During Class Invention

Name(s) with Lab section in Group

Weighted Average[2]

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1. Suppose we have a collection of 15 marbles in a container. 40 % of the marbles are red and 60 % of the marbles are black. The orange marbles weigh 6.00 grams and the black marbles weigh 8.00 grams.

a) Calculate the average mass of the marbles in the container. (clearly show how you arrived at your answer.)

$$\textbf{\# of red marbles} = 15 * \left(\frac{\text{40 red marbles}}{\text{100 marbles}}\right) = \text{6 red marbles}$$

$$\textbf{\# of black marbles} = 15 * \left(\frac{\text{60 black marbles}}{\text{100 marbles}}\right) = \text{9 black marbles}$$

$$\frac{6.00 + 6.00 + 6.00 + 6.00 + 6.00 + 6.00 + 8.00 + 8.00 + 8.00 + 8.00 + 8.00 + 8.00 + 8.00 + 8.00 + 8.00 \text{ grams}}{\text{15 marbles}}$$

= 7.2 grams

or

$$\text{average mass} = \frac{\text{6 RM} * \text{6.00 grams} + \text{9 BM} * \text{8.00 grams}}{\text{15 marbles}}$$

$$= \frac{\text{108.0 grams}}{\text{15 marbles}} = \text{7.20 grams}$$

b) Do any marbles in the container have the same mass as the average mass?

No the masses of the two marbles is 6.00 g (red) or 8.00 grams (black). There are no marbles with a mass of 7.20 grams.

2. Suppose we have another collection of 40 marbles in a different container. 40 % of the marbles are red and 60 % of the marbles are black. The orange marbles weigh 6.00 grams and the black marbles weigh 8.00 grams.

a) Calculate the average mass of the marbles in the container.

$$\text{average mass} = \frac{40 * 0.40 * \text{6.00 grams} + 40 * 0.60 * \text{8.00 grams}}{\text{40 marbles}}$$

$$= \frac{\text{288. grams}}{\text{40 marbles}} = \text{7.20 grams}$$

3. Outline your strategy for calculating the average mass of a collection of orange and black marbles if the total number of marbles is not know.

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[2] Inspired by Moog, R.S. and Farrell, J. J. Chemistry A Guided Inquiry. John Wiley, Sons. New York, 1996. Page 5.

We can re-write the equation used in Q1 abd Q2 using the variable T_M for the total number of marbles in the sample; FA for the fractional abundance for each marble, MM for the marble mass.

$$\text{average mass} = \frac{T_M * FA_{red} * MM_{red} + T_M * FA_{black} * MM_{black}}{T_M}$$

$$\text{average mass} = \frac{T_M * 0.40 * 6.00 \text{ grams} + T_M * 0.60 * 8.00 \text{ grams}}{T_M}$$

factoring the numerator, we have

$$\text{average mass} = T_M * \frac{0.25 * 5.00 \text{ grams} + 0.75 * 7.00 \text{ grams}}{T_M}$$

the total marbles cancels and the equation reduces to,

average mass = 0.40 * 6.00 grams + 0.60 * 8.00 grams

So we see that the total number of marbles cancels out of the equation.

average mass = fraction of marbles_1 * mass of marble_1 + fraction of marbles_2 * mass of marble_2

4. Suppose we have a collection of marbles in a container. 20 % of the marbles are orange and 80 % of the marbles are white. The orange marbles weigh 4.00 grams and the white marbles weigh 10.00 grams.

a) Calculate the average mass of the marbles in the container.

We can re-write the equation used in Q3 using the variable T_M for the total number of marbles in the sample.

$$\text{average mass} = \frac{T_M * 0.20 * 4.00 \text{ grams} + T_M * 0.80 * 10.00 \text{ grams}}{T_M}$$

factoring the numerator, we have

$$\text{average mass} = T_M * \frac{0.20 * 4.00 \text{ grams} + 0.80 * 10.00 \text{ grams}}{T_M}$$

the total marbles cancels and the equation reduces to,

average mass = 0.20 * 4.00 grams + 0.80 * 10.00 grams = 8.80 grams

So we see that the total number of marbles cancels out of the equation.

average mass = fraction of marbles_1 * mass of marble_1 + fraction of marbles_2 * mass of marble_2

5. The element boron is composed of two different isotopes, ^{10}B and ^{11}B. The percent abundance of ^{10}B is 19.78 % and the percent abundance of ^{11}B is 80.22 %. The relative atomic mass of ^{10}B is 10.01294 u and the relative atomic mass of ^{11}B is 11.00931 u. Calculate the (relative weighted) average atomic mass of boron.

The equation we derived in Q3 can now be expressed in terms of isotopic mass and fractional abundance of the isotope.

average mass = Σ(fraction abundance$_i$ * isotopic mass$_i$)
average mass = fraction abundance$_1$ * isotopic mass$_1$ + fraction abundance$_2$ * isotopic mass$_2$

Substituting the data from this problem,

average mass = 0.1978 * 10.01294 u + 0.8022 * 11.00931 u = 10.81 u

6. If you could reach in and pick a single atom from a sample of boron what would be the most probable mass of the atom of boron you selected. Explain.

The most probable mass of a boron atom is 11.00931 u since that isotope has the highest percentage abundance.