

23. VANDER WAAL'S EQUATION

23.1 In order to explain the behaviour of real gases, it is therefore necessary to apply suitable corrections to the ideal gas equation. It was van der Waal (in 1873) suggested two corrections.

- (i) Volume correction
- (ii) Pressure correction

23.2 Since none of the gases is known to behave according to ideal gas equation, these gases are called as *real gases*.

23.3 $(P + a/V^2)(V - b) = RT$ (for one mole of the gas)

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT \text{ (for } n \text{ mol. of the gas)}$$

23.4 It is the modification of ideal gas equation $PV = nRT$

a and b are van der Waal's constants whose values depend on the nature of the gas.

23.5 The Vander Waal's Constant 'a' is a measure of the magnitude of the attractive forces among the molecules of the gas. Greater is the value of 'a' larger are the intermolecular forces of attraction. It has value in the order of $SO_2 > NH_3 > H_2O > CO$.

23.6 Units of 'a' are $atm L^2 mol^{-2}$ or $atm dm^6 mol^{-2}$ or $Nm^4 mol^{-2}$.

23.7 The constant 'b' is effective volume of gas molecules. Larger the value of 'b' larger the molecular volume and diameter.

23.7.1 The constant b is also called *co-volume* or *excluded volume*. The excluded volume for n molecules of gas = $4n v_m$ i.e., it is 4 times the actual volume occupied by a molecule (v_m)

23.8 Units of 'b' are $L mol^{-1}$ or $m^3 mol^{-1}$

23.9 Calculation of Van der Waal's constants 'b' and 'a' :

Excluded volume is nb for n moles of gases.

$$\therefore b = \frac{\text{Volume}}{n} = \frac{\text{litre}}{\text{mole}}$$

Thus, unit of 'b' is litre Per mole or $m^3 mole^{-1}$

$$\text{From equation } P_{\text{correction}} = \frac{an^2}{V^2}$$

$$a = \frac{PV^2}{n^2} = \frac{(\text{Pressure})(\text{Volume})^2}{(\text{mole})^2}$$

$$= \frac{(Nm^{-2})(m^3)^2}{(\text{mole})^2} = Nm^4 mole^{-2}$$

or $atm litre^2 mole^{-2}$

23.10 Van der Waal's equation at different Temperature and Pressure**Condition I** : When Pressure is extremely low :

For one mole of gas

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

or $PV = RT - \frac{a}{V} + Pb + \frac{ab}{V^2}$

Condition II : When Pressure is extremely high :

For one mole of gas

$$PV = RT + Pb$$

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

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

where Z is compressibility factor.

Condition III : When temp. is extremely high:

For one mole of gas

$$PV = RT.$$

Condition IV : When Pressure is low :

For one mole of gas

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

or $PV = RT + Pb - \frac{a}{V} + \frac{ab}{V^2}$

or $\frac{PV}{RT} = 1 - \frac{a}{VRT}$

or $Z = 1 - \frac{a}{VRT}$

Condition V : For hydrogen :

Molecular mass of hydrogen is small hence value of 'a' will be small owing to smaller intermolecular

force. Thus the terms $\frac{a}{V}$ and $\frac{ab}{V^2}$ may be ignored. Then Van der Waal's equation becomes

$$PV = RT + Pb$$

or $\frac{PV}{RT} = 1 + \frac{Pb}{RT}$

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

in case of hydrogen compressibility factor is always greater than one.

GASEOUS STATE

23.11 Vander wall constant of some gases

[Note :- Only for Reference]

Name of Gas	a		b	
	Atm litre ²	Nm ⁴ mole ⁻²	litre mole ⁻¹	10 ³ m ³ mole ⁻¹
Hydrogen	0.245	0.0266	0.0266	0.0266
Oxygen	1.360	0.1378	0.0318	0.0318
Nitrogen	1.390	0.1408	0.0391	0.0391
Chlorine	6.493	0.6577	0.0562	0.0562
Carbon dioxide	3.590	0.3637	0.0428	0.0428
Ammonia	4.170	0.4210	0.0371	0.0371
Sulphur dioxide	6.710	0.678	0.0564	0.0564
Methane	2.253		0.0428	

23.12 Merits of Vander Waal's Equation :

- The van der Waals' equations holds good for real gases upto moderately high pressures.
- The equation represents the trend of the isotherms representing the variation of PV with P for various gases.
- From the Van der Waal's equation it is possible to obtain expressions for Boyle temperature, critical constants and inversion temperature in terms of the van der Waal's constants 'a' and 'b'
- van der Waal's equation is useful in obtaining a 'reduced equation of state' which being a general equation of state has the advantage that a single curve can be obtained for all gases when the equation is graphically represented by plotting the variables.

24. DEVIATION FROM IDEAL GAS BEHAVIOUR

24.1 Real gases deviate from ideal behaviour because of the following two faulty assumptions of kinetic theory.

- The actual volume occupied by the molecules is negligible as compared to the total volume of the gas.
- The forces of attraction and repulsion between the molecules of the gas are negligible.

25. COMPRESSIBILITY FACTOR

25.1 The extent of deviation of a real gas from ideal behaviour is expressed in terms of compressibility factor Z.

25.2 It is mathematically expressed as

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

(The plot of Z v/s P for N₂ gas at different temperature is shown here)

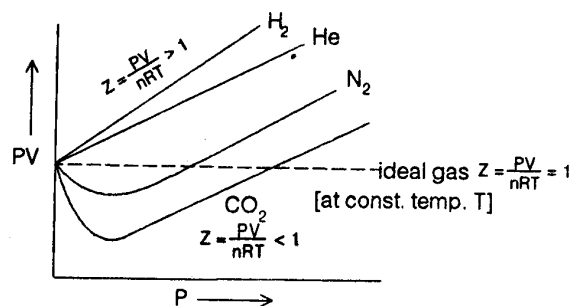


Fig. 4 Deviations of gases from ideal gas behaviour at constant temperature.

25.3 Greater is the departure of Z from unity more is the deviation from ideal behaviour.

- (i) When $Z < 1$, this implies that gas is more compressible
- (ii) When $Z > 1$, it means the gas is less compressible
- (iii) When $Z = 1$, the gas is ideal.

25.4 If $Z < 1$ the gas is said to show negative deviations i.e., it is more compressible than expected from ideal behaviour if $Z > 1$ the gas is said to show Positive deviations.

25.5 For most gases, $Z < 1$ at low Pressures and increases with Pressure and then becomes > 1 . For H_2 and He, Z is always greater than 1, This is because of their small size, than negligible.

25.6 As the temp. increases, the deviation form ideal behaviour decreases. The temp. at which a real gas behaves like an ideal gas is called Boyle temperature.

25.7 Gases behave like ideal gases only at high temp. and low Pressure.

25.8 Easily liquefiable gases e.g., CO_2 , SO_2 , NH_3 etc. deviate more from ideal behaviour.

26. OTHER EQUATIONS OF STATE

26.1 Clausius equation $\left[P + \frac{a}{T(V+c)^2} \right] (V - b) = RT$. Here c is an other constant besides a , b and R .

26.2 Bertgelot equation $\left(P + \frac{a}{TV^2} \right) (V - b) = RT$. On simplifying the equation expressing a , b and R in terms of critical constant we get the equation :

$$PV = RT \left[1 + \frac{a}{128 P_C} \frac{T_e}{T} \left(1 - 6 \frac{T_C^2}{T^2} \right) \right].$$

26.3 Dieterici Equation $P = \frac{RT}{V-b} \cdot e^{-a/RTV}$. The expression is derived on the basis of the concept that molecules near the well will have higher Potential energy then those in the bulk.

GASEOUS STATE

26.4 Kammealingh onnes equation. It is the most general or satisfactory expression for equation expresses PV as a power series of P at given temperature.

$$PV = A + BP + CP^2 + DP^3 + \dots$$

Here coefficients A, B, C etc. are known as first, second and third etc. viral temperature.

- * Viral coefficients are different for different gases.
- * At very low Pressure, first viral coefficient = RT.
- * At high pressure, other viral coefficient also become important and must be considered.

27. BOYLE'S TEMPERATURE

27.1 The temperature at which the real gas exhibits ideal behaviour for considerable range of pressure-

$$T_b = \frac{a}{bR} \text{ (Where a and b are vander waal's constant)}$$

27.2 At this temperature the PV - P curve (Known as Amagats's isotherm) is parallel to the P axis.

27.3 The Boyle's temp. Varies from one gas to another.

27.4 If for any gas, the constant experimental temperature is below the Boyle temp., the compressibility

factor Z (equal to $\frac{PV}{RT}$) first decreases from unity and then starts increasing, exceeding unity at very high pressure (Fig)

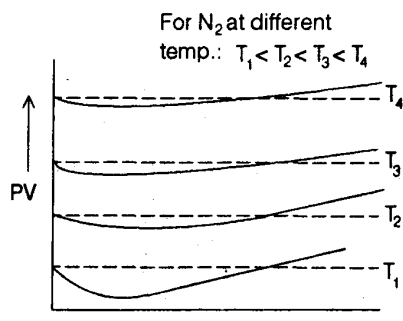


Fig. 5 Deviations of gases from ideal gas behaviour - temperature effect.

Example. Nitrogen and carbon dioxide

27.5 If the constant experimental temp. is above the Boyle temp. of the gas there is no dip in the PV - P isotherm and the compressibility factor starts increasing from unity right from the beginning .

27.6 $T_B = \frac{a}{Rb}$

28. THE CRITICAL STATE

28.1 There is a state (defined by pressure and temp.) for every substance at which the vapour state and liquid state are indistinguishable This state is known as critical state which is defined by critical temp. and critical pressure.

28.2 Critical temperature (T_c) of a gas is that temp. above which the gas can not be liquefied however large the pressure may be -

$$T_c = \frac{2a}{27Rb}$$

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28.3 Critical pressure (P_c) is the minimum pressure which must be applied to a gas to liquefy it at its critical temp.

$$P_c = \frac{a}{27b^2}$$

28.4 Critical volume (V_c) is the volume occupied by one mole of the substance at its critical temp. and critical pressure

$$V_c = 3b$$

28.5 Vapour and Gas:- A substance in the gaseous state below this temperature is called a vapour and above this temperature is called a gas.

28.6 $P_c V_c = \frac{3}{8} R T_c$

28.7 A gas may be liquified by cooling and compressing

28.8 A gas can be liquified only when the temp. is below its critical temp.

SOLVED EXAMPLES

Q.1 The behaviour of a real gas is usually depicted by plotting compressibility factor Z versus P at a constant temperature. At high temperature and high pressure, Z is usually more than one. This fact can be explained by Vander Waal's equation when

- (A) The constant a is negligible and not b
- (B) The constant b is negligible and not a
- (C) Both the constants a and b are not negligible
- (D) Both the constants a and b are negligible.

Ans. (A)

From Vander Waal's equation

$$\left[P + \frac{a}{V^2} \right] (V - b) = nRT \quad \dots(1)$$

$$\therefore Z = \frac{PV}{nRT} \text{ if } Z > 1 \text{ then } PV > nRT$$

which is possible from (1) when $\frac{a}{V^2}$ is negligible.

$$\text{i.e., } P(V - b) = RT$$

$$\text{or } PV = RT + Pb$$

$$\text{or } PV > RT.$$

Q.2 The numerical value of $\frac{RT}{PV}$ for a gas at critical conditions is times of $\frac{RT}{PV}$ at normal conditions:

- (A) 3
- (B) $\frac{8}{3}$
- (C) $\frac{3}{4}$
- (D) $\frac{3}{8}$

Ans. (B)

$$\begin{aligned} \frac{RT_c}{P_c V_c} &= \frac{8}{3} = \frac{8}{3} \times 1 \\ &= \frac{8}{3} \times \frac{RT}{PV} \end{aligned}$$

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Q.3 The ratio of excluded volume or non compressible volume of gas and actual volume of gas is :
(A) 2 (B) 4 (C) 3 (D) 0.5.

Ans. (B)

Q.4 A gas undergoing expansion through a porous plug exhibits heating if its temperature is :
(A) More than inversion temperature (B) Less than inversion temperature
(C) Less than critical temperature (D) Less than Boyle temperature.

Ans. (D)

Q.5 At 0°C the average and total kinetic energy of 0.6 mol of an ideal gas are :
(A) $3.405 \times 10^3 \text{ J mol}^{-1}$ and $2.043 \times 10^3 \text{ J}$ respectively
(B) $4.805 \times 10^5 \text{ J mol}^{-1}$ and $4.508 \times 10^5 \text{ J}$ respectively
(C) $0.0821 \times 10^3 \text{ J mol}^{-1}$ and $6.02 \times 10^3 \text{ J}$ respectively
(D) $1.021 \times 10^3 \text{ J mol}^{-1}$ and $2.401 \times 10^3 \text{ J}$ respectively.

Ans. (A)

Average K.E. per mole of the gas is given by :

$$\begin{aligned} \text{K. E.} &= \frac{3}{2} RT \\ &= \frac{3}{2} (8.324 \text{ JK}^{-1} \text{ mol}^{-1}) (273 \text{ K}) \end{aligned}$$

and

$$\begin{aligned} \text{Average K.E./mole} &= 3.405 \times 10^3 \text{ J mol}^{-1} \\ \text{total K.E. of 0.6 mol of gas is :} \\ &= (0.6 \text{ mol}) (3.405 \times 10^3 \text{ J mol}^{-1}) \\ &= 2.043 \times 10^3 \text{ J.} \end{aligned}$$

Q.6 Two moles of CO_2 (g) confined to 855 cm^3 volume at 300 K exerts a pressure of 44.27 atm. If the value of 'b' is $42.8 \text{ cm}^3 \text{ mol}^{-1}$, the value of 'a' is :

(A) $4.85 \text{ k Pa. dm}^3 \text{ mol}^{-2}$ (B) $3.65 \text{ k Pa. dm}^3 \text{ mol}^{-2}$
(C) $3.65 \text{ k dm}^3 \text{ mol}^{-1}$ (D) $3.65 \text{ k Pa dm}^{-3} \text{ mol}^2$.

Ans. (B)

Vander Waals equation of state is :

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

$$\text{Hence, } \frac{n^2 a}{V^2} = \frac{nRT}{V - nb} - P$$

$$\begin{aligned} &= \frac{(2 \text{ mol})(8.314 \text{ JK}^{-1} \text{ mol}^{-1})(300 \text{ K})}{(0.855 \text{ dm}^3) - (2 \text{ mol})(0.0428 \text{ dm}^3 \text{ mol}^{-1})} - (44.27 \times 101.325 \text{ k Pa}) \\ &= 6.483 \times 10^3 \text{ k Pa.} - 4.486 \times 10^3 \text{ k Pa.} \\ &= 1.997 \times 10^3 \text{ k Pa.} \end{aligned}$$

$$\text{Now, } a = \frac{V^2}{n^2} (1.997 \times 10^3 \text{ k Pa.}) = \frac{(0.855 \text{ dm}^3)^2}{(2 \text{ mol})^2} (1.997 \times 10^3 \text{ k Pa.})$$

$$a = 3.65 \text{ k Pa. dm}^3 \text{ mol}^{-2}.$$

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Q.7 Compressibility factor of N_2 at $-50^\circ C$ and 800 atm. pressure is 1.95. Moles of N_2 gas required to fill a gas cylinder of 100 litre capacity are :

- (A) 22.40 (B) 224.08 (C) 2240.8 (D) 223.0.

Ans. (C)

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

or
$$n = \frac{PV}{ZRT} = \frac{800 \times 100}{1.95 \times 0.0821 \times 223} = 2240.8$$

Q.8 Vander Waal's equation for one mol of H_2 gas at very high pressure will be :

- (A) $PV = \frac{aRT}{V^2}$ (B) $PV = RT - \frac{a}{V}$ (C) $PV - Pb = RT$ (D) $P = \frac{V-b}{RT}$

Ans. (D)

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

or
$$PV - Pb + \frac{a}{V} - \frac{ab}{V^2} = RT$$

when P is very high, Pb over weighs $\frac{a}{V}$ so

$$PV - Pb = RT$$

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

or
$$P = \frac{RT}{(V-b)}$$

Q.9 One way of writing the equation of state for real gases is

$$PV = RT \left[1 + \frac{B}{V} + \dots\right]$$

where B is a constant. An approximate expression for B in terms of the Vander Waal's constants 'a' and 'b' is :

(A) $B = a - \frac{b}{RT}$

(B) $B = b - \frac{a}{RT}$

(C) $B = RT - \frac{a}{b}$

(D) $B = RT - \frac{b}{a}$

Ans. (B)

For one mole of a Vander Waal's gas, we have

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

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Ex.12 The units of Vander Waal's constant 'b' is

- (A) Liters atm⁻¹ (B) Litres mole⁻² (C) Atmosphere litre⁻¹ (D) Litres² moles²

Sol. (B)

Excluded volume is nb for n moles of gases.

$$\therefore b = \frac{\text{Volume}}{n} = \frac{\text{Litre}}{\text{mole}}$$

Ex.13 Vander Wall's forces in the molecular solids and liquids generally-

- (A) Are found in only systems having permanent dipole moment
(B) Are for the most part repulsive
(C) Increase with increasing size of atoms and molecules involved
(D) Result in high melting and boiling temperatures

Sol. (C)

Since, as the size increases. The volume occupied by gaseous molecules does not remain insignificant.

Ex.14 In Vander Waal's equation of state for a non-ideal gas, the term that account for intermolecular forces is -

- (A) (v - b) (B) RT (C) $\left(p + \frac{a}{v^2}\right)$ (D) (RT)⁻¹

Sol. (C)

The Vander Waal's constant 'a' is a measure of the magnitude of the attractive forces among the molecules of the gas.

Ex.15 A real gas most closely approaches the behaviour of an ideal gas at :

- (A) 15 atmosphere and 200 K (B) 1 atm and 273 K
(C) 0.5 atm and 500 K (D) 15 atm and 500 K.

Sol. (C)

Since at low pressure $\frac{a}{v^2}$ becomes insignificant hence

$$PV = RT.$$

Similarly at high temp.

$$PV = RT.$$

Ex.16 The temperature at which real gases obey the ideal gas laws over a wide range of pressure is called -

- (A) Critical temperature (B) Boyle temperature
(C) Inversion temperature (D) Reduce temperature

Sol. (B)

Boyle Temp $T_b = \frac{a}{bR}$ (where a & b are Vander Waal's constant)

Ex.17 The compressibility factor for on ideal gas is

- (A) 1.5 (B) 1.0 (C) 2.0 (D) ∞

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Sol. (B)

For an ideal gas

$$PV = RT$$

or $z = \frac{PY}{RT} = 1$ (where z = compressibility factor)

GASEOUS STATE

UNSOLVED PROBLEMS

- Q.1** Deviations from ideal behaviour will be more if the gas is subjected to :
(A) low temperature and high pressure (B) high temperature and low pressure
(C) low temperature (D) high temperature
- Q.2** Non-ideal gases approach ideal behaviour :
(A) high temperature and high pressure (B) high temperature and low pressure
(C) low temperature and high pressure (D) low temperature and low pressure
- Q.3** van der Waals' equation explains the behaviour of :
(A) ideal gases (B) real gases (C) mixture of gases (D) di-atomic gases
- Q.4** The critical temperature of a gas is that temperature :
(A) above which it can no longer remain in the gaseous state
(B) above which it cannot be liquefied by pressure
(C) at which it solidifies
(D) at which the volume of the gas becomes zero
- Q.5** The van der Waals' equation for a real gas is :
(A) $\left(P + \frac{a}{V^2}\right)(V - b) = nRT$ (B) $\left(P + \frac{an^2}{V^2}\right)(V - b) = nRT$
(C) $\left(P + \frac{a}{V^2}\right)(V + b) = nRT$ (D) $P = \frac{nRT}{(V - nb)} - \frac{n^2a}{V^2}$
- Q.6** In van der Waals' equation of state for a non-ideal gas the term that accounts for intermolecular force is :
(A) $\left(P + \frac{a}{V^2}\right)$ (B) $(V - b)$ (C) RT (D) $\frac{1}{RT}$
- Q.7** The units of 'a' in van der Waals' equation $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$ are :
(A) atom litre² mol⁻² (B) atom litre mol⁻² (C) atom litre mol⁻¹ (D) atom litre² mol⁻¹
- Q.8** The temperature at which real gases obey the ideal gas laws over a wide range of pressure is called :
(A) critical temperature (B) Boyle temperature
(C) inversion temperature (D) reduced temperature
- Q.9** The value of van der Waals' constant 'a' for gases O₂, N₂, NH₃ and CH₄ are 1.360, 1.390, 4.170 and 2.253 litre² atm mol⁻² respectively. The gas which can be most easily liquefied is :
(A) O₂ (B) N₂ (C) NH₃ (D) CH₄

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- Q.10** A real gas obeying van der Waals' equation will resemble an ideal gas if the :
(A) constant a and b are small (B) a is large and b is small
(C) a is small and b is large (D) constants a and b are large
- Q.11** The compressibility factor of a gas is defined as $Z = \frac{PV}{RT}$. The compressibility factor of an ideal gas is :
(A) 0 (B) 1 (C) -1 (D) infinity
- Q.12** An ideal gas is one which obeys :
(A) gas laws (B) Boyle's law (C) Charles' law (D) Avogadro's law
- Q.13** When helium is allowed to expand into vacuum, heating effect is observed. This is due to the fact that :
(A) helium is an inert gas (B) helium is an inert gas
(C) helium is an ideal gas (D) the inversion temperature of helium is very low
- Q.14** The non-compressible volume of a gas is.....times the actual volume of gas molecules :
(A) 2 (B) 4 (C) 3 (D) 2.5
- Q.15** Match the following :
- | List I | List II |
|----------------------------|----------------------------|
| (a) Inversion temperature | (i) a/Rb |
| (b) Boyle's temperature | (ii) $8a/27Rb$ |
| (c) Critical temperature | (iii) $2a/Rb$ |
| (A) A-(i), B-(ii), C-(iii) | (B) A-(iii), B-(ii), C-(i) |
| (C) A-(iii), B-(i), C-(ii) | (D) A-(i), B-(iii), C-(ii) |
- Q.16** For three different gases values of van der Waals' constant 'a' and 'b' are given. What is the correct order of liquefaction of gases :
- | Gases | a | b | |
|-------|-----|-------|-----------------------|
| X_2 | 1.3 | 0.090 | (A) $X_2 > Y_2 > Z_2$ |
| Y_2 | 4.1 | 0.023 | (B) $Y_2 > Z_2 > X_2$ |
| Z_2 | 2.2 | 0.075 | (C) $Z_2 > Y_2 > X_2$ |
| | | | (D) $X_2 > Z_2 > Y_2$ |
- Q.17** Match the following :
- | List I | List II |
|----------------------------|----------------------------|
| (a) P_c | (i) $3b$ |
| (b) V_c | (ii) $8a/27Rb$ |
| (c) T_c | (iii) $a/27b^2$ |
| (A) A-(i), B-(ii), C-(iii) | (B) A-(iii), B-(ii), C-(i) |
| (C) A-(ii), B-(iii), C-(i) | (D) A-(iii), B-(i), C-(ii) |
- Q.18** Gas having minimum value of 'b'
(A) O_2 (B) He (C) H_2 (D) All same

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Q.19 Which gas can easily be liquefied

- (A) CO (B) CO₂ (C) NH₃ (D) Cl₂

Q.20 Match the following :

List I

- (a) U_{rms}/U_{av}
 (b) U_{av}/U_{mp}
 (c) U_{rms}/U_{mp}
 (A) A-(iii), B-(ii), C-(i)
 (C) A-(iii), B-(i), C-(ii)

List II

- (i) 1.22
 (ii) 1.13
 (iii) 1.08
 (B) A-(i), B-(ii), C-(iii)
 (D) A-(ii), B-(iii), C-(i)

Q.21 If force of attraction between the molecules is negligible, van der Waals' equation (for one mole) will become :

- (A) $PV = RT + Pb$ (B) $P = \frac{RT}{V-b} - \frac{a}{V^2}$ (C) $PV = RT + a/V$ (D) $PV = RT - a/V$

Q.22 van der Waals' equation for :

- (a) High pressure (i) $PV = RT + Pb$
 (b) Low pressure (ii) $PV = RT - a/V$
 (c) Force of attraction is negligible (iii) $PV = RT + a/V$
 (d) Volume of molecules is negligible (iv) $\left(P + \frac{a}{V^2}\right)(V - b) = RT$
 (A) A (iv), B (ii), C (i), D (ii) (B) A (i), B (ii), C (iii), D (iv)
 (C) A (iv), B (iii), C (ii), D (i) (D) A (iv), B (ii), C (iii), D (i)

Q.23 van der waals' constants for three different gases are given :

Gas	a	b
X	3.0	0.025
Y	10.0	0.030
Z	6.0	0.035

Which is correct ?

- (A) Maximum critical temperature–Y (B) Most ideal behaviour–X
 (C) Maximum molecular volume–Z (D) All are correct

ANSWERS

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	A	B	B	B	D	A	A	B	C	A	B	A	D	B	C
Que.	16	17	18	19	20	21	22	23							
Ans.	B	D	B	C	D	A	A	D							