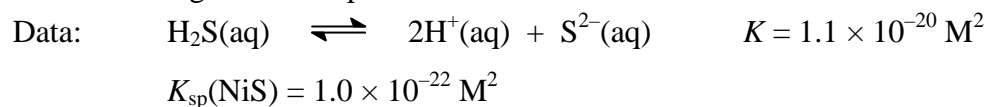


**Marks**  
**5**

- The pH of a solution can be controlled by adding small amounts of gaseous HCl. Assuming no change in volume, calculate what the pH of the solution must be to just dissolve 1.00 g of NiS suspended in 1.0 L of water.



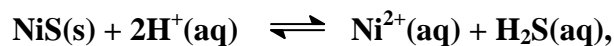
For the dissolution  $\text{NiS}(\text{s}) \rightleftharpoons \text{Ni}^{2+}(\text{aq}) + \text{S}^{2-}(\text{aq})$ ,

$$K_{\text{sp}} = [\text{Ni}^{2+}(\text{aq})][\text{S}^{2-}(\text{aq})].$$

For the acid dissociation,  $\text{H}_2\text{S}(\text{aq}) \rightleftharpoons 2\text{H}^+(\text{aq}) + \text{S}^{2-}(\text{aq})$ ,

$$K = \frac{[\text{H}^+(\text{aq})]^2[\text{S}^{2-}(\text{aq})]}{[\text{H}_2\text{S}(\text{aq})]}$$

Combining these two equilibria gives, for the overall reaction,



$$K_{\text{eq}} = \frac{[\text{Ni}^{2+}(\text{aq})][\text{H}_2\text{S}(\text{aq})]}{[\text{H}^+(\text{aq})]^2} = \frac{K_{\text{sp}}}{K} = \frac{1.0 \times 10^{-22}}{1.1 \times 10^{-20}} = 9.1 \times 10^{-3}$$

The formula mass of NiS is (58.69 (Ni) + 32.07 (S))  $\text{g mol}^{-1} = 90.76 \text{ g mol}^{-1}$ . The amount in 1.00 g is therefore,

$$\text{number of moles} = \frac{\text{mass}(\text{g})}{\text{molar mass}(\text{g mol}^{-1})} = \frac{1.00 \text{ g}}{90.76 \text{ g mol}^{-1}} = 0.0110 \text{ mol}$$

In the dissolution  $\text{NiS}(\text{s}) \rightleftharpoons \text{Ni}^{2+}(\text{aq}) + \text{S}^{2-}(\text{aq})$ , so if 0.0110 mol of NiS(s) completely dissolves in 1.0 L,  $[\text{Ni}^{2+}(\text{aq})] = 0.011 \text{ M}$ . From the overall reaction, each mole of NiS which dissolves produces one mole of  $\text{H}_2\text{S}(\text{aq})$  so  $[\text{H}_2\text{S}(\text{aq})] = 0.011 \text{ M}$ . Hence,

$$[\text{H}^+(\text{aq})]^2 = \frac{(0.011 \text{ M})(0.011 \text{ M})}{9.1 \times 10^{-3}} \quad \text{or} \quad [\text{H}^+(\text{aq})] = 0.12 \text{ M}$$

$$\text{pH} = -\log_{10}[\text{H}^+(\text{aq})] = -\log_{10}(0.12) = 0.94$$

pH = 0.94