K_p (B)

Hydrogen can be made as shown: $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H = +206\ kJ\ mol^{-1}$

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. $K_p = \frac{(p\,H_2)^3\ x\ (p\,CO)}{(p\,CH_4)\ x\ (p\,H_2O)}$

b State the units of K_p. **kPa^2**

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 = $\frac{6.0}{14.0}\ x\ 1500 = 642.9\ kPa$ carbon monoxide = $\frac{2.0}{14.0}\ x\ 1500 = 214.3\ kPa$

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

e Calculate K_p for this equilibrium.

$$K_p = \frac{(p\,H_2)^3\ x\ (p\,CO)}{(p\,CH_4)\ x\ (p\,H_2O)} = \frac{(642.9)^3\ x\ (214.3)}{(321.4)\ x\ (321.4)} = 5.51\ x\ 10^5\ kPa^2$$

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.

$3H_2(g) + CO(g) \rightleftharpoons CH_4(g) + H_2O(g)$

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