# Summary

**Temperature Scale:**

$$\frac{C-O}{100-0}=\frac{K-273}{373-273}=\frac{F-32}{212-32}=\frac{R-R(O)}{R(100)-R(O)}$$ where R = Temp. on unknown scale.

BOYLE'S LAW and MEASUREMENT OF PRESSURE:

At constant temperature, $V\alpha\frac{1}{P}$

$$P_1V_1=P_2V_2$$

**Charles Law:**

At constant pressure, V α T or $\frac{V_1}{T_1}=\frac{V_2}{T_2}$

**Gay – Lussac's Law:**

At constant volume, $\frac{P_1}{T_1}=\frac{P_2}{T_2}\rightarrow$ temp on absolute scale

**Equation of State:**

Combining all the relations

$\frac{PV}{T}=$ constant (dependent on amount of the gas (n))., $\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$

**Ideal Gas Equation:**

PV = nRT

PV = $\frac{w}{m}RT$ or $P=\frac{d}{m}$ RT or PM = dRT

m = molecular mass of the gas

**Dalton's Law of Partial Pressure:**

$P_1=\frac{n_1RT}{v}, P_2=\frac{n_2RT}{v}, P_3=\frac{n_3RT}{v}$ and so on.

Total pressure = $P_1 + P_2 + P_3 + \ldots\ldots$

Partial pressure = mole fraction X Total pressure.

**Amagat's law of partial volume:**

V = V1 + V2 + V3 + ……

**Average Molecular Mass of Gaseous Mixture:**

$$M_{mix}=\frac{Total\ mass\ of\ mixture}{Total\ no.of\ in\ \ mixture}=\frac{n_1M_1+n_2M_2+n_3M_3}{n_1+n_2+n_3}$$

GRAHAM'S LAW:

Rate of diffusion $r\propto\frac{1}{\sqrt{d}}$; d = density of gas

$$\frac{r_1}{r_2} = \frac{\sqrt{d_2}}{\sqrt{d_1}} = \frac{\sqrt{M_2}}{\sqrt{M_1}} = \sqrt{\frac{V.D_2}{V.D_1}}$$ V.D is vapour density

r = volume flow rate = $\frac{dV_{out}}{dt}$; r = mole flow rate = $\frac{dn_{out}}{dt}$

r = distance travelled by gaseous molecule per unit time = $\frac{dx}{dt}$

General form of the grahams law of diffusion

$$rate \propto \frac{P}{\sqrt{TM}} A$$

P – Pressure, A – cross section area of hole, T – Temp., M – mol. Wt.

**Kinetic Theory of Gases:**

PV = $\frac{1}{3} mN \overline{U^2}$ Kinetic equation of gases

Where $\overline{U^2}$ is mean square speed

Average K.E. = $\frac{3}{2} kT$ (only dependent on temperature net on nature of the gas.)

K = Boltzman constant.

Average K.E for one mole = $N_A \left( \frac{1}{2} m\overline{U^2} \right) = \frac{3}{2} KN_A T = \frac{3}{2} RT$

- Root mean square speed

$$U_{rms} = \sqrt{\overline{U^2}} = \sqrt{\left( \frac{U_1^2 + U_2^2 + U_3^2 + ....U_N^2}{N} \right)} = \sqrt{\frac{3kT}{m}}$$

$$U_{rms} = \sqrt{\frac{3RT}{M}}$$ molar mass must be in kg / mole.

- Average speed

$$U_{av} = \frac{U_1 + U_2 + U_3 + ............U_N}{N}$$

$$U_{avg.} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8KT}{\pi m}}$$ K is Boltzman constant

- Most Probable speed

$$U_{MPS} = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2KT}{m}}$$

It is the speed possessed by maximum no. of molecules.

**Real Gases:**

$$Z = \frac{(PV)_{real}}{(PV)_{ideal}} \Rightarrow Z = \frac{PV}{nRT} = \frac{PV_m}{RT} \qquad Z = \frac{V_m}{V_m \ ideal}$$

Conclusions:

Z = 1 for ideal gas, Z > 1 at all pressure for He / $H_2$

Z < 1 at low pressure (for all other gases), Z > 1 at high pressure (for all other gases)

b → excluded volume per mole of gas = $N_A 4\left\{\frac{4}{3}\pi r^3\right\}$

for n moles excluded volume = nb

$V_i$ = V – nb volume correction

Vander waal's equation is

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

**Verification of Vander Waal's Equations:**

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

(a) At low pressure (at separate temp.)

$$\left(P+\frac{a}{v_m^2}\right)V_m=RT, \qquad Z=1-\frac{a}{V_mRT} \qquad Z<1$$

(b) At high pressure (moderate temp.)

$V_M$ will be low

$$P(V_m-b)=RT\ , \qquad Z=\frac{Pb}{RT}+1 \qquad Z>1$$

(c) At low pressure and very high temperature.

$V_M$ will be very large

$PV_m$ = RT (ideal gas condition)

(d) For H2 or H2 a ≃ 0

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

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

- Boyle's temp.

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

- **Critical Constants:**

$$V_c=3b, \quad P_c=\frac{a}{27b^2}, \qquad T_c=\frac{8a}{27Rb}$$

At critical point, the slope of PV curve (slope of isotherm) will be zero

$$\left(\frac{\partial P}{\partial V_m}\right)_{T_C} = 0 \ldots\ldots\ldots\text{(i)} \qquad\qquad \frac{\partial}{\partial V_m}\left(\frac{\partial P}{\partial V_m}\right)_{T_C} = 0 \quad \ldots\ldots\text{(ii)}$$

At all other point slope will be negative,

**Virial Equation of State:**

It is a generalised equation of gaseous state and all other equation can be written in the form of virial equation of state.

Z is expressed in power series expansion of P of $\left(\frac{1}{V_m}\right)$

$$Z = 1 + \frac{B}{V_m} + \frac{C}{V_m^2} + \frac{D}{V_m^3} + \ldots\ldots$$

B – second virial coefficient, C – third virial coefficient, D – fourth virial coefficient.

**Vander wall equation in virial form:**

$$Z = \left(1 + \frac{b}{V_m} + \frac{b^2}{V_m^2} + \frac{b^3}{V_m^3} + \ldots\ldots\right) - \frac{a}{V_m RT} = 1 + \frac{1}{V_m}\left(b - \frac{a}{RT}\right) + \frac{b^2}{V_m^2} + \frac{b^3}{V_m^3} + \ldots\ldots$$

**Reduced Equation of State:**

$$\left(P_r + \frac{3}{V_r^2}\right)(3V_r - 1) = 8T,$$

# Practice Questions

1. Assuming ideal gas behaviour, the ratio of density of ammonia to that of hydrogen chloride at same temperature and pressure is: (Atomic wt. of Cl 35.5 u)

(a) 1.46

(b) 1.64

(c) 0.46

(d) 0.64

2. A certain quantity of a gas occupied 100 ml when collected over water at 15°C and 750 mm pressure. It occupies 91.9 ml in dry state at NTP. Find the V.P. of water at 15°C

(a) 20 mm

(b) 13.2 mm

(c) 18 mm

(d) none

3. The virial equation for 1 mole of a real gas is written as :

PV = RT

$$\left[1+\frac{A}{V}+\frac{B}{V^2}+\frac{C}{V^3}+\text{......to higher power of n}\right]$$

Where A, B and C are known as virial coefficients. If van der waal's equation is written in virial form, then, what will be the value of B?

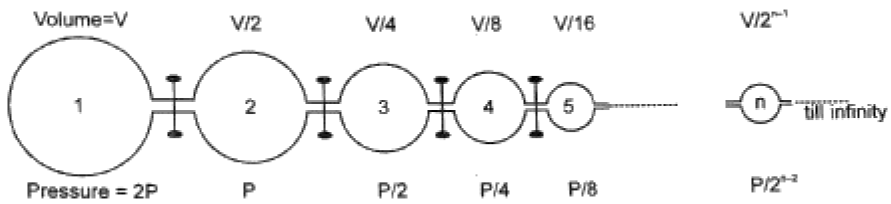
(a) $a-\frac{b}{RT}$

(b) $b^3$

(c) $b-\frac{a}{RT}$

(d) $b^2$

4.




Infinite number of flasks are connected to one another as shown above. The volumes and pressures in each flask vary as shown. The stopcocks are initially closed. The common pressure, when all the stopcocks are opened is : (Assume constant temperature)

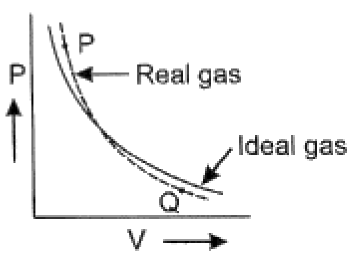
(a) P

(b) $\frac{1}{2}P$

(c) $\frac{P}{4}$

(d) $\frac{4}{3}P$

5. At point P and Q, the real gas deviation with respect to ideal gas is respectively:




(a) Positive, negative

(b) Positive, positive

(c) Negative, positive

(d) Negative, negative

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

(a) low pressure & low temperature

(b) high pressure & high temperature

(c) low pressure & high temperature

(d) high pressure & low temperature

7. If the number of molecules of $SO_2$ (molecular weight = 64) effusing through an orifice of unit area of cross section per unit time at 0°C and 1 atm pressure is n, the number of He molecules (atomic weight = 4) effusing under similar conditions at 273°C and 0.25 atm is :

(a) $\frac{n}{\sqrt{2}}$

(b) $n\sqrt{2}$

(c) $2n$

(d) $\frac{n}{2}$

8. A gaseous mixture contains three gases A, B and C with a total number of moles of 10 and total pressure of 10 atm. The partial pressure of A and B are 3 atm and 1 atm respectively and if C has molecular weight of 2g/mol. Then, the weight of C present in the mixture will be :

(a) 8 g

(b) 12 g

(c) 3 g

(d) 6 g

9. 1 mol of a gaseous aliphatic compound $C_nH_{3n}O_m$ is completely burnt in an excess of oxygen. The contraction in volume is (assume water get condensed out)

(a) $\left(1+\frac{1}{2}n-\frac{3}{4}m\right)$

(b) $\left(1+\frac{3}{4}n-\frac{1}{4}m\right)$

(c) $\left(1-\frac{1}{2}n-\frac{3}{4}m\right)$

(d) $\left(1-\frac{3}{4}\right)n-\frac{1}{2}m$

10. At what temperature will the total KE of 0.3 mol of He be the same as the total KE of 0.40 mol of Ar at 400 K?

(a) 533 K

(b) 400 K

(c) 346 K

(d) 300 K

11. The volume of a gas increases by a factor of 2 while the pressure decreases by a factor of 3. Given that the number of moles is unaffected, the factor by which the temperature changes is :

(a) $\frac{3}{2}$

(b) $3 \times 2$

(c) $\frac{2}{3}$

(d) $\frac{1}{2} \times 3$

12. Which has maximum internal energy at 290 K ?

(a) Neon gas

(b) Nitrogen gas

(c) Ozone gas

(d) Equal

13. There are $6.02 \times 10^{22}$ molecules each of $N_2$, $O_2$ and $H_2$ which are mixed together at 760 mm and 273 K. The mass of the mixture in grams is :

(a) 6.2

(b) 4.12

(c) 3.09

(d) 7

14. At 27°C, a gas is compressed to half of its volume. To what temperature it must now be heated so that gas occupies just its original volume ?

(a) 54°C

(b) 600°C

(c) 327°C

(d) 327 K

15. A gas in an open container is treated from 2°C to 127°C. The fraction of original amount of gas remaining in the container will be.

(a) $\frac{3}{4}$

(b) $\frac{1}{4}$

(c) $\frac{1}{2}$

(d) $\frac{1}{8}$

16. A V $dm^3$ flask contains gas A and another flask of 2V $dm^3$ contains gas B at the same temperature. If density of gas A is 3.0 $g/dm^{-3}$ and of gas B is 1.5 g $dm^3$ and mol wt. of A = $\frac{1}{2}$ mol. wt of B, then the ratio of pressure exerted by gases is

(a) $\frac{P_A}{P_B} = 2$

(b) $\frac{P_A}{P_B} = 1$

(c) $\frac{P_A}{P_B} = 4$

(d) $\frac{P_A}{P_B} = 3$

17. At low pressure, vander waal's equation is reduced to $\left[P+\frac{a}{V^2}\right]$ V = RT. The compressibility factor can be given as:

(a) $1-\frac{a}{RTV}$

(b) $1-\frac{RTV}{a}$

(c) $1+\frac{a}{RTV}$

(d) $1+\frac{RTV}{a}$

18. 300 ml of a gas at 27°C is cooled to -3°C at constant pressure, the final volume is:

(a) 540 ml

(b) 135 ml

(c) 270 ml

(d) 350 ml

19. In the ideal gas equation, the gas constant R has the dimension of

(a) Mole-atm/K

(b) Litre/mole

(c) Litre-atm/K/mole

(d) erg/K

20. 3.7 gm of a gas at 25°C occupied the same volume as 0.184 gm of hydrogen at 17°C and at the same pressure. What is the molecular mass of the gas ?

(a) 82.66

(b) 41.33

(c) 20.67

(d) 10.33

21. 180 ml of hydrocarbon diffuses through a porous membrane in 15 minutes while 120 ml of $SO_2$ under identical conditions diffused in 20 minutes. What is the molecular mass of the hydrocarbon?

(a) 8

(b) 16

(c) 24

(d) 32

22. At what temperature will hydrogen molecules have the same root mean square speed as nitrogen molecules at 27°C?

(a) 21.43°C

(b) 42.86 K

(c) 21.43 K

(d) 42.86°C

23. What is the total pressure exerted by the mixture of 7.0 g of $N_2$, 2g of hydrogen and 8.0 g of sulphur dioxide gases in a vessel of 6L capacity that has been kept at 27°C.

(a) 2.5 bar

(b) 4.5 bar

(c) 10 atm

(d) 5.7 atm

24. An open flask containing air is heated from 300 K to 500 K. What percentage of air will be escaped to the atmosphere, if the pressure is kept constant ?

(a) 80

(b) 40

(c) 60

(d) 20

25. At STP a container has 1 mole of $H_2$, 2 moles Ne, 3 moles $O_2$ and 4 moles $N_2$. Without changing total pressure of 2 moles of $O_2$ is removed, the partial pressure of $O_2$ will be decreased by

(a) 26%

(b) 40%

(c) 58.33%

(d) 66.66%

26. Density of methane, at 250°C and 6 atm pressure, is [R = 0.0821 atm] :

(a) 2.236 g/L

(b) 8 g/L

(c) 12 g/L

(d) 16 g/L

27. The ratio among the most probable velocity, mean velocity and root mean square velocity is given by-

(a) 1 : 2: 3

(b) $1 : \sqrt{2} : \sqrt{3}$

(c) $\sqrt{2} : \sqrt{3} : \sqrt{8/\pi}$

(d) $\sqrt{2} : \sqrt{8/\pi} : \sqrt{3}$

28. The compressibility factor for nitrogen at 330 K and 800 atm is 1.90 and 200 atm is 1.10. A certain mass of $N_2$ occupies a volume of 1 $dm^3$ at 330 K and 800 atm calculate volume occupied by same quantity of $N_2$ gas at 750 K and 200 atm.

(a) 1 L

(b) 2 L

(c) 3 L

(d) 4 L

29. If the weight of 5.6 litres of a gas at N.T.P. is 11 gram. The gas may be:

(a) $PH_3$

(b) $COCl_2$

(c) NO

(d) $N_2O$

30. The density of vapour of a substance (X) at 1 atm pressure and 500 K is 0.8 kg/$m^3$. The vapour effuses through a small hole at a rate of 4/5 times slower than oxygen under the same condition. What is the compressibility factor (Z) of the vapour ?

(a) 0.974

(b) 1.35

(c) 1.52

(d) 1.22

## Answer Keys:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. c | 2. b | 3. d | 4. d | 5. a | 6. c | 7. a | 8. b | 9. d | 10. a |
| 11. c | 12. c | 13. a | 14. b | 15. a | 16. c | 17. a | 18. c | 19. c | 20. b |
| 21. b | 22. c | 23. d | 24. b | 25. c | 26. a | 27. d | 28. d | 29. d | 30. c |

**"Detail solutions are mentioned in the content library"**