Hydrates and solution calculations

Student activity • calculation workshop

YEAR 10 / LESSON 52 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

The question

What does the water in a crystal contribute to its mass?

Use clearly labelled invented mass data to find water of crystallisation. Then compare hydrated and anhydrous formula masses. A separate Chemistry-only extension applies solution concentration and reacting-volume calculations.

Equipment

- Booklet, calculator and periodic table

Desk activity only; no chemicals or equipment for heating are issued.

Course coverage: Shared core: 1.31–1.33 hydrate/formula data. Chemistry-only extension: 1.34C, questions 5–6 and step 5. No hydrate heating or solution preparation is carried out.

Plan, model or apparatus sketch

Draw a calculation route from mass readings to the hydrate formula.

Method and reasoning

Read the whole sequence before starting

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1. Read the hypothetical hydrate data. Subtract the empty-container mass to find hydrate mass and final residue mass; the mass loss is assigned to water only under the stated model assumptions.

2. Calculate the amounts of anhydrous $CuSO_4$ and water using the supplied molar masses. Divide water amount by $CuSO_4$ amount to find x in $CuSO_4 \cdot xH_2O$.

3. Explain how incomplete drying, reabsorbed water, decomposition or lost solid would affect the result. Constant mass alone does not prove that only water was lost.

4. Compare the mass of one mole of hydrated salt with one mole of anhydrous salt. Complete shared-core questions 1–4.

5. Chemistry only: complete questions 5–6. Use final solution volume in dm^3, the full hydrate molar mass and the balanced acid–alkali mole ratio.

6. Check the units and preserve your intermediate values. Correct the idea that a hydrate is simply salt with unmeasured water on its surface.

Cleanup

- Keep calculations and corrections; return shared materials.

Record your evidence

Blank spaces are for your own work

YEAR 10 / LESSON 52 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

Reference and task data

Hypothetical $CuSO_4 \cdot xH_2O$ data assume only water is lost and $CuSO_4$ remains chemically intact. $M(CuSO_4)=160$ g mol^{-1}; $M(H_2O)=18$ g mol^{-1}. For the concentration extension use $CuSO_4 \cdot 5H_2O$, $M=250$ g mol^{-1}. Neutralisation extension: 20.0 cm^3 0.100 mol dm^{-3} H_2SO_4 reacts completely with 25.0 cm^3 NaOH; $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$. These are calculation scenarios, not practical results.

Invented measurement	Mass / g	Your derived quantity
Empty container	20.00	
Container + hydrate	22.50	
Container + dry residue	21.60	

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

YEAR 10 / LESSON 52 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

1. Find hydrate, residue and water masses from the table.

2. Calculate x and write the hydrated formula with the crystallisation dot.

3. Explain why incomplete dehydration would normally make the calculated x too small.

4. Explain water of crystallisation and why an ionic hydrate does not consist of discrete $CuSO_4$ molecules.

5. Chemistry only: 2.50 g $CuSO_4 \cdot 5H_2O$ is made up to 100 cm^3 solution. Calculate its amount and $CuSO_4$ amount concentration; explain why dividing 2.50 by 160 is wrong.

6. Chemistry only: use the supplied neutralisation data to calculate the NaOH concentration.