Compressibility, Boyle's Temperature

Course on States of Matter for Class XI

akhilesh • Lesson 18 • Aug 11, 2021

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$$\frac{6 \times 10^{20}}{6 \times 10^{23}} = 10^{-3}$$

S-II

$$KE_{1\,mol} = \frac{3}{\cancel{2}} \times \cancel{8}^{4} \times 300$$

$$= 3600$$

$$= \underline{3.6}$$

$P^2/T^{3/2}$

10

$$\lambda = \frac{\cancel{k}\,T}{\sqrt{2}\,\pi\sigma^2 P}$$

$$2.6\times10^{-5} = \frac{8.314}{N_A}\times\frac{3\omega}{\sqrt{2}\,\pi\sigma^2 P}$$

X Y

10 40

$\sigma_Y = \sigma_y$

1 Sec

Z_{11}

$d < 16$ cm

$$Z_{12} = \pi\sigma^2 \sqrt{\frac{8RT}{\pi}\left(\frac{1}{M_1} + \frac{1}{M_2}\right)} \times N^{*}_{inert}$$

diffusion coefficient $\propto \lambda V_{avg}$

$$\propto \frac{T}{P} \times \sqrt{T}$$

$$\propto \frac{T^{3/2}}{P}$$

$$\frac{(4)^{3/2}}{2} = \frac{8}{2} = 4$$

$$P = P_{obs} \oplus \underline{P_{corr}}$$

Consider a molecule 'B' which is about to collide the wall of the container.

This molecule will experience a retarding force towards the centre of container due to which its speed decreases.

Hence it exert less force than it would have if there were no forces of attraction.

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Pressure of gas

Vol. of gas $= V_{cont}$

a, b are <u>temperature independent</u>

but <u>gas dependent</u>

Vander Waal's const

find P of 1 mol real gas in a 2 lit container at 300 K. Given $a = 2$ atm lit^2 mol^{-2}

$R = 0.08$ atm. lit/mol/K $\qquad b = 0.4$ lit/mol.

A) 12

B) 14.5

C) 15.5

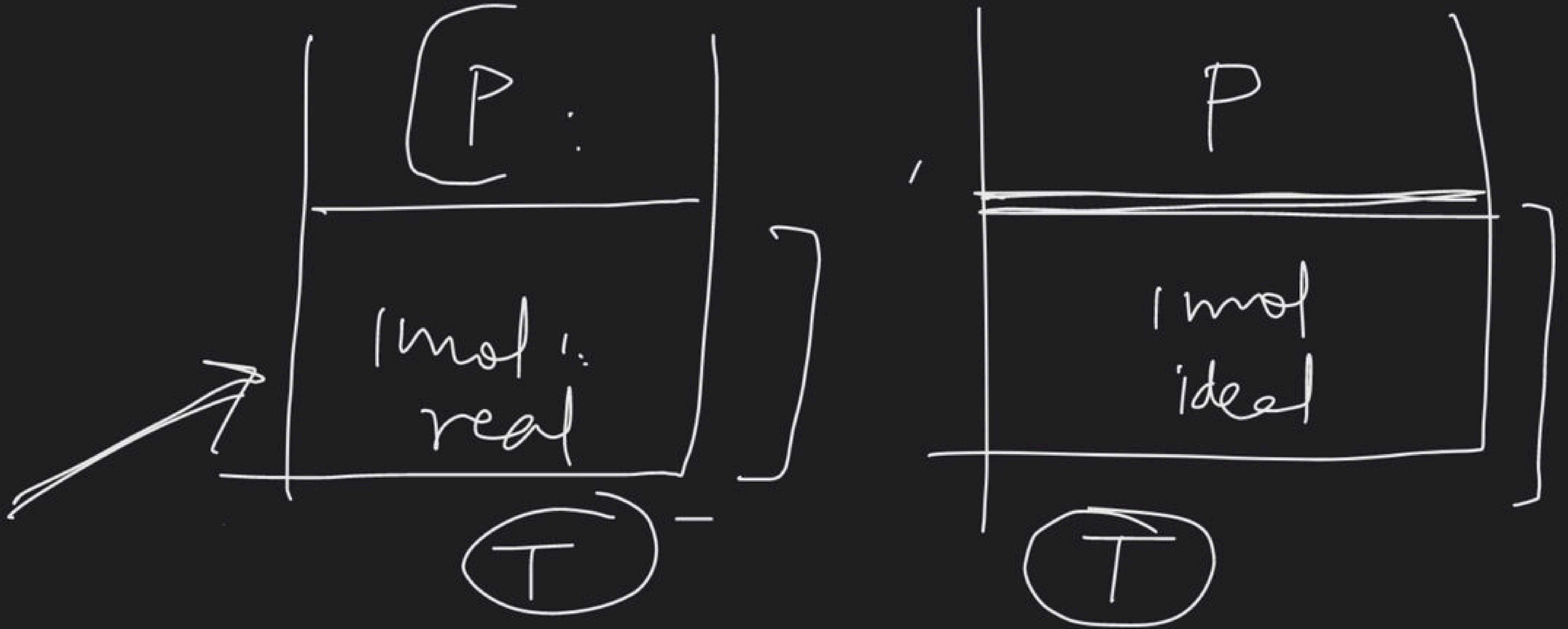
D) None

$$P \times 2 = 1 \times 0.08 \times 300$$

$$P = 12$$

Compressibility factor (Z)

$$Z = \frac{V_{real}}{V_{ideal}} = \frac{\text{Vol of real gas}}{\left(\text{Vol. of ideal gas at same } T, P\right)} = \frac{PV}{nRT}$$



$$V = \frac{nRT}{P}$$

$$\boxed{Z = \frac{PV}{nRT} = \frac{V_{real}}{V_{ideal}}}$$

$$\underline{a = 0.5}$$

$$\boxed{PV = ZnRT}$$

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Z vs P (At const n & T)

$$\boxed{V_m = V/n}$$

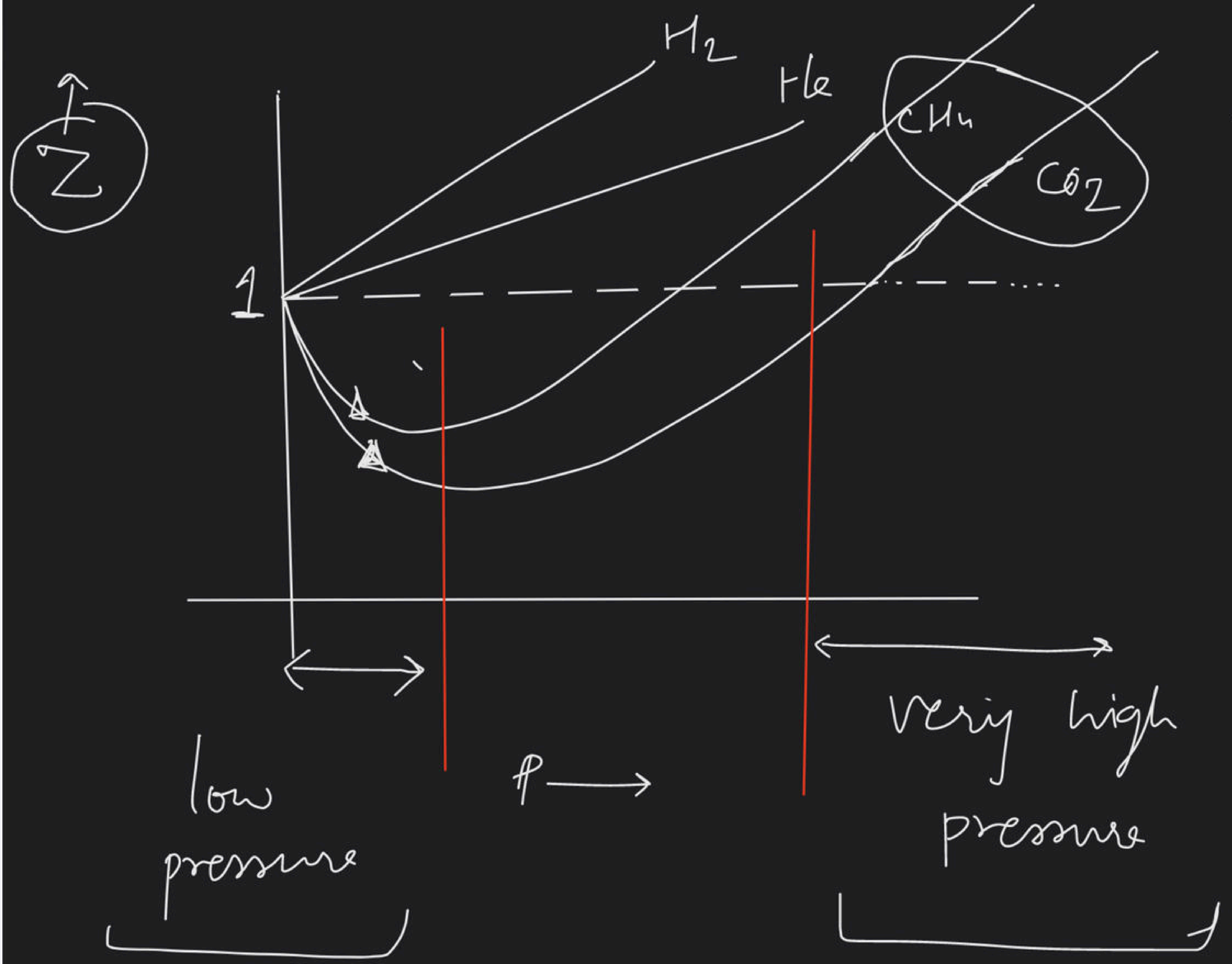
molar volume

$$Z = \frac{PV}{nRT} = \frac{PV_m}{RT}$$

$$\cancel{n}\left(P + \frac{an^2}{V^2}\right)\left(\frac{V}{n} - b\right) = \cancel{n}RT$$

$$\left(P + \frac{a}{V_m^2}\right)\left(V_m - b\right) = RT$$

At $T = 298\ K$



Q.2 If Z is the compressibility factor, van der Waals' equation at low pressure can be written as :

b

[JEE-MAINS-2014]

(1) $Z = 1 - \frac{Pb}{RT}$ (2) $Z = 1 + \frac{Pb}{RT}$ (3) $Z = 1 + \frac{Pb}{RT}$ (4) $Z = 1 - \frac{a}{V_m RT}$

Q.3 The compressibility factor for a real gas at high pressure is :- **[AIEEE-2012]**

(1) $1 - \frac{Pb}{RT}$ (2) $1 + \frac{PT}{Pb}$ (3) 1 a (4) $1 + \frac{Pb}{RT}$

Case - I   In low pressure region

$$\left(P + \frac{a}{V_m^2}\right)\left(V_m - \cancel{b}\right) = RT$$

low   low   high   Low

$$\boxed{Z = 1 - \frac{a}{V_m RT}}$$

$$PV_m + \frac{a}{V_m} = RT$$

$$Z = \frac{PV_m}{RT} = 1 - \frac{a}{V_m RT}$$

Case-IV At very high pressure :→

	P	V
At	high	low
At	very high	low

$$\left(P + \cancel{\frac{a}{V_m^2}}\right)\left(V_m - b\right) = RT$$

P: very high

$\frac{a}{V_m^2}$: high

V_m: low

b: low

$$\frac{PV_m}{RT} - \frac{Pb}{RT} = \frac{RT}{RT}$$

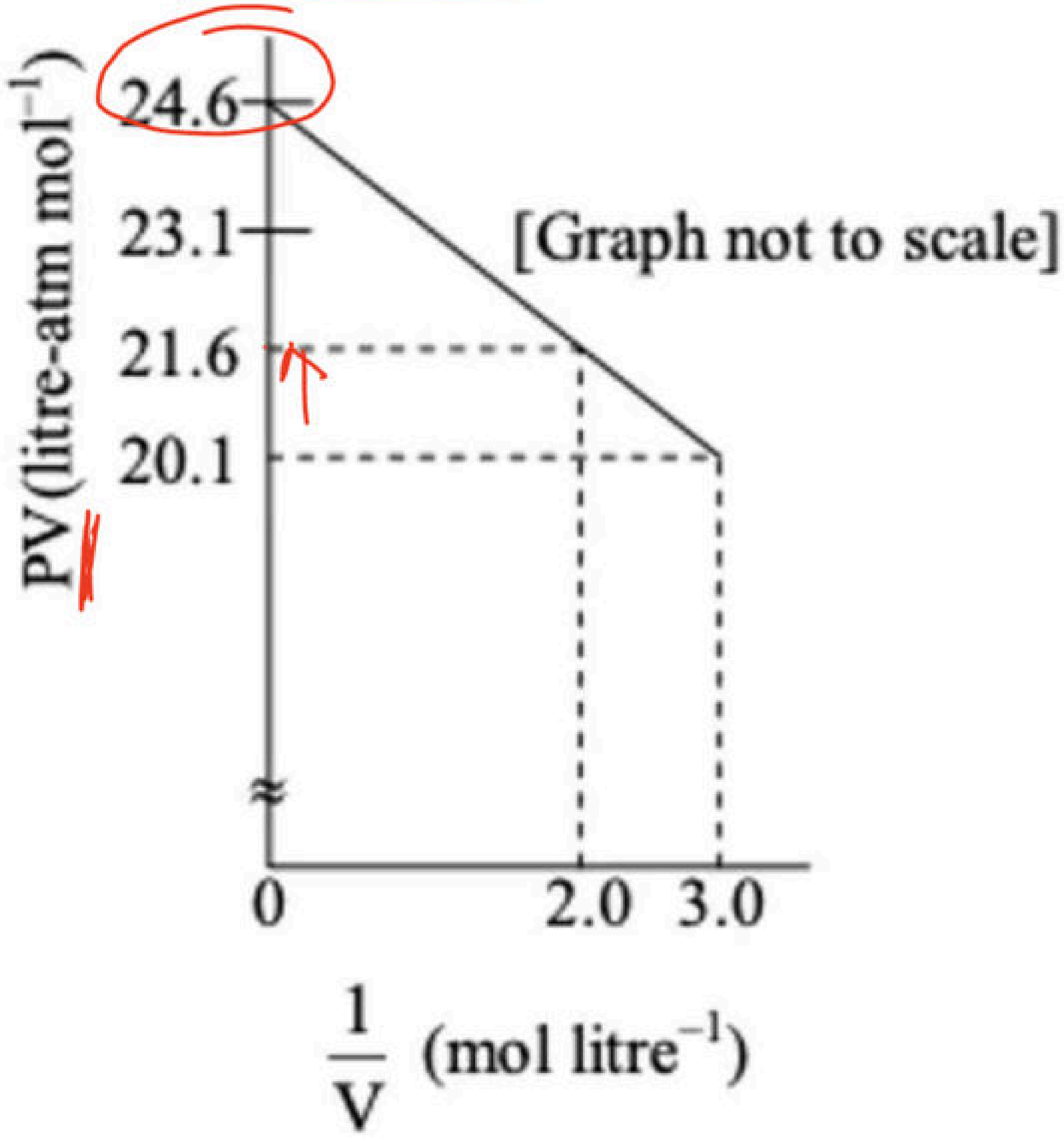
$$Z = 1 + \frac{Pb}{RT}$$

Q.13 For one mole of a van der Waals' gas when b = 0 and T = 300 K, the PV vs. 1/V plot is shown below. The value of the van der Waals' constant a (atm. litre^2 mol^{-2}) is

[JEE 2012]

$$\frac{PV_m}{RT} = 1 - \frac{a}{V_m RT}$$

$$PV_m = RT - a\left(\frac{1}{V_m}\right)$$



$$\frac{a}{1} = 1.5$$

$$RT = 24.6$$

(A) 1.0 (B) 4.5 (C) 1.5 (D) 3.0

S-1 1-14

NCERT ✓

very high

high →

low

very low

$$b = 4 \times \frac{4}{3}\pi r^3 \times N_A$$

radius