Counting Numbers of Atoms and Molecules – POGIL Activity

Lab Challenge

Introduction

BB's, the ammunition for the popular rifle used to introduce youngsters to the safe use of fire arms, are Cu plated steel spheres approximately 3 mm in diameter. Steel is composed almost entirely of iron. For the purposes of this lab, we will consider BB's to be 100% iron. In this exercise you will invent a rapid method for counting large quantities of BB's very rapidly.

Objective: Using equipment given to you to develop a method for counting BB's in the 5 to 50 kilodozen range. You method should allow you to determine the number of BB's in a sample in this range in under five minutes.

Your final method can only use equipment available in the lab or similar equipment of smaller or larger size as needed. If your method requires using smaller or larger equipment than that in the lab, indicate what equipment that will be and indicate the size or range needed for that equipment.

Lab Data and calculations:

Describe your method for determining the number of BB's.

Part 1 – Defining the mole

Consider relationship between a dozen objects and the mass of a dozen objects.

1. How many donuts in a dozen donuts?

12

2. How many BBs in a dozen BBs?

12

3. How many cars in a dozen cars?

12

4. Do you think that a dozen BB's and a dozen cars weigh the same amount?

NO

5. If one BB weighs 0.3678 g, what is the mass of one dozen BB's?

$(0.3678\text{ g})(12) = 4.414\text{ g}$

6. What assumption(s) did you make in answering questions 5?

7. If one dozen of object A and one dozen of object B have the same mass, how does the mass of object A relate to the mass of object B?

A + B have the same ~~mass objects~~

8. Consider question 7. In order for there to be a direct relation relationship between the number of dozens of objects and the mass, what must be true?

Defining a kilodozen

9. What is a kilogram?

x1,000 a gram

10. What does kilo mean in the metric system.

x1,000

11. Define Kilodozen.

Kilo = 1,000 dozen = 12 Kilodozen = 12,000

What is the mass of a kilodozen Bb's?

1 BB = 0.3678g

$$\frac{12{,}000\text{ BB}}{1\text{ BB}} = \frac{x\text{ g}}{0.3678\text{ g}}$$

or

$$\frac{12{,}000\text{ BB}}{1\text{ BB}} \left| \frac{0.3678\text{ g}}{} \right. = 44.14\text{ g}$$

44.14g

The Mole – The Chemist's Dozen
In the above exercise, we used a kilodozen (a fixed amount of things) to describe a large number of BB's.

12. A 2008 Toyota Prius has a curb weight of 2932 lbs. How much would 2 kilodozen 2008 Toyota Prius's weigh? 1P = 2932 lbs.

$\frac{24{,}000\ \text{P}}{1\ \text{P}} \mid \frac{2932\ \text{lbs.}}{} = 703{,}680{,}000\ \text{lbs.}$

The mole, like a dozen or a kilodozen is a fixed number of things.
1 mole of things = 6.0221415×10^{23} things. (6.0221415×10^{23} is referred to as Avogadro's number.)

13. Fill in the blank
6.02×10^{23} to a mole is like 12 to a dozen.

14. What would one mole of BB's weigh in grams? ~~In lbs?~~

$\frac{6.02 \times 10^{23}}{1\ \text{BB}} \mid \frac{0.3678\text{g}}{} = 2.21 \times 10^{23}\ \text{g of BB}$

15. Which weighs more: a ~~kilodozen~~ Prius's or a mole of BB's? Explain why this is so when one BB weighs so much less than one Prius. mole

One mole is the mass of the object. The Prius weighs more (> molar mass).

16. One atom of Fe atom weighs 9.2741×10^{-23} g.
What is the mass of 1 mole of Fe atoms?
1 atom = 1 mole

$(9.2741 \times 10^{-23}\ \text{g})(6.02 \times 10^{23}\ \text{mole}) = 55.83\ \text{g}$

The mass of one mole of any type of like items is referred to as the **molar mass (MM)**.

17. What is the units of MM?
(Hint: recall that it is the mass per mole. What mass unit do we measure regularly in the chemistry lab?)

grams/mole

Confirm that your answer to this question is correct before proceeding.

18. Examine the entry for iron on the periodic table.
In what way does the MM of Fe determined above relate to this entry?

The mass given is the mass in grams if 6.02×10^{23} atoms were present.

19. Based on this observation, what is the molar mass of fluorine atoms? Of zinc atoms?

F: 18.999 g/mol Zn: 65.39 g/mol

20. How many iron atoms are in one BB? (remember, you measure the mass of BB's earlier)

$\frac{0.3678\text{g}}{x\ \text{atoms}} = \frac{55.85\text{g}}{6.02 \times 10^{23}\ \text{atoms}} = 3.96 \times 10^{21}\ \text{atoms}$

21. How many moles of iron atoms are in one BB?

$\frac{x\ \text{mole}}{3.96 \times 10^{21}\ \text{atoms}} = \frac{1\ \text{mole}}{6.02 \times 10^{23}\ \text{atoms}} = 6.58\ \text{moles}$

22. How many moles of F atoms are in 38.00 g of fluorine gas?

$\frac{1\ \text{mol}}{19\text{g}} = \frac{x\ \text{mol}}{38\text{g}}$ 2 moles

23. How many moles of Zn atoms are in 1.215 g of Zn?

$\frac{1\ \text{mol}}{65.37\text{g}} = \frac{x\ \text{mol}}{1.215\text{g}}$ 0.01856 moles

The Chemist's Preference – Should we use number of moles or actual numbers of atoms?
For each pair of statements below, select the one that you think would be most likely to hear or see used? Explain why you chose the one you did. In each case, the same quantity is being described.

24 a. A home in Tucson, AZ will easily use over 15,000 kilowatt hours of electricity per month in the summer.
b. A home in Tucson, AZ will easily use over 54,000,000,000 watt seconds of electricity per month in the summer.

Smaller number ; converted

25 a. A 13.4 ton boulder fell on to the highway blocking traffic.
b. A 26,800 lb boulder fell on to the highway blocking traffic.

Smaller, simpler number

26 a. The nearest star to the earth other than the sun is 4.3 light years away.
b. The nearest star to the earth other than the sun is 8.4×10^{13} miles away.

Smaller number

27. Considering your answers above put either "more" or "fewer" in the sentence below blank in this sentence: "In general, when describing measurements, the preference is to write numbers that require fewer digits."

28. Based on this statement, which quantity is more likely to be used to describe the amount of a substance that we are using in a lab experiment: the moles of atoms, molecules, formula units, etc. or the actual numbers of atoms, molecules, formula units, etc.?

moles

the simplest way to describe a measurement than the actual number of atoms, molecules, formula units, etc.