Oxford Cambridge and RSA

A level Chemistry A

H432/01 Periodic table, elements and physical chemistry

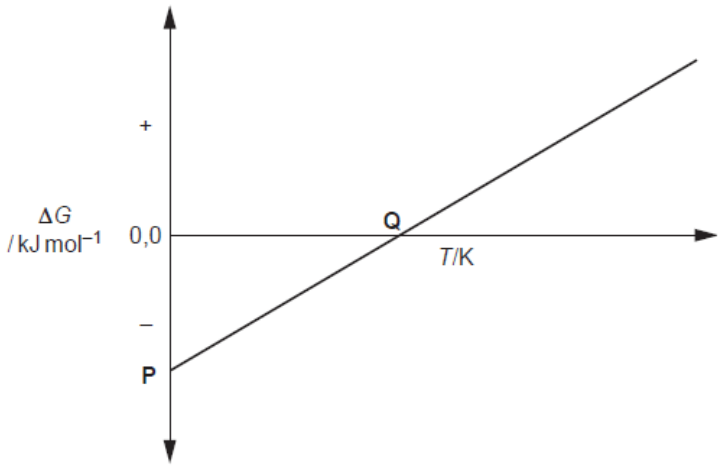
Question Set 3

1 (a) (i) This question is about free energy changes, ΔG, enthalpy changes, ΔH, and temperature, T.

The Gibbs' equation is shown below.

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

A chemist investigates a reaction to determine how ΔG varies with T.The results are shown in **Fig. 1.1**.



What is significant about the gradient of the line and the values **P** and **Q** shown in **Fig. 1.1**?

Explain your reasoning. **[4]**

(b) (i) Iron can be extracted from its ore Fe_3O_4 using carbon.
Several equilibria are involved including **equilibrium 18.1**, shown below.

equilibrium 18.1 Fe3O4(s) + 4C(s) ⇌ 3Fe(s) + 4CO(g)

$\Delta H = +676.4$ kJ mol^{-1}
$\Delta S = +703.1$ J K^{-1} mol^{-1}

Why is **equilibrium 18.1** a *heterogeneous* equilibrium?

[1]

(ii) Write the expression for K_p for **equilibrium 18.1**.

[1]

(iii) The forward reaction in **equilibrium 18.1** is only feasible at high temperatures.

- Show that the forward reaction is **not** feasible at 25 °C.
- Calculate the minimum temperature, in K, for the forward reaction to be feasible.

[3]

(iv) Another equilibrium involved in the extraction of iron from Fe_3O_4 is shown below.

$Fe_3O_4(s) + 4CO(g) \rightleftharpoons 3Fe(s) + 4CO_2(g)$ $\Delta H = -13.5\,kJ\,mol^{-1}$

Enthalpy changes of formation, $\Delta_f H$, for $Fe_3O_4(s)$ and $CO_2(g)$ are shown in the table

Compound	$\Delta_f H$ / kJ mol^{-1}
$Fe_3O_4(s)$	–1118.5
$CO_2(g)$	–393.5

Calculate the enthalpy change of formation, $\Delta_f H$, for CO(g).

$\Delta_f H$, for CO(g) = …… kJ mol^{-1}

[3]

Total Marks for Question Set 3: 12