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.

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$

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

$(0.06\ L_{HCl})(1\ \frac{mol}{L}) = 0.06\ mol\ HCl$

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

∴ Limiting Reactant = NaOH

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

$q = (105\ g)(4.184\ J/g \cdot °C)(28.5°C - 23°C)$

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

d) Calculate ΔH in kJ/mol_{rxn}.

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

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 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.

$q = mc\Delta T$ (ΔT: too low; m, c: too low)

$\Delta H = \frac{q}{n_{LR}}$ ← lower q causes calculated ΔH to also be lower

Student A

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

$$CaCO_3 + 2\ NH_3 \rightarrow CaCN_2 + 3\ H_2O \qquad \Delta H = +90.1\ kJ/mol_{rxn}$$

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 $\Delta H°$, is total bond energy of reactants or products greater? Explain your reasoning.

Products are greater. ΔH is positive.

3. Calculate $\Delta H°$ for the following reaction. Standard heats of formation are provided.

$$3\ CH_4(g) + 2\ H_2O(l) + CO_2(g) \rightarrow 4\ CO(g) + 8\ H_2(g)$$

Substance	$\Delta H°_f$ (kJ/mol)
$CO(g)$	−110.5
$CO_2(g)$	−393.5
$CH_4(g)$	−75
$H_2O(l)$	−286

4. Calculate the heat of formation of $SO_3(g)$ from its elements. The formation of $SO_3(g)$ is represented in the equation below.

$$\mathbf{S(s) + \frac{3}{2}\,O_2(g) \rightarrow SO_3(g)} \qquad \mathbf{\Delta H = ?}$$

Given:

$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$ $\quad \Delta H = -198\ kJ/mol_{rxn}$

$SO_2(g) \rightarrow S(s) + O_2(g)$ $\quad \Delta H = 297\ kJ/mol_{rxn}$

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.

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$

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

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

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

HCl	+ $NaOH$	$\rightarrow$ H_2O	+ $NaCl$
0.06 mol	0.045 mol		
$-0.045\left(\frac{1}{1}\right)$	−0.045		
0.015 mol	∅		

∴ LR = NaOH

c) Calculate q_{sys} in kJ.

$m = 60 + 45 = 105\ g$

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

$q_{sys} = -2.42\ kJ$

d) Calculate ΔH in kJ/mol_{rxn}.

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

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.

Student B

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

$$CaCO_3 + 2\ NH_3 \rightarrow CaCN_2 + 3\ H_2O \qquad \Delta H = +90.1\ kJ/mol_{rxn}$$

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 $\Delta H°$, is total bond energy of reactants or products greater? Explain your reasoning.

Reactants are greater because ΔH is positive

3. Calculate $\Delta H°$ for the following reaction. Standard heats of formation are provided.

$$3\ CH_4(g) + 2\ H_2O(l) + CO_2(g) \rightarrow 4\ CO(g) + 8\ H_2(g)$$

Substance	$\Delta H°_f$ (kJ/mol)
$CO(g)$	−110.5
$CO_2(g)$	−393.5
$CH_4(g)$	−75
$H_2O(l)$	−286

4. Calculate the heat of formation of $SO_3(g)$ from its elements. The formation of $SO_3(g)$ is represented in the equation below.

$$\mathbf{S(s) + \frac{3}{2}\,O_2(g) \rightarrow SO_3(g)} \qquad \mathbf{\Delta H = ?}$$

Given:

$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$ $\quad \Delta H = -198\ kJ/mol_{rxn}$

$SO_2(g) \rightarrow S(s) + O_2(g)$ $\quad \Delta H = 297\ kJ/mol_{rxn}$

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.

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$$

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

$$60\ g\ HCl \left| \frac{1\ mol\ HCl}{36.46\ g\ HCl} \right. = 1.646\ mol\ HCl \left| \frac{1\ mol\ H_2O}{1\ mol\ HCl} \right. = 1.646\ mol\ H_2O$$

$$45\ g\ NaOH \left| \frac{1\ mol\ NaOH}{40\ g\ NaOH} \right. = 1.125\ mol\ NaOH \left| \frac{1\ mol\ H_2O}{1\ mol\ NaOH} \right. = 1.125\ mol\ NaOH$$

∴ LR = NaOH

c) Calculate q_{sys} in kJ.

$q = mc\Delta T$

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

$q_{sys} = -2.42\ kJ$

d) Calculate ΔH in kJ/mol_{rxn}.

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

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 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 ($\Delta H = \frac{q_{sys}}{n_{LR}}$)

Student C

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

$$CaCO_3 + 2\ NH_3 \rightarrow CaCN_2 + 3\ H_2O \qquad \Delta H = +90.1\ kJ/mol_{rxn}$$

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 $\Delta H°$, is total bond energy of reactants or products greater? Explain your reasoning.

Reactants are greater.
ΔH is positive and $\Delta H = \Sigma_{\text{Bonds Broken}} - \Sigma_{\text{Bonds Formed}}$

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

3. Calculate $\Delta H°$ for the following reaction. Standard heats of formation are provided.

$$3\ CH_4(g) + 2\ H_2O(l) + CO_2(g) \rightarrow 4\ CO(g) + 8\ H_2(g)$$

Substance	$\Delta H°_f$ (kJ/mol)
$CO(g)$	−110.5
$CO_2(g)$	−393.5
$CH_4(g)$	−75
$H_2O(l)$	−286

4. Calculate the heat of formation of $SO_3(g)$ from its elements. The formation of $SO_3(g)$ is represented in the equation below.

$$\mathbf{S(s) + \frac{3}{2}O_2(g) \rightarrow SO_3(g)} \qquad \mathbf{\Delta H = ?}$$

Given:

$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$ $\quad \Delta H = -198\ kJ/mol_{rxn}$

$SO_2(g) \rightarrow S(s) + O_2(g)$ $\quad \Delta H = 297\ kJ/mol_{rxn}$

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.

$HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

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

$(0.06)(1) = 0.06$ mol

$(0.045)(1) = 0.045$ mol

0.06 0.045

-0.045 -0.045

0.015 Ø LR

c) Calculate q_{sys} in kJ.

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

$q_{sys} = -2416$

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 $\Delta H = \frac{q}{n_{LR}}$ to yield a smaller ΔH.

Student D

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

$$CaCO_3 + 2\,NH_3 \rightarrow CaCN_2 + 3\,H_2O \qquad \Delta H = +90.1\ kJ/mol_{rxn}$$

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 $\Delta H°$, is total bond energy of reactants or products greater? Explain your reasoning.

Products are greater because ΔH = products − reactants, since ΔH is positive then products must be larger than reactants.

3. Calculate $\Delta H°$ for the following reaction. Standard heats of formation are provided.

$$3\,CH_4(g) + 2\,H_2O(l) + CO_2(g) \rightarrow 4\,CO(g) + 8\,H_2(g)$$

Substance	$\Delta H°_f$ (kJ/mol)
$CO(g)$	−110.5
$CO_2(g)$	−393.5
$CH_4(g)$	−75
$H_2O(l)$	−286

4. Calculate the heat of formation of $SO_3(g)$ from its elements. The formation of $SO_3(g)$ is represented in the equation below.

$$\mathbf{S(s) + \frac{3}{2}\,O_2(g) \rightarrow SO_3(g)} \qquad \mathbf{\Delta H = ?}$$

Given:

$2\,SO_2(g) + O_2(g) \rightarrow 2\,SO_3(g)$ $\quad \Delta H = -198\ kJ/mol_{rxn}$

$SO_2(g) \rightarrow S(s) + O_2(g)$ $\quad \Delta H = 297\ kJ/mol_{rxn}$

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.

$NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$

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

$\frac{60\ g\ HCl}{} \left| \frac{1\ mol\ HCl}{36.46\ g\ HCl} \right. = 1.646\ mol\ HCl$

$\therefore LR = NaOH$

$\frac{45\ g\ NaOH}{} \left| \frac{1\ mol\ NaOH}{40\ g\ NaOH} \right. = 1.125\ mol\ NaOH$

c) Calculate q_{sys} in kJ.

$q = (105\ g)(4.184)(28.5\ °C - 23\ °C)$

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

d) Calculate ΔH in kJ/mol_{rxn}.

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

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

Student E

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

$$CaCO_3 + 2\,NH_3 \rightarrow CaCN_2 + 3\,H_2O \qquad \Delta H = +90.1\ kJ/mol_{rxn}$$

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. $\Delta H = \Sigma_{\text{Bonds Broken}} - \Sigma_{\text{Bonds Formed}}$.

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

$$3\,CH_4(g) + 2\,H_2O(l) + CO_2(g) \rightarrow 4\,CO(g) + 8\,H_2(g)$$

Substance	$\Delta H°_f$ (kJ/mol)
$CO(g)$	−110.5
$CO_2(g)$	−393.5
$CH_4(g)$	−75
$H_2O(l)$	−286

4. Calculate the heat of formation of $SO_3(g)$ from its elements. The formation of $SO_3(g)$ is represented in the equation below.

$$\mathbf{S(s) + \frac{3}{2}\,O_2(g) \rightarrow SO_3(g)} \qquad \mathbf{\Delta H = ?}$$

Given:

$2\,SO_2(g) + O_2(g) \rightarrow 2\,SO_3(g)$ $\quad \Delta H = -198\ kJ/mol_{rxn}$

$SO_2(g) \rightarrow S(s) + O_2(g)$ $\quad \Delta H = 297\ kJ/mol_{rxn}$

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.

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$

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

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

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

$0.06\ mol\ HCl \left| \frac{1\ mol\ NaCl}{1\ mol\ HCl} \right. = 0.06\ mol\ NaCl$ ∴ LR = NaOH

$0.045\ mol\ NaOH \left| \frac{1\ mol\ NaCl}{1\ mol\ NaOH} \right. = 0.045\ mol\ NaCl$

c) Calculate q_{sys} in kJ.

$0.06\ mol\ HCl \left| \frac{36.46\ g\ HCl}{1\ mol\ HCl} \right. = 2.19\ g\ HCl$

$0.045\ mol\ NaOH \left| \frac{40\ g\ NaOH}{1\ mol\ NaOH} \right. = 1.8\ g\ NaOH$

$m = 2.19\ g + 1.8\ g = 3.99\ g$

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

$q = 91.8\ J$

d) Calculate ΔH in kJ/mol_{rxn}.

$\Delta H = \frac{-0.0918\ kJ}{0.045\ mol} = -2.04\ kJ/mol_{rxn}$

$q_{sys} = -0.0918\ kJ$

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 $\Delta H = \frac{q}{n_{LR}}$ both q and ΔH would be too low.

Student F

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

$$CaCO_3 + 2\ NH_3 \rightarrow CaCN_2 + 3\ H_2O \qquad \Delta H = +90.1\ kJ/mol_{rxn}$$

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 $\Delta H°$, 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 $\Delta H°$ for the following reaction. Standard heats of formation are provided.

$$3\ CH_4(g) + 2\ H_2O(l) + CO_2(g) \rightarrow 4\ CO(g) + 8\ H_2(g)$$

Substance	$\Delta H°_f$ (kJ/mol)
$CO(g)$	−110.5
$CO_2(g)$	−393.5
$CH_4(g)$	−75
$H_2O(l)$	−286

4. Calculate the heat of formation of $SO_3(g)$ from its elements. The formation of $SO_3(g)$ is represented in the equation below.

$$\mathbf{S(s) + \frac{3}{2}\,O_2(g) \rightarrow SO_3(g)} \qquad \mathbf{\Delta H = ?}$$

Given:

$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$ $\quad \Delta H = -198\ kJ/mol_{rxn}$

$SO_2(g) \rightarrow S(s) + O_2(g)$ $\quad \Delta H = 297\ kJ/mol_{rxn}$