During a severe magnetic storm, Earth is surrounded by a disk of plasma called the Ring Current. The outer diameter of this disk is about 4 times Earth’s radius (1 Re = 6,378 kilometers) while the inside radius is about 1.5 times Earth’s radius. The thickness of this disk is about 2,000 kilometers. The volume of a ring-shaped disk is given by the formula

\[ V = \pi \times (R^2 - r^2) \times h \]

where \( R \) is the outer radius, \( r \) is the inner radius, and \( h \) is the thickness of the disk. Use this formula to answer the questions below.

**Question 1** - If the density of the Ring Current particles is about 10,000 atoms per cubic centimeter, how many atoms are present in this disk of plasma?

**Question 2** – If the atoms are mostly oxygen atoms, and an oxygen atom has a mass of about \( 2.0 \times 10^{-20} \) kilograms, what is the total mass of the Ring Current?
This problem is suitable for students who have taken Algebra 1.

In this activity, students will use the formula for the volume of a ring. They will substitute numerical values into the formula. They will use scientific notation throughout. They will work with positive and negative exponents.

**Question 1** - If the density of the Ring Current particles is about 10,000 atoms per cubic centimeter, how many atoms are present in this disk of plasma?

**Answer:** We have to multiply the density of the gas by the volume of the disk to find the number of atoms. The volume of a ring-shaped disk is given by \( V = \pi \times (R^2 - r^2) \times h \), where \( R \) is the outer radius, \( r \) is the inner radius, and \( h \) is the thickness of the disk.

The outer radius \( R = 4.0 \times 6378 \times 100000 \text{ cm} = 2.55 \times 10^9 \text{ cm} \).
The inner radius \( r = 1.5 \times 6378 \times 100,000 \text{ cm} = 9.57 \times 10^8 \text{ cm} \).
The height \( h = 2000 \times 100000 \text{ cm} = 2.0 \times 10^8 \text{ cm} \).

So from the formula:

\[
V = (3.14) \times \left[ (2.55 \times 10^9)^2 - (9.57 \times 10^8)^2 \right] \times 2.0 \times 10^8 \text{ cubic centimeters}
\]

\[
V = 3.14 \times \left[ 6.50 \times 10^{18} - 9.16 \times 10^{17} \right] \times 2.0 \times 10^8 \text{ cubic centimeters.}
\]

\[
V = 3.51 \times 10^{27} \text{ cubic centimeters.}
\]

The total number of oxygen atoms is then Density x Volume or

\[
N = 10,000 \times 3.51 \times 10^{27} \text{ atoms.}
\]

\[
N = 3.51 \times 10^{31} \text{ atoms.}
\]

**Question 2** – If the atoms are mostly oxygen atoms, and an oxygen atom has a mass of about 2.0 x 10-20 kilograms. If one metric ton equals 1000 kilograms, what is the total mass of the Ring Current?

**Answer:** Multiply the answer from Question 1 by the mass of an oxygen atom, and convert from kilograms to metric tons.

\[
\text{Mass} = (3.51 \times 10^{31}) \times (2.0 \times 10^{-20}) = 7.02 \times 10^{11} \text{ kilograms}
\]

\[
= 7.02 \times 10^8 \text{ metric tons.}
\]