

Comparison of Heat Retention in Fresh Water and Salt Water Samples

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Abstract: Heat retention in salt water and fresh water was compared with a view to identifying the one that is best at retaining heat. To achieve this, 150 ml and 100 ml of distilled water at room temperature (29°C) were heated separately to 100 °C (boiling point). Measured values (5g, 10g and 15g) of table salt were each added to 100 ml and 150 ml of distilled water to reach a level of salinity and the solution was heated to boiling point. A cooling system was set up to continuously mix the solution during cooling process to maintain uniform temperature and mercury-in-glass thermometer was used to record the temperature drop at every 10 minutes interval. The graphs of the temperature against time were plotted using Matlab to obtain the cooling rate. The results showed that the salt water has the capacity to retain more heat than the fresh water, and the concentration of salt in salt solution also determines the heat retention ability.

Keywords: heat retention, fresh water, salt water, temperature, concentration.

1. Introduction

In physics, heating is transfer of energy from a hotter body to a colder one, other than by work or transfer of matter [1]. This transfer can occur by a variety of processes but the most familiar form of heating is conduction between two bodies in thermal contact. Heating is a dissipative process that occurs spontaneously whenever there is a suitable physical pathway between the bodies. The pathway can be direct, as in conduction and radiation, or indirect, as in convective circulation. Heat is a central concept in thermodynamics and statistical mechanics, and is also important in chemistry, engineering, and other disciplines [2], [3].

Heat capacity is an extensive property of matter, meaning it is proportional to the size of the system [4]. When expressing the same phenomenon as an intensive property, the heat capacity is divided by the amount of substance, mass, or volume, so that the quantity is independent of the size or extent of the sample. The molar heat capacity is the heat capacity per mole of a pure substance and the specific

heat capacity, often simply called specific heat, is the heat capacity per unit mass of a material [5]. The heat capacity of most systems is not a constant. Rather, it depends on the state variables of the thermodynamic system under study. In particular it is dependent on temperature itself, as well as on the pressure and the volume of the system.

Different measurements of heat capacity can therefore be performed, most commonly either at constant pressure or at constant volume. The values thus measured are usually subscripted (by p and V , respectively) to indicate the definition. Gases and liquids are typically also measured at constant volume. Measurements under constant pressure produce larger values than those at constant volume because the constant pressure values also include heat energy that is used to do work to expand the substance against the constant pressure as its temperature increases. This difference is particularly notable in gases where values under constant pressure are typically 30% to 66.7% greater than those at constant volume [6]. The specific heat capacities of substances comprising molecules (as distinct from monatomic gases) are not fixed constants and vary somewhat

depending on temperature. Accordingly, the temperature at which the measurement is made is usually also specified.

Temperature reflects the average randomized kinetic energy of particles in matter, while heat is the transfer of thermal energy across a system boundary into the body or from the body to the environment. Translation, rotation, and a combination of the two types of energy in vibration (kinetic and potential) of atoms represent the degrees of freedom of motion which classically contribute to the heat capacity of matter, but loosely bound electrons may also participate. On a microscopic scale, each system particle absorbs thermal energy among the few degrees of freedom available to it, and at sufficient temperatures, this process contributes to the specific heat capacity that classically approaches a value per mole of particles [7]. This limit, which is about 25 joules per kelvin for each mole of atoms, is achieved by many solid substances at room temperature.

In addition, quantum effects require that whenever energy is stored in any mechanism associated with a bound system which confers a degree of freedom, it must be stored in certain minimal-sized deposits (quanta) of energy, or else not stored at all [8]. Such effects limit the full ability of some degrees of freedom to store energy when their lowest energy storage quantum amount is not easily supplied at the average energy of particles at a given temperature. In general, for this reason, specific heat capacities tend to fall at lower temperatures where the average thermal energy available to each particle degree of freedom is smaller, and thermal energy storage begins to be limited by these quantum effects. Due to this process, as temperature falls toward absolute zero, so also does heat capacity.

Heat retention refers to the amount of heat an object or material can store overtime. If you have ever been to the beach during sunset, you have likely experienced heat retention in action. While the sand can burn your feet during a hot summer's day, once the sun goes down it rapidly becomes cooler. In comparison, the ocean remains warm long after the sun disappears. This is because sand is a poor retainer of heat, while water is a better one. In the case of alloys, there are several conditions in which small impurity concentrations can greatly affect the specific heat. Alloys may exhibit marked difference in behavior even in the case of small amounts of impurities being one element of the alloy; for example impurities in semiconducting ferromagnetic alloys may lead to quite different specific heat properties.

Fresh water is naturally occurring water on the Earth's surface in ice sheets, ice caps, glaciers, icebergs, bogs, ponds, lakes, rivers and streams, and underground as groundwater in aquifers and underground streams [9], [10]. Fresh water is generally characterized by having low concentrations of dissolved salts and other total dissolved solids. The term specifically excludes seawater and brackish water although it does include mineral-rich waters such as chalybeate springs. The term "sweet water" has been used to describe fresh water in contrast to salt water.

Salinity is the saltiness or dissolved salt content (such as sodium chloride, magnesium and calcium sulfates and bicarbonate) of a body of water or in soil. Salinity is an important factor in determining many aspect of chemistry of

natural waters and biological process within it, and is a thermodynamic state variable that along with temperature and pressure governing physical characteristic like density and heat capacity of the water [11], [12].

In this paper, experiment was carried out to compare the heat retention in salt water and fresh water with a view to identifying the one that is best at retaining heat.

2. Materials and methods

The experiment was carried out in the laboratory under room temperature (29⁰C) and pressure (760 mmHg) with the following apparatus: beakers, mercury-in-glass thermometer, Bunsen burner, tripod stand, weighing scale, distilled water, salt (NaCl), copper calorimeters and stop watch.

2.1 The experiment

(i) 150 ml of distilled water at room temperature was measured and the content was transferred into a beaker and placed on Bunsen burner. The content was allowed to boil and the time taken to reach boiling point (100⁰C) was recorded. It was then transferred into a well- lagged copper calorimeter with stirrer to give a uniform temperature. Mercury- in- glass thermometer was used to record the change in temperature at every ten minutes till the temperature dropped to room temperature.

(ii) Another 150 ml of distilled water at room temperature was measured and 5g of salt was added. The content was transferred into a beaker and placed on Bunsen burner. It was allowed to boil and the time taken to reach boiling point (100⁰C) was also recorded. It was then transferred into a well- lagged copper calorimeter with stirrer to give a uniform temperature. Mercury- in- glass thermometer was also used to record the temperature difference at every ten (10) minutes till the temperature dropped to room temperature. The same procedure was repeated for 10 g and 15g of salt in 150 ml of distilled water.

Steps (i) and (ii) were repeated for 100 ml of water. The same procedure was also repeated for 10 g and 15 g of salt in 100 ml of distilled water.

3. Results

Room temperature = 29⁰C

Time taken for 150 ml of distilled water to reach boiling point = 4 min. 19s

Time taken for 150 ml of distilled water +5g of salt to reach boiling point = 3 min. 30s

Time taken for 150 ml of distilled water +10g of salt to reach boiling point = 3 min 20s

Time taken for 150 ml of distilled water +15g of salt to reach boiling point = 3 min. 21s

0 minute represents the time the solution was transferred into calorimeter

Table 1: Result of 150 ml

Time (minutes)	Temp. of 150 ml of dist.H2O (°C)	Temp. of 150 ml of dist.H2O + 5g salt (°C)	Temp. of 150 ml of dist.H2O + 10g salt (°C)	Temp. of 150 ml of dist.H2O + 15g salt (°C)
0	96	96	96	96
10	82	89	87	81
20	75	81	77	75
30	70	76	72	70
40	66	72	68	66
50	61	68	64	63
60	57	66	61	60
70	52	63	57	56
80	48	60	55	54
90	44	57	53	52
100	41	54	50	49
110	38	51	48	47
120	34	48	46	44
130	31	43	43	41
140	28	40	40	38
150		37	37	35
160		35	34	32
170		32	31	30
180		30	29	28

Table 2: Result of 100 ml

Time (minutes)	Temp. of 100 ml of dist.H2O (°C)	Temp. of 100 ml of dist.H2O + 5g salt (°C)	Temp. of 100 ml of dist.H2O + 10g salt (°C)	Temp. of 100 ml of dist.H2O + 15g salt (°C)
0	94	94	94	94
10	75	89	81	78
20	65	81	79	72
30	63	75	76	68
40	57	73	71	64
50	54	70	68	61
60	52	68	66	59
70	50	65	63	56
80	48	63	60	52
90	46	60	57	49
100	44	57	55	46
110	41	54	53	43
120	39	51	50	40
130	37	48	47	37
140	34	44	43	35
150	33	41	40	33
160		39	37	
170		37	33	
180		33		

Room temperature = 29°C

Time taken for 100 ml of distilled water to reach boiling point = 3 min. 23s

Time taken for 100 ml of distilled water +5g of salt to reach boiling point = 2 min. 30s

Time taken for 100 ml of distilled water +10g of salt to reach boiling point = 2 min 40

Time taken for 100 ml of distilled water +15g of salt to reach boiling point = 2 min. 38s

0 minute represents the time the solution was transferred into calorimeter

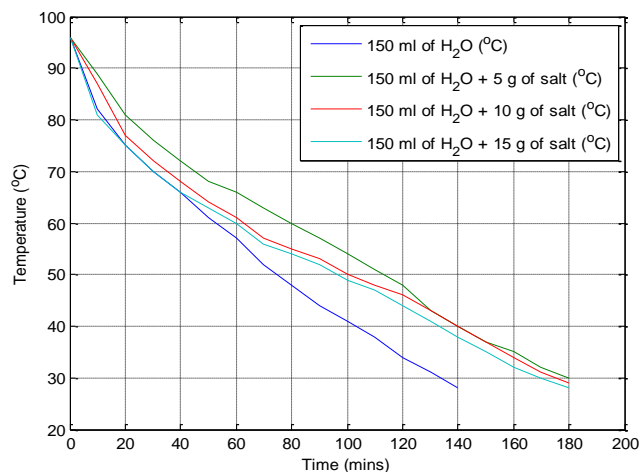


Figure 1: Graph of temperature against time for 150 ml

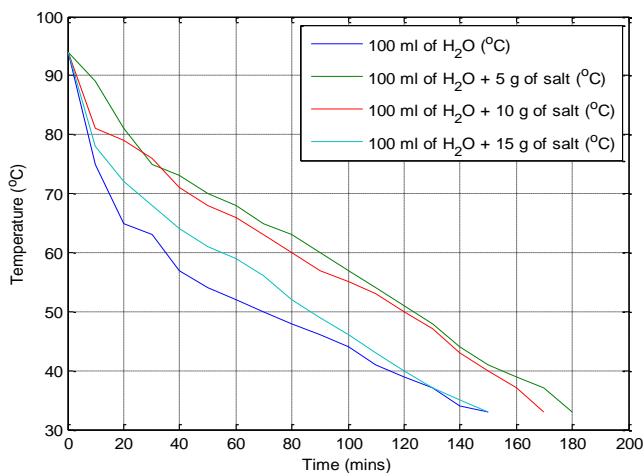


Figure 2: Graph of temperature against time for 100 ml

4. Discussion

Figure 1 shows the graph of temperature against time for 150 ml of distilled water and 150 ml of different concentrations (5g, 10g and 15g) of salt solution in 150 ml. For 150 ml of distilled water, it took 4 mins 19s to reach boiling point, while the salt solutions took 3 mins 30s, 3 mins 20s and 3 mins 21s for 5g, 10g and 15g respectively. This shows that the addition of salt in distilled water decreases the time taken to reach boiling point. It was observed that the distilled water lost its heat energy faster than the salt solutions because it returned to room temperature at 140°C while salt solutions got to room temperature at 180°C. This is an indication that the presence of salt has an effect on the heat retention of water. The temperature drop is between 2°C and 6°C except between 0 min and 10 mins where it was observed to be between 7°C and 15°C, indicating low retention at those times. The graph also shows that the 5g salt solution has higher heat retention ability than 10g and 15g solutions, implying that the concentration of salt also determines the heat retention in salt water.

Figure 2 is the graph of temperature against time for 100 ml of distilled water and 100 ml of different concentrations (5g, 10g and 15g) of salt solution. For 100 ml of distilled water, it took 3 mins 23s to reach boiling point, while the salt solutions took 2 mins 30s, 2 mins 40s and 2 mins 38s for 5g, 10g and 15g respectively. This shows that the concentration of salt in distilled water has an effect on its boiling point. It was also observed that the distilled water lost its heat energy faster than salt solutions but the 15g salt concentration behaved in a similar way to 100 ml of distilled water from 130°C to 160°C. This shows that the concentration of salt also has an effect on the volume of distilled water used. The difference in temperature was also higher between 0 min and 10 mins.

5. Conclusion

It has been shown in this study that the addition of salt in distilled water decreases the time taken to reach boiling point because the salt solutions took lesser time for both 150 ml

and 100 ml. The distilled water lost its heat energy faster than the salt solutions; an indication that the presence of salt has an effect on the heat retention of water. The concentration of salt also determines the heat retention in salt water because the 5g salt solution has higher heat retention ability than 10g and 15g solutions.

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