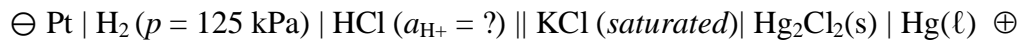


### Problem 11-08 pH from cell potential

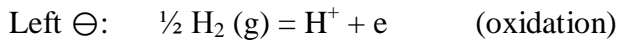
Hydrogen electrode, saturated under hydrogen pressure of 125 kPa (standard state  $p^{\text{st}} = 101.325$  kPa), was immersed into an aqueous hydrogen chloride solution and this half-cell was connected via a salt bridge with saturated calomel electrode ( $E_{\text{red, calom}} = 0.2503$  V), all at the temperature of 15 °C:



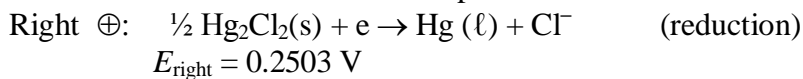
The potential of this cell was determined to be 0.39 V. Assuming ideal behaviour of hydrogen determine pH of the HCl solution.

[pH = 2.4 ]

Solution:



$$E_{\text{left}} = 0 - \frac{RT}{F} \ln \frac{a_{\text{H}^+}}{a_{\text{H}_2}^{1/2}}, \quad a_{\text{H}_2} \approx \frac{p_{\text{H}_2}}{p^{\text{st}}} = \frac{125}{101,325}$$
$$= \frac{RT}{F} \cdot \ln 10 \cdot \underbrace{(-\log a_{\text{H}^+})}_{\text{pH}} + \frac{RT}{2F} \ln \frac{p_{\text{H}_2}}{p^{\text{st}}}$$



$$E = E_{\text{left, ox}} + E_{\text{right, red}}$$

$$E = \frac{RT}{F} \cdot \ln 10 \cdot \text{pH} + \frac{RT}{2F} \ln \frac{p_{\text{H}_2}}{p^{\text{st}}} + E_{\text{red, calom}}$$

$$0.39 = \frac{8.314 \cdot 288.15}{96485.3} \cdot \ln 10 \cdot \text{pH} + \frac{8.314 \cdot 288.15}{2 \cdot 96485.3} \cdot \ln \frac{125}{101.325} + 0.2503$$

$$\text{pH} = 2.3979$$