# 2021-PE-27-39

EE24BTECH11010 - BALAJI B

1) The donor concentration in a sample of n-type silicon is increased by a factor of 100. Assuming the sample to be non-degenerate, the shift in the Fermi level (in meV) at $300K$ (rounded off to the nearest integer) is ——————
   (Given $k_BT = 25meV$ at $300K$) [2021 PH]

2) Two observers O and O' observe two events P and Q. The observers have a constant relative speed of $0.5c$. In the units, where the speed of light, c, is taken as unity, the observer O obtained the following coordinates:
   Event P : $x = 5$, $y = 3$, $z = 5$, $t = 3$
   Event Q : $x = 5$, $y = 1$, $z = 3$, $t = 5$
   The length of the space-time interval between these two events, as measured by O', is L. The value of $|L|$ (in integer) is ——————— [2021 PH]

3) A light source having its intensity peak at the wavelength $289.8nm$ is calibrated as $10,000K$ which is the temperature of an equivalent black body radiation. Considering the same calibration, the temperature of light source (in K) having its intensity peak at the wavelength $579.6nm$ (rounded off to the nearest integer) is ——————
   [2021 PH]

4) A hoop of mass M and radius R rolls without slipping along a straight line on a horizontal surface as shown in the figure. A point mass m slides without friction along the inner surface of the hoop, performing small oscillations about the mean position. The number of degrees of freedom of the system (in integer) is ———
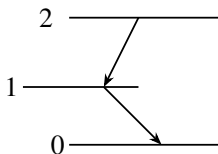   [2021 PH]
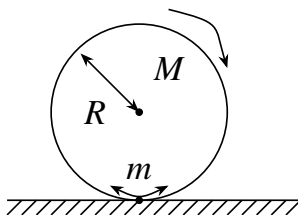
5) Three non-interacting bosonic particles of mass m each, are in a one- dimensional infinite potential well of width a. The energy of the third excited state of the system is $x \times \frac{h^2\pi^2}{ma^2}$. The value of x (in integer) is ——————
   [2021 PH]

6) The spacing between two consecutive S- branch lines of the rotational Raman spectra of hydrogen gas is $243.2cm^{-1}$. After excitation with a laser of wavelength $514.5cm$, the Stoke's line appeared at $17611.4cm^{-1}$ for a particular energy level. The wavenumber (rounded off to the nearest integer), in cm^{-1} , at which Stoke's line will appear for the next higher energy level is —————— [2021 PH]

7) The transition line, as shown in the figure, arises between $^2D_{\frac{3}{2}}$ and $^2P_{\frac{1}{2}}$ states without any external magnetic field. The number of lines that will appear in the presence of a weak magnetic field (in integer) is _____ [2021 PH]
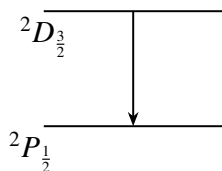
8) Consider the atomic system as shown in the figure, where the Einstein A coefficients for spontaneous emission for the levels are $A_{2\rightarrow1} = 2 \times 10^7\,s^{-1}$ and $A_{1\rightarrow0} = 10^8\,s^{-1}$. If 10^{14} atoms/cm^3 are excited from level 0 to level 2 and a steady state population in level 2 is achieved, then the steady state population at level 1 will be $x \times 10^{13}$. The value of x (in integer) is _____ [2021 PH]

9) If **a** and **b** are constant vectors, **r** and **p** are generalized positions and conjugate momenta, respectively, then for the transformation $Q = \mathbf{a} \cdot \mathbf{p}$ and $P = \mathbf{b} \cdot \mathbf{r}$ to be canonical, the value of $\mathbf{a} \cdot \mathbf{b}$ (in integer) is _____ [2021 PH]

10) The below combination of logic gates represents the operation
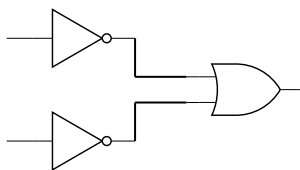
[2021 PH]

11) In a semiconductor, the ratio of the effective mass of hole to electron is $2 : 11$ and the ratio of average relaxation time for hole to electron is $1 : 2$. The ratio of the mobility of the hole to electron is [2021 PH]

a) $4 : 9$ c) $9 : 4$

b) $4 : 11$ d) $11 : 4$

12) Consider a spin $S = \frac{\hbar}{2}$ particle in the state $|\phi\rangle = \frac{1}{3}\begin{pmatrix} 2+i \\ 2 \end{pmatrix}$. The probability that a measurement finds the state with $S_x = +\frac{\hbar}{2}$ is [2021 PH]
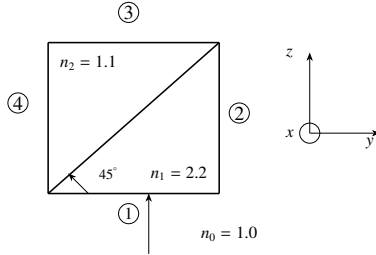
a) $\frac{5}{18}$ b) $\frac{11}{18}$ c) $\frac{15}{18}$ d) $\frac{17}{18}$

13) An electromagnetic wave having electric field $E = 8\cos{(kz - \omega t)}\,\hat{y}\,Vcm^{-1}$ is incident at 90°(normal incidence) on a square slab from vacuum (with refractive index $n_0 = 1.0$) as shown in the figure. The slab is composed of two different materials with refractive indices n_1 and n_2. Assume that the permeability of each medium is the same. After passing through the slab for the first time, the electric field amplitude, in Vcm^{-1}, of of the electromagnetic wave, which emerges from the slab in region 2, is closest to   [2021 PH]

③

$n_2 = 1.1$

④   ②

45° $n_1 = 2.2$

①

$n_0 = 1.0$

z

x y

a) $\frac{11}{1.6}$ b) $\frac{11}{3.2}$ c) $\frac{11}{13.8}$ d) $\frac{11}{25.6}$