DU Ph.D. 2013

Q1. Two events in a particular reference frame are separated in space by a distance 'ΔL'. In another frame, which is moving with a speed 'v' relative to the first frame, the two events are separated by 'Δx' in space and 'Δt' in time. Which all of the following statement is true?

(a) $(\Delta L)^2 = (\Delta x)^2$ (b) $(\Delta L)^2 = \gamma^2 (\Delta x)^2$

(c) $(\Delta L)^2 = c^2\beta^2(1-\gamma^2)(\Delta t)^2$ (d) $(\Delta L)^2 = (\Delta x)^2 - c^2(\Delta t)^2$

Q2. The electric field of a plane wave is given by $E(z,t) = \hat{y}E_0 \sin(kz+\omega t)$. The magnetic fields is given by

(a) $B(z,t) = \hat{x}B_0 \sin(kz+\omega t)$ (b) $B(z,t) = -\hat{x}B_0 \sin(kz+\omega t)$

(c) $B(z,t) = \hat{z}B_0 \sin(kz+\omega t)$ (d) $B(z,t) = -\hat{z}B_0 \sin(kz+\omega t)$

Q3. A particle is released with zero initial velocity in a region where there is an electric field E in the y direction and a magnetic field B in the z direction. The condition that is necessary for the existence of a Lorentz frame in which the (transformed) electric field E' vanished is

(a) $|E| \le c|B|$ (b) $c|B| \le |E|$

(c) $|E|^2 \le c^2|B|^2$ (d) $c^2|B|^2 \le |E|^2$

Q4. For the following mnemonic instructions for 8051 microcontroller

$MOVA, \#56H$

$MOV\ R1, \#50H$

$MOV\ 50H, \#45H$

$XCHDA, @R1$

The contents in A and $R1$ will be, respectively

(a) $56H$ and 45H (b) $45H$ and 50H

(c) $50H$ and 56H (d) $45H$ and 56H

Q5. Consider two identical superconductors separated by a thin layer of insulator ($10-20\overset{0}{A}$ thick) A DC magnetic field is applied through the circuit. A de voltage of $1\mu V$ is applied across the junctions, as a result of it

(a) An ac current with frequency $241.8\ MHz$ will flow through the circuit

(b) An ac current with frequency $983.6\ MHz$ will flow through the circuit

(c) A dc current of $1\mu A$ will flow through the circuit

(d) No current shall flow as the circuit remain open.

Q6. Mass spectrometers separate isotopes of different element based on their

(a) Mass
(b) Electronic Charges
(c) Mass divided by electric charge
(d) None of these.

Q7. An Ideal gas undergoes a isothermal process starting with a pressure of $2\times10^5\ Pa$ and a volume of $6\,cm^3$. Which of the following might be the final pressure and the temperature of the final state?

(a) $4\times10^5\ Pa$ and $4\,cm^3$
(b) $8\times10^5\ Pa$ and $2\,cm^3$
(c) $6\times10^5\ Pa$ and $2\,cm^3$
(d) $3\times10^5\ Pa$ and $6\,cm^3$

Q8. The Temperature of two identical gases is from initial temperature to same final temperature. For gas A the process is carried out as constant volume while for gas B it is carried at constant pressure. The change in entropy

(a) Is greater for gas A
(b) Is greater for gas B
(c) same for A and B
(d) The entropies of A and B do not change in these processes

Q9. A bag contains 100 balls marked 1 to 100 (without repetition). You are asked to pick up any three balls at random (without replacement). Construct the product N of the three individual numbers on the ball ($N = N_1N_2N_3$) markings the probability P that N is divisible by 3 is best approximate

(a) $P\approx0.3$
(b) $P\approx0.5$
(c) $P\approx0.7$
(d) $P\approx0.9$

Q10. Consider an ideal intrinsic semiconductor in thermal equilibrium. No external force or fields are applied to this semiconductor. At temperatures above $0K$, the electron concentration in the conduction band is non-zero because

(a) Some electrons from dopant atoms will overcome the bandgap by gained thermal energy

(b) Some electrons from dopant atoms will overcome the ionization energy by gained thermal energy

(c) Some electrons from the conduction band will overcome the bandgap by gained thermal energy

(d) Some electrons from the valence band will overcome the bandgap by gained thermal energy

Q11. The distribution of electrons in the condition band is given by

(a) (density of quantum states) x (energy of a state)

(b) (density of quantum states) x (probability a state is occupied)

(c) (energy of quantum states) x (probability a state is occupied)

(d) (energy of quantum states) x (chemical potential of a state)

Q12. The number of independent components of a real, symmetric $n \times n$ matrix is

(a) n^2 (b) $n^2 - 1$ (c) $\frac{n(n+1)}{2}$ (d) $\frac{n(n-1)}{2}$

Q13. Consider the two definite integrals $l_1 = \int_{-5}^{5} \frac{1}{x^2} dx$ and $l_2 = \int_{-5}^{5} \frac{1}{x^2} dx$, which of the following is true

(a) $l_1 = -\frac{2}{5}, l_2 = 0$ (b) $l_1 = -\frac{2}{5}, l_2 = -\frac{1}{25}$

(c) $l_2 = 0$ while l_1 is undefined

(d) Both l_1 and l_2 are undefined

Q14. $\vec{A},\vec{B}$ and $\vec{C}$ are three linearly independent vectors in the usual three dimensions. Consider the quantity $D=\left[\vec{A}\times\left(\vec{B}\times\vec{C}\right)\right].\left\{\left[\vec{B}\times\left(\vec{C}\times\vec{A}\right)\right]\times\left[\vec{C}\times\left(\vec{A}\times\vec{B}\right)\right]\right\}$ then

(a) $D=0$

(b) $D^2=\left(\vec{A}^2\vec{B}^2\vec{C}^2\right)^3$

(c) $D^2=\left[\left(\vec{A}^2-\vec{B}^2\right)\vec{C}^4+\left(\vec{B}^2-\vec{C}^2\right)\vec{A}^4+\left(\vec{C}^2-\vec{A}^2\right)\vec{B}^4\right]^3$

(d) $D=\left[\vec{A}.\left(\vec{B}\times\vec{C}\right)\right]^3$

Q15. A square wave of frequency 1 Hz has Fourier components with frequencies

(a) ranging from $-\infty$ to $+\infty$ (b) ranging from 0 to $+\infty$

(c) ranging continuously from $1Hz$ to $+\infty$ (d) ranging discretely from $1Hz$ to $+\infty$

Q16. The contour integral of the function $\frac{1}{z-2}$ taken clockwise around thee circle $|z|=5$ is

(a) $-2\pi i$ (b) $4\pi i$ (c) $-2\pi i$ (d) zero

Q17. The Legendre polynomial $P_5(\cos\theta)$ is

(a) an odd function of θ

(b) an odd function of $\cos\theta$

(c) an even function of $\cos\theta$

(d) neither even nor odd as a function of θ

Q18. The Newton-Raphson method for finding a root of a function fails when slope of the function at the root becomes

(a) zero (b) infinite

(c) either one of them (d) None of these

Q19. The value of mid-point after third iteration of bisection method for finding the root of a function $f(x)=x^3-1$ in the starting interval $[1,2]$ is

(a) 1.501 (b) 1.735 (c) 1.625 (d) 1.125

Q20. Molybdenum has a BCC crystal structure, an atomic radius of $0.1363\ nm$, and an atomic weight of $95.94\ g/mol$. The density of the material is

(a) $25.88\ g/cm^3$ (b) $10.22\ g/cm^3$

(c) $4.04\ g/cm^3$ (d) $14.41\ g/cm^3$

Q21. A capacitor of capacitance $0.5\ \mu F$ and leakage resistance of $10\ M\Omega$ is charged to a certain voltage, V_0, and then insulated. Find the time the voltage will take to fall to one third $\left(\frac{V_0}{3}\right)$ its original value

(a) 220×10^{-3} sec (b) 2.39 sec (c) 5.49 sec (d) 95×10^{-3} sec

Q22. Which of the following cannot be a state in $j.j$ coupling schemer for n_1p^1, n_2p^1

(a) $\left(\frac{1}{2},\frac{1}{2}\right)_{01}$ (b) $\left(\frac{1}{2},\frac{3}{2}\right)_{12}$ (c) $\left(\frac{3}{2},\frac{3}{2}\right)_{23}$ (d) $\left(\frac{3}{2},\frac{3}{2}\right)_{0123}$

Q23. The rotational constant for HCI molecule is $10.5\ cm^{-1}$. The wave number (in cm^{-1}) of the third line in the pure rotational spectra is

(a) 21.0 (b) 31.5 (c) 63.0 (d) 73.5

Q24. In pure vibrational mode of a diatomic molecule, the energy levels are at $\frac{1}{2}\omega_{OSC}, \frac{5}{2}\omega_{OSC}$ and $\frac{7}{2}\omega_{OSC}$. Total number of spectral lines in the spectra due to transition between above states are

(a) One (b) Two (c) Three (d) Four

Q25. Consider an ensemble of N distinguishable particles where each particle can have energy ε and 0. Let N_1 particle be in the energy level $\varepsilon\left(N-N_2\right)$ in the energy level 0 and let the total energy of the system be E. The temperature T of the system as a function of E and N is given by (k_B is Boltzmann's constant)

(a) $T^{-1} = -\frac{k_B}{\varepsilon}\ln\left(\frac{E}{N\varepsilon - E}\right)$ (b) $T^{-1} = \frac{k_B}{\varepsilon}\ln\left(\frac{E}{N\varepsilon - E}\right)$

(c) $T^{-1} = -\frac{k_B}{\varepsilon}\ln\left(\frac{E}{N\varepsilon + E}\right)$ (d) $T^{-1} = -\frac{k_B}{\varepsilon}\ln\left(\frac{NE}{\varepsilon - E}\right)$

Q26. Consider two single-particle levels whose energies are ε and $-\varepsilon$. Into thee levels, we place two electrons (no more than one electron of the same spin per level). The entropy of system at $T = 0$ is

(a) 0 (b) $\ln 6$ (c) ∞ (d) 1

Q27. Consider $NaCl$ crystal, which is cubic with a lattice spacing of , say, $1\overset{0}{A}$ (Angstrom). It has some free electrons captured within the lattice. Estimate the longest wavelength of the light that such electron can absorb:

(a) $1\overset{o}{A}$ (b) $2\overset{o}{A}$ (c) $100\overset{o}{A}$ (d) $1000\overset{o}{A}$

Q28. A quantum mechanical particle of mass 'm' and constrained to move in one dimension has a probability density

$$P(x) = \begin{cases} ax^2 & \text{for } |x| < b \\ 0 & \text{otherwise} \end{cases}$$

where 'a' is a constant.

The minimal kinetic energy that is possesses is

(a) Zero (b) $\frac{1}{2}m\dot{x}^2$ (c) $\frac{\hbar^2}{2mb^2}$ (d) $\frac{5\hbar}{2mb^2}$

Q29. For a particle in a box, the difference between consecutive energy eigenvalues increases with 'n' (the level number) whereas for the harmonic oscillator, it is independent of 'n'. Consider, instead, a particle in kx^4 potential (with $k > 0$). The difference between consecutive energy eigenvalues now

(a) Increases with 'n' (b) decreases with 'n'

(c) is independent of 'n' (d) is a non monotonic function of 'n'

Q30. Imagine a hypothetical world where the charge of the electron and the proton do not have the same magnitude, but obey $Q_e = \frac{-2Q_p}{3}$. In all other respects, this universe is identical to ours. In such a universe, the atomic numbers of three lightest inert atoms would be

(a) $Z = 12, Z = 24$ and Z=36 (b) $Z = 2, Z = 10$ and Z=18

(c) $Z = 3, Z = 15$ and Z=27 (d) No inert atoms will exist

Q31. A particle of unit mass moves in the two dimensional potential

$$V(x,y)=\frac{1}{2}\left(x^2+y^2+\lambda xy\right)$$

where $\lambda>0$ is a constant.

To $0(\lambda)$, the three lowest energy eigenvalues, in units of $\hbar$, are

(a) $1, 2-\frac{\lambda}{4}, 2+\frac{\lambda}{4}$ (b) $\frac{1}{2}, \frac{3}{2}-\frac{\lambda}{4}, \frac{5}{2}+\frac{\lambda}{4}$

(c) $1-\frac{\lambda}{4}, 2+\frac{\lambda}{4}, 3-\frac{\lambda}{4}$ (d) $1, 2-\frac{\lambda}{4}, 3+\frac{\lambda}{4}$

Q32. For central potential $V(r)=\frac{\alpha}{r^2}$ where α is negative constant,

(a) Orbits are elliptical,

(b) Orbits are closed, but not elliptical

(c) There are no closed orbits

(d) The existence of closed orbits depends on the total energy

Q33. Consider a linear system of a point mass 'm' attached to two identical springs (of spring constant 'k') which, in turn, are fixed to two walls parallel to each other. Let the distance between the walls be '$2L$'where'L' is the equilibrium length of each spring. Now, give the mass a small displacement in a direction transverse to thee system. The motion of the mass will be described by

(a) Simple harmonic motion with a frequency $\omega=\sqrt{\frac{k}{m}}$

(b) Simple harmonic motion with a frequency $\omega=\sqrt{\frac{2k}{m}}$

(c) Two normal modes with frequencies $\omega_1=\sqrt{\frac{k}{m}}$ and $\omega_2=\sqrt{\frac{3k}{m}}$

(d) Completely anharmonic motion

Q34. In four (space) dimensions, the Lagrangian of point particle is given by

$$L = q_1^2\left(\dot{q}_1^2+\dot{q}_2^2+\dot{q}_3^2+\dot{q}_4^2\right)+\frac{\alpha}{\left(q_2^2+q_3^2\right)}$$

where 'α' is a constant. The conserved quantities are

(a) Energy Alone

(b) Linear momentum and angular momentum

(c) Energy and angular momentum

(d) Energy and a component each of linear and angular momenta

Q35. Two point masses are connected by a spring, and the whole system is constrained to move on a surface of a sphere. The number of independent coordinates needed to describe the system (degree of freedom) is

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

Q36. A symmetrical top moves under gravity with one point fixed. The following statement about its angular momentum $\vec{J}$ and angular velocity $\vec{\omega}$ is generally true:

(a) $\vec{J}$ is independent of time; $\vec{\omega}$ is not

(b) $\vec{\omega}$ is independent of time; $\vec{J}$ is not

(c) Both $\vec{J}$ and $\vec{\omega}$ are independent of time

(d) neither $\vec{J}$ nor $\vec{\omega}$ is independent of time

Q37. If x, y and z are the components of position vector and L_x, L_y and L_z are the components of the angular momentum, the Position bracket $\{x, L_y\}$ is equal to

(a) z (b) L_z (c) Zero (d) None of these

Q38. For a system two bodies of mass 'm' and '$2m$' respectively, the reduced mass is equal to

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

Q39. In a scanning electron microscope a typical accelerating voltage is $10\,kV$. The wavelength of the electro is roughly

(a) $10^{-15}\,m$ (b) $10^{-13}\,m$ (c) $10^{-11}\,m$ (d) $10^{9}\,m$

Q40. At $t=0$, a harmonic oscillator is in a state given by $0.6|0\rangle+0.8|1\rangle$ in usual notation. After a time $2\pi/\omega$ has elapsed, the probability of finding it in the ground state is

(a) 1 (b) 0.6 (c) 0.36 (d) None of these

Q41. Based on extreme single particle shell model, the magnetic moment of ${}^{113}Cd\,(Z=48)$ is

(a) $-1.913\mu_N$ (b) $-1.688\mu_N$ (c) $+1.913\mu_N$ (d) $+1.688\mu_N$

Q42. For the given nuclear transition below, which one is the correct?

$$ {}^{111}_{50}Sn\left(\frac{7}{2^+}\right)\rightarrow {}^{111}_{49}\,\text{ln}\left(\frac{9}{2^+}\right) $$

(a) Allowed, Gamow – Teller Transition

(b) Allowed, Fermi Transition

(c) Allowed, mixed Transition (Both Fermi and Gamow-Teller)

(d) First Forbidden, Fermi Transition

Q43. Isospin (T) and third component of iso-spin T_3 of ${}^{12}B$ and ${}^{12}N$ nuclei are

(a) $1, 1$ and $1, -1$ (b) $1, -1$ and $1, -1$

(c) $1, 1$ and $1, 1$ (d) $0, 1$ and $0, -1$

Q44. Which option is fully correct for nuclear forces?

(a) Spin Independent; charge symmetric and charge independent

(b) Spin dependent, charge asymmetric and charge independent

(c) Spin dependent, charge asymmetric and charge independent

(d) Spin dependent, charge asymmetric and charge dependent

Q45. In a transistor amplifier when signal changes by $0.012V$, the base and collector current change by $10\,\mu A$ and $\text{i}0.8\,mA$, respectively. The current gain and input impedance are respectively equal to

(a) $80,\ 1.2\,K\Omega$ (b) $12.5,\ 15\,K\Omega$

(c) $12.5\times10^{-3},\ 1.2\,K\Omega$ (d) $80,\ 15\,K\Omega$

Q46. The total number of 1's in a 15 bit shift register is to be counted by clocking into a counter which is preset to 0. The counter must have which one of the following:

(a) 4 - bits (b) 5 - bits (c) 16 - bits (d) 6 - bits

Q47. The number of comparator circuits required to build a three-bit simultaneous A/D converter is

(a) 7 (b) 8 (c) 15 (d) 16

Q48. The cavity lifetime of a solid state laser is given by (where η is the refractive index, d is crystal length, R_1 and R_2 are reflectivities of the two end surfaces, α is loss factor and C as velocity of light in Air).

(a) $\frac{2\eta d}{C\left(2\alpha d+\ln R_2R_1\right)}$ (b) $\frac{2\eta d}{C\left(2\alpha d-\ln R_2R_1\right)}$

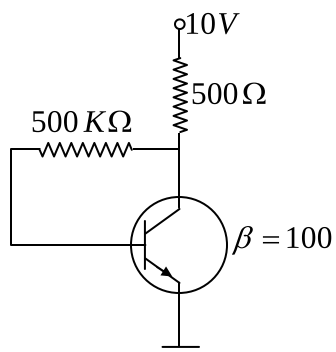
(c) $\frac{2\eta d}{C\left(\alpha d+\ln R_2R_1\right)}$ (d) $\frac{2\eta d}{C\left(\alpha d-\ln R_2R_1\right)}$

Q49. The intensity of sunlight hitting the earth is $1300\,Wm^{-2}$. The pressure exerted by this if it strikes a perfect absorber and a perfect reflector are respectively

(a) $4.3\times10^{-6}\,Nm^{-2}, 8.6\times10^{-6}\,Nm^{-2}$ (b) $1.3\times10^{-6}\,Nm^{-2}, 1.3\times10^{-6}\,Nm^{-2}$

(c) $4.3\times10^{-6}\,Nm^{-2}, 4.3\times10^{-6}\,Nm^{-2}$ (d) $1.3\times10^{-6}\,Nm^{-2}, 2.6\times10^{-6}\,Nm^{-2}$

Q50. The emitter current in the given circuit is



(a) $18\,mA$

(b) $18\,\mu A$

(c) $1.8\,mA$

(d) $1.8\,\mu A$