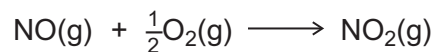


- 4** The oxides nitrogen monoxide (NO) and nitrogen dioxide (NO<sub>2</sub>) both contribute to atmospheric pollution.

The table gives some data for these oxides and for oxygen.

|                     | $S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$ | $\Delta H_f^\ominus / \text{kJ mol}^{-1}$ |
|---------------------|---|---|
| O <sub>2</sub> (g)  | 211   | 0   |
| NO(g)               | 205   | +90                                       |
| NO <sub>2</sub> (g) | 240   | +34                                       |

Nitrogen monoxide is formed in internal combustion engines. When nitrogen monoxide comes into contact with air, it reacts with oxygen to form nitrogen dioxide.



- 4 (a)** Calculate the enthalpy change for this reaction.

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(2 marks)

- 4 (b)** Calculate the entropy change for this reaction.

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(2 marks)



- 4 (c) Calculate the temperature below which this reaction is spontaneous.

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(2 marks)

- 4 (d) Suggest **one** reason why nitrogen dioxide is **not** formed by this reaction in an internal combustion engine.

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(1 mark)

- 4 (e) Write an equation to show how nitrogen monoxide is formed in an internal combustion engine.

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(1 mark)

- 4 (f) Use your equation from part (e) to explain why the free-energy change for the reaction to form nitrogen monoxide stays approximately constant at different temperatures.

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(2 marks)

