Final Exam General Chemistry II (CHEM 102) Summer I 7/1/13 Monday 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. [There are 200 pts on this exam (easier to grade) but it is only worth 180 pts. It does not have 20 pts extra credit. I'll just prorate it to 180 pts.]

$q = m\,C\,\Delta T$ $q = n\,\Delta H_{vaporization}$ $q = n\,\Delta H_{fusion}$ $pH + pOH = 14$ $pKa + pKb = 14$

$K_a \times K_b = 1.0 \times 10^{-14}$ $[H_3O^+][OH^-] = 1.0 \times 10^{-14} = k_W$ p (anything) = - log (anything)

$pH = pK_a + \log \{ [base] / [acid] \}$ M = molarity = moles / liter

$\Delta H^o_{RXN} = \Sigma\, n_{product}\, \Delta H^o_f(product) - \Sigma\, n_{reactant}\, \Delta H^o_f(reactant)$

$\Delta G^o_{RXN} = \Sigma\, n_{product}\, \Delta G^o_f(product) - \Sigma\, n_{reactant}\, \Delta G^o_f(reactant)$

$\Delta S^o_{RXN} = \Sigma\, n_{product}\, S^o_f(product) - \Sigma\, n_{reactant}\, S^o_f(reactant)$

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 40 pts pts total)

1) Place the following compounds in order of **increasing** strength of intermolecular forces. 1) E

F_2 I_2 Cl_2 $F_2 < Cl_2 < I_2$

↑ smallest ↑ largest

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

2) Determine the pH of a 0.023 M HNO_3 solution. $pH = -\log(0.023) = 1.64$ 2) C

A) 12.36 B) 3.68 C) 1.64 D) 2.30 E) 2.49

3) Which of the following is a transition metal element? 3) D

A) U B) K C) Sn D) Pd E) Pr

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

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

5) Consider the following reaction at equilibrium. What effect will removing NO_2 have on the system? 5) B

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

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

6) Which of the following compounds exhibits hydrogen bonding? 6) B

A) CH_3Cl B) NH_3 C) HI D) CH_3OCH_3

7) Define freezing. 7) B

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

8) Give the symbol for fluorine. 8) C

A) Fr B) Fl C) F D) Fu E) Fo

9) What is the conjugate base of H_2CO_3 ? 9) A

A) HCO_3^- B) H_3O^+ C) CO_3^{2-} D) OH^- E) H_2O

10) Choose the pair of substances that are most likely to form a miscible solution. 10) B

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

11) Which of the following has an ionic bond ? 11) E

A) O_2 B) SO_2 C) Ne D) CO E) KBr

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

$$2\,Na(s) + 2\,H_2O(l) \rightleftharpoons 2\,NaOH(aq) + H_2(g)$$

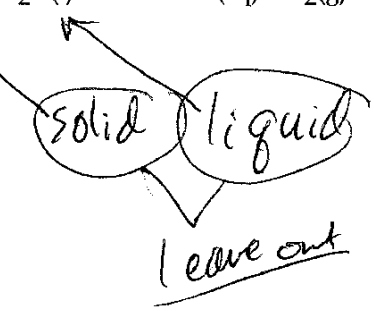
A) $K = [H_2][NaOH]^2$

B) $K = [H_2][NaOH]^{-2}$

C) $K = \dfrac{[Na]^2[H_2O]^2}{[NaOH]^2[H_2]}$

D) $K = \dfrac{[NaOH]^{1/2}[H_2]}{[Na]^{1/2}[H_2O]^{1/2}}$

E) $K = \dfrac{[NaOH]^2[H_2]}{[Na]^2[H_2O]^2}$



13) The rate-determining elementary reaction step in a reaction mechanism. 13) C

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

14) Identify the compound with the standard free energy of formation equal to zero. 14) D

A) NO(*g*)
B) It is hard to determine.
C) NaCl(*s*)
D) $N_2(g)$
E) $O_3(g)$

15) Identify the weak acid. 15) B

A) H_2SO_4
B) HF
C) HBr
D) HNO_3
E) not enough information is available

16) Identify the solute with the highest van't Hoff factor. 16) A

A) $Al_2(SO_4)_3$
B) NH_4Cl
C) K_2CO_3
D) LiCl
E) HO CH_2CH_2 OH

17) What is the ground-state electron configuration for the element chromium (Z = 24)? 17) D

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

18) The complete electron configuration of gallium, element 31, is _____. 18) A

A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^1$

B) $1s^4 2s^4 2p^{10} 3s^4 3p^9$

C) $1s^2 2s^2 2p^{10} 3s^2 3p^{10} 4s^2 3d^3$

D) $1s^4 2s^4 2p^8 3s^4 3p^8 4s^3$

E) $1s^4 2s^4 2p^6 3s^4 3p^6 4s^4 3d^3$

19) Given the following balanced equation, determine the rate of reaction with respect to $[NH_3]$. 19) D

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

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

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

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

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

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

20) Give the expression for the solubility product constant for $PbCl_2$. 20) B

A) $\frac{[Pb^{2+}][Cl^-]^2}{[PbCl_2]}$

B) $[Pb^{2+}][Cl^-]^2$

C) $\frac{[Pb^{2+}]^2[Cl^-]}{[PbCl_2]}$

D) $\frac{[PbCl_2]}{[Pb^{2+}][Cl^-]^2}$

E) $[Pb^{2+}]^2[Cl^-]$

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. (90 pts)

1) In the periodic table: (10 pts)

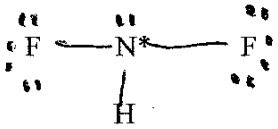
a. What is the elemental symbol for **lithium** ? Li (2 pt)

b. How much does one mole of **Mg** weigh ? 24.3050 grams (2 pt)

c. What **period** is element **Kr** in ? 4 (2 pt)

d. For the element **Ba**, the group number is IIA (2 pt) and the charge for the ionic form of **Ba** is +2 (show formula if applicable) (2 pts) group # = charge on ion

2) The correct Lewis Dot structure for the NF_3 is given below. Answer the following for the Lewis Dot structure shown below. (2 pts each, 8 pts total)



a. How many electron pairs is around the atom with the * ? 4

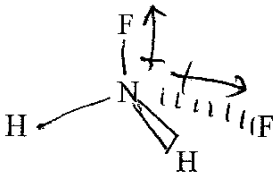
b. How many lone pairs is around the atoms with the * ? 1

b. The VSEPRT geometry of electron pairs is tetrahedral.

c. The VSEPRT geometry of the molecule is trigonal pyramidal

graded consistent w @ + ⑥

3) Intermolecular forces question: (9 pts total)



VSEPRT molecular shape = tetrahedral

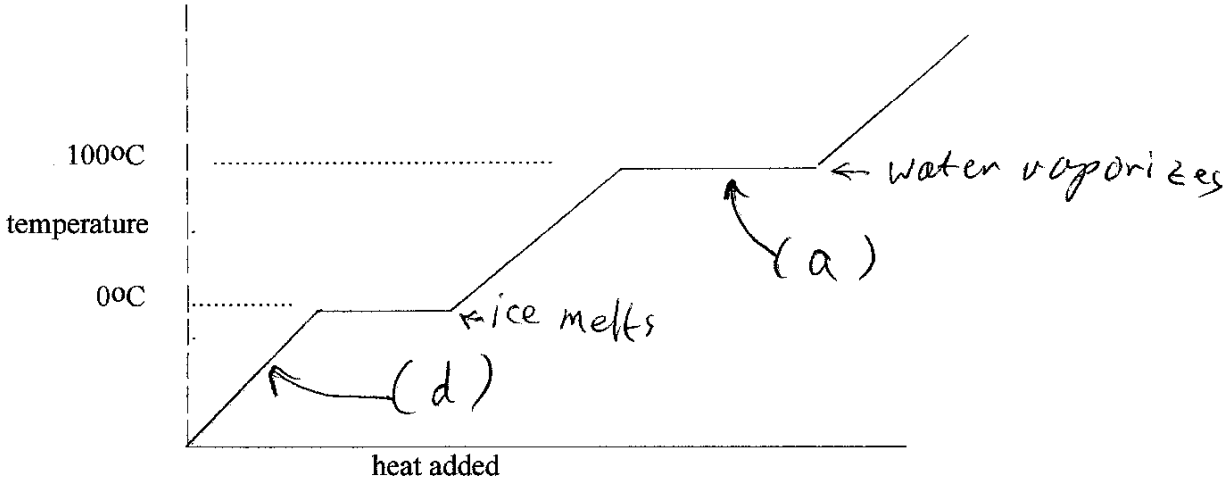
(a) For the molecule shown, draw a dipole moment arrow for each bond in the molecule. (The dipole moment arrow should look like (⟶) (4 pts)

(b) The dipole moment for the molecule as a whole is [(zero) or (not zero)] (circle one) (3 pts)

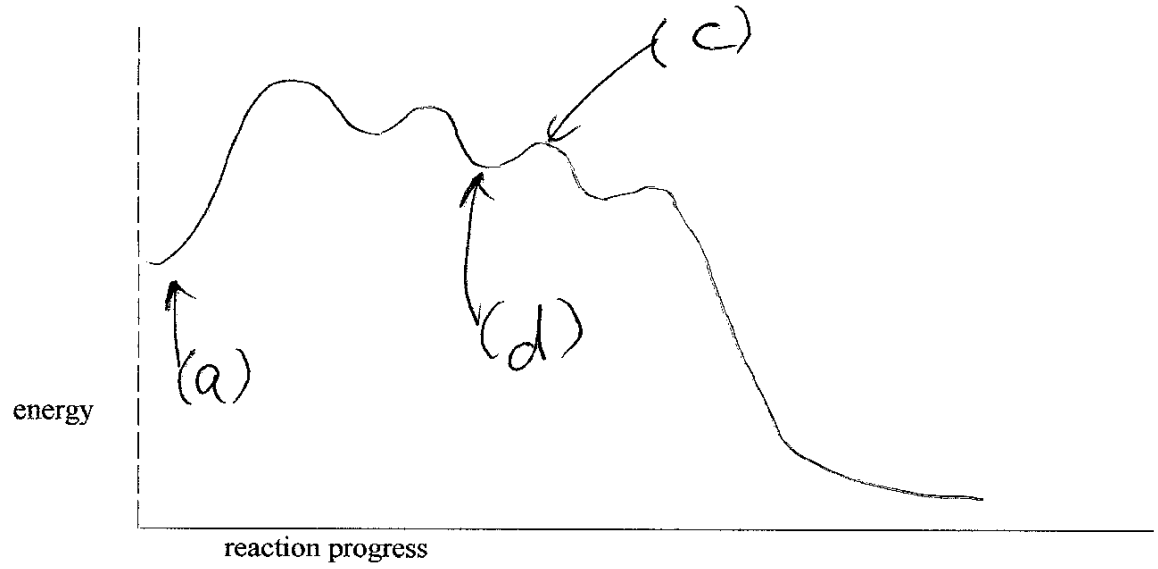
(c) The intermolecular force for this molecule is [(London force) or (dipole-dipole) or (hydrogen bonding)] (circle one) (2 pts)

4) For the following chart for the interconversion of water under Pressure = 1.00 atm, (8 pts, 4 pts each)

Match the equation which you would use to calculate the heat from the equations shown by filling in the parenthesis with a letter. You may use each letter, one time, many times or not at all.
(a) $q = n\,\Delta H_{vaporization}$ (b) $q = m\ C_{water}\,\Delta T$ (c) $q = m\ C_{steam}\,\Delta T$ (d) $q = m\ C_{ice}\,\Delta T$ (e) $q = n\,\Delta H_{fusion}$



5) 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. (12 pts total, 4 pts each)



6) 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. (8 pts)

$2\ NO\ (g) \xrightarrow{k_1} N_2O_2\ (g)$ elementary reaction mechanism step (1) fast

$N_2O_2\ (g) + O_2\ (g) \xrightarrow{k_2} 2\ NO_2\ (g)$ elementary reaction mechanism step (2) slow

$2\ NO\ (g) + O_2\ (g) \rightarrow 2\ NO_2\ (g)$ overall reaction

2 pt 2 pt 2 pt

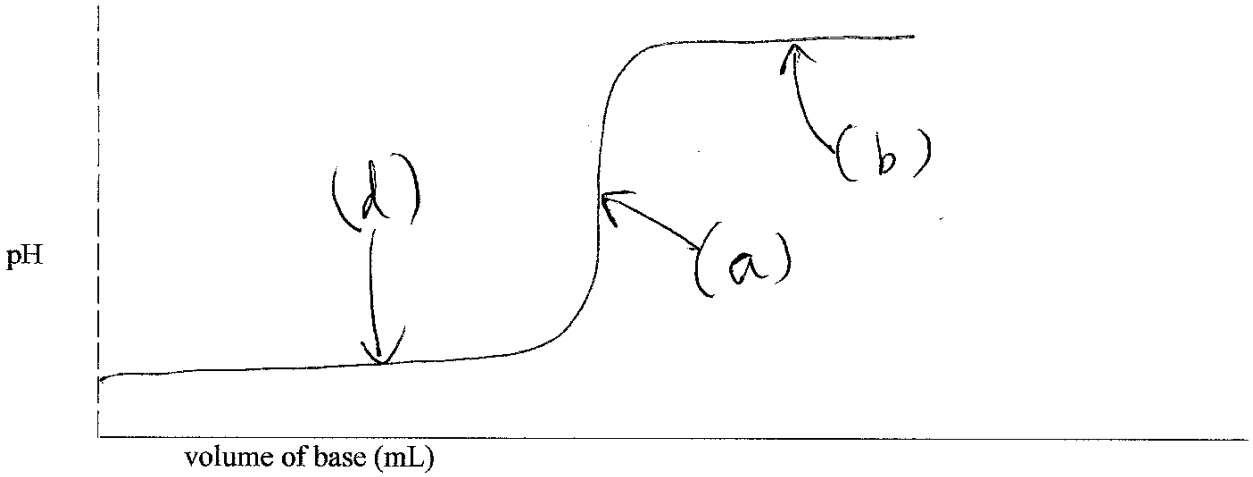
Rate = $k_2 [N_2O_2] [O_2]$

wrong power 1 pt each

gave equilibrium constant -5

8) In the following titration graph for a strong acid to which is added a strong base, match the letter with the appropriate parenthesis. The equations below are absolutely correct except for you not knowing which of the equations goes with which part of the graph until you fill in the parenthesis with the correct letter. (12 pts, 4 pts each)

(a) $[H^+] = 1.0 \times 10^{-7}$
(b) $[OH^-]$ = (# moles base - # moles acid)/ {(mL volume acid + mL volume base) x (1 Liter/1000 mL) }
(c) $[H^+]$ = concentration of the strong acid
(d) $[H^+]$ = (# moles acid - # moles base) / {(mL volume acid + mL volume base) x (1 Liter /1000 mL)}



7) $2\,SO_3\,(g) \rightarrow 2SO_2(g) + O_2\,(g)$ $\quad K_{eq} = 3.1 \times 10^{-4}$

Initially you have $[SO_3\,(g)] = 0.453$ M. What is the equilibrium concentration of the $SO_2\,(g)$ and the concentration of $O_2\,(g)$ in molarity ? (I am not looking for the final answer. Just set up the problem because you do not have enough time to actually complete the algebra.) (13 pts)

a. Fill out the table shown below. (7 pts, 1 pt per table block)

$2\,SO_3\,(g) \rightarrow 2\,SO_2\,(g) + O_2\,(g)$

	$[SO_3]$	$[SO_2\,(g)]$	$[O_2\,(g)]$
initial	(1) 0.453 M	(2) 0	zero
change	(3) $-2X$	(4) $+2X$	$+X$
equilibrium	(5) $0.453 - 2X$	(6) $2X$	(7) X

b. Write out the equilibrium constant expression using $[SO_3]$, $[SO_2]$, and $[O_2]$ (2 pts)

$K_{eq} = \dfrac{[SO_2]^2[O_2]}{[SO_3]^2}$

c. Write out the equilibrium constant expression for the equation using your equilibrium values. (2 pts)

$K_{eq} = \dfrac{(2x)^2(x)}{(0.453-2x)^2}$ Wrong power -1

d. Write out the equilibrium constant expression for the reaction using your equilibrium values with your simplifying approximation. (2 pts)

$x << 0.453$

$K_{eq} = \dfrac{(2x)^2(x)}{(0.453)^2}$

9. For the following molecule, $[Mn(CO)(NH_3)_5]Cl_2$ (10 pts total, 2 pts each blank)

What are the ligands ? CO, NH3

What is the transition metal ? Mn

What is the coordination complex ? $[Mn(CO)(NH_3)_5]^{+2}$

What is the coordination compound ? $[Mn(CO)(NH_3)_5]Cl_2$

What is the coordination number ? 6

Part III. Long Answer Please show work for full credit and to receive partial credit. (70 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. Problems with multiple part are graded consistently:**
example: (a) answer goes to give (b) goes to answer (c) If your (a) is incorrect but your (b) comes from your own (a) then you get full credit for (b). If your (b) is correct but you cannot possibly get your (b) from your incorrect (a) then you lose points for both (a) & (b) ****

1) Your job is to make up 15.2 mL of a 0.250 M solution of NaCl in water because your saline solution is supposed to be mixed later with a pharmaceutical which degrades in any other concentration and volume of the salt solution to otherwise kill your patient . (OK there is no such drug. I just made up the problem.) (20 pts total)

a. How many grams of salt (molar mass NaCl = 58.5 g/mol) do you need ? (15 pts)

5pt 5pt

$15.2\,mL \times \frac{0.250\,mol\,NaCl}{1000\,mL\,NaCl\,soln} \times \frac{58.5\,g}{1\,mol\,NaCl}$

$= 0.222\,g\,NaCl$

how calculate -1 | math 2pt | both in 3pt | attempt -8

b. How would you make up the solution ? Explain how you make up the solution in at least 2 sentences. (don't forget the difference between molality and molarity) (5 pts) (show work)

You would weigh out 0.222 g NaCl. You accurately mark up 15.2 mL in glassware. Add the NaCl to the glassware + add H_2O to 15.2 mL

molality not molarity -1

attempt -2

2) **Titration of a strong acid to which you add a strong base: (equivalence point volume = 29.7 mL of the base)**: For 25.0 mL of HI of concentration of 0.422 M and a LiOH concentration of 0.355 M, what is the $[H_3O^+]$ concentration after the addition of 25 mL of the Li OH ? You must show work for full credit. (26 pts)

25 mL LiOH solution is less than 29.7 mL so this is a before equivalence point problem.

$$\#\text{ moles } H_3O^+ = 25.0\text{ mL HI} \times \frac{0.422\text{ mol } H^+}{1000\text{ mL HI}} = 0.01055\text{ mol } H_3O^+$$ (6pt)

$$\#\text{ moles } OH^- = 25.0\text{ mL LiOH} \times \frac{0.355\text{ mol } OH^-}{1000\text{ mL LiOH}} = 8.875 \times 10^{-3}\text{ mol } OH^-$$ (6pt)

$$\text{Volume total} = 25.0\text{ mL HI} + 25.0\text{ mL LiOH} = 50.0\text{ mL soln} \times \frac{1\text{ L}}{1000\text{ mL}}$$ (6pt)

$$\text{Volume total} = 0.0500\text{ L soln}$$

$$M_{(H_3O^+)} = \frac{(0.0106\text{ mol } H_3O^+ - 8.88 \times 10^{-3}\text{ mol})}{0.0500\text{ L soln}} = 0.0344\text{ M } H_3O^+$$ (6pt)

treated as before e.p. −5

2pt math

attempt +13

3) For a reaction $CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$ (24 pts total)

a. What is the $\Delta H^\circ_{reaction}$ for this reaction ? (An equation which you need for this is given at the very top of this exam near your name.) $\Delta H^\circ_f[CH_4(g)] = -74.6$ kJ / mol $\Delta H^\circ_f[CO_2(g)] = -393.5$ kJ / mol $\Delta H^\circ_f[H_2O(g)] = -241.8$ kJ / mol (8 pts) (Even if you get the wrong number here, you will get full credit for later parts of this problem if you do those parts correctly. If you cannot answer this question make up some number and continue to the next question.)

$$\Delta H^\circ_{RXN} = \left\{ \underset{CO_2}{1\,mol}\,\Delta H_f^\circ[CO_2(g)] + \underset{H_2O}{2\,mol}\,\Delta H_f^\circ[H_2O(g)] \right\} - \left\{ \underset{CH_4}{1\,mol}\,\Delta H_f^\circ[CH_4(g)] + \underset{O_2}{2\,mol}\,\Delta H_f^\circ[O_2(g)] \right\}$$

$$\Delta H^\circ_{RXN} = \left\{ (-393.5\,kJ) + (2\,mol)(-241.8\,kJ/mol) \right\} - \left\{ 1\,mol(-74.6\,kJ/mol) + 2\,mol(0\,kJ/mol) \right\}$$

(2 pt) (2 pt) (1 pt) (1 pt)

$$\Delta H^\circ_{RXN} = \left\{ -393.5\,kJ - 483.6\,kJ \right\} + 74.6\,kJ$$

$$\Delta H^\circ_{RXN} = -802.5\,kJ$$

2pt.

$$\Delta H^\circ_{RXN} = -802.5\,kJ \times \frac{1000\,J}{1\,kJ} = -8.025 \times 10^5\,J$$

multiply instead of sum −3
product & reactant backward −3
math −1

b. If the ΔS°_{rxn} for the above reaction is -5.3 J/K what is the ΔG°_{rxn} at T = 298 K ?
($\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$) (watch the units) (8 pts)

$\Delta G^\circ_{RXN} = \Delta H^\circ - T\Delta S^\circ$

$\Delta G^\circ_{RXN} = -8.025 \times 10^5 J - (298K)(-5.3 J/K)$

$\Delta G^\circ_{RXN} = -8.025 \times 10^5 J + 1.579 \times 10^3 J$

$\Delta G^\circ_{RXN} = -8.01 \times 10^5 J$

wrong but consistent w@ OK

attempt -5

Math + algebra -1

c. For the reaction above, what is the equilibrium constant at T = 298 K ? ($\Delta G^\circ_{rxn} = -RT \ln K$)
(R=8.134 J/mol K) Leave the answer as ln K = final answer. (Do not try to get the antilog.) (8 pts)

$\Delta G^\circ_{RXN} = -RT \ln K$

$\ln K = \frac{-\Delta G^\circ_{RXN}}{RT}$

attempt -5

math + algebra -1

$\ln K = \frac{-(-8.01 \times 10^5 J)}{(8.134 J/molK)(298K)}$

$\ln K = 330$

Final Exam General Chemistry II (CHEM 102) Summer I 7/1/13 Monday Dr. Hahn Exam # _____

Name_____ (print) Name _____(sign)

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$q = m\ C\ \Delta T$ $q = n\ \Delta H_{vaporization}$ $q = n\ \Delta H_{fusion}$ $pH + pOH = 14$ $pKa + pKb = 14$

$K_a \times K_b = 1.0 \times 10^{-14}$ $[H_3O^+][OH^-] = 1.0 \times 10^{-14} = k_W$ p (anything) = - log (anything)

$pH = pK_a + \log \{ [base] / [acid] \}$ M = molarity = moles / liter

$\Delta H^o_{RXN} = \Sigma\ n_{product}\ \Delta H^o_f(product) - \Sigma\ n_{reactant}\ \Delta H^o_f(reactant)$

$\Delta G^o_{RXN} = \Sigma\ n_{product}\ \Delta G^o_f(product) - \Sigma\ n_{reactant}\ \Delta G^o_f(reactant)$

$\Delta S^o_{RXN} = \Sigma\ n_{product}\ S^o_f(product) - \Sigma\ n_{reactant}\ S^o_f(reactant)$

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 40 pts pts total)

1) Place the following compounds in order of **increasing** strength of intermolecular forces. 1) _____

F_2 I_2 Cl_2

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

2) Determine the pH of a 0.023 M HNO_3 solution. 2) _____

A) 12.36 B) 3.68 C) 1.64 D) 2.30 E) 2.49

3) Which of the following is a transition metal element? 3) _____

A) U B) K C) Sn D) Pd E) Pr

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

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

5) Consider the following reaction at equilibrium. What effect will removing NO_2 have on the system? 5) _____

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

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

6) Which of the following compounds exhibits hydrogen bonding? 6) _____

A) CH_3Cl B) NH_3 C) HI D) CH_3OCH_3

7) Define freezing. 7) _____

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

8) Give the symbol for fluorine. 8) _____

A) Fr B) Fl C) F D) Fu E) Fo

9) What is the conjugate base of H_2CO_3 ? 9) _____

A) HCO_3^- B) H_3O^+ C) CO_3^{2-} D) OH^- E) H_2O

10) Choose the pair of substances that are most likely to form a miscible solution. 10) _____

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

11) Which of the following has an ionic bond ? 11) _____

A) O_2 B) SO_2 C) Ne D) CO E) KBr

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

$$2\ Na(s) + 2\ H_2O(l) \rightleftharpoons 2\ NaOH(aq) + H_2(g)$$

A) $K = [H_2][NaOH]^2$

B) $K = [H_2][NaOH]^{-2}$

C) $K = \dfrac{[Na]^2[H_2O]^2}{[NaOH]^2[H_2]}$

D) $K = \dfrac{[NaOH]^{1/2}[H_2]}{[Na]^{1/2}[H_2O]^{1/2}}$

E) $K = \dfrac{[NaOH]^2[H_2]}{[Na]^2[H_2O]^2}$

13) The rate-determining elementary reaction step in a reaction mechanism. 13) _____

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

14) Identify the compound with the standard free energy of formation equal to zero. 14) _____

A) $NO(g)$
B) It is hard to determine.
C) $NaCl(s)$
D) $N_2(g)$
E) $O_3(g)$

15) Identify the weak acid. 15) _____

A) H_2SO_4
B) HF
C) HBr
D) HNO_3
E) not enough information is available

16) Identify the solute with the highest van't Hoff factor. 16) _____

A) $Al_2(SO_4)_3$
B) NH_4Cl
C) K_2CO_3
D) LiCl
E) $HO\,CH_2CH_2\,OH$

17) What is the ground-state electron configuration for the element chromium (Z = 24)? 17) _____

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

18) The complete electron configuration of gallium, element 31, is _____. 18) _____

A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^1$

B) $1s^4 2s^4 2p^{10} 3s^4 3p^9$

C) $1s^2 2s^2 2p^{10} 3s^2 3p^{10} 4s^2 3d^3$

D) $1s^4 2s^4 2p^8 3s^4 3p^8 4s^3$

E) $1s^4 2s^4 2p^6 3s^4 3p^6 4s^4 3d^3$

19) Given the following balanced equation, determine the rate of reaction with respect to $[NH_3]$. 19) _____

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

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

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

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

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

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

20) Give the expression for the solubility product constant for $PbCl_2$. 20) _____

A) $\dfrac{[Pb^{2+}][Cl^-]^2}{[PbCl_2]}$

B) $[Pb^{2+}][Cl^-]^2$

C) $\dfrac{[Pb^{2+}]^2[Cl^-]}{[PbCl_2]}$

D) $\dfrac{[PbCl_2]}{[Pb^{2+}][Cl^-]^2}$

E) $[Pb^{2+}]^2[Cl^-]$

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. (90 pts)

1) In the periodic table: (10 pts)

a. What is the elemental symbol for **lithium** ? _____ (2 pt)

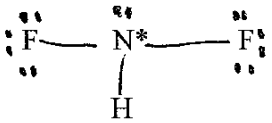
b. How much does one mole of **Mg** weigh ? _____ grams (2 pt)

c. What **period** is element **Kr** in ? _____ (2 pt)

d. For the element **Ba**, the group number is _____ (2 pt) and the charge for the ionic form of **Ba** is

_____ (show formula if applicable) (2 pts)

2) The correct Lewis Dot structure for the NF_2H is given below. Answer the following for the Lewis Dot structure shown below. (2 pts each, 8 pts total)



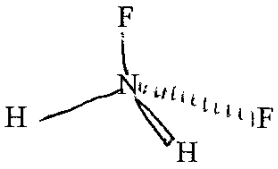
a. How many electron pairs is around the atom with the * ? _____

b. How many lone pairs is around the atoms with the * ? _____

b. The VSEPRT geometry of electron pairs is _____

c. The VSEPRT geometry of the molecule is _____

3) Intermolecular forces question: (9 pts total)



VSEPRT molecular shape = tetrahedral

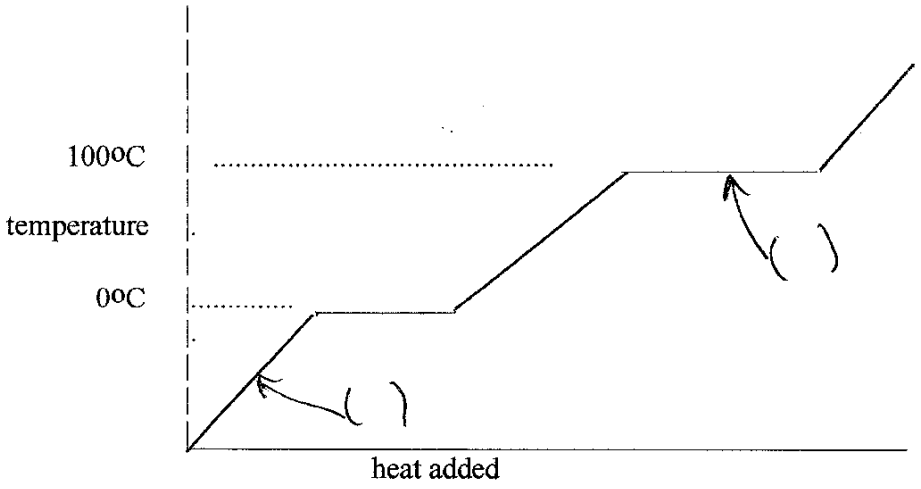
(a) For the molecule shown, draw a dipole moment arrow for each bond in the molecule. (The dipole moment arrow should look like (⟶) (4 pts)

(b) The dipole moment for the molecule as a whole is [(zero) or (not zero)] (circle one) (3 pts)

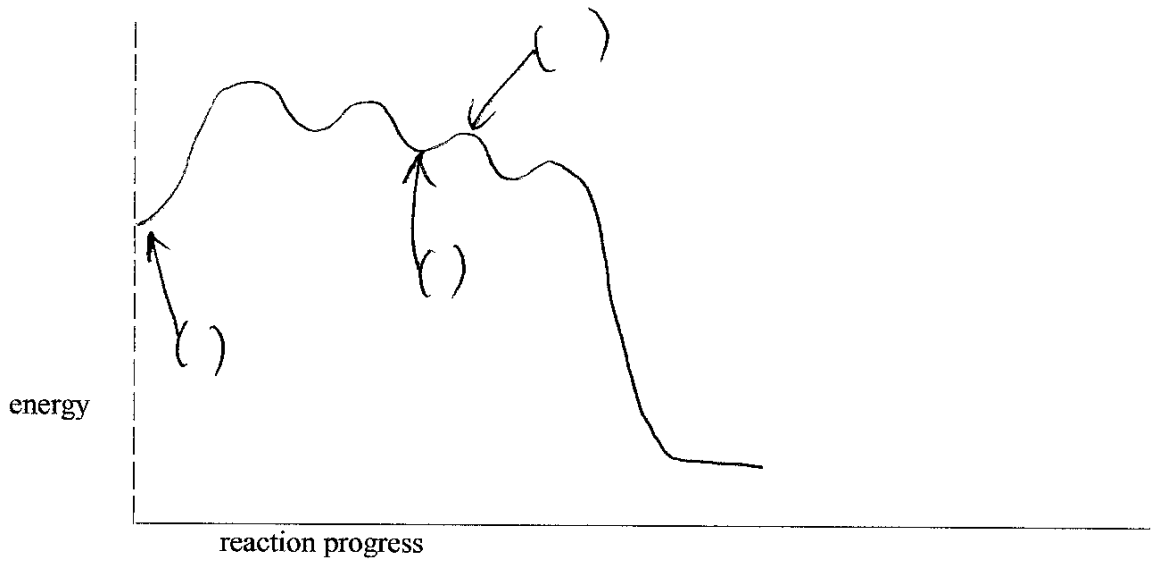
(c) The intermolecular force for this molecule is [(London force) or (dipole-dipole) or (hydrogen bonding)] (circle one) (2 pts)

4) For the following chart for the interconversion of water under Pressure = 1.00 atm, (8 pts, 4 pts each)

Match the equation which you would use to calculate the heat from the equations shown by filling in the parenthesis with a letter. You may use each letter, one time, many times or not at all.
(a) $q = n\,\Delta H_{vaporization}$ (b) $q = m\ C_{water}\,\Delta T$ (c) $q = m\ C_{steam}\,\Delta T$ (d) $q = m\ C_{ice}\,\Delta T$ (e) $q = n\,\Delta H_{fusion}$



5) 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. (12 pts total, 4 pts each)



6) 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. (8 pts)

$2\ NO\ (g) \xrightarrow{k_1} N_2O_2\ (g)$ elementary reaction mechanism step (1) fast

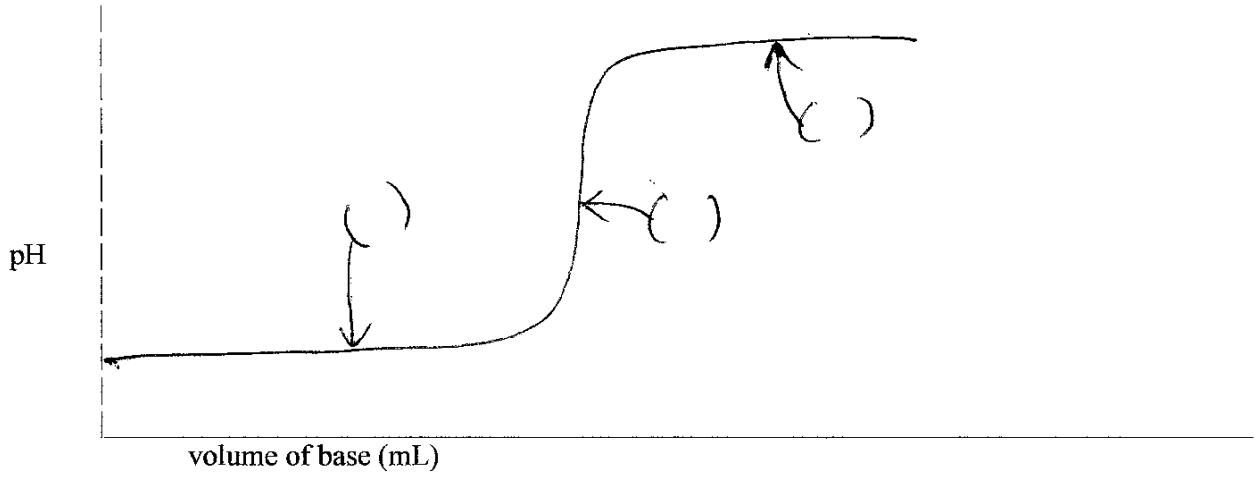
$N_2O_2\ (g) + O_2\ (g) \xrightarrow{k_2} 2\ NO_2\ (g)$ elementary reaction mechanism step (2) slow

$2\ NO\ (g) + O_2\ (g) \rightarrow 2\ NO_2\ (g)$ overall reaction

Rate = _____

8) In the following titration graph for a strong acid to which is added a strong base, match the letter with the appropriate parenthesis. The equations below are absolutely correct except for you not knowing which of the equations goes with which part of the graph until you fill in the parenthesis with the correct letter. (12 pts, 4 pts each)

(a) $[H^+] = 1.0 \times 10^{-7}$
(b) $[OH^-]$ = (# moles base - # moles acid)/ {(mL volume acid + mL volume base) x (1 Liter/1000 mL) }
(c) $[H^+]$ = concentration of the strong acid
(d) $[H^+]$ = (# moles acid - # moles base) / {(mL volume acid + mL volume base) x (1 Liter /1000 mL)}



7) $2\ SO_3\,(g) \rightarrow 2SO_2(g) + O_2\,(g)$ $\quad K_{eq} = 3.1 \times 10^{-4}$

Initially you have $[SO_3\,(g)] = 0.453$ M. What is the equilibrium concentration of the $SO_2\,(g)$ and the concentration of $O_2\,(g)$ in molarity ? (I am not looking for the final answer. Just set up the problem because you do not have enough time to actually complete the algebra.) (13 pts)

a. Fill out the table shown below. (7 pts, 1 pt per table block)

$2\ SO_3\,(g) \rightarrow 2\ SO_2\,(g) + O_2\,(g)$

	$[SO_3]$	$[SO_2\,(g)]$	$[O_2\,(g)]$
initial	(1)	(2)	zero
change	(3)	(4)	+ X
equilibrium	(5)	(6)	(7)

b. Write out the equilibrium constant expression using $[SO_3]$, $[SO_2]$, and $[O_2]$ (2 pts)

$K_{eq} =$ _____

c. Write out the equilibrium constant expression for the equation using your equilibrium values. (2 pts)

d. Write out the equilibrium constant expression for the reaction using your equilibrium values with your simplifying approximation. (2 pts)

9. For the following molecule, $[Mn(CO)(NH_3)_5]Cl_2$ (10 pts total, 2 pts each blank)

What are the ligands ? _____

What is the transition metal ? _____

What is the coordination complex ? _____

What is the coordination compound ? _____

What is the coordination number ? _____

Part III. Long Answer Please show work for full credit and to receive partial credit. (70 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. Problems with multiple part are graded consistently:**
example: (a) answer goes to give (b) goes to answer (c) If your (a) is incorrect but your (b) comes from your own (a) then you get full credit for (b). If your (b) is correct but you cannot possibly get your (b) from your incorrect (a) then you lose points for both (a) & (b) ****

1) Your job is to make up 15.2 mL of a 0.250 M solution of NaCl in water because your saline solution is supposed to be mixed later with a pharmaceutical which degrades in any other concentration and volume of the salt solution to otherwise kill your patient . (OK there is no such drug. I just made up the problem.) (20 pts total)

a. How many grams of salt (molar mass NaCl = 58.5 g/mol) do you need ? (15 pts)

b. How would you make up the solution ? Explain how you make up the solution in at least 2 sentences. (don't forget the difference between molality and molarity) (5 pts) (show work)

2) **Titration of a strong acid to which you add a strong base: (equivalence point volume = 29.7 mL of the base)**: For 25.0 mL of H I of concentration of 0.422 M and a LiOH concentration of 0.355 M, what is the $[H_3O^+]$ concentration after the addition of 25 mL of the Li OH ? You must show work for full credit. (26 pts)

3) For a reaction $CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$ (24 pts total)

a. What is the $\Delta H^\circ_{reaction}$ for this reaction in Joules (convert to Joules at the end of the problem) ? $\Delta H^\circ_f[CH_4(g)] = -74.6$ kJ / mol $\Delta H^\circ_f[CO_2(g)] = -393.5$ kJ / mol $\Delta H^\circ_f[H_2O(g)] = -241.8$ kJ / mol (8 pts) (Even if you get the wrong number here, you will get full credit for later parts of this problem if you do those parts correctly. If you cannot answer this question make up some number and continue to the next question.)

$[\Delta H^\circ_{RXN} = \Sigma\, n_{product}\, \Delta H^\circ_f(\text{product}) - \Sigma\, n_{reactant}\, \Delta H^\circ_f(\text{reactant})]$, 1000 Joule = 1 kJ

b. If the ΔS°_{rxn} for the above reaction is -5.3 J/K what is the ΔG°_{rxn} at T = 298 K ?
($\Delta G^{\circ} = \Delta H^{\circ} - T \Delta S^{\circ}$) (watch the units) (8 pts)

c. For the reaction above, what is the equilibrium constant at T = 298 K ? ($\Delta G^{\circ}_{rxn} = - RT \ln K$)
(R=8.134 J/mol K) Leave the answer as ln K = final answer. (Do not try to get the antilog.) (8 pts)