

Moles, isotopes and chemical formulas

AP Chemistry · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems cover the mole concept, molar mass, isotopes and mass spectra, empirical and molecular formulas, and the composition of mixtures. They follow the style of AP Chemistry unit 1.

Early problems use one conversion; later problems combine several steps, including combustion data and mixtures. Show units on every line and keep three significant figures unless told otherwise.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 1

Problem 1 Molar mass (easy)

Use A_r : Ca = 40.08, O = 16.00, H = 1.008.

1. Calculate the molar mass of calcium hydroxide, $\text{Ca}(\text{OH})_2$.
2. State how many moles of hydroxide ions are in 1 mol of the compound.

Problem 2 Water in moles (easy)

A water bottle holds 54.0 g of water. Use $M = 18.015 \text{ g/mol}$.

1. Calculate the amount of water in mol.
2. Calculate the number of molecules.

Problem 3 Mass from moles (easy)

Aarav in Pune measures 0.250 mol of sodium hydroxide, NaOH ($M = 40.00 \text{ g/mol}$).

1. Calculate the mass he must weigh out.
2. State the number of sodium ions present.

Problem 4 Iron nails (easy)

A box of iron nails contains 0.500 mol of iron atoms ($A_r = 55.85$).

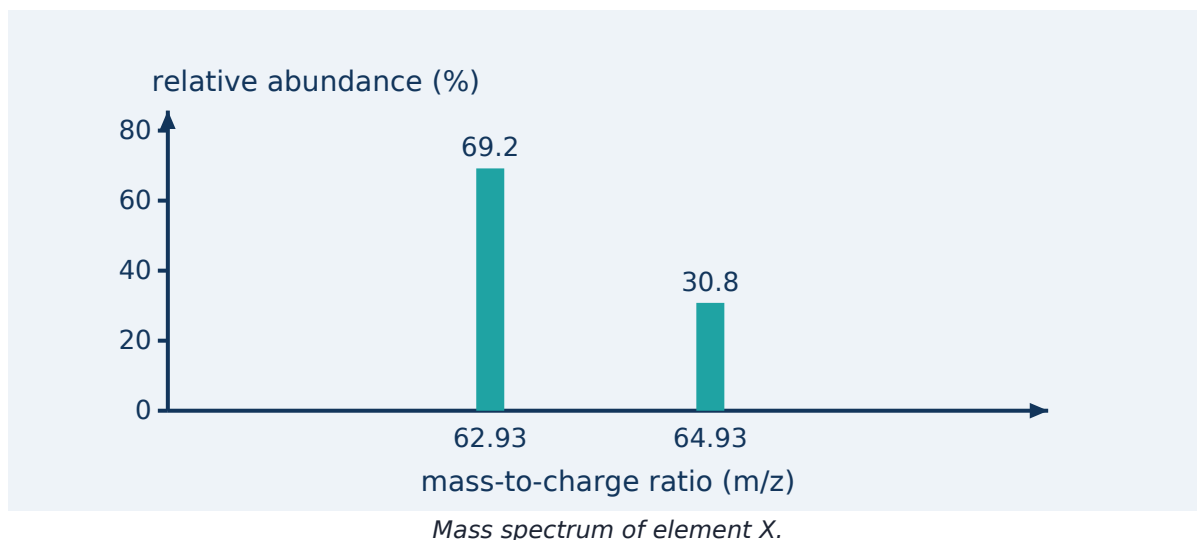
1. Calculate the number of atoms.
2. Calculate the mass of iron in grams.

Problem 5 Reading a mass spectrum (easy)

The figure shows the mass spectrum of element X.

1. State how many isotopes it has.

- Calculate the average atomic mass using the isotope masses on the axis.
- Identify X from the periodic table.



Problem 6 Percent composition of carbon dioxide (easy)

Use $M(\text{CO}_2) = 44.009 \text{ g/mol}$, $A_r(\text{C}) = 12.011$.

- Calculate the mass percent of carbon.
- Calculate the mass percent of oxygen.

Problem 7 Pure or mixed? (easy)

Chiamaka in Lagos lists five materials: distilled water, brass, seawater, a gold bar and air.

- Classify each as a pure substance or a mixture.
- Describe one test that could show that seawater is a mixture.

Problem 8 Formula of an iron oxide (medium)

Heating 5.58 g of iron in oxygen gives an oxide containing 2.40 g of oxygen.

- Calculate the moles of iron and of oxygen.
- Determine the empirical formula.
- Name the oxide.

Problem 9 From empirical to molecular formula (medium)

A hydrocarbon has empirical formula CH_2 and molar mass 70.1 g/mol.

- Calculate the empirical formula mass.
- Determine the molecular formula.

Problem 10 Nitrogen in a fertiliser (medium)

Wanjiru in Nairobi buys pure ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$, for her farm.

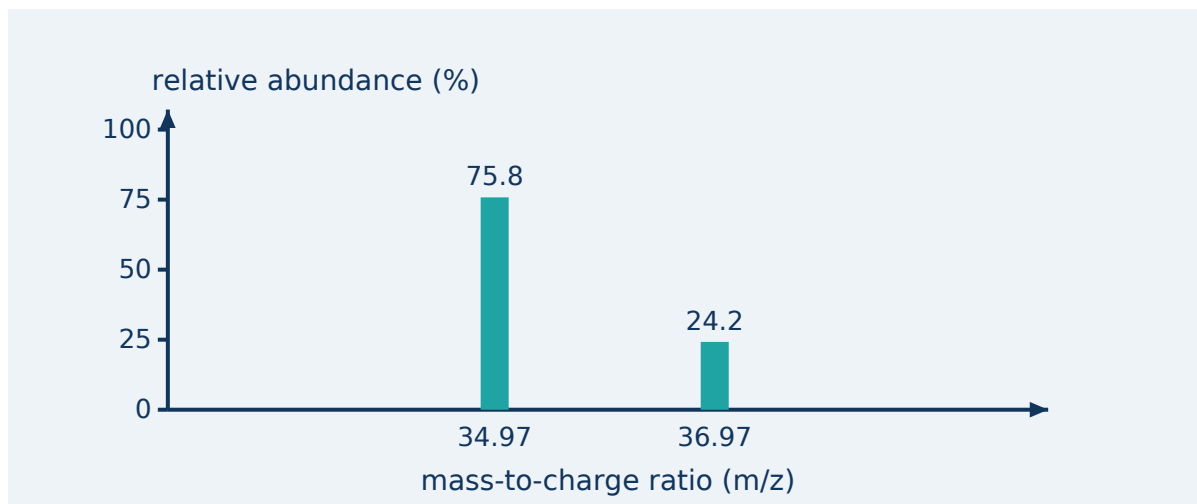
- Calculate its molar mass.

2. Calculate the mass percent of nitrogen.
3. Calculate the mass of nitrogen in a 250 g portion.

Problem 11 Chlorine isotopes (medium)

The figure shows the mass spectrum of chlorine atoms.

1. State the two isotopes and their abundances.
2. Calculate the average atomic mass.
3. Explain why no peak appears at 35.45.



Mass spectrum of a chlorine sample.

Problem 12 Water of crystallisation (medium)

A 3.50 g sample of hydrated magnesium sulfate, $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$, leaves 1.710 g of MgSO_4 ($M = 120.37 \text{ g/mol}$) on heating.

1. Calculate the mass of water lost.
2. Calculate the moles of water and of MgSO_4 .
3. Determine x .

Problem 13 Combustion of a hydrocarbon (medium)

Burning 0.280 g of a hydrocarbon gives 0.880 g of CO_2 and 0.360 g of H_2O .

1. Calculate the moles of carbon.
2. Calculate the moles of hydrogen.
3. Determine the empirical formula.

Problem 14 Salt and sand (medium)

An 8.00 g mixture of salt and sand is dissolved in water and filtered. The dried sand has a mass of 5.20 g.

1. Calculate the mass of salt.
2. Calculate the mass percent of salt in the mixture.

3. Calculate the moles of NaCl ($M = 58.44 \text{ g/mol}$).

Problem 15 A gas mixture (medium)

A cylinder contains 0.300 mol of nitrogen gas and 0.100 mol of oxygen gas.

1. Calculate the mass of each gas ($M(\text{N}_2) = 28.014$, $M(\text{O}_2) = 31.998 \text{ g/mol}$).
2. Calculate the mass percent of nitrogen in the mixture.
3. Calculate the mole fraction of nitrogen.

Problem 16 Isotope abundances from an average (hard)

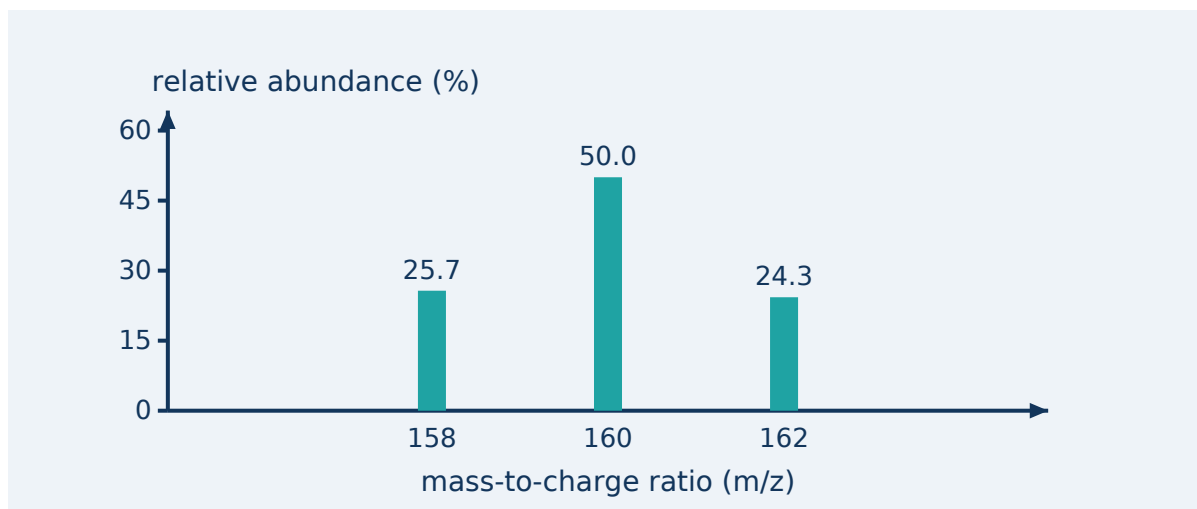
Gallium has two isotopes, 68.926 u and 70.925 u. Its average atomic mass is 69.72 u.

1. Let x be the fraction of the lighter isotope and write an equation for the average mass.
2. Solve for x .
3. State the percent abundance of each isotope.

Problem 17 Mass spectrum of a diatomic molecule (hard)

Bromine has isotopes with mass numbers 79 (50.7 %) and 81 (49.3 %). The figure shows peaks for the molecule Br_2 .

1. Explain why there are three peaks and state the mass of each combination.
2. Calculate the relative probability of each combination.
3. Check that the figure matches your values.



Mass spectrum of Br_2 molecules.

Problem 18 Vitamin C (hard)

Vitamin C is 40.9 % C, 4.58 % H and 54.5 % O by mass, with molar mass about 176 g/mol.

1. Calculate the moles of each element in 100 g.
2. Find the empirical formula.
3. Find the molecular formula.

Problem 19 Nitrogen in a mixed fertiliser (hard)

A 10.0 g sample of fertiliser contains only ammonium nitrate, NH_4NO_3 ($M = 80.04 \text{ g/mol}$), and potassium chloride, KCl ($M = 74.55 \text{ g/mol}$). It holds 2.80 g of nitrogen.

1. Calculate the mass fraction of N in NH_4NO_3 .
2. Calculate the mass of NH_4NO_3 in the sample.
3. Calculate the mass percent of KCl and the moles of KCl .

Problem 20 Combustion analysis of an organic acid (hard)

A 0.5000 g sample of a compound containing C, H and O gives 0.7328 g of CO_2 and 0.3000 g of H_2O on complete combustion. Its molar mass is 60.05 g/mol.

1. Calculate the mass of carbon and the mass of hydrogen in the sample.
2. Find the mass of oxygen by difference.
3. Determine the empirical and molecular formulas.