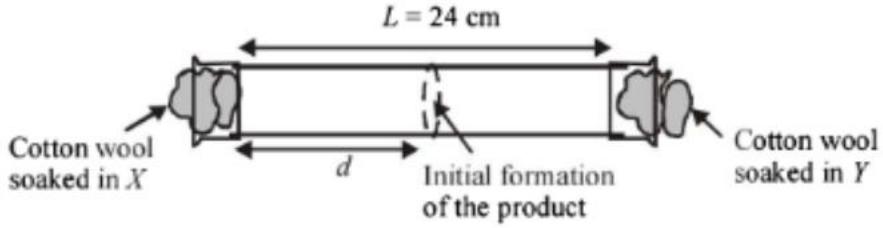
Question 1

X and Y are two volatile liquids with molar weights of 10 g mol^{-1} and 40 g mol^{-1} respectively. Two cotton plugs, one soaked in X and the other soaked in Y, are simultaneously placed at the ends of a tube of length $L = 24$ cm, as shown in the figure. The tube is filled with an inert gas at 1 atmosphere pressure and a temperature of 300 K. Vapours of X and Y react to form a product which is first

observed at a distance d cm from the plug soaked in X. Take X and Y to have equal molecular diameters and assume ideal behaviour for the inert gas and the two vapours.



1. The value of d in cm (shown in the figure), as estimated from Graham's law, is ***(JEE Adv. 2014)***
   (a) 8 (b) 12
   (c) 16 (d) 20
2. The experimental value of d is found to be smaller than the estimate obtained using Graham's law. This is due to ***(JEE Adv. 2014)***
   (a) Larger mean free path for X as compared to that of Y
   (b) Larger mean free path for Y as compared to that of X
   (c) Increased collision frequency of Y with the inert gas as compared to that of X with the inert gas
   (d) Increased collision frequency of X with the inert gas as compared to that of Y with the inert gas

(c) According to Graham's law of diffusion, if all conditions are identical,

$$r = \frac{1}{\sqrt{M}}$$

As in this question, all conditions are identical for X and Y, then

$$\frac{r_x}{r_y} = \sqrt{\frac{M_y}{M_x}}$$

Question 1

$$\frac{d}{24-d} = \sqrt{\frac{40}{10}} = 2$$

$$\Rightarrow\ d = 48 - 2d\ \Rightarrow\ 3d = 48 \Rightarrow\ d = 16\ \text{cm}$$

(d) The general formula of mean free path (λ) is

$$\lambda = \frac{RT}{\sqrt{2}\pi d^2 N_A p}$$

(d = diameter of molecule, p = pressure inside the vessel)

Since d and p are same for both gases, ideally their λ are same. Hence it must be the higher drift speed of X due to which it is facing more collisions per second with the inert gas in comparison to gas Y. Hence X faces more resistance from inert gas than Y and hence covers lesser distance than that predicted by Graham's law.