Chapter 3. Kinetic Theory of gases and Radiation

MCQ's (1 Mark Each)

1) The average energy per molecule is proportional to

(a) the pressure of the gas (b) the volume of the gas

(c) the absolute temperature of the gas (d) the mass of the gas

Ans: c) the absolute temperature of the gas

2) The number of degrees of freedom, for the vibrational motion of a polyatomic molecule depends on the

(a) geometric structure of the molecule (b) mass of the molecule

(c) energy of the molecule (d) absolute temperature of the molecule

Ans: a) geometric structure of the molecule

3) The power radiated by a perfect blackbody depends only on its

(a) material (b) nature of surface (c) colour (d) temperature

Ans: d) temperature

4) If the absolute temperature of a body is doubled, the power radiated will increase by a factor of

(a) 2 (b) 4 (c) 8 (d) 16

Ans: d) 16

5) Calculate the value of λ_{max} for radiation from a body having surface temperature 3000 K.
($b = 2.897 \times 10^{-3}$ m K)

(a) 9935 Å (b) 9656 Å (c) 9421 Å (d) 9178 Å

Ans: b) 9656 Å

6) The molar specific heat of a gas at constant volume is 12307.69 J kg^{-1} K^{-1}. If the ratio of the two specific heats is 1.65, calculate the difference between the two molar specific heats of gas.

(a) 7999 J kg^{-1} K^{-1} (b) 7245 J kg^{-1} K^{-1}

(c) 6890 J kg^{-1} K^{-1} (d) 4067 J kg^{-1} K^{-1}

Ans: a) 7999 J kg^{-1} K^{-1}

7) Calculate the energy radiated in one minute by a blackbody of surface area 200 cm^2 at 127°C
($\sigma = 5.7 \times 10^{-8}$ J m^{-2} s^{-1} K^{-4})

(a) 1367.04 J (b) 1698.04 J (c) 1751.04 J (d) 1856.04 J

Ans: c) 1751.04 J

Very Short Answer (VSA) (1 MARK Each)

1) Under which condition laws of Boyle, Charles, and Gay-Lussac are valid?
2) On what, the values of absorption coefficient, reflection coefficient and transmission coefficient depend, in addition to the material of the object on which the radiation is incident?
3) Why the temperature of all bodies remains constant at room temperature?
4) Above what temperature all bodies radiate electromagnetic radiation?
5) State the formula for the mean free path.
6) If the density of nitrogen is 1.25 kg/m^3 at a pressure of 10^5 Pa, find the root mean square velocity of oxygen molecules. (Ans: Vrms = $489.89\ m/s$)
7) Find kinetic energy of 3 liter of a gas at S.T.P given standard pressure is 1.013 x 10^5 N/m^2.

(Ans: K.E.= $455.8\ J$ **)**

8) Determine the pressure of nitrogen at 0^{o}C if the density of nitrogen at N.T.P. is 1.25 kg/m^3 and R.M.S. speed of the molecules at N.T.P. is 489 m/s.

(Ans: P **= 99633.75 N/m)**

Short Answer I (SA1) (2 MARKS Each)

1) State factors on which the amount of heat radiated by a body depends.
2) Show that for monoatomic gas the ratio of the two specific heats is 5:3.
3) Show that for diatomic gas the ratio of the two specific heats is 7:5.
4) Show the graphical representation of radiant power of a black body per unit range of wavelength as a function of wavelength.
5) Draw neat, labeled diagram of Ferry's black body.
6) Explain mean free path of a gas molecule.
7) State and explain law of equipartition of energy.
8) Define degrees of freedom of a system.
9) Compare the rate of radiation of metal body at 727 ^{o}C and 227 ^{o}C.

(Ans: 16)

10) 1000 calories of radiant heat are incident on a body. If the body absorbs 400 calories of heat, find the coefficient of emission of the body. ***(Ans: a=e=0.4)***

11) A metal cube of length 4 cm radiates heat at the rate of 10 J/s. Find its emissive power at given temperature.

(Ans: E = 1041.66 $J/s\ m^2$**)**

Short Answer II (SA2) (3 MARKS Each)

1) Show that the root mean square speed of the molecules of gas is directly proportional to the square root of the absolute temperature of the gas.
2) Show that the average energy of the molecules of gas is directly proportional to the absolute temperature of gas.
3) Calculate the ratio of two specific heats of polyatomic gas molecule.
4) Explain the construction and working of Ferry's black body.
5) Compare the rates of emission of heat by a blackbody maintained at 627°C and at 127°C, if the blackbodies are surrounded by an enclosure at 27°C. What would be the ratio of their rates of loss of heat?

   (*Ans* $\frac{R_1}{R_2} = \frac{10.28}{1}$)

6) Determine the molecular kinetic energy (i) per mole (ii) per gram (iii) per molecule of nitrogen molecules at 227°C, R = 8.310 J mole^{-1} K^{-1}, No = 6.03 x 10^{26} moleculesKmole^{-1}. Molecular weight of nitrogen = 28.

   (Ans

   (i) ***K.E. per mole*** = 6.232×10^{3} ***J/mole***

   (ii) ***K.E. per kilogram*** = 0.225×10^{3} ***J/kg***

   (iii) ***K.E. per kmole*** = 1.048×10^{-23} ***J)***

7) The velocity of three molecules, are 2 km s^{-1}, 4 km s^{-1}, 6 km s^{-1}. Find (i) mean square velocity (ii) root mean square velocity.

   (Ans: i) mean square velocity, $\overline{V^2} = 18.66$ ***km s^{-1} ii) root mean square velocity,*** $V_{rms} = 4.319$ ***km s^{-1})***

Long Answer (LA) (4 marks Each)

1) Explain spectral distribution of a blackbody radiation.
2) Derive expression for average pressure of an ideal gas.
3) Derive Mayer's relation.