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Class: 11
Subject: Chemistry
Topic: Kinetic theory of gases
No. of Questions: 33

1. The unit of universal gas constant in S.I.unit is

A. calorie per degree Celsius

B. joule per mole

C. joule/k × mole

D. none of these

Sol: C

Nature of gas constant, R :

$$R = \frac{P \times V}{nT} = \frac{\text{Pressure} \times \text{Volume}}{\text{Mole} \times \text{Degree (K)}}$$

$$= \frac{\left(\frac{\text{Force}}{\text{Area}}\right) \times \text{Volume}}{\text{Mole} \times \text{Degree (K)}}$$

$$= \frac{\text{Force}}{(\text{Length})^2} \times \frac{(\text{Length})^3}{\text{Mole} \times \text{Degree}}$$

$$= \frac{\text{Force} \times \text{Length}}{\text{Mole} \times \text{Degree}}$$

= Work per degree per mol.

Units of R—Various units of gas constant R, are given as—

(i) $P = 1$ atm, $V = 22.4$ L, $T = 273$ K

$$R = \frac{1 \text{atm} \times 22.4 \text{ L}}{273 \text{ K}}$$

$$= \boxed{0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}}$$

$$= 0.0821 \text{ dm}^3 \text{ atm mol}^{-1} \text{ K}^{-1}$$

(ii) When P is expressed in dynes per square centimetre *i.e.*,

$P = 76 \times 981 \times 13.6$ dyne cm^{-2}, $V = 22400$ mL and $T = 273$ K

Then $R = 8.314 \times 10^7$ erg K^{-1} mol^{-1}

$$= \boxed{8.314 \text{ J K}^{-1} \text{ mol}^{-1}} \quad (10^7 \text{ erg} = 1\text{J})$$

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2. In the equation PV = RT, V stands for the volume of

A. any amount of gas

B. one gram of gas

C. one gram molecule of gas

D. one liter of gas

Sol: C

The given equation is PV = RT;
This is the gas equation. Here V is the volume of one mole of gas, T is the temperature of the gas, R is the universal gas constant.

3. The average translational kinetic energy per gm mole of a gas is given by

A. 3/2 RT

B. 1/2 RT

C. 2/3 RT

D. None of these

Sol: A

4. The specific heat of a gas in isothermal process is

A. Zero
B. Negative
C. Remains constant
D. Infinite

Sol: d

5. The specific heat of a gas in isothermal process is

A. Zero
B. Negative
C. Remains constant

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D. Infinite

Sol: d

6. The specific heat of a gas in isothermal process is

A. Zero
B. Negative
C. Remains constant
D. Infinite

Sol: d

For one gm mole of the gas, the average kinetic energy $E_k = \frac{3}{2} k \cdot T \times N$

$$\boxed{E_k = \frac{3}{2} RT}$$

where N is Avogadro's number ($= 6.02 \times 10^{23}$)

7. In the vander waal equation the critical pressure Pc is given by

A. $27\ b^2$

B. $a / 27\ b^2$

C. 28 ab

D. none of these

Sol: B

Critical pressure, $P_C = \frac{a}{27 b^2}$

This is the pressure to be applied to the gas to liquefy it at critical temperature is called critical pressure.

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8. According to kinetic theory of gas, the r. m.s velocity of gas molecules is directly proportional to

A. T

B. $\sqrt{T}$

C. J

D. none of these

Sol: B

According to the gas theory, r.m.s velocity of gas molecules is directly proportional to the square root of temperature of the gas, or C (r.m.s) = sqrt (3RT/M); so 2nd option is the answer.

9. Molecules of a gas behave like a

A. rod

B. sphere

C. perfectly elastic rigid sphere

D. none of these

Sol: C

10. All molecules of a gas in a vessel

A. rotational distribution

B. Maxwellian distribution of sphere

C. kinetic distribution

D. none of these

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Sol: B

11. Pressure exerted by a perfect gas is equal to

A. 5/3 of mean K.E per unit vol.

B. 4/3 of mean K.E per unit vol.

C. 2/3 of mean K.E per unit vol.

D. None

Sol: C

For one gm mole of the gas, the average kinetic energy $E_k = \frac{3}{2} k \cdot T \times N$

$$\boxed{E_k = \frac{3}{2} RT}$$

where N is Avogadro's number (= $6\cdot02 \times 10^{23}$)

or, $\boxed{E_k = \frac{3}{2} PV}$

or, $\boxed{P = \frac{2}{3} \frac{E_k}{V}}$

12. If the pressure in a closed vessel is reduced by drawing out some gas, the mean free path of the molecule

A. is decreased

B. is increased

C. is same

D. none of these

Sol: B

13. For Boyles law to be hold the gas should be

A. perfect & of constant mass & temp.

B. decrease

C. remain constant

D. none of the above

Sol: A

Boyle's law is obeyed at constant temperature, according to which pressure of a fixed mass of a gas is inversely proportional to its volume. So mass and temperature need to be constant to obey Boyle's law.

14. Real gas obeys ideal gas law more closely at

A. very low P & T

B. very low pressure

C. very low temperature

D. none of these

Sol: B

15. Of the following properties of gas molecules the one that is same for all gases at a particular temperature is

A. P.E

B. Heat energy

C. Light energy

D. K.E

Sol: D

16. V_{rms} velocity of a gas molecule depend upon

A. P

B. V

C. T

D. none

Sol: C

Since root mean square velocity = sqrt (3RT/M), so 3rd option is the answer.

17. Pressure of gas decreases on increasing vol. because

A. molecules strike less frequently

B. molecules strike vigorously

C. both 1 & 2

D. none of these

Sol: A

Pressure decreases when volume is increased. It is due to the reason that molecules strike less frequently and force of attraction between them decreases since the distance between them decreases. So there is decrease in the pressure with increase of volume.

18. The deviation of a gases from the ideal gas behavior is due to

A. repulsion of molecules

B. attraction & repulsion of molecules

C. attraction of molecules

D. none of these

Sol: C

19. The specific heat of a gas in isothermal process is

A. Zero
B. Negative
C. Remains constant
D. Infinite

Sol: D

20. The V_{rms} velocity of four particle of 4 m/s, 2 m/s, 3 m/s, 5 m/s is

A. 45 m/s

B. 48 m/s

C. 46 m/s

D. $\sqrt{54}$/2 m/s

Sol: D

R.M.S velocity of four particles with velocity 2 m/s, 4 m/s, 5 m/s, 3 m/s is sqrt $\{4^2 + 2^2 + 5^2 + 3^2)/4\}$
Or $\sqrt{54}$ /2 m/s is the answer.

21. According to kinetic theory of gases, molecules

A. collide with each other inelastically

B. collide with each other elastically

C. do not collide

D. none of these

Sol: B

Molecules collide with each other elastically. The collisions are elastic, i.e. there is no loss of energy during collision, only direction of motion is changed.

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22. For an ideal gas, at constant volume, if the pressure is increased,

A. the temperature will decrease

B. the temperature will increase

C. the temperature will remain same

D. none of these

Sol: B

Since Pv =nRT; when pressure is increased by keeping the volume constant, temperature will increase to make the equation satisfied.

23. The density of an ideal gas is

A. directly proportional to P

B. directly proportional to P and inversely proportional to T

C. directly proportional to T

D. none of these

Sol: B

$$PV = \frac{m}{M}RT$$

Density (d) is mass divided by volume (m/V), and we can rearrange the equation so that m/V is on one side:

$$d = \frac{m}{V} = \frac{PM}{RT}$$

Thus, the density of a gas is directly proportional to its molar mass, M.

24. Write two condition when real gases obey the ideal gas equation (PV = nRT). N → number of mole.

Sol: (i) Low pressure (ii) High temperature

25. If the number of molecule in a container is doubled. What will be the effect on the rms speed of the molecules?

Sol: No effect

26. Two vessels of the same volume are filled with the same gas at the same temperature. If the pressure of the gas in these vessels be in the ratio 1 : 2 then state

(1) The ratio of the rms speeds of the molecules.
(2) The ratio of the number of molecules.

Sol: (1) As the temperature is same rms speeds are same.

(3) $P = \frac{1}{3}\frac{mnc^2}{V}$ $\quad P \alpha nc^2 \frac{P_1}{P_2} = \frac{n_1}{n_2} = \frac{1}{2}$

27. Why gases at high pressure and low temperature show large diviation from ideal gas behaviour.

Sol: When temp is low and pressure is high the intermolecular forces become appreciable thus the voluem occupied by the molecular is not negligibly small as composed to volume of gas.

28. Two thermally insulated vessels 1 and 2 are filled. With air at temperatures (T_1, T_2), volume (V_1, V_2) at pressure (P_1, P_2) respectively. If the valve joining the two vessels is opened what is temperature of the vessel at equilibrium.

Sol:

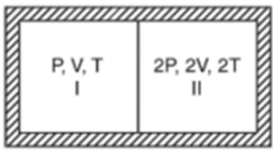
number of mole = Constant

$\mu_1 + \mu_2 = \mu$

$$\frac{P_1V_1}{RT_1} + \frac{P_2V_2}{RT_2} = \frac{P(V_1 + V_2)}{RT}$$

from Boyles law $P(V_1 + V_2) = P_1V_1 + P_2V_2 \Rightarrow T = \frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}$

29. A partition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartment. What is the ratio of the number of molecules in compartments I and II ?

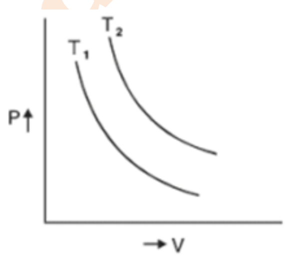


Sol:

5. $n = \frac{pV}{kT}$ $\quad h' = \frac{2p\ 2\nu}{2kT} = \frac{2p\nu}{kT}$

$\frac{n}{n'} = \frac{1}{2}$

30. Isothermal curves for a given mass of gas are shown at two different temperatures T_1 and T_2 state whether $T_1 > T_2$ or $T_2 > T_1$, justify your answer.



Sol:

$T = \frac{PV}{\mu R}$ T α P V (man is constant)(μ is constant)

since PV is greater for the curve at T_2 than for the curve T_1 therefore $T_2 > T_1$

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31. An air bubble of volume 1.0 cm^3 rises from the bottom of a lake 40 m deep at a temperature of 12 °C To what volume does it grow when if reaches the surface which is at a temperature of 35 °C ?

Sol:

1. $v_1 = 10^{-6} m^3$

Pressure on bubble P_1 = water pressure + Atmospheric pressure

$= \rho gh + P_{atm}$

$= 4.93 \times 10^5$ Pa

$T_1 = 285$ k. $T_2 = 308$ k

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{4.93 \times 10_5 \times 1 \times 10^{-6} \times 308}{285 \times 1.01 \times 10^5} = 5.3 \times 10^{-6} m^3$$

32. An electric bulb of volume 250 cm^3 was realed off during manufacture at a pressure of 10^3 mm of Hg at 27 °C. Find the number of air molecules in the bulb-
(R = 8.31 J $mole^{-1}$ K^{-1}, $N_\Lambda = 6.02 \times 10^{23}$ $mole^{-1}$)
(density of mercury p = 13.6×10^3 kg m^{-3})

Sol:

$V = 250$ cc $= 250 \times 10^{-6}$ m^3

$P = 10^{-6}$ m $\rho = 13.6 \times 10^3$ kg/m^3

$T = 300$ K

$$\mu = \frac{PV}{RT} = \frac{h\rho gV}{RT} = 1.3 \times 10^{-8} \text{mole}$$

number of molecule $= \mu N_A = 8 \times 10^{15}$

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33. 0.014 kg of nitrogen is enclosed in a vessel at a temperature of 27 °C . How much heat has to be transferred to the gas to double the rms speed of its molecules.

Sol:

Number of mole in 0.014 kg of Nitrogen.

$$n = \frac{0.014 \times 10^3}{28} = \frac{1}{2} \text{mole}$$

$$C_V = \frac{5}{2}R = \frac{5}{2} \times 2 = 5 \quad \text{cal / mole k}$$

$$\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} \qquad T_2 = 4T_1$$

$$\Delta T = T_2 - T_1 = 4T_1 - T_1 = 3T_1$$

$$= 3 \times 300 = 900 \text{ K}$$

$$\Delta Q = n\, c_v\, \Delta T = \frac{1}{2} \times 5 \times 900 = 2250 \text{ cal}$$