

Name Key (print) Name _____ (sign)

Please show work for partial credit and full credit on the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If you run out of space, continue on the empty back pages but clearly label where the remaining answers can be found. (Please count your exam pages and make sure there are 5 pages) For the multiple choice, put the Test Form number (CA or CB) on the scantron and be sure to fully erase any wrong answer pencil marks. and fully mark your correct answers.

$$q = m C \Delta T \quad q = n C \Delta T \quad q = n \Delta H_{\text{vap}} \quad \Delta H^\circ = \Delta H^\circ_f(\text{products}) - \Delta H^\circ_f(\text{reactants})$$

$$\text{work} = -P \Delta V, 1 \text{ Liter atm} = 101.33 \text{ Joule} \quad \Delta G = \Delta H - T \Delta S \quad K = {}^\circ\text{C} + 273.15$$

MULTIPLE CHOICE. Choose the one best alternative.

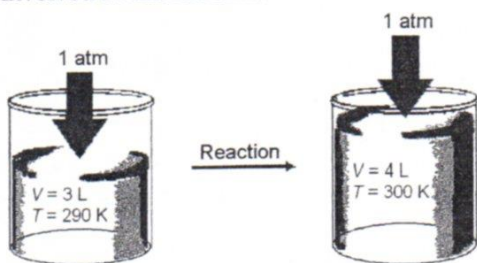
- 1) Which of the following can be interpreted as a measure of randomness? 1) C
 A) temperature B) enthalpy **C) entropy** D) free energy
- 2) For the reaction $\text{I}_2(\text{g}) \rightarrow \text{I}_2(\text{s})$, $\Delta H^\circ = -62.4 \text{ kJ}$ at 25°C . Based on these data, at 25°C 2) D
 A) $\Delta H^\circ_{\text{vap}} = 62.4 \text{ kJ/mol}$. **g \rightarrow s** B) $\Delta H^\circ_{\text{vap}} = -62.4 \text{ kJ/mol}$. **sub**
 C) $\Delta H^\circ_{\text{sub}} = -62.4 \text{ kJ/mol}$. **D) $\Delta H^\circ_{\text{sub}} = 62.4 \text{ kJ/mol}$.** **s \rightarrow g**
- 3) Which of the following is expected to have the greatest viscosity? 3) A
A) $\text{C}_5\text{H}_{11}\text{OH}$ B) C_6H_{14} C) C_5H_{12} D) CH_4 **reverse +**
- 4) Given: $4 \text{ NO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{ N}_2\text{O}_5(\text{g}) \quad \Delta H^\circ = -110.2 \text{ kJ}$ **← RW + 110.2** 4) A
 find ΔH° for $8 \text{ N}_2\text{O}_5(\text{g}) \rightarrow 16 \text{ NO}_2(\text{g}) + 4 \text{ O}_2(\text{g})$. **$\times 4 = +440.8$**
A) 440.8 kJ B) -440.8 kJ C) -220.4 kJ D) 220.4 kJ
- 5) For most chemical reactions 5) A
A) the difference between ΔH and ΔE is very small.
 B) ΔH is equal to ΔE .
 C) ΔE is much larger than ΔH .
 D) ΔH is much larger than ΔE .
- 6) Which combination always results in a reaction being spontaneous? 6) C
 A) ΔH is positive and ΔS is negative. B) ΔH is negative and ΔS is negative.
C) ΔH is negative and ΔS is positive. D) ΔH is positive and ΔS is positive.

$$\Delta G = \Delta H - T \Delta S$$

$$(-) = (-) - T(+)$$

- 7) Imagine a reaction that results in a change in both volume and temperature, as shown in the diagram below. What is the sign of the work being done and the sign of the enthalpy change involved in this reaction?

7) D



$$V_f - V_i = (4 - 3)$$

$$\Delta V = 1$$

$$P = (-1 \text{ atm})$$

$$W = (-1 \text{ atm})(1 \text{ L})$$

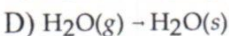
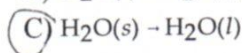
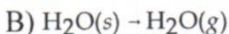
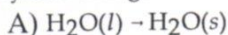
- A) $w = +$ and $\Delta H = +$
 C) $w = -$ and $\Delta H = +$

B) $w = +$ and $\Delta H = -$

D) $w = -$ and $\Delta H = -$

$$T_f = T_i = \text{exothermic } (\Delta H -)$$

- 8) The enthalpy of fusion, or heat of fusion (ΔH_{fusion}), of water is positive and corresponds to which physical change? 8) C



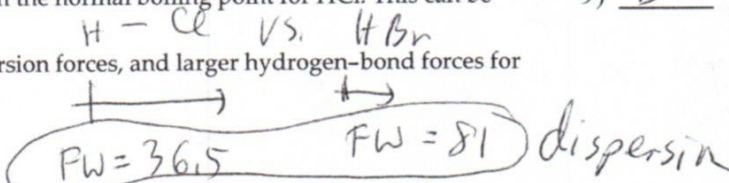
- 9) The normal boiling point for HBr is higher than the normal boiling point for HCl. This can be explained by 9) B

- A) larger dipole-dipole forces, larger dispersion forces, and larger hydrogen-bond forces for HBr.

- B) larger dispersion forces for HBr.**

- C) larger dipole-dipole forces for HBr.

- D) larger hydrogen-bond forces for HBr.



- 10) Calculate the work, w , gained or lost by the system when a gas expands from 15 L to 35 L against a constant external pressure of 1.5 atm. ($1 \text{ L} \cdot \text{atm} = 101 \text{ J}$) ($w = -P\Delta V$) 10) C

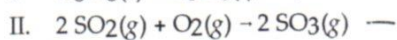
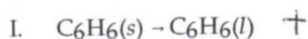
A) +5.3 kJ

B) -5.3 kJ

C) -3.0 kJ

D) +3.0 kJ

- 11) Determine the sign of ΔS° for each of the following:



- A) ΔS° should be negative for I and positive for II.

- B) ΔS° should be positive for I and positive for II.

- C) ΔS° should be negative for I and negative for II.

- D) ΔS° should be positive for I and negative for II.**

$$\Delta V = 35 - 15 = (20 \text{ L}) \quad 11) \quad \underline{D}$$

$$(20 \text{ L})(1.5 \text{ atm}) = 30 \text{ L atm}$$

$$\times \frac{101 \text{ J}}{1 \text{ L atm}} = 3030 \text{ J}$$

$$- 3,030 \text{ J}$$

- 12) Which of the following best explains why ΔH_{vap} is usually higher than ΔH_{fusion} ? 12) B
- A) Vaporization increases the entropy of molecules.
 B) Vaporization involves the breaking of all bonds between molecules.
 C) Vaporization involves the breaking of bonds within molecules.
 D) Vaporization occurs at high temperature.
- 13) For a process at constant pressure, 13) C
- A) $\Delta E = \Delta H$. B) $\Delta E = q$ and $w = 0$.
 C) $\Delta H = q$. D) $\Delta E = w$ and $q = 0$.
- 14) For which should the standard heat of formation ΔH_f° be zero at 25°C? 14) C
- A) O(g) B) NaI(s) C) O₂(g) D) CBr₄
- 15) When a substance melts at its normal melting point, the sign of ΔH is + and the sign of ΔS of this phase change is +. 15) C
- A) +, - B) -, - C) +, + D) -, +
- 16) The heat of vaporization of water at 100°C is 40.66 kJ/mol. Calculate the quantity of heat that is absorbed/released when 20.00 g of steam condenses to liquid water at 100°C. (formula mass H₂O = 18.02 g/mol) ($q = n\Delta H_{\text{vap}}$) 16) D
- A) 45.2 kJ of heat are absorbed. B) 813.2 kJ of heat are released.
 C) 813.2 kJ of heat are absorbed. D) 45.2 kJ of heat are released.

$$\Delta H_{\text{vap}} = 40.66 \text{ kJ/mol} \quad q = (1.11)(40.66 \text{ kJ/mol})$$

$$\frac{20.00 \text{ g H}_2\text{O}}{18.02 \text{ g/mol}} = 1.11 \text{ mol} \quad q = 45.14 \text{ kJ}$$

Part II: Short Answers

Please show work on all questions for partial credit even on questions which do not specify! (40 total pts)
 Hint: Please watch the units on all work to ensure that your answer is correct.

$q = m C \Delta T$ $q = n C \Delta T$ $q = n \Delta H_{\text{vap}}$ $\Delta H^\circ = \Delta H^\circ_f(\text{products}) - \Delta H^\circ_f(\text{reactants})$
 $\text{work} = -P \Delta V$, 1 Liter atm = 101.33 Joule $\Delta G = \Delta H - T \Delta S$ $K = {}^\circ\text{C} + 273.15$

1. a. You do a reaction in a calorimeter with 78.2 grams of water. The reaction results in a temperature change from 85.2 °C to 35.9 °C. Assuming that the calorimeter has a negligible effect on the heat and the specific heat of water is a good approximation for the specific heat of the reaction solution. What is the heat (q) generated? [$q = m C \Delta T$, $C(\text{water}) = 4.18 \text{ J/(g } ^\circ\text{C)}$] (10 pts)

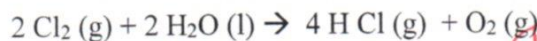
$q = (78.2 \text{ g}) [4.18 \text{ J/(g } ^\circ\text{C})] [35.9^\circ\text{C} - 85.2^\circ\text{C}] = -16115 \text{ J}$
 $q = -16.1 \text{ kJ}$
Wrong unit -2 *sign - 1/2 pt* *math -1*

b. What is the enthalpy change (ΔH) for the reaction which you did in the calorimeter? (2 pts)

$\Delta H = +16.1 \text{ kJ}$ *sign - 1/2*

c. what is the system? [(water & calorimeter assembly) or (reaction)] (circle one) (2 pts)

2. Given the following enthalpy of formation, what is the enthalpy of the reaction at standard conditions. [$\Delta H^\circ = \Delta H^\circ_f(\text{products}) - \Delta H^\circ_f(\text{reactants})$] (10 pts)

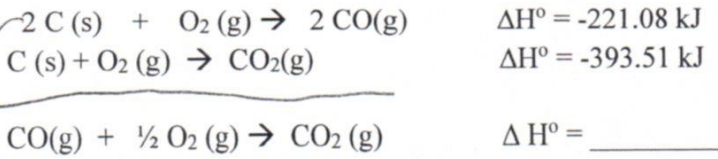


$\Delta H^\circ_f [\text{HCl}(\text{g})] = -92.31 \text{ kJ/mol}$

$\Delta H^\circ_f [\text{H}_2\text{O}(\text{l})] = -285.8 \text{ kJ/mol}$

$\{4 \Delta H^\circ_f [\text{HCl}(\text{g})] + \Delta H^\circ_f [\text{O}_2(\text{g})]\} -$
 $\{2 \Delta H^\circ_f [\text{Cl}_2(\text{g})] + 2 \Delta H^\circ_f [\text{H}_2\text{O}(\text{l})]\}$
 $\{4(-92.31 \text{ kJ}) + 0\} - \{0 + 2(-285.8 \text{ kJ})\}$
 202.3 kJ
left off -1 *algebra -2* *math -1* *sign - 1/2*
made up # ≠ 0 *backward -1*

3. Given the following reactions and the enthalpies for the reaction as noted, what is the enthalpy of the reaction given? (Hess' Law) (10 pts)



math -1 pt

reverse



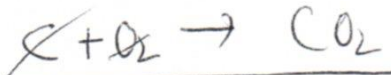
$$\Delta H^\circ = +221.08 \text{ kJ}$$

-1/2 backward or not / 2

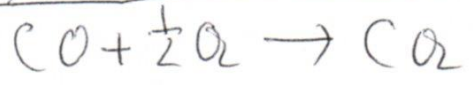
1/2



$$\Delta H^\circ = + \frac{221.08 \text{ kJ}}{2} = 110.54$$



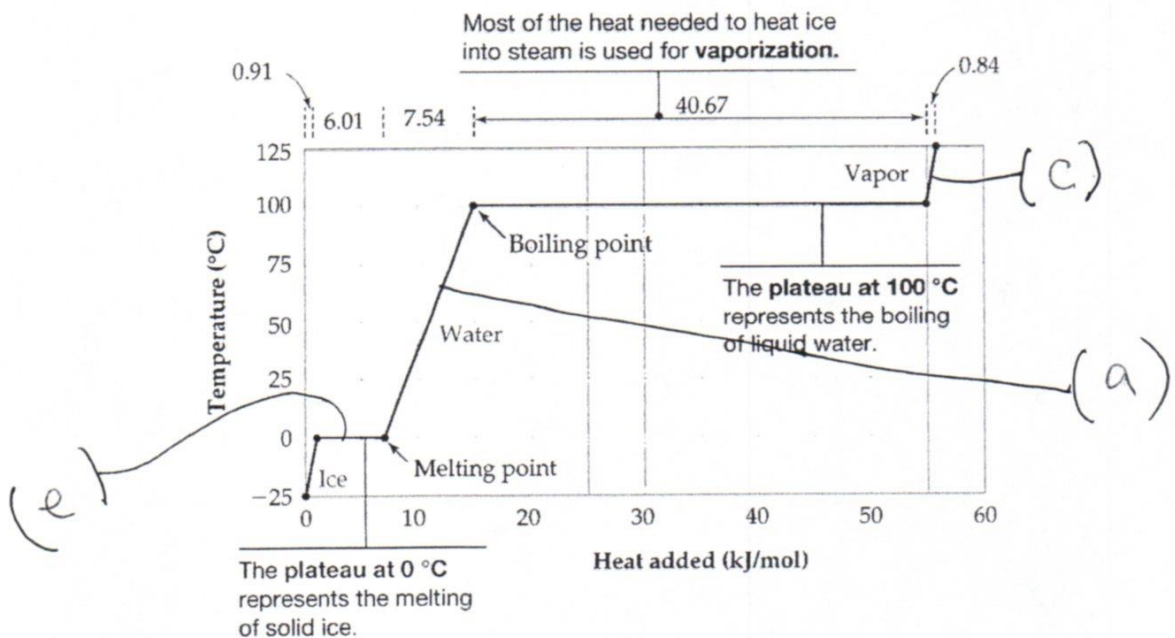
$$\Delta H^\circ = -393.51 \text{ kJ} \quad 3 \text{ pt}$$



$$\Delta H^\circ = -282.97 \text{ kJ} \quad 3 \text{ pt}$$

4 For the plot of the temperature of water with heat, match the parts of the plot with the possible equations given below by filling in the blank with the letter of the equation. **Each blank will only have ONE letter which matches.** (6 pts, 2 pts each blank)

- (a) $q = n C_{(\text{liquid water})} \Delta T$ (b) $q = n C_{(\text{ice})} \Delta T$ (c) $q = n C_{(\text{steam})} \Delta T$ (d) $q = n \Delta H_{\text{vap}}$ (e) $q = n \Delta H_{\text{fusion}}$



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$$\text{work} = -P \Delta V, 1 \text{ Liter atm} = 101.33 \text{ Joule} \quad \Delta G = \Delta H - T \Delta S \quad K = ^\circ\text{C} + 273.15$$

MULTIPLE CHOICE. Choose the one best alternative.

- 1) For a process at constant pressure, 1) B
 A) $\Delta E = \Delta H$. B) $\Delta H = q$.
 C) $\Delta E = q$ and $w = 0$. D) $\Delta E = w$ and $q = 0$.
- 2) Which of the following can be interpreted as a measure of randomness? 2) B
 A) enthalpy B) entropy C) free energy D) temperature
- 3) Which of the following is expected to have the greatest viscosity? 3) C
 A) C_5H_{12} B) CH_4 C) $\text{C}_5\text{H}_{11}\text{OH}$ D) C_6H_{14}
H bond + large Fm
greatest intermolecular
- 4) The normal boiling point for HBr is higher than the normal boiling point for HCl. This can be explained by 4) D
 A) larger dipole-dipole forces, larger dispersion forces, and larger hydrogen-bond forces for HBr.
 B) larger hydrogen-bond forces for HBr.
 C) larger dipole-dipole forces for HBr.
 D) larger dispersion forces for HBr.
HBr vs. HCl
+ → Fm = 81 *+ → Fm = 36.5*
- 5) The first law of thermodynamics 5) B
 A) defines energy.
 B) is a statement of conservation of energy.
 C) provides a criterion for the spontaneity of a reaction.
 D) defines water energy.
- 6) For most chemical reactions 6) A
 A) the difference between ΔH and ΔE is very small.
 B) ΔE is much larger than ΔH .
 C) ΔH is equal to ΔE .
 D) ΔH is much larger than ΔE .

7) Which of the following states the first law of thermodynamics (conservation of energy)?

A) $\Delta H = \Delta E + P\Delta V$

B) $\Delta E_{\text{system}} = -\Delta E_{\text{surroundings}}$

C) $q = sm\Delta T$

D) $w = -P\Delta V$

7) B

8) When a substance melts at its normal melting point, the sign of ΔH is + and the sign of ΔS of this phase change is +.

A) +, -

B) +, +

C) -, -

D) -, +

8) B

9) Calculate the work, w , gained or lost by the system when a gas expands from 15 L to 35 L against a constant external pressure of 1.5 atm. (1 L · atm = 101 J) ($w = -P\Delta V$)

A) +5.3 kJ

B) -5.3 kJ

C) -3.0 kJ

D) +3.0 kJ

9) C

10) Given: $4 \text{NO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{N}_2\text{O}_5(\text{g})$ $\Delta H^\circ = -110.2 \text{ kJ}$
find ΔH° for $8 \text{N}_2\text{O}_5(\text{g}) \rightarrow 16 \text{NO}_2(\text{g}) + 4 \text{O}_2(\text{g})$.

A) -440.8 kJ

B) 440.8 kJ

C) 220.4 kJ

D) -220.4 kJ

- 3,03 kJ
10) B

11) The enthalpy of fusion, or heat of fusion (ΔH_{fusion}), of water is positive and corresponds to which physical change?

A) $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{g})$

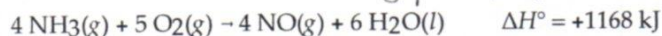
B) $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{s})$

C) $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{s})$

D) $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$

11) D

12) How much heat is absorbed/released when 10.00 g of $\text{NH}_3(\text{g})$ reacts in the presence of excess $\text{O}_2(\text{g})$ to produce $\text{NO}(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ according to the following chemical equation? (formula mass of $\text{NH}_3 = 17.04 \text{ g/mol}$)



A) 686.0 kJ of heat are absorbed.

B) 171.5 kJ of heat are absorbed.

C) 171.5 kJ of heat are released.

D) 686.0 kJ of heat are released.

12) B

13) Which combination always results in a reaction being spontaneous?

A) ΔH is positive and ΔS is negative.

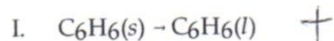
B) ΔH is positive and ΔS is positive.

C) ΔH is negative and ΔS is negative.

D) ΔH is negative and ΔS is positive.

13) D

14) Determine the sign of ΔS° for each of the following:



A) ΔS° should be positive for I and positive for II.

B) ΔS° should be negative for I and negative for II.

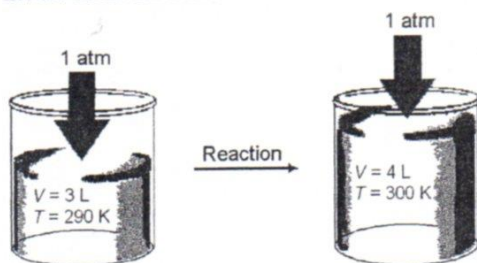
C) ΔS° should be negative for I and positive for II.

D) ΔS° should be positive for I and negative for II.

14) D

15) Imagine a reaction that results in a change in both volume and temperature, as shown in the diagram below. What is the sign of the work being done and the sign of the enthalpy change involved in this reaction?

15) D



$\Delta V = 4 - 3 = 1$
 $w = (-1\text{ atm})(1\text{ L})$

- A) $w = +$ and $\Delta H = +$
C) $w = -$ and $\Delta H = +$

- B) $w = +$ and $\Delta H = -$
D) $w = -$ and $\Delta H = -$

16) Which of the following compounds has the highest boiling point?

16) C

- A) $\text{H}_3\text{C}-\text{O}-\text{CH}_3$
C) $\text{HOCH}_2\text{CH}_2\text{OH}$

- B) $\text{CH}_3\text{CH}_2\text{OH}$
D) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

Part II: Short Answers

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 $\text{work} = -P \Delta V$, 1 Liter atm = 101.33 Joule $\Delta G = \Delta H - T \Delta S$ $K = ^\circ\text{C} + 273.15$

1. a. You do a reaction in a calorimeter with 18.2 grams of water. The reaction results in a temperature change from 25.2 °C to 49.2 °C. Assuming that the calorimeter has a negligible effect on the heat and the specific heat of water is a good approximation for the specific heat of the reaction solution. What is the heat (q) generated? [$q = m C \Delta T$, $C(\text{water}) = 4.18 \text{ J}/(\text{g } ^\circ\text{C})$] (10 pts)

$$q = (18.2 \text{ g}) \left(4.18 \frac{\text{J}}{\text{g } ^\circ\text{C}} \right) (49.2 - 25.2 ^\circ\text{C}) = 1825.8 \text{ J}$$

$$q = 1.83 \text{ kJ}$$

wrong unit -2

math -1

sign -2 pt

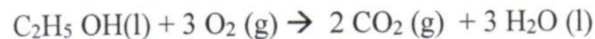
b. What is the enthalpy change (ΔH) for the reaction which you did in the calorimeter? (2 pts)

$$\Delta H = -1.83 \text{ kJ}$$

sign -1

c. what is the system? [(water & calorimeter assembly) or (reaction)] (circle one) (2 pts)

2. Given the following enthalpy of formation, what is the enthalpy of the reaction at standard conditions. [$\Delta H^\circ = \Delta H^\circ_f(\text{products}) - \Delta H^\circ_f(\text{reactants})$] (10 pts)



$$\Delta H^\circ_f [\text{C}_2\text{H}_5\text{OH}(\text{l})] = -277.7 \text{ kJ/mol}$$

$$\Delta H^\circ_f [\text{H}_2\text{O}(\text{l})] = -285.8 \text{ kJ/mol}$$

$$\Delta H^\circ_f [\text{CO}_2(\text{g})] = -393.5 \text{ kJ/mol}$$

math sign -1/2

algebra -2

math -1

left off +

backwards -1

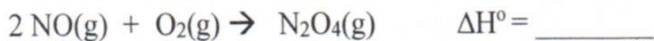
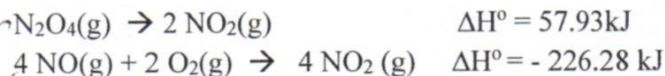
made up # for O2 ≠ 0

$$\left\{ 2 \Delta H^\circ_f [\text{CO}_2(\text{g})] + 3 \Delta H^\circ_f [\text{H}_2\text{O}(\text{l})] \right\} - \left\{ \Delta H^\circ_f [\text{C}_2\text{H}_5\text{OH}(\text{l})] + 3 \Delta H^\circ_f [\text{O}_2(\text{g})] \right\}$$

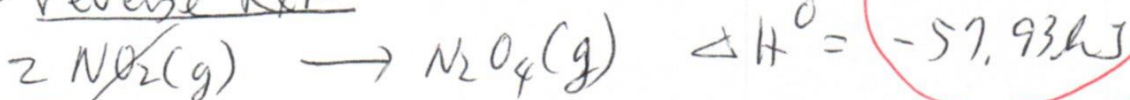
$$= \left\{ 2(-393.5 \text{ kJ}) + 3(-285.8 \text{ kJ}) \right\} - \left\{ -277.7 \text{ kJ} + 0 \right\}$$

$$= -1366.7 \text{ kJ}$$

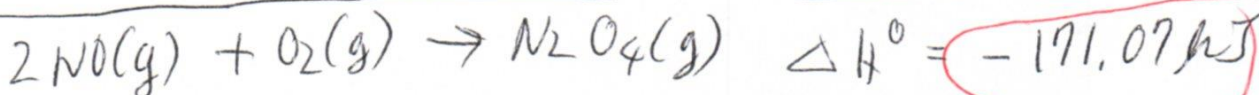
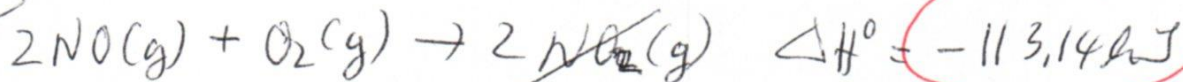
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reverse rxn



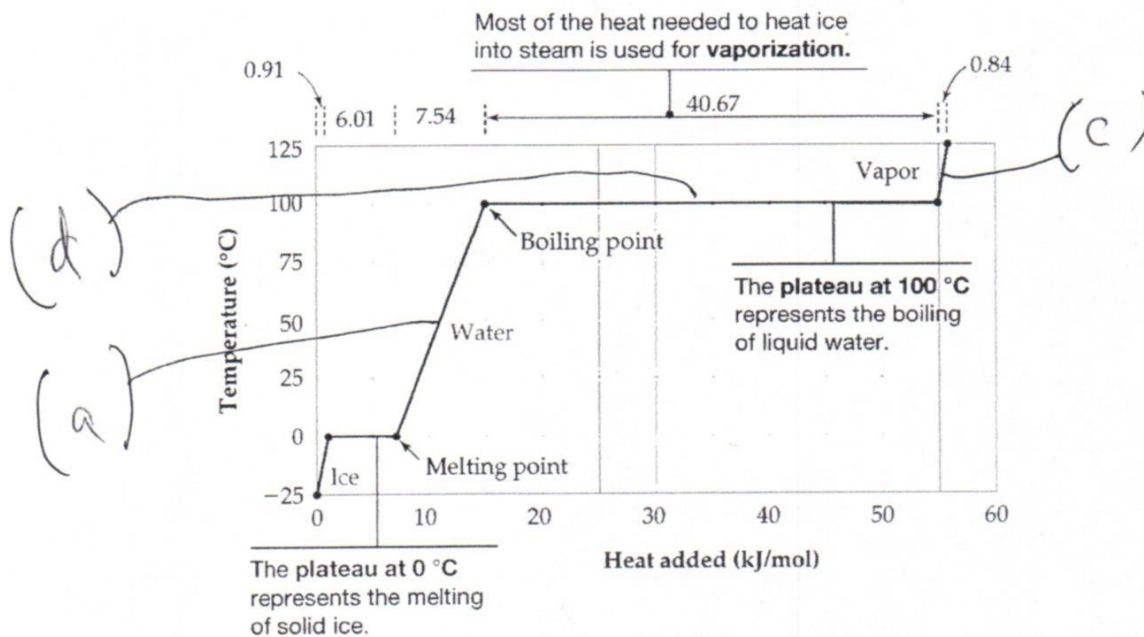
$\div 2$



backward
-1/2 Rxn sign
3pt
3pt
3pt

4 For the plot of the temperature of water with heat, match the parts of the plot with the possible equations given below by filling in the blank with the letter of the equation. **Each blank will only have ONE letter which matches.** (6 pts, 2 pts each blank)

- (a) $q = n C_{(\text{liquid water})} \Delta T$ (b) $q = n C_{(\text{ice})} \Delta T$ (c) $q = n C_{(\text{steam})} \Delta T$ (d) $q = n \Delta H_{\text{vap}}$ (e) $q = n \Delta H_{\text{fusion}}$



Name Key (print) Name _____ (sign)

Please show work for partial credit and full credit on the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If you run out of space, continue on the empty back pages but clearly label where the remaining answers can be found. (Please count your exam pages and make sure there are 5 pages) For the multiple choice, put the Test Form number (CA or CB) on the scantron and be sure to fully erase any wrong answer pencil marks, and fully mark your correct answers.

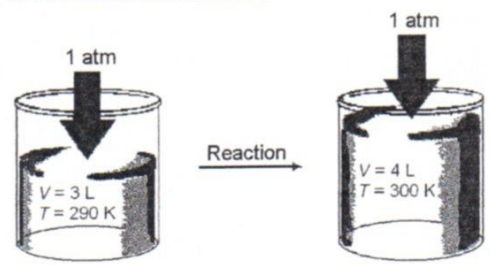
$q = m C \Delta T$ $q = n C \Delta T$ $q = n \Delta H_{\text{vap}}$ $\Delta H^\circ = \Delta H^\circ_f(\text{products}) - \Delta H^\circ_f(\text{reactants})$
 $\text{work} = -P \Delta V$, 1 Liter atm = 101.33 Joule $\Delta G = \Delta H - T \Delta S$ $K = ^\circ\text{C} + 273.15$

pink
 MC same as CA
 Scrambled

MULTIPLE CHOICE. Choose the one best alternative.

1) When a substance melts at its normal melting point, the sign of ΔH is _____ and the sign of ΔS of this phase change is _____.
 A) -, + B) +, + C) -, - D) +, - 1) B

2) Imagine a reaction that results in a change in both volume and temperature, as shown in the diagram below. What is the sign of the work being done and the sign of the enthalpy change involved in this reaction? 2) D



- A) $w = +$ and $\Delta H = +$ B) $w = +$ and $\Delta H = -$
 C) $w = -$ and $\Delta H = +$ D) $w = -$ and $\Delta H = -$

3) The normal boiling point for HBr is higher than the normal boiling point for HCl. This can be explained by
 A) larger dipole-dipole forces for HBr.
 B) larger dipole-dipole forces, larger dispersion forces, and larger hydrogen-bond forces for HBr.
 C) larger hydrogen-bond forces for HBr.
 D) larger dispersion forces for HBr. 3) D

4) Calculate the work, w , gained or lost by the system when a gas expands from 15 L to 35 L against a constant external pressure of 1.5 atm. (1 L · atm = 101 J) ($w = -P\Delta V$)
 A) +3.0 kJ B) -5.3 kJ C) +5.3 kJ D) -3.0 kJ 4) D

- 5) Which combination always results in a reaction being spontaneous? 5) C
 A) ΔH is negative and ΔS is negative. B) ΔH is positive and ΔS is positive.
 C) ΔH is negative and ΔS is positive. D) ΔH is positive and ΔS is negative.
- 6) For a process at constant pressure, 6) D
 A) $\Delta E = q$ and $w = 0$. B) $\Delta E = w$ and $q = 0$.
 C) $\Delta E = \Delta H$. D) $\Delta H = q$.
- 7) Which of the following is expected to have the greatest viscosity? 7) D
 A) C_5H_{12} B) C_6H_{14} C) CH_4 D) $C_5H_{11}OH$
- 8) For most chemical reactions 8) C
 A) ΔH is much larger than ΔE .
 B) ΔH is equal to ΔE .
 C) the difference between ΔH and ΔE is very small.
 D) ΔE is much larger than ΔH .
- 9) The first law of thermodynamics 9) A
 A) is a statement of conservation of energy.
 B) defines water energy.
 C) defines energy.
 D) provides a criterion for the spontaneity of a reaction.
- 10) Which of the following compounds has the highest boiling point? 10) B
 A) CH_3CH_2OH B) $HOCH_2CH_2OH$
 C) $H_3C-O-CH_3$ D) $CH_3CH_2CH_2CH_3$
- 11) Given: $4 NO_2(g) + O_2(g) \rightarrow 2 N_2O_5(g)$ $\Delta H^\circ = -110.2 \text{ kJ}$ 11) B
 find ΔH° for $8 N_2O_5(g) \rightarrow 16 NO_2(g) + 4 O_2(g)$.
 A) -220.4 kJ B) 440.8 kJ C) -440.8 kJ D) 220.4 kJ
- 12) Which of the following states the first law of thermodynamics (conservation of energy)? 12) A
 A) $\Delta E_{\text{system}} = -\Delta E_{\text{surroundings}}$ B) $\Delta H = \Delta E + P\Delta V$
 C) $q = sm\Delta T$ D) $w = -P\Delta V$
- 13) Which of the following can be interpreted as a measure of randomness? 13) D
 A) temperature B) free energy C) enthalpy D) entropy

14) Determine the sign of ΔS° for each of the following:

14) B

- I. $\text{C}_6\text{H}_6(\text{s}) \rightarrow \text{C}_6\text{H}_6(\text{l})$
II. $2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{SO}_3(\text{g})$

- A) ΔS° should be positive for I and positive for II.
B) ΔS° should be positive for I and negative for II.
C) ΔS° should be negative for I and positive for II.
D) ΔS° should be negative for I and negative for II.

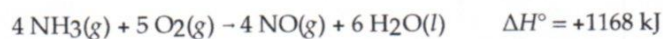
15) The enthalpy of fusion, or heat of fusion (ΔH_{fusion}), of water is positive and corresponds to which physical change?

15) D

- A) $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{s})$ B) $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{s})$
C) $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{g})$ D) $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$

16) How much heat is absorbed/released when 10.00 g of $\text{NH}_3(\text{g})$ reacts in the presence of excess $\text{O}_2(\text{g})$ to produce $\text{NO}(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ according to the following chemical equation? (formula mass of $\text{NH}_3 = 17.04 \text{ g/mol}$)

16) A



- A) 171.5 kJ of heat are absorbed. B) 686.0 kJ of heat are absorbed.
C) 171.5 kJ of heat are released. D) 686.0 kJ of heat are released.

Part II: Short Answers

Please show work on all questions for partial credit even on questions which do not specify. (40 total pts)

Hint: Please watch the units on all work to ensure that your answer is correct.

$$q = m C \Delta T \quad q = n C \Delta T \quad q = n \Delta H_{\text{vap}} \quad \Delta H^\circ = \Delta H^\circ_f(\text{products}) - \Delta H^\circ_f(\text{reactants})$$

$$\text{work} = -P \Delta V, 1 \text{ Liter atm} = 101.33 \text{ Joule} \quad \Delta G = \Delta H - T \Delta S \quad K = ^\circ\text{C} + 273.15$$

1. a. You do a reaction in a calorimeter with 350.9 grams of water. The reaction results in a temperature change from 41.5 °C to 95.6 °C. Assuming that the calorimeter has a negligible effect on the heat and the specific heat of water is a good approximation for the specific heat of the reaction solution. What is the heat (q) generated? [$q = m C \Delta T$, $C(\text{water}) = 4.18 \text{ J}/(\text{g } ^\circ\text{C})$] (10 pts)

$$q = (350.9 \text{ g}) (4.18 \frac{\text{J}}{\text{g } ^\circ\text{C}}) (95.6^\circ\text{C} - 41.5^\circ\text{C})$$

$$q = 79351.824 \text{ J} = 79.4 \text{ kJ}$$

math -1

sign - 1/2 pt

wrong unit
-2

- b. What is the enthalpy change (ΔH) for the reaction which you did in the calorimeter? (2 pts)

$$\Delta H = -79.4 \text{ kJ}$$

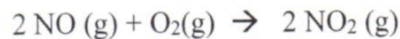
sign - 1/2

- c. what is the system? [(water & calorimeter assembly) or (reaction)] (circle one) (2 pts)

backward -1

2. Given the following enthalpy of formation, what is the enthalpy of the reaction at standard conditions.

$$[\Delta H^\circ = \Delta H^\circ_f(\text{products}) - \Delta H^\circ_f(\text{reactants})] \text{ (10 pts)}$$



$$\Delta H^\circ_f [\text{NO}(\text{g})] = 90.37 \text{ kJ/mol}$$

$$\Delta H^\circ_f [\text{NO}_2(\text{g})] = 33.8 \text{ kJ/mol}$$

$$\Delta H^\circ = 2 \Delta H^\circ_f [\text{NO}_2(\text{g})] - \{ 2 \Delta H^\circ_f [\text{NO}(\text{g})] + 0 \}$$

$$\Delta H^\circ = 2(33.8 \text{ kJ}) - 2(90.37 \text{ kJ})$$

$$\Delta H^\circ = -113.14 \text{ kJ}$$

$$-113.1 \text{ kJ}$$

made up # for O2 to

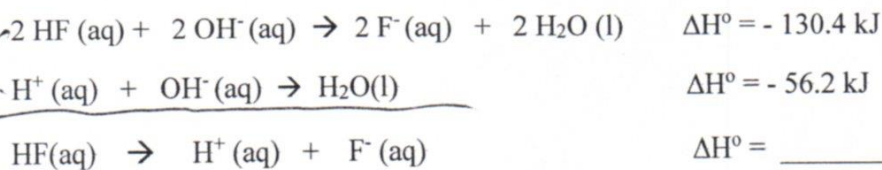
algebra -2

math +1

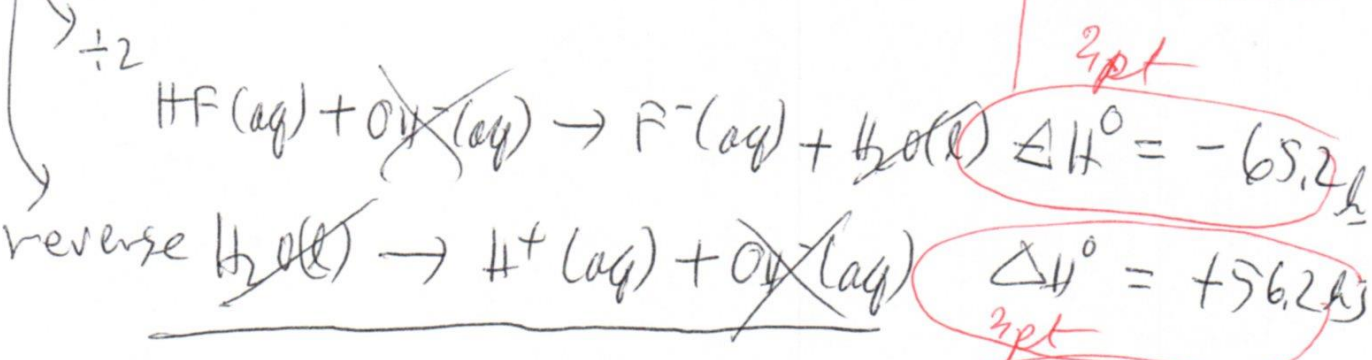
sign - 1/2

left off -1

3. Given the following reactions and the enthalpies for the reaction as noted, what is the enthalpy of the reaction given? (Hess' Law) (10 pts)

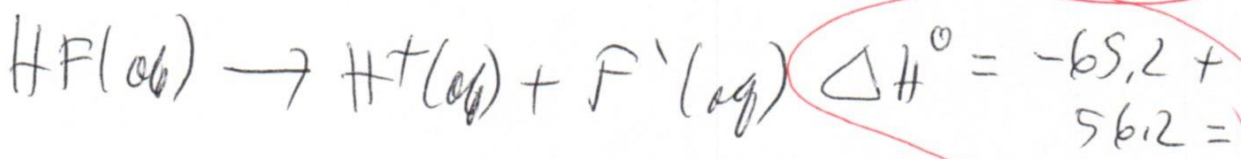


backward or not divide -1/2



2pt

$\Delta H^\circ = -65.2 + 56.2 =$

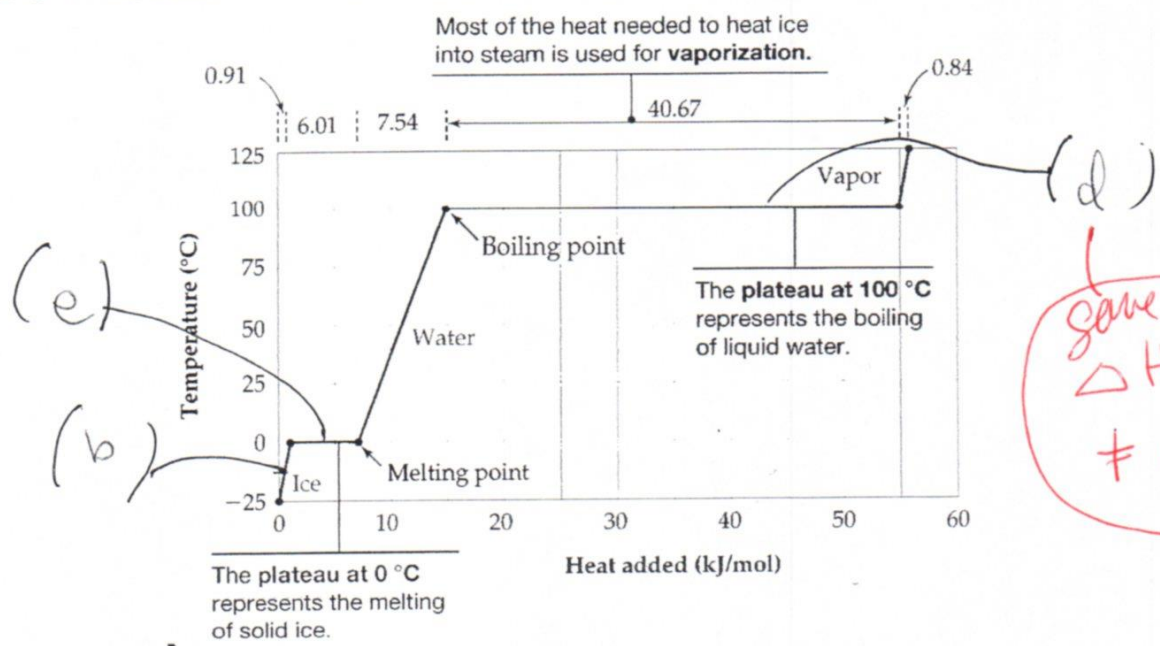


4 For the plot of the temperature of water with heat, match the parts of the plot with the possible equations given below by filling in the blank with the letter of the equation. **Each blank will only have ONE letter which matches.** (6 pts, 2 pts each blank)

-9pt

- (a) $q = n C_{(\text{liquid water})} \Delta T$ (b) $q = n C_{(\text{ice})} \Delta T$ (c) $q = n C_{(\text{steam})} \Delta T$ (d) $q = n \Delta H_{\text{vap}}$ (e) $q = n \Delta H_{\text{fusion}}$

3pt



gave written ΔH_{vap} $\neq n \Delta H_{\text{vap}}$