How large is a mole of M&M's?

Objectives: Determine the volume of a mole of M&M's. Using dimensional analysis, determine whether or not it would fill the volume of the school.

Background: The mole is a unit of measure (similar to a dozen) and is equivalent to 6.02×10^{23} representative particles of that substance. Avogadro determined this number by stating that a mole of any substance contains 6.02×10^{23} representative particles of that substance.

Procedures & Data:

1. Obtain a cup with M&M's.

2. Pour the M&M's out onto a CLEAN towel and count them.
   Number of M&Ms's = **52**

3. Determine the mass of your sample of M&M's.
   Mass of M&M sample = **45.15 g**

4. If the density of a milk chocolate M&M is 0.88 g/cm³, determine the volume of you sample of M&M's.
   Volume of M&M's _____

5. Determine the volume of one M&M.
   Volume of one M&M _____

6. Measure the volume of your desk drawer by measuring the length (**24.2 cm**), width (**36.4 cm**), and depth (**10.0 cm**) in centimeters.
   Volume of desk drawer in cubic centimeters (cm³) _____

7. Use dimensional analysis to determine the number of M&M's that would fit in your desk drawer.
   Example of dimensional analysis: convert 101,376 inches to miles
   101,376 inches x 1 foot   x   1 mile = 1.6 miles
                      12 inches   5280 ft

   Number of M&M's able to fit in desk drawer _____
   Hint: You know the volume of the desk drawer and the volume of one M&M from #5

8. The dimensions of the school are approximately 150 meters in length by 70 meters in depth and 6.5 meters in height. Convert these distances to cm.
   For example: 20 meters   x   100 cm   =   2000 cm
                              1 m

   Volume of the school in cubic centimeters _____

9. How many representative particles are in one mole of M&M's?
   Number of representative particles in one mole of M&M's _____
   Hint: What is the number of units in one mole of anything?

10. Determine the volume needed to hold a mole of M&M's _____
    Hint: The volume for one M&M is close to 1 cm³. Therefore, how many cm³ are needed to hold a mole of M&M's

11. Would a mole of M&M's fill up the school? _____
    Hint: Compare the volume of the school in #8 and compare which is larger.

Questions

1. Milk chocolate as found in M&M's is composed of 70% of the sugar sucrose. Sucrose is broken down by our bodies to form two simple sugars that the body uses for fuel. The chemical equation for this reaction is:

$$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$
   Sucrose   Glucose   Fructose
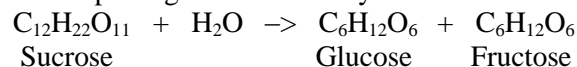
   a) How many molecules are in a mole of sucrose (*Remember how many units are in a mole of anything*)?

   b) What is the molar mass of one mole of sucrose?

   c) What is the molar mass of one mole of glucose?

   d) What is the molar mass of one mole of fructose?

   e) What is the molar mass of one mole of water?

   f) Which compounds are reactants and which are products in this reaction?

2. Caffeine is found in small amounts in the chocolate of the M&M's. Caffeine functions in the body to stimulate the cortex of the brain, and in small doses can improve attention, concentration and coordination. Caffeine acts on the kidneys to increase water elimination through frequent urination. It stimulates the action of the heart and causes blood vessels to widen everywhere but in the brain, where vessels are constricted. And, by altering the activity of calcium ions, caffeine increases the contracting power of skeletal muscles which makes them less susceptible to fatigue.

   a) Caffeine has the chemical formula of $C_8H_{10}N_4O_2$. Determine the molar mass of caffeine.

   b) A cup of cocoa contains 0.015 grams of caffeine. Does a cup of cocoa contain a mole of caffeine? (Compare this with your answer from part a)

3. Calcium carbonate is the principal mineral found in limestone, marble, chalk, pearls and the shells of marine animals such as clams. It is also a component of the antacids for when you eat too many M&M's.

   a) What is the molar mass of calcium carbonate?

4. **Covert the following problems to the specified quantities.** *Please show your fence post!*
   a) 4.6×10^{23} molecules of sucrose to moles of sucrose.

   b) 10.0 g of ethanol (an alcohol) C_2H_5OH to moles of ethanol.

   c) 4.55 moles of potassium bromide to grams of the same compound.

   d) 12.375 grams of magnesium hydroxide (found in Tums) to moles of magnesium hydroxide.

   e) 2.5 moles of bromine gas to liters of the same gas at STP.

   f) 12 g of lead (II) iodide (that causes lead poisoning in children) to moles.

   g) 3.41×10^{23} formula units of aluminum sulfate (also found in some antacids) to moles.

   h) 50.00 liters of carbon monoxide gas at STP to moles of gas.