Solubility curves

Potassium nitrate • measured masses, observed crystallisation

YEAR 10 / LESSON 3 / SINGLE CHEMISTRY ONLY

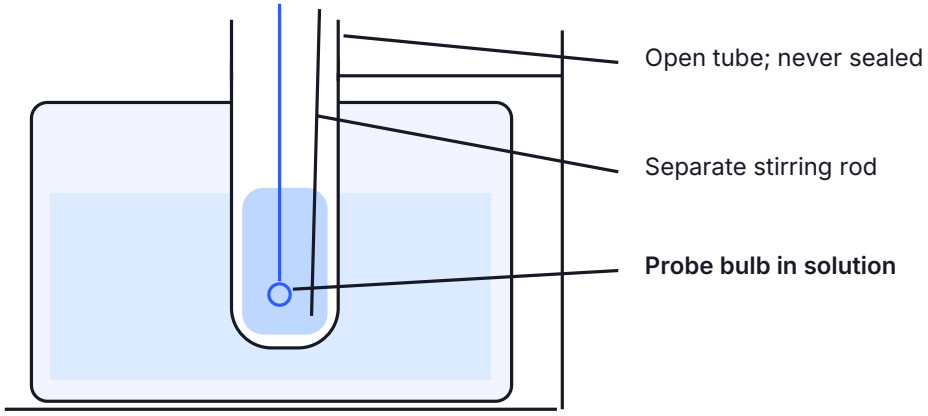
The question

How can the temperature at which crystals first appear help us estimate a solubility curve?

A solubility value tells us how much solute can dissolve in a stated mass of solvent at a particular temperature. You will prepare a solution with known masses of potassium nitrate and water, dissolve all the solid by gentle warming, and watch it cool. The first persistent crystals provide an estimate of the saturation temperature for that composition. Pooling several compositions gives an experimental solubility curve. Crystals can appear late if a solution supercools: this is an estimate, not an exact equilibrium measurement.

Wear eye protection. Potassium nitrate solid is an oxidiser: keep it away from combustible material, avoid dust and do not taste it. Use only the issued quantity. Heat only in the electric water bath; no naked flames, direct heating, boiling, evaporation to dryness or sealed tubes. Keep the tube upright and pointed away from people. Treat glass and the bath as hot; use the holder or clamp and a heatproof mat. Do not force the thermometer against the glass. Tell the teacher about splashes, spills or breakages; wash hands afterwards.

The apparatus



Electric water bath • about 70 °C

Schematic, not to scale. Clamp the tube clear of the heater and bath base; keep bath water below the tube mouth.

Course links: 1.5C — solubility units; 1.6C — plotting and interpreting curves; 1.7C — a solubility investigation. Single Chemistry only; this is not a Double Award practical.

Prepare a known mixture

One composition per group • pool the class data

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Equipment • groups of two or three

• Splash-resistant eye protection

• One clean, dry heat-resistant test tube (approximately 150 × 16 mm), rack and label

• Balance reading to 0.01 g, weighing boat and clean spatula

• Distilled-water wash bottle or dropper for weighing water into the tube

• 0–110 °C non-mercury thermometer or suitable probe, readable to 1 °C or better

• Smooth glass stirring rod; do not use the thermometer as a stirrer

• Clamp stand and clamp; heat-resistant tube holder; heatproof mat

• Teacher-managed electric water bath at about 70 °C (maximum 75 °C); tube held upright, not touching the heater or bath base

• White card behind the tube to help you see small crystals

• Teacher-issued potassium nitrate: assigned target mass of 2.00, 3.00, 4.00 or 5.00 g; 5.00 g distilled water per group

• Labelled container for cooled potassium nitrate solutions; cool-water bath only if directed

Before you begin

Your teacher assigns one salt mass. The targets are 2.00, 3.00, 4.00 or 5.00 g in 5.00 g water. Use the actual measured masses in calculations. Repeat the cooling observation on the same mixture; do not add more salt or water between readings.

1. Label your dry test tube. Place it upright in a stable support on the balance, tare, then add 5.00 g distilled water using a dropper. Record the actual mass, not just the target. Tare again and add your assigned target mass of potassium nitrate. Record the actual mass added. Do not include the tube or support in either recorded mass.

2. Set the tube upright in the teacher-managed water bath using a clamp. Keep bath water below the tube mouth and the tube clear of the heater and bath base. Place the probe bulb in the liquid, away from the tube wall and bottom. Stir gently with the separate glass rod.

Warm, cool and observe

Record the first persistent crystals, not a predicted temperature

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3. Warm only until the last solid disappears and the solution is clear. Do not boil it or leave it heating unnecessarily. If solid remains at the permitted bath temperature, ask the teacher; do not add unmeasured water or raise the temperature yourself.

4. Lift the tube safely with the holder and secure it upright in the clamp, over a heatproof mat, to cool in air. Keep the probe in the solution. Stir gently with the rod and look against the white card. Do not shake, stopper or handle the hot tube with bare hands.

5. Watch for the first tiny crystals that persist in the liquid as you stir. Immediately record the solution temperature and your observation. Do not use crystals dried on the tube rim as the endpoint. If you miss the start, say so. If no crystals appear by room temperature, tell the teacher; use a cool-water bath only as directed.

6. Rewarm the same mixture just enough to dissolve the crystals, then repeat the cooling observation once. Do not change either mass. Record both readings separately. If they differ by more than 2 °C, flag the pair for discussion; this is a classroom comparison rule, not a certified uncertainty. Do not hide a missed or unclear endpoint in a mean.

7. Calculate 100 × (actual mass of potassium nitrate ÷ actual mass of water). Pair this value with your mean first-crystal temperature when both endpoints were clear; otherwise mark it for review. Collect class results for at least four different compositions, keeping group IDs and any uncertainty notes.

8. Plot mean first-crystal temperature on the horizontal axis and estimated solubility in g potassium nitrate per 100 g water on the vertical axis. Draw a smooth trend through the evidence; do not force it through every point or the origin. Show questionable points clearly and do not extrapolate beyond your measured range.

Cleanup

• Allow the tube and solution to cool. Return the mixture to the teacher-designated potassium nitrate collection container; do not mix it with other waste or return it to the stock bottle.

• Rinse apparatus only as the teacher directs. Return equipment, wipe the bench as instructed and wash hands.

Record your evidence

All temperature and observation spaces start blank

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Name / group: _____ Date: _____

Actual water mass / g	Actual KNO_3 mass / g	Balance resolution / g

Cooling run	First persistent crystals / °C	Observation / endpoint confidence
1		
2		

Mean when both endpoints are clear: _____ °C. Difference: _____ °C. Flag a difference greater than 2 °C; retain both readings.

Calculate your point

Estimated solubility = 100 × mass of KNO_3 / mass of water

Class results • retain each group's evidence

Group / mixture	Water / g	KNO_3 / g	Mean first-crystal / °C	Solubility / g per 100 g water

Circle uncertain points; record the reason here. Use another table if more groups contribute.

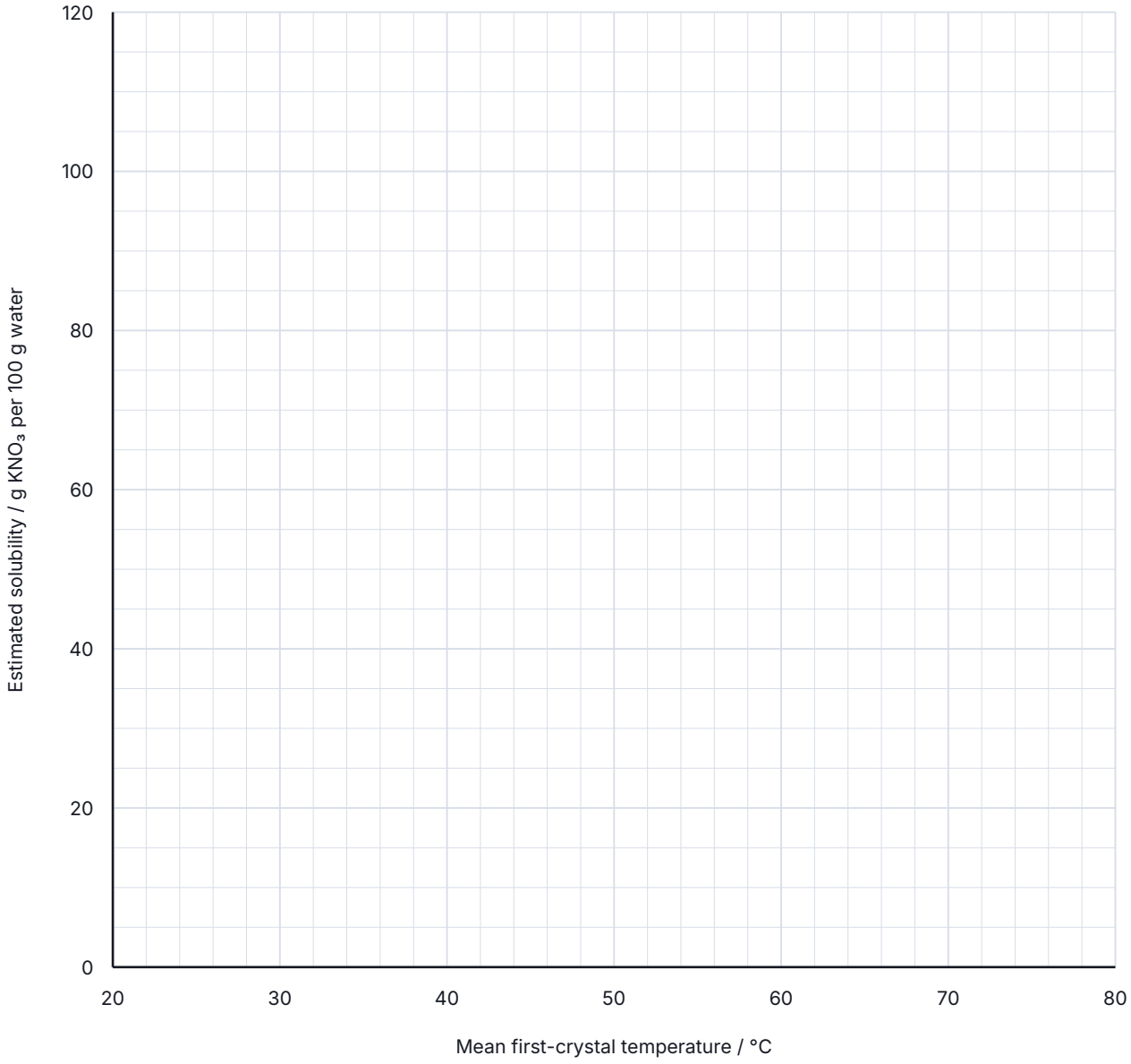
Plot the solubility curve

Temperature on x • estimated solubility on y

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Plot the measured class points. Draw a smooth trend where the evidence supports one. Do not force the curve through the origin, and do not replace outliers with textbook values.

Graph title: _____



Blank plotting grid; no expected curve or observations are supplied. If a genuine result falls outside these axes, choose a suitable scale on separate graph paper.

Explain and evaluate

Use your own evidence; show workings and units

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1. Use your measured masses to calculate the estimated solubility for your mixture. Show the substitution and units. Why is the denominator the mass of water, not the mass of solution?

2. Describe the trend supported by the class data. Explain why this experiment measures an amount that can dissolve, not how fast it dissolves.

3. Use your curve to estimate solubility at a temperature between two measured points. State the temperature, the estimate and its units. Why is interpolation preferable to extending the curve outside the measured range?

4. A separate calculation example: a salt has solubilities of 80 g per 100 g water when hot and 40 g per 100 g water when cold. How much solid could crystallise from a saturated hot solution containing 10.0 g water? Assume no water is lost. These are invented numbers for practice, not potassium nitrate observations.

5. Explain how delayed crystallisation (supercooling) could affect a plotted point. How would evaporation during warming affect a calculation that still uses the original water mass?

6. Choose one limitation visible in your own results. Suggest a specific improvement and explain how it would help. Do not replace an unclear observation with an expected value.

Method background: Pearson Edexcel chemistry practical guidance uses first-crystal temperatures as a solubility investigation. This school version uses measured masses and an electric water bath. Follow your teacher's instructions.