KTOG **Marks: 30**

ANSWER KEY

Physics

Q.1 B	Q.2 D	Q.3 D	Q.4 D	Q.5 C	Q.6 A	Q.7 B	Q.8 B
Q.9 D	Q.10 C	Q.11 A	Q.12 B	Q.13 A	Q.14 A	Q.15 A	Q.16 A
Q.17 C	Q.18 B	Q.19 A	Q.20 C	Q.21 B	Q.22 D	Q.23 D	Q.24 C
Q.25 C	Q.26 A	Q.27 A	Q.28 D	Q.29 A	Q.30 A		

Physics

Q.1 The rms velocity of a particle is v at pressure P. If the pressure increases by three times and temperature increases by four times, then rms velocity will become

Correct option: (B)

$v_{rms} = \sqrt{\frac{3RT}{M}} \Longrightarrow v_{rms} \propto \sqrt{T}$

rms velocity is independent of pressure.

Therefore, the rms velocity will be twice the original velocity i.e. 2v

Q.2 A balloon contains 300 m^3 of He at 27 °C and 1 atm. pressure. Then, the volume of He at –13 °C and 0.5 atm. pressure will be

Correct option: (D)

P_1 = 1 atm, V_1 = 300 m^3, T_1 = 27 °C = 300 K

P_2 = 0.5 atm, T_2 = – 13 °C = 260 K

From Ideal gas equation:

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

$$\frac{1 \times 300}{300} = \frac{0.5 \times V_2}{260}$$

$$\frac{260}{0.5} = V_2$$

V_2 = 520 m^3

Q.3 Two containers are filled; each with a different gas. The two containers are at the same temperature. If the molecular weights of the two gases are M_A and M_B, then the average momenta (in magnitude) of the molecules are related as

Correct option: (D)

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

Let momentum of A, $p_A = M_Ac_A = M_A\sqrt{\frac{3RT}{M_A}}$

$\therefore$ 3 RT = $\frac{p_A^2 M_A}{M_A^2} = \frac{p_A^2}{M_A}$ ....(i)

Let momentum of B = $p_B = M_Bc_B = M_B\sqrt{\frac{3RT}{M_B}}$

$\therefore$ 3 RT = $\frac{p_B^2 M_B}{M_B^2} = \frac{p_B^2}{M_B}$ ....(ii)

From equations (i) and (ii) we get,

$$\frac{p_A^2}{M_A} = \frac{p_B^2}{M_B}$$

$$\therefore p_A^2 = \left(\frac{M_A}{M_B}\right) p_B^2$$

$$\therefore p_A = \left(\frac{M_A}{M_B}\right)^{1/2} p_B$$

Q.4 Two spherical black bodies have radii 'R_1' and 'R_2'. Their surface temperatures are T_1 K and T_2 K respectively. If they radiate the same power, the ratio $\frac{R_1}{R_2}$ is

Correct option: (D)

For any spherical body of radius R kept at temperature T, the power radiated or rate of loss of heat by it can be given as,

$$\frac{dQ}{dt} = \sigma AT^4 = \sigma\left(4\pi R^2\right)T^4$$

$\therefore$ For two spherical blackbodies having same power, we get

$$\left(\frac{R_1}{R_2}\right)^2 = \left(\frac{T_2}{T_1}\right)^4$$

$$\therefore \left(\frac{R_1}{R_2}\right) = \left(\frac{T_2}{T_1}\right)^2$$

Q.5 On investigation of light from three different stars A, B and C, it was found that in the spectrum of A, the intensity of red colour is maximum; in B the intensity of blue colour is maximum and in C the intensity of yellow colour is maximum. From these observations, it can be concluded that

Correct option: (C)

The color of the star is related to its surface temperature. The hotter the star, the bluer the color and the cooler the star, the redder the color.

Star A has the maximum intensity of red color, so its temperature is the lowest. Star B has the maximum intensity of blue color, so its temperature is the highest. Star C has the maximum intensity of yellow color, so its temperature lies in between the temperatures of A

and B.
Therefore, the temperature of B is maximum; A is minimum and C is intermediate.

Q.6 If temperature of black body increases from 17°C to 307°C, then the rate of radiation increases by
Correct option: (A)

Given: $T_1 = 17^\circ C = 273 + 17 = 290\ K$

$$T_2 = 307^\circ C = 273 + 307 = 580\ K$$

Rate of radiation $\frac{\mathrm{dQ}}{\mathrm{dt}} \propto T^4$

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

Q.7 The temperature of an open room of volume 30 m^3 increases from 17 °C to 27 °C due to sunshine. The atmospheric pressure in the room remains 1 × 10^5 Pa. If n_i and n_f are the number of molecules in the room before and after heating, then $n_f - n_i$ will be
Correct option: (B)

Using ideal gas equation,
before heating, at T_1 = 17 + 273 = 290 K,
PV = n_1R × 290 ....(i)
After heating, at T_2 = 27 + 273 = 300 K,
PV = n_2R × 300 ....(ii)
where, n_1 and n_2 are number of moles at T_1 and T_2 respectively.
From equations (i) and (ii),

$$n_2 - n_1 = \frac{PV}{R \times 300} - \frac{PV}{R \times 290}$$

But, $n_f - n_i = (n_2 - n_1)N_A$
i.e., $n_f - n_i$ =

$$-\frac{PV}{R} \times \left(\frac{10}{290 \times 300}\right) \times 6.023 \times 10^{23}$$

Given: P = 10^5 Pa and V = 30 m^3

$$\therefore \quad n_f - n_i = -\frac{10^5 \times 30 \times 10 \times 6.023 \times 10^{23}}{8.3 \times 290 \times 300}$$

= -2.5×10^{25}

Q.8 A piece of iron is heated in a flame. It first becomes dull red then becomes reddish yellow and finally turns to white hot. The correct explanation for the above observation is possible by using
Correct option: (B)

From Wien's displacement law,
$\lambda_m \propto \frac{1}{T}$
$\therefore \lambda_m T$ = constant

Q.9 If the temperature of the sun is doubled, the rate of energy received by the earth will be increased by a factor
Correct option: (D)

From Stefan's law,
Rate of energy emission $R \propto T^4$

$$\therefore \quad \frac{R_2}{R_1} = (2)^4 = 16$$

Q.10 Of the following properties of gas molecules, the one that is same for all gases at a particular temperature is
Correct option: (C)

Q.11 The black discs x, y and z have radii 1 m, 2 m and 3 m respectively. The wavelengths corresponding to maximum intensity are 200 nm, 300 nm and 400 nm respectively. The relation between emissive power E_x, E_y and E_z is
Correct option: (A)

Emissive power $E = \sigma \mathrm{A}T^4 \quad \Rightarrow E \propto \mathrm{A}T^4$

$A = \pi R^2 \qquad \Rightarrow A \propto R^2$

Given, R_1 =1 m, R_2 =2 m, R_3 =3 m
$\Rightarrow A_x : A_y : A_z :: 1 : 4 : 9 \quad$ …(i)

By Wien's displacement law

$$\lambda_{\max} T = constant \qquad \Rightarrow T \propto \frac{1}{\lambda}$$

Given,
λ_{max1} =200 nm, λ_{max2} =300 nm, λ_{max3} = 400 nm
$\Rightarrow \lambda_x : \lambda_y : \lambda_z :: \quad 2 : 3 : 4$

$$\frac{1}{T_x} : \frac{1}{T_y} : \frac{1}{T_z} :: 2 : 3 : 4$$

$$\therefore \quad T_x : T_y : T_z :: \frac{1}{2} : \frac{1}{3} : \frac{1}{4}$$

or $T_x : T_y : T_z :: 6 : 4 : 3 \quad$ …(ii)

Comparing the product AT^4 for the 3 discs

From (i) and (ii), we have,

for disc x : $A_xT_x^4 = 1 \times (6)^4 = 1296$

for disc y : $A_yT_y^4 = 4 \times (4)^4 = 1024$

for disc z : $A_zT_z^4 = 9 \times (3)^4 = 729$

$\therefore \; E_x > E_y > E_z$.

Q.12 In M.K.S. system, Stefan's constant is denoted by σ. In C.G.S. system multiplying factor of σ will be

Correct option: (B)

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

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

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

Q.13 The unit of Stefan's constant is:

Correct option: (A)

By Stefan's law, $\dfrac{dQ}{dt} = A\sigma T^4$

$$\therefore \sigma = \frac{dQ}{dt} \times \frac{1}{AT^4} = \left(\frac{J}{s}\right) \times \frac{1}{m^2 \times K^4} = W/m^2K^4$$

Q.14 A black body radiates maximum energy at wavelength λ_m at temperature 2200 K. Its corresponding wavelength at temperature 3300 K will be

Correct option: (A)

According to Wien's law,

$\lambda_m T$ = constant

$$\therefore \; \frac{\lambda'_m}{\lambda_m} = \frac{T}{T'} = \frac{2200}{3300} = \frac{2}{3}$$

$$\therefore \; \lambda'_m = \frac{2}{3}\lambda_m$$

Q.15 An ideal gas has pressure 'P', volume 'V' and absolute temperature 'T'. If 'm' is the mass of each molecule and 'K' is the Boltzmann constant then density of the gas is

Correct option: (A)

Ideal gas

PV = nRT

n → no. of moles

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

m → mass of the molecule of gas

M → molecular weight

$P = \dfrac{m}{MV} RT$

$\rho = \dfrac{mass}{Volume}$

$P = \left(\dfrac{\rho RT}{M}\right)$

$\rho = \dfrac{PM}{RT}$

$\Rightarrow \rho = \dfrac{PM}{RT}$

k → Boltzmann constant

$k = \dfrac{R}{N} \Rightarrow R = Nk$ ….(1)

$m = \dfrac{M}{N}$ ….(2)

m = mass of each molecule

Using (1);

$\rho = \dfrac{PM}{kNT}$

$\Rightarrow \rho = \dfrac{P}{kT}\dfrac{M}{N}$

From (2), we can write:

$\Rightarrow \rho = \dfrac{Pm}{KT}$

Q.16 The specific heat of argon at constant pressure and constant volume are C_p and C_V respectively. It's density 'ρ' at N.T.P. will be [P and T are pressure and temperature respectively at N.T.P.]

Correct option: (A)

$C_p - C_v = R$

$R = (C_p - C_v)$ M …(molar specific heat) …(i)

Ideal gas equation , PV = nRT

$PV = n(C_p - C_v)$ MT …[From(i)]

$PV = \dfrac{m}{M}(C_p - C_v)$ MT

$P = \dfrac{m}{V}(C_p - C_v)$ T

$\rho = \dfrac{\mathbf{P}}{(\mathbf{C_p} - \mathbf{C_v})\mathbf{T}}$

Q.17 294 joule of heat energy is required to raise the temperature of 2 moles of an ideal gas from 30 °C to 35 °C at constant pressure. The specific heat at constant pressure will be
(R = 8.4 J/mole K)
Correct option: (C)

$C_p = \dfrac{Q}{n\Delta T} = \dfrac{294}{2 \times 5} = 29.4$ J/mole K

Q.18 For a perfectly black body, coefficient of absorption is
Correct option: (B)

Q.19 An athermanous metal plate has the coefficient of absorption 0.65. Its coefficient of reflection is
Correct option: (A)

For athermanous substances, $t_r = 0$

∴ a + r + 0 = 1

∴ r = 1 – 0.65 = 0.35

Q.20 A blackbody at 227 °C radiates heat at the rate of 7 cal/cm²s. At a temperature of 727 °C, the rate of heat radiated in the same units will be
Correct option: (C)

By Stefan's law,

$Q \propto T^4 \Rightarrow \dfrac{Q_1}{Q_2} = \left(\dfrac{T_1}{T_2}\right)$

$\therefore \dfrac{7}{Q_2} = \left(\dfrac{273+227}{273+727}\right)^4 = \dfrac{1}{16}$

$\therefore Q_2 = 112 \dfrac{\text{cal}}{\text{cm}^2 \times \text{s}}$

Q.21 What is average velocity of gas, if velocities of three molecules of gas are 3 m/s, 4 m/s and 5 m/s?
Correct option: (B)

Average velocity = $\dfrac{3+4+5}{3}$ = 4 m/s

Q.22 In a spectral distribution of black body radiation the wave length corresponding to maximum intensity
Correct option: (D)

According to Wien's displacement law

λT = constant

$\therefore \lambda \propto \dfrac{1}{T}$

Q.23 A black rectangular surface of area 'A' emits energy 'E' per second at 27 °C. If length and breadth are reduced to $\dfrac{1}{3}^{\text{rd}}$ of initial value and temperature is raised to 327 °C then energy emitted per second becomes
Correct option: (D)

For any two bodies of radii R_1 and R_2, kept at temperatures T_1 and T_2, the power radiated or rate of loss of heat by them can be give as,

$$\frac{Q_1}{Q_2} = \left(\frac{R_1}{R_2}\right)^2 \times \left(\frac{T_1}{T_2}\right)^4$$

In case of non-spherical bodies, $\left(\dfrac{R_1}{R_2}\right)^2$ can be replaced by $\left(\dfrac{A_1}{A_2}\right)$ where A_1, A_2 are areas of the given bodies.

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

$$\left(\frac{\frac{l}{3} \times \frac{b}{3}}{l \times \text{b}}\right)\left(\frac{327+273}{27+273}\right)^4$$

$$= \left(\frac{1}{9}\right)\left(\frac{600}{300}\right)^4$$

Q.24 Two spheres 'S_1' and 'S_2' have same radii but temperatures are 'T_1' and 'T_2' respectively. Their emissive power is same and emissivity is in the ratio 1 : 4. Then the ratio 'T_1' to 'T_2' is
Correct option: (C)

Given: $\dfrac{Q_1}{A_1 t} = \dfrac{Q_2}{A_2 t}$

But $A_1 = A_2$ as radii are same

$\therefore Q_1 = Q_2$

$\therefore e_1 \sigma A T_1^4 = e_2 \sigma A T_2^4$

$\therefore \dfrac{T_1^4}{T_2^4} = \dfrac{e_2}{e_1} = \dfrac{4}{1}$

$$\therefore \frac{T_1}{T_2} = \left(\frac{4}{1}\right)^{\frac{1}{4}} = \frac{\sqrt{2}}{1}$$

Q.25 One blackbody at temperature T is surrounded by another blackbody at temperate T_1 (T_1 < T). At T, the radiation emitted by inner blackbody per unit area per second is proportional to

Correct option: (C)

The radiation emitted by a blackbody is proportional to the fourth power of its temperature. This is known as Stefan-Boltzmann Law. The formula is:

$P = \sigma A T^4$

Where: P is the power radiated, σ is the Stefan-Boltzmann constant, A is the surface area of the blackbody, T is the absolute temperature.

The net radiation emitted by the inner blackbody is the difference between the radiation emitted by it and the radiation absorbed from the surrounding blackbody. Therefore, the net radiation emitted by the inner blackbody is proportional to the difference of fourth powers of temperature of two bodies.

Q.26 The unit of Stefan's constant in S.I. system will be

Correct option: (A)

To find the unit of Stefan's constant in the SI system, we use the Stefan-Boltzmann law:

$E = \sigma T^4$

Where: E is the energy radiated per unit area per unit time (i.e., power per unit area) → units: $W/m^2 = J/sm^2$

σ is the Stefan's constant

T is the absolute temperature in Kelvin (K)

Rearranging the equation:

$\sigma = \frac{E}{T^4}$ ⇒ Units of σ = $\frac{Joule}{m^2 \cdot s \cdot K^4}$

So, the correct answer is:

$(Joule/m^2 s)\ K^{-4}$

Q.27 According to the kinetic theory of gases, when two molecules of a gas collide with each other then

Correct option: (A)

Q.28 If the emissive and absorptive powers of a body are E and A respectively at temperature T, then the emissive power of a blackbody will be

Correct option: (D)

Kirchhoff's Law of Radiation states that the ratio of the emissive power (E) to the absorptive power (A) of a body is equal to the emissive power of a blackbody (E_b) at the same temperature and wavelength. Mathematically, this is expressed as:

$E/A = E_b$.

So the answer is E/A.

Q.29 A hot and a cold body are kept in vacuum separated from each other. Which of the following causes decrease in temperature of the hot body?

Correct option: (A)

In vacuum, heat flows by the radiation mode only.

Q.30 Two gases A and B are at absolute temperatures 350 K and 420 K respectively. The ratio of average kinetic energy of the molecules of gas B to that of gas A is

Correct option: (A)

Average $K.E. \propto T$

$$\frac{K.E._B}{K.E._A} = \frac{T_B}{T_A} = \frac{420}{350} = \frac{6}{5}$$