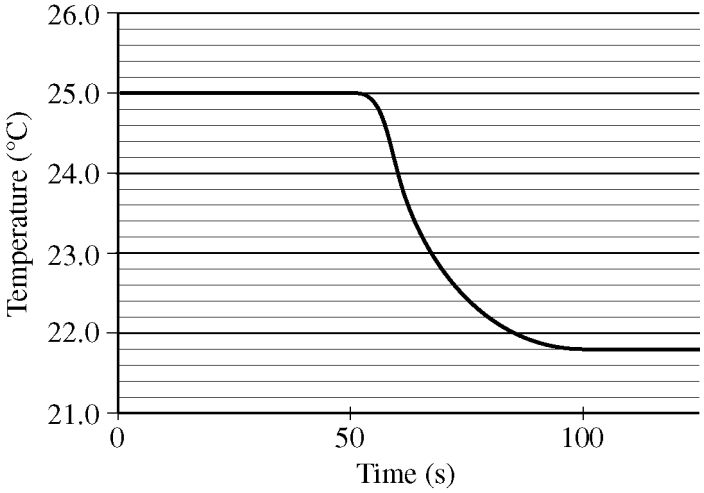
2. A student performs an experiment to determine the molar enthalpy of solution of urea, $H_2NCONH_2$. The student places 91.95 g of water at 25°C into a coffee-cup calorimeter and immerses a thermometer in the water. After 50 s, the student adds 5.13 g of solid urea, also at 25°C, to the water and measures the temperature of the solution as the urea dissolves. A plot of the temperature data is shown in the graph below.




(a) Determine the change in temperature of the solution that results from the dissolution of the urea.

(b) According to the data, is the dissolution of urea in water an endothermic process or an exothermic process? Justify your answer.

(c) Assume that the specific heat capacity of the calorimeter is negligible and that the specific heat capacity of the solution of urea and water is $4.2\ \text{J g}^{-1}\ \text{°C}^{-1}$ throughout the experiment.

(i) Calculate the heat of dissolution of the urea in joules.

(ii) Calculate the molar enthalpy of solution, $\Delta H^\circ_{soln}$, of urea in kJ $\text{mol}^{-1}$.

(d) Using the information in the table below, calculate the value of the molar entropy of solution, $\Delta S^\circ_{soln}$, of urea at 298 K. Include units with your answer.

| | Accepted Value |
|---|---|
| $\Delta H^\circ_{soln}$ of urea | $14.0\ \text{kJ mol}^{-1}$ |
| $\Delta G^\circ_{soln}$ of urea | $-6.9\ \text{kJ mol}^{-1}$ |

(e) The student repeats the experiment and this time obtains a result for $\Delta H^\circ_{soln}$ of urea that is 11 percent below the accepted value. Calculate the value of $\Delta H^\circ_{soln}$ that the student obtained in this second trial.

(f) The student performs a third trial of the experiment but this time adds urea that has been taken directly from a refrigerator at 5°C. What effect, if any, would using the cold urea instead of urea at 25°C have on the experimentally obtained value of $\Delta H^\circ_{soln}$? Justify your answer.