CHAPTER 4 Physical transformations of pure substances

TOPIC 4A Phase diagrams of pure substances

Discussion questions

4A.1 Describe how the concept of chemical potential unifies the discussion of phase equilibria.

4A.2 Why does the chemical potential change with pressure even if the system is incompressible (that is, remains at the same volume when pressure is applied)?

4A.3 Explain why four phases cannot be in equilibrium in a one-component system.

4A.4 Discuss what would be observed as a sample of water is taken along a path that encircles and is close to its critical point.

Exercises

4A.1(a) How many phases are present at each of the points marked in Fig. 4.1a?
4A.1(b) How many phases are present at each of the points marked in Fig. 4.1b?

4A.2(a) The difference in chemical potential between two regions of a system is $+7.1\,\text{kJ mol}^{-1}$. By how much does the Gibbs energy change when 0.10 mmol of a substance is transferred from one region to the other?
4A.2(b) The difference in chemical potential between two regions of a system is $-8.3\,\text{kJ mol}^{-1}$. By how much does the Gibbs energy change when 0.15 mmol of a substance is transferred from one region to the other?

4A.3(a) What is the maximum number of phases that can be in mutual equilibrium in a two-component system?
4A.3(b) What is the maximum number of phases that can be in mutual equilibrium in a four-component system?

For problems relating to one-component phase diagrams, see the Integrated activities section of this chapter.

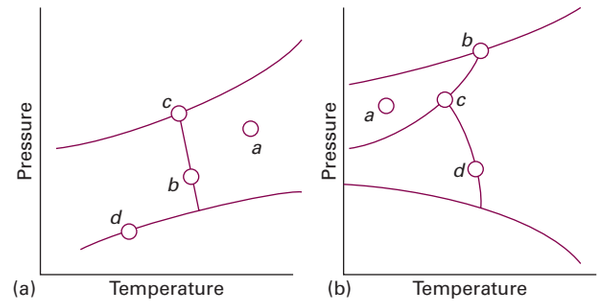

Figure 4.1 The phase diagrams referred to in (a) Exercise 4A.1(a) and (b) Exercise 4A.1(b).

TOPIC 4B Thermodynamic aspects of phase transitions

Discussion questions

4B.1 What is the physical reason for the fact that the chemical potential of a pure substance decreases as the temperatures is raised?

4B.2 What is the physical reason for the fact that the chemical potential of a pure substance increases as the pressure is raised?

4B.3 How may differential scanning calorimetry (DSC) be used to identify phase transitions?

4B.4 Distinguish between a first-order phase transition, a second-order phase transition, and a λ-transition at both molecular and macroscopic levels.

Exercises

4B.1(a) Estimate the difference between the normal and standard melting points of ice.
4B.1(b) Estimate the difference between the normal and standard boiling points of water.

4B.2(a) Water is heated from 25 °C to 100 °C. By how much does its chemical potential change?
4B.2(b) Iron is heated from 100 °C to 1000 °C. By how much does its chemical potential change? Take $S_m^{\ominus} = 53\,\text{J K}^{-1}\,\text{mol}^{-1}$ for the entire range.