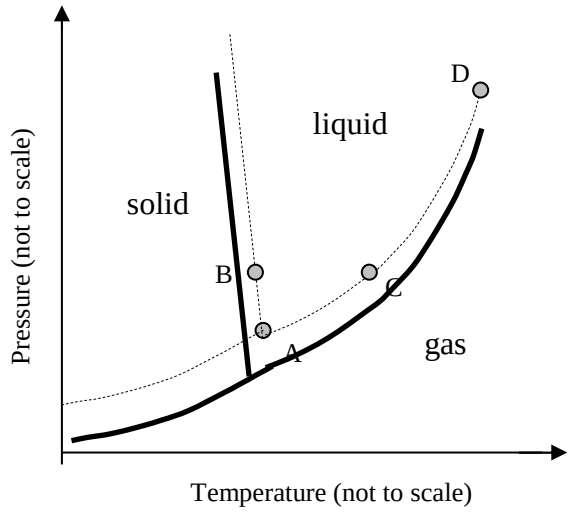
Marks 3

Addition of salt to water raises its boiling point and lowers its melting point. Sketch the phase diagram for water containing salt, showing how it relates to the phase diagram for water (shown as dotted lines below).

The melting point is lowered so the solid – liquid boundary is shifted to lower temperature.

The boiling point is raised so the liquid – gas boundary is shifted to higher temperature.



In terms of the relative entropies of all relevant species, explain why the boiling point of salt water is higher than that of pure water.

Boiling water leads to a large increase in its entropy: $\Delta_{sys}S > 0$.

Because boiling requires breaking bonds, it is endothermic and requires energy from the surroundings. This lowers the entropy of the surroundings: $\Delta_{surr}S < 0$.

The boiling $\Delta_{univ}S$ to be positive. The boiling point is the temperature at which the gain in the entropy of the water is larger than the loss in the entropy of the surroundings.

When salt water is boiled, the $Na^+(aq)$ and $Cl^-(aq)$ ions form NaCl(s). This greatly reduces their entropy. Hence, when salt water boils the entropy gain is much smaller than when pure water boils.

Because $\Delta_{sys}S$ is less positive for boiling salt water, a *higher* temperature is required before it is larger than the loss in the entropy of the surroundings.

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.