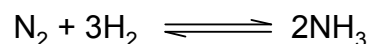


## Partial Pressure in Haber Process

The following equilibrium is established when hydrogen and nitrogen are passed over heated iron



- a. Express the equilibrium constant,  $K_p$ , in terms of the equilibrium partial pressures  $p(\text{N}_2)$ ,  $p(\text{H}_2)$ ,  $p(\text{NH}_3)$ , of the three species

$$K_p = \frac{p(\text{NH}_3)^2}{p(\text{N}_2) \times p(\text{H}_2)^3}$$

- b. If the moles of nitrogen and hydrogen were initially 1 and 3 respectively, and the moles of ammonia at equilibrium was 0.8, calculate the moles of nitrogen and hydrogen at equilibrium.

	$\text{N}_2$	$\text{H}_2$	$\text{NH}_3$
mole ratio	1	3	2
initial number of moles	1	3	0
final number of moles	?	?	0.8

0.8 moles of  $\text{NH}_3$  have formed

Therefore 0.4 moles of  $\text{N}_2$  have reacted (since 0.4 moles of  $\text{N}_2$  would form 0.8 moles of  $\text{NH}_3$ )

Therefore 0.6 moles of  $\text{N}_2$  remain

0.4 moles of  $\text{N}_2$  have reacted

Therefore 1.2 moles of  $\text{H}_2$  have reacted

Therefore 1.8 moles remain

final number of moles	0.6	1.8	0.8
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- c. If the total pressure of the system is  $4 \times 10^7 \text{ Nm}^{-2}$ , calculate  $K_p$ .

$$\begin{aligned} \text{mole fraction of } \text{N}_2 &= \frac{0.6}{(0.6 + 1.8 + 0.8)} \\ &= \frac{0.6}{3.2} \\ &= 0.188 \end{aligned}$$

c. If the total pressure of the system is  $4 \times 10^7 \text{ Nm}^{-2}$ , calculate  $K_p$ .

$$\begin{aligned}\text{mole fraction of N}_2 &= \frac{0.6}{(0.6 + 1.8 + 0.8)} \\ &= \frac{0.6}{3.2} \\ &= 0.188\end{aligned}$$

$$\begin{aligned}\text{partial pressure of N}_2 &= 0.188 \times 4 \times 10^7 \\ &= \underline{7.50 \times 10^6 \text{ Nm}^{-2}}\end{aligned}$$

$$\begin{aligned}\text{mole fraction of H}_2 &= \frac{1.8}{(0.6 + 1.8 + 0.8)} \\ &= \frac{1.8}{3.2} \\ &= 0.563\end{aligned}$$

$$\begin{aligned}\text{partial pressure of H}_2 &= 0.563 \times 4 \times 10^7 \\ &= \underline{2.25 \times 10^7 \text{ Nm}^{-2}}\end{aligned}$$

$$\begin{aligned}\text{mole fraction of NH}_3 &= \frac{0.8}{(0.6 + 1.8 + 0.8)} \\ &= \frac{0.8}{3.2} \\ &= 0.250\end{aligned}$$

$$\begin{aligned}\text{partial pressure of NH}_3 &= 0.250 \times 4 \times 10^7 \\ &= \underline{1.00 \times 10^7 \text{ Nm}^{-2}}\end{aligned}$$

$$\begin{aligned}K_p &= \frac{p(\text{NH}_3)^2}{p(\text{N}_2) \times p(\text{H}_2)^3} \\ &= \frac{(1.00 \times 10^7)^2}{(7.50 \times 10^6) (2.25 \times 10^7)^3} \\ &= \frac{1 \times 10^{14}}{7.5 \times 10^6 \times 11.39 \times 10^{21}} \\ &= \frac{1 \times 10^{14}}{85.43 \times 10^{27}} \\ &= 0.0117 \times 10^{-13} \\ &= 1.17 \times 10^{-15}\end{aligned}$$