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Chapter 6 (Physical chemistry)

Numericals:

. ***Example: 1***

The surface tension of toluene at 293 K is 0.028 N m^{-1} and its density at this temperature is 0.866 x 10^3 kg m^{-3}. If the surface tension of water is 0.07275 Nm^{-1} and density 0.9982 x 10^3 kg m^{-3}, calculate the ratio of number of drops of liquid to that of water?

Solution: Given : -

Surface tension of toluene	γ_t	=	0.028 N m^{-1}
Surface tension of water	γ_w	=	0.07275 N m^{-1}
Density of toluene	d_t	=	0.866 × 10^3 kg m^{-3}
Density of water	d_w	=	0.9982 × 10^3 kg m^{-3}
Number of drops of toluene		=	n_t
Number of drops of water		=	n_w

We have, $\frac{\gamma_t}{\gamma_w} = \frac{n_w\, d_t}{n_t\, d_w}$ OR $\frac{n_t}{n_w} = \frac{\gamma_w\, d_t}{\gamma_t\, d_w}$

$\therefore \quad \frac{n_t}{n_w} = \frac{0.07275 \times 0.866 \times 10^3}{0.028 \times 0.9982 \times 10^3} =$ 2.25drops

Example: 2

Water required 120.5 seconds to flow through a viscometer and the same volume of acetone required 49.5 seconds. If the densities of water and acetone at 293 K are 9.982 x 10^2 kg m^{-3} and 7.92 x 10^2 kg m^{-3} respectively and the coefficient of viscosity of water at 293 K is 10.05 Pascal second, calculate the coefficient of viscosity of acetone at this temperature.

Solution: Given : -

Flow time of acetone	t_a	=	49.5 sec.
Flow time of water	t_w	=	120.5 sec.
Density of acetone	d_a	=	7.92 × 10^2 kg m^{-3}
Density of water	d_w	=	9.982 × 10^2 kg m^{-3}
Coefficient of viscosity of water	η_w	=	10.05 Pascal sec.
Coefficient of viscosity of acetone	η_a	=	?

We have, $\frac{\eta_a}{\eta_w} = \frac{t_a\, d_a}{t_w\, d_w}$ OR $\eta_a = \frac{t_a\ d_a}{t_w\, d_w} \times \eta_w$

$\therefore \quad \eta_a = \frac{49.5 \times 7.92 \times 10^2 \times 10.05}{120.5 \times 9.982 \times 10^2} =$ 3.257 Pascal sec.

Example: 3

In the determination of surface tension of a liquid by the drop number method, it gives 55 drops while water gave 25 drops for the same volume. The densities of the liquid and water are 0.996 and 0.800 g cm-3 respectively. Find the surface tension of the liquid if that of the water is 72.0 dynes cm-1.

Solution: Given : -

Surface tension of liquid γl = ?

Surface tension of water γw = 72.0 dynes cm-1

Density of liquid dl = 0.996g cm-3

Density of water dw = 0.800 g cm-3

Number of drops of liquid = nl =55

Number of drops of water = nw =25

We know

$$\frac{\gamma l}{\gamma_w} = \frac{\text{nwdl}}{\text{nldw}} \qquad \gamma l = \gamma w \times \frac{nwdl}{nldw}$$

$$\frac{25 \times 0.996 \times 72}{0.800 \times 55}$$

$$\frac{\gamma l}{72} = \frac{25 \times 0.996}{0.800 \times 55}$$

$$\frac{\gamma l}{72} = \frac{24.9}{44}$$

$$\gamma l = \frac{72\ x\ 24.9}{44} = 40.74$$ dynes cm-1

Example: 4

In an experiment with Ostwald viscometer, the time of flow of water and ethanol are 80 sec and 175 sec at 20ºC. The density of water = 0.998 g cm-3 and that of ethanol = 0.790 g cm-3. The viscosity of water at 20ºC is 0.01008 poise. Calculate the viscosity of ethanol.

Solution: Given : -

Flow time of ethanol te = 175 sec.

Flow time of water tw = 80sec.

Density of ethanol da = 0.790 g cm-3

Density of water dw = 0.998 g cm-3

Coefficient of viscosity of water ηw= 0.01008 poise

Coefficient of viscosity of ethanol ηa = ?

We know

$$\frac{\eta e}{\eta w} = \frac{te.de}{tw.dw}$$

$$\eta e = \eta w.\frac{te.de}{tw.dw}$$

$$\eta e = \frac{0.01008\ x\ 175\ x\ 0.790}{80\ x\ 0.998}$$

$$\frac{1.3935}{79.84}$$

= 0.01784 poise

Example: 5

In an experiment with Ostwald's viscometer, pure water took 1.52 minutes to flow through the capillary at 20ºC. For the same volume of another liquid of density 0.80 g cm-3 the flow time was 2.25 minutes. Find the relative viscosity of the liquid and its absolute viscosity in centipoises. Density of water at 20ºC is 0.9982 and absolute viscosity of water is 1.005 centipoise.

Solution: Given : -

Flow time of liquid ta = 2.25min. = 145 sec

Flow time of water tw = 1.52min. = 112 sec

Density of liquid da = 0.80 g cm-3

Density of water dw = 0.9982 cm-3

Coefficient of viscosity of water ηw= 1.005 centipoise.

Coefficient of viscosity of acetone ηa= ?

Relative viscosity of the liquid= nl/nw = ?

We know

$$\frac{\eta l}{\eta w} = \frac{tl.dl}{tw.dw}$$

$$\eta l = \frac{\eta w.tl.dl}{tw.dw}$$

$$\eta l = \frac{1.005\ x\ 145\ x\ 0.80}{112\ x\ 0.9982}$$

$\frac{116.58}{111.79} = 1.042$ Centipoise

Relative viscosity = $\frac{\eta l}{\eta w} = \frac{1.0428}{1.005} = 1.037$ centipoise

Assignment:

1) The coefficient of viscosity of two liquids at 298 K is 1.408 x 10^{-3} kg m^{-1} s^{-1} and 1.594 x 10^{-3} kg m^{-1} s^{-1} and their densities are 8.07 x 10 ^{2}kg m^{-3} and 10.17 x 10 ^{2}kg m-3 respectively. If the time of flow for the first liquid is 100 seconds, calculate the time of flow for the second liquid.