

Entropy, Gibbs energy and reaction feasibility

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

How can a solid that takes in heat from its surroundings still dissolve by itself? You dissolve ammonium nitrate in a simple calorimeter, measure the temperature fall, calculate the enthalpy change per mole and then use entropy to explain why the process is spontaneous.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R1.4

Aim

To measure the enthalpy change on dissolving ammonium nitrate, then use it with a given entropy change to decide why the process is spontaneous even though it is endothermic.

Equipment

- Polystyrene cup with lid, thermometer (0.1 °C divisions) or temperature probe, stirrer
- 100.0 cm³ measuring cylinder or pipette, balance (0.01 g)
- Solid ammonium nitrate: three samples of about 4 g, 8 g and 12 g, each weighed exactly

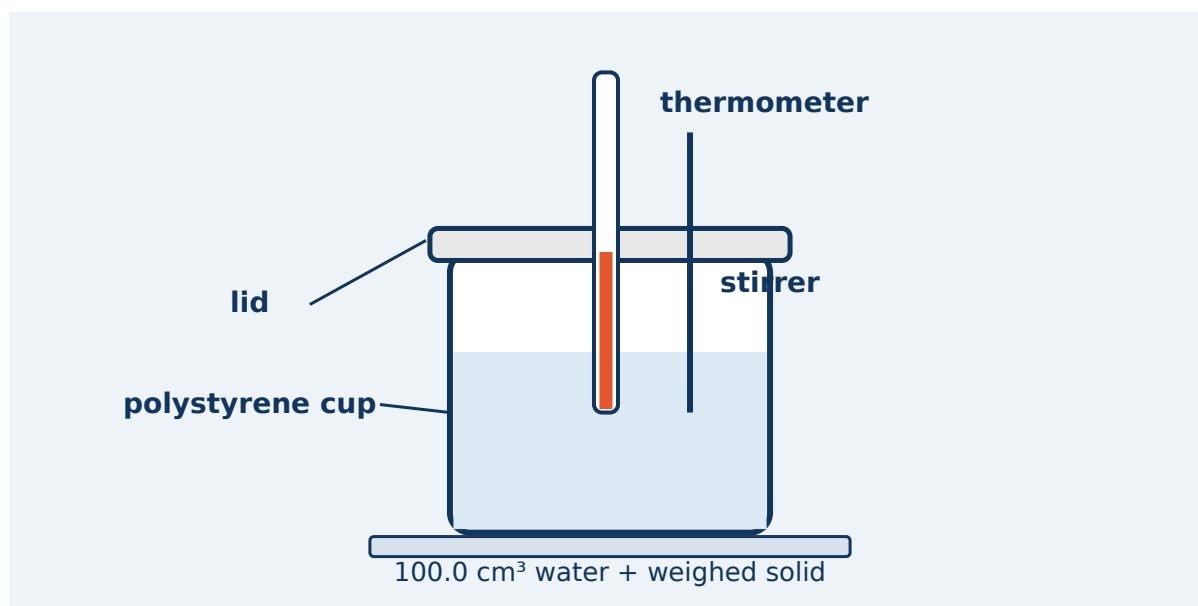
Safety

Safety

Wear eye protection. Ammonium nitrate is an oxidising solid: keep it away from fuels and do not heat it. Wash hands after use and wipe up spills with plenty of water.

Method

1. Measure 100.0 cm³ of water into the cup, stir and record the temperature every 30 s for 2 minutes.
2. At the 2 minute mark add the weighed ammonium nitrate and replace the lid straight away.
3. Stir gently and record the temperature every 30 s until it has been rising for 2 minutes.
4. Record the lowest temperature reached.
5. Rinse the cup and repeat with the other two masses.



Simple calorimeter for measuring the temperature change on dissolving a solid.

Results

Sample results (M_r of $\text{NH}_4\text{NO}_3 = 80.0$; specific heat capacity of the solution taken as $4.18 \text{ J g}^{-1} \text{ K}^{-1}$; mass of solution taken as 100.0 g):

Trial	Mass of NH_4NO_3 (g)	Initial temperature ($^{\circ}\text{C}$)	Lowest temperature ($^{\circ}\text{C}$)	Temperature fall ($^{\circ}\text{C}$)
1	4.00	21.0	18.2	2.8
2	8.00	21.0	15.5	5.5
3	12.00	21.2	12.8	8.4

Analysis questions

Question 1 Moles dissolved

Calculate the moles of ammonium nitrate dissolved in each trial.

Question 2 Heat absorbed

Calculate the heat energy absorbed from the water in each trial using $q = mc\Delta T$.

Question 3 Enthalpy of solution

Calculate ΔH in kJ/mol for each trial and give the mean. Give the sign.

Question 4 Comparing with the data

The data-book value is $+25.7 \text{ kJ/mol}$. Calculate the percentage difference of your mean.

Question 5 Entropy and spontaneity

Using $\Delta S = +108.7 \text{ J K}^{-1} \text{ mol}^{-1}$ and $T = 294 \text{ K}$, calculate ΔG for dissolving and explain why it dissolves although it is endothermic.

Question 6 Minimum entropy change

Calculate the minimum value of ΔS that would make dissolving spontaneous at 294 K with your mean ΔH .

Question 7 Improving the lab

Suggest one source of error that makes the measured ΔH too small and one improvement.