N.B.Navale

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PHYSICS

3.KINETIC THEORY OF GASES,9.KINETIC THEORY OF GASES AND RADIATION

Single Correct Answer Type

1. Who propounded the hypothesis that exchange of heat radiation takes place between the bodies at all temperature?
   a) Kirchhoff   b) Stefan
   c) Prevost   d) Newton
2. Real gases obey ideal gas laws more closely at
   a) High pressure and low temperature
   b) Low pressure and high temperature
   c) High pressure and high temperature
   d) Low pressure and low temperature
3. A cycle tyre bursts suddenly. This represents an
   a) Isothermal process   b) Isobaric process
   c) Isochoric process   d) Adiabatic process
4. The kinetic energy of one g-mole of a gas at normal temperature and pressure is
   $(R = 8.31 \text{ J/mole} - \text{K})$
   a) 0.56×10^4 J   b) 1.3×10^2 J
   c) 2.7×10^2 J   d) 3.4×10^3 J
5. One mole of an ideal gas at temperature T is cooled isochorically till the gas pressure drops from P to $\frac{p}{n}$. Then, the gas was restored to the initial temperature isobarically. The net amount of heat absorbed by the gas in the process is
   a) nRT   b) $\frac{RT}{n}$
   c) $RT(1 - n^{-1})$ d) $RT(n - 1)$
6. The amount of heat given to a system in a cyclic thermodynamical process
   a) Is completely changed with work
   b) Is completely changed into internal energy
   c) Brings about reduction in temperature
   d) Brings about increase in temperature
7. Three black discs 'x', 'y', 'z' have radii 1m, 2m and 3m respectively. The wavelengths corresponding to maximum intensity are 200, 300 and 400 nm respectively. The relation between emissive powers 'E_x', 'E_y' and 'E_z' is
   a) $E_x > E_y > E_z$ b) $E_x < E_y < E_z$
   c) $E_x = E_y = E_z$ d) $E_x > E_y > E_z$
8. For athermanous substances, coefficient of transmission is :
   a) Zero   b) Greater than one
   c) Equal to one   d) Less than one
9. At pressure P and absolute temperature T, a mass M of an ideal gas fills a closed container of volume V. An additional mass 2M of the same gas is introduced into the container and the volume is then reduced to $\frac{V}{3}$ and the temperature to $\frac{T}{3}$. The pressure of the gas will now be
   a) $\frac{P}{3}$ b) P   c) 3P   d) 9P
10. Which of the following cannot determine the state of a thermodynamic system?
    a) Pressure and volume
    b) Volume and temperature
    c) Temperature and pressure
    d) Any one of pressure, volume or temperature
11. Coefficient of transmission is 0.22 and coefficient of reflection is 0.74 for a given body. For a given body, at given temperature, the coefficient of emission is
    a) 0.4   b) 0.04   c) 0.96   d) 0.22
12. At constant pressure, which of the following is true?
    a) $c \propto \sqrt{\rho}$ b) $c \propto \frac{1}{\rho}$
    c) $c \propto \rho$ d) $c \times \frac{1}{\sqrt{\rho}}$
13. The amount of radiation emitted by a perfectly black body is proportional to
    a) temperature
    b) fourth root of temperature
    c) fourth power of temperature
    d) square of temperature
14. Two thermometers A and B are exposed to sunlight. The valve of A is painted black but that of B is not painted. The correct statement regarding this case is :
    a) Temperature of B will rise faster
    b) Temperature of A will remain more than B

c) Both of A and B show equal rise from. the beginning
d) Temperature of A will rise faster than B but the final temperature will be same in both

15. The speed of sound in hydrogen at NTP is 1270 ms^{-1}. Then, the speed in a mixture of hydrogen and oxygen in the ratio 4: 1 by volume will be
a) 317 ms^{-1} b) 635 ms^{-1}
c) 830 ms^{-1} d) 950 ms^{-1}

16. Two moles of helium are mixed with n moles of hydrogen. The root mean square speed of the gas molecules in the mixture is $\sqrt{2}$ times the speed of sound in the mixture. Then, the value of n is
a) 1 b) 3/2
c) 2 d) 3

17. A gas for which $\gamma = 1.5$ is suddenly compressed to $\left(\frac{1}{4}\right)^{\text{th}}$ of the initial volume. Then the ratio of the final to the initial pressure is
a) 1 : 16 b) 1 : 8 c) 1 : 4 d) 8 : 1

18. Two solid spheres of radii R_1 and R_2 are made of the same material and have similar surfaces. These are raised to the same temperature and then allowed to cool under identical conditions. The ratio of their initial rates of loss of heat are
a) $\frac{R_1}{R_2}$ b) $\frac{R_2}{R_1}$ c) $\frac{R_1^2}{R_2^2}$ d) $\frac{R_2^2}{R_1^2}$

19. A perfect gas of volume 10 litre n compressed isothermally to a volume of 1 litre. The rms speed of the molecules will
a) Decrease 5 times b) Remain unchanged
c) Increase 5 times d) Increase 10 times

20. When a gas is in thermal equilibrium, its molecules have
a) a certain constant energy
b) the same energy
c) zero energy
d) different energies whose average remain constant

21. A monoatomic gas of pressure 'P' having volume 'V' expands isothermally to a volume '2V' and then adiabatically to a volume '16V'. The final pressure of the gas is
(ratio of specific heats= $\frac{5}{3}$)
a) $\frac{P}{16}$ b) $\frac{P}{8}$
c) $\frac{P}{32}$ d) $\frac{P}{64}$

22. Newton's law of cooling is applicable for
a) Any excess of temperature over the surrounding
b) Small excess of temperature over the surrounding
c) Large excess of temperature over the surrounding
d) Very large excess of temperature over the surrounding

23. A polyatomic gas with n degrees of freedom has a mean energy per molecule given by (N is Avogadro's number)
a) $\frac{nk_BT}{N}$ b) $\frac{nk_BT}{2N}$ c) $\frac{nk_BT}{2}$ d) $\frac{3k_BT}{N}$

24. Molar specific heat at constant volume C_v for a monoatomic gas is
a) $\frac{3}{2}R$ b) $\frac{5}{2}R$ c) 3R d) 2R

25. The R.M.S. velocity of the molecules in a gas at 27°C is 300 m/s. The R.M.S. velocity of the molecules in the same gas at 927°C is
a) 1200 m/s b) 600 m/s
c) 150 m/s d) 75 m/s

26. Coefficient of emission or emissivity (e) is defined as
a) Ratio of emissive power of a body to that of a emissive power of perfectly black surface at the same temperature
b) Product of the emissive powers of the body and perfectly black body at the same temperature
c) Ratio of emissive power of the body to that of perfectly black body
d) Product of emissive powers of the body and perfectly black body

27. Heat is transmitted from higher to lower temperature through molecular collision in :
a) Conduction b) Convection
c) Radiation d) Combustion

28. If a perfectly black body at absolute temperature T is kept on a surrounding at lower absolute temperature T_0.The net loss of energy by the black body per unit area per unit time is : (σ – is Stefan's constant)
a) σT^4 b) σT_0^4
c) $\sigma(T^4 - T_0^4)$ d) $\sigma(T^4 + T_0^4)$

29. The wavelength of maximum emitted energy of a body at 700 K is 4.08 μm. If the temperature of the body is raised to 1400 K, the wavelength of maximum emitted energy will be

a) 1.02 μm b) 16.32 μm c) 8.16 μm d) 2.04 μm

30. If the molecular weight of two gases are M_1 and M_2, then at a temperature, the ratio of rms velocity c_1 and c_2 will be

a) $\left(\frac{M_1}{M_2}\right)^{1/2}$ b) $\left(\frac{M_2}{M_1}\right)^{1/2}$

c) $\left(\frac{M_1 - M_2}{M_1 + M_2}\right)^{1/2}$ d) $\left(\frac{M_1 + M_2}{M_1 - M_2}\right)^{1/2}$

31. Distribution of energy in the spectrum of a black,–body can be correctly represented by

a) Wien's law b) Stefan's law

c) Planck's law d) Kirchhoff's law

32. The black body have

a) good absorption of heat capacity

b) better absorption of heat capacity

c) best absorption of heat capacity

d) no absorption of heat capacity

33. The temperature of a body falls from 50 °C to 40 °C in 10 minutes. If the temperature of the surroundings is 20 °C, then temperature of the body after another 10 minutes will be

a) 36.6 °C b) 33.3 °C c) 35 °C d) 30 °C

34. Kinetic energy per unit volume of a gas is

a) $\frac{3P}{2}$ b) $\frac{2P}{3}$ c) $\frac{P}{2}$ d) $\frac{P}{3}$

35. Which of the following statements is wrong?

a) Rough surfaces are better radiators than smooth surface

b) Highly polished mirror-like surfaces are very good radiators

c) Black surfaces are better absorbers than white ones

d) Black surfaces are better radiators than white

36. Riche's experiment verified

a) Stefan's law of Radiation

b) Newton's law of cooling

c) Kirchhoff's law

d) Prevost's theory

37. Two perfect gases at absolute temperatures T_1 and T_2 are mixed. There is no loss of energy. The temperature of mixture of masses of molecules are m_1 and m_2; and the number of molecules in the gases are n_1 and n_2 respectively, is

a) $\frac{T_1 + T_2}{2}$ b) $\frac{n_1T_1 + n_2T_2}{n_1 + n_2}$

c) $\frac{n_1T_2 + n_2T_1}{n_1 + n_2}$ d) $\sqrt{T_1T_2/n_1n_2}$

38. A body at absolute temperature T having surface area A and emissivity e is kept in a room which is at lower absolute temperature T_0. The rate of loss of heat by a body is :

a) $eA\sigma T^4$ b) $eA\sigma (T^4 - T_0^4)$

c) $eA\sigma (T - T_0)$ d) $A\sigma (T^4 - T_0^4)$

39. Heat is supplied to a diatomic gas at constant pressure. The ratio of ΔQ: ΔU: ΔW is [ΔQ= amount of heat supplied, ΔU= Increase in the internal energy, ΔW= amount of work done]

a) 7:5:2 b) 5:3:2

c) 2:3:5 d) 2:5:7

40. The r. m. s. velocity of hydrogen molecules at temperature T is seven times the r. m. s. velocity of nitrogen molecules at 300 K. This temperature T is (Molecular weights of hydrogen and nitrogen are 2 and 28 respectively)

a) 1350 K b) 1700 K

c) 1050 K d) 2100 K

41. When the temperature of a gas is raised from 30°C to 90°C, the percentage increase in the R.M.S. velocity of the molecules will be

a) 10% b) 15% c) 20% d) 17.5%

42. Bottom surface of kettles are

a) Blackened

b) Polished white

c) Neither polished white nor blackened

d) Half polished white and half blackened

43. The temperature of two bodies A and B are respectively 727°C and 327°C. The ratio $H_A : H_B$ of the rates of heat radiated by them is

a) 727 : 327 b) 5 : 3 c) 25 : 9 d) 625 : 81

44. The mean free path of a gas molecule depends on the molecular diameter (σ) as

a) σ b) σ^{-1} c) σ^{-2} d) σ^2

45. The intensity of solar energy per metre square on earth's surface is about

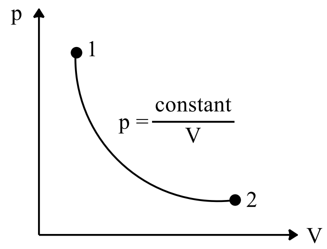
a) $1.3 kw/m^2$ b) $10^{-4} kw/m^2$

c) $10^2 kw/m^2$ d) $10^{-1} kw/m^2$

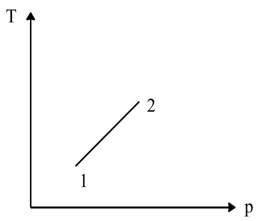
46. At 0 °C the density of a fixed mass of a gas divided by pressure is x. At 100°C, the ratio will be

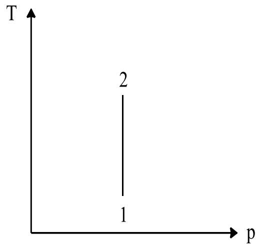
a) x b) $\frac{273}{373}$x c) $\frac{373}{273}$x d) $\frac{100}{273}$x

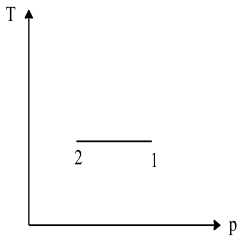
47. Consider $p - V$ diagram for an ideal gas shown in figure

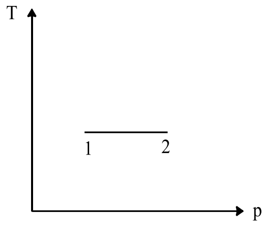


Out of the following diagrams which represents the $T - p$ diagram?

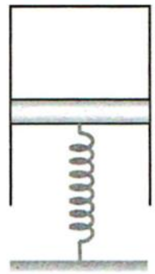
a) 

b) 

c) 

d) 

48. For a perfectly black body, its absorptive power is
 a) 1 b) 0.5 c) 0 d) Infinity
49. The radiation energy density per unit wavelength at a temperature T has a maximum at a wavelength λ_0. At temperature 2T, it will have a maximum at a wavelength
 a) $4\lambda_0$ b) $2\lambda_0$ c) $\frac{\lambda_0}{2}$ d) $\frac{\lambda_0}{4}$
50. Which of the following body emits more heat
 a) a body which is rough and black
 b) a body which is rough and white
 c) a body which is smooth but white
 d) a body which is smooth but black
51. Emissivity of perfectly black body is
 a) zero b) infinity c) one d) constant
52. One mole of an ideal gas is kept enclosed under a light piston having an area of cross-section $10^{-2} m^2$ which is connected to a compressed spring of spring constant 10 N/m. The volume of the gas is $0.83\ m^3$ and its temperature is 100 K. The gas is heated so that it compresses the spring further by 0.1 m. The work done by the gas in the process is: (Take $R = 8.3\ J/K - mole$ and suppose there is no atmosphere)



 a) 0.5 J b) 1.0 J c) 1.5 J d) 3 J
53. Heat is applied to a rigid diatomic gas at constant pressure. The ratio ΔQ: ΔU: ΔW is
 a) 7:5:2 b) 5:2:7
 c) 5:7:2 d) 2:5:7
54. The internal latent heat is heat:
 a) greater than
 b) equal to
 c) less than
 d) depends upon state of matter and
55. Emissive power of a black body at a temperature 300 K is 81 J/m^2s. Another one is an ordinary body having emissivity 0.8 at 500 K. What is the emissive power of ordinary body?
 a) 500 J/m^2s b) 800 J/m^2s
 c) 600 J/m^2s d) 400 J/m^2s
56. The mean free path is inversely proportional to:
 a) molecular diameter
 b) fourth power of the molecular diameter
 c) Square root of the molecular diameter
 d) Square of the molecular diameter
57. If coefficient of absorption of a body is 0.74 and coefficient of reflection is 0.22, then a value of coefficient of transmission is
 a) 0.04 b) 0.02 c) 0.01 d) 0.74
58. The ratio of the densities of the two liquids is 2 : 3 and the ratio of their specific heats is 3 : 2 What will be the ratio of their thermal heat capacities, when same volume of both liquids are taken ?
 a) 2: 3 b) 3: 2 c) 9: 4 d) 1: 1
59. Sweet makers do not clean the bottom of cauldron because
 a) Emission power of black and bright surface is more
 b) Absorption power of black and bright surface is more
 c) Black and rough surface absorbs more heat
 d) Transmission power of black and rough surface is more
60. The amount of heat energy required to raise

the temperature of 1 g of Helium at N.T.P., from T_1K to T_2K is

a) $\frac{3}{8}N_Ak_B(T_2-T_1)$ b) $\frac{3}{2}N_Ak_B(T_2-T_1)$
c) $\frac{3}{4}N_Ak_B(T_2-T_1)$ d) $\frac{3}{4}N_Ak_B\left(\frac{T_2}{T_1}\right)$

61. One black body at temperature T is surrounded by another black body at temperate $T_1(T_1 < T)$. At T, the radiation emitted by inner blackbody per unit area per second is proportional to
a) Difference of temperature of two blackbodies
b) Fourth power of difference of temperature of two black-bodies
c) Difference of fourth powers of temperature of two bodies
d) Sum of fourth powers of temperature of the bodies

62. Which of the following is not a thermodynamical function?
a) Enthalpy b) Work done
c) Gibb's energy d) Internal energy

63. The amount of heat energy radiated per second by the surface depends on
a) the nature of surface only
b) the area of the surface only
c) the difference of temperature between the surface and the surrounding only
d) the nature of surface, area of the surface and the temperature of body

64. First law of thermodynamics is a special case of
a) Newton's law
b) Law of conservation of energy
c) Charle's law
d) Law of heat exchange

65. When temperature of an ideal gas is increased from 27°C to 227°C, its R.M.S. speed changed from 400 metre/s to v_s. The v_s is
a) 516 metre/s b) 450 metre/s
c) 310 metre/s d) 746 metre/s

66. The molecules of a gas move in
a) different direction with same velocities
b) different direction with different velocities
c) same direction with same velocity
d) same direction with different velocity

67. Consider a spherical shell of radius R at temperature T. The black body radiation inside it can be considered as an ideal gas of photons with internal energy per unit volume $u = \frac{U}{V} \propto T^4$ and pressure $P = \frac{1}{3}\left(\frac{U}{V}\right)$. If the shell now undergoes an adiabatic expansion the relation T and R is
a) $T \propto e^{-R}$ b) $T \propto e^{-3R}$ c) $T \propto \frac{1}{R}$ d) $T \propto \frac{1}{R^3}$

68. The translational kinetic energy of the molecules of a gas at absolute temperature (T) can be doubled
a) By increasing T to 4T b) By increasing T to 2T
c) By decreasing T to $\frac{T}{2}$ d) By increasing T to $\sqrt{2}$T

69. The' mean free path is inversely proportional to
a) molecular diameter
b) square of the molecular diameter
c) square root 6f the molecular diameter
d) fourth power of the molecular diameter

70. A star (P) behaves like a perfectly black body emitting radiant energy at temperature 'T'. Another star (Q) also behave like perfectly black body emitting radiant energy at temperature T/4 and has radius eight times the radius of star (P). The ratio of radiant energy emitted by (P) to that by (Q) is
a) 1:8 b) 4:1
c) 1:4 d) 1:1

71. The substance which are transparent to thermal radiation are
a) athermanous b) diathermanous
c) thermo electric d) radioactive

72. The rate of emission of a black body at 0°C is its rate of emission at 273°C is
a) 4 *R* b) 8 *R*
c) 16 *R* d) 32 *R*

73. Six molecules speeds 2 unit, 5 unit, 3 unit, 6 unit, 3 unit and 5 unit, respectively. The rms speed is
a) 4 unit b) 1.7 unit
c) 4.2 unit d) 5 unit

74. If the temperature of a perfectly black body increases two times then the rate of radiation of the body also increases by
a) eight times b) two times
c) sixteen times d) four times

75. Wien's displacement law fails at
a) low temperature b) high temperature
c) short wavelengths d) long wavelengths

76. Which of the following statements is CORRECT for any thermodynamic system?

a) The internal energy changes in all processes
b) The temperature of a system can be increased without heating it
c) The work done is never zero in thermodynamic processes
d) The work done in an adiabatic process is always zero

77. If temperature of black body increases from 17°C to 307°C, then the rate of radiation increases by
a) 16 b) 2
c) 4 d) $\left(\frac{307}{17}\right)^4$

78. The temperature at which the molecules of nitrogen will have the same R.M.S. velocity as the molecules of oxygen at 127°C is
a) 77 °C b) 350 °C c) 273 °C d) 457 °C

79. The mean kinetic energy per molecule per degree , of freedom of a gas is
a) 1/2 KT b) 3/2 RT c) 1/2 RT d) 3/2 KT

80. The number of degrees of freedom of molecules of argon gas is
a) 1 b) 2 c) 3 d) 6

81. The absolute temperature of a gas is determined by
a) the average momentum of the molecules
b) the velocity of sound in the gas
c) the number of molecules in the gas
d) the mean square velocity of the molecules

82. External latent heat of a substance is
a) always positive
b) always negative
c) sometimes positive and some times negative
d) none of these

83. If velocities of 3 molecules are 5 m/s, 6 m/s and 7 m/s respectively, then their mean square velocity in m/s^2 is
a) 1 b) 36.7 c) 6 d) 2

84. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its temperature. The ratio of $\frac{C_p}{C_v}$ for the gas is
a) $\frac{4}{3}$ b) 2 c) $\frac{5}{3}$ d) $\frac{3}{2}$

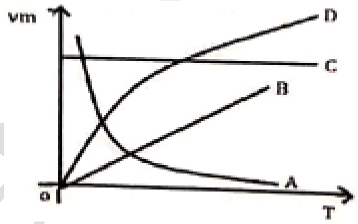
85. If the emissive and absorptive powers of a body are E and A respectively at temperature T, then the emissive power of a black body will be
a) $\frac{EA}{T}$ b) EAT c) $\frac{A}{E}$ d) $\frac{E}{A}$

86. A molecule of a perfect gas travels, between two successive collisions along a
a) parabolic both b) straight-line
c) curved path d) zigzag path

87. At constant temperature, the pressure of gas is decreased by 20%. The percentage change in volume
a) Decreases by 25% b) Decreases by 20%
c) Increases by 29% d) Increases by 25%

88. At which of the following temperatures would the molecules of a gas have twice the average kinetic energy they have at 20°C?
a) 586°C b) 80°C
c) 40°C d) 313°C

89. For a perfectly black body, the graph is plotted between the frequency of radiation with maximum intensity (v_m) and the absolute temperature 'T'. Out of the following which is the correct graph?

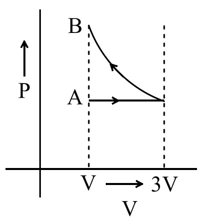


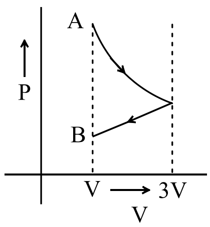
a) A b) C
c) D d) B

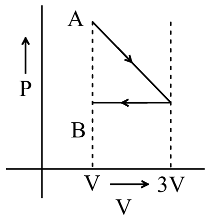
90. Mean free path of a gas molecule in a container depends upon
a) temperature of the gas molecule only
b) diameter of the gas molecule only
c) density of the gas molecule only
d) temperature diameter and density of the gas molecule

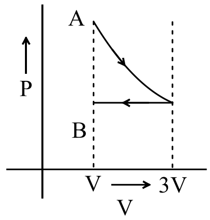
91. If average velocity becomes 4 times, then what will be the effect on rms velocity at that temperature?
a) 1.4 times b) 4 times
c) 2 times d) $\frac{1}{4}$ times

92. One mole of an ideal gas goes from an initial state A to final state B via two processes: It first undergoes isothermal expansion from volume V to 3V and then its volume is reduced from 3V to V at constant pressure. The correct P-V diagram representing the two processes is

a) 

b) 

c) 

d) 

93. At a certain temperature, the ratio of the rms velocity of H_2 molecules to O_2 molecules is
a) 1: 1 b) 1: 4
c) 4: 1 d) 16: 1

94. Molecules of a gas behave like
a) Inelastic rigid sphere
b) Perfectly elastic rigid sphere
c) Inelastic non-rigid sphere
d) Perfectly elastic non-rigid sphere

95. The original temperature of a black body is 727°C. The temperature to which the black body must be raised so as to double the total radiant energy is
a) 2000°C b) 1454°C
c) 1190°C d) 917°C

96. The energy spectrum of a black body exhibits a maximum around a wavelength λ_0. The temperature of the black body is now changed such that the energy is maximum around a wavelength $\frac{3\lambda_0}{4}$. The power radiated by the black body will now increase by a factor of
a) $\frac{256}{81}$ b) $\frac{64}{27}$ c) $\frac{16}{9}$ d) $\frac{4}{3}$

97. Ordinary bodies 'A' and 'B' radiate maximum energy with wavelength difference 4μm. The absolute temperature of body 'A' is 3 times that of 'B'. The wavelength at which body 'B' radiates maximum energy is
a) 4μm b) 8μm
c) 12μm d) 6μm

98. Two solid spheres, of radii R_1 and R_2 made of same material and have similar surfaces. The spheres are raised to the same temperature and then allowed to cool under identical conditions. Assuming spheres to be perfect conductors of heat, then the ratio of initial rates of cooling are
a) $\frac{R_1^4}{R_2^4}$ b) $\frac{R_2}{R_1}$
c) $\frac{R_1^2}{R_2^2}$ d) $\frac{R_2^3}{R_1^3}$

99. The volume of a given mass of air at temperature 27°C is 100 c.c. If its temperature is raised to 57°C maintaining the pressure constant, then the increase in its volume is
a) 100 c.c. b) 130 c.c. c) 10 c.c. d) 30 c.c.

100. The maximum wavelength of radiation emitted by a star is 289.8 nm. Then intensity of radiation for the start is
(Given: Stefan's constant= $5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$, Wien's constant, b = 2898 μmK)
a) $5.67 \times 10^{-12}\ Wm^{-2}$ b) $5.67 \times 10^{8}\ Wm^{-2}$
c) $10.67 \times 10^{14}\ Wm^{-2}$ d) $10.67 \times 10^{7}\ Wm^{-2}$

101. In the equation $\frac{PV}{4} = RT$, V represents
a) Volume of container
b) Volume of one mole of a gas
c) Volume of 4 mole of a gas
d) Volume of $\frac{1}{4}$ mole of a gas

102. The value of 'γ' for a gas is given as $\gamma = 1 + \frac{2}{f}$, where 'f' is the number of degrees of freedom of a molecule of a gas. What is the ratio of '$\gamma_{monoatomic}/\gamma_{diatomic}$'?
Diatomic gas consists of rigid gas molecules
a) $\frac{25}{21}$ b) $\frac{3}{10}$
c) $\frac{21}{25}$ d) $\frac{10}{3}$

103. At constant pressure, which of the following is TRUE?
a) $c \propto \sqrt{\rho}$ b) $c \propto \rho$ c) $c \propto \frac{1}{\rho}$ d) $c \propto \frac{1}{\sqrt{\rho}}$

104. If the temperature of the sun increases by 100%, the maximum energy radiated by the sun would correspond to
a) radio wave region b) ultra violet region
c) infrared region d) visible region

105. The temperature of hydrogen at which the RMS speed of its molecules is equal to that of oxygen molecules at a temperature of 31°C is
a) -216 °C b) -235 °C c) -254 °C d) -264 °C

106. A black body radiates maximum energy at wavelength 'λ' and its emissive power is 'E'. Now, due to change in temperature of that body, it radiates maximum energy at wavelength $\frac{2\lambda}{3}$. At that temperature, emissive power is
a) $\frac{81E}{16}$ b) $\frac{91E}{16}$
c) $\frac{54E}{16}$ d) $\frac{27E}{16}$

107. If a body is good absorber of heat then it is
a) a poor reflector and transmitter

b) a poor reflector and good transmitter
c) a good reflector and transmitter
d) none of these

108. The following four gases are at the same temperature. The gas whose molecules have the maximum r.m.s. velocity is
a) hydrogen b) helium
c) nitrogen d) oxygen

109. Two spheres P and Q of same color having radii 8 cm and 2 cm kept at temperature 127°C and 527°C respectively. The ratio of the energy by P and Q in the same time is
a) 1 b) 0.5
c) 3 d) 2

110. Water is usually heated by :
a) Conduction b) Convection
c) Radiation d) Combustion

111. In Boyle's law, the quantity that remains constant is
a) PV b) TV c) $\frac{V}{T}$ d) $\frac{P}{T}$

112. In the kinetic theory of gases, it is assumed that the gas molecules:
a) Repel each other.
b) Collide elastically.
c) Move with uniform velocity.
d) are mass less particles.

113. The volume occupied by the gas molecules v in a container of volume V, according to kinetic theory of gases
a) $v = V$ b) $v < V$ c) $v > V$ d) $v \geq V$

114. The power of a black body at temperature 200 K is 544 W. Its surface area is
(Take, $\sigma = 5.67 \times 10^{-8} \mathrm{Wm^{-2}\ K^{-4}}$)
a) $6 \times 10^{-2}\ \mathrm{m^2}$ b) $6\ \mathrm{m^2}$
c) $6 \times 10^{-6}\ \mathrm{m^2}$ d) $6 \times 10^{2}\ \mathrm{m^2}$

115. Which of the following statements is correct for any thermodynamic system?
a) The internal energy changes in all processes
b) Internal energy and entropy are state functions
c) The change in entropy can never be zero
d) The work done in adiabatic process is always zero

116. If pressure of gas is reduced, the mean free path of gas molecules.
a) increases b) decreases
c) becomes 0 d) remains constant

117. According to Newton's law of cooling, the rate of cooling of a body is proportional to $(\Delta\theta)^n$, where $\Delta\theta$ is the difference of the temperature of the body and the surroundings, and n is equal to
a) One b) Two c) Three d) Four

118. Two vessels separately contain two ideal gases A and B at the same temperature. The pressure of A is twice that of B. Under such conditions, the density of A is found to be 1.5 times the density of B. The ratio of molecular weights of A and B is
a) 2 b) $\frac{3}{4}$
c) $\frac{1}{2}$ d) $\frac{2}{3}$

119. The heat by gm of water is given by (L is latent heat of vaporization)
a) ML b) L/M c) M/L d) 100 ML

120. A surface at temperature T_0 kelvin receives power P by radiation from a small sphere at temperature $T > T_0$ and at a distance d. If both T and d are doubled, the power received by the surface will become
a) P b) $2P$
c) $4P$ d) $16P$

121. The mechanical equivalent of heat is
a) a physical quantity
b) a dimensional quantity
c) a conversion factor
d) all of the above

122. The energy spectrum of a black body exhibits a maximum around a wavelength 'λ'. The temperature of a black body is now changed such that the energy is maximum around a wavelength $\frac{3\lambda}{4}$. The power radiated by a black body will now increase by a factor
a) $\frac{5}{3}$ b) $\frac{256}{81}$
c) $\frac{128}{27}$ d) $\frac{86}{9}$

123. In the refrigerator, freezer is kept in the topmost part so that
a) Full chamber of the fridge is quickly cooled
b) Motor is not affected
c) Lost heat can be taken from the surrounding
d) More heat is taken from the surrounding

124. On any planet, the pressure of atmosphere implies (C_{rms} = R.M.S velocity of molecules and V_e = escape velocity)
a) $C_{rms} << Ve$ b) $C_{rms} > Ve$
c) $C_{rms} = Ve$ d) $C_{rms} = 0$

125. The perfect gas equation for 4 gram of

hydrogen gas is:

a) PV=RT b) PV=2RT

c) PV=RT/2 d) PV=4RT

126. The temperature of the sun cannot be found out by using:

a) Weins displacement low

b) Kepler's law of motion

c) Stefan's –Boltzmann law

d) Planks law

127. The rms velocity of gas molecules is 300 ms^{-1}. The rms velocity of molecules of gas with twice the molecular weight and half the absolute temperature is

a) 300 ms^{-1} b) 600 ms^{-1}

c) 75 ms^{-1} d) 150 ms^{-1}

128. Thermal radiations may exhibit the following phenomenon

a) interference only

b) diffraction only

c) polarisation only

d) interference, polarisation and diffraction

129. One mole of an ideal gas at an initial temperature of T K does 6 R joules of work adiabatically. If the ratio of specific heats of this gas at constant pressure and at constant volume is 5/3, the final temperature of gas will be

a) $(T + 2.4)K$ b) $(T - 2.4)K$

c) $(T + 4)K$ d) $(T - 4)K$

130. The root mean square velocity of the molecules in a sample of helium is 5/7 th that of the molecules in a sample of hydrogen. If the temperature of the hydrogen is 0°C, that of helium sample is about

a) 0°C b) 4 K

c) 273°C d) 100°C

131. At what temperature will the R.M.S. velocity for H_2 molecule is same as that for O_2 molecule at 127°C?

a) 27°C b) −248°C c) −127°C d) 35°C

132. A perfectly black body emits a radiation at temperature 'T_1' K. If it is to radiate at 16 times this power, its temperature 'T_2' K should be

a) $8T_1$ b) $4T_1$

c) $2T_1$ d) $16T_1$

133. If the r. m. s. speed of gas molecules is 400 m/s, then the density of that gas at N. T. P. in kg/m^3 is

[Take atmospheric pressure $P = 10^5\ N/m^2$]

a) $\frac{15}{8}$ b) $\frac{25}{8}$

c) $\frac{5}{8}$ d) $\frac{11}{8}$

134. A thin circular plate, a sphere and a cube of same mass and material are heated to 100°C temperature. Now if hey are allowed to cool, which of these three cool first?

a) cube b) plate

c) sphere d) all at the same time

135. Three objects coloured black, gray and white can withstand hostile conditions up to 2800°C. These objects are thrown into a furnace where each of them attains a temperature of 2000°C. Which object will glow brightest?

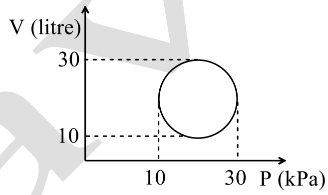
a) The white object

b) The black object

c) All glow with equal brightness

d) Gray object

136. Heat energy absorbed by a system in going through a cyclic process shown in figure is



a) $10^7\pi$ J b) $10^4\pi$ J c) $10^2\pi$ J d) $10^{-3}\pi$ J

137. An ideal gas occupies a volume 'V' at a pressure 'P' and absolute temperature T. The mass of each molecule is 'm'. If 'K_a' is the boltzmann's constant, then the density of gas is given by expression

a) $\frac{P.m}{2K_B.T}$ b) $\frac{K_B.T}{P.m}$

c) $\frac{P.m}{K_B.T}$ d) $\frac{3K_B.T}{2P.m}$

138. The average kinetic energy of the molecules of a gas is

a) inversely proportional to the absolute temperature of the gas

b) directly proportional to the absolute temperature of the gas

c) independent upon the absolute temperature of the gas

d) all of these

139. When the rms velocity of a gas is denoted by 'V', which of the following relations is true? (T = absolute temperature of the gas)

a) $\frac{V^2}{T}$ = constant b) VT^2 = constant

c) $\frac{V}{T^2}$ = constant d) V^2T = constant

140. Out of 10 J of radiant energy incident on a

surface, the energy absorbed by the surface is 2 J and the energy reflected is 7 J. Then, coefficient of transmission of the body is

a) 0.2 b) 0.7 c) 0.1 d) Zero

141. If 150 J of energy is incident on area $2\ m^2$. If $Q_r = 15$ J, coefficient of absorption is 0.6, then amount of energy transmitted is

a) 50 J b) 45 J
c) 40 J d) 30 J

142. The substances through which heat radiations can pass are called as :

a) Conductors b) Absorbers
c) Diathermanous d) Athermanous

143. S.I. unit of universal gas constant is

a) cal/°C b) J/mol
c) $J\ mol^{-1}K^{-1}$ d) J/kg

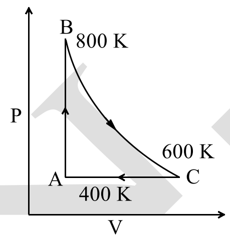
144. A black sphere has radius 'R' whose rate of radiation is 'E' at temperature 'T'. If radius is made '$\frac{R}{3}$' and temperature '3T', the rate of radiation will be

a) 16E b) 3E
c) E d) 9E

145. The wavelength of maximum energy released during an atomic explosion was 2.93×10^{-10} m. The maximum temperature attained must be (Take, Wien's constant $= 2.93 \times 10^{-3}$ m − K)

a) 5.86×10^7 K b) 10^{-13} K
c) 10^{-7} K d) 10^7 K

146. One mole of diatomic ideal gas undergoes a cyclic process ABC as shown in figure. The process BC is adiabatic. The temperatures at A, B and C are 400 K, 800 K and 600 K respectively. Choose the correct statement



a) The change in internal energy in whole cyclic process is 250 R
b) The change in internal energy in the process CA is 700 R
c) The change in internal energy in the process AB is −350 R
d) The change in internal energy in the process BC is −500 R

147. A hot liquid is kept in a big room. Its temperature is plotted as a function of time. Which of the following curves may represent the pot?(figure)

a) curve 1 b) curve 2
c) curve 2 d) both curve 2 & 3

148. Athermanous bodies are those

a) Which do not allow heat radiation to pass through
b) Which allow heat radiation to pass through
c) Which are special type of black bodies
d) Which are insulators

149. A liquid cools from 70 °C to 60 °C in 5 minutes. If the temperature of the surrounding is constant at 30°C, then the time taken by the liquid to cool from 60 °C to 50 °C is

a) 5 minutes b) 10 minutes
c) 7 minutes d) 8 minutes

150. Suppose the sun expands so that its radius becomes 100 times its present radius and its surface temperature becomes half of its present value. The total energy emitted by it then will increase by a factor of

a) 10^4 b) 625 c) 256 d) 16

151. Value of two principal specific heats of a gas (in cal $molK^{-1}$ determined by different students are given. Which is most reliable?

a) 5,2 b) 6,5
c) 7,5 d) 7,4

152. Newton's law of cooling is also applicable to

a) Convection losses
b) Natural convection losses
c) Forced convection losses
d) Conduction losses

153. The wrong statement according to the kinetic theory of gases is

a) There is loss of kinetic energy of molecules on striking the wall
b) The potential energy of ideal gases is zero
c) The molecules are in random motion
d) Gas molecules are solid spherical point masses

154. The r. m. s. velocity of molecules of gas is directly proportional to :

a) $(pressure)^2$ b) $(pressure)^{1/2}$
c) (temperature). d) $(temperature)^{1/2}$

155. Newton's law of cooling can be obtained from

a) Rayleigh's law b) Stefan's law
c) Wien's law d) Planck's law

156. A body radiates heat at high temperature T. The rate of radiation of heat is proportional to

a) T^4 b) T^5 c) T^2 d) T^3

157. Rate of loss of heat of two spheres at same temperature having radii in ratio 1 : 2 is
a) 1/2 b) 2/1 c) 1/4 d) 4/1

158. An ideal black-body is at room temperature. If it is thrown into a furnace, it will be observed that
a) Initially it is the darkest and at later times the brightest
b) It is the darkest at all times
c) It cannot be distinguished at all times
d) Initially it is the darkest and at later times it cannot be distinguished

159. A sphere of density ρ, specific heat capacity c and radius r is hung by a thermally insulated thread in an enclosure which is kept at a lower temperature than the sphere. The temperature of the sphere starts to drop at a rate which depends upon the temperature difference between the sphere and the enclosure and the nature of the surface of the sphere and is proportional to
a) $c/r^3\rho$ b) $1/r^3\rho c$ c) $3r^3\rho c$ d) $1r\rho c$

160. Rice takes longest time to cook:
a) at the sea level
b) in srinager
c) at mount Everest
d) in submarine 100 m below the surface of sea

161. At constant pressure, the mean free path of a gas varies with temperature (T) according to the following relation:
a) $\lambda \propto T$ b) $\lambda \propto \frac{1}{T}$ c) $\lambda \propto \sqrt{T}$ d) $\lambda \propto \frac{1}{\sqrt{T}}$

162. In Fery' s black body, the area of black body is
a) area of opening
b) inner area of body
c) outer area of body
d) area of complete body along with area of opening

163. If the radius of the star is 'r' and it acts as a black body, the temperature of the star having rate of radiation 'R' is (σ = Stefan's constant)
a) $\left(\frac{4\pi r^2}{R\sigma}\right)^{1/4}$ b) $\left(\frac{R}{4\pi r^2\sigma}\right)^{-1/2}$
c) $\frac{R}{4\pi r^2\sigma}$ d) $\left(\frac{R}{4\pi r^2\sigma}\right)^{1/4}$

164. A black body radiates 6 J/cm^2s when its temperature is 127 °C. How much heat will be radiated per square centimeter per second when its temperature is 527 °C?
a) 6 J b) 12 J c) 96 J d) 48 J

165. The mean free path of molecules of a gas (radius r) is inversely proportional to
a) r^3 b) r^2 c) r d) $\sqrt{r}$

166. A rectangular black body of temperature 127°C has surface area 6 cm × 3 cm of rate of radiation 'E'. If its temperature is increased by 400°C and surface area is reduced to half the initial value then rate of radiation is
a) 4E b) 8E
c) 6E d) 12E

167. An ideal black-body at room temperature is thrown into a furnance. It is observed that
a) Initially it is the darkest body and becomes the brightest later
b) It is the darkest body at all times
c) It cannot be distinguished at all times
d) Initially it is the darkest body and can not be distinguished later

168. The internal energy change in a system that has absorbed 2 kcal of heat and done 500 J of work is
a) 8900 J b) 6400 J c) 5400 J d) 7900 J

169. Let the r. m. s. velocity of molecule of a given mass of gas be C_1 at temperature 27°C. When the temperature is increased to 327°C, the r. m. s. velocity of C_2. Then the ratio $\frac{C_2}{C_1}$ is
a) $\sqrt{2}$ b) 4
c) 2 d) $2\sqrt{2}$

170. Two vessels of equal volume contains equal masses of oxygen in one at 4000k and hydrogenin the other at 300⁰k. The ratio of rms speed of the molecules of hydrogen to that of the molecules of oxygen is:
a) ¾ b) 4/3 c) $2\sqrt{2}$ d) $3\sqrt{2}$

171. Velocities of three molecules are 2, 3 and 4 m/s. Ratio of mean velocity to R.M.S. velocity is
a) <1 b) =1 c) >1 d) >2

172. If m represents the mass of each molecule of a gas and T its absolute temperature, then the root mean square velocity of the gaseous molecule is proportional to
a) mT b) $m^{1/2}T^{1/2}$
c) $m^{-1/2}T$ d) $m^{-1/2}T^{1/2}$

173. The average K.E. of hydrogen molecules at 27°C is E. The average K.E. at 327°C is
a) K.E. b) $\sqrt{2}$ K.E. c) 2 K.E. d) 4 K.E.

174. Spectrum of a perfectly black body is :
a) line emission spectrum
b) band emission spectrum

c) continuous emission spectrum
d) line absorption spectrum

175. For a gas, if the ratio of specific heats at constant pressure and volume is γ, then value of degree of freedom is
a) $\frac{3\gamma - 1}{2\gamma - 1}$ b) $\frac{2}{\gamma - 1}$
c) $\frac{9}{2}(\gamma - 1)$ d) $\frac{25}{2}(\gamma - 1)$

176. In M.K.S. system, Stefan's constant is denoted by σ. In C.G.S. system multiplying factor of σ will be
a) 1 b) 10^3 c) 10^5 d) 10^2

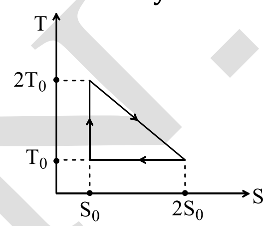
177. The area enclosed between $E_\lambda - \lambda$ curve and $\lambda -$ axis is equal to
a) σT^4 b) B c) σT^5 d) $1/b'$

178. Ratio of specific heats $\left(\frac{C_P}{C_V}\right)$ for a gas is always
a) Negative b) More than one
c) Between zero and one d) Zero

179. 5 moles of oxygen is heated at constant volume from 10°C to 20°C. The change in the internal energy of the gas is (the gram molecular specific heat of oxygen at constant pressure, $C_p = 8$ cal/mol °C and $R = 8.3$ J/mol °C)
a) 200 calories b) 300 calories
c) 100 calories d) None of these

180. If one mole of an ideal gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with one mole of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$. The value of 'γ' for the mixture is
a) 1.53 b) 3.07
c) 1.40 d) 1.50

181. The temperature-entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is



a) 1/3 b) 2/3 c) 1/2 d) 1/4

182. How much heat energy in joules must be supplied to 14 g of nitrogen at room temperature to raise its temperature by 40°C at constant pressure?
(Take, molecular weight of $N_2 = 28$ g, $R =$ constant)
a) 50 R b) 60 R
c) 70 R d) 80 R

183. For the same rise in temperature of one mole of gas at constant volume, heat required for a non-linear triatomic gas is K times that required for monoatomic gas. The value of K is
a) 1 b) 0.5
c) 2 d) 2.5

184. An ideal gas having volume 'V' at 27°C is heated at constant pressure. If the volume of the gas becomes 2.5 V, then the final temperature reached is
a) 177°C b) 477°C
c) 327°C d) 600°C

185. We have a sample of gas characterized by P, V and T and another sample of gas characterized by 2P, V/4 and 2T. What is the ratio of the number of molecules in the first and second samples?
a) 2:1 b) 16:1
c) 8:1 d) 4:1

186. If E_b is emissive power of a black body and E is the emissive power of any ordinary body at Same temperature, then
a) $E_b = E$ b) $E_b > E$ c) $E_b < E$ d) $E_b \approx E$

187. Under steady state, the temperature of a body
a) decrease with time
b) does not change with time and is same at all the points of the body
c) increase with time
d) does not change with time but can be different at different point of the body

188. The pressure exerted in terms of total kinetic energy per unit volume (E) is
a) $\frac{3}{2}E$ b) E c) $\frac{2}{3}E$ d) $\sqrt{3}\,E$

189. Kinetic theory of gases is based upon the assumptions
a) matter consists of minute particles
b) the molecules are constantly in a state of random motion
c) there exist intermolecular force between the molecules
d) all of these

190. Given: $v_1 = 3$ m/s, $v_2 = 4$m/s, $v_3 = 5$m/s. What is mean square velocity?
a) 50 m/s b) 12 m/s c) 4.5 m/s d) 16.7 m/s

191. The distance travelled by a molecule between two successive collisions is called as
a) Mean free path b) Free path
c) Path length d) Range

192. E is emissive power, and 'a' is the coefficient of absorption of a body at a certain temperature, E_b is the emissive power of a perfectly black body at that temperature then according to Kirchhoff's law

a) $E = \frac{E_b}{a}$ b) $\frac{E}{a} = E_b$ c) $E.E_b = a$ d) $E.E_b = \frac{1}{a}$

193. The temperature at which the velocity of oxygen will be half that of hydrogen at NTP is
a) 1092°C b) 1492°C
c) 273°C d) 819°C

194. A jar has mixture of Hydrogen and Oxygen gases in the ratio 1 : 5. Then the ratio of mean KE. of hydrogen and oxygen molecules is
a) 1: 16 b) 1: 5 c) 1:4 d) 1:1

195. We write the relation for Boyle's law in the form, $PV = k_B$ when the temperature remains constant. In this relation, the magnitude of k_B depends upon the
a) Nature of the gas used in the experiment
b) Magnitude of g in the laboratory
c) Quantity of the gas enclosed
d) Atmospheric pressure

196. The temperature of a black body is increased by 50%, then the percentage of increase of radiation is approximately
a) 100% b) 25%
c) 400% d) 500%

197. A body having a surface area of 50 cm^2 radiates 300 J of energy per minute at a temperature of 727 °C. The emissivity of the body is
(Stefan's constant $= 5.67 \times 10^{-8} W/m^2K^4$)
a) 0.09 b) 0.018 c) 0.36 d) 0.54

198. One mole of an ideal gas requires 207 J heat to raise the temperature by 10 K, when heated at constant pressure. If the same gas is heated at constant volume to raise the temperature by 10 K, then heat required is [given gas constant $R = 8.3 J/(mol - K)$]
a) 96.6 J b) 124.2 J c) 198.8 J d) 215.4 J

199. Coefficient of emission of a surface does NOT depends upon
a) Wavelength of radiation
b) Nature of the surface
c) Temperature of the surface
d) Surrounding medium

200. The R.M.S velocity of a gas molecule is given by
a) $1.5\sqrt{\frac{RT}{M}}$ b) $1.73\sqrt{\frac{RT}{M}}$ c) $1.73\sqrt{\frac{R}{MT}}$ d) $1.73\sqrt{\frac{T}{MR}}$

N.B.Navale

Date : 28.03.2025 **TEST ID: 49**
Time : 03:00:00 **PHYSICS**
Marks : 200

3.KINETIC THEORY OF GASES,9.KINETIC THEORY OF GASES AND RADIATION

: ANSWER KEY :

1)	c	2)	b	3)	d	4)	d	105)	c	106)	a	107)	a	108)	a
5)	c	6)	a	7)	a	8)	a	109)	a	110)	b	111)	a	112)	b
9)	c	10)	d	11)	b	12)	d	113)	b	114)	b	115)	b	116)	a
13)	c	14)	d	15)	b	16)	c	117)	a	118)	b	119)	a	120)	c
17)	d	18)	c	19)	b	20)	a	121)	c	122)	b	123)	a	124)	a
21)	d	22)	b	23)	c	24)	a	125)	b	126)	b	127)	d	128)	d
25)	b	26)	a	27)	a	28)	c	129)	d	130)	c	131)	b	132)	c
29)	d	30)	b	31)	c	32)	c	133)	a	134)	d	135)	b	136)	c
33)	b	34)	a	35)	b	36)	c	137)	c	138)	b	139)	a	140)	c
37)	b	38)	b	39)	a	40)	c	141)	b	142)	c	143)	c	144)	d
41)	a	42)	a	43)	d	44)	c	145)	d	146)	d	147)	a	148)	a
45)	c	46)	b	47)	c	48)	a	149)	c	150)	b	151)	c	152)	c
49)	c	50)	a	51)	c	52)	b	153)	a	154)	d	155)	b	156)	a
53)	a	54)	a	55)	a	56)	d	157)	c	158)	a	159)	d	160)	c
57)	a	58)	d	59)	c	60)	a	161)	a	162)	a	163)	d	164)	c
61)	c	62)	b	63)	d	64)	b	165)	b	166)	b	167)	a	168)	d
65)	a	66)	b	67)	c	68)	b	169)	a	170)	c	171)	a	172)	d
69)	b	70)	b	71)	b	72)	c	173)	c	174)	c	175)	b	176)	b
73)	c	74)	c	75)	d	76)	b	177)	a	178)	b	179)	b	180)	d
77)	a	78)	a	79)	a	80)	c	181)	a	182)	c	183)	c	184)	b
81)	d	82)	c	83)	b	84)	d	185)	d	186)	b	187)	d	188)	c
85)	d	86)	b	87)	d	88)	d	189)	d	190)	d	191)	b	192)	b
89)	d	90)	d	91)	b	92)	d	193)	d	194)	d	195)	c	196)	c
93)	c	94)	b	95)	d	96)	a	197)	b	198)	b	199)	d	200)	b
97)	d	98)	b	99)	c	100)	b								
101)	c	102)	a	103)	d	104)	b								

N.B.Navale

Date : 28.03.2025 **TEST ID: 49**
Time : 03:00:00 **PHYSICS**
Marks : 200

3.KINETIC THEORY OF GASES,9.KINETIC THEORY OF GASES AND RADIATION

: HINTS AND SOLUTIONS :

Single Correct Answer Type

3 **(d)**

The process is very fast; so the gas fails to gain or lose heat. Hence this process in adiabatic

4 **(d)**

$$E = \frac{3}{2}RT = \frac{3}{2} \times 8.31 \times 273 = 3.4 \times 10^3 J$$

7 **(a)**

$\lambda_m T = k$

$$E = \frac{\sigma A T^4}{A} \Longrightarrow E \propto T^4$$

$$\therefore E \propto \frac{A}{\lambda^4}$$

$$E_x : E_y : E_z = \frac{1}{\lambda_x^4} : \frac{1}{\lambda_y^4} : \frac{1}{\lambda_z^4}$$

$$= \frac{1}{(200)^4} : \frac{1}{(300)^4} : \frac{1}{(400)^4}$$

$$= E_x > E_y > E_z$$

9 **(c)**

The equation of state is, $PV = nRT$

$\Rightarrow P = \frac{nRT}{V}$ (ideal gas condition)

Let for M mass there is μ moles, then for mass 3M, there are $\frac{3Mn}{M} = 3\mu$ moles

Let $n' = 3n, T' = T/3$ and $V' = \frac{V}{3}$

Then $P' = \frac{n'RT'}{V'} = \frac{3nR\frac{T}{3}}{V/3} = \frac{3nRT}{V} = 3P$

10 **(d)**

State of a thermodynamic state cannot be determined by a single variable (P or V or T)

11 **(b)**

Using, $a + r + t = 1$,

$a + 0.74 + 0.22 = 1 \Rightarrow a = 0.04$

By Kirchoff's law, $a = e \Rightarrow e = 0.04$

12 **(d)**

Pressure due to an ideal gas is given by

$$p = \frac{M}{3V}c^2$$

Putting $\frac{M}{V} = \rho$, the density of gas.

$$p = \frac{1}{3}\rho c^2 \Rightarrow c = \sqrt{\left(\frac{3p}{\rho}\right)}$$

$$c \propto \frac{1}{\sqrt{\rho}}$$

$$\therefore\ c \propto \frac{1}{\sqrt{\rho}}$$

15 **(b)**

As given, the volumes of hydrogen and oxygen in a mixture is 4: 1, so let V be the volume of oxygen. The volume of hydrogen will be $4V$. If ρ_m be the density of mixture, then

$$\rho_m = \frac{4V \times 1 + V \times 16}{5V} = 4$$

As,

$$v \propto \left(\frac{1}{\rho}\right)^{\frac{1}{2}}$$

$\therefore$ Velocity in mixture $= \frac{1270}{(4)^{1/2}} = 635\ ms^{-1}$

16 **(c)**

The root mean square speed of the gas,

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}, v_{\text{sound}} = \sqrt{\frac{\gamma RT}{M}}, v_{\text{rms}} = \sqrt{2}v_{\text{sound}}$$

Solving it, we get

$\sqrt{3} = \sqrt{2}\gamma \Rightarrow \gamma = \frac{3}{2}$ for the mixture.

As, $\gamma = \frac{C_p}{C_V} = \frac{n_1 C_{p_1} + n_2 C_{p_2}}{n_1 + n_2} \times \frac{n_1 + n_2}{n_1 C_{V_1} + n_2 C_{V_2}}$

$$\gamma = \frac{n_1 C_{p_1} + n_2 C_{p_2}}{n_1 C_{V_1} + n_2 C_{V_2}}$$

For helium, $C_{p_1} = \frac{5}{2}R, C_{V_1} = \frac{3}{2}R$

For hydrogen, $C_{p_2} = \frac{7}{2}R, C_{V_2} = \frac{5}{2}R$

$$\frac{3}{2} = \frac{2\left(\frac{5}{2}R\right) + n\left(\frac{7}{2}R\right)}{2\left(\frac{3}{2}R\right) + n\left(\frac{5}{2}R\right)} = \frac{10 + 7n}{6 + 5n}$$

or $20 + 14n = 18 + 15n \Rightarrow n = 2$

17 **(d)**

As the change is sudden, the process is adiabatic

$\therefore P_1V_1^\gamma = P_2V_2^\gamma$

$\therefore \frac{P_2}{P_1} = \left[\frac{V_1}{V_2}\right]^\gamma = \left[\frac{4}{1}\right]^{3/2} = \frac{8}{1}$

18 **(c)**

Rate of loss of heat per sec $= \sigma A(T^4 - T_0^4)$

$= \sigma(4\pi R^2)(T^4 - T_0^4)$

$\therefore \left(\frac{dQ}{dt}\right)_1 = \sigma 4\pi R_1^2(T^4 - T_0^4)$ and

$\left(\frac{dQ}{dt}\right)_2 = \sigma 4\pi R_2^2(T^4 - T_0^4)$

$\therefore \frac{(dQ/dt)_1}{(dQ/dt)_2} = \frac{R_1^2}{R_2^2}$

19 **(b)**

Since it is compressed isothermally, the temperature remains constant. The rms speed is given by,

$$c = \sqrt{\frac{3RT}{M}}$$

Since temperature T remains constant, the rms speed remains unchanged.

21 **(d)**

$\gamma = \frac{5}{3}$

Case I: $P_1V_1 = P_2V_2$

$PV = P_2 \times 2V$

$\therefore P_2 = \frac{P}{2}$

Case II: $P_2V_2^\gamma = P_3V_3^\gamma$

$\left(\frac{P}{2}\right)(2V)^\gamma = P_3(16V)^\gamma$

$P_3 = \frac{P}{2}\frac{(2V)^\gamma}{(16V)^\gamma} = \frac{P}{2}\left(\frac{1}{8}\right)^\gamma$

$= \frac{P}{2}\left(\frac{1}{2^3}\right)^{\frac{5}{3}} = \frac{P}{2}\left(\frac{1}{2}\right)^5$

$= \frac{P}{2 \times 32} = \frac{P}{64}$

25 **(b)**

$c_{rms} \propto \sqrt{T}$

$\therefore \frac{300}{c_{rms}} = \sqrt{\frac{27 + 273}{927 + 273}} = \sqrt{\frac{300}{1200}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$

$\therefore c_{rms} = 2 \times 300 \Rightarrow c_{rms} = 600 m/s$

29 **(d)**

According to Wien's law, $\lambda_{m_1}T_1 = \lambda_{m_2} = T_2$

$\therefore \lambda_{m_2} = \frac{\lambda_{m_1}T_1}{T_2} = 4.08 \times \frac{700}{1400} = 2.04 \mu m$

30 **(b)**

As, $\frac{1}{2}Mc^2 = \frac{3}{2}RT$ or $c = \left(\frac{3RT}{M}\right)^{1/2}$

$\Rightarrow c \propto \frac{1}{\sqrt{M}}$

So, $\frac{c_1}{c_2} = \left(\frac{M_2}{M_1}\right)^{1/2}$

31 **(c)**

Because Planck's law explains the distribution of energy correctly at low temperature as well as at high temperature.

33 **(b)**

In first case,

$\frac{50-40}{10} = K\left[\frac{50+40}{2} - 20\right]$ ...(i)

In second case,

$\frac{40-\theta_2}{10} = K\left[\frac{40+\theta_2}{2} - 20\right]$ ...(ii)

By solving equations (i) and (ii), $\theta_2 = 33.3$ °C

35 **(b)**

Highly polished mirror-like surfaces are good reflectors but not good radiators

37 **(b)**

We know that, $E = \frac{3}{2}nkT$

$\therefore$ (where, k = Boltzmann's constant)

$\therefore \frac{3}{2}n_1kT_1 + \frac{3}{2}n_2kT_2 = \frac{3}{2}(n_1 + n_2)kT$

$\Rightarrow T = \frac{n_1T_1 + n_2T_2}{(n_1 + n_2)}$

39 **(a)**

$$\Delta Q = nC_p\Delta T = \frac{7}{2}nR\Delta T \quad \left[C_p = \frac{7}{2}R\right]$$

$$\Delta U = nC_v\Delta T = \frac{5}{2}nR\Delta T \quad \left[C_v = \frac{5}{2}R\right]$$

$$\Delta W = \Delta W - \Delta U = nR\Delta T$$

$$\therefore \Delta Q : \Delta U : \Delta W = 7:5:2$$

40 **(c)**

$$C_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{C_H}{C_N} = \sqrt{\frac{T}{2} \times \frac{28}{300}} = \sqrt{\frac{14T}{300}}$$

$$\therefore \frac{14T}{300} = 49$$

$$T = \frac{49 \times 300}{14} = 1050\ K$$

41 **(a)**

$$c_{r.m.s.} = \sqrt{\frac{3RT}{M}}$$

$$\therefore \frac{(c_{rms})_2}{(c_{rms})_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{(273+90)}{(273+30)}} \approx 1.1$$

$$\therefore \% \text{ increase} = \left[\frac{(c_{rms})_2}{(c_{rms})_1} - 1\right] \times 100$$

$$= 0.1 \times 100 = 10\%$$

43 **(d)**

$Q \propto T^4$

$$\Rightarrow \frac{H_A}{H_B} = \left(\frac{273+727}{273+327}\right)^4 = \left(\frac{10}{6}\right)^4 = \left(\frac{5}{3}\right)^4 = \frac{625}{81}$$

46 **(b)**

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

$$\therefore \frac{m}{VP} \Rightarrow \frac{\text{density}}{P} = \frac{M}{RT}$$

$$\left(\frac{\text{density}}{P}\right)_{\text{At } 0^\circ C} = \frac{M}{R(273)} = x \quad \dots (i)$$

$$\left(\frac{\text{density}}{P}\right)_{\text{At } 100^\circ C} = \frac{M}{R(373)} = x \quad \dots (ii)$$

$\therefore$ From equations (i) and (ii) we get,

$$\therefore \left(\frac{\text{density}}{P}\right)_{\text{At } 100^\circ C} = \frac{273x}{373}$$

47 **(c)**

In the diagram, T is constant and $p_1 > p_2$. This situation is represented by curve (iii), in the given options. In which $p_1 > p_2$ and straight line parallel to pressure axis represents constant temperature.

49 **(c)**

According to Wien's law,

$\lambda_m T = \lambda'_m T'$

$$\therefore \lambda_0 T = \lambda' \times 2T \Rightarrow \lambda' = \frac{\lambda_0}{2}$$

53 **(a)**

$$dQ = dU + dW$$

$$CpdT = C_v dT + RdT$$

$$C_p = C_v + R$$

For a diatomic gas

$$C_v = \frac{5}{2}R, C_p = \frac{7}{2}R$$

$$\therefore \Delta Q : \Delta U : \Delta W :: \frac{7}{2R} : \frac{5}{2}R : R :: 7:5:2$$

55 **(a)**

For the black body,

Using, $E_b = \sigma T^4$,

$\therefore 81 = \sigma(300)^4 \quad \dots(i)$

For ordinary body, Using,

$E = e\sigma T^4$,

$\therefore E = 0.8 \times \sigma \times (500)^4$

$= 0.8 \times \frac{81}{(300)^4} \times (500)^4 \quad \dots$From (i)

$$\therefore E = \frac{64.8 \times 625}{81} = 500\ J/m^2 s$$

57 **(a)**

Using, $a + r + t = 1$,

$t = 1 - (a + r) = 1 - (0.74 + 0.22)$

$= 1 - 0.96 = 0.04$

60 **(a)**

Amount of energy required is given as,

$$E = \frac{f}{2}nRT = \frac{f}{2}NK(T_2 - T_1)$$

$$\therefore E = \frac{f}{2}(n \cdot N_A) \cdot k_B \cdot (T_2 - T_1)$$

Where $N = n.N_A$ and k_B = Boltzmann constant

$$\therefore E = \frac{3}{2}\, n\, N_A\, K_B(T_2 - T_1) \cdot \quad \dots [\because f = 3 \text{ for } H_e]$$

Now, $n = \frac{m}{M} = \frac{1}{4}$

$$\therefore E = \frac{3}{2} \times \frac{1}{4} N_A\, k_B(T_2 - T_1) = \frac{3}{8} N_A\, k_B(T_2 - T_1)$$

64 **(b)**

Heat supplied to a gas raises its internal energy and does some work against expansion, so it is a special case of law of conservation of energy

65 **(a)**

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

$$\therefore \frac{v_s}{400} = \sqrt{\frac{(273+227)}{(273+27)}} = \sqrt{\frac{5}{3}}$$

$\therefore v_s = 400\sqrt{5/3} \approx 516$ m/s

67 **(c)**

$P = \frac{1}{3}\left(\frac{U}{V}\right) = \frac{1}{3}kT^4$ ... (1)

($\because \frac{u}{V} \propto T^4$ and k is constant of proportionality)

$PV = nRT$ ...(2)

$\frac{nRT}{V} = \frac{1}{3}kT^4 \Rightarrow V \propto T^{-3}$

Volume of spherical shell of radius $R = \frac{4}{3}\pi R^3$ i.e.,

$V \propto R^3$

$\Rightarrow R \propto \frac{1}{T}$

68 **(b)**

Kinetic energy is directly proportional to absolute temperature.

70 **(b)**

Radiant energy emitted per second $E \propto T^4 A$

$\therefore E \propto T^4 \times r^2$ where r is the radius.

$$\therefore \frac{E_P}{E_Q} = \frac{T^4x^2}{\left(\frac{T}{4}\right)^4 (8r)^2} = \frac{T^4r^2 \times (4)^4}{T^4r^2 \times (8)^2} = 4$$

72 **(c)**

As we know, $R \propto T^4$

$$\because \frac{R'}{R} = \frac{(273+273)^4}{(273+0)^4} = \frac{16 \times (273)^4}{(273)^4}$$

$\Rightarrow R' = 16R$

73 **(c)**

We have,

$$v_{\text{rms}} = \sqrt{\frac{v_1^2 + v_2^2 + \cdots + v_n^2}{n}}$$

$$= \sqrt{\frac{4+25+9+36+9+25}{6}}$$

$$= \sqrt{\frac{108}{6}} = \sqrt{18} = 3\sqrt{2}$$

$= 3 \times 1.414 = 4.2$ unit

77 **(a)**

Rate of radiation

$$\frac{dQ}{dt} \propto T^4$$

$T_1 = 17°C = 273 + 17 = 290$ K

$T_2 = 307°C = 273 + 307 = 580$ K

$$\therefore \frac{\left(\frac{dQ}{dt}\right)_2}{\left(\frac{dQ}{dt}\right)_1} = (580/290)^4 = 2^2 = 16$$

78 **(a)**

$$(c_{rm.s.})_N = \sqrt{\frac{3RT_N}{M_N}} \text{ and } (c_{rm.s.})_O = \sqrt{\frac{3RT_O}{M_O}}$$

Given that, $(c_{rm.s.})_H = (c_{rm.s.})_O$

$\therefore \frac{3RT_N}{M_N} = \frac{3RT_O}{M_O}$

$\therefore \frac{T+273}{28} = \frac{127+273}{32}$

$\therefore T + 273 = \frac{400}{32} \times 28 = 350$ K

$\therefore T = 350 - 273 = 77°C$

83 **(b)**

Mean square velocity $= \frac{(5)^2+(6)^2+(7)^2}{3}$

$= \frac{25+36+49}{3} = \frac{110}{3} = 36.7 \text{ m/s}^2$

84 **(d)**

For an adiabatic process,

$P \propto T^{\gamma/\gamma-1}$

Given that, $P \propto T^3$

$\therefore \frac{\gamma}{\gamma-1} = 3 \Rightarrow \gamma = 3\gamma - 3$

$\therefore -2\gamma = -3 \Rightarrow \gamma = \frac{3}{2}$

87 **(d)**

At constant temperature

$P_2V_2 = P_1V_1$

$$\therefore V_2 = \frac{P_1V_1}{P_2} = \frac{P_1V_1}{0.8P_1} = \frac{V_1}{0.8} = 1.25V_1$$

$\therefore V_2 - V_1 = 0.25\, V_1$

88 **(d)**

Kinetic energy of the molecules of a gas is directly proportional to the absolute temperature.

$\therefore \frac{K_2}{K_1} = \frac{T_2}{T_1}$

$T_1 = 20°C = 293\text{ K}, \frac{K_2}{K_1} = 2$

$\therefore 2 = \frac{T_1}{293}$ or $T_2 = 2 \times 293 = 586\text{ K}$

$\therefore T_2 = 586 - 273 = 313°C$

89 **(d)**
By Wien's displacement law
$\lambda_m T = \text{constant}$
$\lambda_m = \frac{c}{v_m}$
$\therefore \frac{T}{v_m} = \text{constant}$
$\therefore v_m \propto T$
Hence graph of v_m against T will be a straight line.

91 **(b)**
According to kinetic theory of gases,

$v_{av} = \sqrt{\frac{8RT}{M\pi}}$ ....(i)

According to kinetic theory of gases,

$v_{rms} = \sqrt{\frac{3RT}{M}}$ ....(ii)

From Eqs. (i) and (ii), we get

$v_{av} = \sqrt{\left(\frac{8}{3\pi}\right)}\, v_{rms}$

$v_{av} = 0.92 v_{rms}$

Therefore, $\frac{v_{av}}{v_{rms}} = \text{constant}$

Hence, root mean square velocity is also become 4 times.

92 **(d)**
1st process is isothermal expansion which is correctly shown in option (D)
2nd process is isobaric compression which is correctly shown in option (D)

93 **(c)**
As, velocity, $v = \sqrt{\frac{3RT}{M}}$

So, $\frac{v_H}{v_O} = \sqrt{\frac{M_O}{M_H}} = \sqrt{\frac{16}{1}} = \frac{4}{1}$

95 **(d)**
$\frac{Q_1}{Q_2} = \frac{(1000)^4}{T_2^4}$

$\frac{1}{2} = \frac{(1000)^4}{T_2^4}$

$T_2 = 2^{1/4} \times 1000 = 1.189 \times 1000 = 1189\text{ K}$
$= 917°C$

96 **(a)**
According to Wien's law,
$\lambda_m T = \text{constant}$
$\therefore \lambda_{m_1} T = \lambda_{m_2} T_2$
$\therefore T_2 = \frac{\lambda_{m_1}}{\lambda_{m_2}} T_1 = \frac{\lambda_0}{\left(\frac{3\lambda_0}{4}\right)} \times T_1 = \frac{4}{3} T_1$
Now, $P \propto T^4$
$\therefore \frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^4$
$\therefore \frac{P_2}{P_1} = \left(\frac{4/3 T_1}{T_1}\right)^4 = \frac{256}{81}$

97 **(d)**
$\lambda_2 - \lambda_1 = 4\mu m$

$T_1 = 3T_2$

$\lambda_1 T_1 = \lambda_2 T_2 \therefore \lambda_1 3T_2 = \lambda_2 T_2$

$\lambda_2 = 3\lambda_1$

$3\lambda_1 - \lambda_1 = 4\mu m$

$2\lambda_1 = 4\mu m$

$\lambda_1 = 2\mu m$

$\therefore \lambda_2 = 6\mu mA$

98 **(b)**
Rate at which heat in radiated is given by

$\frac{dQ}{dt} = \sigma A T^4$

$\therefore ms\frac{d\theta}{dt} = \sigma A T^4$

$\frac{d\theta}{dt} = \frac{\sigma A T^4}{ms} = \frac{\sigma \times 4\pi R^2 \times T^4}{\frac{4}{3}\pi R^3 \rho \times s} = \frac{3\sigma T^4}{R\rho s}$

$\therefore \frac{d\theta}{dt} \propto \frac{1}{R}$

$$\therefore \frac{\left(\frac{d\theta}{dt}\right)_1}{\left(\frac{d\phi}{dt}\right)_1} = \frac{R_2}{R_1}$$

99 **(c)**

$$\frac{V_2}{V_1} = \frac{T_2}{T_1}$$

$$\frac{V_2 - V_1}{V_1} = \frac{T_2 - T_1}{T_1} = \frac{330 - 300}{300}$$

$$V_2 - V_1 = \frac{30V_1}{300} = 10 \text{ C.C.}$$

102 **(a)**

$$v_{monoatomic} = 1 + \frac{2}{3} = \frac{5}{3}$$

$$v_{diatomic} = 1 + \frac{2}{5} = \frac{7}{5}$$

$$\therefore \frac{v_{monoatomic}}{v_{diatomic}} = \frac{5/3}{7/5} = \frac{25}{21}$$

105 **(c)**

$$\frac{C_H}{C_0} = \sqrt{\frac{T_H}{T_0} x \frac{M_0}{M_H}}$$

$$1 = \sqrt{\frac{T_H}{304} X \frac{32}{2}}$$

$$1 = \frac{T_H}{304} X 16$$

$$\therefore T_H = 19K = -254^0C$$

106 **(a)**

$$\lambda_{max} T_1 = \lambda_{2max} T_2$$

$$E = \sigma A T_1^4$$

$$T_2 = \frac{\lambda_1 T_1}{\lambda_2}$$

$$\frac{E_2}{E_1} = \frac{T_2^4}{T_1^4}$$

$$\therefore E_2 = E_1 \times \frac{\lambda_1^4 T_1^4}{\lambda_2^4} \times \frac{1}{T_1^4}$$

$$= E \times \frac{\lambda_1^4}{\frac{16}{81}\lambda_1^4} = \frac{81}{16} E$$

108 **(a)**

$C_{rms} \propto \frac{1}{\sqrt{M}}$. The r.m.s. velocity is inversely proportional to square root of molecular weight of gases . Therefore we get maximum r.m.s. velocity for the gas which having minimum molecular weight .

109 **(a)**

Energy radiated

$$Q = \sigma 4\pi r^2 t T^4$$

$$\therefore \frac{Q_1}{Q_2} = \left(\frac{r_1}{r_2}\right)^2 \left(\frac{T_1}{T_2}\right)^4$$

$$= \left(\frac{8}{2}\right)^2 \left(\frac{400}{800}\right)^4$$

$$= (4)^2 (1/2)^4 = 1$$

114 **(b)**

According to Stefan's law, $\frac{Q}{At} = \sigma T^4$

Here,

$\frac{Q}{t} = 544$ W, $T = 200$ K,

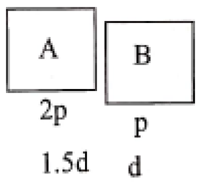
$\sigma = 5.67 \times 10^{-8} \text{Wm}^{-2} \text{ K}^{-4}$

$$\therefore A = \frac{Q}{\sigma t T^4} = \frac{544}{5.67 \times 10^{-8} \times (200)^4} = 6 \text{ m}^2$$

117 **(a)**

According to Newton's law,
Rate of cooling $\propto$ temperature difference, $\Delta\theta$

118 **(b)**



For ideal gas,

$$PV = RT$$

$$M = \rho V$$

$$\therefore \frac{PM}{\rho} = RT$$

$$\therefore \frac{P_A M_A}{\rho_A} = \frac{P_B M_B}{\rho_B}$$

$$\frac{M_A}{M_B} = \frac{\rho_A}{\rho_B} \times \frac{P_B}{P_A} = \frac{3}{2} \times \frac{1}{2} = \frac{3}{4}$$

120 **(c)**

Power, $P \propto T^4$ and $P \propto \frac{1}{d^2}$, therefore

$$P \propto \frac{T^4}{d^2} \propto \frac{2^4}{2^2} = 2^2$$

$= 4$ times, i.e. $4P$

122 **(b)**

By Wien's displacement law,

$\lambda T = \text{constant}$

$\therefore \lambda T = \lambda' T'$

$\frac{T'}{T} = \frac{\lambda}{\lambda'}$

$= \frac{\lambda}{\left(\frac{3}{4}\right)\lambda} = \frac{4}{3}$

Power radiated, $P \propto T^4$

$\therefore \frac{P'}{P} = (T'/T)^4 = (4/3)^4 = 256/81$

127 **(d)**

rms velocity, $v = \sqrt{\frac{3pV}{M}} = \sqrt{\frac{3H1}{M}}$

and the new rms velocity, $v_1 = \sqrt{\frac{3R\left(\frac{T}{2}\right)}{(2M)}} = \frac{1}{2}\sqrt{\frac{3RT}{M}}$

$= \frac{v}{2} = \frac{300}{2} = 150\ \text{ms}^{-1}$

129 **(d)**

Using, $W = \frac{R(T_i - T_f)}{\gamma - 1}$

$= 6R = \frac{R(T - T_f)}{\left(\frac{5}{3} - 1\right)}$

$\therefore T_f = (T - 4)K$

130 **(c)**

As, $\left(\frac{v_{He}}{v_H}\right) = \sqrt{\frac{\rho_H}{\rho_{He}}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$

or $(v_{He})_t = (v_{He_e})_0 \sqrt{\frac{T}{T_0}}$

$\therefore \frac{(v_{He_e})_t}{(v_H)_0} = \frac{(v_{H_e})_0}{(v_H)_0}\sqrt{\frac{T}{T_0}} = \frac{5}{7}$

or $T \approx 2T_0 = 2 \times 273 = 546°K = 273°C$

131 **(b)**

Using, $c_{rms} = \sqrt{\frac{3RT}{M}}$,

$(c_{rms})_O = \sqrt{\frac{3RT_1}{M_O}}$ and $(c_{rms})_H = \sqrt{\frac{3RT_2}{M_H}}$

Given that,

$(c_{rms})_O = (c_{rms})_H, T_H = 127 + 273 = 400\ K$

$\therefore \sqrt{\frac{3RT_1}{M_O}} = \sqrt{\frac{3RT_2}{M_H}}$

$\therefore \frac{T_1}{M_O} = \frac{T_2}{M_H}$

$\therefore T_2 = T_1 \times \frac{M_H}{M_O} = 400 \times \frac{2}{32}$

$= 25\ K = 25 - 273 = -248\ °C$

132 **(c)**

$\frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^4$

$\therefore 16 = \left(\frac{T_2}{T_1}\right)^4$

$\therefore \frac{T_2}{T_1} = 2$

133 **(a)**

$P = \frac{1}{3}\rho C^2$

$\therefore \rho = \frac{3P}{C^2} = \frac{3 \times 10^5}{(400)^2} = \frac{3 \times 10^5}{16 \times 10^4} = \frac{30}{16} = \frac{15}{8}$

135 **(b)**

Black body has maximum radiated energy at same temperature

136 **(c)**

For a cyclic process, $\Delta U = 0$

$\therefore$ By 1st law of thermodynamics,

$\Delta Q = \Delta U + \Delta W = 0 + \Delta W$

$=$ Area of closed curve

$\therefore \Delta Q = \pi r^2 = \pi\left(\frac{20}{2}\right)^2$ kPa × litre

$= 100\pi \times 10^3 \times 10^{-3} J = 100\ \pi\ J$

137 **(c)**

For one mole of an ideal gas

$PV = Nk_BT$

Where N is Avogadro number

If M is the mass of the gas then the density is given by

$\rho = \frac{M}{V}$ or $V = \frac{M}{\rho}$

$\therefore P.\frac{M}{\rho} = Nk_BT$

$\therefore \rho = \frac{PM}{Nk_BT}$

But $\frac{M}{N} = m =$ mass of each molecule

$\therefore \rho = \frac{Pm}{k_BT}$

139 **(a)**

R. M. S. velocity is given by

$V = \sqrt{\frac{3RT}{M}}$

$\therefore V^2 = \frac{3RT}{M}$

$\therefore \frac{V^2}{T} = \frac{3R}{M} =$ constant

140 **(c)**

$Q = Q_a + Q_r + Q_t$

$\therefore 10 = 2 + 7 + Q_t \Rightarrow Q_t = 1$ J

$\therefore$ Coefficient of transmission, $t = \frac{Q_t}{Q} = \frac{1}{10} = 0.1$

141 **(b)**

When thermal radiations (Q) fall on a body, they are partly reflected, partly absorbed and partly transmitted, i.e. $Q = Q_a + Q_f + Q_t$

and $\frac{Q_a}{Q} + \frac{Q_r}{Q} + \frac{Q_t}{Q} = a + r + t = 1$

or

$0.6 + \frac{15}{150} + x = 1 \Rightarrow 0.1 + 0.6 + x = 1$

Transmitting power, $t = \frac{Q_t}{Q}$ or $0.3 = \frac{Q_t}{150} \Rightarrow Q_t =$ 45 J

144 **(d)**

$E = \frac{dQ}{dt} = \sigma AT^4$

$\frac{E_2}{E_1} = \frac{A_2T_2^4}{A_1T_1^4}$

$R_2 = \frac{R_1}{3}, \frac{A_2}{A_1} = \frac{4\pi R_2^2}{4\pi R_1^2} = \frac{R_2^2}{R_1^2} = \left(\frac{1}{3}\right)^2 = \frac{1}{9}$

$T_2 = 3T_1$

$\therefore \frac{E_2}{E_1} = \frac{1}{9} \times (3)^4 = 9$

$\therefore E_2 = 9E_1 = 9E$

145 **(d)**

Apply Wien's displacement law,

$\lambda_m T = 2.93 \times 10^{-3}$

$T = \frac{2.93 \times 10^{-3}}{\lambda_m} = \frac{2.93 \times 10^{-3}}{2.93 \times 10^{-10}} = 10^7$ K

146 **(d)**

$\Delta u = nC_v\Delta T = 1 \times \frac{5R}{2}\Delta T$

For BC, $\Delta T = 600 - 800 = -200$ K

$\therefore \Delta u = \frac{5R}{2} \times -200 = -500$ R

149 **(c)**

According to Newton's law of cooling,

In first case, $\frac{70-60}{5} = K\left[\frac{70+60}{2} - 30\right]$

$\Rightarrow K = \frac{2}{35}$°C/min

In 2^{nd} case, $\frac{60-50}{t} = K\left[\frac{60+50}{2} - 30\right]$

$\therefore \frac{10}{t} = \frac{2}{35}[55 - 30]$

$\therefore t = \frac{10 \times 35}{2 \times 25} = 7$ min

150 **(b)**

$\frac{Q_2}{Q_1} = \left(\frac{r_2^2}{r_1^2}\right) \times \left(\frac{T_2}{T_1}\right)^4 = \left(\frac{100}{1}\right)^2 \times \left(\frac{1}{2}\right)^4 = 625$

151 **(c)**

As, $C_p - C_V = R = 2\text{cal}(\text{molK})^{-1}$. Difference in the two value must be 2.

$C_p = 7$ and $C_V = 5$

157 **(c)**

By Stefan's law,

Rate of loss of heat $\propto$ Area

For sphere, $A = 4\pi r^2 \Rightarrow A \propto r^2$

$\therefore R_1 \propto r_1^2$ and $R_2 \propto r_2^2$

$\therefore \frac{R_1}{R_2} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$

159 **(d)**

$mc\frac{d\theta}{dt} = \sigma A(T^4 - {T_0}^4)$

$\therefore \frac{d\theta}{dt} = \frac{\sigma 4\pi r^2(T^4 - T_0^4)}{\left(\frac{4}{3}\pi r^3\rho c\right)}$

$\therefore \frac{d\theta}{dt} \propto \frac{1}{r\rho c}$

163 **(d)**

$R = \sigma AT^4 = 4\pi r^2\sigma T^4$

$\therefore T^4 = \frac{R}{4\pi r^2\sigma}$

$\therefore T = \left(\frac{R}{4\pi r^2 \sigma}\right)^{1/4}$

164 **(c)**

Heat radiated per second per unit area $\propto T^4$

Here, $T_1 = 127°C = 400\ K$

$T_2 = 527\ °C = 800K$

Since $T_2 = 2T_1$ and $E \propto T^4$,

$\frac{E_2}{E_1} = \left(\frac{T_2}{T_1}\right)^4 = \left(\frac{2T_1}{T_1}\right)^4 = (2)^4 = 16$

$\therefore E_2 = 16E_1 = 16 \times 6 = 96\ J$

165 **(b)**

$\lambda = \frac{1}{\lambda d^2 n\sqrt{2}} = \frac{1}{4\pi r^2 n\sqrt{2}}$

$\Rightarrow \lambda \propto \frac{1}{r^2}$

166 **(b)**

$E = \sigma A T^4$

$\therefore \frac{E_2}{E_1} = \frac{A_2}{A_1}\left(\frac{T_2}{T_1}\right)^4$

$T_1 = 127°C = 127 + 273 = 400\ K$

$T_2 = 527°C = 800\ K$

$\therefore \frac{T_2}{T_1} = 2$

$A_2 = \frac{A_1}{2}$

$\therefore \frac{A_2}{A_1} = \frac{1}{2}$

$\therefore \frac{E_2}{E_1} = \frac{1}{2} \times (2)^4 = \frac{16}{2} = 8$

167 **(a)**

Initially, the black body at room temperature is darkest and when placed in furnace, it absorbs hear till its temperature becomes that of furnance. After this, it emits the radiation of all wavelengths and appears bright

168 **(d)**

By 1st law of thermodynamics,

$\therefore \Delta Q = \Delta U + \Delta W$

$2 \times 10^3 \times 4.2 = \Delta U + 500$

$\therefore \Delta U = 7900\ J$

169 **(a)**

$T_1 = 27°C = 27 + 273 = 300\ k$

$T_2 = 327°C = 327 + 273 = 600\ k$

$\frac{C_2}{C_1} = \sqrt{T_2/T_1} = \sqrt{600/300} = \sqrt{2}$

170 **(c)**

$C_H = \sqrt{\frac{3RT_H}{M_H}}\ \&\ C_0 = \sqrt{\frac{3RT_0}{M_0}}$

$T_H = 300^0 K\ T_0 = 400^0 K$

$M_H = 2\ M_0 = 32$

$\frac{C_H}{C_0} = \sqrt{\frac{T_H}{M_H} \cdot \frac{M_0}{T_0}} = \sqrt{\frac{300}{2} x \frac{32}{400}} = \sqrt{3 \text{ x } 4}$

$\frac{C_H}{C_0} = 2\sqrt{3}$

171 **(a)**

$c_{mean} = \frac{2+3+4}{3} = 3\ m/s$

$c_{r.m.s.} = \sqrt{\frac{2^2+3^2+4^2}{3}} = \sqrt{\frac{4+9+16}{3}} = \sqrt{\frac{29}{3}}$

$= 3.109\ m/s$

$\therefore \frac{c_{mean}}{c_{r.m.s.}} = \frac{3}{3.109} < 1$

172 **(d)**

We know that, $\bar{v}^2 = \frac{3RT}{M}$

$\Rightarrow\ v_{rms} = \sqrt{\frac{3RT}{M}}$

The root mean square speed of the molecules of a gas is directly proportional to the square root of the absolute temperature of the gas and inversely proportional to the square root of the mass of molecules of the gas.

So, $v_{rms} \propto \sqrt{T}$ and $v_{rms} \propto \frac{1}{\sqrt{m}}$

or $v_{rms} = m^{-1/2} \times T^{1/2}$

173 **(c)**

$K.E._{av} = \frac{3}{2} k_B T$

$\therefore K.E._{av} \propto T$

$\therefore \frac{K.E._2}{K.E._1} = \frac{T_2}{T_1} = \frac{600}{300} = 2$

$\therefore K.E._2 = 2K.E._1 = 2K.E.$

175 **(b)**

As, $\gamma = 1 + \frac{2}{f}$ (where, f = degree of freedom)

$\gamma - 1 = \frac{2}{f}$ or $\frac{f}{2} = \frac{1}{\gamma - 1} \Rightarrow f = \frac{2}{\gamma - 1}$

176 **(b)**

In M.K.S. system, unit of σ is $\frac{1}{m^2 \times s \times K^4}$

$$\therefore 1\frac{J}{m^2 \times s \times K^4} = \frac{10^7 erg}{10^4 cm^2 \times s \times K^4}$$

$$= 10^3 \frac{erg}{cm^2 \times s \times K^4}$$

178 **(b)**

$C_P > C_v$, hence $\frac{C_P}{C_v}$ is always more than one.

179 **(b)**

$$\Delta U = nC_v\Delta T = n(C_p - R)\Delta T$$

$$= 5 \times \left(8 - \frac{8.36}{4.18}\right) \times 10 = 5 \times 6 \times 10$$

$$= 300 \text{ calories}$$

180 **(d)**

For monoatomic gas: $C_v = \frac{3}{2}, C_p = \frac{5}{2}$

For diatomic gas: $C_v = \frac{5}{2}, C_p = \frac{7}{2}$

$\therefore$ Average value $C_v = \frac{1 \times \frac{3}{2} + 1 \times \frac{5}{2}}{1+1} = 2$

Average value $C_p = \frac{1 \times \frac{5}{2} + 1 \times \frac{7}{2}}{1+1} = 3$

$$\therefore \gamma' = \frac{C_p}{C_v} = \frac{3}{2} = 1.5$$

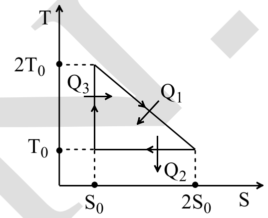
181 **(a)**

$$Q_1 = T_0S_0 + \frac{1}{2}T_0S_0 = \frac{3}{2}T_0S_0$$

$Q_2 = T_0S_0$ and $Q_3 = 0$

$$\therefore \eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$$

$$= 1 - \frac{Q_2}{Q_1} = 1 - \frac{2}{3} = \frac{1}{3}$$



182 **(c)**

Here,

$\Delta T = 40°C$

$C_p = \frac{7}{2}R$

(for diatomic gases)

Number of moles, $\mu = \frac{14}{28} = \frac{1}{2}$

Heat supplied at constant pressure, $Q = \mu C_p \Delta T$

$$\Rightarrow Q = \frac{1}{2} \times \frac{7}{2}R \times 40 = 70R$$

183 **(c)**

For a non-linear triatomic gas, $C_V = 3R$ and for monoatomic gas, $C_V' = \frac{3}{2}R$

$$\therefore \frac{Q}{Q'} = \frac{C_V}{C_V'} = K = \frac{3R}{\frac{3}{2}R} = 2$$

184 **(b)**

If pressure is constant, then

$$\frac{V_2}{V_1} = \frac{T_2}{T_1}$$

$\frac{V_2}{V_1} = 2.5, T_1 = 27°C = 27 + 273 = 300K$

$$\therefore 2.5 = \frac{T_2}{300}$$

$$\therefore T_2 = 300 \times 2.5 = 750K = 750 - 273 = 477°C$$

185 **(d)**

PVT

$2P, \frac{V}{4,2T}$

$P_1V_1 = n_1RT_1;$

$P_2V_2 = n_2RT_2$

$$\frac{n_1}{n_2} = \frac{\frac{P_1V_1}{RT_1}}{\frac{P_2V_2}{RT_2}} = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2V_2}$$

$$= \frac{PV}{T} \times \frac{2T \times 2}{2P \times \frac{V}{4}} = 4:1$$

188 **(c)**

$$\frac{K.E.}{Volume} = E = \frac{3}{2}P \Rightarrow P = \frac{2}{3}E$$

190 **(d)**

Mean square velocity $= \frac{3^2+4^2+5^2}{3}$

$$= \frac{50}{3} \approx 16.67 \text{ m/s}$$

193 **(d)**

Given, $v_{O_2} = \frac{1}{2}v_{H_2}$

$$\therefore \sqrt{\frac{3RT}{32}} = \frac{1}{2}\sqrt{\frac{3R \times 273}{2}}$$

$$\Rightarrow \frac{T}{32} = \frac{273}{8}$$

$$\Rightarrow T = 4 \times 273$$

$$\Rightarrow T = 1092 \text{ K} = 1092 - 273$$

$$\Rightarrow T = 819^\circ\text{C}$$

194 **(d)**

K.E. per molecule is independent of nature of nature of the gas.

196 **(c)**

When temperature of a black body is increased by 50%, then

$$T_2 = \frac{150}{100}T_1 = \frac{2}{3}T_1$$

According to Stefan's law, $\frac{E_2}{E_1} = \left(\frac{T_2}{T_1}\right)^4 = \left(\frac{3}{2}\right)^4 = \frac{81}{16}$

Percentage increase in radiation

$$\frac{(E_2 - E_1)}{E_1} \times 100 = \frac{(81 - 16)}{16} \times 100 \approx 400\%$$

197 **(b)**

$$\frac{dQ}{dt} = \sigma T^4 Ae$$

$$\therefore \frac{300}{60} = 5.67 \times 10^{-8} \times (727 + 273)^4 \times 50 \times 10^{-4} \times e$$

$$\therefore \frac{300}{60} = 5.67 \times 10^{-8} \times 10^{12} \times 50 \times 10^{-4} \times e$$

$$\therefore e = \frac{300}{283.50 \times 60} = 0.0176 \approx 0.018$$

198 **(b)**

$Q_p = m.C_p\Delta\theta$ and $Q_v = m.C_v.\Delta\theta$

$$\therefore \frac{Q_v}{Q_p} = \frac{C_v}{C_p}$$

Using, $C_p - C_v = R$ we get,

$$\frac{C_v}{C_p} = 1 - \frac{R}{C_p} = 1 - \frac{8.3}{20.7} \approx 0.6$$

$$\therefore Q_v = Q_p.\frac{C_v}{C_p} = 207 \times 0.6 = 124.2 \text{ J}$$