

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)

NA = not attempted

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 22 pts total)

NW = no work

- 1) The specific heat capacity of liquid mercury is $0.14 \text{ J/g}^\circ\text{C}$. 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 ? 1) D

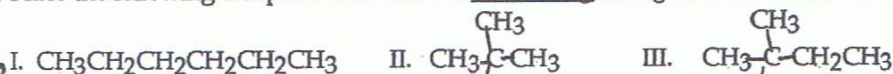
- A) 36 J
B) 1.7 J
C) 0.0013 J
D) 15 J
E) $7.7 \times 10^2 \text{ J}$

$$q = m c \Delta T$$

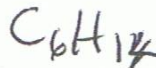
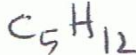
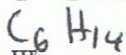
$$q = (5.00 \text{ g})(0.14 \text{ J/g}^\circ\text{C})(36.5 - 15.0)$$

$$q = 15 \text{ J}$$

- 2) Place the following compounds in order of decreasing strength of intermolecular forces. 2) C



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



all dispersion forces

smallest

so smallest intermolecular force

- 3) How much energy is required to vaporize 48.7 g of dichloromethane (CH_2Cl_2) at its boiling point, if its ΔH_{vap} is 31.6 kJ/mol ? (formula mass of $\text{CH}_2\text{Cl}_2 = 85.03 \text{ g/mol}$) 3) D

- A) 55.1 kJ B) 15.4 kJ C) 31.2 kJ D) 18.1 kJ E) 6.49 kJ

- 4) Which one of the following has a low density? 4) C

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

best overlap - higher intermolecular force

$$48.7 \text{ g CH}_2\text{Cl}_2 \times \frac{1 \text{ mol CH}_2\text{Cl}_2}{85.03 \text{ g CH}_2\text{Cl}_2} = 0.573 \text{ mol}$$

$$q = (0.573 \text{ mol})(31.6 \text{ kJ/mol}) = 18.1 \text{ kJ}$$

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

5) E



- A) CH₃CH₃ < CH₄ < CH₃CH₂CH₃
 B) CH₃CH₂CH₃ < CH₄ < CH₃CH₃
 C) CH₄ < CH₃CH₂CH₃ < CH₃CH₃
 D) CH₃CH₂CH₃ < CH₃CH₃ < CH₄
 E) CH₄ < CH₃CH₃ < CH₃CH₂CH₃

larger molar mass - larger intermolecular force

6) Calculate the amount of heat (in kJ) required to raise the temperature of a 79.0 g sample of ethanol from 24.9 °C to 111.9 °C. The specific heat capacity of ethanol is 2.42 J/g°C.

6) E

- A) 73.6 kJ B) 12.9 kJ C) 28.4 kJ D) 57.0 kJ E) 16.6 kJ

7) Which of the following statements is TRUE?

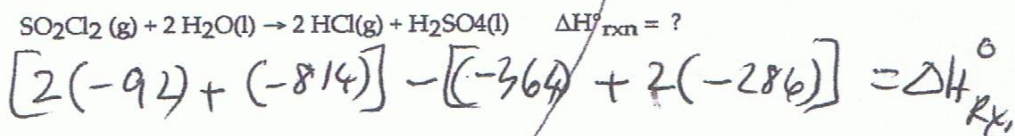
7) E

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

8) Use the ΔH_f° information provided to calculate $\Delta H_{\text{rxn}}^\circ$ for the following:

8) B

ΔH_f° (kJ/mol)	
-364	SO ₂ Cl ₂ (g)
-286	H ₂ O(l)
-92	HCl(g)
-814	H ₂ SO ₄ (l)



- A) +161 kJ B) -62 kJ C) -422 kJ D) -256 kJ E) +800. kJ

9) Define boiling.

9) B

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

10) Define sublimation.

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

$q = mc\Delta T$
 $q = (79.0 \text{ g}) \left(\frac{2.42 \text{ J}}{\text{g}^\circ\text{C}} \right) (111.9 - 24.9)$

10) B

11) Identify a substance that is not in its standard state.

- A) Ne B) O₃ C) Ca D) O₂ E) H₂(g)

11) E

accepted (B) or (E) bc did not discuss O₃

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (51 pts)

12)

1. For the element P (phosphorus) (2 pts each, 10 pts)

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

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

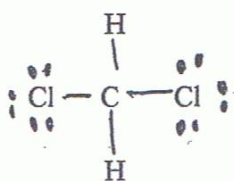
The electron configuration is 1s², 2s², 2p⁶, 3s², 3p³ (use notation 1s², etc)

The valence electron configuration is 3s², 3p³ (use notation 1s², etc)

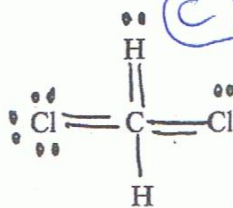
2. a. What is the number of valence electrons in the molecule Cl₂ H₂ C (show work) 20 3 pts

$$2(7e) + 2(1e) + 4 = 20$$

b. Which of the following is a correct Lewis Dot structure for the molecule Cl₂ H₂ C Circle the number of the correct Lewis Dot structure (3 pts)



10 x 2 = 20e
(1)



(2)

C has more than octet
too many e
H has more than duet

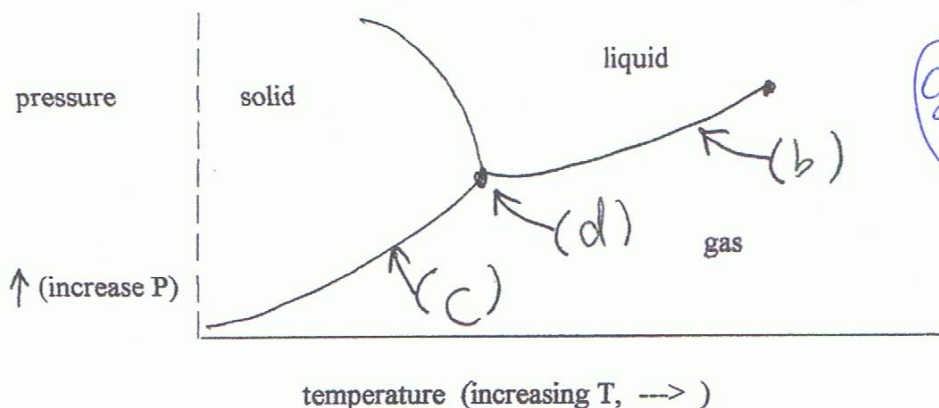
$$12 \times 2 = 24e$$

only elements in period 3 + higher can expand octet

3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (2 pts each, 6 pts)

(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to liquid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point

solid

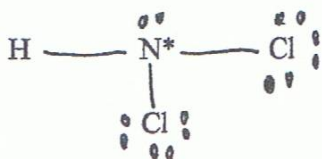


gave extra
wrong -1

as in
b+c

in one
blank

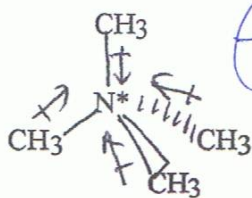
4. Given the correct Lewis Dot Structure below, (2 pts each, 8 pts)



- The number of electron pairs around the atom with the * is 4.
- The geometry of the electrons around the atom with the * is tetrahedral.
- The number of lone pairs on the atom with the * is 1.
- the VSEPR shape of the molecule is trigonal pyramidal.

reversed
-2

5. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPR shape of the molecule at the * is tetrahedral (4 pts each, 16 pts)

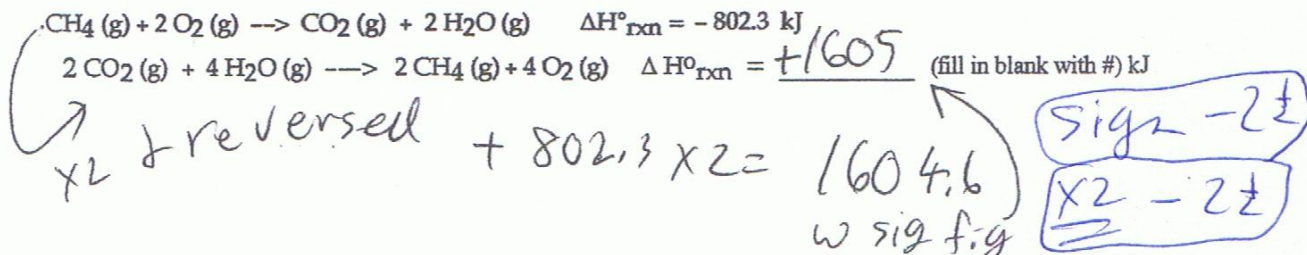


each vector -1 pt.
wrong direction -1 each

- a. Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like $\text{+} \longrightarrow$)
- 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)

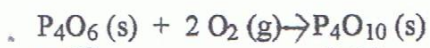
d. The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)

6. Given the following reaction, and the enthalpy associated with the reaction, if you rewrite the reaction as shown, what is the new enthalpy for the newly written reaction? (show work) (5 pts)

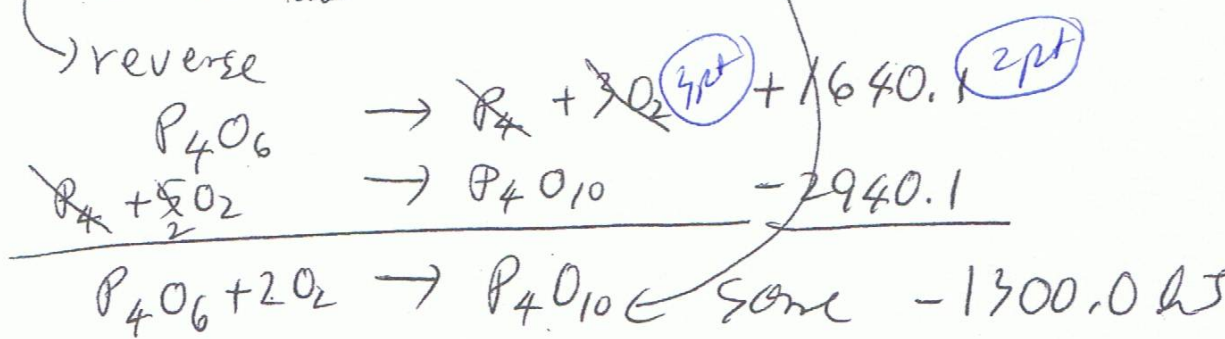
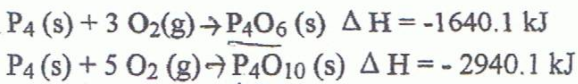


Part III Long Answer: Show all work for full credit and for partial credit. (26 pts)

1. a. Apply Hess's Law to the following to calculate ΔH for the reaction. (10 pts)



given the following reactions and enthalpies



correct rxn 3 pt each
 correct # 2 pt each

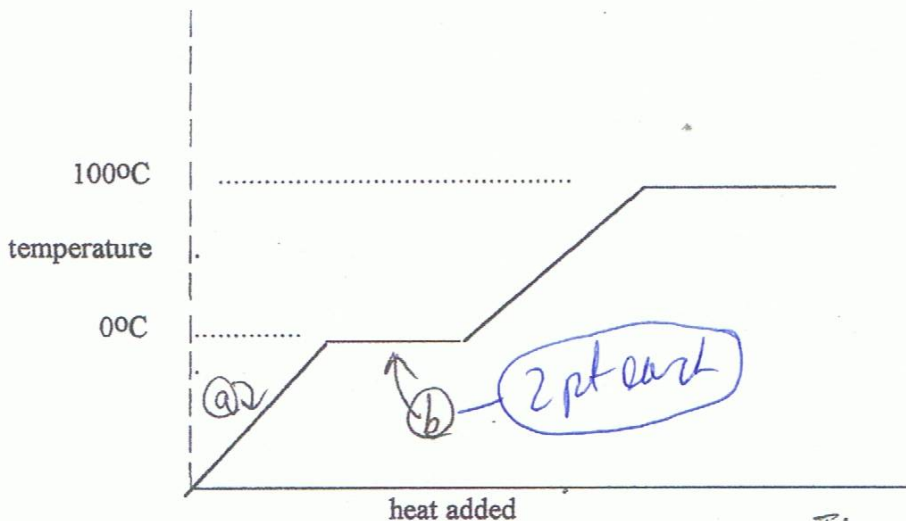
bad attempt (-8)
 good attempt (-6)
 (added ΔH together)
 final sign wrong (-1)
 did not final sum (-2)
 math (-1)

heat is leaving
 from rxn
 |
 exothermic

b. Based on your calculated enthalpy, is the reaction [(endothermic) or (exothermic)] (2 pts)(circle one)

either graded
consistent w yours @ or
ok if guessed

2. For the following chart for the interconversion of water under Pressure = 1.00 atm,



Part 1: What is the heat needed (a) to warm 14.5 grams ice from -15°C to 0°C and then (b) to melt the ice? ($q = m C \Delta T$, $C_{\text{ice}} = 2.09 \text{ J/g}^{\circ}\text{C}$, $q = n \Delta H_{\text{fusion}}$, $\Delta H_{\text{fusion}} = 6.02 \text{ kJ/mol}$, molar mass of water = 18.02 g/mol) (10 pts)

$$\textcircled{a} q = (14.5 \text{ g}) (2.09 \text{ J/g}^{\circ}\text{C}) (0 - (-15)) = 455 \text{ J}$$

warm

$$\text{for } q \text{ melt} \quad 14.5 \text{ g} \times \frac{\text{mol}}{18.02 \text{ g}} = 0.805 \text{ mol}$$

$$455 \text{ J} \times \frac{\text{kJ}}{1000 \text{ J}}$$

$$\textcircled{b} q = (0.805 \text{ mol}) (6.02 \frac{\text{kJ}}{\text{mol}}) = 4.85 \text{ kJ}$$

melt

Part 2: label the graph above with (a) and (b) for your (a) and (b) which you calculated above. by drawing an arrow to parts of the graph above and labeling with (a) & (b). (4 pts)

(a) 5 pts. (b) 5 pts in part 1 NW = 1/2 off
50% off

5 pts (a) $q_{\text{warm}} = (14.5 \text{ g}) \left(2.09 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}} \right) [0 - (-15^\circ\text{C})] =$
 $455 \text{ J} \rightarrow 455 \text{ J} \times \frac{\text{kJ}}{1000 \text{ J}} = 0.455 \text{ kJ}$

5 pts (b) $14.5 \text{ g} \times \frac{\text{mol}}{18.02 \text{ g}} = 0.805 \text{ mol}$

$q_{\text{melt}} = (0.805 \text{ mol}) \left(6.02 \frac{\text{kJ}}{\text{mol}} \right) = 4.85 \text{ kJ}$

not mole used 1 mol -2
-2

bad attempt -8 math -1

heat for
warming +
melting
 $0.455 \text{ kJ} +$
 $4.85 \text{ kJ} =$
 5.31 kJ

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)

NA = not attempted

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 22 pts total)

NW = no work

1) Which of the following statements is TRUE?

1) E

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

2) Identify a substance that is not in its standard state.

2) A

- A) H Accepted B bc did not discuss O₃ B) O₃ C) Ca D) O₂ E) Ne

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

CH₄ CH₃CH₂CH₃ CH₃CH₃

- A) CH₃CH₃ < CH₄ < CH₃CH₂CH₃
 B) CH₄ < CH₃CH₂CH₃ < CH₃CH₃
 C) CH₃CH₂CH₃ < CH₄ < CH₃CH₃
 D) CH₄ < CH₃CH₃ < CH₃CH₂CH₃
 E) CH₃CH₂CH₃ < CH₃CH₃ < CH₄

larger molecular - larger dispersion force

4) Define boiling.

4) E

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

5) 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?

5) A

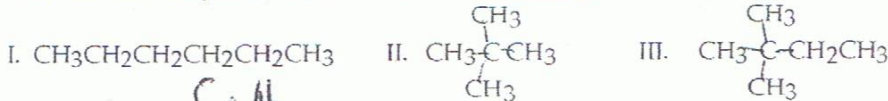
- A) 15 J
 B) 1.7 J
 C) 7.7×10^2 J
 D) 36 J
 E) 0.0013 J

$$q = m C \Delta T \quad \Delta T = 36.5 - 15.0$$

$$q = (5.00 \text{ g}) \left(\frac{0.14 \text{ J}}{\text{g}^\circ\text{C}} \right) (36.5 - 15.0)$$

6) How much energy is required to vaporize 48.7 g of dichloromethane (CH_2Cl_2) at its boiling point, if its ΔH_{vap} is 31.6 kJ/mol? (formula mass of $\text{CH}_2\text{Cl}_2 = 85.03 \text{ g/mol}$) 6) E
 A) 15.4 kJ B) 6.49 kJ C) 55.1 kJ D) 31.2 kJ E) 18.1 kJ

7) Place the following compounds in order of decreasing strength of intermolecular forces.



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

C_6H_{14}

C_5H_{12}

C_6H_{14}

smallest
 so smallest
 intermolecular
 force

more branched
 less intermolecular
 force

all dispersion

8) Which one of the following has a low density?

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

$q = (0.573 \text{ mol})(31.6 \text{ kJ/mol}) = 18.1 \text{ kJ}$

$48.7 \text{ g} \times \frac{\text{mol}}{85.03 \text{ g}} = 0.573 \text{ mol}$

9) Calculate the amount of heat (in kJ) required to raise the temperature of a 79.0 g sample of ethanol from 24.9 °C to 111.9 °C. The specific heat capacity of ethanol is 2.42 J/g°C.

- A) 16.6 kJ B) 28.4 kJ C) 57.0 kJ D) 12.9 kJ E) 73.6 kJ

10) Define sublimation.

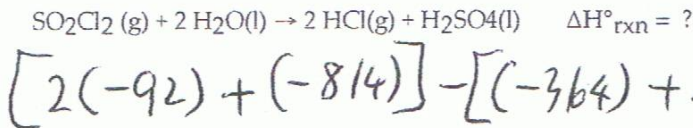
- A) the phase transition from solid to gas
 B) the phase transition from liquid to solid
 C) the phase transition from liquid to gas
 D) the phase transition from gas to solid
 E) the phase transition from gas to liquid

$q = mc\Delta T$

$q = (79.0 \text{ g})(2.42 \frac{\text{J}}{\text{g}^\circ\text{C}})(111.9 - 24.9)$

11) Use the ΔH_f° information provided to calculate $\Delta H_{\text{rxn}}^\circ$ for the following:

	ΔH_f° (kJ/mol)
$\text{SO}_2\text{Cl}_2(\text{g})$	-364
$\text{H}_2\text{O}(\text{l})$	-286
$\text{HCl}(\text{g})$	-92
$\text{H}_2\text{SO}_4(\text{l})$	-814



$[2(-92) + (-814)] - [(-364) + 2(-286)] = \Delta H_{\text{rxn}}^\circ$

- A) +161 kJ B) +800. kJ C) -422 kJ D) -62 kJ E) -256 kJ

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (51 pts)

12)

1. For the element S (sulfur) (2 pts each, 10 pts)

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

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

The electron configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^4$

The valence electron configuration is $3s^2, 3p^4$

accepted 16

sign -1

said $2p^3$ instead of $3p^3$ -1

not valence -1

$3s^2, 3p^4$

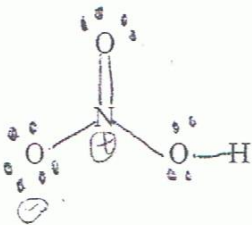
left off -1

2. a. What is the number of valence electrons in the molecule HNO_3 (show work) 24 3 pts

$$1e + 5e + 3(6e) = 24$$

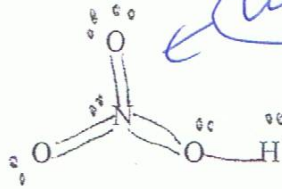
wrong # valence e on one atom -1

b. Which of the following is a correct Lewis Dot structure for the molecule HNO_3 Circle the number of the correct Lewis Dot structure (3 pts)



(1)

$$12 \times 2 = 24e$$



(2)

$$13 \times 2 = 26e$$

wrong # e

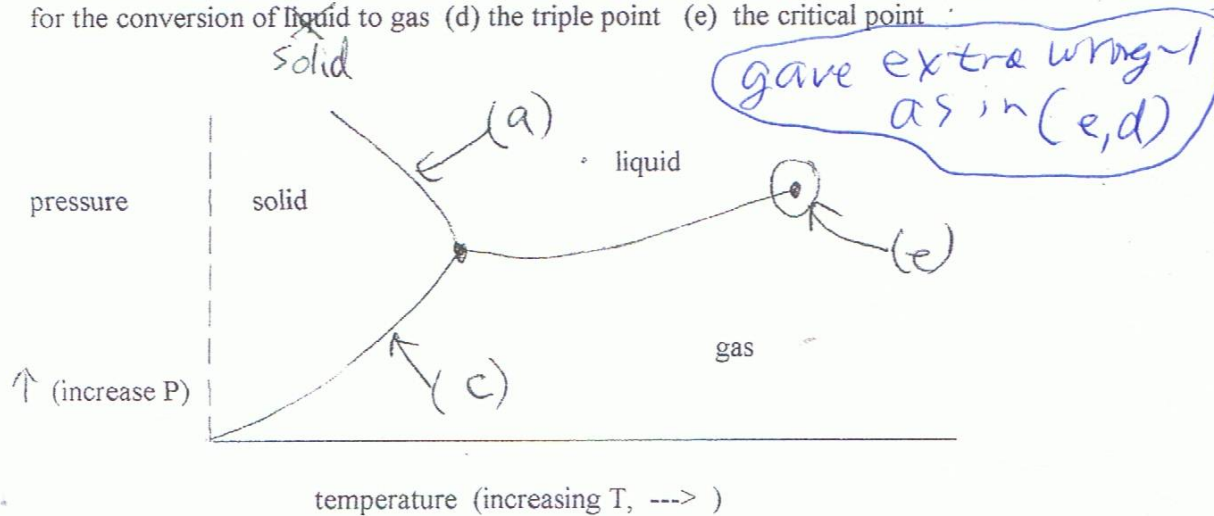
N has more than octet
H has more than duet

only elements in period 3 + higher can expand octet

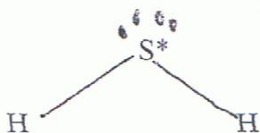
wrong work -1 pt
NW -2
math 1/2

3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (2 pts each, 6 pts)

(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to liquid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point



4. Given the correct Lewis Dot Structure below, (2 pts each, 8 pts)



The number of electron pairs around the atom with the * is 4.

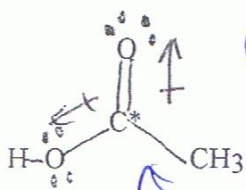
The geometry of the electrons around the atom with the * is tetrahedral.

The number of lone pairs on the atom with the * is 2.

the VSEPR shape of the molecule is bent.

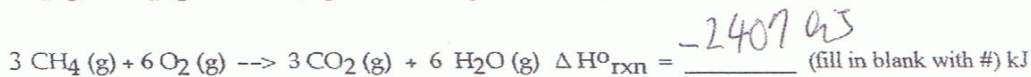
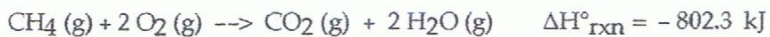
reversed
-2

5. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPR shape of the molecule at the * is trigonal planar (4 pts each, 16 pts)



each vector -1pt
 wrong direction -1 each
 gave vector here -1

- a. Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like \rightarrow)
- 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)
6. Given the following reaction, and the enthalpy associated with the reaction, if you rewrite the reaction as shown, what is the new enthalpy for the newly written reaction? (5 pts)



$$3(-802.3) = -2406.9 \text{ kJ}$$

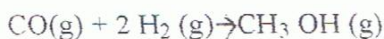
w sig. fig

$$-2407 \text{ kJ}$$

sign -2 ±
x 3 -2 ±

Part III Long Answer: Show all work for full credit and for partial credit. (26 pts)

1. a. Apply Hess's Law to the following to calculate ΔH for the reaction. (10 pts)



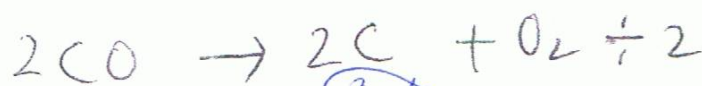
given the following reactions and enthalpies



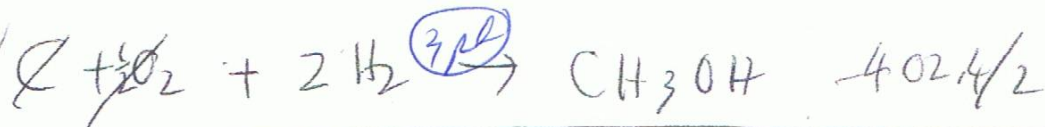
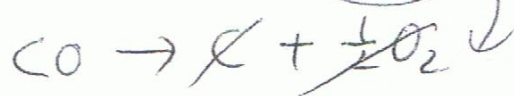
→ graded consistent w your @ or OK if guessed

b. Based on your calculated enthalpy, is the reaction [(endothermic) or (exothermic)] (2 pts)
(circle one)

reverse
 Correct rxn 3 pt each
 Correct # 2 pt each



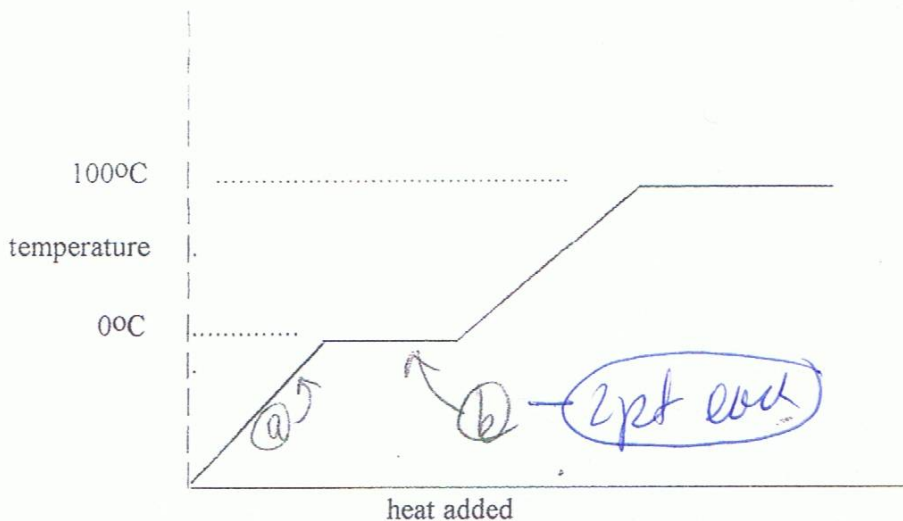
+221.0/2



$$+110.5 - 201.2 = -90.7 \text{ kJ}$$

bad attempt -8
 good attempt -6
 (add ΔH together)
 final sign wrong -1
 did not final sum -2
 math -1

2. For the following chart for the interconversion of water under Pressure = 1.00 atm.



NW - 50% off

math -1

- Part 1: What is the heat needed (a) to warm 25.9 grams ice from $-30\text{ }^{\circ}\text{C}$ to $0\text{ }^{\circ}\text{C}$ and then (b) to melt the ice? ($q = m C \Delta T$, $C_{\text{ice}} = 2.09\text{ J/g}^{\circ}\text{C}$, $q = n \Delta H_{\text{fusion}}$, $\Delta H_{\text{fusion}} = 6.02\text{ kJ/mol}$, molar mass of water = 18.02 g/mol) (10 pts)

$$q_{\text{sum}}(\text{warm} + \text{melt}) = 10.29\text{ kJ} + 1.623\text{ kJ} = 11.91\text{ kJ}$$

- Part 2: label the graph above with (a) and (b) for your (a) and (b) which you calculated above. by drawing an arrow to parts of the graph above and labeling with (a) & (b). (4 pts)

$$q = m C \Delta T$$

wrong mass -2

bad attempt -8

5pts

$$q_{\text{warm}} = (25.9\text{ g}) \left(\frac{2.09\text{ J}}{\text{g}^{\circ}\text{C}} \right) [0^{\circ}\text{C} - (-30)] = 1623\text{ J} = 1.623\text{ kJ}$$

$$25.9\text{ g ice} \times \frac{\text{mol ice}}{18.02\text{ g}} = 1.44\text{ mol ice}$$

not mol -2, used 1 mol -2

5pts

$$q_{\text{melt}} = (1.44\text{ mol ice}) \left(6.02 \frac{\text{kJ}}{\text{mol}} \right) = 8.67\text{ kJ}$$

10.29 kJ

Name Key (print) Name _____ (sign)

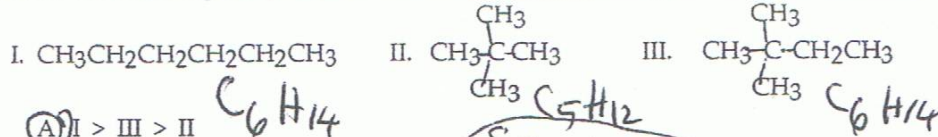
Please show work for partial credit on the Long Answers and in some of the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

NA = not attempted

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 22 pts total)

NW = no work

1) Place the following compounds in order of decreasing strength of intermolecular forces. 1) A



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

all dispersion

smallest 505 smallest intermolecular force

branched less intermolecular

2) Which one of the following has a definite shape and volume? 2) B

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

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



- A) $\text{CH}_4 < \text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_3$
- B) $\text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_4 < \text{CH}_3\text{CH}_3$
- C) $\text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_3 < \text{CH}_4$
- D) $\text{CH}_4 < \text{CH}_3\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_3$
- E) $\text{CH}_3\text{CH}_3 < \text{CH}_4 < \text{CH}_3\text{CH}_2\text{CH}_3$

larger has highest intermolecular force

4) 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 4) A

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

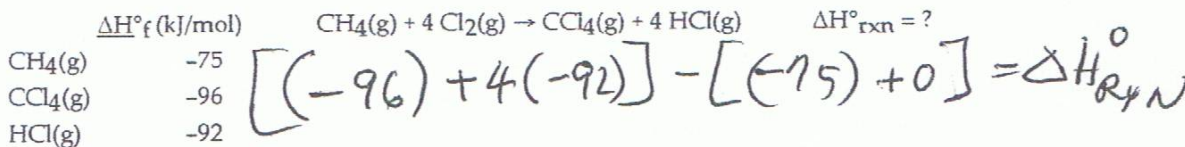
$$q = m C \Delta T$$

$$q = (47.8 \text{ g}) (1.05 \frac{\text{J}}{\text{g}^\circ\text{C}}) (57.0^\circ\text{C})$$

$$q =$$

5) Use the information provided to determine $\Delta H^\circ_{\text{rxn}}$ for the following reaction:

5) E



- A) -71 kJ B) -113 kJ C) +79 kJ D) +113 kJ **E) -389 kJ**

6) Define sublimation.

6) D

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

$$q = n \Delta H_{\text{vap}}$$

$$n = 158 \text{ g} \times \frac{\text{mol}}{58.14 \text{ g}} = 2.72 \text{ mol}$$

7) Define freezing.

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

$$q = (2.72 \text{ mol})(24.3 \frac{\text{kJ}}{\text{mol}})$$

8) How much energy is required to vaporize 158 g of butane (C₄H₁₀) at its boiling point, if its ΔH_{vap} is 24.3 kJ/mol? (formula mass of C₄H₁₀ = 58.14 g/mol)

8) C

- A) 38.4 kJ B) 89.4 kJ **C) 66.1 kJ** D) 15.1 kJ E) 11.2 kJ

9) Identify a substance that is not in its standard state.

- A) H₂ B) Ca C) O₂ **D) CO** E) Ne

9) D

10) The specific heat capacity of solid copper metal is 0.385 J/gK. How many joules of heat are needed to raise the temperature of a 1.55-kg block of copper from 33.0°C to 77.5°C?

10) C

- A) 26.6 J
 B) 5.58×10^{-6} J
C) 2.66×10^4 J
 D) 1.79×10^5 J
 E) 0.00558 J

$$1.55 \text{ kg} \times \frac{1000 \text{ g}}{\text{kg}} = 1.55 \times 10^3 \text{ g}$$

$$q = (1.55 \times 10^3 \text{ g}) \left(\frac{0.385 \text{ J}}{\text{g}^\circ\text{C}} \right) (77.5^\circ\text{C} - 33.0^\circ\text{C})$$

11) Which of the following statements is TRUE?

11) E

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

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (51 pts)

12) 1. For the element Cl (chlorine) (2 pts each, 10 pts)

The group number is VII A the charge for an ion (if one exists) is -1 = 7-8

The number of valence electrons (for a neutral atom) is 7

The electron configuration is 1s², 2s², 2p⁶, 3s², 3p⁵ (use notation 1s², etc)

The valence electron configuration is 3s², 3p⁵ (use notation 1s², etc)

2. a. What is the number of valence electrons in the molecule HNC₃ + 26 3

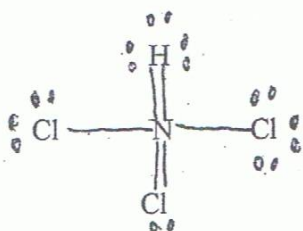
pts
(show work)

left off - 1

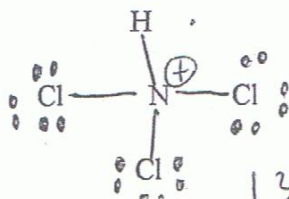
$$1e + 5e + 3(7e) = 27 - 1 = 26$$

H N C charge

b. Which of the following is a correct Lewis Dot structure for the molecule HNC₃ +
Circle the number of the correct Lewis Dot structure (3 pts)



(1)



(2)

$15 \times 2 = 30e$

wrong # e

N has more than octet
H has more than duet
only elements in period 3+ higher can expand octet

wrong # valence e on one atom - 1/2

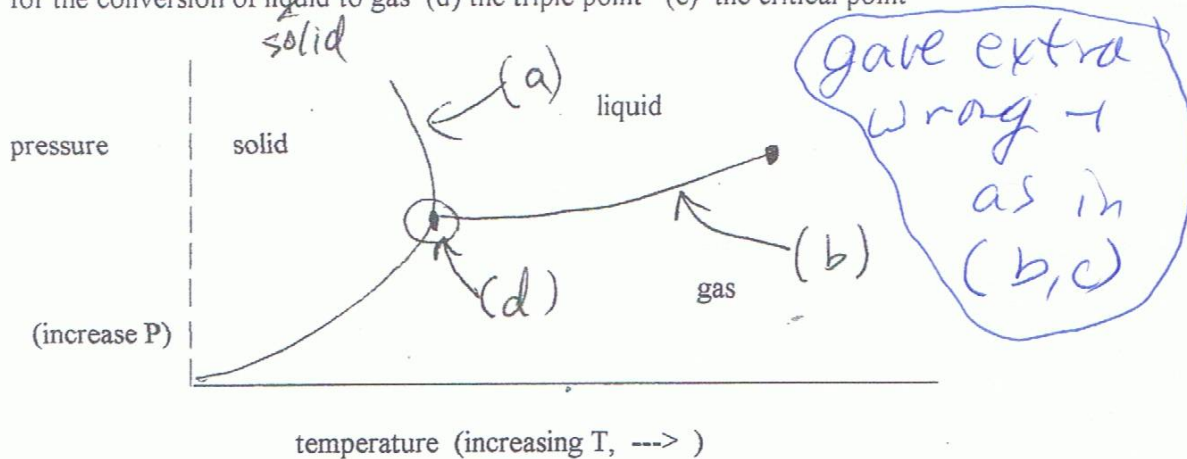
wrong work - 1/2

hw - 2

math - 1/2

3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (2 pts each, 6 pts)

(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to liquid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point



4. Given the correct Lewis Dot Structure below, (2 pts each, 8 pts)



The number of electron pairs around the atom with the * is 4

The geometry of the electrons around the atom with the * is tetrahedral

The number of lone pairs on the atom with the * is 2

the VSEPR shape of the molecule is bent

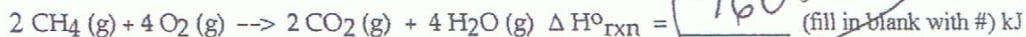
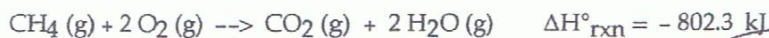
reversed
-2

5. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPR shape of the molecule at the * is bent (4 pts each, 16 pts)



- Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like $\text{---}+\text{-----}\text{---}$)
- The vector sum of the dipole moment for the molecule is (zero) or (not zero) (circle one)
- The molecule as a whole is (polar) or (nonpolar) (circle one)
- The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)

6. Given the following reaction, and the enthalpy associated with the reaction, if you rewrite the reaction as shown, what is the new enthalpy for the newly written reaction? (5 pts)



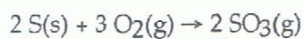
multiply by 2 \rightarrow

$$-802.3 \times 2 = \underline{-1604.6 \text{ kJ}}$$

sign	-2½
x 2	-2½

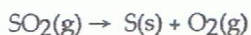
Part III Long Answer: Show all work for full credit and for partial credit. (26 pts)

1 a Apply Hess's Law to the following to calculate ΔH for the reaction. (10 pts)

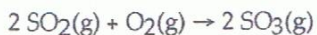


$$\Delta H^\circ_{\text{rxn}} = ?$$

Given:



$$\Delta H^\circ_{\text{rxn}} = +296.8 \text{ kJ}$$



$$\Delta H^\circ_{\text{rxn}} = -197.8 \text{ kJ}$$

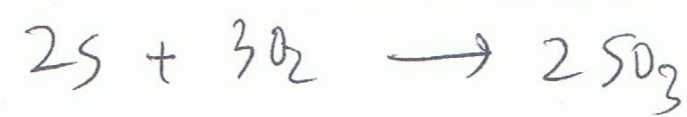
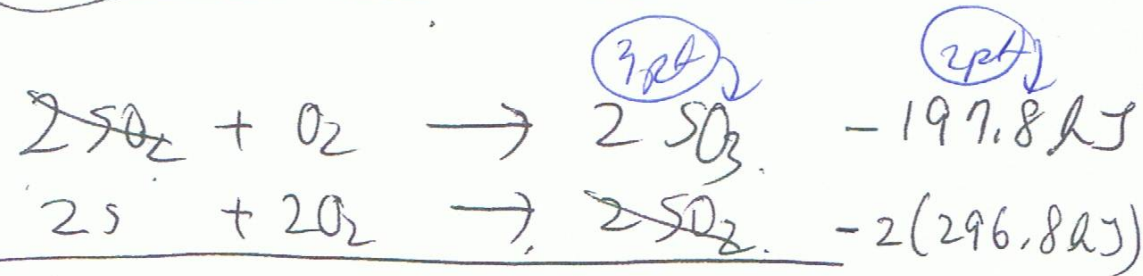
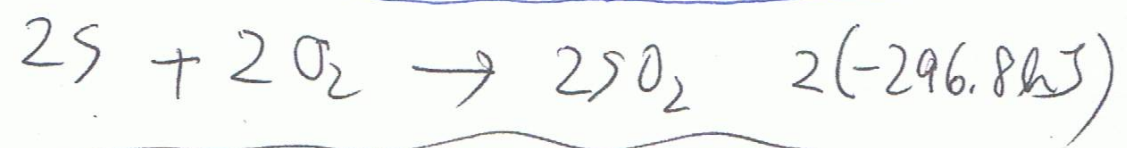
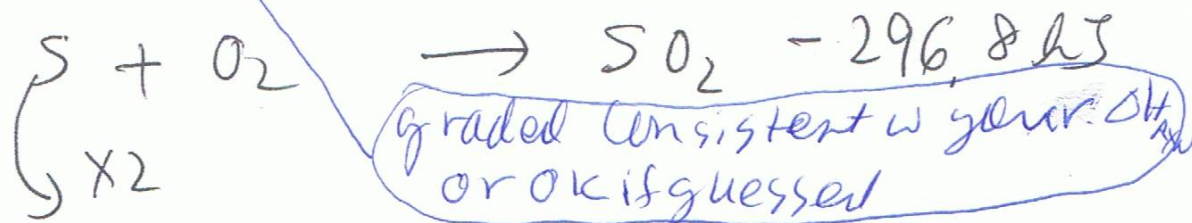
bad attempt - 8
 good attempt - 6
 added ΔH together
 final wrong sign - 1
 did not first sum - 2

b. Based on your calculated enthalpy, is the reaction [(endothermic) or (exothermic)] (2 pts)(circle one)

correct rxn 3pt each
 correct # 2pt

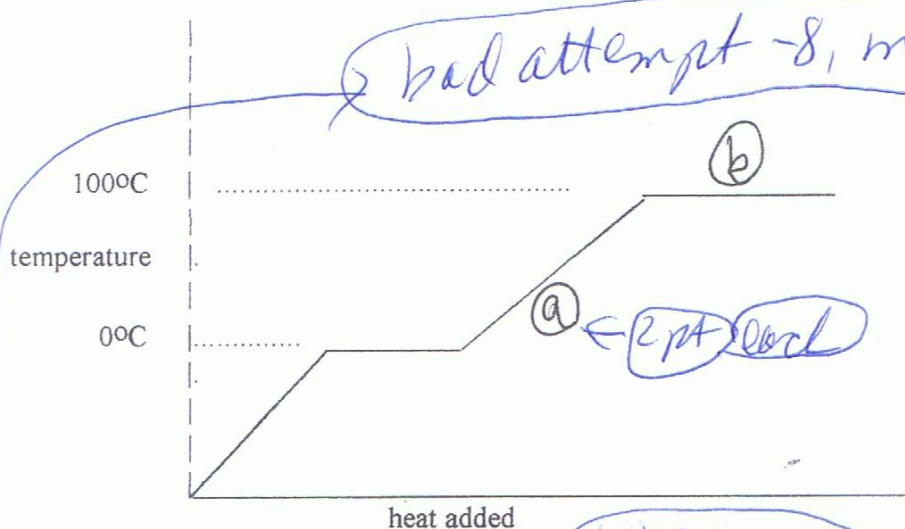
math +

reverse



$$\Delta H^\circ_{\text{rxn}} = -197.8 \text{ kJ} + (-593.6 \text{ kJ}) = -790.6 \text{ kJ}$$

2. For the following chart for the interconversion of water under Pressure = 1.00 atm,



Part 1: What is the heat needed (a) to warm 32.5 grams of water from 26.2 °C to 100.0 °C and then (b) to vaporize all of the water at 100°C ($q = m C \Delta T$, $C_{\text{water}} = 4.184 \text{ J/g}^\circ\text{C}$, $q = n \Delta H_{\text{vaporization}}$, $\Delta H_{\text{vaporization}} = 40.7 \text{ kJ/mol}$) (10 pts) (molar mass $\text{H}_2\text{O} = 18.02 \text{ g/mol}$)

Part 2: label the graph above with (a) and (b) for your (a) and (b) which you calculated above. by drawing an arrow to parts of the graph above and labeling with (a) & (b). (4 pts)

5pt

$$q = (32.5 \text{ g}) \left(\frac{4.184 \text{ J}}{\text{g}^\circ\text{C}} \right) (100.0 - 26.2)$$

$$q = 10035.3 \text{ J} \rightarrow 10035.3 \text{ J} \times \frac{\text{kJ}}{1000 \text{ J}} = 10.0 \text{ kJ}$$

$$32.5 \text{ g} \times \frac{\text{mol}}{18.02 \text{ g}} = 1.80 \text{ mol}$$

5pt

$$q = (1.80 \text{ mol}) (40.7 \text{ kJ/mol})$$

$$q = 73.3 \text{ kJ}$$

not mole -2
used 1 mol -2

$$\text{total } q = 10.0 \text{ kJ} + 73.3 \text{ kJ} = 83.3 \text{ kJ}$$

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)

NA = not attempted

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 22 pts total)

NW = no work

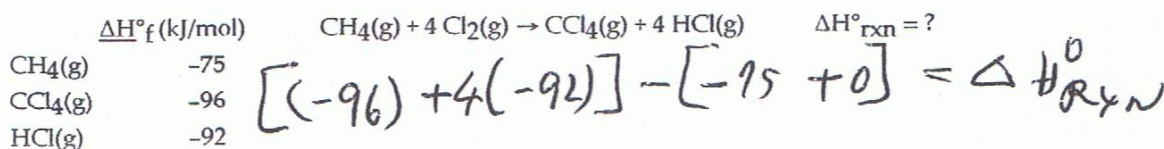
1) Define sublimation.

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

1) B

2) Which of the following statements is TRUE?

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

2) E3) Use the information provided to determine $\Delta H^{\circ}_{\text{rxn}}$ for the following reaction:

A) -113 kJ

B) +79 kJ

C) +113 kJ

D) -71 kJ

 E) -389 kJ3) E

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

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

4) A5) How much energy is required to vaporize 158 g of butane (C_4H_{10}) at its boiling point, if its ΔH_{vap} is 24.3 kJ/mol? (formula mass of C_4H_{10} = 58.14 g/mol)

A) 89.4 kJ

B) 11.2 kJ

C) 38.4 kJ

D) 15.1 kJ

 E) 66.1 kJ

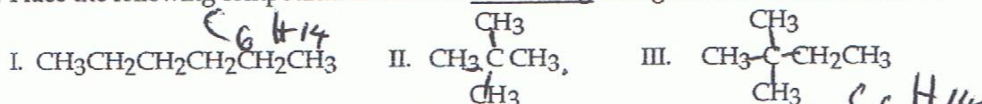
$$n = 158 \text{ g} \times \frac{\text{mol}}{58.14 \text{ g}} = 2.72 \text{ mol}$$

$$q = (2.72 \text{ mol}) \left(24.3 \frac{\text{kJ}}{\text{mol}} \right) =$$

5) E

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

6) E



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

$\uparrow \text{C}_5\text{H}_{12}$ (branched less dispersion)
 all dispersion
 smallest
 so smallest intermolecular force

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

7) B



- A) $\text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_3 < \text{CH}_4$
 B) $\text{CH}_4 < \text{CH}_3\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_3$
 C) $\text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_4 < \text{CH}_3\text{CH}_3$
 D) $\text{CH}_4 < \text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_3$
 E) $\text{CH}_3\text{CH}_3 < \text{CH}_4 < \text{CH}_3\text{CH}_2\text{CH}_3$

larger has highest intermolecular

8) Define freezing.

8) A

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

9) Identify a substance that is not in its standard state.

9) B

- A) O_2 B) CO C) Ne D) Ca E) H_2

not an element

10) 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

10) B

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

11) The specific heat capacity of solid copper metal is 0.385 J/gK. How many joules of heat are needed to raise the temperature of a 1.55-kg block of copper from 33.0°C to 77.5°C?

11) D

- A) $1.79 \times 10^5 \text{ J}$
 B) $5.58 \times 10^{-6} \text{ J}$
 C) 26.6 J
 D) $2.66 \times 10^4 \text{ J}$
 E) 0.00558 J

$$q = m c \Delta T$$

$$q = (47.8 \text{ g}) \left(1.05 \frac{\text{J}}{\text{g}^\circ\text{C}} \right) (57.0^\circ\text{C})$$

$$q = 2860.83 \text{ J}$$

$$\div 1000 \rightarrow 2.86 \text{ kJ}$$

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (51 pts)

12) 1. For the element Si (silicon) (2 pts each, 10 pts)

The group number is IVA the charge for an ion (if one exists) is -4 or +4 $4 - 8 = -4$

The number of valence electrons (for a neutral atom) is 4

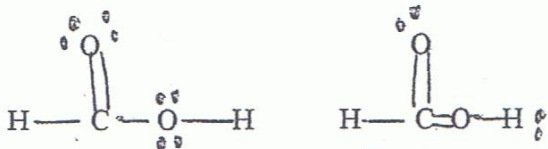
The electron configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^2$ (use notation $1s^2, etc$)

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

2. a. What is the number of valence electrons in the molecule H_2CO_2 18 3 pts (show work)

$$2(1e) + 4e + 2(6e) = 18$$

b. Which of the following is a correct Lewis Dot structure for the molecule H_2CO_2 Circle the number of the correct Lewis Dot structure (3 pts)



(1)

$$9 \times 2 = 18$$

(2) $8 \times 2 = 16$

too few e

C, & both O has less than octet, it has more than duet

accepted 14
said neutral OK

said $2p^2$ instead of $3p^3 - 1$

not valence -1

left out -1

wrong # valence e one atom -1

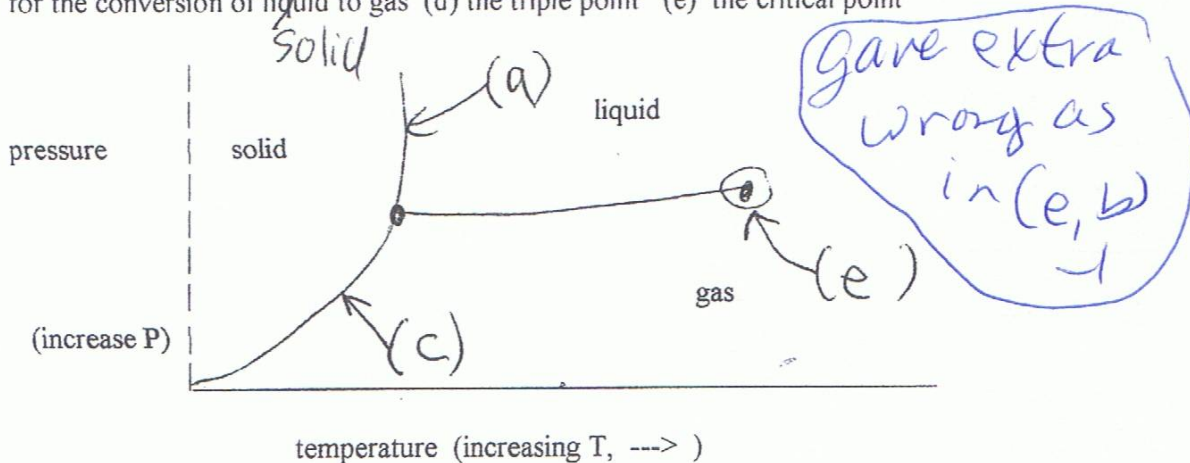
wrong work -1/2

NW -2

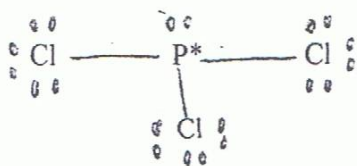
math -1

3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (2 pts each, 6 pts)

(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to liquid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point



4. Given the correct Lewis Dot Structure below, (2 pts each, 8 pts)



The number of electron pairs around the atom with the * is 4

The geometry of the electrons around the atom with the * is tetrahedral

The number of lone pairs on the atom with the * is 1

the VSEPR shape of the molecule is trigonal pyramidal

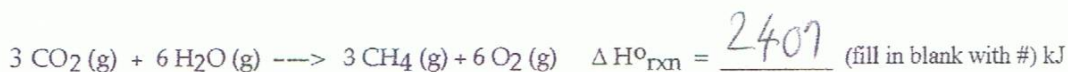
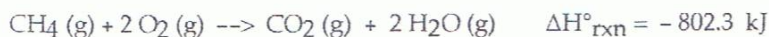
reversed
2
said trigonal -1

5. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPR shape of the molecule at the * is trigonal pyramidal (4 pts each, 16 pts)



each vector - 1 pt
wrong direction - 1/2 each

- Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like $\text{+} \text{-----} \text{>}$)
 - The vector sum of the dipole moment for the molecule is (zero) or (not zero) (circle one)
 - The molecule as a whole is (polar) or (nonpolar) (circle one)
 - The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)
6. Given the following reaction, and the enthalpy associated with the reaction, if you rewrite the reaction as shown, what is the new enthalpy for the newly written reaction? (5 pts)



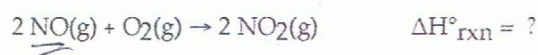
$\times 3$ & reversed

$$(+802.3) \times 3 = 2406.9 \text{ kJ}$$

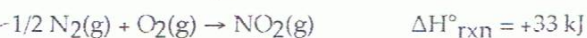
sign - 2 pt
not $\times 3$ - 2 pt

Part III Long Answer: Show all work for full credit and for partial credit. (26 pts)

1 a. Apply Hess's Law to the following to calculate ΔH for the reaction. (10 pts)



Given:

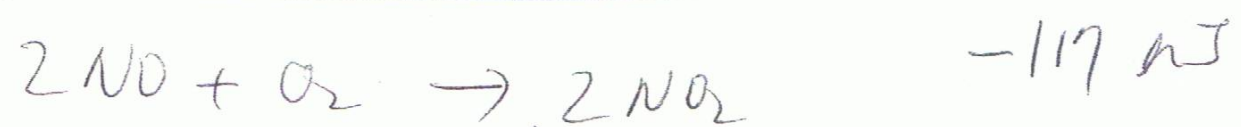
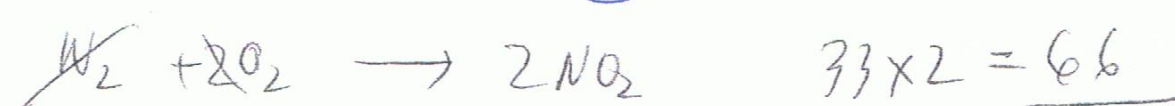


either graded consistent w yours @ or OK if guessed

b. Based on your calculated enthalpy, is the reaction [(endothermic) or (exothermic)] (2 pts)(circle one)

reverse

Correct rxn instead correct # 2pt each



bad attempt -8

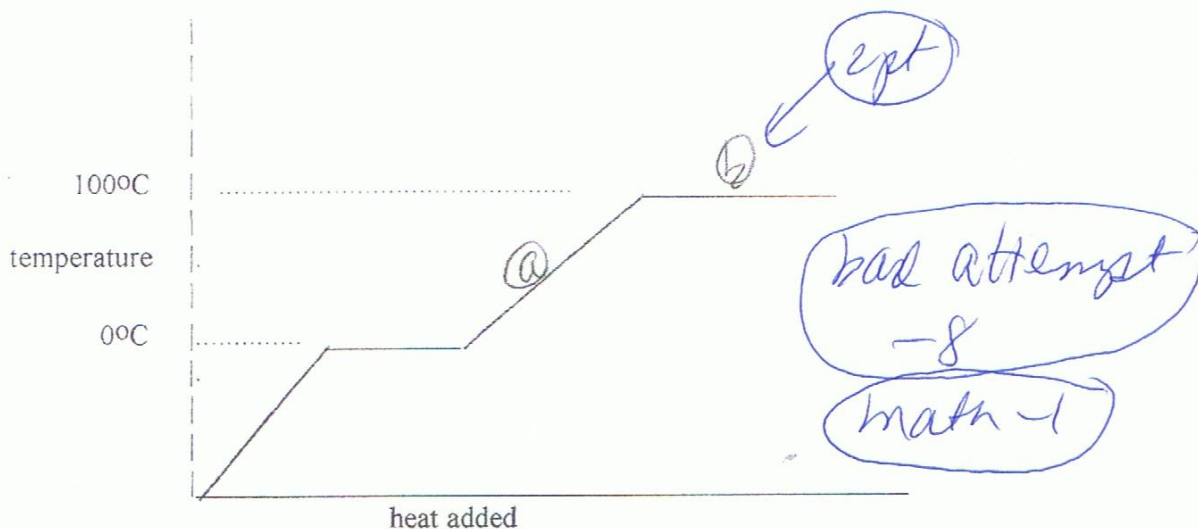
good attempt -6
(added ΔH together)

final sign wrong -1

did not do final sum -2

math -1

2. For the following chart for the interconversion of water under Pressure = 1.00 atm,



Part 1: What is the heat needed (a) to warm 88.6 grams of water from 30.9 °C to 100.0 °C and then (b) to vaporize all of the water at 100 °C ($q = m C \Delta T$, $C_{\text{water}} = 4.184 \text{ J/g} \cdot \text{°C}$, $q = n \Delta H_{\text{vaporization}}$, $\Delta H_{\text{vaporization}} = 40.7 \text{ kJ/mol}$) (10 pts)

T_i T_f
 molar mass $\text{H}_2\text{O} = 18.02 \text{ g/mol}$

NW - 50% off

wrong mass -2

Part 2: label the graph above with (a) and (b) for your (a) and (b) which you calculated above. by drawing an arrow to parts of the graph above and labeling with (a) & (b). (4 pts)

(5 pt) $q = m C \Delta T = (88.6 \text{ g}) \left(\frac{4.184 \text{ J}}{\text{g} \cdot \text{°C}} \right) (100.0 \text{ °C} - 30.9 \text{ °C})$
 $q = 25619.5 \text{ J} \rightarrow 25619.5 \text{ J} \times \frac{\text{kJ}}{1000 \text{ J}} = 25.6 \text{ kJ}$

(5 pt) $q = (4.92 \text{ mol}) (40.7 \text{ kJ/mol}) = 200 \text{ kJ}$
 $n = 88.6 \text{ g} \times \frac{\text{mol}}{18.02 \text{ g}} = 4.92 \text{ mol}$

not mole -2 / used 1 mol -2

total $q = 25.6 \text{ kJ} + 200 \text{ kJ} = 226 \text{ kJ}$

Name _____ (print) Name _____ (sign)

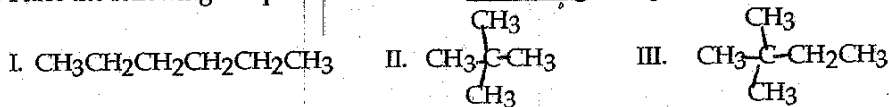
Please show work for partial credit on the Long Answers and in some of the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 22 pts total)

1) The specific heat capacity of liquid mercury is $0.14 \text{ J/g } ^\circ\text{C}$. 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 ? 1) _____

- A) 36 J
- B) 1.7 J
- C) 0.0013 J
- D) 15 J
- E) $7.7 \times 10^2 \text{ J}$

2) Place the following compounds in order of decreasing strength of intermolecular forces. 2) _____



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

3) How much energy is required to vaporize 48.7 g of dichloromethane (CH_2Cl_2) at its boiling point, if its ΔH_{vap} is 31.6 kJ/mol ? (formula mass of $\text{CH}_2\text{Cl}_2 = 85.03 \text{ g/mol}$) 3) _____

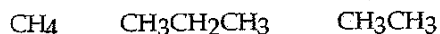
- A) 55.1 kJ
- B) 15.4 kJ
- C) 31.2 kJ
- D) 18.1 kJ
- E) 6.49 kJ

4) Which one of the following has a low density? 4) _____

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

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

5) _____



- A) CH₃CH₃ < CH₄ < CH₃CH₂CH₃
- B) CH₃CH₂CH₃ < CH₄ < CH₃CH₃
- C) CH₄ < CH₃CH₂CH₃ < CH₃CH₃
- D) CH₃CH₂CH₃ < CH₃CH₃ < CH₄
- E) CH₄ < CH₃CH₃ < CH₃CH₂CH₃

6) Calculate the amount of heat (in kJ) required to raise the temperature of a 79.0 g sample of ethanol from 24.9 °C to 111.9 °C. The specific heat capacity of ethanol is 2.42 J/g°C.

6) _____

- A) 73.6 kJ
- B) 12.9 kJ
- C) 28.4 kJ
- D) 57.0 kJ
- E) 16.6 kJ

7) Which of the following statements is TRUE?

7) _____

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

8) Use the ΔH°_f information provided to calculate $\Delta H^{\circ}_{\text{rxn}}$ for the following:

8) _____

	ΔH°_f (kJ/mol)	$\text{SO}_2\text{Cl}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l}) \rightarrow 2 \text{HCl}(\text{g}) + \text{H}_2\text{SO}_4(\text{l})$	$\Delta H^{\circ}_{\text{rxn}} = ?$
$\text{SO}_2\text{Cl}_2(\text{g})$	-364		
$\text{H}_2\text{O}(\text{l})$	-286		
$\text{HCl}(\text{g})$	-92		
$\text{H}_2\text{SO}_4(\text{l})$	-814		

- A) +161 kJ
- B) -62 kJ
- C) -422 kJ
- D) -256 kJ
- E) +800. kJ

9) Define boiling.

9) _____

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

10) Define sublimation.

10) _____

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

11) Identify a substance that is not in its standard state.

A) Ne

B) O₃

C) Ca

D) O₂

E) H

11) _____

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (51 pts)

12)

1. For the element P (phosphorus) (2 pts each, 10 pts)

The group number is _____ the charge for an ion (if one exists) is _____

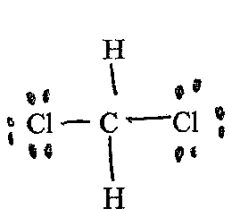
The number of valence electrons (for a neutral atom) is _____

The electron configuration is _____ (use notation 1s², etc)

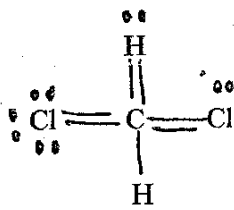
The valence electron configuration is _____ (use notation 1s², etc)

2. a. What is the number of valence electrons in the molecule Cl₂ H₂ C _____ 3 pts
(show work)

b. Which of the following is a correct Lewis Dot structure for the molecule Cl₂ H₂ C
Circle the number of the correct Lewis Dot structure (3 pts)



(1)

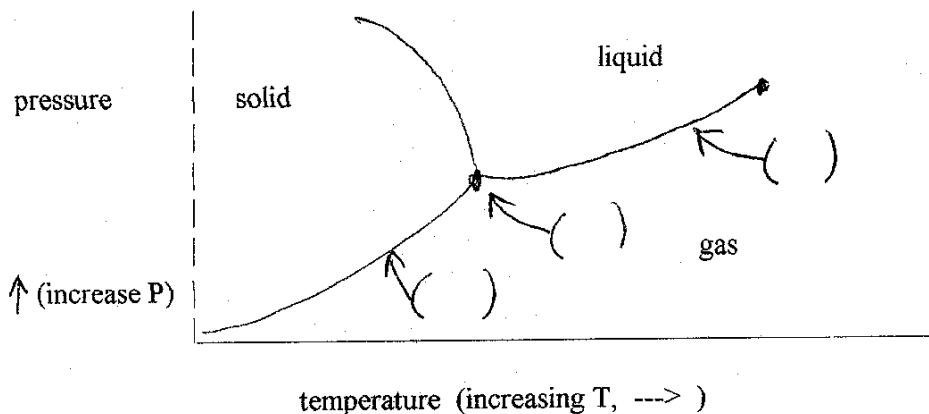


(2)

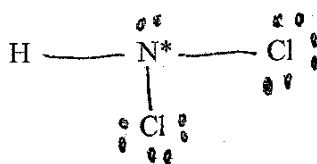
3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (2 pts each, 6 pts)

(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to liquid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point

Solid



4. Given the correct Lewis Dot Structure below, (2 pts each, 8 pts)



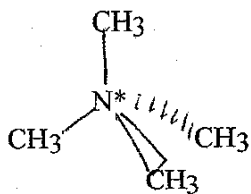
The number of electron pairs around the atom with the * is _____.

The geometry of the electrons around the atom with the * is _____.

The number of lone pairs on the atom with the * is _____.

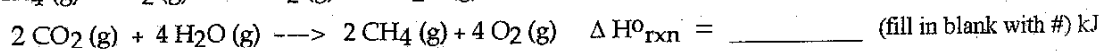
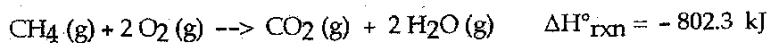
the VSEPR shape of the molecule is _____.

5. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPR shape of the molecule at the * is tetrahedral (4 pts each, 16 pts)



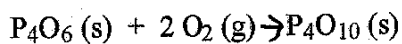
- Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like $\text{---} \oplus \text{-----} \rightarrow$)
- The vector sum of the dipole moment for the molecule is (zero) or (not zero) (circle one)
- The molecule as a whole is (polar) or (nonpolar) (circle one)

- d. The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)
6. Given the following reaction, and the enthalpy associated with the reaction, if you rewrite the reaction as shown, what is the new enthalpy for the newly written reaction? (show work) (5 pts)

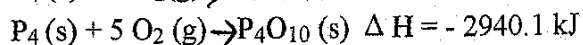
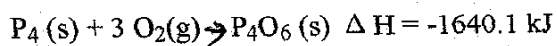


Part III Long Answer. Show all work for full credit and for partial credit. (26 pts)

1. a. Apply Hess's Law to the following to calculate ΔH for the reaction. (10 pts)

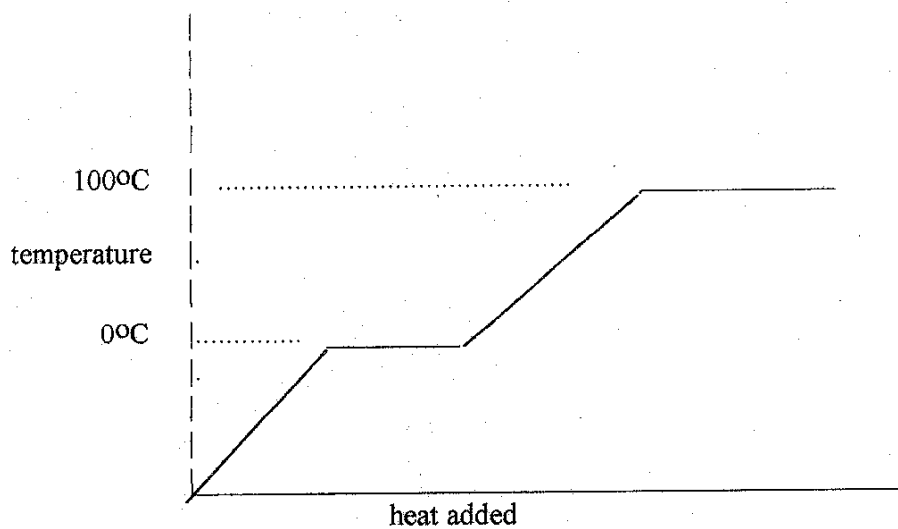


given the following reactions and enthalpies



b. Based on your calculated enthalpy, is the reaction [(endothermic) or (exothermic)] (2 pts)(circle one)

2. For the following chart for the interconversion of water under Pressure = 1.00 atm,



Part 1: What is the heat needed (a) to warm 14.5 grams ice from -15°C to 0°C and then (b) to melt the ice? ($q = m C \Delta T$, $C_{\text{ice}} = 2.09 \text{ J/g}^{\circ}\text{C}$, $q = n \Delta H_{\text{fusion}}$, $\Delta H_{\text{fusion}} = 6.02 \text{ kJ/mol}$, molar mass of water = 18.02 g/mol) (10 pts)

Part 2: label the graph above with (a) and (b) for your (a) and (b) which you calculated above. by drawing an arrow to parts of the graph above and labeling with (a) & (b). (4 pts)

Name _____ (print) Name _____ (sign)

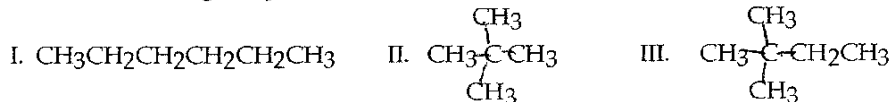
Please show work for partial credit on the Long Answers and in some of the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 22 pts total)

- 1) Which of the following statements is TRUE? 1) _____
- A) $q_{\text{system}} = -q_{\text{surrounding}}$
 - B) ΔH_{rxn} can be determined using a coffee cup calorimeter.
 - C) Energy is neither created nor destroyed, excluding nuclear reactions.
 - D) State functions do not depend on the path taken to arrive at a particular state.
 - E) All of the above are true.
- 2) Identify a substance that is not in its standard state. 2) _____
- A) H
 - B) O₃
 - C) Ca
 - D) O₂
 - E) Ne
- 3) Place the following compounds in order of increasing strength of intermolecular forces. 3) _____
- CH₄ CH₃CH₂CH₃ CH₃CH₃
- A) CH₃CH₃ < CH₄ < CH₃CH₂CH₃
 - B) CH₄ < CH₃CH₂CH₃ < CH₃CH₃
 - C) CH₃CH₂CH₃ < CH₄ < CH₃CH₃
 - D) CH₄ < CH₃CH₃ < CH₃CH₂CH₃
 - E) CH₃CH₂CH₃ < CH₃CH₃ < CH₄
- 4) Define boiling. 4) _____
- A) A gas becomes a liquid.
 - B) A solid becomes a liquid.
 - C) A gas becomes a solid.
 - D) A solid becomes a gas.
 - E) A liquid becomes a gas.
- 5) 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? 5) _____
- A) 15 J
 - B) 1.7 J
 - C) 7.7×10^2 J
 - D) 36 J
 - E) 0.0013 J

6) How much energy is required to vaporize 48.7 g of dichloromethane (CH_2Cl_2) at its boiling point, if its ΔH_{vap} is 31.6 kJ/mol? (formula mass of $\text{CH}_2\text{Cl}_2 = 85.03 \text{ g/mol}$) 6) _____
 A) 15.4 kJ B) 6.49 kJ C) 55.1 kJ D) 31.2 kJ E) 18.1 kJ

7) Place the following compounds in order of decreasing strength of intermolecular forces. 7) _____



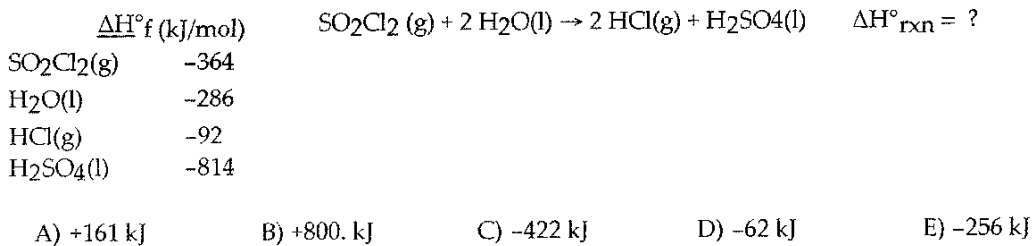
- A) III > I > II
 B) I > III > II
 C) III > II > I
 D) I > II > III
 E) II > III > I

8) Which one of the following has a low density? 8) _____
 A) liquid
 B) gas
 C) solid
 D) none of the above
 E) all of the above

9) Calculate the amount of heat (in kJ) required to raise the temperature of a 79.0 g sample of ethanol from 24.9 °C to 111.9 °C. The specific heat capacity of ethanol is 2.42 J/g°C. 9) _____
 A) 16.6 kJ B) 28.4 kJ C) 57.0 kJ D) 12.9 kJ E) 73.6 kJ

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

11) Use the ΔH_f° information provided to calculate $\Delta H_{\text{rxn}}^\circ$ for the following: 11) _____



Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (51 pts)

12)

1. For the element S (sulfur) (2 pts each, 10 pts)

The group number is _____ the charge for an ion (if one exists) is _____

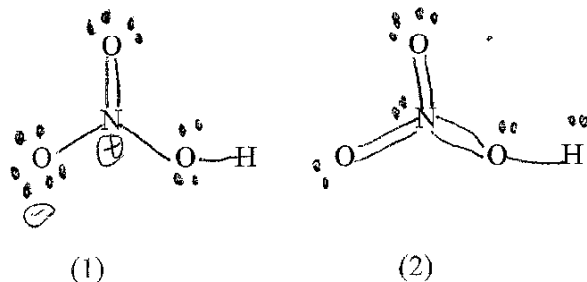
The number of valence electrons (for a neutral atom) is _____

The electron configuration is _____ (use notation $1s^2$)

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

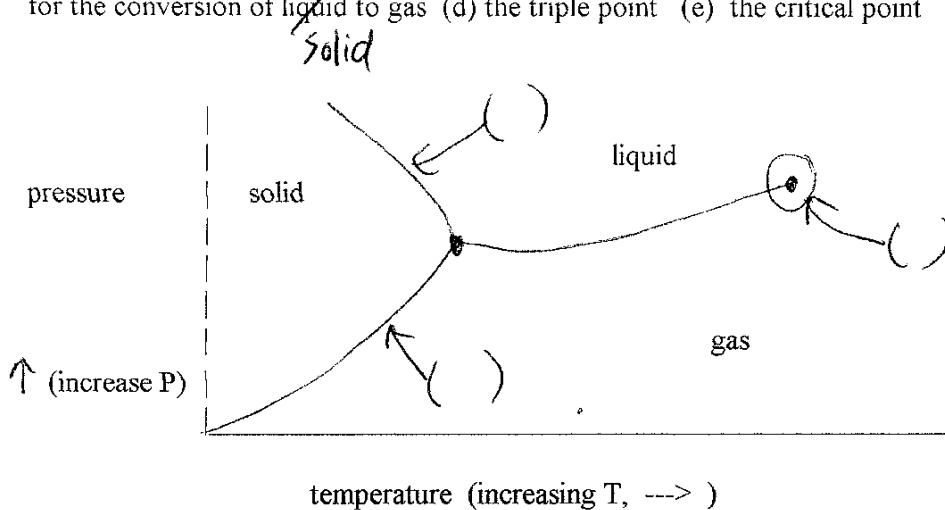
2. a. What is the number of valence electrons in the molecule HNO_3 _____ 3 pts
(show work)

b. Which of the following is a correct Lewis Dot structure for the molecule HNO_3
Circle the number of the correct Lewis Dot structure (3 pts)



3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (2 pts each, 6 pts)

(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to liquid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point



4. Given the correct Lewis Dot Structure below, (2 pts each, 8 pts)



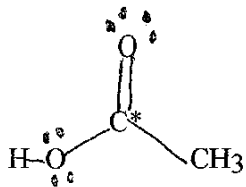
The number of electron pairs around the atom with the * is _____.

The geometry of the electrons around the atom with the * is _____.

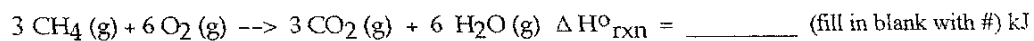
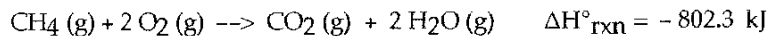
The number of lone pairs on the atom with the * is _____.

the VSEPR shape of the molecule is _____.

5. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPR shape of the molecule at the * is trigonal planar (4 pts each, 16 pts)

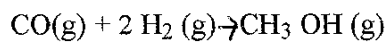


- Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like \rightarrow)
 - The vector sum of the dipole moment for the molecule is (zero) or (not zero) (circle one)
 - The molecule as a whole is (polar) or (nonpolar) (circle one)
 - The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)
6. Given the following reaction, and the enthalpy associated with the reaction, if you rewrite the reaction as shown, what is the new enthalpy for the newly written reaction? (5 pts)

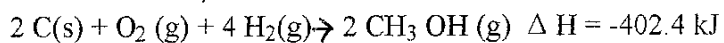
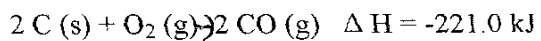


Part III Long Answer: Show all work for full credit and for partial credit. (26 pts)

1. a. Apply Hess's Law to the following to calculate ΔH for the reaction. (10 pts)

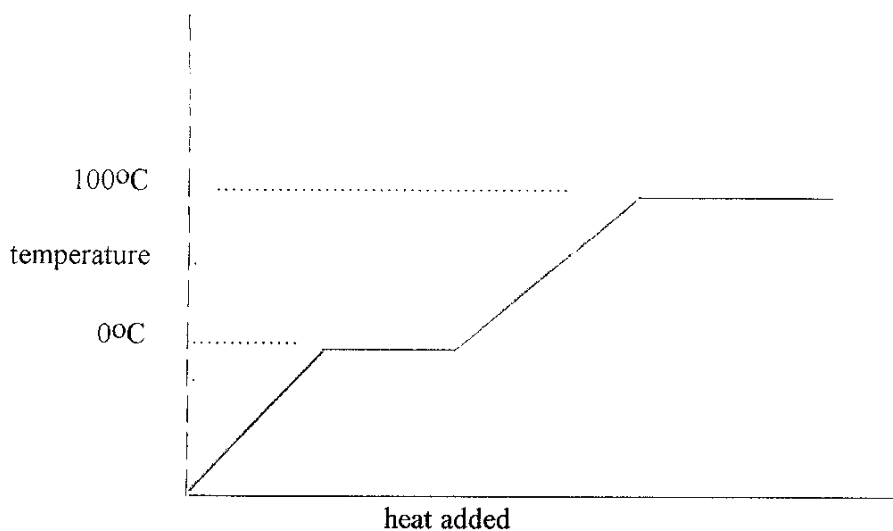


given the following reactions and enthalpies



- b. Based on your calculated enthalpy, is the reaction [(endothermic) or (exothermic)] (2 pts)
(circle one)

2. For the following chart for the interconversion of water under Pressure = 1.00 atm,



Part 1: What is the heat needed (a) to warm 25.9 grams ice from $-30\text{ }^{\circ}\text{C}$ to $0\text{ }^{\circ}\text{C}$ and then (b) to melt the ice? ($q = m C \Delta T$, $C_{\text{ice}} = 2.09\text{ J/g}^{\circ}\text{C}$, $q = n \Delta H_{\text{fusion}}$, $\Delta H_{\text{fusion}} = 6.02\text{ kJ/mol}$, molar mass of water = 18.02 g/mol) (10 pts)

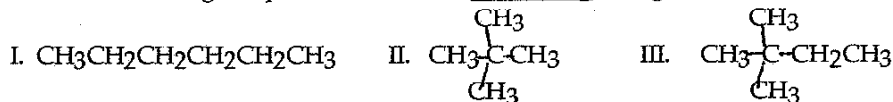
Part 2: label the graph above with (a) and (b) for your (a) and (b) which you calculated above. by drawing an arrow to parts of the graph above and labeling with (a) & (b). (4 pts)

Name _____ (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)

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 22 pts total)

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

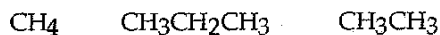


- A) I > III > II
 B) I > II > III
 C) III > II > I
 D) III > I > II
 E) II > III > I

2) Which one of the following has a definite shape and volume? 2) _____

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

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



- A) $\text{CH}_4 < \text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_3$
 B) $\text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_4 < \text{CH}_3\text{CH}_3$
 C) $\text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_3 < \text{CH}_4$
 D) $\text{CH}_4 < \text{CH}_3\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_3$
 E) $\text{CH}_3\text{CH}_3 < \text{CH}_4 < \text{CH}_3\text{CH}_2\text{CH}_3$

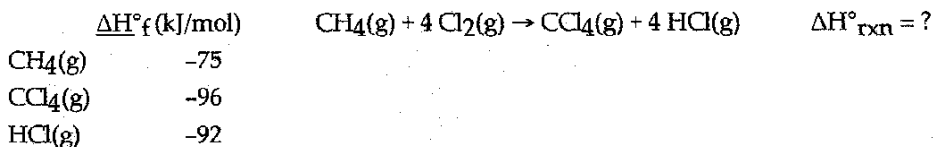
4) Calculate the amount of heat (in kJ) necessary to raise the temperature of 47.8 g benzene by 57.0 4) _____

°C. The specific heat capacity of benzene is 1.05 J/g°C

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

5) Use the information provided to determine $\Delta H^\circ_{\text{rxn}}$ for the following reaction:

5) _____



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

6) Define sublimation.

6) _____

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

7) Define freezing.

7) _____

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

8) How much energy is required to vaporize 158 g of butane (C_4H_{10}) at its boiling point, if its ΔH_{vap} is 24.3 kJ/mol? (formula mass of C_4H_{10} = 58.14 g/mol)

8) _____

- A) 38.4 kJ B) 89.4 kJ C) 66.1 kJ D) 15.1 kJ E) 11.2 kJ

9) Identify a substance that is not in its standard state.

9) _____

- A) H_2 B) Ca C) O_2 D) CO E) Ne

10) The specific heat capacity of solid copper metal is 0.385 J/gK. How many joules of heat are needed to raise the temperature of a 1.55-kg block of copper from 33.0°C to 77.5°C?

10) _____

- A) 26.6 J
- B) 5.58×10^{-6} J
- C) 2.66×10^4 J
- D) 1.79×10^5 J
- E) 0.00558 J

11) Which of the following statements is TRUE?

11) _____

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

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (51 pts)

12) 1. For the element Cl (chlorine) (2 pts each, 10 pts)

The group number is _____ the charge for an ion (if one exists) is _____

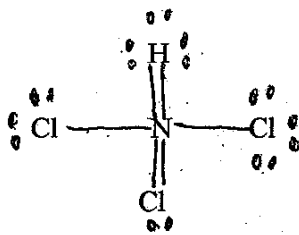
The number of valence electrons (for a neutral atom) is _____

The electron configuration is _____ (use notation $1s^2$, etc)

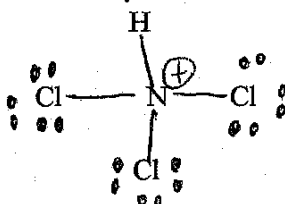
The valence electron configuration is _____ (use notation $1s^2$, etc)

2. a. What is the number of valence electrons in the molecule HNC_3^+ _____ 3
pts
(show work)

b. Which of the following is a correct Lewis Dot structure for the molecule HNC_3^+
Circle the number of the correct Lewis Dot structure (3 pts)



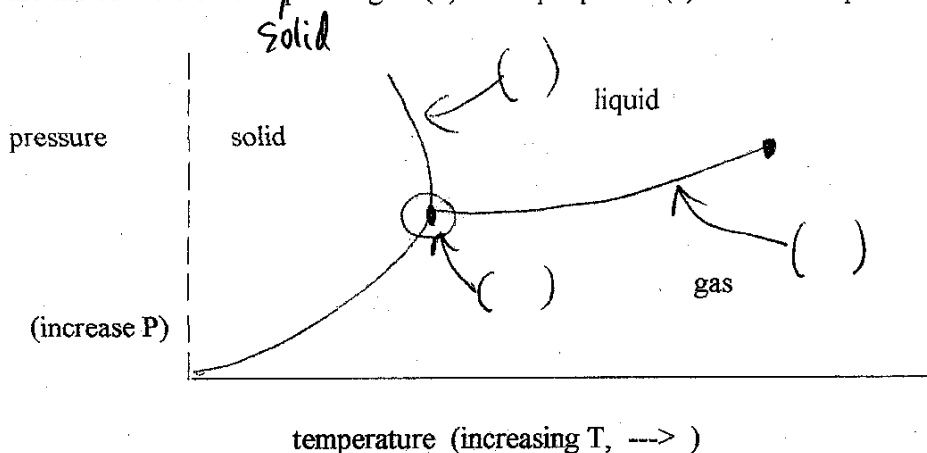
(1)



(2)

3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (2 pts each, 6 pts)

(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to liquid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point



4. Given the correct Lewis Dot Structure below, (2 pts each, 8 pts)



The number of electron pairs around the atom with the * is _____.

The geometry of the electrons around the atom with the * is _____.

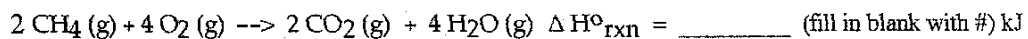
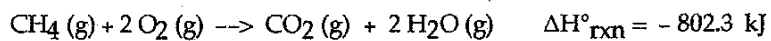
The number of lone pairs on the atom with the * is _____.

the VSEPR shape of the molecule is _____.

5. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPR shape of the molecule at the * is bent (4 pts each, 16 pts)

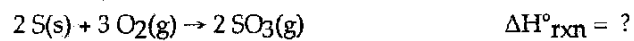


- Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like \rightarrow)
 - The vector sum of the dipole moment for the molecule is (zero) or (not zero) (circle one)
 - The molecule as a whole is (polar) or (nonpolar) (circle one)
 - The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)
6. Given the following reaction, and the enthalpy associated with the reaction, if you rewrite the reaction as shown, what is the new enthalpy for the newly written reaction? (5 pts)

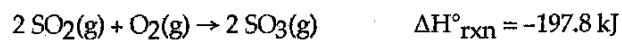
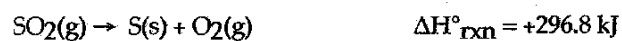


Part III Long Answer: Show all work for full credit and for partial credit. (26 pts)

1 a Apply Hess's Law to the following to calculate ΔH for the reaction. (10 pts)

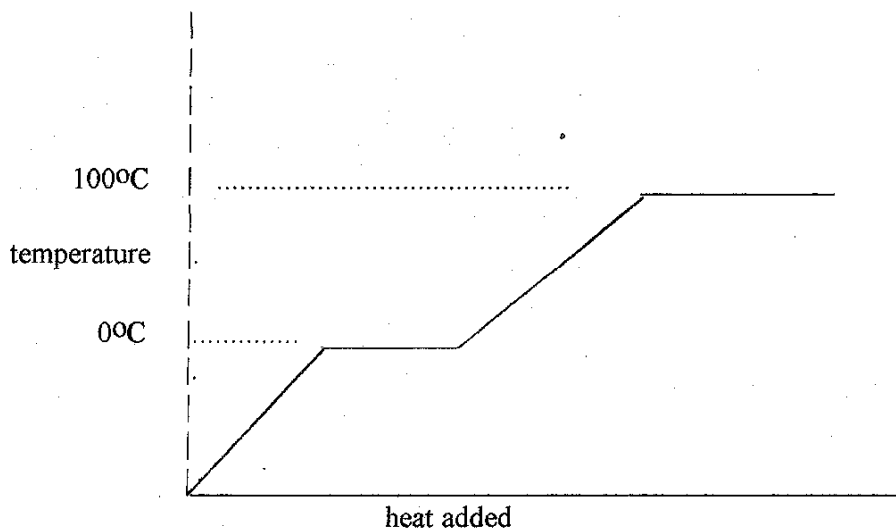


Given:



b. Based on your calculated enthalpy, is the reaction [(endothermic) or (exothermic)] (2 pts)(circle one)

2. For the following chart for the interconversion of water under Pressure = 1.00 atm,



Part 1: What is the heat needed (a) to warm 32.5 grams of water from 26.2 °C to 100.0 °C and then (b) to vaporize all of the water at 100°C ($q = m C \Delta T$, $C_{\text{water}} = 4.184 \text{ J/g } ^\circ\text{C}$, $q = n \Delta H_{\text{vaporization}}$, $\Delta H_{\text{vaporization}} = 40.7 \text{ kJ/mol}$) (10 pts)

Part 2: label the graph above with (a) and (b) for your (a) and (b) which you calculated above. by drawing an arrow to parts of the graph above and labeling with (a) & (b). (4 pts)

Name _____ (print) Name _____ (sign)

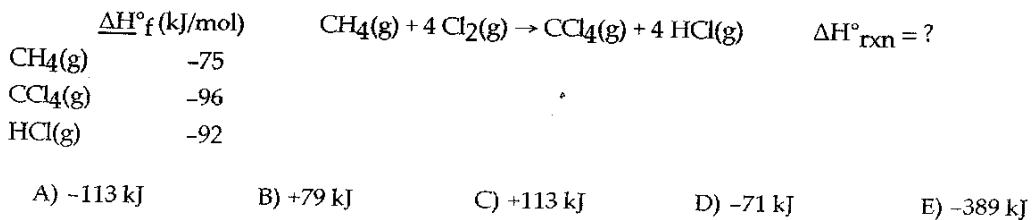
Please show work for partial credit on the Long Answers and in some of the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If I cannot read your work, I obviously cannot grade it. (1 pts print and sign exam)

Part I MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts per question, 22 pts total)

- 1) Define sublimation. 1) _____
 A) the phase transition from liquid to solid
 B) the phase transition from solid to gas
 C) the phase transition from liquid to gas
 D) the phase transition from gas to liquid
 E) the phase transition from gas to solid

- 2) Which of the following statements is TRUE? 2) _____
 A) State functions do not depend on the path taken to arrive at a particular state.
 B) $q_{\text{system}} = -q_{\text{surrounding}}$
 C) Energy is neither created nor destroyed, excluding nuclear reactions.
 D) ΔH_{rxn} can be determined using a coffee cup calorimeter.
 E) All of the above are true.

- 3) Use the information provided to determine $\Delta H^{\circ}_{\text{rxn}}$ for the following reaction: 3) _____

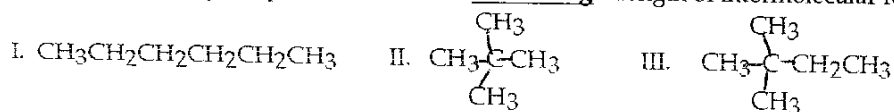


- 4) Which one of the following has a definite shape and volume? 4) _____
 A) solid
 B) gas
 C) liquid
 D) none of the above
 E) all of the above

- 5) How much energy is required to vaporize 158 g of butane (C₄H₁₀) at its boiling point, if its ΔH_{vap} is 24.3 kJ/mol? (formula mass of C₄H₁₀ = 58.14 g/mol) 5) _____
 A) 89.4 kJ B) 11.2 kJ C) 38.4 kJ D) 15.1 kJ E) 66.1 kJ

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

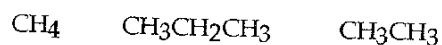
6) _____



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

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

7) _____



- A) $\text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_3 < \text{CH}_4$
- B) $\text{CH}_4 < \text{CH}_3\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_3$
- C) $\text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_4 < \text{CH}_3\text{CH}_3$
- D) $\text{CH}_4 < \text{CH}_3\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_3$
- E) $\text{CH}_3\text{CH}_3 < \text{CH}_4 < \text{CH}_3\text{CH}_2\text{CH}_3$

8) Define freezing.

8) _____

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

9) Identify a substance that is not in its standard state.

9) _____

- A) O_2 B) CO C) Ne D) Ca E) H_2

10) 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

10) _____

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

11) The specific heat capacity of solid copper metal is 0.385 J/gK. How many joules of heat are needed to raise the temperature of a 1.55-kg block of copper from 33.0°C to 77.5°C?

11) _____

- A) $1.79 \times 10^5 \text{ J}$
- B) $5.58 \times 10^{-6} \text{ J}$
- C) 26.6 J
- D) $2.66 \times 10^4 \text{ J}$
- E) 0.00558 J

Part II Short Answer: Write the word or phrase or circle the choice that best completes each statement or answers the question. (51 pts)

12) 1. For the element Si (silicon) (2 pts each, 10 pts)

The group number is _____ the charge for an ion (if one exists) is _____

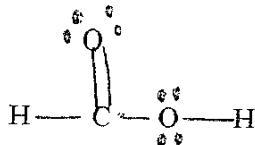
The number of valence electrons (for a neutral atom) is _____

The electron configuration is _____ (use notation $1s^2$, etc)

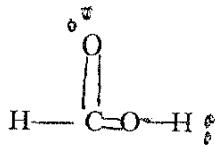
The valence electron configuration is _____ (use notation $1s^2$, etc)

2. a. What is the number of valence electrons in the molecule H_2CO_2 _____ 3 pts
(show work)

b. Which of the following is a correct Lewis Dot structure for the molecule H_2CO_2
Circle the number of the correct Lewis Dot structure (3 pts)



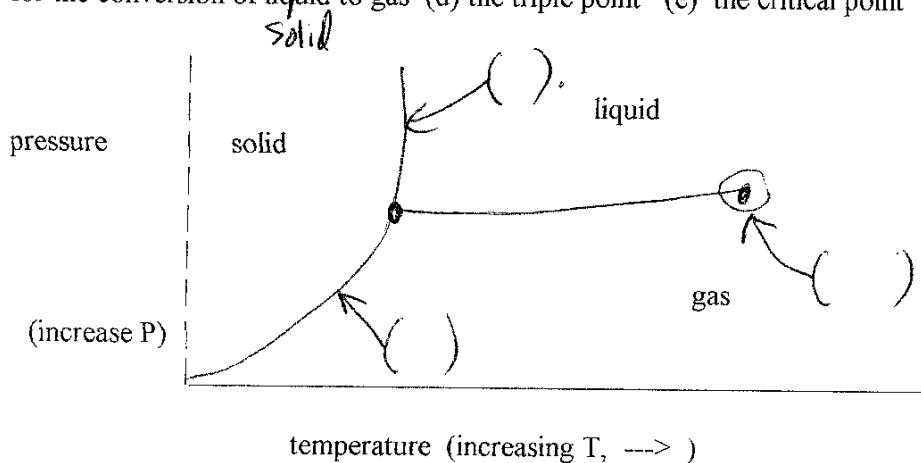
(1)



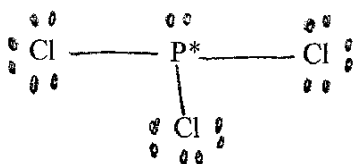
(2)

3. In the Phase Diagram shown below, match the following with the blanks on the diagram. (2 pts each, 6 pts)

(a) a line for the conversion of solid to liquid (b) a line for the conversion of gas to liquid (c) a line for the conversion of liquid to gas (d) the triple point (e) the critical point



4. Given the correct Lewis Dot Structure below, (2 pts each, 8 pts)



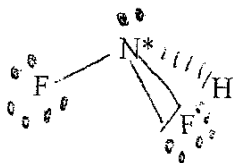
The number of electron pairs around the atom with the * is _____.

The geometry of the electrons around the atom with the * is _____.

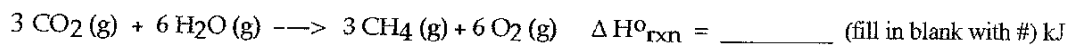
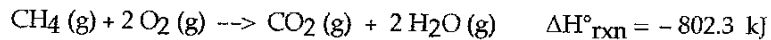
The number of lone pairs on the atom with the * is _____.

the VSEPR shape of the molecule is _____.

5. Given the following molecule what is the intermolecular force? To answer this question, complete the following. Note: the VSEPR shape of the molecule at the * is trigonal pyramidal (4 pts each, 16 pts)

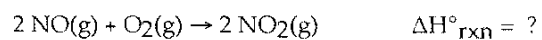


- Draw in the individual bond dipole vectors on the molecule shown. (vectors should look like $\begin{array}{c} \text{---} \\ | \\ \text{---} \end{array} \text{-----} \rightarrow$)
 - The vector sum of the dipole moment for the molecule is (zero) or (not zero) (circle one)
 - The molecule as a whole is (polar) or (nonpolar) (circle one)
 - The intermolecular force for the molecule is (dispersion forces) or (dipolar) or (hydrogen bonding) (circle one)
6. Given the following reaction, and the enthalpy associated with the reaction, if you rewrite the reaction as shown, what is the new enthalpy for the newly written reaction? (5 pts)

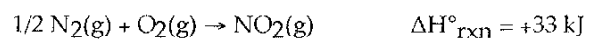


Part III Long Answer: Show all work for full credit and for partial credit. (26 pts)

1 a. Apply Hess's Law to the following to calculate ΔH for the reaction. (10 pts)

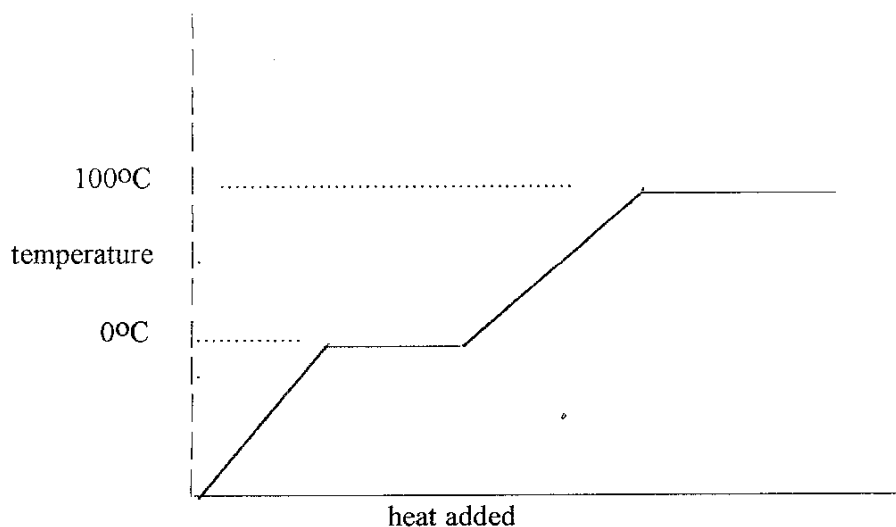


Given:



b. Based on your calculated enthalpy, is the reaction [(endothermic) or (exothermic)] (2 pts)(circle one)

2. For the following chart for the interconversion of water under Pressure = 1.00 atm,



Part 1: What is the heat needed (a) to warm 88.6 grams of water from 30.9 °C to 100.0 °C and then (b) to vaporize all of the water at 100°C ($q = m C \Delta T$, $C_{\text{water}} = 4.184 \text{ J/g}^\circ\text{C}$, $q = n \Delta H_{\text{vaporization}}$, $\Delta H_{\text{vaporization}} = 40.7 \text{ kJ/mol}$) (10 pts)

Part 2: label the graph above with (a) and (b) for your (a) and (b) which you calculated above. by drawing an arrow to parts of the graph above and labeling with (a) & (b). (4 pts)