Question 9.13:

What is the density of water at a depth where pressure is 80.0 atm, given that its density at the surface is 1.03×10^3 kg m^{-3}?

Answer 9.13:

Let the given depth be h. Pressure at the given depth, $p = 80.0$ atm $= 80 \times 1.01 \times 10^5$ Pa

Density of water at the surface, $\rho_1 = 1.03 \times 10^3$ kg m^{-3}

Let ρ_2 be the density of water at the depth h, let V_1 be the volume of water of mass m at the surface.

Let V_2 be the volume of water of mass m at the depth h and let ΔV be the change in volume.

$$\Delta V = V_1 - V_2$$

$$= m\left(\frac{1}{\rho_1} - \frac{1}{\rho_2}\right)$$

$$\therefore \frac{\Delta V}{V_1} = 1 - \frac{\rho_1}{\rho_2} \quad \ldots(i)$$

Bulk modulus, $B = \frac{pV_1}{\Delta V}$

$$\frac{\Delta V}{V_1} = \frac{p}{B}$$

Compressibity of water $= \frac{1}{B} = 45.8 \times 10^{-11}$ Pa^{-1}

$$\therefore \frac{\Delta V}{V_1} = 80 \times 1.013 \times 10^5 \times 45.8 \times 10^{-11} = 3.71 \times 10^{-3}$$

For equations (*i*) and (*ii*), we get:

$$1 - \frac{\rho_1}{\rho_2} = 3.71 \times 10^{-3}$$

$$\rho_2 = \frac{1.03 \times 10^3}{1 - (3.71 \times 10^{-3})} = 1.034 \times 10^3 \text{ kg m}^{-3}$$

Therefore, the density of water at the given depth (h) is 1.034×10^3 kg m^{-3}.

Question 9.14:

Compute the fractional change in volume of a glass slab, when subjected to a hydraulic pressure of 10 atm.

Answer 9.14:

Hydraulic pressure exerted on the glass slab, $p = 10$ atm $= 10 \times 1.013 \times 10^5$ Pa

Bulk modulus of glass, $B = 37 \times 10^9$ Nm^{-2}

$$\text{Bulk modulus, } B = \frac{p}{\frac{\Delta V}{V}}$$

Where, $\frac{\Delta V}{V}$ = Fractional change in volume

$$\therefore \frac{\Delta V}{V} = \frac{p}{B} = \frac{10 \times 1.013 \times 10^5}{37 \times 10^9} = 2.73 \times 10^{-5}$$

Hence, the fractional change in the volume of the glass slab is 2.73×10^{-5}.

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