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DETERMINATION OF HEAT OF NEUTRALIZATION OF ACID PRESENT IN APPLE JUICE USING NAOH

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ABSTRACT

Determination of heat of neutralization has been determined for fresh vegetable or fruit juices for finding whether the juice is strong electrolyte or weak and whether the juice is acidic or basic in nature. There are two types of electrolyte weak and strong. The study is based on the theory of heat of neutralization which is the heat release when 1 gram equivalent of acid neutralised by a base or wise versa. The heat of neutralization is pH dependent which shows the acidity and basicity of the substance. Neutralization process is generally exothermic in nature. Heat of neutralization is known as Enthalpy of neutralization and has a unit KJ/mol. Juices plays an important role in human health.

KEYWORDS: Neutralization, electrolyte, Enthalpy, Juice and Health.

INTRODUCTION

In chemical reactions usually we see an energy change and in thermochemistry, we study the amount of heat absorbed or evolved. Generally the reactions taking place in the chemical sciences are breaking and making of chemical bonds. When energy is released in a reaction (when chemical bonds break) it is called as exothermic reaction and when energy gets absorbed (when chemical bonds form) in the reaction then it is endothermic reaction. The heat of neturalization is the change that occurs in the heat when a neutralization reaction takes place between one equivalent of an acid and a base to form salt and water. Heat of neutralization is generally negative cause heat releases when acid and base reacts.

Acid + Base → Salt + Water

Neutralization reaction is a type of double displacement reaction. Heat of neutralization is affected by quantity of acid and base and the strength of the acid and base. When an acid is neutralised, its pH increases towards seven and when a base is neutralised, its pH decreases towards seven.

The heat of neutralisation of an acid is defined as the amount of heat evolved when one equivalent of an acid and one equivalent of a base undergo a neutralisation reaction to form water and a salt. Similarly the heat of neutralisation of a base is the amount of heat evolved when 1 g equivalent of the base is completely neutralised by 1 g equivalent of the acid.

$$HA + BOH \rightleftharpoons AB + H_2O + \Delta H$$

where, HA is the acid, BOH is the base, AB is the salt and **Δ**H is the heat of neutralization.

Neutralization takes place in everyday life, for example; antacids contains bases such as aluminum hydroxide $Al(OH)_3$ and magnesium hydroxide $Mg(OH)_2$ to neutralize the excess acid in the stomach, the waste of many factories contains acids. If all this waste is released into water bodies then the acids will harm the marine life hence certain bases are added into the acid waste to neutralize the acid.

The enthalpy of neutralization of any strong acid with a strong base is always the same, i.e., 57.1 kJ. This is because the strong acids, strong bases and the salts they form, are all completely ionized in dilute aqueous solution.

For weak acids or bases, the heat of neutralization is pH-dependent. In the absence of any added mineral, acid or alkali some heat is required for complete dissociation. The total heat evolved during neutralization will be smaller than that of for strong acid and strong base.

Heat of neutralization of strong acid and weak base is less than 13.7 kcal mol-1.

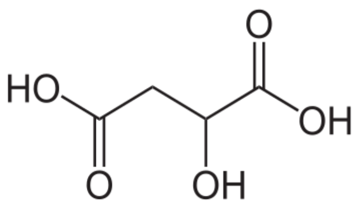
Heat of neutralisation of weak acid and strong base is less than the heat of neutralisation of strong acid and strong base. Fruit acidity in cultivated apples is majorly determined by malic acid, which accounts for up to 90% of total organic acids. Citric acid also exists in mature apple fruits; however, it exhibits a very low to undetectable concentration in cultivated apples. Sheele isolated malic acid from unripe apples in 1785. Malic acid name is derived from a Latin word "Malum" which means apples.

Malic acid is a dicarboxylic acid. Malic acid has a smooth and tart taste. It is highly soluble in water. It is used in beverages and as a flavouring agent in the sour confectionery sector. As other organic acids, malic acid has found to be an effective agent for inactivating common food pathogens on fresh vegetables. Malic acid is also used for metal cleaning and finishing, textile finishing, electroless plating, pharmaceutical, infusions and paints. Malic acid is a diprotic acid. It is a white, odorless, crystalline solid. In contrast to other fruit acids, it is very hygroscopic and has a tendency to lump. It has an asymmetric carbon and it occurs as l-isomer and d-isomer. The l-isomer of malic acid is its natural form.

It's molecular formula is C_4H_6O.

Malic acid's structural formula DL-Malic acid

Here we used sodium hydroxide (NaOH) as the base which is also known as caustic soda. We used sodium hydroxide as the base cause it is a very strong base. It is one of the



simplest hydroxide. It is an ionic compound. It is a highly caustic base. It is highly soluble in water and it has lower solubility in polar solvents such as ethanol and methanol. NaOH is insoluble in ether and other non-polar solvents. It abdorbs moisture and carbon dioxide from the air. Pure sodium hydroxide is colourless crystalline solid. Sodium hydroxide is used in industries in the manufacture of sodium salts and detergents, pH regulation and organic synthesis. Usually it's aqueous solution is used. It is taken in the use to neutralize acids.

To calculate the heat of neutralization of apple juice, we will neutralize it with 1N NaOH in a thermos flask and with the help of thermometer we will observe the heat change. Determination of the heat of neutralization of an acid-base reaction and the specific heat capacity with the help of coffee cup calorimetry was studied by AMRP Bope gedera and coworkers.[1] An introductory discovery experiment on thermochemical analysis of neutralisation reaction was developed by Kenneth V Mills and coworkers.[2] A milli-scale isoperibol continuous flow calorimeter to measure the heat of reaction based on an elaborated heat transfer model was studied by Marlies Moser and et al.[3]

Ultrafast and Energy-saving Synthesis of Nitrogen and Chlorine Co-doped Carbon Nanodots with the help of heat of neutralisation for Selective Detection of Cr(VI) in Aqueous Phase was proposed by Qin Hu and coworkers.[4] Preparation of nitrogen and oxygen enriched hierarchically porous carbon (NOHPC) by neutralization reaction in synthesis of carbon materials for supercapacitors by Wen Yan and coworkers.[5] Reverse Electrodialysis Chemical Cell for Energy Harvesting from Controlled Acid–Base Neutralization studied by Ying Mei and his team.[6]

Determination of heat of neutralization of sulphuric and hydrochloric acid by sodium hydroxide using a microcalorimeter of the Tian-Calvet type was propounded by H.M. Papee and et al.[7] Measurement of heat of neutralisation of sodium hydroxide and hydrochloric acid solutions at 25° for concentrations from 3 to 16 molal with an accuracy of 0.1% or better by Paul Bender and coworkers.[8] The heat of neutralization of sodium hydroxide with hydrochloric acid was found to reach very high values at the highest concentrations in the study by Getson Kegeles.[9]

The study of heat of neutralization of carbon dioxide with muscle and it's dissociation curve by determining the heat of combination of H_2CO_3 with living frog's muscle was proposed by G. Stella.[10]

The heat of neutralisation of Hydrogen-Bentonite was discovered by W.H. Slabaugh.[11] Accurate data for the heat of neutralisation of acetic acid and its change with concentration was determined by Theodore W. Richards and his team.[12]

Heat of neutralization of strong acids by strong bases in mixed water - dioxane solutions was studied by Hidehiko Kido and et al.[13] Determination of cement content of soil-cement by heat of neutralization by Scavuzzo and team.[14] The heat of neutralization of acid clays and cation-exchange resins was propounded by N.T. Coleman and et al.[15] The heat of neutralization in water of a series of pyridine bases was determined by calorimetric measurements in thermochemical studies by L. Sacconi and coworkers.[16]

The study of heats of neutralization of sodium hydroxide and hydrobromic acid solutions was measured at 25 for reactant concentrations from 3 to 16 molal, with an accuracy of 0.1% by Wendell J. Biermann and coworkers.[17] A continuous-flow calorimeter and the determination of the heat of neutralization of a solution of hydrochloric acid by one of sodium hydroxide was determined by Frederick G. Keyes and his team.[18] The heat of neutralization of hydroxylamine and tetramethyl ammonim hydroxide was studied by Emil O. Ellingson.[19]

Heat of neutralization at constant concentration and the heat of ionization of water was determined by RH Lambert and et al.[20] Heats of solution and neutralization of Lewis acids and bases in acetic anhydride was proposed by Ram Parkash and his team.[21] Examination of continuous variation of study of heat of neutralization was done by Dennis W. Mahoney and coworkers.[22]

Thermochemistry of flourine compounds. Part III. Heats of solution and neutralization in bromine trifluoride was propounded by G.W. Rirchards and et al.[23] A calorimetric study of heat of neutralization of water at 25° was done by John D. Hale and team.[24] Calorimetric study of the enthalpy of neutralization of polygalacturonic acid obtained during its neutralization by either tetraalkylammonium or alkaline hydroxide solution was propounded by D.Rudan-Tasič and et al.[25]

Heat of neutralization of continuous flow calorimeter was studied by Louis J. Gillespie and his team.[26] Heats of solution and neutralization of protonic acids and bases in ethanol was propounded by Ram Parkash and coworkers.[27] Determination of standard enthalpy of formation of fluoride ion in aqueous solution according to data on heat of neutralization of hydrofluoric acid solution by Vasilev and his team.[28] The use of the Dewar flask in measurements of heats of neutralisation was proposed by J. Howard Mathews and coworkers.[29] Preparation of nucleus-staining with biomolecule-mimicking nitrogen-doped carbon dots by a fast neutralization heat strategy was done by Yan-Fei Kang and et al.[30]

MATERIAL AND METHODOLOGY

1) Freshly prepared apple juice.

2) 1N NaOH (sodium hydroxide).

3) Burner, thermos flask, beaker, tripod stand, thermometer, distilled water, wire gauze, stop watch.

METHODOLOGY

First take an apple, wash it and grate it, then we put the grated apple in a muslin cloth and strain its juice in a jar. Now clean the the thermos flask and beaker nicely with water and dry them.

First find the water equivalent of the thermos flask. For this take 20 ml of water and heat it upto 72°C and again take 20 ml of water and note its temperature with the help of thermometer then add both of them in the thermos flask and close its lid for five minutes then open it's lid and check the temperature of the mixture and note the readings down. From the formula calculate the water equivalent of thermos flask.

Now take 20 ml of 1 N NaOH and note its temperature and then take 20 ml of freshly prepared apple juice and also note down its temperature with the help of thermometer. Now add both of them in the thermos flask and close its lid then after five minutes open the lid of the flask and note down the temperature of the mixture of apple juice and sodium hydroxide. Then calculate the heat of neutralization of the acid and base mixture.

Observation Table

Table no. (1): Measurement of water equivalent of thermos flask.

S.No	Temperature of cold water(t_1) (in°C)	Temperature of hot water(t_2) (in°C)	Temperature of mixture(t_3) (in°C)
1)	21°C	72°C	41°C

Table no. (2): Measurement of enthalpy of neutralization of apple juice using NaOH.

S.No	Temperature of NaOH(t_4) (in°C)	Temperature of apple juice(t_4) (in°C)	Temperature of mixture(t_5) (in°C)
1)	20°C	20°C	24°C

6. Calculation

1) <u>To calculate the water equivalent of thermos flask</u>→

Volume of cold water = 20 ml

Temperature of cold water (t_1) = 21°C

Volume of hot water = 20 ml

Temperature of hot water (t_2) = 72°C

Temperature of mixture (t_3) = 41°C

$$\text{Water equivalent (W)} = \frac{100\,(t_2 - t_3)}{(t_3 - t_1)} - 100$$

$$W = \frac{100\,(72-41)}{(41-21)} - 100$$

$$W = \frac{100 \times 31}{20} - 100$$

$W = 55$

2) To calulate the enthalpy of neutralization of acid present in apple juice using NaOH→

Volume of 1N NaOH = 20 ml

Temperature of NaOH (t_4) = 20°C

Volume of apple juice = 20 ml

Temperature of apple juice (t_4) = 20°C

Temperature of mixture (t_5) = 24°C

Heat of neutralization (Q) = (100+100+W) (t_5−t_4) cal

$$Q = (200+55)\ (24-20)$$

$$Q = 1020 \text{ cal}$$

Enthalpy of neutralization (H) = $\frac{10 \times Q}{1000}$ k.cal

$$H = \frac{10 \times 1020}{1000}$$

$$H = 10.2 \text{ k.cal}$$

RESULT AND DISCUSSION

As we known according to the definition of heat of neutralization when acid and base reacts then energy is released along with the formation of salt and water. The released energy is called heat of neutralization. Hence the temperature of the mixture of acid and base will be more in amount than the temperature of acid and base taken initially which shows that neutralisation is an exothermic reaction.

The acid present in apple juice is malic acid and the base used is 1N NaOH. Initially their temperature was 20°C and then the temperature of the mixture of the acid and base came out to be 24°C which is a raise in the temperature as explained above.

The value of enthalpy of neutralization of apple juice (malic acid) in this experiment is 10.2 k.cal.

The value of heat of neutralization of weak acid is always less than that of strong acid and strong base, i.e 57.1 kJ/mol. Malic acid is a weak acid and its value of heat of neutralization is came out to be 10.2 k.cal which is less than the heat of neutralization of strong acid and strong base which is as per desired.

CONCLUSION

The value of heat of neutralization of apple juice in this experiment is came out to be 10.2 k.cal. The value of heat of neutralisation for weak acid is around 10 k.cal. The value of heat of neutralisation of apple juice is near the standard result. Hence it can be conclude that apple juice contains weak acid namely malic acid.

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