Research area to volume ratio of a

Research Question: Will 200mL of liquid undergo more heat loss as the surface area to volume ratio of a beaker increases? Background: The purpose of this experiment is to measure the effect of changing the surface area (of the beaker) to volume (of the water inside it) ratio on the rate at which heat inside the beaker is lost. Heat is a form of energy that flows due to a difference in temperature. Energy is transferred when two objects are at different temperatures and brought together. Heat transfer/loss in the form of convection happens when heat is transferred by the movement of a heated fluid such as air or water, this concept is relevant when investigating whether liquid undergoes more heat loss in a beaker as the surface to volume ratio increases.

Hypothesis: If the surface area is larger, and thus the surface area to volume ratio, more heat within the beaker is disclosed to its surroundings, and since there is lower molecular motion/kinetic energy within these surroundings, the diffusion of heat from the breaker will cause the heat of the surroundings to increase through convention. As a result, more heat will be lost, and the liquid will cool down faster at a larger surface area. Therefore I expect there to be a positive correlative relationship between the rate at which heat is lost, and the surface area to volume ratio, since the value of this ratio might decrease as the volume and hence the surface areas increase. Independent Variables – Surface Area, SA (m^2) Volume V (mL) Dependent Variables – Temperature Change, T (°C)Control Variables – Volume of Water, V, (mL)Total time of experimentation per trial, t (s)Starting temperature of water, T (°C)Room Temperature, T (°C)Type of Liquid, C (Cal)Controlled VariableEffect on ResultHow it will be controlledVolume of Water, VMaking the volume of water inside the beaker inconsistent over different beakers will make the amount of heat disclosed to its surroundings also inconsistent. This is to be avoided. Keeping the volume of water at 200mL in each beaker. Total time of experimentation per trial, tKeeping the time constant will make sure that data can be compared over a fixed amount of time. Per trial a constant time of 5 minutes (300 seconds) will be taken.

Starting temperature of water, TIf the starting temperature is higher in some beakers, they might lose faster. Therefore the initial temperatures have to be kept constantWater will be released from the kettle into the beakers when boiling. I will then start timing separately for each beaker when it’s water reaches 50°C.

Room Temperature, TIf the room temperature would be warmer or colder, the rate at which temperature changes would also vary. Therefore it has to be kept constant. All trials were done in one day at a room temperature of 24°C. Type of Liquid, CIf different liquids are used throughout the experiment, the capacities will be different. This will affect the rate at which heat is lost. Always using tap water Materials List: Five beakers (250mL, 400mL, 600mL, 1000mL, 2000mL)Five Thermometers for each beakerFive stopwatches to record change in temperature over 5 minutesKettle to heat up waterStepwise Procedure: Fill kettle with tap water Heat up water using kettle until it boils (100°C)Fill each of the five Beakers at 200mLWhen a beaker reaches 50°C the timer will be started at different times for each timerStop the timer after five minutes for each beaker Record the temperature exactly after five minutes for each beakerResults: Measurement Uncertainties: Uncertainty MagnitudeReasonVolume of Water (200mL)

±10mLThe readings when filling the beakers with 200mL may differ slightly from the actual volume of liquid presentHeight of Beaker ±0. 1cmReadings from digital tape measure might differ slightly from the actual height of the beakerDiameter of Beaker±0.

1cmReadings from digital tape measure might differ slightly from the actual diameter of the beakerInitial Temperature±0. 1°CDetermining on the thermometer exactly where the temperature dropped to 50°C may have been inaccurate due to estimation and the imprecise increments providedTemperature after 5 Minutes±0. 1°CDetermining on the thermometer exactly what the temperature is after 5 minutes might have been inaccurate due to estimation the imprecise increments providedRaw Data: Table 1 – Final Temperature per beaker after 5 minutes from a starting Temperature of 50°C Analysis of Raw Data: The total uncertainty of the temperatures recorded is ±0. 2 since both the uncertainty of the initial temperature of 50°C is taken into consideration, as well as the uncertainty of the final temperatures after five minutes (both uncertainties being ±0.

1). As the surface area and volume of the beakers increases, the amount of heat lost increases subsequently. Processed Data: Table 2 – Measurements of Height and Radius for Five Beakers Uncertainty for the Surface Area of the Beakers: Table 3 – Calculations for the Surface Area and Surface Area to Volume RatioThe data from Table 3 shows that as the volume and surface area of the beakers increase, the ratio of the volume of the water and surface area of the beaker becomes larger. Table 4 – Average Final Temperatures for each Surface Area to Volume RatioPresentation and Analysis of Processed DataThere is a negative correlative relationship between the surface area to volume ratio and the temperature of the liquid. Taking into consideration that the starting temperature of the cooling period of 5 minutes, is 50°C±0. 1°C, the most significant conclusion that is to be taken from table 4, is that most heat is lost at the lowest surface area to volume ratio.

The least heat loss of the liquid inside the beaker took place at the highest temperature of 47. 14°C±0. 02. The following data better illustrates this relationship.

Using the following formula, the percentage changes in terms of temperatures per surface area to volume ratio were calculated. Table 5 – Percentage Changes in Terms of Temperatures per Surface Area to Volume RatioThe corresponding graph shows a correlative positive relationship between the surface area to volume ratio and the percentage change in temperatures. Therefore the graph further supports the notion that as the surface area to volume ratio increases, the amount of heat lost from the water increases. Conclusion: The purpose of this lab was to investigate how the surface area of a beaker to volume of the water ratio can affect the rate at which heat is lost within the beaker. I predicted that as the surface area to volume ratio increased, the mass motion of molecules increased to the surroundings of the beaker through convection. This is because a larger surface area to volume has a larger body space through which the loose molecules are to be released. Therefore the largest surface area to volume ratio will lose the most amount of heat energy due to there being a larger area compared to the transfer of kinetic energy from inside the beaker. The heat loss mostly took place by means of convection because of the contact between the hot water and the surrounding colder air.

The colder air heats up and is then induced inside the beaker to the hot water, as a result the cooler air will circulate continuously until the water is cool. The results obtained from the experiment support this prediction. After having measured the temperature change in the five beakers from an initial temperature of 50°C±0.

1°C, the raw data showed how more heat was lost as the volume of the beaker increased. Furthermore, the processed data showed that as the surface area to volume ratio increased, more heat inside the beaker is lost. After having calculated the percentage change in temperatures per beaker, and this data was plotted, there was an obvious positive correlation between the amount of heat lost and the surface area to volume ratio. The uncertainty boxes resemble the changes in temperature of the 5 beakers. The uncertainties consistently increase, the 250ml beaker (lowest surface area to volume ratio) has the lowest data spread, and hence the lowest error bar, while the 2000ml beaker has the highest (highest surface area to volume ratio). Evaluation: ErrorType of ErrorHow it can be reducedUsing the same volume of water for each beaker.

When the beaker has a greater volume, there will be additional collisions between molecules, hence more internal heat in the water, since the heat is only released from the top surface of the beaker. Systematic ErrorUsing beakers with the same volume but only different surface areasThermal Insulation might have taken place with the beaker and the table. Therefore the temperature of the water could have been decreased by an external forceRandom ErrorTo prevent this heat loss instead of setting the beakers on a table, they could have been placed on a wool carpetThe temperatures being different in parts of the beaker. There is possibly heat directly lost at the top of the beaker due to the the transfer of energy between differences sources by means of electromagnetic radiation. Extra heat could have also been lost due to convection, where energy is transferred to the surroundings of the beaker through the mass motion of the loose molecules.

Random ErrorStirring the water can keep the temperature of the water at constant at different sections of the beaker