

1. Calculate the pressure exerted by 22 g of carbon dioxide in 0.5 dm³ at 300 K using:

(a) the ideal gas law and

(b) Van der Waal's equation respectively.

Given : [a = 3.6 atm litre²mol⁻², b = 0.04 litre mol⁻¹, R = 0.08 L-atm/K-mol]

①

Solution: $n_{CO_2} = \frac{22}{44} = \frac{1}{2}$ mole , V = 0.5 L , T = 300 K , P = ?

a) Ideal gas eqn: $PV = nRT$
 $\Rightarrow P = \frac{1}{2} \times \frac{(0.08)(300)}{0.5} = 24 \text{ atm.}$

b) Vanderwaal's gas eqn:

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

$$a = 3.6 \text{ atm L}^2\text{mol}^{-2} \quad b = 0.04 \text{ L mol}^{-1}$$

$$\Rightarrow \left(P + 3.6 \times \frac{0.5 \times 0.5}{0.5 \times 0.5}\right) (0.5 - 0.5 \times 0.04) = 0.5 \times 0.08 \times 300$$

$$\Rightarrow (P + 3.6)(0.5 - 0.02) = 12$$

$$\Rightarrow (P + 3.6) = 12 / 0.48 = 25$$

$$P = 25 - 3.6$$

$$P = 21.4 \text{ atm}$$

2. Calculate from the Van der Waals equation, the temperature at which 192 g of SO_2 would occupy a volume of 6 dm^3 at 15 atm pressure. [$a = 5.68 \text{ atm L}^2 \text{ mol}^{-2}$, $b = 0.06 \text{ L mol}^{-1}$]

2

Solution:

$$\text{Volume} = 6 \text{ dm}^3 = 6 \text{ L} \quad [\because 1 \text{ dm}^3 = 1 \text{ litre}] \quad (1 \text{ dm}^3 = 1 \text{ decimetre})$$

$$m_{\text{SO}_2} = 192 \text{ gm}, \quad P = 15 \text{ atm}$$

$$n_{\text{SO}_2} = \frac{192}{64} \quad \left[\begin{array}{l} \text{Given amount (in gm)} \\ \text{Molar Mass} \end{array} \right], \quad V = 6 \text{ L} \quad [\because 1 \text{ dm}^3 = 1 \text{ L}]$$

$$= 3 \text{ mole}$$

$$\text{Van der waal's gas eqn: } (P + \frac{a n^2}{V^2})(V - nb) = nRT$$

$$\Rightarrow \left(15 + \left(5.68 \times \frac{9}{6 \times 6} \right) \right) (6 - (3)0.06) = (3 \times 0.0821)T$$

$$\Rightarrow (15 + 1.42) (6 - 0.18) = (3 \times 0.0821)T$$

$$\Rightarrow \frac{16.42 \times 5.82}{3 \times 0.0821} = T$$

$$T = 388 \text{ K}$$

3. The density of water vapour at 328.4 atm and 800 K is 135.0 g/dm³. Determine the molar volume, V_m and the compression factor of water vapour.

(3)

Solution : density = $135 \frac{\text{gm}}{\text{dm}^3} = 135 \frac{\text{gm}}{L}$

here, $\therefore 135 \text{ gm vapour occupies} = 1 \text{ Litre}$

$$\therefore 18 \text{ gm vapour occupies} = \frac{1}{135} \times 18$$

$$= 0.1333 \text{ L/mole}$$

molar volume = 0.1333 L/mole

Compression factors ; $Z = \frac{P V_m}{R T}$

$$P = 328.4 \text{ atm} \quad T = 800 \text{ K} \quad V_m = 0.1333 \text{ L}$$

$$Z = \frac{328.4 \times 0.1333}{0.0821 \times 800}$$

$$Z = 0.667$$

4. At 300 K and under a pressure of 10.1325 MPa, the compressibility factor of O₂ is 0.9. Calculate the mass of O₂ necessary to fill a gas cylinder of 45 dm³ capacity under the given conditions.
 [R = 0.08 L-atm/K-mol]

(4)

Solution : $P = 10.1325 \text{ MPa}$ $\left[\because 1.01325 \times 10^5 \text{ Pa} = 1 \text{ atm} \right]$
 $= 100 \text{ atm}$

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

$$\Rightarrow Z = 0.9, \quad P = 100 \text{ atm} \quad V = 45 \text{ L} \quad n = \frac{w}{M_{O_2}} = \frac{w}{32}$$

$$\textcircled{1} \quad Z = \frac{PV}{nRT}$$

$$0.9 = \frac{100 \times 45 \times 32}{w \times 0.08 \times 300}$$

$$\Rightarrow w = \frac{100 \times 45 \times 32}{0.08 \times 300 \times 0.9} = 6.67 \text{ Kg.}$$

5. 1 mole of CCl_4 vapours at 27°C occupies a volume of 40 L. If Van der Waals constants are $24.6 \text{ L}^2 \text{ atm mol}^{-2}$ and 0.125 L mol^{-1} , then, calculate compressibility factor in
 (a) Low pressure region (b) High Pressure region [$R = 0.082 \text{ L-atm/K-mol}$]

If at 200 K & 500 atm density of CH_4 is 0.216 mol/L then its compressibility factor (Z) is

Solution 5) $n = 1 \text{ mole}$, $T = 300 \text{ K}$, $V = 40 \text{ L}$ $a = 24.6 \text{ L}^2 \text{ atm mol}^{-2}$
 $b = 0.125 \text{ L mol}^{-1}$

a) Low pressure region:

$$Z = 1 - \frac{a}{4RT}$$

$$Z = 1 - \frac{24.6}{40 \times 0.082 \times 300}$$

$$Z = 1 - 0.025$$

$$\boxed{Z = 0.975}$$

Using van der waal's eq: $(P + \frac{an^2}{V^2})(V - nb) = nRT$

$$\Rightarrow \left(P + \frac{24.6}{40 \times 40}\right)(40 - 0.125) = (0.082)300$$

$$\Rightarrow (P + 0.015375)(39.875) = 24.6$$

$$\Rightarrow (P + 0.015375) = 0.617$$

$$P = 0.617 - 0.015375$$

$$\boxed{P \approx 0.6 \text{ atm}}$$

b) High pressure region: $Z = 1 + \frac{Pb}{RT}$

$$Z = 1 + \frac{0.6 \times 0.125}{0.082 \times 300}$$

$$\boxed{Z = 1.003}$$

6. If at 200 K & 500 atm, density of CH_4 is 0.246 gm/ml then its compressibility factor (Z) is approx 2.0×10^x . 'x' is:

(6)

Solution: $d_{\text{CH}_4} = 0.246 \text{ gm/ml}$ $\left[\because d = \frac{w}{V} \right]$

$$\text{Molar volume} = \frac{1}{0.246} \times 16 \text{ ml.} = \frac{16}{0.246} \times 10^{-3} \text{ L}$$

$$Z = \frac{500 \times 16 \times 10^{-3}}{0.246 \times 0.0821 \times 200} \left[\because Z = \frac{PV_m}{RT} \right]$$

$$Z \approx 2$$

$$X = 0$$

$$Z = 2 \times 10^0$$

7. Certain mass of a gas occupy 500 ml at 2 atm and 27°C. Calculate the volume occupied by same mass of the gas at 0.3 atm and 227°C. The compressibility factors of gas at the given condition are 0.8 and 0.9, respectively.

K1

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

ATQ : $Z_1 = \frac{P_1 V_1}{n R T_1}$ $Z_2 = \frac{P_2 V_2}{n R T_2}$

$$\frac{Z_1}{Z_2} = \frac{P_1 V_1}{T_1} \times \frac{T_2}{P_2 V_2}$$

$$\Rightarrow \frac{0.8}{0.9} = \frac{2 \times 0.5}{300} \times \frac{500}{0.3(V_2)}$$

$$V_2 = 6.25 \text{ L}$$

8. The vander waal's constant for a gas are $a = 1.92 \text{ atm L}^2 \text{ mol}^{-2}$, $b = 0.06 \text{ L mol}^{-1}$. If $R = 0.08 \text{ L atm K}^{-1} \text{ mol}^{-1}$, what is the Boyle's temperatruo of this gas.

Solution: 8

$$T_B = \frac{a}{Rb} = \frac{1.92}{0.08 \times 0.06}$$

$$\boxed{T_B = 400 \text{ K}}$$

9. The Van der Waals constant for O_2 are $a = 1.642 \text{ atm L}^2 \text{ mol}^{-2}$ and $b = 0.04 \text{ L mol}^{-1}$. Calculate the temperature at which O_2 gas behaves ideally for longer range of pressure.

Solution: 9 At Boyle's temp^o, gas behaves ideally for longer range of pressure.

$$So, T_B = \frac{a}{Rb} = \frac{1.642}{0.0821 \times 0.04}$$

$$\boxed{T_B = 500 \text{ K}}$$

10. The Van der Waals constants for gases A, B and C are as follows

Gas	a/[atm L ² mol ⁻²]	b/[L mol ⁻¹]
A	8.21	0.050
B	4.105	0.030
C	1.682	0.040

Which gas has (i) the highest critical temperature, (ii) the largest molecular volume, and (iii) most ideal behaviour around 500 K?

Solution: i) $T_c = \frac{8}{27} \left(\frac{a}{Rb} \right) = \frac{8}{27} (T_B)$

ii) As b increases Volume increases.

iii) $T_B = \frac{a}{Rb}$

for gas 'A': $T_B = \frac{8.21}{(0.0821) 0.05} = 2000\text{K}$

$$T_c = \frac{8}{27} \times T_B = \frac{8}{27} (2000) = 592.6\text{K}$$

for gas 'B': $T_B = \frac{4.105}{(0.0821) 0.03} = \frac{5000}{3} = 1666.66\text{K}$

$$T_c = \frac{8}{27} (T_B) = \frac{8}{27} \times \frac{5000}{3} = 493.82\text{K}$$

for gas 'C': $T_B = \frac{1.682}{(0.0821) (0.04)} = \cancel{512.18}\text{K}$

$$T_c = \frac{8}{27} (T_B) = \frac{8}{27} (512.18) = 151.75\text{K}$$

11. For a real gas, if at critical conditions molar volume of gas is 8.21 litre at 3 atm, then critical temperature (in K) will be :

Solution: 1) At critical conditions, $P = P_c$, $T = T_c$, $V_m = V_c$
 $\gamma = 3/8$

$$\text{So, } \gamma = \frac{P_c V_c}{R T_c}$$

$$\frac{3}{8} = \frac{3 \times 8.21}{0.0821 (T_c)}$$

$$T_c = 800 \text{ K}$$

12. An unknown gas behaves ideally at 540K in low pressure region, then calculate the temperature
(in K) below which it can be liquified by applying pressure

Solution: In low pressure region, gas behaves ideally at Boyle's temp., So $T_B = \frac{a}{Rb} = 540\text{K}$

Below critical temperature, gas can be liquified.

$$T_c = \frac{8}{27} \frac{a}{Rb} = \frac{8}{27} \times 540$$

$T_c = 160\text{K}$

1. The density of mercury is 13.6 g/cm³. Estimate the value of 'b' (in cm³/mole).

$$\textcircled{1} \text{ molar volume of mercury} = \frac{200}{13.6} \text{ cm}^3$$

$$\text{so value of } b = \frac{200}{13.6} \times 4 = 58.82$$

2. The molarity of O₂ gas at 72 atm and 300K is 6M. Calculate the value of Z for O₂.
(Use : R = 0.08 atm-litre/K-mole).

$$\textcircled{2} \quad PV = ZnRT$$

$$P = Z \frac{n}{V} RT$$

$$P = Z CRT$$

$$72 = Z(6)(0.08 \times 300)$$

$$Z = 0.5$$

3. Calculate the amount of He (in gm) present in the 10 litre container at 240 atm and 300K. Given value of "b" for He is $0.08 \text{ dm}^3 \text{ mol}^{-1}$; $R = 0.08 \text{ atm lit mol}^{-1} \text{ K}^{-1}$.

$\frac{P}{n}$

$$P(V - nb) = nRT$$

$$240(10 - 0.08n) = n(0.08)(300)$$

$$240(10 - 0.08n) = 24n$$

$$100 - 0.8n = 24n$$

$$n = \frac{100}{1.8} \Rightarrow \text{mass of He} = \frac{100}{1.8} \times 4 \\ = 222.22 \text{ gm}$$

4. For a real gas (mol. mass = 30) if density at critical point is 0.40 g/cm^3 and its $T_c = \frac{2 \times 10^5}{821} \text{ K}$, then calculate Van der Waals constant a (in $\text{atm L}^2 \text{ mol}^{-2}$).

4: critical volume $V_c = \frac{\text{molar mass}}{\text{density at}}$

$$V_c = \frac{30}{0.4} \text{ c.m}^3$$

$$V_c = 75 \text{ c.m}^3$$

$$3b = 75$$

$$b = 25 \frac{\text{c.m}^3}{\text{mol}} = 0.025 \frac{\text{litrre}}{\text{mol}}$$

$$T_c = \frac{2 \times 10^5}{821}$$

$$\frac{8a}{27Rb} = \frac{2 \times 10^5}{821}$$

$$\frac{8a}{27 \times 0.0821 \times 0.025} = \frac{2 \times 10^5}{821}$$

$$a = 1.6875 \text{ atm L}^2 \text{ mol}^{-2}$$

5. Calculate the volume occupied by 0.2 mole of a Vander waal gas at 27°C and 0.0821 atm.

$$[a = 4.105 \text{ L}^2 \text{ atm mol}^{-2}, b = \frac{1}{6} \text{ L mol}^{-1}]$$

c

$$T_b = \frac{a}{Rb} = \frac{4.105}{(0.0821)(1/6)} = 300 \text{ K}$$

so at 300 K this gas will behave like
ideal gas

$$PV = nRT$$

$$(0.0821)V = 0.2(0.0821)(300)$$

$$V = 60 \text{ litre}$$

6. At what pressure and 127°C, the density of O₂ gas becomes 1.6 g/L ?

[a = 4.0 atm L² mol⁻², b = 0.4 Lmol⁻¹, R = 0.08 L - atm/ K-mol]

*6 mass of 1 litre gas = 1.6 gm

$$= \frac{1.6}{32} = \frac{1}{20} \text{ mol}$$

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

$$\left(P + \frac{4(\frac{1}{20})^2}{(\cancel{100})^2} \right) \left(1 - \frac{1}{20} \times 0.4 \right) = \frac{1}{20} \times 0.08 \times 400$$

$$\left(P + \frac{1}{100} \right) (0.98) = 1.6$$

$$P = 1.622 \text{ atm}$$

1 The correct expression for the Van der Waals equation of state is :

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

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

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

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

① vanderwaal's equation for n mole of gas

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

Correct option (D)

2 At relatively high pressure, Van der Waals equation reduces to :

(A) $PV_m = RT$

(B) $PV_m = RT + \frac{a}{V_m}$

(C) $PV_m = RT + Pb$

(D) $PV_m = RT - \frac{a}{V_m^2}$

② for one mole of real gas, vanderwaal's equation can be written as

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

and at high pressure, value of $\frac{a}{V_m^2}$ can

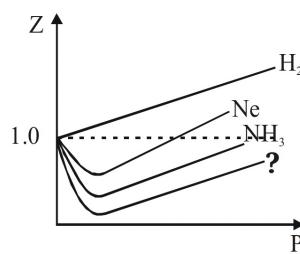
be neglected w.r.t to P .

∴ $(P)(V_m - b) = RT$

$$PV_m = RT + Pb$$

Correct option (C)

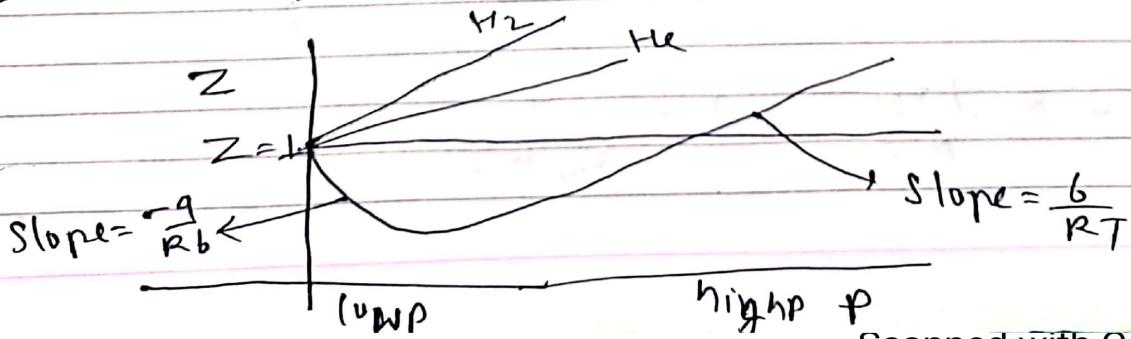
3 Observe the following Z vs P graph.



The missing gas in the above graph can be :

- (A) He (B) Ar (C) C₅H₁₂ (D) All are correct

③ Z vs p graph for real ideal gas



At low pressure region.

$$\text{Slope} = -\frac{a}{RT}$$

and for larger value of a, slope will be more negative. and for C₅H₁₂, value of a is maximum due to its larger size, correct option (C)

- 4 Correct option regarding a container containing 1 mol of a gas in 22.4 litre container at 273 K is
- (A) If compressibility factor (Z) > 1 then 'P' will be less than 1 atm.
 - (B) If compressibility factor (Z) > 1 then 'P' will be greater than 1 atm.
 - (C) If 'b' dominates, pressure will be less than 1 atm.
 - (D) If 'a' dominates, pressure will be greater than 1 atm.

④ for ideal gas, pressure of one mole of gas in a 22.4 L container at 273 K will be 1 atm.

In case of real gas, for $Z > 1$, repulsive forces exist between molecules and so pressure will be greater than one atm.

b dominates means more repulsion and a dominates means more attraction and if more attraction is there, pressure will be less than one atm and vice versa.

(B)

5. If 'V' is actual volume of 1 molecule of gas then, excluded volume (b) of 1 mole of gaseous molecule is -

- (A) $4 N_A V$ (B) $N_A V$ (C) V/N_A (D) V

⑤ actual volume of 1 molecule = V
So excluded volume of 1 molecule = $4V$
and excluded volume of one mol
of gas molecules = $4 \times N_A \times V$

(A)

6. Consider the equation $Z = \frac{PV}{RT}$, Which of the following statements is correct :

- (A) When $Z > 1$ real gases are easier to compress
(B) When $Z = 1$ real gases are easier to compress
(C) When $Z > 1$ real gases are difficult to compress
(D) When $Z < 1$ real gases are difficult to compress

⑥ when $Z < 1$, attraction forces exist and in this condition real gases are easier to compress.

$Z = 1$, means there is no attraction or repulsion.

and if $Z > 1$, due to force of repulsion real gases are difficult to compress.

(C)

- 7.. Compressibility factor of ideal gas is :-

- (A) $z > 1$ (B) $z > 1$ (C) $z = 1$ (D) $z = \infty$

⑦ compressibility factor (Z) for ideal gas is 1. (C)

8. The density of a gaseous substance at 1 atm pressure and 750 K is 0.30 g/lt. If the molecular weight of the substance is 27, the dominant forces existing among gas molecules is -
 (A) Attractive (B) Repulsive (C) Both (A) and (B) (D) None of these

(8)

$$PM = Z \alpha RT$$

$$Z = \frac{PM}{\alpha RT}$$

$$Z = \frac{1 \times 27}{0.3 \times 0.0821 \times 750}$$

$$Z = 1.46$$

$Z > 1$, so repulsive forces exist among gas molecules.

9. The third virial coefficient of a He gas is 4×10^{-2} (lit/mol)², then what will be volume of 2 mole He gas at 1 atm 273K ($273K > T_B$)
 (A) 22.0 lit (B) 44.0 lit (C) 44.8 lit (D) 45.3 lit

(9)

$273K > T_B$, means force of repulsion is present. the van der waal's coefficient a can be neglected.

third viral Coefficient $b^2 = 4 \times 10^{-2}$ (lit/mol)²

$$b = 2 \times 10^{-1} \text{ lit/mol}$$

$$P(V - nb) = nRT$$

$$1(V - 2 \times 0.2) = 2 \times 0.0821 \times 273$$

$$V - 0.4 = 44.8$$

$$V = 45.2 \text{ L}$$

(D)

10. At low pressure the vander waals equation is reduced to -

$$(A) Z = \frac{pV_m}{RT} = 1 - \frac{a}{RTV_m}$$

$$(B) Z = \frac{pV_m}{RT} = 1 + \frac{a}{RT} p$$

$$(C) pV_m = RT$$

$$(D) Z = \frac{pV_m}{RT} = 1 - \frac{a}{RT}$$

(10) ~~vanderwaal's gas equation for one mole of gas~~

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

Low pressure \rightarrow high volume
 $V_m - b \approx V_m$

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

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

(A)

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

11. The values of Van der Waals constant 'a' for the gases O₂, N₂, NH₃ and CH₄ are 1.360, 1.390, 4.170 and 2.253 L atm mol⁻² respectively. The gas which can most easily be liquefied is :

(A) O₂

(B) N₂

(C) NH₃

(D) CH₄

(11) ~~The 'a' values for a given gas~~ 9x

measure of intermolecular forces of attraction.
 more is the value of 'a', more will be the
 intermolecular forces of attraction and
 easier to liquefy.

(C)

12. The values of critical temperatures of few gases are given below:

Gases : H₂ He O₂ N₂

T_c(K) 33.2 5.2 154.3 126

From the above data arrange the given gases in the increasing order of ease of their liquification.

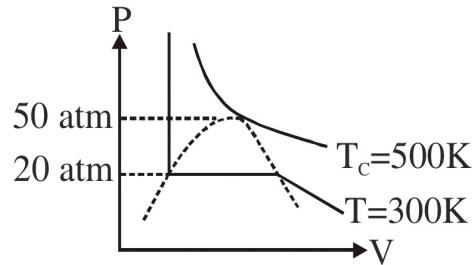
- (A) O₂, N₂, H₂, He (B) He, N₂, O₂, H₂ (C) He, H₂, N₂, O₂ (D) H₂, N₂, O₂, He

Ques 12 Order to ease to liquification of g & T_c

$$T_c = \frac{89}{273.16}$$

Ans

1. For real gas the P-V curve was experimentally plotted and it had the following appearance. With respect to liquification, choose the incorrect statement :



- (A) At $T = 500 \text{ K}$, $P = 40 \text{ atm}$, the state will be liquid
(B) At $T = 300 \text{ K}$, $P = 50 \text{ atm}$, the state will be gas
(C) At $T < 300 \text{ K}$, $P = 20 \text{ atm}$, the state will be gas
(D) At $300 \text{ K} < T < 500 \text{ K}$, $P > 50 \text{ atm}$, the state will be liquid

① from graph

- Ⓐ At $T = 500 \text{ K}$, $P = 40 \text{ atm}$ the state will be gas.
- Ⓑ At $T = 300 \text{ K}$, $P = 50 \text{ atm}$ the state will be liquid.
- Ⓒ At $T < 300 \text{ K}$, $P = 20 \text{ atm}$, the state will be liquid
- Ⓓ At $300 \text{ K} < T < 500 \text{ K}$, $P > 50 \text{ atm}$ the state will be liquid.
so option A, B & C are incorrect.
- ② Ⓛ

2. Select the incorrect statement (s)

- (A) The critical constant for a Vander Waal's gas is $V_c = 3b$, $P_c = \frac{a}{27b^2}$ and $T_c = \frac{a}{27Rb}$
- (B) At 56 K a gas may be liquified if its critical temperature is -156°C .
- (C) U_{avg} of gas in a rigid container can be doubled when the pressure is quadrupled by pumping in more gas at constant temperature
- (D) At extremely low pressure, all real gases behave ideally.

..... incorrect.

- ② A Critical vol $V_c = 3b$.
 Critical Pressure $P_c = \frac{a}{27b^2}$
 Critical temp $T_c = \frac{8a}{27Rb}$
- B $T_c = -156^\circ\text{C} = 117\text{ K}$
 Gas can be liquid below critical temperature
- C $U_{\text{Avg}} = \sqrt{\frac{8RT}{\pi M}}$, so no effect of pressure at constant temperature.
- D Extremely low pressure i.e. very high volume
 a & b neglected so real gas behave as a ideal gas.
 Option A & C are incorrect.

3. A 1 litre vessel contains 2 moles of a vanderwaal's gas.

Given data : $a = 2.5 \text{ atm-L}^2 \text{ mole}^{-2}$ $T = 240 \text{ K}$

$b = 0.4 \text{ L-mole}^{-1}$ $RT = 20 \text{ L-atm mole}^{-1}$

Identify the correct options about the gas sample :

- (A) Pressure of gas = 190 atm
- (B) Compressibility factor = 4.75
- (C) Attraction forces are dominant in the gaseous sample
- (D) T_B (Boyle temperature) = 75 K

③ Vanderwaal's equation:

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

$$\left(P + \frac{2.5 \times 2^2}{1^2} \right) (1 - 2 \times 0.4) = 2 \times 20$$

$$(P + 10)(0.2) = 40$$

$$P = 190 \text{ atm}$$

Compressibility factor

$$Z = \frac{PV}{nRT} = \frac{190 \times 1}{2 \times 20} = \frac{19}{4} = 4.75$$

$Z > 1$, so repulsion force dominate

$$\text{Boyle Temperature } T_B = \frac{a}{Rb} = \frac{2.5}{\frac{20 \times 0.4}{240}}$$

$$= 75 \text{ K}$$

Option A, B, D are correct

4. Choose the correct statement(s) among the following -

- (A) A gas having higher value T_c is easy to liquify
- (B) The radius of molecules of gas having same value of T_c/P_c is same
- (C) Hydrogen gas can be liquified at its boyle temperature by application of pressure.
- (D) Real gas show negative deviation from ideal behaviour at low pressure condition.

④ (A) Higher the T_c , faster is the liquification of gas.

(B) $\frac{T_c}{P_c} = \frac{8a/27Rb}{a/27b^2} = \frac{8}{R} b$

i.e. $\frac{T_c}{P_c} \propto b$

b = size (radius) of molecule
Vanderwaal const
particular gas b is same.

(C) Hydrogen is an almost permanent gas

(d) In low pressure region $Z < 1$
Real gas show negative deviation
from ideal behaviour.

Select the INCORRECT statement(s):

- (A) At Boyle's temperature a real gas behaves like an ideal gas irrespective of pressure.
- (B) At critical condition, a real gas behaves like an ideal gas.
- (C) On increasing the temperature four times, collision frequency (Z_1) becomes double at constant volume.
- (D) At high pressure Van der Waals constant 'b' dominates over 'a'.

5

(A) Boyle's temperature: The temperature at which real gas behave as an ideal gas over an appreciable pressure range.

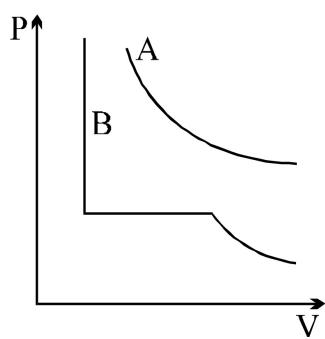
(B) Real gas behaves like an ideal gas at low pressure & high temperature, not at critical condition.

(C) At constant volume,
Collision frequency $Z_1 \propto \sqrt{T}$
if we take four-times temperature.
then collision frequency will be double.

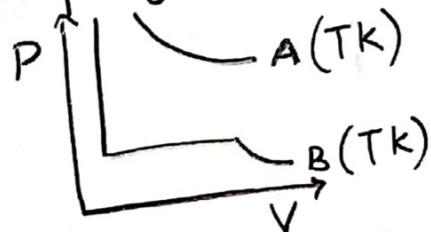
(D) At high pressure 'b' dominates over 'a'

6. Which of the following is true?

- (A) $T_A < T < T_B$ (B) $T_A > T > T_B$
- (C) $T_A > T_B > T$ (D) none of above



⑥ Graph given



for A, critical temp (T_A) below T
temperature i.e. $T > T_A$

for B, critical temp (T_B) above T
temperature i.e. $T < T_B$

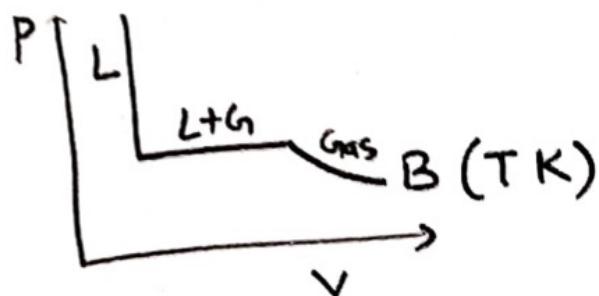
Hence $\frac{1}{T_A} < \frac{1}{T} < \frac{1}{T_B}$

7. The correct statement(s) is/are

- (I) Pressure correction term will be more negligible for gas B at T K.
 - (II) The curve for gas 'B' will be of same shape as for gas A if $T > T_B$
 - (III) Gas 'A' will show same P v/s V curve as of gas 'B' if $T > T_A$
- (A) III only
 - (B) II and III
 - (C) II only
 - (D) All

⑦ Graph of B only

(I)



Graph of B represent gas
can be liquid so pressure
correction term i.e 'a' can never
be negligible.

(II) If $T > T_B$ then graph of B
gas like



Which is same shape of gas 'A' graph.

(III) If $T > T_A$ then graph of A
gas



This curve is not same as gas
'B' curve.

only II option is correct.

8.

Match the column :

Column-I

- (A) Boyle's temperature
 (B) Compressibility factor
 (C) Real gas with very large molar volume
 (D) Critical temperature

Column-II

- (P) Depends on 'a' and 'b'
 (Q) Depends on identity of real gas
 (R) The temperature at which $\frac{dZ}{dP} = 0$
 at low pressure region.
 (S) $PV = nRT$
 (T) $\frac{8a}{27Rb}$

Ⓐ Boyle's temperature (T_B) : → The temperature at which real gas behave as an ideal gas in low pressure range.

$$T_B = \frac{8a}{27Rb}$$

T_B is depend on 'a' & 'b' Which is identity of real gas.

In low pressure region Compressibility factor

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

$$\frac{dZ}{dP} = 0$$

Correct option for A → P, Q, R, S

Ⓑ Compressibility factor depends on 'a' & 'b'.

Option for B → P, Q

Ⓒ Real gas very large molar volume i.e $V_m \rightarrow \infty$, $P \rightarrow 0$ so a & b neglect so gas behave as an ideal gas.

Option for C → S

Ⓓ Critical temperature (T_c)

$$T_c = \frac{8a}{27Rb}$$

Option for D → P, Q, T

- 1 'a' and 'b' are Van der Waals constants for gases. Chlorine is more easily liquefied than ethane because :-

[AIEEE-2011]

- (1) a for Cl_2 < a for C_2H_6 but b for Cl_2 > b for C_2H_6
- (2) a for Cl_2 > a for C_2H_6 but b for Cl_2 < b for C_2H_6
- (3) a and b for Cl_2 > a and b for C_2H_6
- (4) a and b for Cl_2 < a and b for C_2H_6

REAL GAS

JEE-MAINS

Solⁿ 1. 'b' represent size of gas molecules and 'a' represent attraction between gas molecules. When any gas represent more attraction its value is ^{high} ~~then the~~ ^{so} gas is ^{more} easily liquified ~~is~~ and size of gas molecules i.e. 'b' is less. So in Question ~~chlorine~~ chlorine is more easily liquified so it value of 'a' is more than 'a' value of C_2H_6 ~~but~~ but 'b' for Cl_2 is less than C_2H_6 .

2. When does a gas deviate the most from its ideal behaviour ? [JEE-MAINS(ONLINE)-2015]

- (1) At high pressure and low temperature
- (2) At high pressure and high temperature
- (3) At low pressure and low temperature
- (4) At low pressure and high temperature

Solⁿ 2. Experimentally found that at low pressure and high temperature real gas behave as a ideal gas.

But a gas deviate the most from its ideal behaviour at high pressure and low temperature.

3. If Z is the compressibility factor, Van der Waals equation at low pressure can be written as :

[JEE-MAINS-2014]

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

Soln 3.

Vanderwaal's eqn:

$$\left(P + \frac{a}{V_m^2} \right) (V_m - b) = RT \quad \dots \dots \dots \textcircled{1}$$

at low pressure $b \approx 0$ so eqn $\textcircled{1}$

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

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

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

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

4. Among the following, the incorrect statement is :

[JEE-Mains-2017(ONLINE)]

- (1) At low pressure, real gases show ideal behaviour
(2) At very large volume, real gases show ideal behaviour
(3) At Boyle's temperature, real gases show ideal behaviour
(4) At very low temperature, real gases show ideal behaviour

Ans ④

- ① At low pressure real gas behave as a ideal gas.
② At very large molar volume real gas behave as a ideal gas.
③ At Boyle's temperature, real gas also show ideal behaviour.
④ At very high temperature real gas behave as a ideal gas.
But in question statement ④ are incorrect because in statement ④ at very low temp is given in which real gas show ideal behaviour.

5. The volume of gas A is twice than that of gas B. The compressibility factor of gas A is thrice than that of gas B at same temperature. The pressures of the gases for equal number of moles are :

(1) $2P_A = 3P_B$
 . (3) $P_A = 2P_B$

(2) $P_A = 3P_B$
 . (4) $3P_A = 2P_B$

[JEE-MAINS-2019]

Soln's.

Compressibility factor

$$Z = \frac{PV}{nRT} \quad \text{for A} \quad Z_A = \frac{P_A V_A}{n_A R T_A}, \quad \text{for B} \quad Z_B = \frac{P_B V_B}{n_B R T_B}$$

given that $V_A = 2V_B$, $n_A = n_B$

$$Z_A = 3Z_B, T_A = T_B$$

$$\frac{Z_A}{Z_B} = \frac{P_A V_A / n_A R T_A}{P_B V_B / n_B R T_B}$$

$$\frac{Z_A}{Z_B} = \frac{P_A V_A}{P_B V_B}$$

$$\frac{3Z_B}{Z_B} = \frac{P_A}{P_B} \times \frac{2V_B}{V_B}$$

$$3 = \frac{P_A}{P_B} \times 2$$

$$2P_A = 3P_B$$

6. At a given temperature T, gases Ne, Ar, Xe and Kr are found to deviate from ideal gas behaviour.

Their equation of state is given as $P = \frac{RT}{V-b}$ at T.

[JEE-MAINS-2019]

Here, b is the van der Waals constant. Which gas will exhibit steepest increase in the plot of Z (compressibility factor) vs p?

- (1) Ne (2) Ar (3) Xe (4) Kr

eqn $P = \frac{RT}{V-b}$

We can say that $V-b$ from eqn

'b' dominate & 'a' is negligible

~~because eqn has~~ 'b' represent size of molecule. If b more \Rightarrow size of molecule more. Xe has more size \Rightarrow this gas will exhibit steepest increase in the plot of Z vs P.

$$P = \frac{RT}{V-b}$$

$$P(V-b) = RT$$

$$PV - Pb = RT$$

$$\frac{PV}{RT} - \frac{Pb}{RT} = 1$$

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

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

so $b \uparrow \Rightarrow Z \uparrow$ i.e. size of molecules $\uparrow \Rightarrow Z \uparrow$

7. Consider the van der Waals constants, a and b, for the following gases.

Gas	Ar	Ne	Kr	Xe
a/ (atm dm ⁶ mol ⁻²)	1.3	0.2	5.1	4.1
b/ (10 ⁻² dm ³ mol ⁻¹)	3.2	1.7	1.0	5.0

[JEE-MAINS-2019]

Which gas is expected to have the highest critical temperature?

(1) Kr

(2) Ne

(3) Ar

(4) Xe

⑦

∴ critical temperature

$$T_c = \frac{8a}{27Rb}$$

for high value of $T_c \rightarrow a$ value is high
& b value is low.

for Kr, a is more & b is low.

8. Consider the following table :

[JEE-MAINS-2]

Gas	a/(k Pa dm ⁶ mol ⁻¹)	b/(dm ³ mol ⁻¹)
A	642.32	0.05196
B	155.21	0.04136
C	431.91	0.05196
D	155.21	0.4382

a and b are vander waals constant. The correct statement about the gases is :

- (1) Gas C will occupy lesser volume than gas A; gas B will be lesser compressible than gas D
- (2) Gas C will occupy more volume than gas A; gas B will be lesser compressible than gas D
- (3) Gas C will occupy more volume than gas A; gas B will be more compressible than gas D
- (4) Gas C will occupy lesser volume than gas A; gas B will be more compressible than gas D

Soln ⑧

In the question 'a' & 'b' value are given

for different gases.

'a' represent force of attraction between gas molecules and 'b' represent repulsion

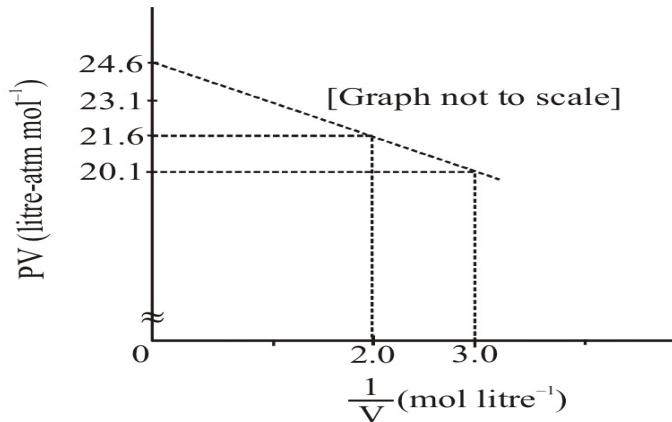
If any gas has more attraction then gas has ~~less~~ more compressible and occupy lesser volume.

If any gas has more repulsion i.e. b has more so this gas has lesser compressible.

so in ~~question~~ question for C & A gases have same value of 'b' so we decide according to value of 'a' \Rightarrow a value of A gas is high as compare to C \Rightarrow so ~~more~~ lesser volume occupy of A gas than C

for B & D gases have same value of 'a' so we decide according to value of 'b'. If value of b is ~~high~~ low, gas has more compressible. Gas B will be more compressible than gas D.

1. For one mole of a Van der Waals gas when $b = 0$ and $T = 300 \text{ K}$, 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]



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

