

Inside the atom: particles and isotopes

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lab

Name: _____ Date: _____ Class: _____

How can a handful of two kinds of bolt model the isotopes of an element? You will weigh mixed handfuls, compare the measured mean mass with a calculated weighted mean, and see why a relative atomic mass is an average that matches no single atom.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS1-1, GCSE C1

Aim

To model isotopes with two sizes of bolt and to show that the average mass of a mixed handful is a weighted mean, just like a relative atomic mass.

Equipment

- Top-pan balance reading to 0.1 g
- About 40 small bolts and 20 large bolts
- Paper cup or tray
- Calculator and graph paper

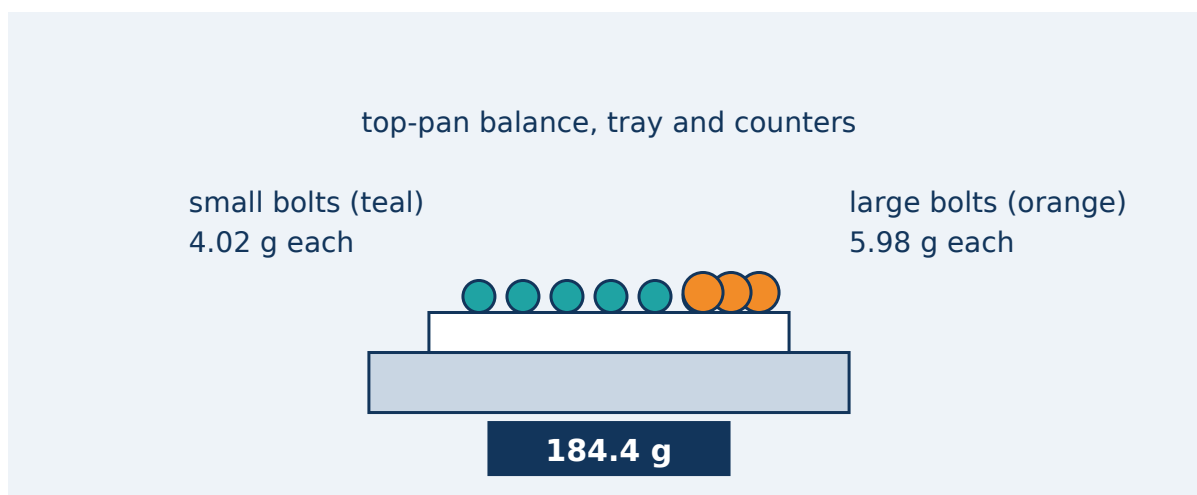
Safety

Safety

Keep bolts off the floor so nobody slips on them. Do not put them in your mouth. Wash your hands after handling metal items.

Method

1. Weigh 10 small bolts and 10 large bolts separately. Divide each mass by 10 to get the mass of one bolt.
2. Take a random handful of 40 bolts without looking. Count how many are small and how many are large.
3. Place all 40 bolts on the tray and record the total mass. Divide by 40 to find the mean mass per bolt.
4. Repeat steps 2 and 3 for four different handfuls.



Weighing a handful of small and large bolts to model isotopes.

Results

Mass of 10 small bolts = 40.2 g, so one small bolt = 4.02 g. Mass of 10 large bolts = 59.8 g, so one large bolt = 5.98 g.

Handful	Small bolts	Large bolts	Total mass / g	Mean mass per bolt / g
1	28	12	184.4	4.61
2	25	15	190.1	4.75
3	31	9	178.5	4.46
4	22	18	196.0	4.90

Analysis questions

Question 1 Predict handful 1

Use the masses of single bolts to calculate the expected mass of handful 1 and its mean mass per bolt.

Question 2 Compare with measurements

Do the same for handfuls 2, 3 and 4. State the largest difference between a calculated and a measured total mass.

Question 3 Plot the graph

Calculate the fraction of large bolts in each handful. Plot mean mass per bolt (y) against fraction of large bolts (x) and draw a line of best fit.

Question 4 Meaning of intercept and gradient

Find the gradient and the y-intercept of your line. State what each one represents.

Question 5 Link to isotopes

State which part of the model matches (a) an isotope, (b) percentage abundance, (c) relative atomic mass.

Question 6 Not a bolt mass

Explain why the mean mass of 4.61 g is not the mass of any single bolt. Give a real chemical example of this.

Question 7 Balance uncertainty

The balance reads to ± 0.1 g. Calculate the percentage uncertainty in the total mass of handful 1 and in the mean mass per bolt.

Question 8 Estimate an unknown mixture

A mystery handful of 40 bolts has a total mass of 192.0 g. Use your graph relationship to estimate the fraction of large bolts, and suggest one way to improve the experiment.