

Quiz

Name: Student A

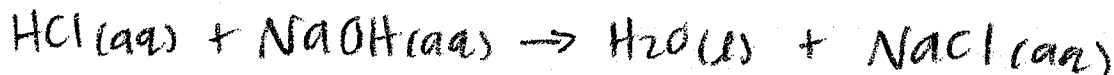
Thermochemistry

Date: _____ Block: _____

1. A mixes 60.0 mL of 1.00 M HCl and 45.0 mL 1.00 M NaOH in an open polystyrene cup calorimeter. Assume the following:

- Both solutions are at 23.0°C before they are combined.
- The densities of all the solutions are the same as that of water (4.184 J g⁻¹ °C⁻¹).
- Any heat lost to the calorimeter or to the air is negligible (i.e. not significant).
- The temperature of the resulting solution is 28.5°C.

a) Write the balanced chemical equation for the reaction that takes place.



b) Determine the limiting reactant. Justify your answer with a calculation.

$$\underset{\text{HCl}}{(0.06 \text{ L})} \left(1 \frac{\text{mol}}{\text{L}}\right) = 0.06 \text{ mol HCl}$$

$$(0.045 \text{ L NaOH}) \left(1 \frac{\text{mol}}{\text{L}}\right) = 0.045 \text{ mol NaOH}$$

∴ Limiting Reactant = NaOH

c) Calculate q_{sys} in kJ. $m = 60 \text{ g} + 45 \text{ g} = 105 \text{ g}$

$$q = (105 \text{ g}) (4.184 \text{ J/g} \cdot ^\circ\text{C}) (28.5^\circ\text{C} - 23^\circ\text{C})$$

$$q = 2416 \text{ J} \quad \boxed{q_{\text{sys}} = -2.42 \text{ kJ}}$$

d) Calculate ΔH in kJ/mol_{rxn}.

$$\Delta H = \frac{-2.42 \text{ kJ}}{0.045 \text{ mol}} = \boxed{-53.7 \text{ kJ/mol}_{\text{rxn}}}$$

e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH ? Explain your reasoning.

ΔH would be too low. If some heat were lost, then that means the measured final T would be too low, causing q and ΔH to be lower than they should be.

$$q = mc\Delta T \quad \Delta H = \frac{q}{n_{\text{LR}}} \quad \begin{array}{l} \text{lower } q \text{ causes calculated} \\ \Delta H \text{ to also be lower} \end{array}$$

↑ too low ↑ too low

2. The thermochemical equation for the reaction between calcium carbonate and ammonia is as follows:

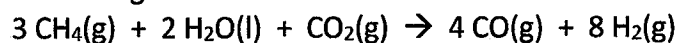


$$\Delta H = +90.1 \text{ kJ/mol}_{\text{rxn}}$$

- a) Is the reaction endothermic or exothermic? Explain your reasoning.
- b) Calculate the grams of liquid water formed when 200.0 kJ of heat are absorbed.
- c) Based on the value of ΔH° , is total bond energy of reactants or products greater? Explain your reasoning.

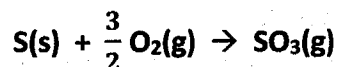
Products are greater. ΔH is positive.

3. Calculate ΔH° for the following reaction. Standard heats of formation are provided.



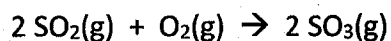
Substance	ΔH°_f (kJ/mol)
CO(g)	-110.5
CO ₂ (g)	-393.5
CH ₄ (g)	-75
H ₂ O(l)	-286

4. Calculate the heat of formation of $\text{SO}_3(\text{g})$ from its elements. The formation of $\text{SO}_3(\text{g})$ is represented in the equation below.

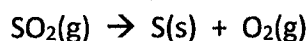


$$\Delta H = ?$$

Given:



$$\Delta H = -198 \text{ kJ/mol}_{\text{rxn}}$$



$$\Delta H = 297 \text{ kJ/mol}_{\text{rxn}}$$

Quiz

Name: Student B

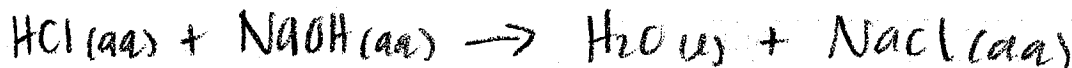
Thermochemistry

Date: _____ Block: _____

1. A mixes 60.0 mL of 1.00 M HCl and 45.0 mL 1.00 M NaOH in an open polystyrene cup calorimeter. Assume the following:

- Both solutions are at 23.0°C before they are combined.
- The densities of all the solutions are the same as that of water (4.184 J g⁻¹ °C⁻¹).
- Any heat lost to the calorimeter or to the air is negligible (i.e. not significant).
- The temperature of the resulting solution is 28.5°C.

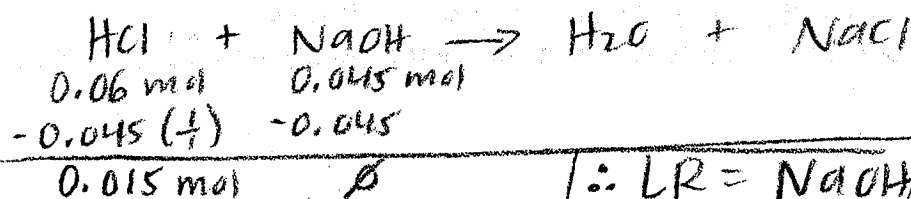
- a) Write the balanced chemical equation for the reaction that takes place.



- b) Determine the limiting reactant. Justify your answer with a calculation.

$$(0.06 \text{ L HCl}) \left(1 \frac{\text{mol}}{\text{L}}\right) = 0.06 \text{ mol HCl}$$

$$(0.045 \text{ L NaOH}) \left(1 \frac{\text{mol}}{\text{L}}\right) = 0.045 \text{ mol NaOH}$$



$$\therefore \text{LR} = \text{NaOH}$$

- c) Calculate q_{sys} in kJ.

$$m = 60 + 45 = 105 \text{ g}$$

$$q = (105 \text{ g}) \left(4.184 \frac{\text{J}}{\text{g}^\circ\text{C}}\right) (28.5^\circ\text{C} - 23^\circ\text{C}) = 2416 \text{ J}$$

- d) Calculate ΔH in kJ/mol_{rxn}.

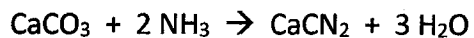
$$q_{\text{sys}} = -2.42 \text{ kJ}$$

$$\Delta H = \frac{2.42 \text{ kJ}}{0.045 \text{ mol}} = 53.7 \text{ kJ/mol rxn}$$

- e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH ? Explain your reasoning.

ΔH would be lower b/c lost heat would cause the measured final T to decrease. Thus, ΔT would be too low, causing q and ΔH to also be too low.

2. The thermochemical equation for the reaction between calcium carbonate and ammonia is as follows:

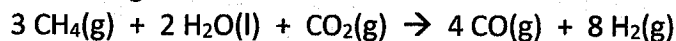


$$\Delta H = +90.1 \text{ kJ/mol}_{\text{rxn}}$$

- a) Is the reaction endothermic or exothermic? Explain your reasoning.
- b) Calculate the grams of liquid water formed when 200.0 kJ of heat are absorbed.
- c) Based on the value of ΔH° , is total bond energy of reactants or products greater? Explain your reasoning.

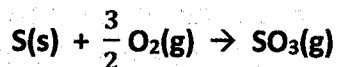
Reactants are greater because ΔH is positive

3. Calculate ΔH° for the following reaction. Standard heats of formation are provided.



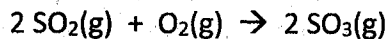
Substance	ΔH°_f (kJ/mol)
CO(g)	-110.5
CO ₂ (g)	-393.5
CH ₄ (g)	-75
H ₂ O(l)	-286

4. Calculate the heat of formation of $\text{SO}_3(\text{g})$ from its elements. The formation of $\text{SO}_3(\text{g})$ is represented in the equation below.

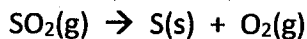


$$\Delta H = ?$$

Given:



$$\Delta H = -198 \text{ kJ/mol}_{\text{rxn}}$$



$$\Delta H = 297 \text{ kJ/mol}_{\text{rxn}}$$

Quiz

Name: Student C

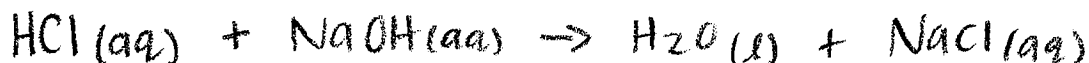
Thermochemistry

Date: _____ Block: _____

1. A mixes 60.0 mL of 1.00 M HCl and 45.0 mL 1.00 M NaOH in an open polystyrene cup calorimeter. Assume the following:

- Both solutions are at 23.0°C before they are combined.
- The densities of all the solutions are the same as that of water (4.184 J g⁻¹ °C⁻¹).
- Any heat lost to the calorimeter or to the air is negligible (i.e. not significant).
- The temperature of the resulting solution is 28.5°C.

- a) Write the balanced chemical equation for the reaction that takes place.



- b) Determine the limiting reactant. Justify your answer with a calculation.

$$\frac{60 \text{ g HCl}}{36.46 \text{ g HCl}} \left| \frac{1 \text{ mol HCl}}{1 \text{ mol HCl}} \right| = 1.646 \text{ mol HCl} \left| \frac{1 \text{ mol H}_2\text{O}}{1 \text{ mol HCl}} \right| = 1.646 \text{ mol H}_2\text{O}$$

$$\frac{45 \text{ g NaOH}}{40 \text{ g NaOH}} \left| \frac{1 \text{ mol NaOH}}{1 \text{ mol NaOH}} \right| = 1.125 \text{ mol NaOH} \left| \frac{1 \text{ mol H}_2\text{O}}{1 \text{ mol NaOH}} \right| = 1.125 \text{ mol H}_2\text{O}$$

- c) Calculate q_{sys} in kJ.

$$q = mc\Delta T$$

$$q = (105 \text{ g}) \left(4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} \right) (28.5^\circ\text{C} - 23^\circ\text{C}) = 2416 \text{ J}$$

- d) Calculate ΔH in kJ/mol_{rxn}.

$$q_{\text{sys}} = -2.42 \text{ kJ}$$

$$\Delta H = \frac{q_{\text{sys}}}{n_{\text{LR}}} = \frac{-2.42 \text{ kJ}}{1.125 \text{ mol}} = -2.15 \text{ kJ/mol}_{\text{rxn}}$$

- e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH ? Explain your reasoning.

ΔH would be lower than it should be because the heat lost would cause final T to be too low. ΔT would be too low, causing q_{sys} to be too low ($q = mc\Delta T$) and ΔH to be too low ($\Delta H = \frac{q_{\text{sys}}}{n_{\text{LR}}}$)

2. The thermochemical equation for the reaction between calcium carbonate and ammonia is as follows:



$$\Delta H = +90.1 \text{ kJ/mol}_{\text{rxn}}$$

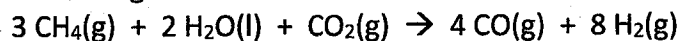
- a) Is the reaction endothermic or exothermic? Explain your reasoning.
- b) Calculate the grams of liquid water formed when 200.0 kJ of heat are absorbed.
- c) Based on the value of ΔH° , is total bond energy of reactants or products greater? Explain your reasoning.

Reactants are greater.

$$\Delta H \text{ is positive and } \Delta H = \sum_{\text{Broken}} \text{Bonds} - \sum_{\text{Formed}} \text{Bonds}$$

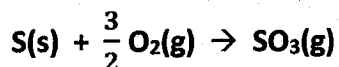
\therefore Bond E of broken bonds must be greater
Bonds are broken in reactants, not products.

3. Calculate ΔH° for the following reaction. Standard heats of formation are provided.



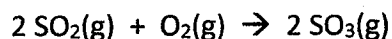
Substance	ΔH°_f (kJ/mol)
CO(g)	-110.5
CO ₂ (g)	-393.5
CH ₄ (g)	-75
H ₂ O(l)	-286

4. Calculate the heat of formation of $\text{SO}_3(\text{g})$ from its elements. The formation of $\text{SO}_3(\text{g})$ is represented in the equation below.

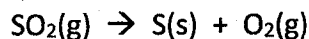


$$\Delta H = ?$$

Given:



$$\Delta H = -198 \text{ kJ/mol}_{\text{rxn}}$$



$$\Delta H = 297 \text{ kJ/mol}_{\text{rxn}}$$

Quiz

Name: Student D

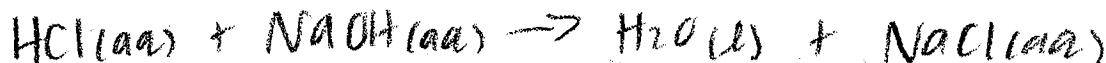
Thermochemistry

Date: _____ Block: _____

1. A mixes 60.0 mL of 1.00 M HCl and 45.0 mL 1.00 M NaOH in an open polystyrene cup calorimeter. Assume the following:

- Both solutions are at 23.0°C before they are combined.
- The densities of all the solutions are the same as that of water (4.184 J g⁻¹ °C⁻¹).
- Any heat lost to the calorimeter or to the air is negligible (i.e. not significant).
- The temperature of the resulting solution is 28.5°C.

a) Write the balanced chemical equation for the reaction that takes place.



b) Determine the limiting reactant. Justify your answer with a calculation.

$$\begin{array}{rcl} (0.06)(1) & = & 0.06 \text{ mol} \\ (0.045)(1) & = & 0.045 \text{ mol} \end{array} \quad \begin{array}{r} 0.06 \quad 0.045 \\ -0.045 \quad -0.045 \\ \hline 0.015 \quad \text{LR} \end{array}$$

c) Calculate q_{sys} in kJ.

$$q = (105 \text{ g})(4.184)(5.5) = 2416 \text{ J}$$

$$q_{\text{sys}} = -2416$$

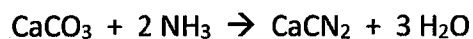
d) Calculate ΔH in kJ/mol_{rxn}.

$$\Delta H = \frac{2416}{0.045} = 53.7$$

e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH ? Explain your reasoning.

ΔH would decrease b/c heat lost causes calculated q (heat) to be too low, which causes $\Delta H = \frac{q}{n_{\text{LR}}}$ to yield a smaller ΔH .

2. The thermochemical equation for the reaction between calcium carbonate and ammonia is as follows:



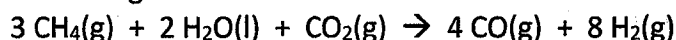
$$\Delta H = +90.1 \text{ kJ/mol}_{\text{rxn}}$$

- a) Is the reaction endothermic or exothermic? Explain your reasoning.
- b) Calculate the grams of liquid water formed when 200.0 kJ of heat are absorbed.
- c) Based on the value of ΔH° , is total bond energy of reactants or products greater? Explain your reasoning.

Products are greater because

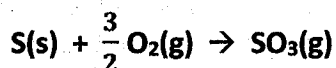
$\Delta H = \text{products} - \text{reactants}$, Since ΔH is positive then products must be larger than reactants.

3. Calculate ΔH° for the following reaction. Standard heats of formation are provided.



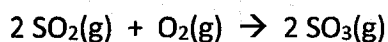
Substance	ΔH°_f (kJ/mol)
CO(g)	-110.5
CO ₂ (g)	-393.5
CH ₄ (g)	-75
H ₂ O(l)	-286

4. Calculate the heat of formation of $\text{SO}_3(\text{g})$ from its elements. The formation of $\text{SO}_3(\text{g})$ is represented in the equation below.

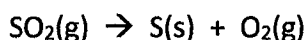


$$\Delta H = ?$$

Given:



$$\Delta H = -198 \text{ kJ/mol}_{\text{rxn}}$$



$$\Delta H = 297 \text{ kJ/mol}_{\text{rxn}}$$

Quiz

Name: Student E

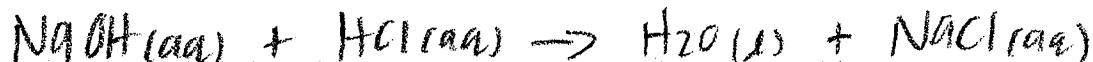
Thermochemistry

Date: _____ Block: _____

1. A mixes 60.0 mL of 1.00 M HCl and 45.0 mL 1.00 M NaOH in an open polystyrene cup calorimeter. Assume the following:

- Both solutions are at 23.0°C before they are combined.
- The densities of all the solutions are the same as that of water (4.184 J g⁻¹ °C⁻¹).
- Any heat lost to the calorimeter or to the air is negligible (i.e. not significant).
- The temperature of the resulting solution is 28.5°C.

a) Write the balanced chemical equation for the reaction that takes place.



b) Determine the limiting reactant. Justify your answer with a calculation.

$$\frac{60 \text{ g HCl}}{36.46 \text{ g HCl}} \times 1 \text{ mol HCl} = 1.646 \text{ mol HCl}$$

$$\frac{45 \text{ g NaOH}}{40 \text{ g NaOH}} \times 1 \text{ mol NaOH} = 1.125 \text{ mol NaOH}$$

$$\therefore \text{LR} = \text{NaOH}$$

c) Calculate q_{sys} in kJ.

$$q = (105 \text{ g}) (4.184) (28.5^\circ\text{C} - 23^\circ\text{C})$$

$$q = 2416 \text{ J}$$

$$q_{\text{sys}} = -2.42 \text{ kJ}$$

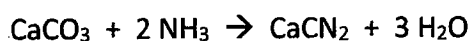
d) Calculate ΔH in kJ/mol_{rxn}.

$$\Delta H = \frac{q}{n_{\text{LR}}} = \frac{-2.42 \text{ kJ}}{1.125 \text{ mol}} = -2.15 \text{ kJ/mol}_{\text{rxn}}$$

e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH ? Explain your reasoning.

ΔH is not affected because ΔH is a ratio that always remains the same.

2. The thermochemical equation for the reaction between calcium carbonate and ammonia is as follows:

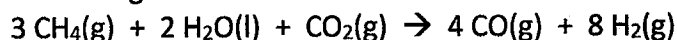


$$\Delta H = +90.1 \text{ kJ/mol}_{\text{rxn}}$$

- a) Is the reaction endothermic or exothermic? Explain your reasoning.
- b) Calculate the grams of liquid water formed when 200.0 kJ of heat are absorbed.
- c) Based on the value of ΔH° , is total bond energy of reactants or products greater? Explain your reasoning.

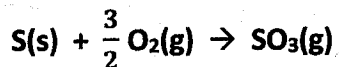
Reactants are greater. $\Delta H = \sum \text{Bonds Broken} - \sum \text{Bonds Formed}$.

3. Calculate ΔH° for the following reaction. Standard heats of formation are provided.



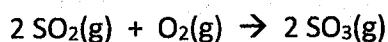
Substance	ΔH°_f (kJ/mol)
CO(g)	-110.5
CO ₂ (g)	-393.5
CH ₄ (g)	-75
H ₂ O(l)	-286

4. Calculate the heat of formation of $\text{SO}_3(\text{g})$ from its elements. The formation of $\text{SO}_3(\text{g})$ is represented in the equation below.

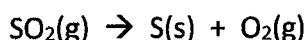


$$\Delta H = ?$$

Given:



$$\Delta H = -198 \text{ kJ/mol}_{\text{rxn}}$$



$$\Delta H = 297 \text{ kJ/mol}_{\text{rxn}}$$

Quiz

Name: Student F

Thermochemistry

Date: _____ Block: _____

1. A mixes 60.0 mL of 1.00 M HCl and 45.0 mL 1.00 M NaOH in an open polystyrene cup calorimeter. Assume the following:

- Both solutions are at 23.0°C before they are combined.
- The densities of all the solutions are the same as that of water (4.184 J g⁻¹ °C⁻¹).
- Any heat lost to the calorimeter or to the air is negligible (i.e. not significant).
- The temperature of the resulting solution is 28.5°C.

- a) Write the balanced chemical equation for the reaction that takes place.



- b) Determine the limiting reactant. Justify your answer with a calculation.

$$(0.06 \text{ L HCl}) \left(1 \frac{\text{mol}}{\text{L}}\right) = 0.06 \text{ mol HCl}$$

$$(0.045 \text{ L NaOH}) \left(1 \frac{\text{mol}}{\text{L}}\right) = 0.045 \text{ mol NaOH}$$

$$\frac{0.06 \text{ mol HCl}}{1 \text{ mol HCl}} \times \frac{1 \text{ mol NaCl}}{1 \text{ mol HCl}} = 0.06 \text{ mol NaCl} \quad \boxed{\therefore \text{LR} = \text{NaOH}}$$

$$\frac{0.045 \text{ mol NaOH}}{1 \text{ mol NaOH}} \times \frac{1 \text{ mol NaCl}}{1 \text{ mol NaOH}} = 0.045 \text{ mol NaCl}$$

- c) Calculate q_{sys} in kJ.

$$\frac{0.06 \text{ mol HCl}}{1 \text{ mol HCl}} \times \frac{36.46 \text{ g HCl}}{1 \text{ mol HCl}} = 2.19 \text{ g HCl}$$

$$\frac{0.045 \text{ mol NaOH}}{1 \text{ mol NaOH}} \times \frac{40 \text{ g NaOH}}{1 \text{ mol NaOH}} = 1.8 \text{ g NaOH}$$

$$m = 2.19 \text{ g} + 1.8 \text{ g} = 3.99 \text{ g}$$

$$\therefore q = (3.99 \text{ g}) \left(4.184 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}}\right) (5.5^\circ\text{C})$$

$$q = 91.8 \text{ J}$$

- d) Calculate ΔH in kJ/mol_{rxn}.

$$\Delta H = \frac{-0.0918 \text{ kJ}}{0.045 \text{ mol}}$$

$$= \boxed{-2.04 \text{ kJ/mol}_{\text{rxn}}}$$

$$\boxed{q_{\text{sys}} = -0.0918 \text{ kJ}}$$

- e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH ? Explain your reasoning.

ΔH would be too low. If heat were lost, then the measured final T of solution would be too low. Since $q = mc\Delta T$ and $\Delta H = \frac{q}{n_{\text{LR}}}$ both q and ΔH would be too low.

2. The thermochemical equation for the reaction between calcium carbonate and ammonia is as follows:

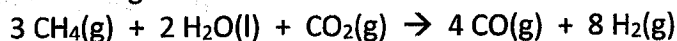


$$\Delta H = +90.1 \text{ kJ/mol}_{\text{rxn}}$$

- a) Is the reaction endothermic or exothermic? Explain your reasoning.
- b) Calculate the grams of liquid water formed when 200.0 kJ of heat are absorbed.
- c) Based on the value of ΔH° , is total bond energy of reactants or products greater? Explain your reasoning.

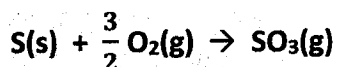
E goes in to break bonds of reactants
 are E is released when bonds of products
 are formed. Since ΔH is positive, then
 the bond E of reactants must be greater
 than that of products.

3. Calculate ΔH° for the following reaction. Standard heats of formation are provided.



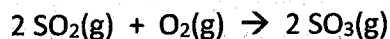
Substance	ΔH°_f (kJ/mol)
CO(g)	-110.5
CO ₂ (g)	-393.5
CH ₄ (g)	-75
H ₂ O(l)	-286

4. Calculate the heat of formation of $\text{SO}_3(\text{g})$ from its elements. The formation of $\text{SO}_3(\text{g})$ is represented in the equation below.

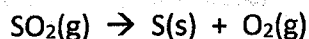


$$\Delta H = ?$$

Given:



$$\Delta H = -198 \text{ kJ/mol}_{\text{rxn}}$$



$$\Delta H = 297 \text{ kJ/mol}_{\text{rxn}}$$