

**PART B
QUESTION 1**

Given: K_H for $\text{CO}_2(\text{g}) = 3.4 \times 10^{-2} \text{ M atm}^{-1}$

To find: $S[\text{CO}_2, \text{aq}]$, solubility concentration of $\text{CO}_2(\text{aq})$
in mol L^{-1} *at equilibrium*

(a) **BEFORE** the bottle is opened ($p(\text{CO}_2, \text{g}) = 5.0 \text{ atm}$)

$$K_H (\text{CO}_2) = \frac{S[\text{CO}_2, \text{aq}]}{p(\text{CO}_2, \text{g})}$$

$$\begin{aligned} S[\text{CO}_2, \text{aq}] &= K_H (\text{CO}_2) \times p(\text{CO}_2, \text{g}) \\ &= (3.4 \times 10^{-2} \text{ M atm}^{-1}) \times (5.0 \text{ atm}) \\ &= 1.7 \times 10^{-1} \text{ M} \\ &= \underline{\underline{0.17 \text{ mol L}^{-1}}} \end{aligned}$$

(b) **AFTER** the bottle is opened ($p(\text{CO}_2, \text{g}) = 3.5 \times 10^{-4} \text{ atm}$)

$$K_H (\text{CO}_2) = \frac{S[\text{CO}_2, \text{aq}]}{p(\text{CO}_2, \text{g})}$$

$$\begin{aligned} S[\text{CO}_2, \text{aq}] &= K_H (\text{CO}_2) \times p(\text{CO}_2, \text{g}) \\ &= (3.4 \times 10^{-2} \text{ M atm}^{-1}) \times (3.5 \times 10^{-4} \text{ atm}) \\ &= 1.19 \times 10^{-5} \text{ M} \\ &= \underline{\underline{1.2 \times 10^{-5} \text{ mol L}^{-1}}} \end{aligned}$$

**PART B
QUESTION 2**

Given: K_H for $\text{O}_2(\text{g}) = 1.3 \times 10^{-3} \text{ M atm}^{-1}$

$p(\text{O}_2, \text{g}) = 0.21 \text{ atm at } 25^\circ\text{C}$

(a) the amount of dissolved oxygen, O_2 , in mol L^{-1} and ppm

$$K_H (\text{O}_2) = \frac{S[\text{O}_2, \text{aq}]}{p(\text{O}_2, \text{g})}$$

$$\begin{aligned} \text{(i)} \quad S[\text{O}_2, \text{aq}] \text{ in } \underline{\underline{\text{mol L}^{-1}}} &= K_H (\text{O}_2) \times p(\text{O}_2, \text{g}) \\ &= (1.3 \times 10^{-3} \text{ M atm}^{-1}) \times (0.21 \text{ atm}) \\ &= 2.73 \times 10^{-4} \text{ M} \\ &= \underline{\underline{2.7 \times 10^{-4} \text{ mol L}^{-1}}} \end{aligned}$$

$$M(O_2) = [2 (15.999)] g mol^{-1} = 31.998 g mol^{-1} = 31.998 \times 10^3 mg mol^{-1}$$

$$\begin{aligned} \text{(ii)} \quad S[O_2, \text{aq}] \text{ in } \underline{\text{ppm}} &= (2.73 \times 10^{-4} \text{ mol L}^{-1}) \times (31.998 \times 10^3 \text{ mg mol}^{-1}) \\ &= \underline{8.736 \text{ mg L}^{-1}} \quad (1 \text{ ppm} = 1 \text{ mg L}^{-1}) \\ &= \underline{\underline{8.7 \text{ ppm}}} \end{aligned}$$

(b) (i) the BOD for the lake in mol L⁻¹ and in ppm

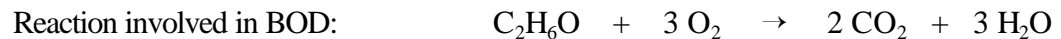
Given: $S(C_2H_6O, \text{aq}) = 5.00 \text{ ppm} = 5.00 \text{ mg L}^{-1}$

$$1 \text{ ppm} = 1 \text{ mg L}^{-1}$$

To find: $S(O_2, \text{aq})$ required to react *completely* with C_2H_6O

$$M(C_2H_6O) = [2 (12.011) + 6 (1.0079) + (15.999)] g mol^{-1} = 46.0684 g mol^{-1} = 46.0684 \times 10^3 mg mol^{-1}$$

$$\begin{aligned} S(C_2H_6O, \text{aq}) \text{ in } \underline{\text{mol L}^{-1}} &= 5.00 \text{ ppm} \\ &= (5.00 \text{ mg L}^{-1}) \div (46.0684 \times 10^3 \text{ mg mol}^{-1}) \\ &= \underline{1.0853 \times 10^{-4} \text{ mol L}^{-1}} \end{aligned}$$



3 moles of O_2 are required to oxidize **1 mole** of organic matter C_2H_6O to $2 CO_2$ and $3 H_2O$

$$\begin{aligned} S(O_2, \text{aq}) \text{ in } \underline{\text{mol L}^{-1}} &= S(C_2H_6O, \text{aq}) \times (3 \text{ moles } O_2 \div 1 \text{ mole } C_2H_6O) \\ &= (1.0853 \times 10^{-4} \text{ mol L}^{-1}) (3) \\ &= \underline{3.256 \times 10^{-4} \text{ mol L}^{-1}} \\ &= \underline{\underline{3.26 \times 10^{-4} \text{ mol L}^{-1}}} \end{aligned}$$

$$M(O_2) = [2 (15.999)] g mol^{-1} = 31.998 g mol^{-1} = 31.998 \times 10^3 mg mol^{-1}$$

$$\begin{aligned} S(O_2, \text{aq}) \text{ in } \underline{\text{ppm}} &= (3.256 \times 10^{-4} \text{ mol L}^{-1}) \times (31.998 \times 10^3 \text{ mg mol}^{-1}) \\ &= \underline{10.419 \text{ mg L}^{-1}} \\ &= \underline{\underline{10.4 \text{ ppm}}} \end{aligned}$$

(ii) It requires **10.4 ppm** dissolved $O_2(\text{aq})$ in order to *completely* react with 5.00 ppm organic matter, C_2H_6O . From Part (a), the amount of dissolved O_2 in natural water at 25°C is **8.7 ppm**. Thus, there is **not** enough dissolved oxygen in the lake.

**PART B
QUESTION 3**

- Given:
- ① $V(\text{oxygenated water}) = 200 \text{ mL}$
 - ② $K_{\text{H}}(\text{O}_2) \text{ at } 4^\circ\text{C} = 2.02 \times 10^{-3} \text{ mol L}^{-1} \text{ atm}^{-1}$
 - ③ $c(\text{Na}_2\text{S}_2\text{O}_3) = 0.02468 \text{ M}$
 - ④ $p(\text{O}_2, \text{g}) = 0.209 \text{ atm}$

To find: $S[\text{O}_2, \text{aq}]$ in ppm and $V(\text{Na}_2\text{S}_2\text{O}_3)$

$$K_{\text{H}}(\text{O}_2) = \frac{S[\text{O}_2, \text{aq}]}{p(\text{O}_2, \text{g})}$$

$$\begin{aligned} S(\text{O}_2, \text{aq}) \text{ in } \underline{\text{mol L}^{-1}} &= K_{\text{H}}(\text{O}_2) \times p(\text{O}_2, \text{g}) \\ &= (2.02 \times 10^{-3} \text{ mol L}^{-1} \text{ atm}^{-1}) \times (0.209 \text{ atm}) \\ &= \underline{4.2218 \times 10^{-4} \text{ mol L}^{-1}} \end{aligned}$$

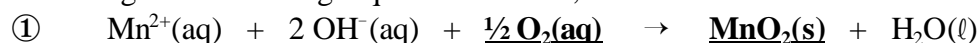
$$M(\text{O}_2) = [2(15.999)] \text{ g mol}^{-1} = 31.998 \text{ g mol}^{-1} = 31.998 \times 10^3 \text{ mg mol}^{-1}$$

$$\boxed{1 \text{ ppm} = 1 \text{ mg L}^{-1}}$$

$$\begin{aligned} S(\text{O}_2, \text{aq}) \text{ in } \underline{\text{ppm}} &= (4.2218 \times 10^{-4} \text{ mol L}^{-1}) \times (31.998 \times 10^3 \text{ mg mol}^{-1}) \\ &= \underline{13.509 \text{ mg L}^{-1}} \\ &= \underline{\underline{13.5 \text{ ppm}}} \end{aligned}$$

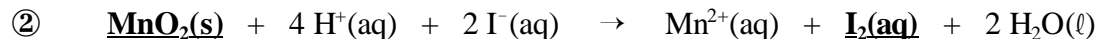
$$\begin{aligned} n(\text{O}_2) \text{ present} &= c(\text{O}_2) \times V(\text{O}_2) \\ &= (4.2218 \times 10^{-4} \text{ mol L}^{-1}) \times (200 \times 10^{-3} \text{ L}) \\ &= \underline{8.4436 \times 10^{-5} \text{ mol}} \end{aligned}$$

According to the following sequential reactions,



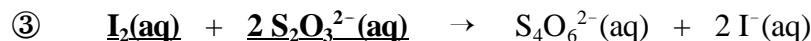
$\frac{1}{2}$ mole of $\text{O}_2(\text{aq})$ produces **1 mole** of $\text{MnO}_2(\text{s})$

$$n(\text{MnO}_2) = n(\text{O}_2) \times (1 \text{ mole MnO}_2 \div \frac{1}{2} \text{ mole O}_2) = (8.4436 \times 10^{-5} \text{ mol}) (2) = \underline{1.68872 \times 10^{-4} \text{ mol}}$$



1 mole of $\text{MnO}_2(\text{s})$ yields **1 mole** of $\text{I}_2(\text{aq})$

$$n(\text{I}_2) = n(\text{MnO}_2) \times (1 \text{ mole I}_2 \div 1 \text{ mole MnO}_2) = \underline{1.68872 \times 10^{-4} \text{ mol}}$$



1 mole of $\text{I}_2(\text{aq})$ reacts with **2 moles** of $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$

$$n(\text{Na}_2\text{S}_2\text{O}_3) = n(\text{I}_2) \times (2 \text{ moles Na}_2\text{S}_2\text{O}_3 \div 1 \text{ mole I}_2) = (\underline{1.68872 \times 10^{-4} \text{ mol}}) (2) = \underline{3.37744 \times 10^{-4} \text{ mol}}$$

$$\begin{aligned} V(\text{Na}_2\text{S}_2\text{O}_3) &= \frac{n(\text{Na}_2\text{S}_2\text{O}_3)}{c(\text{Na}_2\text{S}_2\text{O}_3)} \\ &= \frac{(3.37744 \times 10^{-4} \text{ mol})}{(0.02468 \text{ mol L}^{-1})} \\ &= \underline{1.3685 \times 10^{-2} \text{ L}} \\ &= \underline{\underline{13.7 \text{ mL}}} \end{aligned}$$