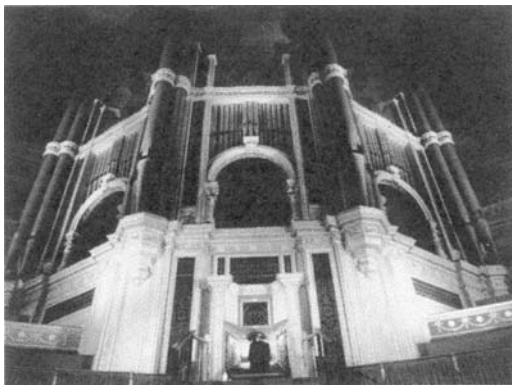
Student worksheet

Entropy and equilibrium

Alternative question 11.

Tin pest

Tin can exists as two stable allotropes: β-tin or white tin, which is metallic, and α-tin or grey tin, which is non-metallic. The conversion from one form to the other occurs at a critical temperature, T_c. The conversion from the metallic form to the powdery non-metallic form is known as *tin pest* or *tin disease*, partly because the accompanying change in density may cause 'warts' to form on the surface.



The organ at the Royal Albert Hall contains 150 tonnes of tin!

Tin pest has been suggested as the cause of organ pipes disintegrating in certain cold churches (previously thought to be the work of the devil), and even as a possible reason for the failure of Captain Scott's expedition to the South Pole, when the tin solder used in the fuel cans deteriorated.

The question refers to the change: white tin ⟶ grey tin

You should use the following data:

	$\Delta_f H^{\ominus}$ /kJ mol^{-1}	$S^{\ominus}$ /J K^{-1} mol^{-1}	Density /g cm^{-3}	Atomic distance to nearest neighbour /pm
White tin	0	51.4	7.31	302
Grey tin	-2.09	44.1	5.75	280

11.

a) Calculate the standard enthalpy change ($\Delta_r H^{\ominus}$) for the change.

It is possible to calculate the standard entropy change ($\Delta_r S^{\ominus}$) for this reaction in a similar way to the above using the standard entropy values (S) given in the table.

b) Calculate $\Delta_r S^{\ominus}$ for this reaction.

The feasibility of any chemical process at an absolute temperature T can be determined by calculating the change in the Gibbs energy ($\Delta_r G$) for the process at that temperature, where

$$\Delta_r G = \Delta_r H - T\,\Delta_r S \quad .$$

continued on page 2

If $\Delta_r G$ is less than zero, the process can take place. If it is greater than zero, it cannot.

c) Calculate $\Delta_r G$ for the change white tin → grey tin at room temperature, 25 °C.

d) Which allotrope of tin is stable at room temperature? Justify your answer.

e) Calculate the temperature, T_c, at which both allotropes are in equilibrium.

f) Calculate the percentage increase in volume as white tin converts to grey tin.

g) Which allotrope possesses the greater coordination number? Justify your answer.