

Equilibrium constant K_p for homogeneous systems – A2 Chemistry P1

1. No.4

0 4

This question is about some gas mixtures at equilibrium.

This reaction can be used to make hydrogen.



0 4 . 1

A mixture of 2.00 mol of $\text{H}_2\text{O(g)}$ and 2.00 mol of CO(g) is allowed to reach equilibrium at a constant temperature in a 20 dm^3 container.
At equilibrium, there are 0.92 mol of $\text{H}_2\text{(g)}$.

Calculate the mole fraction of $\text{H}_2\text{(g)}$ in the equilibrium mixture.**[2 marks]**

Amounts remaining
 $\text{H}_2 = 0.92 \text{ mol}$ $\text{H}_2\text{O} = 2.00 - 0.92 = 1.08 \text{ mol}$ $\text{CO} = 2.00 - 0.92 = 1.08 \text{ mol}$ $\text{CO}_2 = 0.92$
 Total = $0.92 + 1.08 + 1.08 + 0.92 = 4.00 \text{ mol}$
 Mole fraction of $\text{H}_2 = \frac{0.92}{4.00} = 0.230$

Mole fraction of $\text{H}_2\text{(g)}$ 0.23

0 4 . 2

State why the equilibrium constant (K_p) for this reaction has no units.**[1 mark]**

The amount in moles of products is the same as reactants so units of partial pressure cancel out.

0 4 . 3

The temperature of the equilibrium mixture formed in Question 04.1 is increased.

How does the amount of $\text{H}_2(\text{g})$ change when the new position of equilibrium is reached?

[1 mark]

Tick (✓) **one** box.

The amount decreases.

☒

The amount does not change.

☐

The amount increases.

☐

Ethanol can be made from ethene and steam.

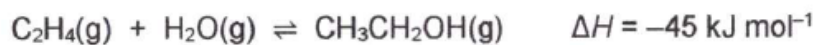


Table 2 shows the mole fractions of each of the gases in an equilibrium mixture at 6000 kPa

Table 2

Gas	Mole fraction
Ethene	0.645
Steam	0.323
Ethanol	0.0321

0 4 . 4

Give an expression for K_p for this reaction.Calculate the value of K_p at 6000 kPa

State the units.

[4 marks]

$$\begin{aligned}
 K_p &= \frac{P_{\text{ethanol}}}{P_{\text{ethene}} P_{\text{steam}}} = \frac{P(\text{CH}_3\text{CH}_2\text{OH})}{P(\text{C}_2\text{H}_4) P(\text{H}_2\text{O})} \\
 &= \frac{0.0321 \times 6000}{(0.645 \times 6000)(0.323 \times 6000)} \frac{\text{kPa}}{(\text{kPa})(\text{kPa})} \\
 &= \frac{192.6}{3870 \times 1938} \frac{1}{\text{kPa}} \\
 &= \frac{2.56 \times 10^{-5}}{2.56 \times 10^{-5}}
 \end{aligned}$$

Units $\rightarrow \text{kPa}^{-1}$

0 4 . 5

State the effect, if any, of an increase in volume of the container on the value of K_p for this reaction at a constant temperature.

[1 mark]

It has no effect.