

HL Questions on the Equilibrium law

1. Phosphorus(V) chloride decomposes when heated according to the equation:



Assume that the total volume is fixed at $V \text{ dm}^3$ and that an initial amount of phosphorus(V) chloride of $a \text{ mol}$ gives $x \text{ mol}$ of chlorine in the equilibrium mixture. The equilibrium constant is represented by K_c .

- i. Show that the equilibrium expression for this reaction is:

$$K_c = x^2 / (a-x)V$$

- ii. Explain how this equation can be used to deduce the effect of increasing the pressure on the equilibrium mixture at the same temperature.

2. Steam reacts with methane in the gaseous state to form carbon dioxide and hydrogen.

- i. State the equation for this reaction.

ii. 54.06 g of steam and 16.04 g of methane are placed in a 1 dm^3 container. When equilibrium has been reached 4.04 g of hydrogen are present in the mixture. Determine the value of K_c for this reaction.

- iii. The reaction is endothermic. State the effect on **(i)** the amount of hydrogen in the equilibrium mixture and **(ii)** the value of the equilibrium constant if the reaction is carried out at a higher temperature to the one above.

3. Hydrogen and iodine react reversibly in the gaseous state to form hydrogen iodide. A particular equilibrium mixture was found to contain 0.45 mol of iodine, 0.55 mol of hydrogen and 2.4 mol of hydrogen iodide. Calculate the value of the equilibrium constant at this temperature.

4. When 1.0 mol of ethanol reacts with 0.5 mol of ethanoic acid at $100 \text{ }^\circ\text{C}$ the mixture contains 0.42 mol of ethyl ethanoate once equilibrium has been reached. Calculate the value of K_c at $100 \text{ }^\circ\text{C}$ for this esterification reaction.

5. i. The standard enthalpy of formation of ethyl ethanoate at 298 K is -480 kJ mol^{-1} and the standard entropy of ethyl ethanoate at 298 K is $+259 \text{ J mol}^{-1} \text{ K}^{-1}$. Use these values and information from Section 12 of the IB data booklet to determine a value for K_c for the esterification reaction between ethanoic acid and ethanol at 298 K.

- ii. Compare your answer to the literature value of 4 at 298 K and suggest one reason which may contribute to the fact that there is such a considerable difference.

