[AQA A2 Paper 1 2017]

Titanium(IV) chloride can be made from titanium(IV) oxide as shown in the equation below:

$$TiO_{2(s)} + 2C_{(s)} + 2Cl_{2(g)} \longrightarrow 2CO_{(g)} + TiCl_{4(l)} \quad [\Delta H = -60.0\ kJmol^{-1}]$$

Some entropy data are shown in the following table:

Substance	Entropy ($JK^{-1}mol^{-1}$)
$TiO_{2(s)}$	50.2
$C_{(s)}$	5.70
$Cl_{2(g)}$	223
$CO_{(g)}$	198
$TiCl_{4(l)}$	253

a) Use the equation and the data in the table to calculate the Gibbs free-energy change for this reaction at 989 °C.Give your answer to the appropriate number of significant figures.
Use your answer to explain whether this reaction is feasible.

① Calculate the entropy change:

$\Delta S = \Delta S_{products} - \Delta S_{reactants}$

$\Delta S_{products} = 253 + (2 \times 198)$
$= 649$

$\Delta S_{reactants} = 50.2 + (2 \times 5.7) + (2 \times 223)$
$= 507.6$

$\Rightarrow \Delta S = 649 - 507.6$
$= 141.4\ JK^{-1}mol^{-1}$

ΔH and ΔS must be in the same units and T in kelvin.

② Sub in values to find ΔG:

$\Delta G = \Delta H - T\Delta S$

$\Delta G = -60000 - (1262 \times 141.4)$
$= -238000\ (Jmol^{-1})$

$\Rightarrow -238\ kJmol^{-1}$ ← negative values of ΔG are feasible.