Observation Table:

S.No	Time (min)	Temperature (°C) t_h (of hot water)	t_c (of cold water)	t_m (of mixture)
1	0	46	30	
2	0.5	45.8	30	
3	1.0	45.6	30	
4	1.5	45.4	30	
5	2.0	45.3	30	
6	2.5	45.2	30	
7	3.0	45.2	30	
8	3.5	45.1	30	
9	4.0	45.1	30	
10	4.5	45	30	
11	5.0	← Mixing →		
12	5.5			36.2
13	6.0			36
14	6.5			35.9
15	7.0			35.9
16	7.5			35.9
17	8.0			35.9
18	8.5			35.9
19	9.0			35.9
20	9.5			35.9
21	10.0			35.9

Date 02.12.2022

Expt. No. 2 Page No.

Aim:
To determine the enthalpy of neutralisation of strong acid and strong base calorimetrically.

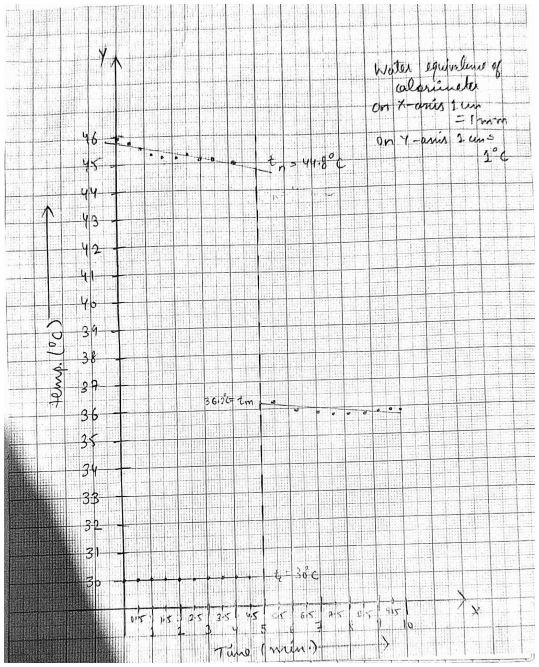
Apparatus:
Thermo flask, glass stirrer, thermometer, stop watch, beaker, measuring cylinder.

Theory:
Calorimeter: It is an apparatus which is used to determine the enthalpies of soln. It is an isolated system which can neither exchange heat nor matter with the surroundings.
In laboratory, we use thermal flask as the calorimeter.

Part A: of the experiment is to determine the heat capacity of calorimeter or water equivalent of calorimeter.

(b) To determine the enthalpy of neutralization of strong acid (1NHCl) and strong base (1N NaOH) using heat capacity measured in part (a).

Heat evolved in any process = msΔt
(where m = mass, s = specific heat, Δt = change in temp)



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Expt. No. Page No.

Heat lost = Heat gained

Water equivalent of calorimeter: is defined as the amount of heat required to raise the temp. of water contained in calorimeter. Enthalpy of neutralisation is defined as the amount of heat evolved when 1 mol of a strong acid is completely neutralised by a strong base.

$H^+ + OH^- \rightleftharpoons H_2O$ + Heat (−57.1 kcal/mol) or (−52.22 kJ/mol)

Procedure:
1. Took 100ml of distilled water in a beaker using pipette and heat it to ~45°C
2. Took 100 ml of distilled water in another beaker (using pipette).
3. Poured the hot water in the thermoflask and dipped a thermometer having least count 0.1°C and also in the water in the beaker (least count 1°C)
4. Recorded the temperature of both hot water as well as cold water for 5 min of intervals of 30 sec each.
5. At exactly 5 min, poured the water at room temp into the hot water in the flask and mixed using

Calculation for water equivalent:

$m_h s(t_h - t_m) = m_c s(t_m - t_c) + c(t_m - t_c)$
$= 100 \times 1 (44.8 - 36.2) = 100 \times 1 (36.2 - 30) + c(36.2 - 30)$
$= 100(8.6) = 100(6.2) + c(6.2)$
$= 860 = 620 + c(6.2)$
$\Rightarrow 6.2c = 240$
$\therefore c = \frac{2400}{62}$
$\therefore c = 38.71$ cal/°C

copper wire stirrer and continue recording the temp of the mixture for another 5 min (after every 30 sec)

Calculations:
Heat lost by the hot = Heat gained by cold water + Heat gained by calorimeter

$m_h s(t_h - t_m) = m_c s(t_m - t_c) + c(t_m - t_c)$
$100 \times 1 \times (t_h - t_m) = 100 \times 1 (t_m - t_c) + c(t_m - t_c)$
$100(t_h - t_m) = (c + 100)(t_m - t_c)$

$c = \frac{100(t_h - t_m)}{t_m - t_c} - 100$

$Q = 100(t_2 - t_1) + c(t_2 - t_1)$
$\Delta H = Q \times 10$

(a) **Calculation for water equivalent:**
$m_h s(t_h - t_m) = m_c s(t_m - t_c) + c(t_m - t_c)$
$100 \times 1 (44.8 - 36.2) = 100 \times 1 (36.2 - 30) + c(36.2 - 30)$
$100(8.6) = 100(6.2) + c(6.2)$
$860 - 620 = 6.2c$
$\Rightarrow c = \frac{2400}{62}$
$\therefore c = +38.71$ cal/°C

Teacher's Signature :

Observation Table:

S.No	Time (in min)	Temperature (°C) t_b (NaOH)	t_a (HCl)	t_m (mixture)
1	0	29.9	33	
2	0.5	29.9	33	
3	1.0	29.9	33	
4	1.5	29.9	33	
5	2.0	29.9	33	
6	2.5	30	33	
7	3.0	30	33	
8	3.5	30	33	
9	4.0	30	33	
10	4.5	29.9	33	
11	5.0	← Mixing →		
12	5.5			46.4
13	6.0			46.4
14	6.5			46.4
15	7.0			46.4
16	7.5			46.4
17	8.0			46.4
18	8.5			46.4
19	9.0			46.4
20	9.5			46.3
21	10			46.3

Expt. No. Page No.

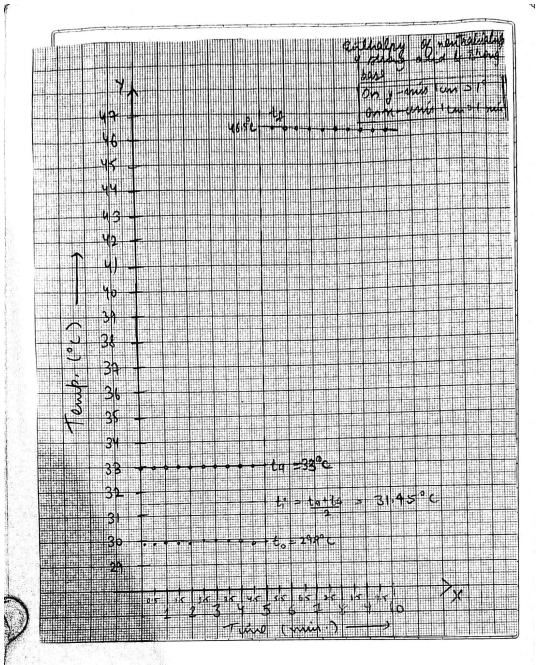
Part B: To determine the enthalpy of neutralisation of strong acid and strong base using heat capacity measured in (a)

$HCl + NaOH \longrightarrow NaCl + H_2O$ + heat

Procedure:
1. Took 100 ml of 1N NaOH soln (using pipette) and poured it in the thermoflask.
Took 100 ml of 1N HCl soln (using pipette) in a separate beaker.
Recorded the temperature of both the solution for 5 min at intervals of 30 sec each.
At exactly 5 min, poured the HCl soln into the NaOH soln in the thermoflask and stir using copper wire stirrer.
Continued the recording of the temp for another 5 min at intervals of 30 sec.

Calculation: Determination of enthalpy of neutralisation of strong acid and strong base.

$Q = 100(t_2 - t_1) + c(t_2 - t_1)$
$= 100(46.5 - 31.45) + 38.71(46.5 - 31.45)$
$= 100(15.05) + 38.71(15.05)$
$= 3010 + 582.58$
$= 3592.58$ cal / mol
$= 24$



Expt. No. _____ Page No. _____

Enthalpy :

$$\Delta H = \frac{Q}{m \times V\,(in\,l)} = \frac{Q}{0.1}$$

$$\Delta H = 100 \times Q \quad 2)$$

$$= 10 \times 3592.58$$

$$= -35925.8 \text{ cal/mol}$$

Result :

The heat capacity of calorimeter is +38.71 cal/°c and enthalpy of neutralization of strong acid and strong base is -35.92 K cal/mol (exothermic)

1/Jan/24

27/6/2022

Teacher's Signature : _____

Expt. No. 6 Page No. _____

Aim : To prepare 2,4,6- tribromoderivative of phenol and determine its mp and percentage yield.

Material Required :

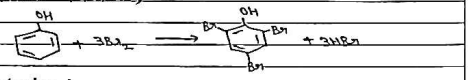
Phenol = 1ml

Bromine = "

Water = 50ml

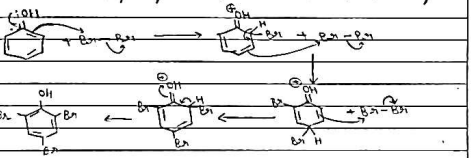
Theory :

2,4,6- tribromophenol is obtained by bromination of phenol with aq solution of bromine. Reaction involved,



Mechanism :

The -OH group is an electron donating, ortho-para directing group. Hence bromination takes place in both o- and p- position. The mechanism is as follows



Teacher's Signature :

Calculation of % yield:

Starting compound = Phenol = C_6H_6O : MW = 94g

Product = 2,4,6 tribromophenol = $C_6H_3OBr_3$: MW = 331g

94 g of phenol gives 331 g of 2,4,6-tribromophenol

∴ 1g of phenol gives $\frac{331}{94} \times 1$ = 3.5g of 2,4,6-tribromophenol

% yield = $\frac{\text{observed yield}}{\text{calculated yield}} \times 100$

observed yield = 1.2g

calculated yield = 3.5

% yield = $\frac{1.2}{3.5} \times 100$

= 25%

Date _____

Expt. No. _____ Page No. _____

Procedure :

In a stoppered conical flask we taked 1ml of phenol and added 50 ml of water. After this we added aqueous solution of bromine (1ml in 20ml of H_2O) in a fumehood with continuous stirring till we obtained a white ppt of 2,4,6 - tribromophenol [in case if we get yellow ppt which indicates excess of bromine, added a pinch of $NaHSO_3$ to the mixture to oxidise excess of bromine - ppt which became white after adding $NaHSO_3$] - added ~ 50g of crushed ice and ~20 ml of cold water. Filtered the ppt obtained and washed thoroughly with cold water so that there is no smell of either phenol or bromine. Dryed the ppt with the help of filter paper. Recorded its % yield and recrystallised some of it in alcohol. Also at last determined the melting point of the recrystallised sample

Result :

The % yield of 2,4,6 - tribromophenol = 90%

MP of 2,4,6- tribromophenol =

Viva Voice Questions
Semester – II (New-CBCS)

Thermochemistry

1. What do you mean by the enthalpy of the reaction?
2. What do you mean by heat capacity of a substance?
3. What is the difference between heat capacity and specific heat?
4. Define heat of formation, heat of combustion, heat of neutralization, heat of solution, heat of dilution?
5. Define heat of neutralization of an acid and a base.
6. What is normally the value of heat of neutralization in case of strong acids against strong bases?
7. What are the units of heat of reaction?
8. How can you determine heat of neutralization using Dewar's flask?
9. Is the heat of neutralization of a weak acid less or more than that of strong acid? Why?
10. 150 mL of 0.5 N HCl solution at 25.35 °C were mixed with 150 mL 0.5 N NaOH solution at the same temperature taken in Dewar flask. The final temperature was recorded to be 28.2 °C. Calculate the heat of neutralization of HCl and NaOH. The water equivalent of Dewar flask was found to be 60g. (Ans -13.68 kcal)
11. Why is the reaction of neutralization carried out in a dilute solution?
12. Define water equivalent of a calorimeter.
13. Define heat of solution.
14. What is the difference between integral heat of solution and differential heat of solution?
15. 7.0 g of KCl was dropped in 200 mL of water taken in Dewar Flask. The temperature was seen to fall through 1.68 °C. Calculate heat of solution of KCl. Water equivalent of Dewar Flask may be taken as 50 g. (Ans 4.470 kcal)
16. Why is the heat of solution of anhydrous salt different from its hydrated sample? (Ans : Because heat of solution of anhydrous salt involves its heat of hydration and heat of solution, whereas heat of hydrated salt involves only its heat of solution.)
17. Define enthalpy/heat of hydration.
18. How will you determine heat of hydration of $CuSO_4$ using Dewar's Flask?
19. The heat of solution of hydrated $CuSO_4.5H_2O$ and anhydrous $CuSO_4$ are 2.80 and -15.89 kcal respectively. How will you determine the heat of hydration of $CuSO_4$?
20. Why enthalpy of neutralization of strong acid and a strong base is always constant?
21. Why enthalpy of neutralization of weak acid is not constant?

pH and Buffer solutions

22. What is a buffer solution? Give the expression for pH of an acidic buffer.
23. Give an example of a basic buffer.
24. Give one example each of an acidic and a basic buffer solution. At what pH value a given buffer shows a maximum buffer capacity? What is the pH range for a buffer solution to show a significant buffer capacity?

Organic Chemistry

25. Give the mechanism of preparation of oxime derivative of a carbonyl compound.
26. What is Schotten- Baumann reaction? (Benzoylation of phenol in presence of NaOH)
27. What is the product of bromination of phenol? Write the mechanism involved.(Ans: product is 2,4,6-tribromophenol.. mechanism..as done in class)
28. Why do we sometimes add sodium bisulphite during the workup of bromination reaction?(Ans: To get rid of the yellow colour of ppt due to the presence of unreacted Br_2. Sodium bisulphite reduce unreacted Br_2 to water soluble Br^- ion)
29. What is a lachrymator? Give an example.(Ans Tear producing substance eg Benzoyl chloride)
30. Why do we recrystallize organic compounds? (Ans : In order to purify them and purity is determined by melting point)
31. Give the four steps followed to recrystallize an organic compound. (Ans : 1. Making a saturated solution, 2. Hot – filtration, 3. Crystallization by slow cooling, 4. Cold – filration)
32. Give the mechanism of Benzoylation of Phenol.
33. Benzoylation of activated benzene in presence of an alkali is called _____ reaction. (Ans: Schotten- Baumann reaction)
34. Which solvent is used in bromination of phenol?(Ans: Water)
35. Which solvent is used in bromination of aniline?(Ans: Acetic acid)
36. Give the mechanism of preparation of 2,4-Dinitrophenylhydrazone of a carbonyl compound. At what specific pH range this reaction is carried out? Why is specific pH range required in this reaction?(Ans : pH between 4 to 5. Because **at low pH (pH<4) N-atom** of 2,4-DNP **gets protonated** and cannot act as a nucleophile to attack carbonyl carbon. And **at high pH or alkaline pH the alkali (OH^-) itself acts as a nucleophile** to attack carbonyl carbon.)

1 . Enthalpy of reaction
The amount of heat evolved or absorbed in a chemical reaction when the number of moles of the reactants as represented by the chemical equation have completely reacted, is called the enthalpy of reaction, It is represented by ΔrH.

2 . The heat capacity of a substance can be defined as the amount of heat required to change its temperature by one degree.

3 . Heat capacity is the amount of heat required to raise the temperature of an object by 1oC. The specific heat of a substance is the amount of energy required to raise the temperature of 1 gram of the substance by 1oC.

4 .
#

Integral Enthalpy of dilution
The amount of heat released or absorbed when a given amount of solvent is added to soln of known concentration at cont . T and P

*****

Standard Enthalpy change invishing change in state.

Enthalpy of Fusion :-

It is the heat subased on absorbed when melk of a substance in solid state a convented. to liquid state at it's melting point.

Enthalpy of Vapuden-

It is the amount heat abissed on sucleased when

I more of a substance in liquid state is converted to

gaseous state at its boiling pobat-

Enthalpy of sublimation It is the amount heat y released absented when I

make of D substance in solid state is converted directly to gaseous state out its sublimation temperatione.

4.

Enthalpy of Phase Change: It is the amount heat released on absorbed when L substance is one phase is converted into another phase at standard TP.

5 . The heat of neutralization is the change in enthalpy that occurs when one equivalent of an acid and one equivalent of a base undergo a neutralization reaction to form water and a salt. Heat of neutralization of strong acid with strong base is -13.7 kcal mol–1.

6 . The enthalpy of neutralization of all strong acids and strong bases is always constant i.e -57.1 kJ.

7 . The units for ΔH° are kiloJoules per mole, or kj/mol.

9 . The enthalpy of neutralisation of a weak acid is less than that of a strong acid. The difference of the latter from the former is known as enthalpy of ionisation of the weak acid.

10 . Solution
Total mass of solution = 150+150=300 g
Q = Total heat produced

= 300×(25–25)cal

= 300×0 = 300cal

Heat of neutralization = Q/150×1000×1/0.5=-13.68 Kcal

Since heat is liberated, heat of neutralization should be negative. So heat of neutralization =-13.68 Kcal.

Hence -13.68kcal is the answer

11. Because all strong acids and bases are totally ionised in dilute solution, the enthalpy of neutralisation for both a strong acid and a strong base is always the same.

12. The amount of water which will absorb the same amount of heat that the calorimeter will absorb.

13. The heat solution is defined as the difference in the enthalpy related to the dissolving substance in a solvent at constant pressure which is leading in infinite dilution. The unit of solution enthalpy is KJ/mol.

14 . The enthalpy change caused by adding a mole of solvent to a very large amount of solution at a constant temperature and pressure is thus known as the molar differential heat of dilution.
The integral heat of dilution, on the other hand, is considered on a larger scale.

16. Ans is given already

17. Enthalpy -- a thermodynamic quantity equivalent to the total heat content of a system. It is equal to the internal energy of the system plus the product of pressure and volume.

19.

[CuSO4(s) aq.. + CuSO4aq. AH =

-15.89 kcal/mol..... (1)

CuSO4.5H2O+ aq. - CuSO4(aq) + 5H2O_AH =

2.8 kcal/mol

CuSO4(aq) +5H2O CuSO4.5H2O+ aq._AH= -

-2.8 kcal..... (2)

Adding eqn (1) & (2), we have

CuSO4(s) + aq. + CuSO4(aq) + 5H2Oα) - -

CuSO4aq. + CuSO4.5H2O+ aq. AH = (-15.89) +

(-2.8)

CuSO4(s) +5H2O(1) - CuSO4.5H2O AH =

-18.69 kcal

Hence the heat of hydration of anhydrous

CaSO4 is -18.69 kcal.

20. because all strong acids and strong bases are completely ionized in dilute solution.

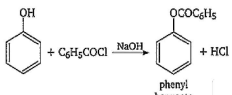
21. because weak bases do not ionise completely in aqueous solution. Therefore, some enegry is required for their complete ionisation and that is why net energy released is less.

22.A buffer solution is a solution that only changes slightly when an acid or a base is added to it.
To calculate the pH of an acid buffer, the Henderson-Hasselbalch equation is used, which is pH = pKa + log(acid/base).

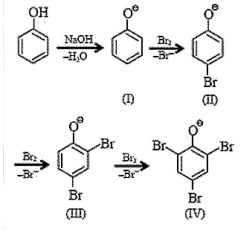
23. Examples:(i) CH3COOH + CH3COONa, (ii) HCN + NaCN

24 Acidic buffer example: Mixture of acetic acid and sodium acetate. Basic buffer example: Mixture of ammonium hydroxide and ammonium chloride.

26 . Schotten Baumann reaction is benzoylation of compounds containing an active hydrogen such as alcohols, phenols or amines with benzoyl chloride in the presence of dilute aq NaOH solution.



27 . 2,4,6-tribromophenol



28. To get rid of the yellow colour of ppt due to the presence of unreacted Br2. Sodium bisulphite reduce unreacted Br2 to water soluble Br- ion)

29 . Lachrymators are chemicals that are strong eye irritants and cause tearing and burning sensations.
Tear producing substance eg Benzoyl chloride

30 . The purpose of recrystallization is to separate or remove the impurities in a solid compound that are dissolved in a solvent to obtain a pure compound.

31.. 1 Making a saturated solution, 2. Hot – filtration, 3. Crystallization by slow cooling, 4. Cold – filration)

32 . Benzoylation of phenol
In this reaction, phenol reacts with benzoylation; the hydroxyl group