

Topic:- DU\_J18\_MSC\_PHY\_Topic01

1) A particle is confined in a one dimensional potential box with impenetrable walls at  $x = \pm a$ . Its energy eigenvalue is 2 eV and corresponds to the eigenfunction of the first excited state. The lowest possible energy of the particle is

[Question ID = 5127]

1. 2.0 eV [Option ID = 20507]
2. 0.5 eV [Option ID = 20505]
3. 4.0 eV [Option ID = 20506]
4. 1.0 eV [Option ID = 20508]

Correct Answer :-

- 0.5 eV [Option ID = 20505]

2) The net magnetic moment of Iron atom in BCC crystal ( $a = 2.857 \text{ \AA}$ ) is  $2.2 \mu_B$  ( $\mu_B = 9.273 \times 10^{-24} \text{ Am}^2$ ). The saturation magnetization of Fe at 0 K is

[Question ID = 5148]

1.  $1750 \text{ Am}^{-1}$  [Option ID = 20589]
2.  $1750 \text{ Am}^{-2}$  [Option ID = 20592]
3. 0 [Option ID = 20590]
4.  $1749.6 \text{ kAm}^{-1}$  [Option ID = 20591]

Correct Answer :-

- $1749.6 \text{ kAm}^{-1}$  [Option ID = 20591]

3) Three dice are thrown simultaneously. The probability that the same number will appear on all the three dice is

[Question ID = 5159]

1.  $1/36$  [Option ID = 20635]
2.  $1/6$  [Option ID = 20633]
3.  $1/18$  [Option ID = 20634]
4.  $1/108$  [Option ID = 20636]

Correct Answer :-

- $1/36$  [Option ID = 20635]

4)

Let us model a star as a spherical black body at temperature  $T$  which radiates to distant points which are at absolute zero. Let us further model a dust cloud around the star as a black spherical shell whose temperature  $T_s$  is determined by radiative equilibrium. What is  $T_s$ ?

[Question ID = 5168]

1.  $2^{-1/2} T$  [Option ID = 20670]
2.  $2^{-1/4} T$  [Option ID = 20669]
3.  $T$  [Option ID = 20672]
4.  $T/2$  [Option ID = 20671]

Correct Answer :-

- $2^{-1/4} T$  [Option ID = 20669]

5) Consider a Carnot reversible heat engine working between the temperatures of melting ice and steam. The efficiency of this heat engine will be approximately equal to

[Question ID = 5160]

1. 37% [Option ID = 20638]
2. 27%. [Option ID = 20637]
3. 100% [Option ID = 20639]
4. None of the above. [Option ID = 20640]

Correct Answer :-

- 27%. [Option ID = 20637]

6) Which one of the following is not a characteristic of CMOS configuration?

[Question ID = 5136]

1. CMOS devices have higher noise-margins. [Option ID = 20543]
2. CMOS devices have low input impedances. [Option ID = 20542]
3. CMOS devices have much lower transconductance than bipolar devices. [Option ID = 20544]
4. CMOS devices dissipate lower static power than bipolar devices. [Option ID = 20541]

Correct Answer :-

- CMOS devices have low input impedances. [Option ID = 20542]

7) The value of the integral

$$\int_0^{2\pi} \frac{d\theta}{(5 - 3 \sin \theta)}$$

is

[Question ID = 5154]

1.  $\frac{2\pi}{3}$  [Option ID = 20615]
2.  $\frac{\pi}{2}$  [Option ID = 20613]
3.  $\frac{\pi}{4}$  [Option ID = 20614]
4.  $\frac{3\pi}{4}$  [Option ID = 20616]

**Correct Answer :-**

- $\frac{\pi}{2}$  [Option ID = 20613]

8) Given  $z = x + iy$ , the contour integration  $\oint_C \frac{dz}{z}$  is equal to (where  $C$  is any anti-clockwise contour going around the origin)

**[Question ID = 5156]**

1.  $-\pi i$  [Option ID = 20624]
2.  $2\pi i$  [Option ID = 20621]
3.  $\pi i$  [Option ID = 20623]
4.  $0$  [Option ID = 20622]

**Correct Answer :-**

- $2\pi i$  [Option ID = 20621]

9) Solution of the differential equation

$$\frac{d^2 y}{dx^2} - 6 \frac{dy}{dx} + 9y = 8e^x \text{ is}$$

**[Question ID = 5155]**

1.  $Axe^{3x} + Be^x$  [Option ID = 20620]
2.  $(Ax + B)e^{3x} + 2e^x$  [Option ID = 20617]
3.  $(Ax^2 + Bx)e^{4x} + 2e^{2x}$  [Option ID = 20619]
4.  $(Ax + B)e^{3x} + 8e^x$  [Option ID = 20618]

**Correct Answer :-**

- $(Ax + B)e^{3x} + 2e^x$  [Option ID = 20617]

10) Train A and train B are running on adjacent rail tracks in the same direction with speeds 43 m/s and 10 m/s, respectively, with train B ahead of train A. When train A is 1000 m behind train B, train A sounds a whistle with frequency 270 Hz in its rest frame. Assuming still air and a speed of sound of 330 m/s, the frequency of the sound as measured by a passenger at rest in train B is equal to

**[Question ID = 5146]**

1. 301 Hz [Option ID = 20581]
2. 280 Hz [Option ID = 20583]
3. 310 Hz [Option ID = 20582]

4. 290 Hz [Option ID = 20584]

Correct Answer :-

• 301 Hz [Option ID = 20581]

11)

An Earth-like exoplanet orbits around a star having a mass  $1/27$  times the mass of Sun. This exoplanet completes one revolution around the star in 365 days just like Earth. Assuming that orbits of both Earth as well as this exoplanet are circular, the distance of the exoplanet from its star is,

[Question ID = 5142]

1. one-ninth of the Earth-Sun distance. [Option ID = 20568]
2. 3 times the Earth-Sun distance. [Option ID = 20566]
3. same as the Earth-Sun distance [Option ID = 20567]
4. One-third of the Earth-Sun distance. [Option ID = 20565]

Correct Answer :-

• One-third of the Earth-Sun distance. [Option ID = 20565]

12) Consider eight electrons in a one dimensional box of length ' $a$ ' extending from  $x = 0$  to  $x = a$ . What is the minimum allowed total energy using Pauli's exclusion principle for the system ( $m =$  mass of electron)

[Question ID = 5128]

1.  $\frac{8h^2}{ma^2}$  [Option ID = 20511]
2.  $\frac{15h^2}{2ma^2}$  [Option ID = 20512]
3.  $\frac{15h^2}{4ma^2}$  [Option ID = 20509]
4.  $\frac{10h^2}{ma^2}$  [Option ID = 20510]

Correct Answer :-

•  $\frac{15h^2}{4ma^2}$  [Option ID = 20509]

13) For an electromagnetic wave traveling in free space, given by  $\vec{E} = E_m \sin(\omega t - \beta z) \hat{y}$ , the magnetic field  $\vec{B}$  will be given by

[Question ID = 5170]

1. None of the above [Option ID = 20680]

2.  $\vec{B} = -\frac{E_m\beta}{\omega} \sin(\omega t - \beta z) \hat{x}$  [Option ID = 20677]

3.  $\vec{B} = -\frac{E_m\beta}{\omega} \cos(\omega t - \beta z) \hat{z}$  [Option ID = 20678]

4.  $\vec{B} = \frac{E_m\beta}{\omega} \sin(\omega t - \beta z) \hat{y}$  [Option ID = 20679]

Correct Answer :-

•  $\vec{B} = -\frac{E_m\beta}{\omega} \sin(\omega t - \beta z) \hat{x}$  [Option ID = 20677]

14) The magnetic field required to bend a non-relativistic charged particle moving with velocity  $v$  into an arc of radius of curvature  $R$  is

[Question ID = 5176]

1. inversely proportional to  $v^2$  and directly proportional to  $R^2$  [Option ID = 20704]
2. inversely proportional to  $v$  and directly proportional to  $R$  [Option ID = 20702]
3. directly proportional to  $v$  and inversely proportional to  $R$  [Option ID = 20701]
4. directly proportional to  $v^2$  and inversely proportional to  $R^2$  [Option ID = 20703]

Correct Answer :-

- directly proportional to  $v$  and inversely proportional to  $R$  [Option ID = 20701]

15) An atom is placed in a magnetic field of sufficient strength for splitting the  $3p$  level. The number of levels resulting due to splitting will be

[Question ID = 5151]

1. 1 [Option ID = 20603]
2. 4 [Option ID = 20604]
3. 3 [Option ID = 20601]
4. 2 [Option ID = 20602]

Correct Answer :-

- 3 [Option ID = 20601]

16) In 3- dimensional space, a particle of mass  $m$  moves in a potential  $B \sin 2\alpha r$  where  $r$  is the distance of the particle from the origin,  $B$  and  $\alpha$  are real constants. Which of the following statement is correct?

[Question ID = 5138]

1. The motion is periodic in  $r$  with an oscillation length scale  $2\pi/\alpha$ . [Option ID = 20550]  
The trajectory of the particle is always confined to a plane passing through the origin. [Option ID = 20552]
2. [Option ID = 20552]
3. The motion is periodic in  $r$  with an oscillation length scale  $\pi/\alpha$ . [Option ID = 20549]

- Symmetry implies that a radial momentum  $p_r$  is conserved because of the periodic nature of the potential.
4. [Option ID = 20551]

**Correct Answer :-**

The trajectory of the particle is always confined to a plane passing through the origin.

[Option ID = 20552]

- 17) Fourier transform of any function  $f(x)$  is defined to be

$$F(k) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(x) \exp(-ikx) dx.$$

Then, given a function  $g(x) = 1$  for  $|x| < 1$  and zero otherwise, its Fourier transform  $G(k)$  is

[Question ID = 5157]

1.  $\sqrt{\frac{2}{\pi}} \frac{\sin(k)}{k}$  [Option ID = 20625]
2.  $\sqrt{\frac{1}{\pi}} \frac{\exp(k)}{k}$  [Option ID = 20626]
3.  $\sqrt{\frac{2}{\pi}} \cos(k)$  [Option ID = 20627]
4.  $\sqrt{\frac{1}{\pi}} \frac{\exp(-k)}{k}$  [Option ID = 20628]

**Correct Answer :-**

•  $\sqrt{\frac{2}{\pi}} \frac{\sin(k)}{k}$  [Option ID = 20625]

- 18) The fine structure splitting of the  $2p$  state of carbon and oxygen atoms in the  $L-S$  coupling scheme will have the energy respectively as

[Question ID = 5163]

1.  ${}^3P_2 > {}^3P_1 > {}^3P_0$  and  ${}^3P_2 > {}^3P_1 > {}^3P_0$  [Option ID = 20651]
2.  ${}^3P_2 < {}^3P_1 < {}^3P_0$  and  ${}^3P_2 < {}^3P_1 < {}^3P_0$  [Option ID = 20652]
3.  ${}^3P_2 > {}^3P_1 > {}^3P_0$  and  ${}^3P_2 < {}^3P_1 < {}^3P_0$  [Option ID = 20650]
4.  ${}^3P_2 < {}^3P_1 < {}^3P_0$  and  ${}^3P_2 > {}^3P_1 > {}^3P_0$  [Option ID = 20649]

**Correct Answer :-**

•  ${}^3P_2 > {}^3P_1 > {}^3P_0$  and  ${}^3P_2 < {}^3P_1 < {}^3P_0$  [Option ID = 20650]

19) The Boolean expression  $(A+B)(A+\bar{B})(\bar{A}+B)$  is equivalent to

[Question ID = 5133]

1.  $A\bar{B}$  [Option ID = 20532]
2.  $\bar{A}B$  [Option ID = 20531]
3.  $\bar{A}\bar{B}$  [Option ID = 20530]
4.  $AB$  [Option ID = 20529]

Correct Answer :-

- $AB$  [Option ID = 20529]

20) Consider a rotating spherical planet such that the effective gravitational attraction at the equator is only 75% of that at the pole. If the linear velocity of a point on the equator is  $v_0$ , what is the escape velocity for a polar particle?

[Question ID = 5139]

1.  $v_0\sqrt{8}$  [Option ID = 20553]
2.  $v_0\sqrt{2}$  [Option ID = 20555]
3.  $2v_0$  [Option ID = 20554]
4.  $4v_0$  [Option ID = 20556]

Correct Answer :-

- $v_0\sqrt{8}$  [Option ID = 20553]

21) If  $f(x)$  is a non-negative continuous function for all  $x$ , such that

$$f(x) + f(x + 1/2) = 1, 0 \leq x \leq \frac{1}{2},$$

then  $\int_0^1 f(x) dx$  is equal to

[Question ID = 5164]

1.  $1$  [Option ID = 20655]
2.  $1/4$  [Option ID = 20654]
3.  $1/2$  [Option ID = 20653]
4.  $2$  [Option ID = 20656]

Correct Answer :-

- $1/2$  [Option ID = 20653]

22)

A charged particle of charge  $q$  and mass  $m$  enters with initial velocity  $u$  along the  $x$  direction into a region defined by  $0 \leq x \leq L$  in which a uniform electric field  $\vec{E}$  is applied along the  $y$  direction. The charged particle gets deflected by distance  $D$  along the  $y$  direction when it emerges out of the region. Which of the following statements is false:

[Question ID = 5175]

1.  $D$  is directly proportional to  $u$  [Option ID = 20699]
2.  $D$  is directly proportional to  $q/m$ . [Option ID = 20697]
3.  $D$  is directly proportional to  $L^2$  [Option ID = 20700]
4.  $D$  is directly proportional to  $\vec{E}$  [Option ID = 20698]

Correct Answer :-

- $D$  is directly proportional to  $u$  [Option ID = 20699]

23) Which of the following current densities can generate the magnetic vector potential  $\vec{A} = y^2 \hat{x} + x^2 \hat{y}$  ?

[Question ID = 5171]

1.  $-\frac{2}{\mu_0} (\hat{x} + \hat{y})$  [Option ID = 20681]
2.  $-\frac{2}{\mu_0} (\hat{x} - \hat{y})$  [Option ID = 20683]
3.  $\frac{2}{\mu_0} (x\hat{x} + y\hat{y})$  [Option ID = 20682]
4.  $\frac{2}{\mu_0} (x\hat{x} - y\hat{y})$  [Option ID = 20684]

Correct Answer :-

- $-\frac{2}{\mu_0} (\hat{x} + \hat{y})$  [Option ID = 20681]

24) Let  $z = x + iy$  where  $x$  and  $y$  are real and  $i = \sqrt{-1}$ . The points  $(x,y)$  in the plane for which  $\frac{z+i}{z-i}$  is purely imaginary lie on

[Question ID = 5152]

1. a hyperbola. [Option ID = 20608]
2. an ellipse [Option ID = 20607]
3. a circle [Option ID = 20605]
4. a straight line [Option ID = 20606]

Correct Answer :-

- a circle [Option ID = 20605]

25) Thermal runaway in a transistor biased in the active region is due to



[Question ID = 5135]

1. change in reverse collector saturation current due to rise in temperature [Option ID = 20540]
2. breakdown under reverse biasing [Option ID = 20537]
3. changes in  $\beta$  which increases with temperature [Option ID = 20538]
4. base-emitter voltage  $V_{BE}$  which decreases with rise in temperature [Option ID = 20539]

Correct Answer :-

- change in reverse collector saturation current due to rise in temperature [Option ID = 20540]

- 26) Life-time of an excited state of an atom that always jumps to the ground state by emitting a photon spontaneously is  $10^{-9}$  second. The frequency of the emitted photon is uncertain at least by an amount

[Question ID = 5130]

1.  $10^4$  Hz. [Option ID = 20520]
2.  $10^8$  Hz. [Option ID = 20517]
3.  $10^5$  Hz. [Option ID = 20519]
4.  $10^6$  Hz. [Option ID = 20518]

Correct Answer :-

- $10^8$  Hz. [Option ID = 20517]

- 27) In a hydrogen-like atom, an electron is bound to a heavy nucleus containing  $Z$  number of protons. In the framework of Bohr's atomic model,  $mv_n r_n = n\hbar$ ,  $n = 1, 2, 3, \dots$ , where  $m$ ,  $v_n$  and  $r_n$  are the electron's mass, speed and radius, respectively, corresponding to the  $n$ -th orbit. If  $a_0 \equiv \frac{\hbar^2}{me^2}$  then,

[Question ID = 5131]

1.  $v_n = \frac{Ze^2}{n\hbar}$  and  $r_n = \frac{n^2}{Z} a_0$  [Option ID = 20521]
2.  $v_n = \frac{Ze^2}{n\hbar}$  and  $r_n = na_0$  [Option ID = 20523]
3.  $v_n = \frac{Zne^2}{\hbar}$  and  $r_n = \frac{n}{Z} a_0$  [Option ID = 20524]
4.  $v_n = \frac{e^2}{n\hbar}$  and  $r_n = \frac{n}{Z} a_0$  [Option ID = 20522]

Correct Answer :-

- $v_n = \frac{Ze^2}{n\hbar}$  and  $r_n = \frac{n^2}{Z} a_0$  [Option ID = 20521]

28)

Four moles of an ideal gas undergo a reversible isothermal compression at  $20^\circ\text{C}$  when 1850 J of work is done on the gas. The change in entropy of the gas in this process is

[Question ID = 5165]

1.  $-1.6 \text{ J/K}$  [Option ID = 20659]
2.  $+1.6 \text{ J/K}$  [Option ID = 20660]
3.  $+6.3 \text{ J/K}$  [Option ID = 20658]
4.  $-6.3 \text{ J/K}$  [Option ID = 20657]

Correct Answer :-

- $-6.3 \text{ J/K}$  [Option ID = 20657]

29) The degeneracy of the lowest Landau level

[Question ID = 5150]

1. Is constant with the magnetic field. [Option ID = 20599]
2. Varies as function of temperature. [Option ID = 20600]
3. Varies linearly with the magnetic field. [Option ID = 20597]
4. Varies exponentially with the magnetic field. [Option ID = 20598]

Correct Answer :-

- Varies linearly with the magnetic field. [Option ID = 20597]

30) The fraction of electrons excited across the energy gap of Silicon ( $E_g = 1.1 \text{ eV}$ ) at room temperature (300 K) is

[Question ID = 5147]

1.  $4 \times 10^{-12}$  [Option ID = 20587]
2.  $7 \times 10^{-18}$  [Option ID = 20585]
3.  $1.7 \times 10^{-12}$  [Option ID = 20586]
4.  $5.712 \times 10^{-10}$  [Option ID = 20588]

Correct Answer :-

- $5.712 \times 10^{-10}$  [Option ID = 20588]

31) A large and spherical soap film of thickness  $d$  has a refractive index  $4/3$ . A narrow beam of yellow light ( $\lambda \approx 6400 \text{ \AA}$ ) is incident on the film at an angle of  $30^\circ$ . What is the value of  $d$  for which a constructive second order interference would occur for the reflected wave?

[Question ID = 5144]

1.  $4800 \text{ \AA}$  [Option ID = 20575]
2.  $3900 \text{ \AA}$  [Option ID = 20573]
3.  $5200 \text{ \AA}$  [Option ID = 20574]

4.  $5500 \text{ \AA}$  [Option ID = 20576]

Correct Answer :-

•  $3900 \text{ \AA}$  [Option ID = 20573]

32) The real part of an analytic complex function is  $u(x, y) = x^2 - y^2$ . The imaginary part of the function is then

[Question ID = 5158]

1.  $2xy$  [Option ID = 20629]
2.  $x^2 - y^2 - 2xy$  [Option ID = 20632]
3.  $x^2 + y^2$  [Option ID = 20630]
4.  $x^2 + y^2 + xy$  [Option ID = 20631]

Correct Answer :-

•  $2xy$  [Option ID = 20629]

33)

A uniformly charged ring of total charge  $Q$  and of radius  $R$ , rotates about an axis perpendicular to its plane and passing through its centre, with angular velocity  $\omega$ . The magnetic field produced at the centre of the ring is

[Question ID = 5172]

1.  $\frac{3\mu_0 Q \omega}{2\pi R}$  [Option ID = 20687]
2.  $\frac{4\pi R}{\mu_0 Q \omega}$  [Option ID = 20688]
3.  $\frac{4\pi R}{\mu_0 Q \omega}$  [Option ID = 20685]
4.  $2\pi R$  [Option ID = 20686]

Correct Answer :-

•  $\frac{\mu_0 Q \omega}{4\pi R}$  [Option ID = 20685]

34)

A child of mass  $3m$  sits on a swing, the base of which has mass  $m$ , while the rope (of length  $\ell$ ) has a negligible mass. An adult pulls back the swing (with the child) until the rope makes an angle of half-a-radian with the vertical, and, then, pushes with a force  $mg$  along the arc of a circle until the rope is exactly vertical, and releases it. If the rope was always taut, for how long did the adult push?

[Question ID = 5140]

1.  $\pi \sqrt{\frac{2\ell}{3g}}$  [Option ID = 20559]

2.  $\frac{\pi}{3} \sqrt{\frac{\ell}{g}}$  [Option ID = 20557]

3.  $\sqrt{\frac{\ell}{g}}$  [Option ID = 20558]

4.  $\sqrt{\frac{2\ell}{3g}}$  [Option ID = 20560]

**Correct Answer :-**

•  $\frac{\pi}{3} \sqrt{\frac{\ell}{g}}$  [Option ID = 20557]

35) The normalized wave functions  $\psi_1$  and  $\psi_2$  correspond to the ground state and the first excited states of a particle in a potential. The operator  $\hat{A}$  acts on the wavefunctions as  $\hat{A}\psi_1 = \psi_2$  and  $\hat{A}\psi_2 = \psi_1$ . The expectation value of the operator  $\hat{A}$  for the state  $\psi = (3\psi_1 + 4\psi_2)/5$  is

[Question ID = 5141]

1. 0 [Option ID = 20563]

2. 0.96 [Option ID = 20561]

3. 0.75 [Option ID = 20564]

4. -0.32 [Option ID = 20562]

**Correct Answer :-**

• 0.96 [Option ID = 20561]

36) A particle of mass  $m$  is confined in the ground state of a one dimensional box extending from  $x = -2L$  to  $x = +2L$ . The wave function of the particle in this state is

$$\Psi(x) = \psi_0 \cos\left(\frac{\pi x}{4L}\right),$$

where  $\psi_0$  is a constant. The energy eigenvalue corresponding to this state is

[Question ID = 5129]

1.  $\frac{\hbar^2 \pi^2}{32mL^2}$  [Option ID = 20513]

2.  $\frac{16mL^2}{\hbar^2 \pi^2}$  [Option ID = 20516]

3.  $\frac{4mL^2}{\hbar^2 \pi^2}$  [Option ID = 20515]

4.  $2mL^2$  [Option ID = 20514]

**Correct Answer :-**

•  $\frac{\hbar^2 \pi^2}{32mL^2}$  [Option ID = 20513]

37) Let  $C$  be the unit circle, travelled counterclockwise. Evaluate

$$\oint_C [(e^{-x^2} - y^3)dx + x^3dy]$$

[Question ID = 5143]

1.  $\sqrt{\frac{\pi}{2}} - 2$  [Option ID = 20572]
2.  $\sqrt{\frac{\pi}{2}} + 2$  [Option ID = 20570]
3.  $2\pi$  [Option ID = 20571]
4.  $\frac{3\pi}{2}$  [Option ID = 20569]

Correct Answer :-

- $\frac{3\pi}{2}$  [Option ID = 20569]

38) Consider a system of 3 non-interacting identical fermions. Each particle can be in any one of four states whose energies are  $-\varepsilon$ ,  $0$ ,  $+\varepsilon$  and  $+2\varepsilon$ . Find the entropy of the system if its total energy  $E = 0$ .

[Question ID = 5177]

1.  $k \ln 2$  [Option ID = 20705]
2.  $0$  [Option ID = 20706]
3.  $k \ln 3$  [Option ID = 20707]
4.  $k \ln 4$  [Option ID = 20708]

Correct Answer :-

- $0$  [Option ID = 20706]

39) A uniform magnetic field  $B$  points along the  $z$  axis. At time  $t = 0$ , a point charge  $q$  of mass  $m$  is released from the origin with a velocity  $\vec{v}$  making an angle  $30^\circ$  with the  $z$ -axis. When the point charge comes back again at  $x = 0$ , the  $z$  coordinate of the charge is

[Question ID = 5173]

1.  $\frac{2\pi m|v|}{\sqrt{3}qB}$  [Option ID = 20690]
2.  $\frac{\sqrt{3}\pi m|v|}{2qB}$  [Option ID = 20689]
3.  $\frac{\pi m|v|}{qB}$  [Option ID = 20692]

4.  $\frac{\pi m|v|}{2qB}$  [Option ID = 20691]

**Correct Answer :-**

•  $\frac{\sqrt{3}\pi m|v|}{2qB}$  [Option ID = 20689]

40)

A thin, uniform and rigid rod  $R$  of mass  $M$  and length  $L$  rests on a flat frictionless table top. A tiny piece of wood of mass  $m = 0.01 M$  sliding on the table towards  $R$  with a velocity  $\vec{v}$  perpendicular to the length of the rod hits one end of  $R$  and gets stuck. The speed of the centre of mass and angular speed of the resulting system are respectively given by

[Question ID = 5145]

1.  $\frac{v}{100}$  and  $\frac{2v}{101L}$  [Option ID = 20578]

2.  $\frac{v}{101}$  and  $\frac{6v}{103L}$  [Option ID = 20577]

3.  $\frac{v}{101}$  and  $\frac{2v}{100L}$  [Option ID = 20580]

4.  $\frac{v}{100}$  and  $\frac{6v}{101L}$  [Option ID = 20579]

**Correct Answer :-**

•  $\frac{v}{101}$  and  $\frac{6v}{103L}$  [Option ID = 20577]

41) The temperature dependence of the magnetic susceptibility ( $\chi$ ) of a paramagnetic material, with Curie temperature ( $T_c$ ), is given by:

[Question ID = 5149]

1.  $C/(T + T_c)$  for  $T > T_c$  [Option ID = 20595]

2.  $C/(T - T_c)$  for  $T < T_c$  [Option ID = 20594]

3.  $C/(T + T_c)$  for all temperatures [Option ID = 20596]

4.  $C/(T - T_c)$  for  $T > T_c$  [Option ID = 20593]

**Correct Answer :-**

•  $C/(T - T_c)$  for  $T > T_c$  [Option ID = 20593]

42) A semiconductor has  $10^{15}$  electrons/cm<sup>3</sup> ( $\mu_e = 5000$  cm<sup>2</sup>/V.s) and  $5 \times 10^{14}$  holes/cm<sup>3</sup> ( $\mu_h = 400$  cm<sup>2</sup>/V.s). If a field of 100V/cm is applied to it, its total conductivity is

[Question ID = 5134]

1.  $83.2 (\Omega\text{cm})^{-1}$  [Option ID = 20536]

2.  $0.832 (\Omega\text{cm})^{-1}$  [Option ID = 20533]
3.  $0.832 (\text{m}\Omega\text{cm})^{-1}$  [Option ID = 20535]
4.  $8.32 (\text{m}\Omega\text{cm})^{-1}$  [Option ID = 20534]

**Correct Answer :-**

- $0.832 (\Omega\text{cm})^{-1}$  [Option ID = 20533]

43) For a mole of ideal gas at  $T = 35^\circ\text{C}$ , what is the work done for an isothermal expansion from a volume  $V_0$  to  $10 V_0$ ?

[Question ID = 5166]

1.  $6 \times 10^3 \text{ J}$  [Option ID = 20661]
2.  $3 \times 10^3 \text{ J}$  [Option ID = 20663]
3.  $10^3 \text{ J}$  [Option ID = 20664]
4.  $10^4 \text{ J}$  [Option ID = 20662]

**Correct Answer :-**

- $6 \times 10^3 \text{ J}$  [Option ID = 20661]

44) An ideal monoatomic gas, initially at  $T = 20^\circ\text{C}$ , expands adiabatically from a volume  $V_0$  to  $5 V_0$ . Then the final temperature is

[Question ID = 5169]

1.  $-20^\circ\text{C}$  [Option ID = 20674]
2.  $-33^\circ\text{C}$  [Option ID = 20676]
3.  $-173^\circ\text{C}$  [Option ID = 20673]
4.  $-113^\circ\text{C}$  [Option ID = 20675]

**Correct Answer :-**

- $-173^\circ\text{C}$  [Option ID = 20673]

45) Consider a body of mass 5 g, which is heated from 100 K to 300 K. The specific heat for the body is 0.1 cal/g/degree. The total change in the entropy of the body is approximately equal to

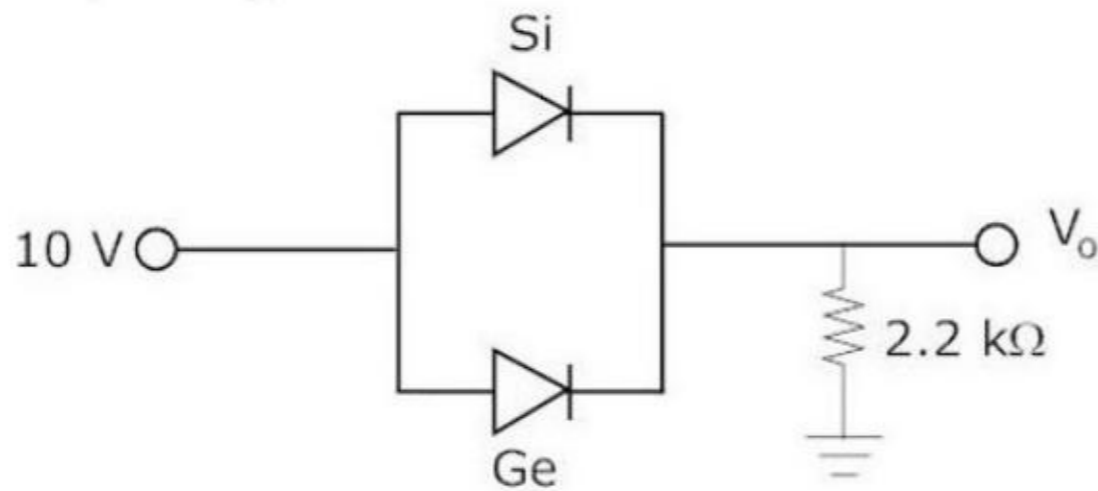
[Question ID = 5161]

1. 0.5 cal/degree. [Option ID = 20643]
2. 100 cal/degree [Option ID = 20641]
3. 50 cal/degree [Option ID = 20642]
4. 0 cal/degree [Option ID = 20644]

**Correct Answer :-**

- 0.5 cal/degree. [Option ID = 20643]

- 46) Two diodes (Si and Ge) are connected in parallel as shown in the figure. Determine the output voltage  $V_o$ . The cut-in voltage for Si and Ge diodes are 0.7 V and 0.2 V, respectively.



[Question ID = 5132]

1. -9.3 V [Option ID = 20527]
2. -9.8 V [Option ID = 20526]
3. +9.3 V [Option ID = 20528]
4. +9.8 V [Option ID = 20525]

Correct Answer :-

- +9.8 V [Option ID = 20525]

- 47) Let  $f: \mathbb{R} \rightarrow \mathbb{R}$  be given by  

$$f(x) = |x^2 - 1|, x \in \mathbb{R}$$
 Then

[Question ID = 5153]

1.  $f$  is discontinuous at  $x = \pm 1$ . [Option ID = 20612]
2.  $f$  has local maxima at  $x = 0$  but no local minimum. [Option ID = 20611]
3.  $f$  has local minima at  $x = \pm 1$  and a local maximum at  $x = 0$ . [Option ID = 20609]
4.  $f$  has local minima at  $x = \pm 1$  but no local maximum. [Option ID = 20610]

Correct Answer :-

- $f$  has local minima at  $x = \pm 1$  and a local maximum at  $x = 0$ . [Option ID = 20609]

- 48) An infinite wire having uniform charge per unit length  $\lambda$  (where  $\lambda$  is negative) lies parallel to an infinite grounded conducting plane. The perpendicular distance between the wire and the plane is  $d$ . The maximum value of charge density induced on the plane is

[Question ID = 5174]

1.  $\frac{|\lambda|}{\pi d}$  [Option ID = 20693]
2.  $2\pi d$  [Option ID = 20695]



3.  $\frac{2|\lambda|}{\pi d}$  [Option ID = 20694]  
4.  $\frac{4\pi d}{|\lambda|}$  [Option ID = 20696]

**Correct Answer :-**

- $\frac{|\lambda|}{\pi d}$  [Option ID = 20693]

49) Two tuning forks with natural frequencies  $\nu_1$  and  $\nu_2$  respectively, are struck at the same time with equal force. The intensity, of the resulting sound, waxes and wanes with time period of 1.5 seconds while the frequency of the sound is 256 Hz. Hence,  $\nu_1$  and  $\nu_2$ , respectively, are

**[Question ID = 5137]**

1. 256.333 Hz and 255.667 Hz [Option ID = 20548]  
2. 256.55 Hz and 255.55 Hz [Option ID = 20547]  
3. 256 Hz and 256.5 Hz [Option ID = 20545]  
4. 256.5 Hz and 257 Hz [Option ID = 20546]

**Correct Answer :-**

- 256.333 Hz and 255.667 Hz [Option ID = 20548]

50) A blackbody at a temperature of 6000 K emits radiation whose intensity spectrum peaks at 600 nm. If the temperature is reduced to 300 K, the spectrum will peak at

**[Question ID = 5162]**

1. 12 nm [Option ID = 20647]  
2. 120  $\mu\text{m}$  [Option ID = 20646]  
3. 120 nm. [Option ID = 20648]  
4. 12  $\mu\text{m}$  [Option ID = 20645]

**Correct Answer :-**

- 12  $\mu\text{m}$  [Option ID = 20645]