Q.12 The surface of copper gets tarnished by the formation of copper oxide. N_2 gas was passed to prevent the oxide formation during heating of copper at 1250 K. However, the N_2 gas contains 1 mole % of water vapour as impurity. The water vapour oxidises copper as per the reaction given below:

$2Cu(s) + H_2O(g) \rightarrow Cu_2O(s) + H_2(g)$

p_{H_2} is the minimum partial pressure of H_2 (in bar) needed to prevent the oxidation at 1250 K. The value of $\ln(p_{H_2})$ is ____.

(Given: total pressure = 1 bar, *R* (universal gas constant) = 8 J K^{-1} mol^{-1}, ln(10) = 2.3. Cu(s) and Cu_2O(s) are mutually immiscible.

At 1250 K: $2Cu(s) + ½\ O_2(g) \rightarrow Cu_2O(s)$; $\Delta G^\theta = -78{,}000$ J mol^{-1}

$H_2(g) + ½\ O_2(g) \rightarrow H_2O(g)$; $\Delta G^\theta = -1{,}78{,}000$ J mol^{-1}; *G* is the Gibbs energy)

Sol. **-14.6**

From the given data:

For $2Cu(s) + H_2O(g) \rightleftharpoons Cu_2O(s) + H_2(g)$

$\Delta G^0 = 100000$

Hence $\Delta G^0 = 100000 = -RT \ln Kp$ and $K_P = \dfrac{P_{H_2}}{P_{H_2O}} \left(P_{H_2O(g)} = 0.01 \text{ bar}\right)$

On calculating; $\ln P_{H_2} = -14.6$