

Heat of Reaction

Spoken Tutorial Project

<http://spoken-tutorial.org>

National Mission on Education through ICT

<http://sakshat.ac.in>

Madhuri Ganapathi

Snehalatha Kaliappan

IIT Bombay

26 April 2017



Learning Objectives



Learning Objectives

We will learn to,



Learning Objectives

We will learn to,

- ▶ **Determine heat change for neutralisation of NaOH and HCl**



Learning Objectives

We will learn to,

- ▶ **Determine heat change for neutralisation of NaOH and HCl**
- ▶ **Calculate heat of reaction for 3 different reactions**



Reactions



Reactions



Reactions

1. $\text{NaOH}(s) + \text{H}_2\text{O}(l) \rightarrow \text{Na}^+(aq) + \text{OH}^-(aq)$
2. $\text{NaOH}(s) + \text{HCl}(aq) \rightarrow \text{Na}^+(aq) + \text{Cl}^-(aq) + \text{H}_2\text{O}(l)$



Reactions

1. $\text{NaOH}(s) + \text{H}_2\text{O}(l) \rightarrow \text{Na}^+(aq) + \text{OH}^-(aq)$
2. $\text{NaOH}(s) + \text{HCl}(aq) \rightarrow \text{Na}^+(aq) + \text{Cl}^-(aq) + \text{H}_2\text{O}(l)$
3. $\text{NaOH}(aq) + \text{HCl}(aq) \rightarrow \text{Na}^+(aq) + \text{Cl}^-(aq) + \text{H}_2\text{O}(l)$



Pre-requisites



Pre-requisites

- ▶ ChemCollective Vlabs interface



Pre-requisites

- ▶ **ChemCollective Vlabs interface**
- ▶ **If not for relevant tutorials please visit our website**
www.spoken-tutorial.org



System Requirement



System Requirement

- ▶ Mac OS v 10.10.5



System Requirement

- ▶ **Mac OS v 10.10.5**
- ▶ **ChemCollective Vlabs v 2.1.0**



System Requirement

- ▶ **Mac OS v 10.10.5**
- ▶ **ChemCollective Vlabs v 2.1.0**
- ▶ **Java v 8**



Hess's Law



Hess's Law

- ▶ Total heat change during the complete course of a reaction is same,



Hess's Law

- ▶ **Total heat change during the complete course of a reaction is same,**
- ▶ **whether the reaction is made in one step or in several steps**



Hess's Law

- ▶ **Total heat change during the complete course of a reaction is same,**
- ▶ **whether the reaction is made in one step or in several steps**
- ▶ **Heat of reaction is also known as standard enthalpy change**



Hess's Law

- ▶ Total heat change during the complete course of a reaction is same,
- ▶ whether the reaction is made in one step or in several steps
- ▶ Heat of reaction is also known as standard enthalpy change
- ▶ $\Delta_r H = \Delta_r H_1 + \Delta_r H_2 + \Delta_r H_3 \dots$



Hess's Law



Hess's Law

$$\blacktriangleright \Delta H_1 + \Delta H_3 = \Delta H_2$$



Hess's Law

- ▶ $\Delta H_1 + \Delta H_3 = \Delta H_2$
- ▶ $R_{x1} + R_{x3} = R_{x2}$



Hess's Law

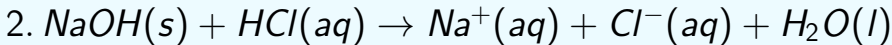
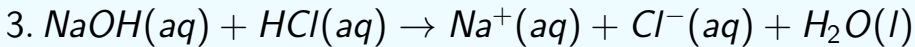
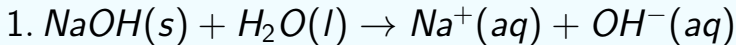
- ▶ $\Delta H_1 + \Delta H_3 = \Delta H_2$
- ▶ $R_{x1} + R_{x3} = R_{x2}$



Hess's Law

▶ $\Delta H_1 + \Delta H_3 = \Delta H_2$

▶ $R_{x1} + R_{x3} = R_{x2}$



Heat of Reaction

- ▶ **Formula for Heat of Reaction (q) is,**
- ▶ $q = m * s * \Delta T$
- ▶ **m = mass of the reactants**
- ▶ **s = specific heat of the solution**
- ▶ **ΔT = change in temperature in the reaction**



Calculation of heat of reaction for Rx1



Calculation of heat of reaction for Rx1

- ▶ $q = m * s * \Delta T$
- ▶ $m = 50 \text{ mL water} + 1 \text{ g NaOH}$
- ▶ $s = 4.2 \text{ J/g}$
- ▶ $\Delta T = (T_2 - T_1) = (30.29 - 25.0) = 5.29$
- ▶ $q = (50 + 1) * 4.2 * (5.29)$
- ▶ $q = 1133.12/1000 = 1.133 \text{ KJ}$



Calculation of heat of reaction for Rx1



Calculation of heat of reaction for Rx1

- ▶ $\Delta H = q / (\text{moles of NaOH})$
- ▶ $\text{Number of moles of NaOH} = 1/40 = 0.025$
- ▶ $\Delta H1 = 1.13312/0.025$
- ▶ $\Delta H1 = 45.32 \text{ KJmol}^{-1}$
- ▶ $\Delta H1 = -45.32 \text{ KJmol}^{-1}$
(Exothermic reaction)



Calculation of heat of reaction for $Rx2$



Calculation of heat of reaction for Rx2

- ▶ $q = m * s * \Delta T$
- ▶ $\Delta T = (T_2 - T_1) = (36.96 - 25.0) = 11.96$
- ▶ $q = (50 + 1) * 4.2 * (11.96) = 2561.83 \text{ Joules}$
- ▶ $q = 2561.83/1000 = 2.56183 \text{ KJ}$
- ▶ $\Delta H_2 = q / (\text{moles of NaOH})$
- ▶ $\Delta H_2 = 2.561/0.025 = 102.47 \text{ KJmol}^{-1}$
- ▶ $\Delta H_2 = -102.47 \text{ KJmol}^{-1}$



Calculation of heat of reaction for Rx3



Calculation of heat of reaction for Rx3

- ▶ $q = m * s * \Delta T$
- ▶ $\Delta T = (T_2 - T_1) = (31.67 - 25.0) = 6.67$
- ▶ $q = (25 + 25) * 4.2 * (6.67) = 1400.7 \text{ Joules}$
- ▶ $q = 1400.7/1000 = 1.400 \text{ KJ}$
- ▶ $\Delta H_3 = 1.400/0.025 = 56.03 \text{ KJmol}^{-1}$
- ▶ $\Delta H_3 = -56.03 \text{ KJmol}^{-1}$



Analysis of Results

- ▶ $\Delta H_1 + \Delta H_3 = \Delta H_2$
- ▶ $-45.32 + (-56.03) = -101.35 \text{ kJ/mol}$
- ▶ $\Delta H_2 = -102.47 \text{ KJ/mol}$



Summary



Summary

We have,

- ▶ **Determined heat change for neutralisation of NaOH and HCl**
- ▶ **Calculated heat of reaction for 3 different reactions**



Assignment



Assignment

1. Explain why the reactions are exothermic



Assignment

1. **Explain why the reactions are exothermic**
2. **Repeat Rx1 using 4 g of NaOH and calculate the heat of reaction**



Assignment

1. Explain why the reactions are exothermic
2. Repeat Rx1 using 4 g of NaOH and calculate the heat of reaction
3. Compare its value with the reaction in which 1 g of NaOH was used



About the Spoken Tutorial Project

- ▶ Watch the video available at http://spoken-tutorial.org/What_is_a_Spoken_Tutorial
- ▶ It summarises the Spoken Tutorial project
- ▶ If you do not have good bandwidth, you can download and watch it



Spoken Tutorial Workshops

The Spoken Tutorial Project Team

- ▶ Conducts workshops using spoken tutorials
- ▶ Gives certificates to those who pass an online test
- ▶ For more details, please write to contact@spoken-tutorial.org



Forum for specific questions

- ▶ Do you have questions in **THIS Spoken Tutorial?**
- ▶ Please visit
<http://forums.spoken-tutorial.org>
- ▶ Choose the minute and second where you have the question
- ▶ Explain your question briefly
- ▶ Someone from our team will answer them



Acknowledgements

- ▶ **Spoken Tutorial Project is a part of the Talk to a Teacher project**
- ▶ **It is supported by the National Mission on Education through ICT, MHRD, Government of India**
- ▶ **More information on this Mission is available at**

<http://spoken-tutorial.org /NMEICT-Intro>

