

Topic 1.4: Composition of Mixtures

Worksheet · AP Chemistry

UNIT 1 · ATOMIC STRUCTURE AND PROPERTIES

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How to Use This Worksheet

Work through the sections in order. Section A checks the ideas, Section B builds the mixture calculations, and Section C mixes everything the way an exam would.

The key skill in this topic is keeping track of which mass you have and which mass you need: the mixture, the component, or the element inside the component. Write the units and the substance name at every step.

Do not look at the answer key until you have attempted every question. The key gives full working, so compare your method, not just your final number.

Section A: Recall and Concepts

A1. Explain why a pure compound has a fixed percent composition but a mixture does not.

A2. A mixture is 30.0% substance X by mass. What does that statement mean in terms of a 100 g sample, and how much X is in a 45.0 g sample?

A3. A mixture contains MgO and MgCO_3 . A student measures the total mass of magnesium in the mixture and tries to work out the mass of MgO from it. Explain why the tracer method fails here, and name a quantity the student could measure instead that would work for MgCO_3 .

A4. A reagent bottle is labelled 85.0% pure. A student weighs out 2.00 g and uses 2.00 g in a mole calculation. State the correct mass of reagent and the direction of the error in the student's moles.

A5. A wet sample has a mass of 8.00 g. After drying, its mass is 7.60 g. Calculate the percent water in the original sample, and state why the original mass is the correct denominator.

Section B: Core Calculations

B1. A solution is made by dissolving 12.0 g of sugar in water to give 120.0 g of solution in total. Calculate the mass percent of sugar in the solution.

B2. An alloy is 8.50% copper by mass. Calculate the mass of copper in a 240 g sample of the alloy.

B3. A brine solution is 12.0% sodium chloride by mass. What mass of brine contains 15.0 g of sodium chloride?

B4. A 50.0 g sample of iron ore is 40.0% Fe_3O_4 by mass. Calculate the mass of iron in the sample. ($M(\text{Fe}_3\text{O}_4) = 231.55 \text{ g/mol}$.)

B5. An impure sample of calcium carbonate has a total mass of 12.5 g and contains 10.0 g of pure CaCO_3 . Calculate the percent purity of the sample.

B6. A mixture of two powders is 35.0% powder A by mass, and the rest is powder B. Calculate the mass of powder B in a 60.0 g sample of the mixture.

Section C: Exam Style

C1. A 5.00 g sample of crushed rock is a mixture of CaCO_3 and SiO_2 . Chemical analysis shows the sample contains 1.20 g of calcium. (a) Calculate the mass of CaCO_3 in the sample. (b) Calculate the mass percent of CaCO_3 in the rock.

C2. A 0.800 g sample is a mixture of NaCl and KCl . The sample contains 0.420 g of chlorine in total. (a) Calculate the mass of NaCl in the mixture. (b) Calculate the mass percent of NaCl in the mixture. ($M(\text{NaCl}) = 58.44 \text{ g/mol}$; $M(\text{KCl}) = 74.55 \text{ g/mol}$.)

C3. A student weighs out 0.500 g of magnesium ribbon that is 92.0% pure; the impurity does not contain magnesium. (a) Calculate the mass of pure magnesium weighed out. (b) Calculate the amount, in moles, of magnesium atoms the student actually has.

Answer Key

A1. A compound's percent composition is fixed by its formula: the atoms are locked in a whole number ratio, so the mass fractions never change. A mixture is a physical blend with no formula, so its composition depends entirely on how much of each component was added, and varies from sample to sample.

A2. It means every 100 g of the mixture contains 30.0 g of X. In a 45.0 g sample: $0.300 \times 45.0 = 13.5$ g of X.

A3. Magnesium is present in both components, so the measured magnesium mass came from MgO and MgCO₃ together and cannot be assigned to one of them. The tracer must occur in only one component. Carbon occurs only in MgCO₃, so measuring the mass of carbon (or of carbonate) would work as the tracer for MgCO₃.

A4. The pure mass is $0.850 \times 2.00 = 1.70$ g. By using 2.00 g, the student overestimates the moles, because the weighed sample includes 0.30 g of impurity that contributes no reagent at all.

A5. Mass of water = $8.00 - 7.60 = 0.40$ g. Percent water = $0.40 \div 8.00 \times 100 = 5.00\%$. The percent describes the composition of the original wet sample, so the original total mass is the denominator; the dry mass is what remains after part of that sample has been removed.

B1. Mass percent = $12.0 \div 120.0 \times 100 = 10.0\%$. The denominator is the total solution mass, sugar and water together.

B2. Mass of copper = $0.0850 \times 240 = 20.4$ g.

B3. Mass of brine = $15.0 \div 0.120 = 125$ g.

B4. Mass of Fe₃O₄ = $0.400 \times 50.0 = 20.0$ g. Iron's fraction in Fe₃O₄ = $3(55.85) \div 231.55 = 167.55 \div 231.55 = 0.7236$. Mass of iron = $20.0 \times 0.7236 = 14.5$ g.

B5. Percent purity = $10.0 \div 12.5 \times 100 = 80.0\%$.

B6. Powder B is $100 - 35.0 = 65.0\%$ of the mixture. Mass of B = $0.650 \times 60.0 = 39.0$ g.

C1. (a) Calcium occurs only in the CaCO₃, so it is the tracer. Fraction of Ca in CaCO₃ = $40.08 \div 100.09 = 0.4004$. Mass of CaCO₃ = $1.20 \div 0.4004 = 3.00$ g. (b) Mass percent = $3.00 \div 5.00 \times 100 = 59.9\%$ (using the unrounded 2.997 g).

C2. (a) Let the mass of NaCl be x g, so the mass of KCl is (0.800 – x) g. Chlorine's fraction in NaCl = $35.45 \div 58.44 = 0.6066$; in KCl = $35.45 \div 74.55 = 0.4755$. Total chlorine: $0.6066x + 0.4755(0.800 - x) = 0.420$. Expanding: $0.6066x + 0.3804 - 0.4755x = 0.420$, so $0.1311x = 0.0396$ and $x = 0.302$ g of NaCl. (b) Mass percent = $0.302 \div 0.800 \times 100 = 37.8\%$.

C3. (a) Pure mass = $0.920 \times 0.500 = 0.460$ g. (b) $n = 0.460 \div 24.31 = 0.0189$ mol of magnesium atoms.

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