**Determining the Composition of Pluto**

The largest satellite of Pluto, called Charon, has been used to determine the total mass of Pluto, which is about 1.31 x 1022 kilograms. Pluto’s diameter has been measured by New Horizons and is 2372 km. Calculate the volume of Pluto and determine its average density.

The volume of a sphere is: \*V = 4/3 πr3 Density is mass divided by volume: D = m/V

\*Convert the volume to m3 and remember to use radius, not diameter.

How does Pluto’s density compare to solid-rock (3000 kg/m3), water-ice (917 kg/m3)?

*Answer: Pluto’s volume will be V = 4/3 πr3 = 6.97 x 1018m3. Its density is 1879 kg/m3. (From the results, Pluto must be some combination of rock and water ice.)*

Pluto is known to be a combination of both rock and ice, but how much of each is present?

Can you create a model of Pluto that matches its average density and predicts what percentage of rock and ice by volume may be present? What percentage of rock and ice by mass must be present?

**Method 1 – Using an Excel spreadsheet**

Have students create a spreadsheet that varies volumes of rock and ice to model the density of Pluto. A sample spreadsheet is shown below:

|  |  |  |
| --- | --- | --- |
| % rock volume | % ice volume | Density of mixture |
| 100 | 0 | 3000 |
| 90 | 10 | 2792 |
| 60 | 40 | 2167 |
| 50 | 50 | 1959 |
| 40 | 60 | 1750 |
| 30 | 70 | 1542 |
| 0 | 100 | 917 |
| 48 | 51 | 1908 |
| 47 | 52 | 1887 |
| 46 | 53 | 1866 |
|  |  |  |

*The spreadsheets results should yield 47% rock and 53% ice by volume. For the sample spreadsheet shown, here is the formula for the “density of mixture” column:*

 *=(((3000\*A2)/100)+((917\*B2)/100))*

*where A2 is the first line of the rock volume (100) and B2 is the first line of the ice volume (0).*

*If the rock volume is (.47 x 6.97 x 1018 m3) = 3.28 x 1018 m3, then multiplying by the rock density,*

*3000 kg/ m3  x 3.26 x 1018 m3, the mass of the rock is 9.83 x 10 21 kg.*

*Dividing by Pluto’s mass:*

*9.83 x 10 21 / 1.31 x 1022 = .75. Pluto is 75% rock (and 25% ice) by mass.*

**Method 2 – Experimentally determining Pluto’s composition**

Materials needed: a scale for the class, plus these items per team: a test tube, a graduated cylinder, sand and crushed ice or snow.

Procedure: Fill the test tube with water, then measure the water with a graduated cylinder to determine the volume of the test tube.

Fill the test tube with sand and mass it. Calculate the density of the sand. Repeat this procedure with crushed ice or snow.

Have students experiment with different ratios of sand to ice to determine Pluto’s composition. Note: This works best if sand is first measured out in the graduated cylinder, then ice is added to fill the test tube.

***Teacher prep:***

Ahead of time, determine the density of your sand and ice, then prepare a “Pluto test tube” of about 47% rock and 53% ice by volume. Mass it to give the class a value for Pluto’s density.

Everyone in the class should have test tubes of uniform size.

Sealing the top of the tube with a piece of tape is a convenient way to keep the contents inside while adding negligible mass, when massing the filled tube.