Final Exam General Chemistry II 5/1 Monday Dr. Hahn Spring 2023 (100 pts, # pages) exam # 21

Name Key (print). 9:30 am Form A

Please show work on all problems for partial & full credit. Please use the back of the exam pages as scratch paper. Good Luck!!

I. Multiple Choice (32 pts) Choose the best statement by circling ONE letter. (obviously no partial credit for multiple choice). (4 pts each number)

1. In the equation $\Delta T_b = i * K_b * m$, circle the one **incorrect or choose the best** statement

(a). ΔT_b represents the change in temperature due to boiling point elevation
(b) i represents the number of particles dissociated from the solute molecule (ionic solute would have i > 1) dissolved in the solution.
(c) K_b represents the boiling point elevation constant for the solvent (usually water).
(d) m = molality of the solute in moles in liters of solution. Kg
(d) All statements above are correct.

2. For the reaction choose one best statement.

$CO\,(aq) + 2H_2\,(aq). \rightarrow CH_3OH.\,(aq)$. The equilibrium constant expression is:

(a). $K_{eq} = \dfrac{[CH_3OH]}{[CO]\,[H_2]^2}$

(b) $K_{eq} = \dfrac{[CO][H_2]_2}{[CH_3OH]}$

(c). $K_{eq} = [CO]\,[H_2]^2$

(d) No one can write an equilibrium constant expression from the given information.

3 Circle all incorrect statements.
(a). F is the most electronegative element.
(b) When a substance is undergoing a phase change (ex: from liquid to solid), all heat goes to make the phase change so that the temperature of the substance does not change until all of the substance has finished undergoing the phase change.
(c) sublimation is the process in which a solid goes to the liquid phase. gas

4. Choose the one best statement.
(a) Enthalpy (H) is a state function
(b) For the reaction $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$ $\Delta H = -286kJ$
Then for the reaction $H_2O(l) \longrightarrow H_2(g) + \frac{1}{2}O_2(g)$ $\Delta H = +286kJ$
(c) For the reaction $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$ $\Delta H = -286kJ$
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$ $\Delta H = 2 \times (-286kJ) = -572kJ$
(d). All statements above are true

5. Choose the best statement about i (the van't Hoff factor) ? Assume that all ionic complexes dissociate completely in water the solvent in which the FP depression or BP elevation is being observed.

(a) NaCl has i ~ 2
(b) $MgCl_2$ has i~ 3
(c). Na_2S has i = 3
(d) All statements above are correct.

6. For the dissociation of $CaF_2(s) \rightleftarrows Ca^{+2}. + 2\,F^-$

To calculate the solubility of the Ca^{+2} from the K_{sp}, which of the following are the best statements ?

(a) $K_{sp} = [Ca^{+2}][F^-]^2$ and $K_{sp} = [x][x]^2$

(b) $K_{sp} = [Ca^{+2}][F^-]^2$ and $K_{sp} = [x][2x]^2$

(c). $K_{sp} = [Ca^{+2}][F^-]$ and $K_{sp} = [x][2x]$

(d). $K_{sp} = [Ca^{+2}][F^-]$ and $K_{sp} = [x][x]$

(e). all statements above are incorrect. You can't calculate solubility from K_{sp}.

7. Which of the following is **NOT true** about acids and bases ?

(a) pH < 7 is an acidic solution. (b) pH= 7 is neutral

(c) pH > 7 is basic. (d) $pH = -\log[OH^-]$. (e) all statement are true

8. Given the above equation, $\Delta G^\circ = \Sigma n \Delta G^\circ_f(\text{products}) - \Sigma n \Delta G^\circ_f(\text{reactants})$. Choose the best statement.

(a) If you have a balanced chemical reaction and a chart of for all of the reactants and product molecules ΔG°_f, you can obtain ΔG° for the reaction
(b) If ΔG° is negative, the reaction will be spontaneous
(c). ΔG°_f for all elements in the most stable standard state is zero.
(d) The n in the equation above is for the coefficient of the balanced chemical equation.
(e). The equation above takes the sum of all of the ΔG°_f for the molecules in the products and subtracts the sum of all of the ΔG°_f for the molecules in the reactants.
(f) All statements above are correct.
(g) Only (a), (b) and (d) are true.

II. Short Answers (45 pts)

1. For the reaction shown. (show work) (8 pts)

$N_2H_4(l) + N_2O_4(g). \rightarrow 2N_2O(g). + 2H_2O(g)$ $\Delta H = -382.1$ kJ/mol
$\leftarrow$

Is this reaction exothermic ? (yes, no) (circle one) (2 pts)

$2\,N_2H_4(l) + 2.\,N_2O_4(g). \rightarrow 4\,N_2O(g). + 4\,H_2O$ What is ΔH ? -764.2 (3 pts)

$2(-382.1) =$

$2N_2O(g). + 2H_2O \rightarrow N_2H_4(l) + N_2O_4(g).$ What is ΔH ? $+382.1$ (3 pts)

2. Given the following reaction, write out the equilibrium constant expression. (reaction is not realistic but written to ask the question). (6 pts)

$C_6H_{12}O_6(aq). +. \; 6\,O_2(aq). \rightarrow 6\,CO_2(aq). +. 6\,H_2O(aq)$
$\leftarrow$

$$K_{eq} = \frac{[CO_2]^6[H_2O]^6}{[C_6H_{12}O_6][O_2]^6}$$

3. (a) For a 0.75 M H Cl solution ? What is the concentration of $[H_3O^+]$. 0.75 M (8 pts, 2 pts each). { $[H_3O^+]\,[OH^-] = 1 \times 10^{-14}$. P(anything) = -log (anything) }

(b) What is the concentration of $[OH^-]$? _____. (show work)

$1 \times 10^{-14} = [H_3O^+][OH^-]$ $\quad OH^- = \frac{1 \times 10^{-14}}{(0.75)} = 1.33 \times 10^{-14}$

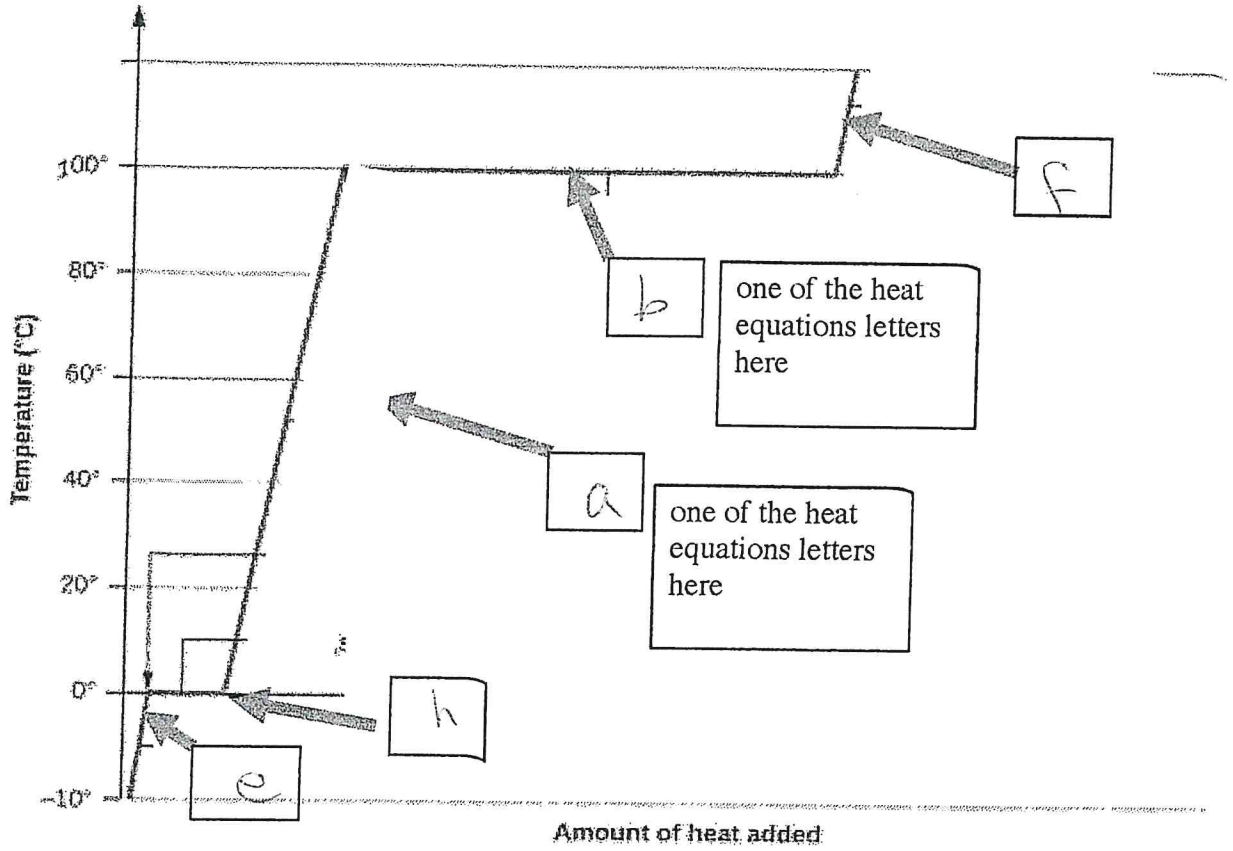
(c). What is the pH of the solution ? 0.12 show work.

$-\log(0.75) = 0.12$

(d). What is the pOH of the solution ? 13.9 (show work)

$-\log(1.33 \times 10^{-14}) = +13.9$

4. Fill in the blanks in the figure below for the Temperature vs. amount of heat added , label the parts of the plot with the following letters (a) $q = n * C_m * \Delta T$. (b) $q = n \Delta H_{fusion}$. (c) $q = n \Delta H_{vaporization}$ (d) water liquid. (e) water solid (f) water gas. (g) phase transition of water (liquid) to water (gas). (h) phase transition of water (solid) to water (liquid). 7 pts total, 1 pt per blank)



5 (a) Given $\boxed{\Delta G = \Delta H - T\,\Delta S}$

If $\Delta H = 1300.2$ J and $\Delta S = 120.4$ J/K at 285.2 K, what is ΔG ? (4 pts)

$\Delta G = 1300.2\,J - (285.2\,K)(120.4\,kJ/1c)$

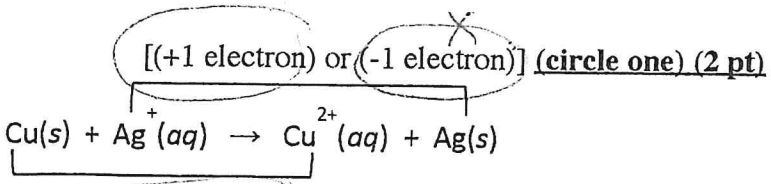
$\Delta G = 1300.2\,J - 34224.0$

$\Delta G = -32924 \rightarrow$ W.s.f. $\rightarrow -3.292 \times 10^4$

(b) Is the reaction [(spontaneous) or (not spontaneous)] Circle one. (2 pts)

6 Given the following reaction, balance the redox reaction by completing the following. I'm not asking for you to balance the redox. Just answer the following questions (which results in you balancing the redox)(10 pt)

(a)



[(+2 electron) or (-2 electron)] **(circle one) (2 pt)**

(b) Is the Ag half reaction [(oxidation of Ag) or (reduction of Ag)] (circle one) (2 pt)

(c) Is the Cu half reaction [(oxidation of Cu) or (reduction of Cu)] (circle one) (2 pt)

(d). To balance the redox equation (2 pts)

[(you should multiply the Ag half reaction by 2) or (you should multiply the Cu half reaction by 2)] (circle one)

Part III. Long Answers (25 pts) Show work where applicable.

1. You are running a calorimetry experiment in which you have a reaction in 50.3. grams water. The water temperature goes up from 23.2 °C to 50.2. °C. (useful stuff: $q = c*m* \Delta T$, C_{water} = 4.184 J/(g°C, density water = 1.00 g/mL) What is the q for the reaction ? (10 pts) (show work)

Mass H_2O = 50.3 g

T_f = 50.2°C

T_i = 23.2°C

$q = \left(4.184 \frac{J}{g°C}\right)(50.3g)(50.2°C - 23.2°C)$

$q = \left(4.184 \frac{J}{g°C}\right)(50.3g)(27.0°C)$

q = 5682.29 J $\rightarrow \frac{kJ}{1000J}$

q = 5.68 kJ

2. (a) What is the pH of a solution of 0. 35 M of H. F. acid with 0.45 M of the F^- added into the solution ? $K_a = 4.9 \times 10^{-10}$. Complete the ICE table and plug into the K_a equation with the equilibrium concentration. Solve for x (H_3O^+) and the pH. (10 pts)

$HF + H_2O(l) \rightleftarrows H_3O^+ + F^-$

0.35 M ----	0	0.45M	Initial
$-x$ ----	$+x$	$+x$	Change
$0.35-x$ -----	x	$0.45+x$	Equilibrium

$$K = \frac{[H_3O^+][F^-]}{[HF]} = \frac{(x)(0.45+x)}{(0.35-x)} \rightarrow x \ll \text{Small}$$

$$K_a = 4.9 \times 10^{-10} = \frac{0.45x}{0.35}$$

$(4.9 \times 10^{-10})(0.35) = 0.4$

$1.72 \times 10^{-10} = 0.45x$

$3.8 \times 10^{-10} = x$

$[H_3O^+] = 3.8 \times 10^{-10}$

$pH = -\log(3.8 \times 10^{-10})$

$pH = 9.4$

(b) Given the Henderson Hasselbalch equation below, what is the pH ? Show the equation with all of the numbers plugged into the equation. (5 pts)

$$pH = pKa + \log \frac{[\text{conjugate base}]}{[\text{acid}]}$$

$$pH = -\log(4.9 \times 10^{-10}) - \log\left(\frac{0.45}{0.35}\right)$$

Final Exam General Chemistry II 5/1 Monday Dr. Hahn Spring 2023 (100 pts, # pages) exam # 28

Name Key (print). 9:30 am Form B

Please show work on all problems for partial & full credit. Please use the back of the exam pages as scratch paper. Good Luck!!

I. Multiple Choice (32 pts) Choose the best statement by circling ONE letter. (obviously no partial credit for multiple choice). (4 pts each number)

1. For the dissociation of $CaF_2(s) \rightleftarrows Ca^{+2} + 2F^-$

To calculate the solubility of the Ca^{+2} from the K_{sp}, which of the following are the best statements ?

(a) $K_{sp} = [Ca^{+2}][F^-]^2$ and $K_{sp} = [x][x]^2$

(b) $K_{sp} = [Ca^{+2}][F^-]^2$ and $K_{sp} = [x][2x]^2$

(c). $K_{sp} = [Ca^{+2}][F^-]$ and $K_{sp} = [x][2x]$

(d). $K_{sp} = [Ca^{+2}][F^-]$ and $K_{sp} = [x][x]$

(e). all statements above are incorrect. You can't calculate solubility from K_{sp}.

2. Which of the following is **NOT true** about acids and bases ?

(a) pH < 7 is an acidic solution. (b) pH= 7 is neutral

(c) pH > 7 is basic. (d) $pH = -\log[OH^-]$. (e) all statement are true

3. Given the above equation, $\Delta G^\circ = \Sigma n \Delta G^\circ_f(\text{products}) - \Sigma n \Delta G^\circ_f(\text{reactants})$. Choose the best statement.

(a) If you have a balanced chemical reaction and a chart of for all of the reactants and product molecules ΔG°_f, you can obtain ΔG° for the reaction
(b) If ΔG° is negative, the reaction will be spontaneous
(c). ΔG°_f for all elements in the most stable standard state is zero.
(d) The n in the equation above is for the coefficient of the balanced chemical equation.
(e). The equation above takes the sum of all of the ΔG°_f for the molecules in the products and subtracts the sum of all of the ΔG°_f for the molecules in the reactants.
(f) All statements above are correct.
(g) Only (a), (b) and (d) are true.

4 Circle all incorrect statements.
(a). F is the most electronegative element.
(b) When a substance is undergoing a phase change (ex: from liquid to solid), all heat goes to make the phase change so that the temperature of the substance does not change until all of the substance has finished undergoing the phase change.
(c) sublimation is the process in which a solid goes to the liquid phase. Gas

5. Choose the one best statement.

(a) Enthalpy (H) is a state function

(b) For the reaction $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$ $\Delta H = -286kJ$
Then for the reaction $H_2O(l) \longrightarrow H_2(g) + \frac{1}{2}O_2(g)$ $\Delta H = +286kJ$

(c) For the reaction $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$ $\Delta H = -286kJ$
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$ $\Delta H = 2 \times (-286kJ) = -572kJ$

(d). All statements above are true

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6. In the equation $\Delta T_b = i * K_b * m$, circle the one **incorrect or choose the best** statement

(a). ΔT_b represents the change in temperature due to boiling point elevation

(b) i represents the number of particles dissociated from the solute molecule (ionic solute would have i > 1) dissolved in the solution.

(c) K_b represents the boiling point elevation constant for the solvent (usually water).

(d) m = molality of the solute in moles in liters of solution.

(d) All statements above are correct.

7. For the reaction choose one best statement.

$CO(aq) + 2H_2(aq) \rightarrow CH_3OH.(aq)$. The equilibrium constant expression is:

(a). $K_{eq} = \dfrac{[CH_3OH]}{[CO]\,[H_2]^2}$

(b) $K_{eq} = \dfrac{[CO][H_2]_2}{[CH_3OH]}$

(c). $K_{eq} = [CO]\,[H_2]^2$

(d) No one can write an equilibrium constant expression from the given information.

8. Choose the best statement about i (the van't Hoff factor) ? Assume that all ionic complexes dissociate completely in water the solvent in which the FP depression or BP elevation is being observed.

(a) NaCl has i ~ 2

(b) $MgCl_2$ has i~ 3

(c). Na_2S has i = 3

(d) All statements above are correct.

II. Short Answers (45 pts)

1. For the reaction shown. (show work) (8 pts)

$N_2H_4(l) + N_2O_4(g). \rightarrow 2N_2O(g). + 2H_2O(g)$ $\Delta H = -452.1$ kJ/mol

Is this reaction exothermic ? (yes, no) (circle one) (2 pts)

$2\,N_2H_4(l) + 2.\,N_2O_4(g). \rightarrow 4\,N_2O(g). + 4\,H_2O$ What is ΔH ? -904.2 (3 pts)

$2(-452.1) =$

$2N_2O(g). + 2H_2O \rightarrow N_2H_4(l) + N_2O_4(g).$ What is ΔH ? $+452.1$ (3 pts)

2. Given the following reaction, write out the equilibrium constant expression. (reaction is not realistic but written to ask the question). (6 pts)

$C_6H_{12}O_6(aq). +. 6\,O_2(aq). \rightarrow 6\,CO_2(aq). +. 6\,H_2O(aq)$

3. (a) For a 1.5 M. H Cl solution ? What is the concentration of $[H_3O^+]$. 1.5 M (8 pts, 2 pts each). { $[H_3O^+]\,[OH^-] = 1 \times 10^{-14}$. P(anything) = -log (anything) }

(b) What is the concentration of $[OH^-]$? _____. (show work)

$[H_3O^+][OH^-] = 1 \times 10^{-14}$ $[OH^-] = \frac{1 \times 10^{-14}}{1.5} = 6.67 \times 10^{-15}$

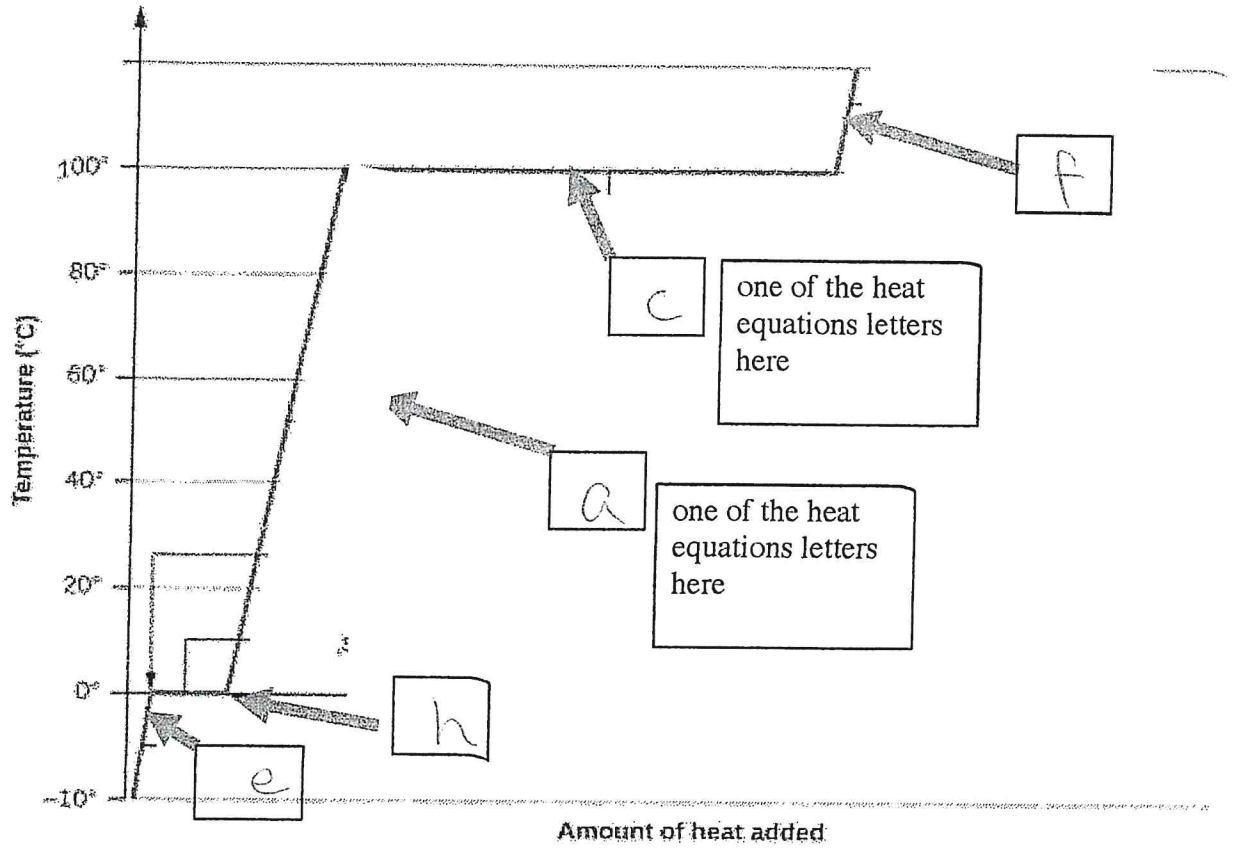
(c). What is the pH of the solution ? 0.18 show work.

$pH = -\log(1.5) = 0.176$

(d). What is the pOH of the solution ? 14.2 (show work)

$pOH = -\log(6.67 \times 10^{-15}) = 14.2$

4. Fill in the blanks in the figure below for the Temperature vs. amount of heat added , label the parts of the plot with the following letters (a) $q = n * C_m * \Delta T$. (b) $q = n \Delta H_{fusion}$. (c) $q = n \Delta H_{vaporization}$(d) water liquid. (e) water solid (f) water gas. (g) phase transition of water (liquid) to water (gas). (h) phase transition of water (solid) to water (liquid). 7 pts total, 1 pt per blank)



5 (a) Given $\boxed{\Delta G = \Delta H - T\,\Delta S}$

If $\Delta H = 5600.2$ J and $\Delta S = 78.4$ J/K at 298.2 K, what is ΔG ? (4 pts)

$\Delta G = 5600.2\,J - (298.2\,K)(78.4\,J/K)$

$\Delta G = 5600.2\,J - 23378.88\,J$

$\Delta G = -17778.6\,J \rightarrow \frac{1\,kJ}{1000\,J} = -17.8\,kJ$

(b) Is the reaction [(spontaneous) or (not spontaneous)] Circle one. (2 pts)

6 Given the following reaction, balance the redox reaction by completing the following. I'm not asking for you to balance the redox. Just answer the following questions (which results in you balancing the redox)(10 pt)

(a)

[(+1 electron) or (-1 electron)] **(circle one) (2 pt)**

$$Cu(s) + Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + Ag(s)$$

[(+2 electron) or (-2 electron)] **(circle one) (2 pt)**

(b) Is the Ag half reaction [(oxidation of Ag) or (reduction of Ag)] (circle one) (2 pt)

(c) Is the Cu half reaction [(oxidation of Cu) or (reduction of Cu)] (circle one) (2 pt)

(d). To balance the redox equation (2 pts)
[(you should multiply the Ag half reaction by 2) or (you should multiply the Cu half reaction by 2)] (circle one)

Part III. Long Answers (25 pts) Show work where applicable.

1. You are running a calorimetry experiment in which you have a reaction in 76.2 grams water. The water temperature goes up from 20.8 °C to 68.7. °C. (useful stuff: $q = c*m*\Delta T$, $C_{water} = 4.184$ J/(g°C, density water = 1.00 g/mL) What is the q for the reaction ? (10 pts) (show work)

$T_i = 20.8°C \quad T_F = 68.7°C$

$m = 76.2\,g\ H_2O$

$$q = \left(4.184 \frac{J}{g°C}\right)(76.2\,g\ H_2O)(68.7°C - 20.8°C)$$

$$q = \left(4.184 \frac{J}{g°C}\right)(76.2\,g\ H_2O)(47.9°C)$$

$$q = 27812.8.48\ J \times \frac{kJ}{1000J}$$

$q = 278$ kJ (w s.f.)

2. (a) What is the pH of a solution of 0.45 M of H. F. acid with 0.60 M of the F^- added into the solution ? $K_a = 4.9 \times 10^{-10}$. Complete the ICE table and plug into the K_a equation with the equilibrium concentration. Solve for x (H_3O^+) and the pH. (10 pts)

$$K_a = \frac{[H_3O^+][F^-]}{[HF]}$$

$HF + H_2O(l) \rightleftarrows H_3O^+ + F^-$

0.45	----	0	0.60	**Initial**
$-x$	----	$+x$	$+x$	**Change**
$0.45-x$	-----	x	$0.60+x$	**Equilibrium**

$$4.9 \times 10^{-10} = \frac{[x](0.60+x)}{(0.45-x)}$$

x << small #

$$4.9 \times 10^{-10} = \frac{(x)(0.60)}{(0.45)}$$

$$\frac{(4.9 \times 10^{-10})(0.45)}{(0.60)} = x$$

$$(4.9 \times 10^{-10})(0.45) = (x)(0.60)$$

$x = 3.7 \times 10^{-10} = [H_3$

(b) Given the Henderson Hasselbalch equation below, what is the pH ? Show the equation with all of the numbers plugged into the equation. (5 pts)

$$pH = pKa + \log \frac{[\text{conjugate base}]}{[\text{acid}]}$$

$pH = -\log(3.7 \times 10^{-7}$

$pH = 9.4$

$$pH = -\log(4.9 \times 10^{-10}) + \log\left(\frac{0.60}{0.45}\right)$$