13) Calculate the amount of heat (in kJ) necessary to raise the temperature of 47.8 g benzene by 57.0 °C . The specific heat capacity of benzene is 1.05 J/g°C $q = m\,C\,\Delta T$ 13) A

A) 2.86 kJ B) 3.85 kJ C) 16.6 kJ D) 1.61 kJ E) 2.59 kJ

14) Which of the following statements is TRUE? 14) E

A) State functions do not depend on the path taken to arrive at a particular state.
B) Energy is neither created nor destroyed, excluding nuclear reactions.
C) q system = - q surrounding
D) ΔH_{rxn} can be determined using a coffee cup calorimeter.
E) All of the above are true.

15) Which one of the following has a definite shape and volume? 15) B

A) gas
B) solid
C) liquid
D) none of the above
E) all of the above

16) Identify the triprotic acid. 16) C

A) H_2SO_4 B) H_2SO_3 C) H_3PO_4 D) HNO_3 E) $HClO_4$

17) Consider the following reaction at equilibrium. What effect will adding more H_2S have on the system? 17) C

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

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

18) Given the following balanced equation, determine the rate of reaction with respect to $[O_2]$. 18) B

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

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

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

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

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

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

19) Which of the following compounds will be most soluble in ethanol (CH_3CH_2OH)? 19) C

A) trimethylamine ($N(CH_3)_3$)

B) acetone (CH_3COCH_3)

C) ethylene glycol ($HOCH_2CH_2OH$)

D) hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$)

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

20) Place the following compounds in order of **decreasing** strength of intermolecular forces. 20) C

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

C_6H_{14} C_5H_{12} C_6H_{14}

smallest

A) III > I > II

B) III > II > I

C) I > III > II

D) II > III > I

E) I > II > III

$\dfrac{550}{1000} = 0.550$

21) Calculate the freezing point of a solution containing 0.067 mol of K Cl and 550.0 grams of water. The molal-freezing-point-depression constant (K_f) for water is 1.86°C/*m*. $\Delta T_f = i * K_b * m$. Use 0°C as the freezing point of water and assume complete dissociation of the K Cl. 21) E

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

22) Give the characteristic of a zero order reaction having only one reactant. 22) B

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

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

$m = \left(\dfrac{0.067}{0.550}\right)$

$m = 0.122$

$\Delta T_f = (2)(1.86)(0.122)$

$\Delta T_f = 0.454$ (FP depression)

$T_f = 0° - 0.454 = E$

23) Express the equilibrium constant for the following reaction. 23) D

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

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

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

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

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

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

24) Use the information provided to determine $\Delta H°_{rxn}$ for the following reaction: 24) E

$$\Delta H°_{rxn} = \{ \Sigma\ n\,\Delta H°_f(\text{products})\} - \{ \Sigma\ n\,\Delta H°_f(\text{products}) \}$$

	$\Delta H°_f$ (kJ/mol)
$CH_4(g)$	−75
$CCl_4(g)$	−96
$HCl(g)$	−92

$CH_4(g) + 4\,Cl_2(g) \rightarrow CCl_4(g) + 4\,HCl(g)$ $\quad \Delta H°_{rxn} = ?$

A) −71 kJ B) +113 kJ C) +79 kJ D) −113 kJ (E) −389 kJ

II. Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (93 points)

1. For the element Ge (atomic number = 32) (3 pts each, 15 pts)

The group number is IV the charge for an ion (if one exists) is +4

The number of valence electrons (for a neutral atom) is 4 $4p^2$ $(Ar)4s^2 3d^{10} 4p^2$

The electron configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}$, (use notation $1s^2$, etc)

The valence electron configuration is $4s^2, 4p^2$ (use notation $1s^2$, etc)

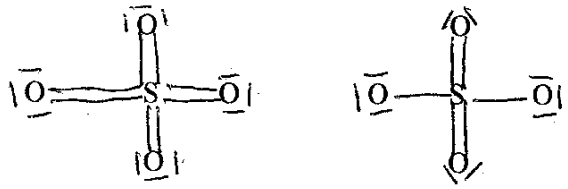
2.. For the molecule given: SO_4^{-2} (12 pts total)

a. What is the total number of valence electrons (hint: anything with a negative charge has that many more electrons, anything with a positive charge has that many fewer electrons) ? You should show work for partial credit and for full credit. (6 pts)

# of valence electrons in the molecule given 32e

S + 4(O) + charge
6 + 4(6) + 2 = 32e

b. Circle the number of the correct Lewis Dot structure (6 pts)

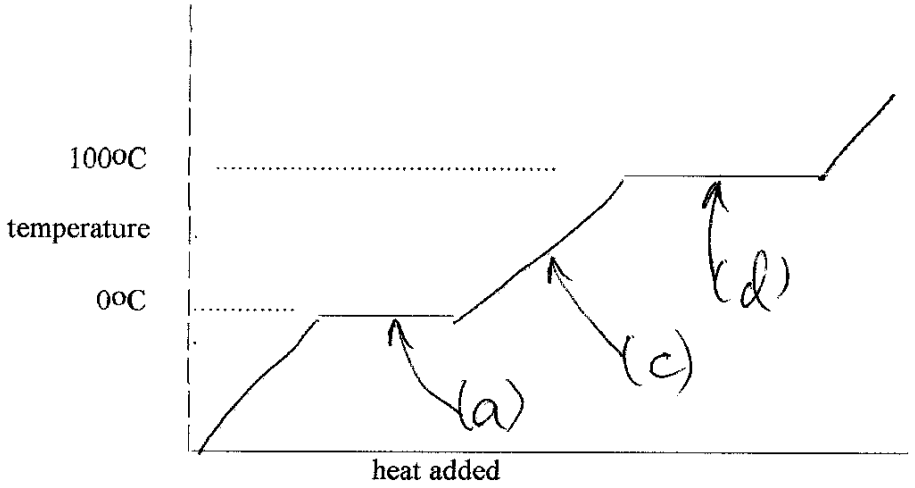


(1) (2)

16 x 2 = 32

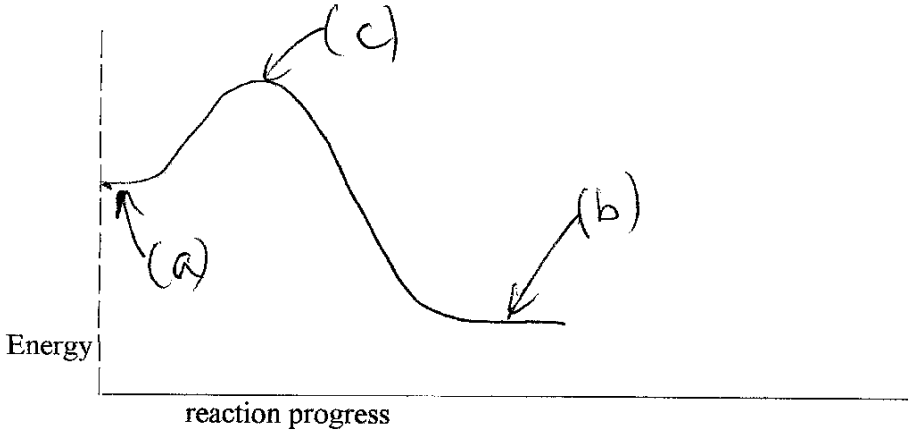
20 x 2 = 40
too many e

3. For the following chart for the interconversion of water under Pressure = 1.00 atm,(4 pts, 12 pts total)

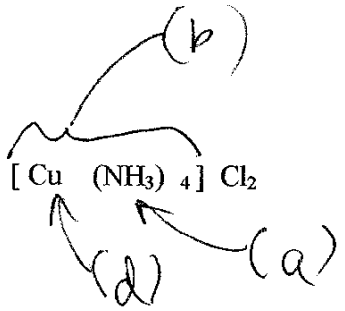


Label the graph above by filling in the parenthesis with the letters shown (a) melting ice (b) heating ice (c) heating liquid water (d) boiling liquid water (e) heating gaseous water (You may use each letter one time, many times or not at all.)

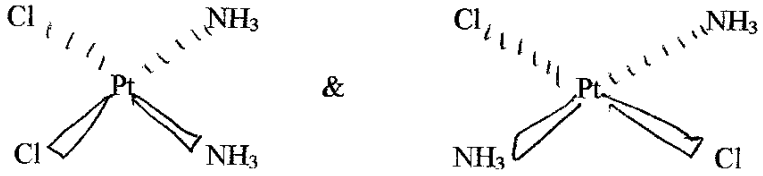
4. For the following energy vs. reaction progress diagram, match the blanks with the appropriate terms.
(a) reactant (b) product (c) transition state (d) intermediate (Each term may be used once, more than once or not at all) (5 pts each, 15 pts total)



4. For the coordination compound given, label each parenthesis with the correct letter. You may use each letter one time, many times or not at all. (a) ligand (b) coordination complex (c) coordination compound (d) metal (3 pts each, 9 pt total)



5. Given the isomer pairs shown, match the kind of isomer by using the letters given. Each blank may have one to as many as four of the possible isomer names. (a) cis/trans isomer type of geometric isomer (b) fac- mer isomer type of geometric isomer (c) coordination isomer type of structural isomer (d) linkage isomer type of structural isomer (12 pts total, 6 pts per blank)



6. For the reactio $3\ NO_2(g) + H_2O(l) \rightarrow 2\ HNO_3\ (aq) + NO\ (g)$ set up the formula to calculate ΔS°_{RXN} by filling in the blanks above. It is possible that you may **not** use all blanks and / or that some of the blanks may have the **number one** in the blank. (Since I am not giving you any numbers or a chart to look up the numbers, you do not need to attempt to actually calculate the final number. Actually it is impossible for you to actually calculate the final numbers because I am not giving you enough information to come up with the final number.) (2 pts each, 18 pts total)

ΔS°_{RXN} = { 2 S°[$HNO_3(aq)$] + 1 S°[$NO(g)$] } -

{ 3 S°[$NO_2(g)$] + { 1)S°[$H_2O(l)$]}

Part III Long Answer: Show all work for full credit and for partial credit. (70 pts)

1. Calculate the pH of a buffer solution with a concentration of 0.50 M H F and 0.25 M Na F.

a. What is the p Ka of HF if Ka is 3.5×10^{-4}. (8 pts)

$pKa = -\log(3.5 \times 10^{-4}) = 3.46$

b. Use the Henderson Hasselbalch to calculate the pH $pH = pK_a + \log \{ [base] / [acid] \}$ (14 pts)

$pH = 3.46 + \log \frac{[F]}{[HF]}$ $pH = 3.46 - 0.30$

$pH = 3.46 + \log \left(\frac{0.25}{0.50} \right)$ $pH = 3.16$

2. 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.) (12 pts total)

$N_2(g) + 3\ H_2(g) \rightarrow 2NH_3\ (g)$

$[N_2]$	$[H_2]$	rate
3	1	7
3	2	14
6	1	14

double $[H_2]$ - double rate

double N_2 - double rate

a. order of the $[N_2]$ is (zero) (one) (circle one)
order of the $[H_2]$ is (zero)(one) (circle one)

b Write the final experimentally (from the data which I gave you in the chart above) determined rate law in terms of the concentration of the reactants with the correct order using a rate constant = k (4 pts)

$rate = k [N_2][H_2]$

3. Equilibrium (36 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 product present initially**: (2pts per blank 18 pts total) (I made up some of the K_{eq} numbers so these numbers do not match real reaction results.)

$N_2\,(g) + O_2\,(g) \rightarrow 2\,NO\,(g)$ $K_{eq} = 5.5 \times 10^{-1}$

If the initial concentration of the $N_2\,(g)$ is 0.825 M, and the initial concentration of $O_2\,(g)$ is 0.022 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]
Initial	0.825	0.022	0
Change	$-x$	$-x$	$+2x$
Equilibrium	$0.825-x$	$0.022-x$	$2x$

b. For the same reaction and the conditions given above, give the expression for the equilibrium constant (K_{eq}) with [concentration of reagent] expressions. (expression mean you show me the equation for Keq in terms of the concentrations (ex: $[H_3O^+]$) To answer this question, you will not be using the results from the table in part (a) above. (9 pts)

$$K = \frac{[NO]^2}{[N_2][O_2]}$$

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. (9 pts)

$$K = \frac{(2x)^2}{(0.825-x)(0.022-x)}$$