

Answer to question #63029, Chemistry / General Chemistry

Question:

A made up element Q has an average atomic mass of 43.6534 and it has four stable isotopes: Q-40 (actual mass = 39.963), Q-42 (actual mass = 41.950), Q-43 (actual mass = 42.982) and Q-45 (actual mass = 44.953). Q-40 makes up 11.53% of the element. Of the remaining three isotopes, one is precisely twice as abundant as one of the others. What are the abundances of all four isotopes?

Solution:

Average atomic mass of element Q is:

$$43.6534 = \sum_{i=1}^4 \frac{\omega_i m_i}{100}$$
$$43.6534 = 39.963 \cdot \frac{11.53}{100} + 41.950 \cdot \frac{x}{100} + 42.982 \cdot \frac{y}{100} + 44.953 \cdot \frac{z}{100}$$

where x , y and z are the mass percentages of Q-42, Q-43 and Q-45, respectively.

Also, we know that the sum of the percentages is always 100%:

$$11.53\% + x + y + z = 100\%$$

Thus, we have a system of two equations with 3 variables and that is not sufficient to get an answer.

From the conditions given, we know that one of the isotopes Q-42, Q-43 and Q-45 is twice as abundant as one of the others, but we don't know, which one, and what is the other one. Hence, we have 6 possible combinations:

1. $x = 2y$
2. $y = 2x$
3. $x = 2z$
4. $z = 2x$
5. $y = 2z$
6. $z = 2y$

When we check the solutions for all the 6 systems of equations, we get non-physical results for the cases 3,4,5. For the cases 1,2 and 6, the values of mass percentages of Q-42, Q-43 and Q-45 are the follows:

	1	2.	6.
x	18.16	10.43	6.10
y	9.08	20.86	27.46
z	61.23	57.18	54.92

Answer: mass percentages of Q-42, Q-43 and Q-45 are 18.6, 9.08 and 61.23, respectively. Or: 10.43, 20.86 and 57.18. Or: 6.10, 27.46 and 54.92.

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