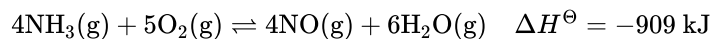


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# SL Paper 2

Consider the following equilibrium:



Nitrogen reacts with hydrogen to form ammonia in the Haber process, according to the following equilibrium.



a.i. Deduce the equilibrium constant expression,  $K_c$ , for the reaction. [1]

a.ii. Predict the direction in which the equilibrium will shift when the following changes occur. [4]

The volume increases.

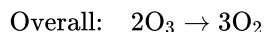
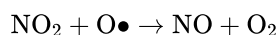
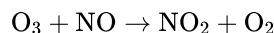
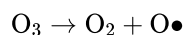
The temperature decreases.

$\text{H}_2\text{O}(\text{g})$  is removed from the system.

A catalyst is added to the reaction mixture.

b. Define the term *activation energy*,  $E_a$ . [1]

c. Nitrogen monoxide, NO, is involved in the decomposition of ozone according to the following mechanism. [2]



State and explain whether or not NO is acting as a catalyst.

d.i. Define the term *endothermic reaction*. [1]

d.ii. Sketch the Maxwell-Boltzmann energy distribution curve for a reaction with and without a catalyst, and label both axes. [3]

e.i. Define the term *rate of reaction*. [1]

f. Iron, used as the catalyst in the Haber process, has a specific heat capacity of  $0.4490 \text{ J g}^{-1} \text{K}^{-1}$ . If 245.0 kJ of heat is supplied to 8.500 kg of iron, initially at a temperature of  $15.25^\circ\text{C}$ , determine its final temperature in K. [3]

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