Past-paper walk-through

Gibbs free energy change, ΔG ▪ 23.4

eXercise

Questions in this set

- 9701/44 N25 Q3 ▪ 9 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 3

9701/44 N25 ▪ Q3 ▪ 9 marks

3 **(a)** Define the term entropy.

Question 3

(b) (i) Place **one** tick (✓) in each row of Table 3.1 to show the sign of the entropy change, ΔS, for each process.

Table 3.1

process	ΔS is negative	ΔS is positive
steam condensing into water		
solid KCl dissolving in water		

[1]

(ii) Chlorine trifluoride, ClF_3, decomposes on heating into its elements, as shown.

reaction 1 $$2ClF_3(g) \rightarrow Cl_2(g) + 3F_2(g)$$

Question 3

Standard entropies are shown in Table 3.2.

Table 3.2

substance	$ClF_3(g)$	$Cl_2(g)$	$F_2(g)$
$S^{\ominus}$ / J K^{-1} mol^{-1}	+281.6	+223.1	+203.0

Calculate the standard entropy change, $\Delta S^{\ominus}$, in J K^{-1} mol^{-1}, for reaction 1.

Question 3

(c) Group 2 carbonates decompose on heating. The decomposition for one of the Group 2 carbonates, MCO_3, is shown in reaction 2.

reaction 2 $$MCO_3(s) \rightarrow MO(s) + CO_2(g)$$

(i) Predict the sign of the entropy change, ΔS, for reaction 2.

Explain your answer.

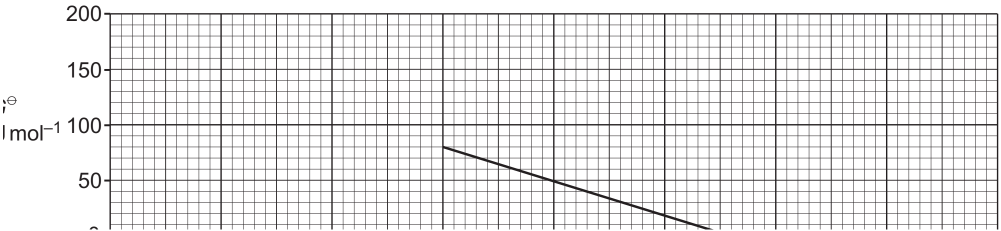
Question 3

(ii) The Gibbs equation is shown.

$$\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$$

Fig. 3.1 shows values of the Gibbs free energy change, $\Delta G^{\ominus}$, in $kJ\,mol^{-1}$, at different temperatures, T, in K, for reaction 2.

Assume $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ values for this reaction remain constant over this temperature range.



Question 3

Question 3

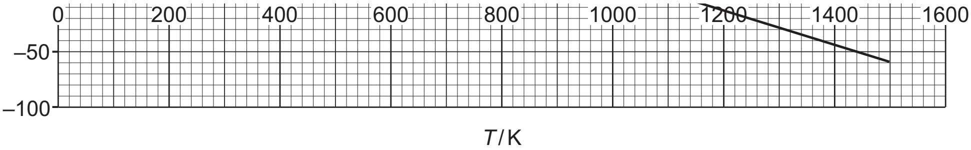


Fig. 3.1

Use the gradient and intercept on the *y*-axis in Fig. 3.1 and the Gibbs equation to determine:

- $\Delta S^{\ominus}$, in $J\,K^{-1}\,mol^{-1}$, for reaction 2
- the minimum temperature, T, in K, at which the reaction is feasible
- $\Delta H^{\ominus}$, in $kJ\,mol^{-1}$, for reaction 2.

Question 3

Question 3

Question 3

[4]

[Total: 9]

Solution 3

(a)

Mark scheme

- number of possible arrangements of particles and energy in a system
- 1

Solution 3

(b)(i) Mark scheme

- process
- ΔS is negative
- ΔS is positive
- steam condensing into water
-
- solid KCl dissolving into water
-
- 1

Solution 3

(b)(ii)

Mark scheme

- M1: three numbers and correct multipliers used
- M2: correct signs and evaluation
- $\Delta So = (3 \times 203.0) + (223.1) - (2 \times 281.6) = (+)268.9$ (J K–1 mol–1)
- 2

Solution 3

(c)(i)

Mark scheme

- positive
- AND
- gas produced / on the right OR less / no gas on left
- 1

Solution 3

(c)(ii) Mark scheme

- M1 and M2: calculation of gradient from the graph for ΔS
- gradient $= (–)140\ /\ 900 = (–)0.1556$
- $\Delta So = (–)0.1556 \times 1000$
- $= (+)155.6 \pm 5$ (J K–1 mol–1)
- M3: $T = 1120 \pm 5$ (K)
- M4: $\Delta Ho = (+)172 \pm 10$ (kJ mol–1)
- 4
- 9701/44

Solution 3

- October/November 2025