



Hydrogen can be made as shown: $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons 3\text{H}_2(\text{g}) + \text{CO}(\text{g}) \quad \Delta H = +206 \text{ kJ mol}^{-1}$

5.0 moles of methane was mixed with 5.0 moles of steam. At equilibrium, there was found to be 6.0 moles of hydrogen. The total pressure was 1500 kPa.

a Write an expression for K_p for this equilibrium. $K_p = \frac{(p \text{H}_2)^3 \times (p \text{CO})}{(p \text{CH}_4) \times (p \text{H}_2\text{O})}$

b State the units of K_p . **kPa²**

c Calculate the moles of each gas at equilibrium.

hydrogen = **6.0** carbon monoxide = **2.0** methane = **3.0** steam = **3.0**

d Calculate the partial pressure of each gas.

hydrogen = $\frac{6.0}{14.0} \times 1500 = 642.9 \text{ kPa}$ carbon monoxide = $\frac{2.0}{14.0} \times 1500 = 214.3 \text{ kPa}$

methane = $\frac{3.0}{14.0} \times 1500 = 321.4 \text{ kPa}$ steam = $\frac{3.0}{14.0} \times 1500 = 321.4 \text{ kPa}$

e Calculate K_p for this equilibrium.

$$K_p = \frac{(p \text{H}_2)^3 \times (p \text{CO})}{(p \text{CH}_4) \times (p \text{H}_2\text{O})} = \frac{(642.9)^3 \times (214.3)}{(321.4) \times (321.4)} = 5.51 \times 10^5 \text{ kPa}^2$$

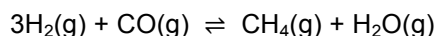
f Explain what would happen to the position of the equilibrium and the value of K_p if the temperature of gases was increased?

equilibrium position moves right in endothermic direction to oppose increase in temperature
 K_p increases

g Explain what would happen to the position of the equilibrium and the value of K_p if the total pressure of gases was increased?

equilibrium position moves left to side with fewer gas molecules to oppose increase in pressure
no change in K_p

h Calculate K_p and state the units for this equilibrium at the same temperature and pressure as the original mixture at the start of the question.



$$K_p = \frac{1}{5.51 \times 10^5} = 1.81 \times 10^{-6} \text{ kPa}^{-2}$$