

## Exemplar exam questions – Chapter 5

### Higher Level only

- 1 a** Use the data below to calculate the entropy change for the following reaction: [2]



Substance	$S^\circ / \text{J K}^{-1} \text{mol}^{-1}$
$\text{N}_2\text{O}_4(\text{g})$	304
$\text{NO}_2(\text{g})$	240

- b** Calculate the Gibbs free energy change for the above reaction at 25 °C and state whether the reaction is spontaneous at this temperature. [3]

### Commentary

When doing calculations it is essential to show all your steps and give as much detail as possible. If you make a mistake it is possible to gain ‘error carried forward’ marks.

- a** It is always worth stating the equation that is to be used (sometimes it gains a mark):

$$\Delta S^\circ = \sum S^\circ_{\text{products}} - \sum S^\circ_{\text{reactants}} \quad [1]$$

$$\Delta S^\circ = 2 \times 240 - 304$$

$$\Delta S^\circ = 176 \text{ J K}^{-1} \text{mol}^{-1} \quad [1]$$

As a final check, look at the equation to see that the sign of  $\Delta S$  makes sense. In this case, 1 mole of gas becomes 2 moles of gas so the entropy increases. This corresponds to the positive sign of  $\Delta S$ .

The units of  $\Delta S$  are different from those of  $\Delta H$  and  $\Delta G$  and this must be remembered. If you are unsure about units it is probably better to leave them out rather than get them wrong. Very often there is no mark for units in most questions, although 1 mark may be subtracted over the whole paper for consistently leaving out units. However, if the units are wrong then it is likely that 1 mark will be lost for each mistake.

Even you can’t get an answer to part **a**, it is worth making up an answer and continuing the question anyway in the hope that error carried forward marks will be obtained. If you do this, then you must state clearly what you are doing.

- b** Two common mistakes in this question are to forget to convert  $\Delta S$  to kJ and to forget to convert the temperature to K.

$$\Delta G = \Delta H - T\Delta S \quad [1]$$

$$\Delta G = 58.0 - 298 \times \frac{176}{1000}$$

$$\Delta G = 5.55 \text{ kJ mol}^{-1} \quad [1]$$

The reaction is not spontaneous as the value of  $\Delta G$  is positive. [1]

The answer should be given to three significant figures as all the data is to this many significant figures. Generally you will not be penalised if your answer is within  $\pm 1$  significant figure of that on the mark scheme.