Table 9.1 Solubility and Henry's constant for oxygen in pure water under 1 atm oxygen pressure

(*Calculated from data in* International Critical Tables, *1928, vol. III, p. 257. McGraw-Hill, New York*)

Temperature (°C)	*Oxygen solubility* ($kg\ m^{-3}$)	*Henry's constant* ($atm\ m^3\ kg^{-1}$)
0	7.03×10^{-2}	14.2
10	5.49×10^{-2}	18.2
15	4.95×10^{-2}	20.2
20	4.50×10^{-2}	22.2
25	4.14×10^{-2}	24.2
26	4.07×10^{-2}	24.6
27	4.01×10^{-2}	24.9
28	3.95×10^{-2}	25.3
29	3.89×10^{-2}	25.7
30	3.84×10^{-2}	26.1
35	3.58×10^{-2}	27.9
40	3.37×10^{-2}	29.7

Table 9.2 Solubility of oxygen in water under 1 atm air pressure

(Calculated from data in Table 9.1 and Henry's law)

Temperature (°C)	*Oxygen solubility* ($kg\ m^{-3}$)
0	1.48×10^{-2}
10	1.15×10^{-2}
15	1.04×10^{-2}
20	9.45×10^{-3}
25	8.69×10^{-3}
26	8.55×10^{-3}
27	8.42×10^{-3}
28	8.29×10^{-3}
29	8.17×10^{-3}
30	8.05×10^{-3}
35	7.52×10^{-3}
40	7.07×10^{-3}

9.8.1 Effect of Oxygen Partial Pressure

According to the *International Critical Tables* [18], the mole fraction of oxygen in air is 0.2099, so the partial pressure of oxygen at 1 atm air pressure is 0.2099 atm. At a given temperature, the effect of gas-phase oxygen partial pressure on solubility is given by Henry's law, Eq. (9.43). Therefore, the solubility of oxygen in water under 1 atm air pressure is 0.2099 times that under 1 atm pure oxygen. Values for solubility of oxygen in water sparged with air are given in Table 9.2.

9.8.2 Effect of Temperature

The variation of oxygen solubility with temperature is shown in Tables 9.1 and 9.2 for water in the range 0–40°C. Solubility falls with increasing temperature. Oxygen solubility in pure water between 0° and 36°C has been correlated by the following equation [15]:

$$C^*_{AL} = 14.161 - 0.3943T + 0.007714T^2 - 0.0000646T^3 \quad (9.44)$$

where C^*_{AL} is oxygen solubility in units of $mg\ l^{-1}$, and T is temperature in °C.

9.8.3 Effect of Solutes

Presence of solutes such as salts, acids and sugars has a significant effect on oxygen solubility in water, as indicated in Tables 9.3 and 9.4. These data indicate that oxygen solubility is decreased by the ions and sugars normally added to fermentation media. The effect on oxygen solubility of ionic and non-ionic solutes such as molasses, corn-steep liquor, protein and antifoam agents is reported in several publications [19–24]. Quicker *et al.* [23] have developed an empirical correlation to correct values of oxygen solubility in water for the effects of cations, anions and sugars: