DIRECTIONS: Do all work legibly on the test paper and place your final answer in the indicated space. Obey the rules of significant figures. SHOW ALL WORK AND UNITS. Failure to follow these instructions will result in loss of credit.

1. Fill in the missing word or phrase. (10)
   w is a -a- number if the system does work on the surroundings. Enthalpy is heat under conditions of constant -b-. A -c- function depends only on the initial and final states. The heat of formation of the most stable form of an elements under standard conditions is -d-. Graphite and diamond are different -e- of carbon. -f- orbitals are "dumbbell shaped while -g- orbitals are spherical. High energy radiation has a short -h-. The quantum number n defines the -l- and -j- of an orbital.

   a. ___________________________  f. ___________________________
   b. ___________________________  g. ___________________________
   c. ___________________________  h. ___________________________
   d. ___________________________  i. ___________________________
   e. ___________________________  j. ___________________________

2. Circle the following which ... (20)
   ....is a \( \Delta H^0 \) reaction a) \( \frac{3}{2} \text{H}_2(g) + \frac{1}{2} \text{N}_2(g) \rightarrow \text{NH}_3(g) \) or 3H(g) \(+\)N(g) \( \rightarrow \)NH\(_3\)(g)
   b) \( \text{SO}_2(g) + \frac{1}{2} \text{O}_2(g) \rightarrow \text{SO}_3(g) \) or \( \frac{1}{8} \text{S}_8(s) + \frac{3}{2} \text{O}_2(g) \rightarrow \text{SO}_3(g) \)
   c) C(graphite) + O\(_2\)(g) \( \rightarrow \) CO\(_2\)(g) or C(diamond) + O\(_2\)(g) \( \rightarrow \) CO\(_2\)(g)
   ....is exothermic d) \( \text{H}_2\text{O}(g) \rightarrow \text{H}_2\text{O}(l) \) or \( \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(g) \)
   ....is the correct energy level diagram for an endothermic reaction e) I or II
   ...is an orbital with \( m_l = 3 \) f) 3d or 5f
   ....is higher in energy g) 4d or 5s .... is larger h) 3p or 4p
   ....is not an allowed orbital i) 11s or 1p ...can hold the most electrons j) 6d or 4f

3. Give the ground state electron configuration for the following elements illustrating Pauli Exclusion Principle and Hund's Rule. Use arrows pointed up or down to represent electrons with opposite spins. (6)

   C (Z = 6) ___________________________
   O (Z = 8) 1\( s \) 2\( s \) 2\( p \)
4. Give the noble gas electron configurations of the following atoms or the identity of the element as required. (16)

a) Ca ________________________  
    f) [Ne]3s²3p² _________

b) S ________________________  
    g) [Ar]4s²3d¹⁰4p³ _________

c) F ________________________  
    h) [Ar]4s¹3d¹⁰ _________

d) Zn ________________________  
    i) [Kr]5s²4d¹ _________

5. Calculate the energy (J) and wavelength (m) of a 3.09 x 10¹⁵ 1/s line. (h=6.63x10⁻³⁴ Js and c=3.00x10⁸ m/s) (6)

\[ E = \]  
\[ \lambda = \]  

For the following Bohr representation of atomic hydrogen (7)

Using an arrow indicate the n=3 to n=2 transition

Is this transition endothermic or exothermic ________________________

Would the wavelength of the n=3 to n=2 transition be longer or shorter than the 4 to 2 transition ________________________

Would the frequency of the n=3 to n=2 transition be larger or smaller than the 4 to 2 transition ________________________

6. Calculate the heat liberated if 100. g of NH₃ (g) (17.0 g/mol) is produced in the following reaction. (5)

\[ 3\text{H}_2(g) + \text{N}_2(g) \rightarrow 2\text{NH}_3(g) \quad \Delta H = -92.0 \text{kJ} \]
7. Calculate the molar enthalpy change (kJ/mol) of the following reaction. When 106 g of Na₂CO₃ (106 g/mol) is added to a cup calorimeter containing 1000. g of 2.00 M HCl(aq) the temperature increased from 22.55 to 28.64 °C. Assume the total mass of all reactants is 1106. g and the specific heat of the solutions is 4.18 J/g°C. (10)

\[ \text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl(aq)} \rightarrow 2\text{NaCl(aq)} + \text{CO}_2(\text{g}) + \text{H}_2\text{O(l)} \quad \Delta H = \text{__________} \]

8. Use the following values to calculate the \( \Delta H^\circ \) of the following reaction. (10)
\( \Delta H^\circ[\text{Na}_2\text{CO}_3(\text{s})]= -1130.9 \text{ kJ/mol}; \Delta H^\circ[\text{CO}_2(\text{g})]= -393.5 \text{ kJ/mol}; \Delta H^\circ[\text{H}_2\text{O(l)}]= -285.8 \text{ kJ/mol}; \Delta H^\circ[\text{HCl(aq)}]= -167.2 \text{ kJ/mol}; \Delta H^\circ[\text{NaCl(aq)}]= -407.1 \text{ kJ/mol}. \)

\[ \text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl(aq)} \rightarrow 2\text{NaCl(aq)} + \text{CO}_2(\text{g}) + \text{H}_2\text{O(l)} \quad \Delta H = \text{__________} \]

9. Use Hess' Law to calculate the \( \Delta H \) for the following reaction from the data given below. (10)
\[ \text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl(aq)} \rightarrow 2\text{NaCl(aq)} + \text{CO}_2(\text{g}) + \text{H}_2\text{O(l)} \quad \Delta H = \text{__________} \]

\[ \text{Na}_2\text{CO}_3(\text{s}) \rightarrow \text{CO}_2(\text{g}) + \text{Na}_2\text{O(s)} \quad \Delta H = 319.8 \text{ kJ} \]
\[ 2\text{NaCl(aq)} + \text{H}_2\text{O(l)} \rightarrow 2\text{HCl(aq)} + \text{Na}_2\text{O(s)} \quad \Delta H = +348.0 \text{ kJ} \]
DIRECTIONS: Do all work legibly on the test paper and place your final answer in the indicated space. Obey the rules of significant figures. SHOW ALL WORK AND UNITS. Failure to follow these instructions will result in loss of credit.

1. Fill in the missing word or phrase. (10) w is a –a- number if the system does work on the surroundings. Enthalpy is heat under conditions of constant –b-. A –c- function dependencies only on the initial and final states. The heat of formation of the most stable form of an elements under standard conditions is –d-. Graphite and diamond are different –e- of carbon. –f- orbitals are “dumbbell shaped” while –g- orbitals are spherical. High energy radiation has a short –h-. The quantum number n defines the –i- and –j- of an orbital.

a. negative  

b. pressure  
c. state  
d. zero  
e. forms allotropes  
f. p  
g. 5  
h. wavelength  
i. size  
j. energy

2. Circle the following which (20)  

a) 3/2H₂(g) + 1/2N₂(g) → NH₃(g) or 3H(g) + N(g) → NH₃(g)  
b) SO₂(g) + 1/2O₂(g) → SO₃(g) or 1/8S₈(s) + 3/2O₂(g) → SO₃(g)  
c) C(graphite) + O₂(g) → CO₂(g) or C(diamond) + O₂(g) → CO₂(g)  
   ...is exothermic  
d) H₂O(g) → H₂O(l) or H₂O(l) → H₂O(g)  
   ...is the correct energy level diagram for an endothermic reaction  
e) I or II  
   ...is an orbital with mₗ = 3  
f) 3d or 5f  
   ....is higher in energy  
g) 4d or 5s  
h) 3p or 4p  
   ....is not an allowed orbital  
i) 11s or 1p  
j) 6d or 4f

3. Give the ground state electron configuration for the following elements illustrating Pauli Exclusion Principle and Hund's Rule. Use arrows pointed up or down to represent electrons with opposite spins. (6)

\[ ^{14}_{6} \text{C} (\text{Z} = 6) \]
\[ ^{16}_{8} \text{O} (\text{Z} = 8) \]
4. Give the noble gas electron configurations of the following atoms or the identity of the element as required. (16)

a) Ca [Ca] 4s² 3d¹⁰
b) S [Ar] 3s² 3p⁴
c) F [He] 2s² 2p⁵
d) Zn [Zn] 4s² 3d¹⁰
f) [Ne] 3s² 3p²

5. Calculate the energy (J) and wavelength (m) of a 3.09 x 10⁻¹⁵ 1/s line. (h=6.63x10⁻³⁴ Js and c=3.00x10⁸ m/s) (6)

\[ E = \frac{hc}{\lambda} \]

\[ E = 2.05 \times 10^{-18} \text{ J} \]

For the following Bohr representation of atomic hydrogen (7)

Using an arrow indicate the n=3 to n=2 transition

Is this trans endothermic or exothermic __exothermic__

Would the wavelength of the n=3 to n=2 transition be longer or shorter than the 4 to 2 transition __shorter__

Would the frequency of the n=3 to n=2 transition be larger or smaller than the 4 to 2 transition __smaller__

6. Calculate the heat liberated if 100. g of NH₃ (g) (17.0 g/mol) is produced in the following reaction. (5)

\[ 3\text{H}_2(g) + \text{N}_2(g) \rightarrow 2\text{NH}_3(g) \quad \Delta H = -92.0 \text{ kJ} \]

\[ q = 100.0 \text{ g NH}_3 \left( \frac{1 \text{ mol NH}_3}{17.0 \text{ g NH}_3} \right) \left( \frac{32.0 \text{ kJ}}{2 \text{ mol NH}_3} \right) = 271 \text{ kJ} \text{ liberated} \]

\[ \Delta H = -271 \text{ kJ} \]
7. Calculate the molar enthalpy change (kJ/mol) of the following reaction. When 106 g of Na$_2$CO$_3$ (106 g/mol) is added to a cup calorimeter containing 1000. g of 2.00 M HCl(aq) the temperature increased from 22.55 to 28.64 °C. Assume the total mass of all reactants is 1106. g and the specific heat of the solutions is 4.18 J/g°C. (10)

$$\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \quad \Delta H = -262.2 \text{kJ} \quad 10^5$$

8. Use the following values to calculate the $\Delta H_x^\circ$ of the following reaction. (10)

$\Delta H_x^\circ[\text{Na}_2\text{CO}_3(\text{s})] = -1130.9 \text{kJ/mol}$; $\Delta H_x^\circ[\text{CO}_2(\text{g})] = -393.5 \text{kJ/mol}$; $\Delta H_x^\circ[\text{H}_2\text{O}(\text{l})] = -285.8 \text{kJ/mol}$; $\Delta H_x^\circ[\text{HCl}(\text{aq})] = -167.2 \text{kJ/mol}$; $\Delta H_x^\circ[\text{NaCl(}\text{aq})] = -407.1 \text{kJ/mol}$.

$$\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \quad \Delta H = -262.2 \text{kJ} \quad 10^5$$

$$\Delta H_x^\circ = \Delta H_x^\circ[\text{Na}_2\text{CO}_3(\text{s})] + \Delta H_x^\circ[\text{HCl}(\text{aq})] + \Delta H_x^\circ[\text{H}_2\text{O}(\text{l})] - \left[2 \text{mol} \times \Delta H_x^\circ[\text{NaCl(}\text{aq})] \right]$$

$$= 2(-407.1 \text{kJ}) + 2(-285.8 \text{kJ}) - (-407.1 \text{kJ})$$

$$= -2.2 \text{kJ}$$

9. Use Hess' Law to calculate the $\Delta H$ for the following reaction from the data given below. (10)

$$\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \quad \Delta H = -262.2 \text{kJ} \quad 10^5$$

$\text{Na}_2\text{CO}_3(\text{s}) \rightarrow \text{CO}_2(\text{g}) + \text{Na}_2\text{O}(\text{s}) \quad \Delta H = 319.8 \text{kJ}$

$2\text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HCl}(\text{aq}) + \text{Na}_2\text{O}(\text{s}) \quad \Delta H = +348.0 \text{kJ}$

$$\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \quad \Delta H = 2(319.8 \text{kJ}) - 348.0 \text{kJ}$$

$$\Delta H = 319.6 \text{kJ} - 348.0 \text{kJ}$$

$$\Delta H = -28.4 \text{kJ}$$