

Entropy, Gibbs energy and spontaneity

AP Chemistry · Lab

Name: _____ Date: _____ Class: _____

Why does a cold pack get cold, and yet dissolve without being pushed? You measure the temperature fall when ammonium nitrate dissolves, calculate ΔH , and then use the idea of spontaneity to say what the entropy change must be.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 9

Aim

To measure the enthalpy change of dissolving ammonium nitrate and use it to find the least entropy increase that makes the process spontaneous.

Equipment

- Ammonium nitrate, 8.00 g
- Distilled water, 100.0 cm³ (100.0 g)
- Polystyrene cup with lid, and a beaker to support it
- Thermometer reading to 0.1 °C
- Balance (0.01 g), stopwatch, stirring rod

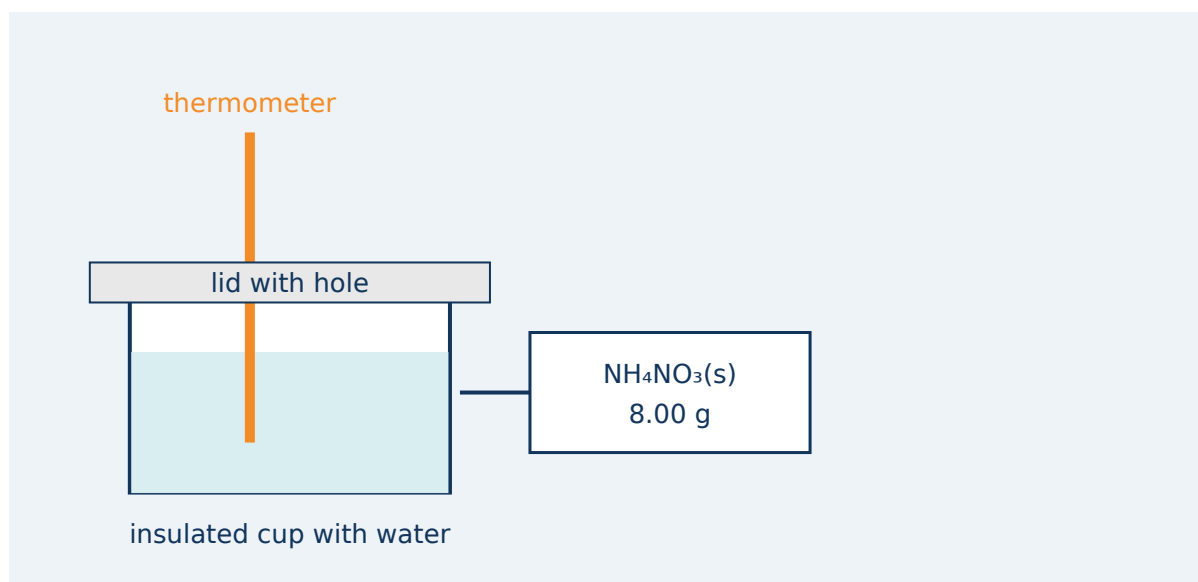
Safety

Safety

Wear eye protection. Ammonium nitrate is an oxidiser, so keep it away from fuels and heat and use only the amount given. Wash hands after the lab and rinse the solution down the sink with plenty of water.

Method

1. Measure 100.0 cm³ of water into the cup and put in the thermometer.
2. Record the temperature every 30 s for 90 s.
3. At 90 s add the weighed ammonium nitrate, put on the lid and stir gently.
4. Record the temperature every 30 s for 3 more minutes.
5. Record the lowest temperature reached.



Set-up: the solid is added to water in an insulated cup.

Results

Sample measurements:

time (s)	temperature ($^{\circ}\text{C}$)
0	21.9
30	21.9
60	21.9
90	mixed at 90 s
120	17.3
150	16.2
180	16.3
210	16.5
240	16.8

Use $c = 4.18 \text{ J}/(\text{g}\cdot\text{K})$ and a total mass of 108.0 g. $M(\text{NH}_4\text{NO}_3) = 80.04 \text{ g/mol}$.

Analysis questions

Question 1 Temperature change

State the temperature change using the lowest temperature reached.

Question 2 Heat absorbed

Calculate the heat absorbed from the water, $q = mc\Delta T$.

Question 3 Enthalpy change per mole

Calculate the amount of NH_4NO_3 and hence ΔH in kJ/mol.

Question 4 Why spontaneous

The solid dissolves spontaneously although ΔH is positive. Deduce the sign of ΔS and explain.

Question 5 Minimum entropy change

Using $\Delta H = +25.7$ kJ/mol, calculate the least ΔS (in J/(mol·K)) for dissolving to be spontaneous at 295 K.

Question 6 Heat gain error

Explain how heat gained from the room affects the measured ΔT and ΔH , and suggest one improvement.

Question 7 Larger sample

Predict the temperature fall if 16.00 g of ammonium nitrate were added to the same 100.0 g of water.