Name: Mrs Hanson

Thermochemistry

Practice Test B

General Chemistry
Honors Chemistry

Objective 1: Use the relationship between mass, specific heat, and temperature change to calculate the heat flow during a chemical or physical process.
Directions: Show all work, including units, to solve the following problems.

1. The specific heat of aluminum metal is 0.90 J/g-K. How many kJ of heat are necessary to raise the temperature of a 15.5 kg block of aluminum from 13°C to 79.5°C?

$q = (15500\,g)(.90\,\frac{J}{g°C})(79.5° - 13°C) = +927675\,J$

2. How much heat energy, in Joules, is absorbed when 1.5 moles of water is warmed from 30°C to 89.3°C?

$1.5\,mol\,H_2O\left(\frac{18\,g\,H_2O}{1\,mol\,H_2O}\right) = 27\,g\,H_2O$

$q = (27\,g\,H_2O)(4.184\,\frac{J}{g°C})(89.3 - 30°C) = +6699\,J$

3. A chunk of silver has a heat capacity of 236 J/°C. If the silver has a mass of 1 kg, calculate the specific heat of silver.

↑ change to grams!

$236\,\frac{J}{°C}\left(\frac{1}{1000\,g}\right) = .236\,\frac{J}{g°C}$

4. When a certain substance with a mass of 50 grams is heated from 30°C to 65°C, it absorbed 245 Joules of heat energy. Calculate the specific heat of the substance , and identify it using the following table:

Water:	4.184 J/g-K
Ice:	2.1 J/g-K
Aluminum:	0.90 J/g-K
Silver:	0.24 J/g-K
Mercury:	0.14 J/g-K

$245\,J = (50\,g)(C_p)(65 - 30°C)$

$C_p = .14\,\frac{J}{g°C}$ = Mercury

5. A student mixed 175 mL of water containing 0.50 mol HCl at 22.5°C with 175 mL of water containing NaOH at the same temperature in a foam cup calorimeter. The temperature of the resulting solution increased to 36°C. How much heat in kilojoules was released by this reaction? Assume the density of the resulting solution was 1.0 g/mL.

$175\,mL\,HCl + 175\,mL\,NaOH = 350\,mL$ total solution $\times\ 1.0\,g/mL = 350\,g$

$q = (350\,g)(4.184\,\frac{J}{g°C})(36° - 22.5°C)$

$q = -19769.4\,J$

Score: _____

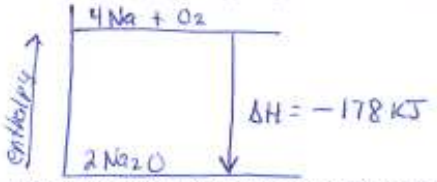
Objective 2: Construct thermochemical equations and enthalpy diagrams for any chemical reaction given thermochemical data. Indicate if the change is endothermic or exothermic.

1. Consider the following reaction:
   $4\ Na(s) + O_2(g) \rightarrow 2Na_2O(s)$ $\Delta H = -178$ kJ

   a. Is this reaction exothermic or endothermic? Explain your choice.

   Exothermic. The value for enthalpy is negative = heat releasing.

   b. Draw a complete enthalpy diagram for this reaction.

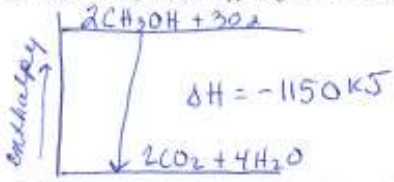


2. The complete combustion of methanol, CH_3OH releases 1150 kJ of heat per mole of the reactant.

   a. Write a balanced thermochemical equation for the reaction.

$2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O \quad \Delta H = -1150 KJ$

   b. Draw a complete enthalpy diagram for the reaction.

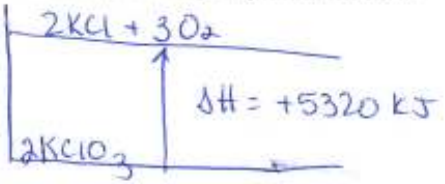


3. Exactly 5320 kJ of heat is required for the decomposition of Potassium Chlorate.

   a. Write a balanced thermochemical equation for the reaction.

$2KClO_3 \rightarrow 2KCl + 3O_2 \quad \Delta H = +5320 KJ$

   b. Draw a complete enthalpy diagram for the reaction.



Score: _____

Objective 3: Calculate enthalpy changes in chemical and physical processes from a thermochemical equation. Indicate if the change is endothermic or exothermic.

Directions: Show all work, including units, to solve the following problems.

1. When copper II carbonate absorbs 3390 kJ of heat energy, it decomposes.
   a. Write the balanced thermochemical equation:

$CuCO_3 \longrightarrow CuO + CO_2 \quad \Delta H = +3390\ kJ$

   b. How much heat is released when 100 grams of copper II carbonate completely decomposes?

$100g\ CuCO_3 \left(\frac{1\ mol\ CuCO_3}{123.5g\ CuCO_3}\right)\left(\frac{+3390\ kJ}{1\ mol\ CuCO_3}\right) = \boxed{2744.94\ kJ}$ endo

2. When zinc metal reacts with nitric acid, 100 kJ of heat is released.
   a. Write the balanced thermochemical equation:

$Zn + 2HNO_3 \rightarrow Zn(NO_3)_2 + H_2 \quad \Delta H = -100\ kJ$

   b. Calculate the amount of heat transferred when 50 grams of zinc metal reacts:

$50g\ Zn \left(\frac{1\ mol\ Zn}{65.4g\ Zn}\right)\left(\frac{-100\ kJ}{1\ mol\ Zn}\right) = \boxed{-76.5\ kJ}$

   c. How many liters of hydrogen gas are produced during an enthalpy change of -50kJ, assuming STP conditions?

$-50kJ \left(\frac{1\ Mol\ H_2}{-100\ kJ}\right)\left(\frac{22.4L\ H_2}{1\ Mol\ H_2}\right) = \boxed{11.2L\ H_2}$

   d. How many kilojoules of heat are released when 3.5×10^{24} formula units of zinc nitrate form?

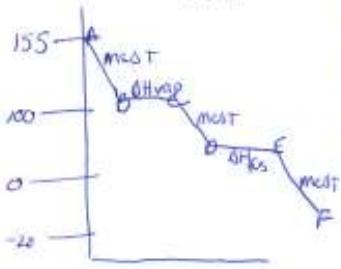
$3.5 \times 10^{24}\ fu\ Zn(NO_3)_2 \left(\frac{1\ mol\ Zn(NO_3)_2}{6.02 \times 10^{23}\ fu\ Zn(NO_3)_2}\right)\left(\frac{-100\ kJ}{1\ mol\ Zn(NO_3)_2}\right) = \boxed{-581.4\ kJ}$

Score: _____

Objective 4: Calculate enthalpy changes that occur using a warming or cooling curve; including phase changes such as melting, freezing, boiling, or condensing.

Directions: Show all work, including units, to solve the following problems. DRAW Diagrams!

1. How much heat (in kJ) is released when 150 grams of steam, gaseous water, at 155°C is converted to ice at -20°C? The molar heat of vaporization for water is 40.7 kJ/mole. The molar heat of fusion for water is 6.01 kJ/mole. The specific heat of water is 4.184 J/g-K. The specific heat of steam, gaseous water, is 1.84 J/g-K. The specific heat of ice is 2.09 J/g-K.



$\overline{AB} = (150g)(1.84\ J/g\text{-}K)(55°C) \div 1000 = -15.18\ kJ$

$\overline{BC} = 150g\ H_2O \left(\frac{1mol\ H_2O}{18g\ H_2O}\right)\left(\frac{40.7\ kJ}{1mol}\right) = -339.17\ kJ$

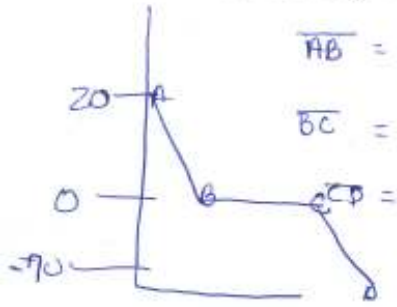
$\overline{CD} = (150g)(4.184\ J/g°C)(100°C) \div 1000 = -62.76\ kJ$

$\overline{DE} = 150g\ H_2O \left(\frac{1mol\ H_2O}{18g\ H_2O}\right)\left(\frac{6.01\ kJ}{1mol}\right) = -50.08\ kJ$

$\overline{EF} = (150g)(2.09\ J/g°C)(20°) \div 1000 = -6.27\ kJ$

2. What is the enthalpy change during the process in which 75 grams of water at 20°C is cooled to ice at -70°C. The specific heat of liquid water is 4.184 J/g-K. The specific heat of ice is 2.09 J/g-K. The molar heat of fusion for water is 6.01 kJ/mol.

-473.46 kJ total



$\overline{AB} = (75g)(4.184\ J/g°C)(20°C) \div 1000 = -6.276\ kJ$

$\overline{BC} = 75g\ H_2O \left(\frac{1mol\ H_2O}{18g\ H_2O}\right)\left(\frac{6.01\ kJ}{1mol}\right) = -25.042\ kJ$

$\overline{CD} = (75g)(2.09\ J/g°C)(70°) \div 1000 = 10.973\ kJ$

total: -42.291 kJ

Score: _____

Objective 5: Calculate the enthalpy change during a dissolving process given thermochemical data.

Directions: Show all work, including units, to solve the following problems.

1. When solid magnesium hydroxide is dissolved into water, forming aqueous magnesium ions and hydroxide ions, 750 kJ/mol of heat energy is released.
   a. Write the balanced thermochemical equation for this physical process:

$$Mg(OH)_{2\,(s)} \xrightarrow{H_2O} Mg^{+2}_{(aq)} + 2OH^{-1}_{(aq)} \quad \Delta H = -750\ kJ$$

   b. How much heat, in kJ, is released when 50 grams of magnesium hydroxide is dissolved in water?

$$50g\ Mg(OH)_2 \left(\frac{1mol\ Mg(OH)_2}{58.3g\ Mg(OH)_2}\right)\left(\frac{-750\ kJ}{1mol\ Mg(OH)_2}\right) = \boxed{-643.2\ kJ}$$

2. When ammonium chloride is dissolved into water, ammonium and chloride ions are released, absorbing 182 kJ of heat energy from the water.
   a. Write this balanced thermochemical equation.

$$NH_4Cl_{(s)} \xrightarrow{H_2O} NH_4^{+}{}_{(aq)} + Cl^{-}_{(aq)} \quad \Delta H = +182\ kJ$$

   b. How many grams of ammonium chloride must be dissolved in water so that 500 kJ of heat is released from the water?

$$500\ kJ \left(\frac{1mol\ NH_4Cl}{+182\ kJ}\right)\left(\frac{53.5g\ NH_4Cl}{1mol\ NH_4Cl}\right) = \boxed{146.98g\ NH_4Cl}$$

   c. Calculate the enthalpy change when 3 moles of chloride ions are released into water.

$$3mol\ Cl^{-1} \left(\frac{182\ kJ}{1mol\ Cl^{-}}\right) = \boxed{+546\ kJ}$$

Score: _____

Objective 6: Apply Hess's law of heat summation to find enthalpy changes for chemical and physical processes.

Directions: Show all work, including units, to solve the following problems.

1. Calculate the enthalpy change for the reaction

   $IF_5(g) \rightarrow IF_3(g) + F_2(g)$

   Given the following enthalpies of reaction

   $IF(g) + F_2(g) \rightarrow IF_3(g)$ $\quad \Delta H = -390$ kJ leave
   $IF(g) + 2F_2(g) \rightarrow IF_5(g)$ $\quad \Delta H = -745$ kJ ←

   $IF + F_2 \rightarrow IF_3 \quad \Delta H = -390$ KJ
   $IF_5 \rightarrow IF + 2F_2 \quad \Delta H = +745$ KJ
   $IF_5 \rightarrow IF_3 + F_2 \quad \Delta H = 355$ KJ

   Answer: +355 KJ

2. Calculate the enthalpy change for the reaction

   $N_2(g) + O_2(g) \rightarrow 2NO$

   Given the following reactions:

   $N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$ $\quad \Delta H = 66.4$ kJ leave
   $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ $\quad \Delta H = -114.2$ kJ ←

   $N_2 + 2O_2 \rightarrow 2NO_2 \quad \Delta H = 66.4$ KJ
   $2NO_2 \rightarrow 2NO + O_2 \quad \Delta H = +114.2$ KJ
   $N_2 + O_2 \rightarrow 2NO \quad \Delta H = 180.6$

   Answer: 180.6 KJ

Score: _____

Objective 7: (Honors Only): Calculate enthalpy changes using standard heats of formation.

Directions: Show all work, including units, to solve the following problems.

1. Using values from the standard table of heats of formation, calculate the value of ΔH for each of the following reactions:
   a. $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$

$\Delta H_{rxn} = \Sigma_{products} - \Sigma_{reactants}$

$\Delta H_{rxn} = [(4 \times 90.37\text{KJ}) + (6 \times -285.83)] - [4 \times -46.19\text{KJ} + 0]$
(4 × 90.37 KJ: NO; 6 × −285.83: H_2O; 4 × −46.19 KJ: NH_3)

$= -1168.74$ KJ

b. $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$

$\Delta H_{RXN} = [(2x - 206.61KJ) + (90.37)] - [(3 \times 33.84) + (-285.83)]$

$= -138.52\ KJ$

2. Given the following thermochemical equation, calculate the ΔH_f for the reactant $SO_2Cl_2(g)$.

$SO_2Cl_2(g) + 2H_2O(l) \rightarrow H_2SO_4(l) + 2HCl(g) \quad \Delta H = -62\ kJ$

$-62\ KJ = [(-814.0\ KJ) + (2x\ -92.3\ KJ)] - [(x) + (2 \times -285.83\ KJ)]$

$-62 = [-998.6] - [x + (571.66)]$ $\quad 936 = -x + 571.66$

$364.94 = -x$

$-364.94 = x\ KJ$

Objective 8: Distributed Practice 1: Determine the limiting reagent and maximum yield of product formed given appropriate data.

Directions: Show all work, including units, to solve the following problems.

1. When lead II nitrate reacts with potassium iodide, a yellow precipitate forms.
   a. Write the balanced equation, circle the precipitate:

$Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$

   b. How many grams of the precipitate form if 50 grams of lead II nitrate reacts with 75 grams of potassium iodide?

L.R. $50g\ Pb(NO_3)_2 \left(\frac{1mol\ Pb(NO_3)_2}{331.2g}\right)\left(\frac{1mol\ PbI_2}{1mol\ Pb(NO_3)_2}\right)\left(\frac{461.2g\ PbI_2}{1mol\ PbI_2}\right) = 69.63g\ PbI_2$

X.S. $75g\ KI \left(\frac{1mol\ KI}{166g\ KI}\right)\left(\frac{1mol\ PbI_2}{2mol\ KI}\right)\left(\frac{461.2g\ PbI_2}{1mol\ PbI_2}\right) = 104.19g\ PbI_2$

2. Calcium hydroxide is neutralized with phosphoric acid.
   a. Write the balanced equation:

$3Ca(OH)_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6H_2O$

   b. How many molecules of water form when 25 grams of calcium hydroxide reacts with 50 grams of phosphoric acid?

L.R. $25g\ Ca(OH)_2 \left(\frac{1mol\ Ca(OH)_2}{\quad}\right)\left(\frac{6mol\ H_2O}{\quad}\right)\left(\frac{6.02 \times 10^{23}\ mlc\ H_2O}{\quad}\right) = 4.07 \times 10^{23}\ mlc$

Objective 9: [redacted]: Distributed Practice 2: Calculate the Percent Yield of a reaction given appropriate data.

Directions: Show all work, including units, to solve the following problems.

1. Lithium and nitrogen react to produce lithium nitride.
   a. Write the balanced equation.

$$6\,Li + N_2 \rightarrow 2\,Li_3N$$

   b. If 5 grams of each reactant undergoes a reaction with a 88.5% yield, how many grams of product are obtained from the reaction?

L.R. $5g\,Li\left(\frac{1mol\,Li}{7g\,Li}\right) = .714mol\,Li\left(\frac{2mol\,Li_3N}{6mol\,Li}\right)\left(\frac{35g\,Li_3N}{1\,Mol\,Li_3N}\right) = 8.33g\,Li_3N$

$\times .885$

X.S. $5g\,N_2\left(\frac{1mol\,N_2}{28g\,N_2}\right) = .179mol\,N_2$

$7.37g\,Li_3N$

2. When hydrogen sulfide gas is bubbled into a solution of sodium hydroxide, the reaction forms sodium sulfide and water. How many grams of sodium sulfide are formed if 1.5 grams of hydrogen sulfide is bubbled into a solution containing 2.00 grams of sodium hydroxide, assuming that the sodium sulfide is made in 92% yield?

Write the balanced equation:

$$H_2S + 2\,NaOH \rightarrow Na_2S + 2\,H_2O$$

X.S. $1.5g\,H_2S\left(\frac{1mol\,H_2S}{34g\,H_2S}\right) = .044mol\,H_2S$

L.R. $2.00g\,NaOH\left(\frac{1mol\,NaOH}{40g\,NaOH}\right) = .05mol\,NaOH\left(\frac{1mol\,Na_2S}{2mol\,NaOH}\right)\left(\frac{78g\,Na_2S}{1mol\,Na_2S}\right) = 1.95g\,Na_2S$

$\times .92$

$1.794g\,Na_2S$

Score: _____