PHYSICS

BOOKS - MBD

BEHAVIOUR OF PERFECT GAS AND KINETIC THEORY

Example

1. What is the lowest temperature attainable according to chalres' law?

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2. What is one mole of an element ?

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3. What is the nature of graph between pressure P and volume V for a gas at constant temperature?

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4. What is the relation between pressure P and density ρ of a gas at constant temperature?

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5. What is the value of Rydberg constant?

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6. What is Boltzmann constant. What is its value in SI units?

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7. If a gas expands at constant temperature:

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8. Can the temperature of a gas be increased by keeping its pressure and volume constant?

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9. What is the physical significance of molar gas constant R?

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10. At what temperature, the gas loses all its energy (i.e. molecular motion ceases).

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11. Why temperature less than absolute zero is not possible?

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12. When a gas is suddenly compressed, temperature rises. Why?

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13. At 273 K, watr solidifies into ice. What happens to the kinetic energy of water molecules?

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14. How do you distinguish between average speed and root mean square speed of the molecules of a gas?

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15. In the light of kinetic theory of gases, why pressure of container increases when the gas is heated?

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16. According to the law of equipartition of energy, the energy associated with each degree of freedom is :

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17. A glass of water is stirred and then allowed to stand until water stope moving. What has happened to kinetic energy of the moving water?

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18. What is mean free path of a gas molecule? Show that the mean free path is inversely proportional to the pressure of the gas. Does the mean free path depend upon the temperature of the gas?

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19. Estimate the fraction of molecular volume to the actual volume occupied by oxygen gas at STP. Take the diameter of an oxygen molecule to be $3\overset{\circ}{A}$.

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20. Molar volume is the volume occupied by 1 mol of any (ideal) gas at standard temperature

and pressure (STP : 1 atmospheric pressure, $0^{\circ} C$). Show that it is 22.4 litres.

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21. An oxygen cylinder of volume 30 litres has an initial gauge pressure of 15 atm and a temperature of $27^{\circ} C$. After some oxygen is withdrawn from the cylinder, the gauge pressure drops to 11 atm and its temperature drops to $17^{\circ} C$. Estimate the mass of oxygen taken out of the cylinder (

$R = 8.31 Jmol^{-1}K^{-1}$, $mo \leq c\underline{a}rmassof$

O_2` = 32 u)

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

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23. Estimate the total number of air molecules (inclusive of oxygen, nitrogen, water vapour and other constituents) in a room of capacity $25.0m^3$ at a temperature of $27^\circ C$ and 1 atm pressure.

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24. Estimate the average thermal energy of a helium atom at room temperature $(27^\circ C)$

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25. Estimate the average thermal energy of a helium atom at the temperature on the surface of the Sun (6000 K)

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26. Estimate the average thermal energy of a helium atom the temperature of 10 million kelvin (the typical core temperature in the case of a star)

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27. Three vessels of equal capacity have gases at the same temperature and pressure. The first vessel contains neon (monatomic), the second contains chlorine (diatomic), and the third contains uranium hexafluoride (polyatomic). Do the vessels contain equal number of respective molecules ? Is the root mean square speed of molecules the same in the three cases? If not, in which case is u_rms the largest ?

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28. At what temperature is the root mean square speed of an atom in an argon gas cylinder equal to the rmsspeed of a helium gas atom at $-20^{\circ}C$? (atomic mass of Ar = 39.9 u, of He = 4.0 u).

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29. Estimate the mean free path and collision frequency of a nitrogen molecule in a cylinder containing nitrogen at 2.0 atm and

temperature $17^{\circ}C$. Take the radius of a nitrogen molecule to be roughly $1.0\mathring{A}$. Compare the collision time with the time the molecule moves freely between two successive collisions (Molecular mass of N_2 = 28.0 u).

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30. A metre long narrow bore held horizontally (and closed at one end) contains a 76 cm long mercury thread, which traps a 15 cm column of

air. What happens if the tube is held vertically with the open end at the bottom ?

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31. From a certain apparatus, the diffusion rate of hydrogen has an average value of $28.7 cm^3 s^{-1}$. The diffusion of another gas under the same conditions is measured to have an average rate of $7.2 cm^3 s^{-1}$. Identify the gas

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32. A gas in equilibrium has uniform density and pressure throughout its volume. This is strictly true only if there are no external influences. A gas column under gravity, for example, does not have uniform density (and pressure). As you might expect, its density decreases with height. The precise dependence is given by the so-called 'law of atmospheres'

$$n_2 = n_1 \exp\left[-(mg)\frac{H_2 - H_1}{kT} \right]$$ where n_2, n_1 refer to number density at heights h_2

and h_1 respectively.Use this relation to derive the equation for sedimentation equilibrium of a suspension in a liquid column:

$$n_2 = n_1 \exp\left[\frac{-mgN_a}{RT}\left(1 - \frac{\rho}{\rho}\right)(h_2 - h_1)\right]$$

where ρ is the density of the suspended particle, and ρ' that of surrounding medium. [N_A is Avogadro's number, and R the universal gas constant].

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33. A cubic vessel (with faces horizontal + vertical) contains an ideal gas at NTP. The vessel is being carried by a rocket which is moving at a speed of $500ms^{-1}$ in vertical direction. The pressure of the gas inside the vessel as observed by us on the ground.

A. (a) remains the same because $500ms^{-1}$ is very much smaller than v_{rms} of the gas.

B. (b) remains the same because motion of the vessel as a whole does not affect the relative motion of the gas molecules and the walls.

C. (c) Will increase by a factor equal to $V_{rms}^2 + (500)^2\Big) / v^2 \_ (rms)$ where v_{rms} was the original mean square velocity of the gas.

D. (d) will be different on the top wall and bottom wall of the vessel.

Answer:

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34. Boyle's law is applicable for an

A. adiabatic process

B. isothermal process

C. isobaric process

D. isochoric process.

Answer:

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35. One mole of H_2 gas is contained in a box of volume $V = 1.00m^3$ at $T = 300K$. The gas is heated to a temperature of T = 3000K and the gas gets converted to a gas of hydrogen atoms. The final pressure would be (considering all gases of be ideal)

A. same as the pressure initially

B. 2 times the pressure initially

C. 10 times the pressure initially

D. 20 times the pressure initially.

Answer:

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36. A vessel of volume V contains a mixture of 1 mole of Hydrogen and 1 mole of Oxygen (both considered as ideal). Let f_1 (v) dv, denote the fraction of molecules with speed between v and (v + dv) with f_2 (v) dv, similarly for oxygen. Then

A. f_1(v) + f_2 (v) = f (v) obeys the Maxwell's distribution law.

B. f_1 (v), f_2 (V) will obey the Maxwell's distribution law separately.

C. Neither f_1 (v), nor f_2 (v) will obey the Maxwell's distribution law.

D. f_2 (v) and f_1 (v) will be the same.

Answer:

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37. An inflated rubber ballon contains one mole of an ideal gas, has a pressure p, volume V and temperature T. If the temperature rises to 1.1 T, and the volume is increase to 1.05 V, the final pressure will be

A. 1.1p

B. p

C. less than p

D. between p and 1.1

Answer:

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38. Diatomic molecules like hydrogen have energies due to both translational as well as rotational motion. From the equation in kinetic theory $pV = \frac{2}{3}E$, E is

A. (a) the total energy per unit volume

B. (b) only the translational part of energy because rotational energy is very small compared to the translational energy.

C. (c) only the translational part of the energy because during collisions with the wall pressure relates to change in linear momentum.

D. (d) the translational part of the energy because rotational energies of molecules can be of either sign and it average over all the molecules is zero.

Answer:

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39. In a diatomic molecule, the rotational energy at a given temperature

A. obeys Maxwell's distribution

B. have the same value for all molecules

C. equals the translational kinetic energy for each molecule.

D. is (2/3) rd the translation kinetic energy for each molecule.

Answer:

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40. When an ideal gas is compressed adiabatically, its temperature rises, the molecules on the average have more kinetic energy than before. The kinetic energy increases,

A. because of collisions with moving parts of the wall only

B. because of collisions with the entire wall

C. because the molecules gets accelerated in their motion inside the volume

D. because of redistribution of energy amongst the molecules.

Answer:

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41. Calculate the number of atms in 39.4 g gold. Molar mass of gold Is 197 g mole^-1.

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42. The volume of a given mass of a gas at $27^\circ C$m 1 atn us 100 cc. What will be it volume at $327^\circ C$?

Given T_1 = 27 + 273 = 300 K, T_2 = 327 + 273 = 600 K , V_1 = 100 cc.

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43. The molecules of a given mass of a gas have root mean squar speeds of $100ms^{-1}$ at $27^{\circ}C$ and 1.00 atmospheric pressure. What will be the root mean square speeds of the molecules of the as at $127^{\circ}C$ and 2.0 atmospheric pressure?

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44. Two molecules of a gas have speeds of $9 \times 10^{6}rms^{-1}$ and $1 \times 10^{6}ms^{-1}$,

respectively. What is the root mean square speed of these molecules?

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45. A gas mixture consists of 2.0 moles of oxygen and 4.0 moles of neon at temperature T. Nelglecting all vibrational modes, calculate the total internal energy of the system. (oxygen has two rotational modes).

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46. Calculate the ratio of the mean free paths of the molecules of two gases having molecular diameters 1 and 2. The gases may be considered under identical conditions of temperature, pressure and volume.

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47. A gas mixture consists of molecules of types A,B and C with masses $m_a > m_B > m_c$ Rank the three types of molecules in decreeasing order of average K.E.

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48. A gas mixture consists of molecules of types A,B and C with masses $m_a > m_B > m_c$ Rank the three types of molecules in decreeasing order of rms speeds.

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49. We have 0.5 g of hydrogen gas in a cubic chamber of size 3 cm kept at NTP. The gas in

the chamber is compressed keeping the temperature constant till a final pressure of 100 atm. Is one justified in assuming the ideal gas law, in the final state? (Hydrogen molecules can be consider as spheres of radius $1A^0$).

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50. When air is pumped into a cycle tyre the volume and pressure of the air in the tyre

both are increased. What about Boyle's law in this case?

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51. A ballon has 5.0 g mole of helium at $7^{\circ}C$ calculate the number of atoms of helium in the ballon.

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52. A ballon has 5.0 g mole of helium at $7^{\circ}C$ calculate the total internal eneryg of the system.

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53. Calculate the number of degrees of freedom of molecules of hydrogen in 1 cc of hydrogen gas at NTP.

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54. An insulated container containing monoatomic gas of molar mass m is moving with a velocity V_o. If the container is suddenly stopped, find the change in temperature.

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55. Explain why moon has no atmosphere.

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56. Explain why there is fall in temperature with altitude?

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57. Ten small planes are flying at a speed of 150km/h in total darkness in an air space that is $20 \times 20 \times 1.5 km^3$ in volume. You are in one of the planes, flying at random within this space with no way of knowing where the other planes are. On the average about how long a

time will elapse between near collision with your plane. Assume for this rough computation that a safety region around the plane can be approximated by a sphere of radius 10m.

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58. A Box of $1.00m^3$ is filled with nitrogen at 1.50 atm at 300 K. The box has a hole of an area 0.010 mm^2. How much time is required

for the pressure to reduce by 0.10 atm. If the pressure outside is 1 atm.

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59. Consider a rectangular block of wood moving with a velocity v_0 in a gas at temperature T and mass density ρ . Assume the velocity is along X-axis and area of cross section of the block perpendicular to v_0 is A. Show that the drag force on the block is

$4(\rho)Av_0\frac{\sqrt{KT}}{m}$, where m is the mass of the gas molecule.

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60. Give reason : a gas exerts pressure on the walls of the container.

A. Gas has weight

B. Gas molecules have momentum

C. Gas molecules collide with each other

D. Gas molecules collide with walls of the container.

Answer:

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61. R.M.S. velocity of nitrogen molecules at N.T.P. is

A. $33ms^{-1}$

B. $493ms^{-1}$

C. $517ms^{-1}$

D. $546ms^{-1}$

Answer:

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62. For a gas, the r.m.s speed at 800 K

A. Four times the value at 200 K

B. Half the value of 200 K

C. Twice the value fo 200 K

D. Same as at 200 K

Answer:

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63. The mean translation kinetic energy of a perfect gas molecule at temperature T is (k = Boltzmann constant)

A. $\frac{1}{2}kt$

B. kt

C. $\frac{3}{2}kT$

D. $2kT$

Answer:

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64. According to kinetic theory of gases the absolute temperature of a gas is directly related to the average of

A. internal energy of gas molecules

B. Kinetic energy of gas molecules

C. Potential energy of gas molecules

D. Gravitational energy of gas molecules

Answer:

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65. The rms speed of the molecules of a gas in a vessel Is $400ms^{-1}$. If half of the gas leaks out at constant temperatuare, the rms speed of the remaining molecules will be

A. $800ms^{-1}$

B. $400\sqrt{2}ms^{-1}$

C. $400ms^{-1}$

D. $200ms^{-1}$

Answer:

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66. AT what temperature is the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at $47^{\circ}C$?

A. 80 K

B. $-73K$

C. 3 K

D. 20 K

Answer:

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67. The kinetic energy of 1g for hydrogen a $27^{\circ}C$ will be

A. $1.87 \times 10^3 J$

B. $1.57 \times 10^3 J$

C. $1.81 \times 10^3 J$

D. $1.73 \times 10^3 J$

Answer:

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68. Th rate of diffusion is

A. Faster in solids than in liquids and gases

B. Faster in liquids and gases

C. Equal to solids, liquids and gases

D. Faster in gases than in liquids and solids.

Answer:

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

A. Calories per degrtee celsius

B. joule per mole

C. $JK^{-1}mol^{-1}$

D. joule per k.g.

Answer:

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70. The r.m.s velocity of gas molecules is $300ms^{-1}$ The r.m.s velocity of molecules of gas with twice the molecular weight and half the absolute temperature is

A. $300ms^{-1}$

B. $600ms^{-1}$

C. $75ms^{-1}$

D. $150ms^{-1}$

Answer:

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

A. is decreased

B. is increased

C. remains unchanged

D. increases or decreases according to the nature of the gas

Answer:

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72. At the same temperature the mean kinetic energies of molecules of hdrogen and oxygen are in the ratio

A. $1:1$

B. $1:16$

C. $8:1$

D. $16:1$

Answer:

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73. Temperature of a gas is a measure of

A. The average kinetic energy of the gaseous molecules

B. The average distance between the molecules of the gas

C.

D. The size of the molecules of the gas.

Answer:

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74. If the mass of all molecules of a gas are halved and their speeds doubled then the ratio of initial and final pressure will be

A. $2:1$

B. $1:2$

C. $4:1$

D. $1:4$

Answer:

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75. Fill in the Blank:

Boyle's law was discovered by _____

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76. Fill in the Blank:

_____ ^ $\circ C$ is known as abosolute zero

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77. Fill in the Blank:

Perfect gas equation for one mole is = ____.

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78. Fill in the Blank:

SI unit of universal gas constant is _____.

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79. Fill in the Blank:

Molecules of a perfect gas behave as perfect _____ spheres.

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80. Fill in the Blank:

At absolute zero, the molecular motion of a gas_____.

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81. Fill in the Blank:

$v_{rms} \propto$ _____.

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82. Fill in the Blank:

In a dynamical system in thermal equilibrium, energy associated with _____ degree of freedom is ____

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83. What are the different methods of increasing the number of molecular collisions per second in a gas?

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84. For a gas deviation from ideal behaviour is maximum at :

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85. The temperature of a gas increases on heating. Explain it on the basis of kinetic theory of gases.

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86. Obtain the demensional formula for R used in the ideal gas equation PV = RT

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87. On what factors does the average kinetic energy of gas molecules depend : Nature of the gas, temperature, volume?

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88. The ratio of vapour densities of two gases at the same temperature is 8:9. Compare the r.m.s. velocities of their molecules

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89. What is average velocity of the molecules of an ideal gas?

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90. Sometimes a cycle with well inflated tyre left in the sun has its tube burst open. Why?

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91. What are the two factors on which the degrees of freedom of a gas depends?

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92. One mole of a gas at S.T.P. occupies volume ____.

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93. One mole of a gas at S.T.P contains molecules equal to ____.

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94. At high pressure and low temperature the gases do not obey ____ laws.

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95. At what temperature, gas molecules are devoid of all motions?

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96. The volume of a gas sample is increased. Why does the pressure which is exerted by the gas decreases?

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97. How is cooling related to evaporation ?

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98. What do you mean by mean free path of a gas molecule?

Watch Video Solution

99. How can γ be determined from the number of degrees of freedom?

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100. Prove that $r^1 = 1 + \frac{2}{n}$ where n is number of degrees of freedom.

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101. State Charles' law.

Watch Video Solution

102. Deduce perfect gas law.

Watch Video Solution

103. What is kinetic theory of gases ? Give its postulates.

Watch Video Solution

104. Give qualitative definition of pressure on the basis of kinetic theory of gases.

Watch Video Solution

105. Derive expression for pressure exerted by gas.

Watch Video Solution

106. Derive relation between pressure nd kinetic energy.

Watch Video Solution

107. Give the kinetic Interpretatin of Temperature.

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108. What is meant by degrees of freedom? Find degrees of freedom for mono di and tri-atomic gas molecule.

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109. What is mean free path of a gas molecule? Show that the mean free path is inversely proportional to the pressure of the gas. Does the mean free path depend upon the temperature of the gas?

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110. Explain the term Avogadro's number and mention some methods for determination of

Avogadro's number. What is significance of Avogadro's number?

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111. State and explain the law of equipartition of energy of a dyamic system and use it to find the value of the ratio of the two specific heats of a monoatomic, and diatomic and a triatomic gas molecule.

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112. R.M.S. velocity of nitrogen molecules at N.T.P. is

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113. Calculate r.m.s velocity of nitrogen molecules at $27^{\circ}C$ and 76 cm of mercury pressure.

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114. 0.014 kg of nitrogen is enclosed in a vessel at a temperature of $27^{\circ} C$. How much heat has to be transferred to the gas to double the r.m.s velocity of its molecules?

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115. A vessel is filled with a gas at a pressure of 76 cm of mercury at a certain temperature. The mass of the gas is increased by 50% by introducing more gas in the vessel at the

same temperature. Find out the resultant pressure of the gas.

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116. Estimate the fraction of molecular volume to the actual volume occupied by oxygen gas at STP. Take the diameter of an oxygen molecule to be $3\overset{\circ}{A}$.

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117. A gas has molar heat capacity C = 37.55 $Jmol^{-1}K^{-1}$, in the process PT = constant, Find the number of degrees of freedom of the molecules of the gas.

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Exercise

1. A gas enclosed in a container is heated up What is the effect on pressure?

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2. At what temperature, gas molecules are devoid of all motions?

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3. Name three gas parameters.

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4. Name three gas laws.

Watch Video Solution

5. Write expression for Boyle's law.

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6. Write expression for Charles's law.

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7. Explain with the help of kinetic theory, why pressure of a gas in its container walls rise when volume is reduced?

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8. Prove that kinetic energy of gas is proportional to absolute temperature.

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9. How is the concept of pressure exerted by the gas explained on the basis of kinetic theory of gases?

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10. Define absolute zero on the basis of kinetic interpretatino of temprature. Explain.

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11. State Boyle's law.

Watch Video Solution

12. State Charles' law.

Watch Video Solution

13. Deduce perfect gas law.

Watch Video Solution

14. Give the main postulates of kinetic theory of matter.

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15. How is the concept of pressure exerted by the gas explained on the basis of kinetic theory of gases?

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16. What is meant by degrees of freedom? Find degrees of freedom for mono di and tri-atomic gas molecule.

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