Laboratory
Report

INTRODUCTION

The trend in the size of particles in the in the different states of matter was investigated. The experiment was carried to ascertain the sizes of atoms in solids. Additionally, the experimentation also sought to determine the size of molecules in the gaseous and liquid phases. The study the size of particles in the various states of matter requires that a specified number of physical quantities are measured. The volume, mass and density were key physical quantities that were studied.

Cubical atomic model and cubical molecular models were influential in determining the size of atoms and molecules respectively. An electronic balance was used to obtain the mass of the samples. Water displacement technique is used to find the volume of the metallic sample. A mathematical formula is used to acquire the capacity of the sample in the gaseous phase.

EXPERIMENTAL PROCEDURE

Measurement of the size of atoms of a solid

Two cylindrical pieces of aluminium and tin metals were obtained. Each of the samples was weighed on an electronic balance and the data recorded. By use of the water displacement technique, the volume of each cylinder was measured. A burette was filled with 20ml of tap water and fixed on the ring stand with a burette's clamp. 15.0ml of water was added from the burette into the graduated cylinder with the metal sample. The final reading of the water volume in the graduated cylinder, V_{fin} was recorded in the table. The density of the metal was substance was calculated and the atomic size D_a was estimated using the cubical atomic model. Finally, the deviation of the estimated value of D_a was calculated.

Measurement size of molecules in fluids

The weight of a clean, dry and empty 50 ml graduated cylinder was determined, and the weight recorded in a table. 15- 25 ml of distilled water was added to the 50 ml graduated cylinder. The precise volume of water, as well as the precise mass of the graduated container with water was recorded. The mass of the water sample was determined using the mass difference. Consequently, the density of water, as well as the size of water molecules was calculated.

Measurement of size of solid and gaseous molecules

Using a test tube holder, one pellet of dry ice with the best cylindrical shape was taken from the cooler. The diameter d_{ice} and the length of the ice cube h_{ice} were quickly measured using a small plastic ruler. The size of the pellet was recorded in the data table. Subsequently, an empty plastic weighing dish was placed on the balanced and zeroed. The pellet was then placed into the weighing dish and the mass of the dry ice sample,

$m_{dry\ ice}$ was recorded. The volume of solid dry ice $V_{dry\ ice}$ was calculated by considering the solid dry ice as a cylinder with diameter d_{ice} and length h_{ice}. The density of the solid dry ice was calculated and the size of carbon dioxide molecule was estimated. The experimentally estimated size of the carbon dioxide molecule D_M was compared with the actual value.

Using a test tube holder, the previously measured dry ice pellet was placed inside a 125ml glass flask. The flask was then placed on the bench in the balance room. The prepared rubber balloon was stretched at the opening, and the neck of the flask was inserted inside the rubber balloon. It was ensured that the opening of the balloon covered about 2cm of the flask's neck. The covering was to ensure that no carbon dioxide produced escaped during the sublimation of the dry ice. To ensure there is no leakage of carbon dioxide from the balloon, a piece of paraffin film was wrapped tightly around the flask's neck. The set-up was left to stand for about 40 minutes so that the entire dry ice pellet sublimated. The final gas volume in the balloon was then recorded. After 40 minutes, the volume of the inflated balloon, V_b was measured.

DISCUSSION

Measurement of the atomic size in solids

The atomic size of two metals was determined. The two metals were tin and aluminium. The mass of the samples was determined to be 14.16g and 29.0 g for aluminium and tin respectively. The volume of the aluminium and tin samples were 6.4ml and 3.91ml respectively. Therefore, the calculated densities were 2.21g/ml and 7.45g/ml for aluminium and tin respectively. For a spherical atomic model, the packing coefficient is 0.54, hence the calculations yield that the atomic diameter for aluminium and tin were 2.22×10^{-8} cm and 2.43×10^{-8} cm respectively. The cubical atomic model, estimated that the atomic diameters are 2.73×10^{-8} cm and 2.98×10^{-8}cm for aluminium and tin respectively. When compared to the theoretical values of the cubical atomic model had a smaller deviation as opposed to the spherical atomic model. The percentage experimental errors for the cubical atomic model were 2.50% and 6.88% for aluminium and tin respectively. On the other hand, the percentage experimental errors for cubical atomic model were 20.71% and 24.06% for aluminium and tin respectively.

Measurement of molecular size in liquids and solids

The mass of the empty graduated cylinder was found to be 104.68g while the mass of the graduated cylinder with water sample was 127.72g. Therefore, the mass of water sample, which is the mass difference, is 20.04 g. The volume of the water sample was determined to be 20.04 ml. Consequently, the density of the water sample was 1g/cm^3. The molecular size of water molecules was determined to be 2.62×10^{-8} cm. Compared to the theoretical value of 2.52×10^{-8}cm, the percentage experimental error was calculated to be 3.97%.

Measurement of molecular size of dry ice sample

The diameter of ice was measured to be 1.5cm while the length was 4.5cm. The volume of dry ice sample was found to be 7.95cm^3. The mass of the dry ice sample was determined to be 11.75g. Consequently, the density of the dry ice sample was 1.48g/cm^3. The experimental molecular size of carbon dioxide at a packing coefficient of 0.7 is 3.26 x 10^{-8} cm. The actual molecular size of carbon dioxide is 4.06 x 10^{-8} cm. Subsequently, percentage deviation of the estimated molecular size was 19.70%.

Determination of the space percentage in gaseous carbon dioxide sample

The circumference of the balloon was determined to be 64.10cm. Similarly, the diameter of the balloon was measured to be 20.4 cm thus the volume of the balloon is 4445.18 cm^3. The total volume of gaseous carbon dioxide was 4570.18 cm^3. Consequently, the actual volume of carbon dioxide molecules in the dry ice sample was 5.57 cm^3. As a result, the percentage of space in a gaseous carbon dioxide samples was established as 99.83%.

The deviations observed in the experiment could have resulted from a variety of sources. Inaccurate readings may have led to the deviations. The inaccurate readings could have resulted from the instruments used as accuracy is not absolutely guaranteed. Additionally, the inaccuracies could have been due to human errors on the student part. Moreover, the many assumptions concerning the shape of the samples also caused considerable deviation of the results.

CONCLUSION

The objectives of the experiment were satisfactorily met though with some slight deviations. The size of atoms, the molecular size and the percentage space values obtained were close enough to the theoretical values. From the results, it can be concluded that the size of atoms or molecules is directly proportional to the molar mass. Tin has a greater molar mass than aluminium and in turn, atoms of tin have a bigger size than atoms of aluminium. Similarly, carbon dioxide has a superior molar mass than water, and carbon dioxide has a larger molecular size than water.