AS level Chemistry A

H032/02 Depth in chemistry

Question Set 10

1. The reaction of ammonia, NH_3, with oxygen to form nitrogen monoxide, NO, is an important industrial process.

The equation for this reaction is shown in **equilibrium 4.1** below.

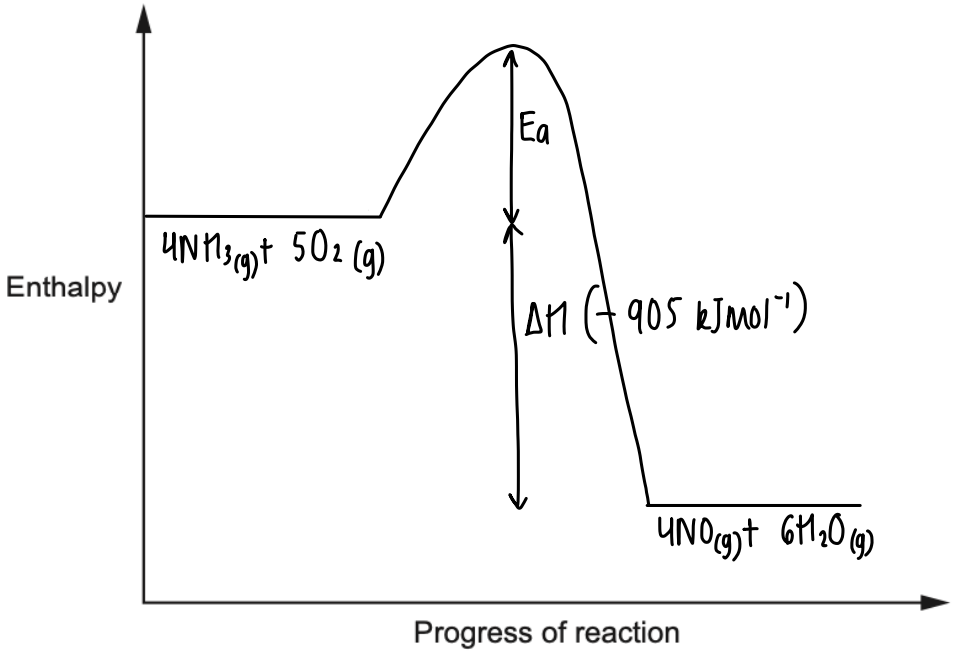
$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -905 \text{ kJ mol}^{-1} \qquad \textbf{Equilibrium 4.1}$$

(a) The forward reaction in **equilibrium 4.1** converts NH_3 into NO.

(i) Complete the enthalpy profile diagram for this reaction.

On your diagram:

- Label the activation energy, E_a
- Label the enthalpy change of reaction, ΔH
- Include the formulae of the reactants and products.



[2]

(ii) 5.10 tonnes of NH_3 are converted into NO.
Calculate the energy released, in kJ, for this conversion.

Give your answer in **standard form** and to an **appropriate** number of significant figures. **[4]**

5.10 tonnes = 5100 kg = 5100000 g

$\Delta H = -905 \text{ kJ mol}^{-1}$

$\text{moles} = \frac{5100000}{17} = 300000$

$\Delta H = 905 \times 300000$

$= 271500000 \div 4$

$\Delta H = 6.79 \times 10^7 \text{ kJ}$

(b) Write an expression for the equilibrium constant, K_c, in **equilibrium 4.1**. **[1]**

$$K_c = \frac{[NO]^4 [H_2O]^6}{[NH_3]^4 [O_2]^5}$$

(c) Predict the conditions of temperature and pressure for a maximum equilibrium yield of nitrogen monoxide in **equilibrium 4.1**.

- Explain your prediction in terms of le Chatelier's principle.
- State and explain how these conditions could be changed to achieve a compromise between equilibrium yield, rate and other operational factors. **[5]**

There are 9 moles of gas on the left and 10 moles on the right so increasing the pressure would move the equilibrium to the right in order to decrease the pressure which would increase the yield of NO

The forward reaction is exothermic so decreasing the temperature would move the equilibrium to the right, in the exothermic direction, in order to increase the temperature. This would increase the yield of NO.

Total Marks for Question Set 4: 12