Gibbs Free Energy Questions

① On heating, silver (I) oxide decomposes into silver and oxygen:

$$2Ag_2O_{(s)} \longrightarrow 4Ag_{(s)} + O_{2(g)} \qquad \Delta H^{\ominus} = +62.0\ kjmol^{-1}$$
$$\Delta S_{system} = +132.8\ J\,k^{-1}mol^{-1}$$

a) Calculate the free energy change, ΔG for this reaction at i) 400K and ii) 600K then comment on the feasibility of the reaction at these temperatures.

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

$\Delta G = +62 - 400 \times \left(\frac{132.8}{1000}\right)$

$\Delta G = +8.88\ kjmol^{-1}$ ∴ NOT FEASIBLE @ 400K

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

$\Delta G = +62 - 600 \times \left(\frac{132.8}{1000}\right)$

$\Delta G = -17.68\ kjmol^{-1}$ ∴ FEASIBLE @ 600K

b) what is the minimum temperature you would have to use to decompose silver (I) oxide?

$T = \frac{\Delta H}{\Delta S_{system}}$ ← when $\Delta G = 0$

$T = \frac{+62}{\left(\frac{132.8}{1000}\right)}$ $\qquad T = 466.9K$

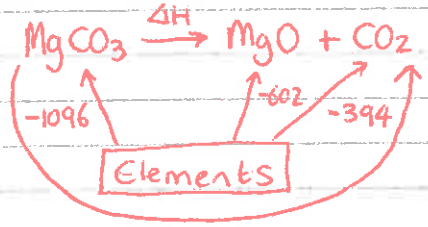
② Magnesium carbonate and barium carbonate both decompose on heating according to the equation

$$XCO_3(s) \rightarrow XO(s) + CO_2(g)$$

	$\Delta H^{\ominus}_{formation}$ (kJmol^{-1})	$S^{\ominus}$ JK^{-1}mol^{-1}
$MgCO_3(s)$	-1096	65·7
$MgO(s)$	-602	26·9
$CO_2(g)$	-394	213·6
$BaCO_3(s)$	-1216	112·1
$BaO(s)$	-554	70·4

a) Calculate ΔH and ΔS_{system} for both reactions, and use these values to calculate ΔG at 900K for both reactions. Comment on the feasibility of both.

i) $MgCO_3 \xrightarrow{\Delta H} MgO + CO_2$



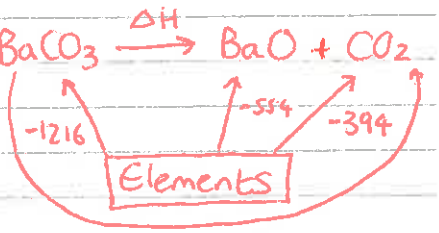
$\Delta H = 1096 + (-996) = +100 kjmol^{-1}$

$\Delta S_{system} = 240·5 - 65·7 = +174·8 JK^{-1}mol^{-1}$

$\Delta G = 100 - 900 \times \left(\frac{174·8}{1000}\right)$

$\Delta G = -57·32$ ∴ feasible @ 900K

ii) $BaCO_3 \xrightarrow{\Delta H} BaO + CO_2$



$\Delta H = 1216 + (-918) = 268 kjmol^{-1}$

$\Delta S_{system} = (70·4 + 213·6) - 112·1 =$ wrong

$\Delta S_{system} = +171·9 JK^{-1}mol^{-1}$

$\Delta G = 268 - 900 \times \left(\frac{171·9}{1000}\right)$

$\Delta G = +113·29$ ∴ NOT FEASIBLE @ 9

b) Calculate the minimum temperature needed to decompose each carbonate.

$MgCO_3$

i) when $\Delta G = 0$

$$T = \frac{\Delta H}{\Delta S_{system}}$$

$$T = \frac{100}{\left(\frac{174·8}{1000}\right)}$$

$T = 572·1K$

$BaCO_3$

ii) when $\Delta G = 0$

$$T = \frac{\Delta H}{\Delta S_{system}}$$

$$T = \frac{268}{\left(\frac{171·9}{1000}\right)}$$

$T = 1559K$

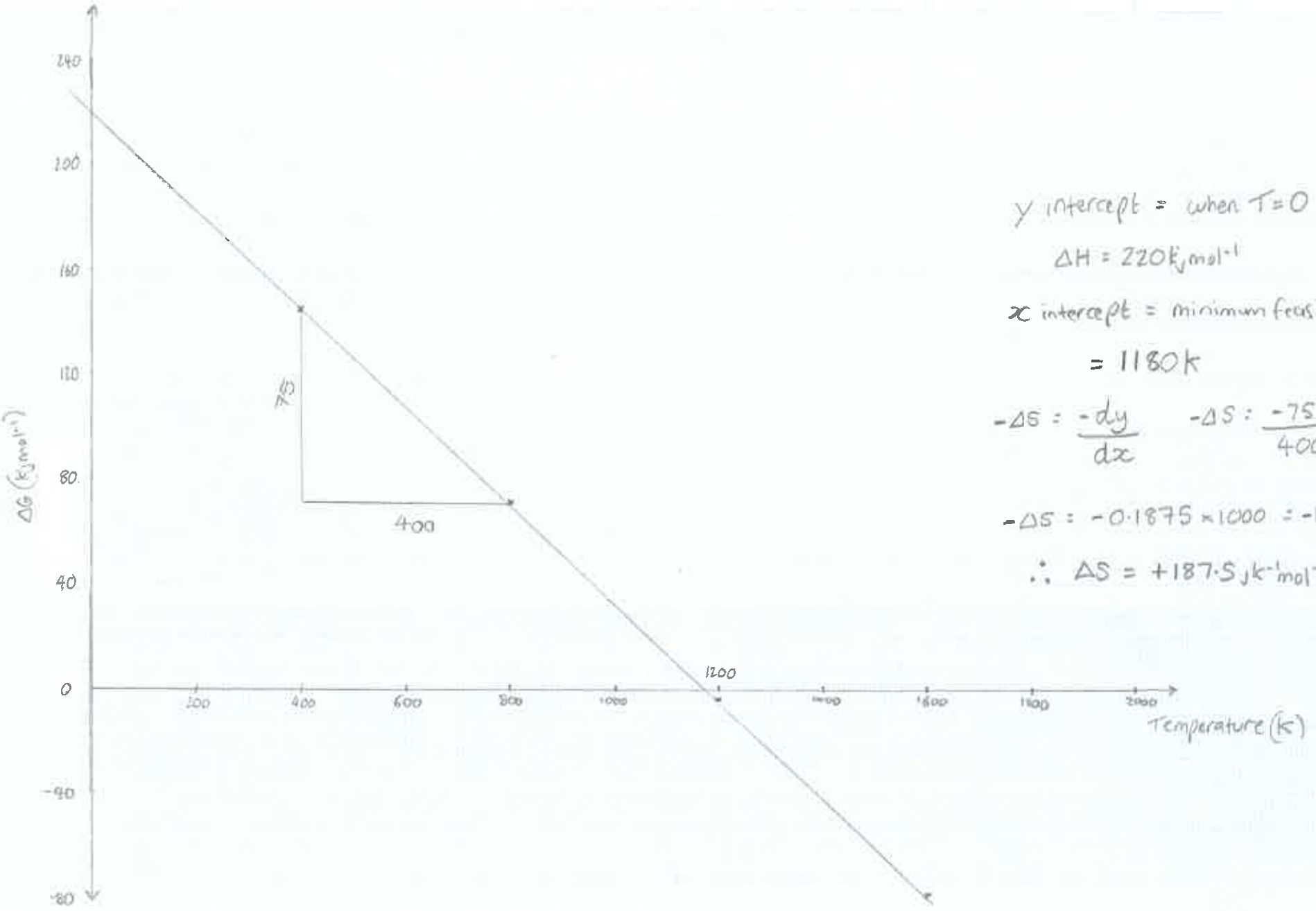
③ When heated strongly, copper (II) sulfate decomposes according to the equation

$$CuSO_{4(s)} \longrightarrow CuO_{(s)} + SO_{3(g)}$$

Plot the following values of ΔG against temperature, T, and use your graph to find a) the enthalpy change for the reaction, b) ΔS_{system} and c) the minimum temperature needed for the decomposition to become feasible.

T (K)	400	800	1200	1600
ΔG (kJmol^{-1})	+145	+71	-4	-78

See graph on next page



y intercept = when $T = 0$ $\Delta G = \Delta H$

$\Delta H = 220 kJ\,mol^{-1}$

x intercept = minimum feasible temperature

$= 1180 K$

$-\Delta S = \frac{-dy}{dx}$ $\quad -\Delta S = \frac{-75}{400}$

$-\Delta S = -0.1875 \times 1000 = -187.5$

$\therefore \Delta S = +187.5 J K^{-1} mol^{-1}$