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Question

it's was a question on a previous test that I was reviewing cause I have a midterm on Friday (in two day).
my prof didn't explain it well! :(

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A hydrometer is a simple device used to measure the specific gravity of liquids. It has two connected parts: a glass bulb (weighted with a heavy metal) and a cylindrical stem (with internal scale marks). When placed in a liquid, the hydrometer floats upright with some part of the stem extending above the liquid surface. In the figure shown, the bulb has a volume of 25 mL and mass of 20 g (including the heavy

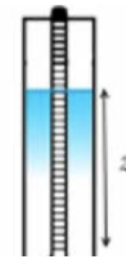


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QUESTION 2 A hydrometer is a simple device used to measure the specific gravity of liquids. It has two connected parts: a glass bulb (weighted with a heavy metal) and a cylindrical stem (with internal scale marks). When placed in a liquid, the hydrometer floats upright with some part of the stem extending above the liquid surface. In the figure shown, the bulb has a

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- b) Mathematical expression for the immersed volume of the hydrometer** $V_{im} = 10^{-6}(25 + 19.63z)$
c) Specific gravity of the given liquid will be $S.G = 0.837$
d) Range of the specific gravity values that can be measured by this hydrometer will be $\Rightarrow 0.761$ to 0.880

Step-by-step explanation**a) Force balance diagram of the hydrometer:**Where, F_b = Buoyant force acting on the hydrometer M = Mass of bulb = 20 g = 20×10^{-3} kg**Ask Expert Tutors**

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$m = \text{Mass of the cylindrical stem} = 2 \text{ g} = 2 \times 10^{-3} \text{ kg}$

$g = \text{Gravitational acceleration} = 9.80 \text{ m/s}^2$

b) The immersed volume of the hydrometer $V_{im} = \text{Volume of the bulb } (V_b) + \text{Immersed volume of the stem } (V_{s_{im}})$

We have $V_b = 25 \text{ mL} = 25 \times 10^{-3} \text{ L} = 25 \times 10^{-6} \text{ m}^3$ ($1\text{L} = 10^{-3} \text{ m}^3$)

Since the shape of the stem is cylindrical hence the volume of the immersed part of the stem will be

$$V_{s_{im}} = A \times z = \frac{\pi}{4} d^2 \times z = \frac{\pi}{4} d^2 z$$

Given in the question $d = 5 \text{ mm} = 5 \times 10^{-3} \text{ m}$

Immersed volume of stem, $V_{s_{im}} = \frac{\pi}{4} \times (5 \times 10^{-3})^2 \times z = 19.63 \times 10^{-6} z$

So, the immersed volume of the hydrometer $V_{im} = 25 \times 10^{-6} + 19.63 \times 10^{-6} z$

Mathematical expression for the immersed volume of the hydrometer $V_{im} = 10^{-6}(25 + 19.63z)$ ----
----(1)

c) The buoyant force formula is given as $F_b = \rho g V_{im}$

Where, $\rho = \text{Density of the test fluid}$

Now, in equilibrium condition, $F_b = (M + m)g$

$$\rho g V_{im} = (M + m)g$$

$$\rho V_{im} = (M + m)$$

$$\rho = \frac{(M+m)}{V_{im}}$$

Using equation (1), we get-

$$\rho = \frac{(M+m)}{10^{-6}(25+19.63z)}$$

We know the specific gravity formula

$$S.G = \frac{\text{Density of test fluid}(\rho)}{\text{Density of water}(\rho_w)}$$

$$S.G = \frac{\rho}{\rho_w} = \frac{(M+m)}{10^{-6}(25+19.63z)\rho_w}$$

Density of water $\rho_w = 1000 \text{ kg/m}^3$

Putting values of "M", "m" and " ρ_w " in the above equation we get-

$$S.G = \frac{(20 \times 10^{-3} + 2 \times 10^{-3})}{10^{-6}(25+19.63z) \times 1000}$$

$$S.G = \frac{22}{(25+19.63z)} \text{ -----(2)}$$

The specific gravity of the liquid for $z = 6.5 \text{ cm} = 0.065 \text{ m}$

$$S.G = \frac{22}{(25+19.63 \times 0.065)}$$

Specific gravity of the given liquid will be $S.G = 0.837$

d) We can calculate the range of the specific gravity by putting the maximum and minimum value of the length of the cylindrical stem in equation(2).

Maximum length of the stem that can be immersed in the liquid will be $z_{max} = 20 \text{ cm} = 0.2 \text{ m}$

Minimum length of the stem that can be immersed in the liquid will be $z_{min} = 0$

$$\text{Maximum specific gravity } S.G_{max} = \frac{22}{(25+19.63z_{min})}$$

$$S.G_{max} = \frac{22}{(25+19.63 \times 0)}$$

$$S.G_{max} = 0.880$$

$$\text{Minimum specific gravity } S.G_{min} = \frac{22}{(25+19.63z_{max})}$$

$$S.G_{min} = \frac{22}{(25+19.63 \times 0.2)}$$

$$S.G_{min} = 0.761$$

Range $\Rightarrow [S.G_{min} \text{ to } S.G_{max}]$

Range of the specific gravity values that can be measured by this hydrometer will be \Rightarrow

0.761 to 0.880

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