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KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established Under Section 3 of UGC Act 1956)

Coimbatore – 641 021.

SYLLABUS

DEPARTMENT OF CHEMISTRY

Semester-II

17CHU211	**CHEMICAL THERMODYNAMICS AND ITS APPLICATIONS PRACTICAL**	**2H 1C**

Instruction Hours/week:L: 0 T:0 P:2 **Marks: Internal: 40 External: 60 Total:100**

Scope

It deals with the fundamental experiments in thermochemistry. The enthalpy of reactions has to be measured.

Objectives

It enables the students to

1. Measure the heat capacity of a calorimeter
2. Measure the enthalpy of neutralisation between acids and bases, and to determine the ionisation of a weak acid
3. Measure the solubility and to determine the enthalpy of hydration of salts.

Thermochemistry:

(a) Determination of heat capacity of a calorimeter for different volumes using (i) change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulphuric acid or enthalpy of neutralization), and (ii) heat gained equal to heat lost by cold water and hot water respectively

(b) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Determination of the enthalpy of ionization of ethanoic acid.

(d) Determination of integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of basicity of a diprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

(f) Determination of enthalpy of hydration of salt.

(g) Study of the solubility of benzoic acid in water and determination of ΔH.

Suggested Readings:

Text Books:

1. Madan, R.L. (2015). *Chemistry for Degree Students.* New Delhi: S. Chand and Company Pvt, Ltd.
2. Khosla, B. D.; Garg, V. C. & Gulati, A. (2011). *Senior Practical Physical Chemistry*. New Delhi: R. Chand & Co.

Reference Books:

3. Athawale, V. D. & Mathur, P. (2011). *Experimental Physical Chemistry.* New Delhi: New Age International.

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LAB MANUAL

Chemical Thermodynamics and Its Applications Practical (17CHU211)

(a) Determination of heat capacity of a calorimeter for different volumes using (i) change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulphuric acid or enthalpy of neutralization), and (ii) heat gained equal to heat lost by cold water and hot water respectively

(b) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Determination of the enthalpy of ionization of ethanoic acid.

(d) Determination of integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of basicity of a diprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

(f) Determination of enthalpy of hydration of salt.

(g) Study of the solubility of benzoic acid in water and determination of ΔH.

DETERMINATION OF ENTHALPY OF BASE HYDROLYSIS BY CALORIMETRY METHOD

Aim:

To determine the enthalpy of base hydrolysis by calorimetry method.

Formula:

The following equation used to determine the enthalpy (ΔH).

Q solution = mCΔT

m = mass of solution in g

C = specific heat capacity J/g C

ΔT = temperature different in degree Celsius (T1-T2)

Specific heat capacity of water = 4.20 J/g C

Specific heat capacity of ice = 2.01 J/g C

Specific heat capacity of steam = 2.01 J/g C

q reaction = solution + q calorimeter

q solution = -q reaction

n = g/molecular weight

$NaOH + H_2O \rightarrow Na^+ + OH^-$

Procedure:

The water was removed completely from the inner beaker of the calorimeter and 50 ml of NaOH 0.5 N solution was taken by the measuring cylinder at the RT thermometer was placed in the NaOH solution and the temperature were recorded for 5 minutes at the interval of one minute. 0.5N H2O solution was similarly taken in the beaker and temperature were recorded for 5 minutes at the interval of one minute. 0.5N H2O solution was similarly taken in the beaker and temperature were recorded .The same H2O solution was then gently added in the NaOH (which was kept in the inner beaker of the calorimeter. (Note: care should be taken not to splash the solution). Temperatures were recorded for 5 minutes at one minute interval. Graph of temperature Vs time was plotted. A vertical line was drawn on the graph for the moment of mixing when the half of the water has been poured. On extrapolation of the temperature lines to this vertical line the intersection points provide the temperature of distilled water (T1) hot water

(T2) and mixture (of distilled and hot water) T3.These were used for the calculation.

Similarly the graph was drawn for heat of neutralization and temperature of NaOH solution (T4) H_2O solution (t5) and reaction mixture (t6) were obtained

Calculation:

Room temperature T1 =

Temperature after the substance added T2 =

$\Delta T = T2 - T1 =$

Weight of empty beaker (W1) =

Weight of the beaker with liquid (W2) =

Mass of the substance added to the beaker (W3) =

Mass of the solution = W2 + W3 - W1

=

Qsolution = $mC\Delta T$

=

Qsolution =

$\Delta H = Qreaction / n$

n = g / molecular weight

=

=

q solution = -q reaction

=

ΔH =

=

S.NO	ROOM TEMPERATURE	MIXTURE TEMPERATURE
1		
2		
3		

Average room temperature=

Average mixture temperature=

RESULT:

Room temperature T1=

Temperature of mixed water T2=

Enthalpy of the reaction ΔH=

DETERMINATION OF ENTHALPY OF IONISATION REACTION

Aim:

To determine the water, equivalent of calorimeter and the heat of neutralization of strong acid (0.5N aq HCl solution) and strong base (0.5N aq.NaOH solution)

Formula:

$Q_{solution} = mC\Delta T$

m = mass of solution in g

C = specific heat capacity J/g ^oC

ΔT=temperature different in degree Celsius (T1-T2)

q reaction = q solution + q calorimeter

$\Delta H = Q_{reaction} / n$ KJ

n = mole of substance

$Q_{solution} = mC\Delta T$ KJ

q solution = -q reaction

n = g/molecular weight

$HCl + NaOH \rightarrow NaCl + H_2O + 13.7$ Kcal

Procedure:

The was removed completely from the inner beaker of the calorimeter and 50 ml of NaOH solution was taken by the measuring cylinder at the RT thermometer was placed in the NaOH solution and the temperature were recorded for 5 minutes at the interval of one minute.0.5 N HCl solution was similarly taken in another beaker and the temperature were recorded. The same HCl solution was then added gently in the NaOH solution (which was kept in the inner beaker of the calorimeter. Note: care should be taken not to splash the solution).Temperature were recorded for 5 minutes at one minute interval.

Graph of temperature Vs time was plotted.

A vertical line was drawn on the graph for the moment of mixing when half of the water has been poured. On extrapolation of the temperature lines to this vertical line. The intersection points provided the temperature of distilled water (T1) hot water (T2) and mixture of distilled water and the hot water (T3). These were used for the calculation.

Similarly a graph was drawn for heat of neutralization and temperature of NaOH solution

(T4) HCl solution (T5) and reaction mixture (T6) were obtained.

Calculation:

Mass of the solution =

Mass of the beaker =

Mass of the solution=

=

$\Delta T = T2-T1$

=

$Q_{solution} = m C\Delta T$

=

=

q solution = -q reaction

=

$\Delta H = Q_{reaction} / n$

n = g / molecular weight

=

ΔH =

=

S.NO	ROOM TEMPERATURE	MIXTURE TEMPERATURE
1		
2		
3		

Average room temperature=

Average mixture temperature=

Result:

Room temperature T1=

Temperature of mixed water t2=

Enthalpy of the reaction ΔH=

DETERMINATION OF ENTHALPY OF HEAT NEUTRALIZATION IN WATER

Aim:

To determine the enthalpy of heat of neutralization in water.

Formula:

$Q_{solution} = mC\Delta T$

m = mass of solution in g

C = specific heat capacity J/g C

ΔT = temperature different in degree Celsius (T1-T2)

The water equivalent of calorimeter as heat capacity of the calorimeter is defined as the mass of water which will be heat through 1^oC by the same amount of heat required to raise the temperature of 1^oC.

Short procedure:

25ml of distilled water was taken by a beaker to measure the laboratory temperature. A thermometer was adjusted to read the temperature of distilled water for a period of 5 minutes at the interval of one minute. In another similar beaker 25 ml of hot water was taken and the reading were recorded in the same way.25 ml of this hot water is then added in the distilled water stir well. The temperature of this water was noted at every two minutes for three times.

Calculation:

Room temperature T1=

Temperature of hot water T2=

Temperature of mixed water T3=

Heat taken by calorimeter T3-T1=

Heat taken by room temperature of water = 25 x 1 x T3-T1

=

Heat taken = heat given

Q(T3-T1) + 25 x 1(T3-T1) = 25 x 1 x T2-T3

Q = 25 x 1(T1+T2 – 2T3/t3-1) Cal

=

=

= Cal

Result:

Heat of neutralization of hot water by cold water was found to be =

DETERMINATION OF ENTHALPY OF SODIUM BENZOATE BY CALORIMETRY METHOD

Aim:

To determine the enthalpy of sodium benzoate by calorimetric method

Formula:

The following equation used to determine the enthalpy (ΔH).

Q solution=mCΔT

m = mass of solution in g

C = specific heat capacity J/g C

ΔT = temperature different in degree celsius (T1-T2)

Specific heat capacity of water = 4.20 J/g C

Specific heat capacity of ice = 2.01 J/g C

Specific heat capacity of steam = 2.01 J/g C

q reaction = solution + q calorimeter

ΔH = Qreaction / n KJ

n = mole of the substance

Q solution = mCΔT

q solution = -q reaction

n = g / molecular weight

$C_6H_5COOH + NaOH \rightarrow C_6H_5COONa+H_2O$

Procedure:

The moisture was removed completely from the inner beaker of the calorimeter and 20 ml of water is taken in the beaker. Benzoic acid is added to the beaker (0.5g). Sodium hydroxide solution is added. The Temperature was recorded for 5 minutes at one minute interval. Graph of temperature Vs time was plotted. A vertical line was drawn on the graph for the moment of mixing when the water has been poured. On extrapolation of the temperature of distilled water t1 and mixture of distilled water and NaOH t2. These were used for the calculation.

Calculation:

Room temperature T1=

Temperature after the substance added T2=

$\Delta T = T2-T1$

Weight of empty beaker =

Weight of the beaker with solution =

Q solution = $mC\Delta T$

=

=

$\Delta H = -Qreaction / n$

n = g / molecular weight

=

=

ΔH =

=

S.NO	ROOM TEMPERATURE	MIXTURE TEMPERATURE
1		
2		
3		

Average room temperature=

Average mixture temperature=

Result:

Room temperature T1=

Temperature of salt formation T2=

Enthalpy of the reaction ΔH=

DETERMINATION OF ENTHALPY BY SALT FORMATION

Aim:

To determine the enthalpy by(copper sulphate) salt hydrolysis.

Formula:

The following equation used to determine the enthalpy (ΔH)

Q solution = mCΔT

m = mass of solution in g

C = specific heat capacity J/g C

ΔT=temperature different in degree Celsius (T1-T2)

Specific heat capacity of water = 4.20 J/g C

Specific heat capacity of ice = 2.01 J/g C

Specific heat capacity of steam = 2.01 J/g C

q reaction = solution + q calorimeter

ΔH = Qreaction / n KJ

n = mole of the substance

Q solution=mCΔT

q solution = -q reaction

n = g / molecular weight

$CuSO_4.5H_2O + H_2SO_4 \rightarrow Cu^{2+} + SO_4^{2-} + H_2O + HSO_4^-$

Procedure:

The water was completely removed from the inner beaker of the calorimeter and water is taken in the beaker and calculates the room temperature (T1) copper sulphate penta hydrate (0.5g) is taken in the beaker. Note the temperature reading as t2. These were used for the calculation.

Calculation:

Room temperature T1=

Temperature after the substance added T2=

ΔT=T2-T1

=

W1=

W2=

Mass of the solution = W2-W1

=

Q solution = mCΔT

=

=

q solution = -q reaction

=

n = g / molecular weight

=

ΔH= -Qreaction / n

=

S.NO	ROOM TEMPERATURE	MIXTURE TEMPERATURE
1		
2		
3		

Average room temperature=

Average mixture temperature=

Result:

Room temperature T1=

Temperature of salt hydrolysis T2=

Enthalpy of the reaction ΔH=

DETERMINATION OF ENTHALPY OF SALT HYDROLYSIS BY CALORIMETRY METHOD.

Aim:

To determine the enthalpy of salt solution(NH4Cl) by calorimetry method.

Formula:

The following equation used to determine the enthalpy (ΔH).

Q solution=mCΔT

m = mass of solution in g

C = specific heat capacity J/g C

ΔT = temperature different in degree celsius (T1-T2)

Specific heat capacity of water = 4.20 J/g C

q reaction = solution + q calorimeter

ΔH = Qreaction / n KJ

n = mole of the substance

q solution = -q reaction

n = g / molecular weight

$NH_4Cl \rightarrow NH_4+ + Cl^-$

Procedure:

The water was completely removed from the inner beaker of calorimeter and water is taken in beaker and calculates the room temperature (T1). Ammonium chloride (1g) is taken in the beaker. Note the temperature reading (T2). These were used for calculation.

Calculation:

Room temperature T1=

Temperature after the substance added T2=

ΔT = T2-T1

=

Mass of the empty beaker W1=

Mass of the beaker with solution W2=

Mass of the substance added W3=

m = W2 - W1 + w3

=

Temperature of salt solution T2=

Enthalpy of the reaction ΔH= Q solution = mCΔT

=

=

q solution = -q reaction

=

n = g / molecular weight

=

ΔH = -Qreaction / n

=

S.NO	ROOM TEMPERATURE	MIXTURE TEMPERATURE
1		
2		
3		

Average room temperature=

Average mixture temperature=

Result:

Room temperature T1=

Temperature of the salt solution T2=

Enthalpy of the reaction ΔH=

DETERMINATION OF ENTHALPY OF SALT SOLUTION

Aim:

To determine the enthalpy of salt solution ($NaNO_3$) by calorimetry method.

Formula:

The following equation used to determine the enthalpy (ΔH)

$Q\ solution = mC\Delta T$

m = mass of solution in g

C = specific heat capacity J/g C

ΔT = temperature different in degree celsius (T1-T2)

Specific heat capacity of water = 4.20 J/g C

q reaction = solution + q calorimeter

$\Delta H = Q reaction / n\ KJ$

n = mole of the substance

$Q\ solution = mC\Delta T$

q solution = -q reaction

n = g / molecular weight

$NaNO_3 \rightarrow Na^+ + NO^{2-}$

Procedure:

The water was completely removed from the inner beaker of the calorimeter and water is taken in the beaker and calculates the room temperature (T1). Sodium nitrite (1g) is added to the beaker. Note the temperature reading (T2). These were used for calculation.

Calculation:

Room temperature T1=

Temperature after the substance added T2=

$\Delta T = T2-T1$

=

Mass of the empty beaker W1=

Mass of the beaker with solution W2=

$m = W2 - W1$

=

Q solution = mCΔT

=

=

q solution = -q reaction

=

n = g / molecular weight

=

ΔH= -Qreaction / n

=

S.NO	ROOM TEMPERATURE	MIXTURE TEMPERATURE
1		
2		
3		

Average room temperature=

Average mixture temperature=

Result:

Room temperature T1=

Temperature of salt solution T2=

Enthalpy of the reaction ΔH=