ALL INDIA TEST SERIES
FOR
CSIR –NET/JRF (PHYSICS) December- 2013

Full Length Test–01

PHYSICAL SCIENCES

TIME: 3 HOURS **MAXIMUM MARKS: 200**

Part 'A' This part shall carry 20 questions pertaining to *General Aptitude with emphasis, On logical reasoning, graphical, analysis, analytical and numerical ability, quantitative comparison, series formation, puzzles etc*. The candidates shall be required to answer any 15 questions. Each question shall be of two marks. The total marks allocated to this section shall be 30 out of 200.

Part 'B' This part shall contain 25 Multiple Choice Questions (MCQs) generally covering the topics given in the Part 'A' (CORE) of syllabus. All questions are compulsory. Each question shall be of 3.5 Marks. The total marks allocated to this section shall be 70 out of 200.

Part 'C' This part shall contain 30 questions from Part 'B'(Advanced) that are designed to test a candidate's knowledge of scientific concepts and/or application of the scientific concepts. The questions shall be of analytical nature where a candidate is expected to apply the scientific knowledge to arrive at the solution to the given scientific problem. A candidate shall be required to answer any 20. Each question shall be of 5 Marks. The total marks allocated to this section shall be 100 out of 200.

There will be negative marking @25% for each wrong answer.

PART-A

ANSWER ANY 15 QUESTONS

Q1. A bag contains 20 balls. 8 balls are green, 7 are white and 5 are red. What is the minimum number of balls that must be picked up from the bag blind – folded (without replacing any of it) to be assured of picking at least one ball of each colour?

(a) 4 (b) 7 (c) 11 (d)16

Q2. A club has 108 members. Two-thirds of them are men and the rest are women. All members are married except for 9 women members. How many married women are there in the club?

(a) 20 (b) 24 (c) 27 (d)30

Q3. A complete cycle of a traffic light takes 60 seconds. During each cycle the light is green for 25 seconds, yellow for 5 seconds, and red for 30 seconds. At a randomly chosen time, the probability that the light will not be green is

(a) 1/3 (b) 1/4 (c) 5/12 (d) 7/12

Q4. A city has a population of 300000 out of which 180000 are males. 50% of the population is literate. If 70% of the males are literate, the number of literate females is

(a) 24,000 (b) 30,000 (c) 54,000 (d) 60,000

Q5. Two cars X and Y start from two places A B respectively which are 700 km apart at 9 a.m. Both the cars run at an average speed of 60 km/hr. Car X stops at 10 a.m. and again starts at 11 a.m. while the other car Y continues to run without stopping. When do the two cars cross each other?

(a) 2:40 p.m. (b) 3:20 p.m.

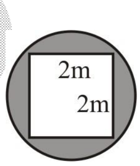
(c) 4:10 p.m. (d) 4:20 p.m.

Q6. A big rectangular plot of area 4320 m2 is divided into 3 square – shaped smaller plots by fencing parallel to the smaller side of the plot. However some area of lan was still left as a square could not be formed. So, 3 more square-shaped plots were formed by fencing parallel to the longer side of the original plot such that no area of the plot was left surplus. What are the dimensions of the original plot?

(a) 160 m × 27 m (b) 240 m × 18 m

(c) 120 m × 36 m (d) 135 m × 32 m

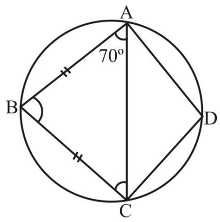
Q7. A square pond has 2m sides and is 1m deep. If it is to be enlarged, the depth remaining the same, into a circular pond with the diagonal of the square as diameter as shown in the figure, then what would be the volume of earth to be removed?



(a) $(2\pi - 4)m^3$ (b) $(4\pi - 4)m^3$

(c) $(4\pi - 2)m^3$ (d) $(2\pi - 2)m^3$

Q8. In the above figure, ABCD is a cyclic quadrilateral, AB = BC and ∠BAC = 70º, then ∠ADC is



(a) 40º (b) 80º

(c) 110º (d) 140º

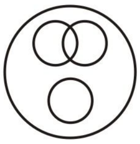
Q9. A solid cube just gets completely immersed in water when a 0.2 kg mass is placed on it. If the mass is removed, the cube is 2 cm above the water level. What is the length of each side if the cube?

(a) 12 cm (b) 10 cm

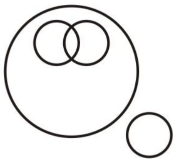
(c) 8 cm (d) 6 cm

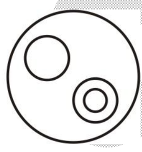
Q10. In a dinner party both fish and meat were served. Some took only fish and some only meat. There were some vegetarians who did not accept either. The rest accepted both first and meat.

Which one of the following diagrams correctly reflects the above situations?

(a)


(b)


(c)


(d)


Q11. An accurate clock shows 8 O' clock in the morning. Through how many degrees will the hour hand rotate when the clock shows 2 O'clock in the afternoon?

(a) 150º (b) 144º

(c) 168º (d) 180º

Q12. A person has to completely put each of three liquids: 403 litres of petrol, 465 litres of diesel and 496 litres of Mobil Oil in bottles of equal size without mixing any of the above three types of liquids such that each bottle is completely filled. What is the least possible number of bottles required?

(a) 34 (b) 44

(c) 46 (d) None of the above

Q13. If all the numbers from 501 to 700 are written, what is the total number of times does the digit 6 appear?

(a) 138 (b) 139

(c) 140 (d) 141

Q14. A two member committee comprising of one male and one female member is to be constituted out of five males and thee females. Amongst the females, Ms a refuses to be a member of the committee in which Mr B is taken as the member. In how many different ways can the committee be constituted?

(a) 11 (b) 12

(c) 13 (d) 14

Q15. Five balls of different colours are to be placed in three different boxes such that any box contains at least one ball. What is the maximum number of different ways in which this can be done?

(a) 90 (b) 120

(c) 150 (d) 180

Q16. In a question of a test paper, there are five items each under List – A and List – B. The examinees are required to match each item under List – A with its corresponding correct item under List – B. Further, it is given that

(i) No examinee has given the correct answer

(ii) Answers of no two examinees are identical

What is the maximum number of examinees who took this test?

(a) 24 (b) 26 (c) 119 (d) 129

Q17. A mixed doubles tennis game is to be played between two teams (each team consists of one male and one female). There are 4 married couples. No team is to consists of a husband and his wife. What is the maximum number of games that can be played?

(a) 12 (b) 21

(c) 36 (d) 42

Q18. There are 8 equidistant points A, B, C, D, E, F, G and H in the clockwise direction on the periphery of a circle. In a time interval t, a person reaches from A to C with uniform motion while another person reaches the point E from the point B during the same time interval with uniform motion. Both the persons move in the same direction along the circumference of the circle and start at the same instant. How much time after the start, will the two persons meet each other?

(a) 4t (b) 7t
(c) 9t (d) Never

Q19. If the radius of the earth were to shrink by one percent, its mass remaining the same, the value of 'g' on the earth's surface would

(a) increase by 0.5% (b) increase by 2%
(c) decrease by 0.5% (d) decrease by 2%

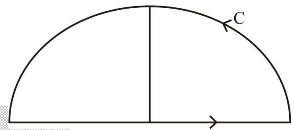
Q20. A person travels from X to Y at a speed of 40 kmph and returns by increasing his speed by 50% . What is his average speed for both the trips?

(a) 36 kmph (b) 45 kmph
(c) 48 kmph (d) 50 kmph

PART-B

ANSWER ANY 20 QUESTONS

Q21. $\oint_c \frac{dz}{z^6+1}$ where c is along the contour as shown in figure. Then the value of integration is along c unit half circle.



(a) $\frac{4\pi}{3}$ (b) $-\frac{4\pi}{3}$

(c) $\frac{3\pi}{3}$ (d) $-\frac{2\pi}{3}$

Q22. $f(z)=\frac{1}{z(z-2)}$ then Laurent series expansion in the region $0<|z|<2$

(a) $-\frac{1}{2}\frac{1}{z}\sum_{n=0}^{\infty}\left(\frac{z}{2}\right)^n$ (b) $\frac{1}{2}\frac{1}{z}\sum_{n=0}^{\infty}\left(\frac{z}{2}\right)^n$

(c) $\frac{1}{z^2}\sum_{0}^{\infty}\left(\frac{2}{z}\right)^2$ (d) $-\frac{1}{z^2}\sum_{0}^{\infty}\left(\frac{2}{z}\right)^2$

Q23. The Fourier transform of a functions $f(x)$ is the form : $F\{f''(x)\}$ is

(a) $+\omega^2 F(f(x))$ (b) $-\omega^2 F(f'(x))$

(c) $-\omega^2(f(x))$ (d) $-\omega^2 F(f(x))$

Q24. The principal value of $\int_{-\infty}^{\infty}\frac{dx}{(x^2-3x+2)(x^2+1)}$ is:

(a) $\frac{\pi}{10}$ (b) $\frac{\pi}{5}$

(c) $\frac{-\pi}{10}$ (d) 0

Q25. A particle of rest mass m_0 is subject to a constant Force F. If it starts from rest from origin at time t = 0 find its position as a function of time.

(a) $\frac{m_0c^2}{F}$ (b) $\frac{m_0c^2}{F}\left[\sqrt{1+(Ft/mc)^2}\right]$

(c) $\frac{m_0c^2}{F}\left[\sqrt{1+(Ft/mc)^2}-1\right]$ (d) $\frac{m_0c^2}{F}\left[\left(1+\frac{Ft}{mc^2}\right)^{1/2}+1\right]$

Q26. If Lagrangian of system is given by

$$L=\frac{1}{2}ml^2(\dot{\theta}_1^2+\dot{\theta}_2^2)+\frac{1}{2}mgl(\theta_1^2+\theta_2^2)-\frac{1}{2}kl^2(\theta_1-\theta_2)^2$$

Where θ_1 and θ_2 are generalized co-ordinate then the equation of motion is given by

(a) $ml^2\ddot{\theta}_1-mgl\theta_1-kl^2(\theta_2-\theta_1)$ (b) $ml^2\ddot{\theta}_1-mgl\theta_1+kl^2(\theta_2-\theta_1)$

(c) $ml^2\ddot{\theta}_2-mgl\theta_2+kl^2(\theta_2-\theta_1)$ (d)

$ml^2\ddot{\theta}_2-mgl\theta_2-kl^2(\theta_2-\theta_1)$

Q27. A Pion at rest decays into a muon and a neutrino. Find the energy of outgoing muon in terms of mass of Pion m_π and mass of muon m_μ.

(a) $\frac{(m_\pi^2-m_\mu^2)c^2}{2m\pi}$ (b) $\frac{(m_\pi^2-m_\mu^2)c^2}{m\pi}$

(c) $\frac{(m_\pi^2+m_\mu^2)c^2}{2m\pi}$ (d) $\frac{(m_\pi^2+m_\mu^2)c^2}{m\pi}$

Q28. Consider the one dimensional wave function where

$$\psi(x)=A\left(\frac{x}{x_0}\right)^n e^{-\frac{x}{x_0}} \qquad x>0$$

$= 0$ Otherwise Where A, n, and x_0 are constant.

Using Schrodinger equation find energy eigen value E for which this wave function is an Eigen function, it is given. $x\to\infty$ $V(x)=0$

(a) $\frac{-\hbar^2}{mx_0^2}$ (b) $\frac{-3\hbar^2}{2mx_0^2}$ (c) $\frac{-\hbar^2}{2mx_0^2}$ (d) $\frac{-2\hbar^2}{mx_0^2}$

Q29. If $\vec{\sigma}_1$ and $\vec{\sigma}_2$ are pauli spin matrices for two particles. If J is total angular momentum $J = \frac{\hbar}{2}(\sigma_1 + \sigma_2)$ then $\vec{\sigma}_1 \cdot \vec{\sigma}_2$ is equivalent to

(a) $\frac{2J^2}{\hbar^2} - I$ (b) $\frac{2J^2}{\hbar^2} - \frac{3I}{2}$

(c) $\frac{2J^2}{\hbar^2} - 3I$ (d) $\frac{2J^2}{\hbar^2} - \frac{I}{2}$

Q30. A one-dimensional quantum harmonic oscillator (whose ground state energy is $\left(\frac{\hbar\omega}{2kT}\right)$ is in thermal equilibrium with heat both at temperature T. The mean value of the oscillator energy is given by

(a) $\frac{\hbar\omega}{2}\sin h\left(\frac{\hbar\omega}{2kT}\right)$ (b) $\frac{\hbar\omega}{2}\cos h\left(\frac{\hbar\omega}{2kT}\right)$

(c) $\frac{\hbar\omega}{2}\tan h\left(\frac{\hbar\omega}{2kT}\right)$ (d) $\frac{\hbar\omega}{2}\cot h\left(\frac{\hbar\omega}{2kT}\right)$

Q31. If $\chi_{1/2}$ and $\chi_{-1/2}$ is the wave function of the S_z component of spin ½ operator then eigen vector corresponding to eigen value $\frac{\hbar}{2}$ of S_y operator is given by

(a) $\chi_{1/2}$ (b) $\chi_{-1/2}$

(c) $\frac{\chi_{1/2} + i\chi_{-1/2}}{\sqrt{2}}$ (d) $\frac{\chi_{1/2} + \chi_{-1/2}}{\sqrt{2}}$

Q32. For a system of electron, assume non-interacting the probability of finding an electron in a state with Energy D above the chemical potential is given by

(a) $\frac{1}{e^{\beta D} + 1}$ (b) $\frac{1}{e^{-\beta D} + 1}$

(c) $\frac{1}{e^{\beta D} - 1}$ (d) $\frac{1}{e^{-\beta D} 1}$

Q33. If q is the heat of vaporization per particle and V_L is the volume per particle in the liquid and V_v is the volume per particle in vapor. Assume the vapor following the ideal gas law and the density is much less then that of the liquid then pressure p is proportional to

(a) $P \propto e^{-\frac{q}{kT}}$ (b) $P \propto e^{\frac{q}{kT}}$

(c) $P \propto e^{-\frac{q}{2kT}}$ (d) $P \propto e^{\frac{q}{2kT}}$

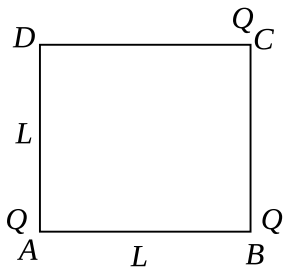
Q: 34 An insulating sphere of radius R carries a charge density $\rho(\vec{r}) = \rho(R^2 - r^2)\cos^2\theta;\ r < R$. The leading order term for the electric field at a distance d, far away from the charge distribution, is proportional to:

(a) d^{-1} (b) d^{-2} (c) d^{-3} (d) d^{-4}

Q: 35. A dielectric cube of side 'a' centered at the origin carries a polarization $\vec{P} = k\vec{r}$, where k is a constant. Then the total surface bound charge is:

(a) $3ka^3$ (b) $-3ka^3$ (c) $\frac{ka^3}{2}$ (d) $-\frac{ka^3}{2}$

Q: 36. Three charges each equal to Q, are placed at the three corners (A, B and C) of a square of side L. Then the magnitude of electric field and Potential at the fourth corner D is respectively:



(a) $\frac{Q}{2\sqrt{2}\pi \in_0 L^2}$, $\left(\frac{2\sqrt{2}+1}{\sqrt{2}}\right)\frac{Q}{4\pi\varepsilon_0 L}$

(b) $\left(2\sqrt{2}+1\right)\frac{Q}{8\pi \in_0 L^2}$, $\left(\frac{2\sqrt{2}+1}{\sqrt{2}}\right)\frac{Q}{4\pi\varepsilon_0 L}$

(c) $\left(2\sqrt{2}+1\right)\frac{Q}{8\pi \in_0 L^3}$, $\left(\frac{2\sqrt{2}+1}{\sqrt{2}}\right)\frac{Q}{8\pi\varepsilon_0 L}$

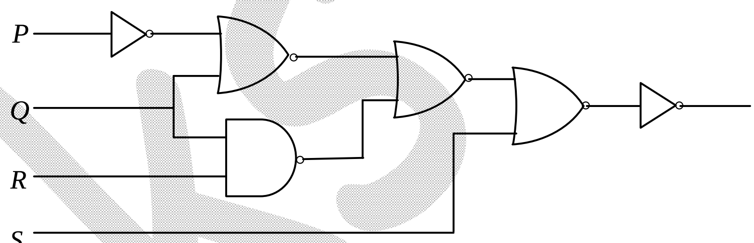
(d) $\left(2\sqrt{2}+1\right)\frac{Q}{8\pi \in_0 L^2}$, $\left(\frac{2\sqrt{2}+1}{\sqrt{2}}\right)\frac{Q}{8\pi\varepsilon_0 L}$

Q: 37. An infinitely long hollow cylinder of radius a carrying a surface charge density σ is rotated about its cylindrical axis with a constant angular speed ω. Then the magnitude of vector potential inside the cylinder at a distance r from its axis is:

(a) $2\mu_0\sigma a\omega r$ (b) $\mu_0\sigma a\omega r$

(c) $\frac{1}{2}\mu_0\sigma a\omega r$ (d) $\frac{1}{4}\mu_0\sigma a\omega r$

Q: 38 The logic expression for the output y of the following circuit is



(a) $Q\overline{\overline{\overline{P}+Q}+\overline{QR}}+S$

(b) $\overline{\overline{\overline{P}+Q}+\overline{QR}+S}$

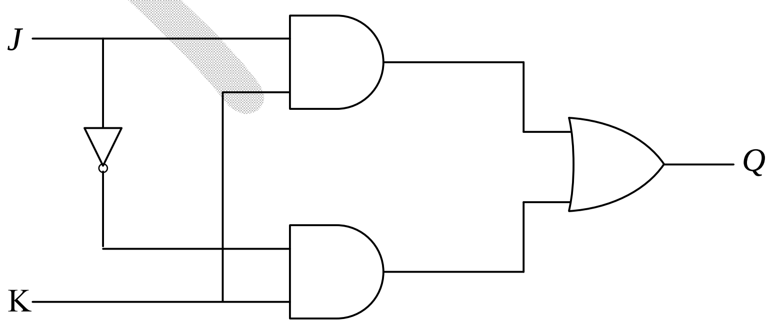
(c) $\overline{\overline{P}+Q+\overline{\overline{QR}}}+S$

(d) $\overline{\overline{\overline{P}+Q}+\overline{QR}}+\overline{S}$

Q: 39 A point charge Q is brought without any acceleration from infinity to a distance d from an infinite plane conducting sheet. The work done on the charge is given by

(a) $\frac{1}{4\pi\epsilon_0}\frac{Q^2}{4d}$ (b) $\frac{1}{4\pi\epsilon_0}\frac{Q^2}{2d}$ (c) $-\frac{1}{4\pi\epsilon_0}\frac{Q^2}{4d}$ (d) $-\frac{1}{4\pi\epsilon_0}\frac{Q^2}{2d}$

Q: 40. The truth table for the given circuit is



(a)

J	K	Q
0	0	1
0	1	0
1	0	1
1	1	0

(b)

J	K	Q
0	0	1
0	1	0
1	0	0
1	1	1

(c)

J	K	Q
0	0	0
0	1	1
1	0	0
1	1	1

(d)

J	K	Q
0	0	0
0	1	1
1	0	1
1	1	0

Q41. A different Sawtooth wave is described by

$$f(x)=\begin{cases}-\frac{1}{2}(\pi+x), & -\pi\le x<0\\ +\frac{1}{2}(\pi+x), & -0<x\le\pi\end{cases}$$

The Fourier series expansion of this function is

(a) $f(x)=2\sum_{n=1}^{\infty}\frac{(-1)^{n+1}}{n}\sin(nx)$ (b) $f(x)=2\sum_{n=1}^{\infty}\frac{(-1)^{n+1}}{n}\frac{\sin(nx)}{n}$

(c) $f(x)=\sum_{n=1}^{\infty}\sin(nx)$ (d) $f(x)=\sum_{n=1}^{\infty}\frac{\sin(nx)}{n}$

Q42. A particle of mass m is confined to a one dimension region $0\le x\le a$ at t =0 its normalised wave function is given by $\psi(x,t=0)=\sqrt{\frac{8}{5a}}\left[1+\cos\left(\frac{\pi x}{a}\right)\right]\sin\left(\frac{\pi x}{a}\right)$ what is average energy of the system.

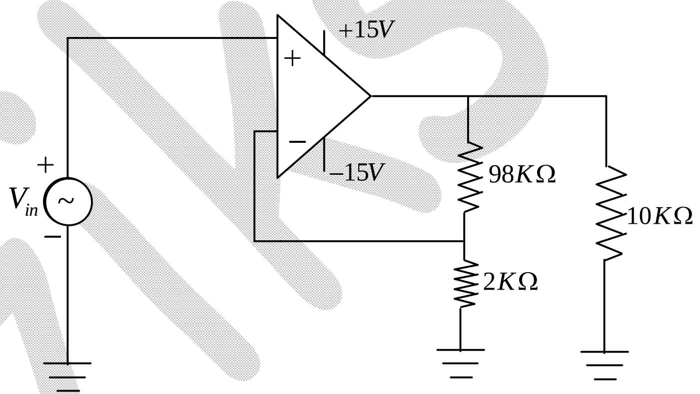
a) $\frac{4\pi^2\hbar^2}{5ma^2}$ b) $\frac{16\pi^2\hbar^2}{5ma^2}$ c) $\frac{8\pi^2\hbar^2}{2ma^2}$ d) $\frac{10\pi^2\hbar^2}{2ma^2}$

Q43. A neutral pion of (rest) mass momentum $p = \frac{3}{4}mc$ decays into two photon, one of the photon emitted in the same direction as the original pion and other in opposite direction. Energy of the each photon is given by

(a) $\frac{mc^2}{4}, mc^2$ (b) $\frac{3mc^2}{8}, \frac{3mc^2}{8}$

(c) $\frac{mc^2}{2}, \frac{mc^2}{2}$ (d) $\frac{5mc^2}{8}, mc^2$

Q: 44. Assuming that the operational amplifier shown in the figure below is ideal. Then the closed loop gain of the circuit is



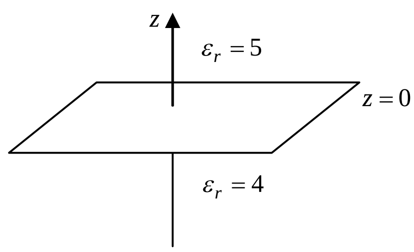
(a) 100

(b) 50

(c) 1000

(d) 200

Q: 45 Assume that $z = 0$ plane is the interface between two linear and homogenous dielectrics (see figure). The relative permittivity's are $\varepsilon_r = 5$ for $z > 0$ and $\varepsilon_r = 4$ for $z < 0$. The electric field in the region $z > 0$ is $\vec{E}_1 = (3\hat{i} + 5\hat{j} - 5\hat{k})kV/m$. If there are no free charges on the interface, the electric field in the region $z < 0$ is given by



(a) $\vec{E}_2 = \left(\frac{3}{4}\hat{i} + \frac{5}{4}\hat{j} + \hat{k}\right)kV/m$

(b) $\vec{E}_2 = (3\hat{i} + 5\hat{j} + \hat{k})kV/m$

(c) $\vec{E}_2 = \left(3\hat{i} + 5\hat{j} - \frac{25}{4}\hat{k}\right)kV/m$

(d) $\vec{E}_2 = \left(3\hat{i} + 5\hat{j} + \frac{25}{4}\hat{k}\right)kV/m$

PART C

ANSWER ANY 20 QUESTONS

Q: 46 Given the initial value problem $y^{(1)}(t) = 1 - t\, y(t)$ with $y(0) = 1$, approximation of $y(1)$ by Runge-Kutta method with h=1 would be:

(a) 1.35 (b)1.31 (c) 1.32 (d)1.34

Q: 47 The moment of Inertia tensor of a shaft is given by

$$I = \begin{pmatrix} 6ma^2 & 0 & 2ma^2 \\ 0 & 8ma^2 & 0 \\ 2ma^2 & 0 & 2ma^2 \end{pmatrix}$$

If shaft is rotational about z axis, then the torque about o (origin) is given by

(a) $2ma^2\omega^2\hat{i}$ (b) $2ma^2\omega^2\hat{j}$

(c) $2ma^2\omega^2\hat{i} + 8ma^2\omega^2\hat{j}$ (d) $2ma^2\omega^2\hat{j} + 8ma^2\omega^2\hat{i}$

Q: 48 For a vector potential $\vec{A}$ the divergence of $\vec{A}$ is $\nabla \cdot \vec{A} = \frac{\mu_0}{4\pi}\frac{Q_0}{r^2}$ where Q_0 is a constant of appropriate dimensions. The corresponding scalar potential $V(\vec{r}, t)$ that makes $\vec{A}$ and V Lorentz gauge invariant is:

(a) $\frac{1}{4\pi \in_0}\frac{Q_o t}{r^2}$ (b) $-\frac{1}{4\pi \in_0}\frac{Q_o t}{r^2}$

(c) $\frac{1}{4\pi \in_0}\frac{Q_o}{r^2}$ (d) $\frac{1}{4\pi \in_0}\frac{Q_o t}{r}$

Q: 49. The potential is defined as

$$V(x) = V_0 \quad 0 < x < L/2$$
$$= 0 \quad L/2 < x < L$$
$$= \infty \quad \text{otherwise}$$

Then from the W.K.B. approximation value of $\sqrt{E_n - V_0} + \sqrt{E_n}$ is given by (En is nth energy eigen value)

(a) $\frac{n\pi\hbar}{\sqrt{2mL}}$ (b) $\frac{2n\pi\hbar}{\sqrt{2mL}}$

(c) $\frac{n\pi\hbar}{\sqrt{mL}}$ (d) $\frac{2n\pi\hbar}{\sqrt{mL}}$

Q: 50. Electron beam enters a uniform magnetic field of 1.0Tesla. The energy difference electrons whose spins are parallel and antiparallel to the field is

(a) 1.01 x 10^{-3} eV (b) 1.16 x 10^{-4} eV

(c) 1.31 x 10^{-5} eV (d) 1.51 x 10^{-2} eV

Q: 51 The force constant of the bond in $^1H^{35}$ Cl is 516N and anharmonicity constant $x_e = 0.0174$. The wave number of the HOT BAND line is

(a) 2988 cm^{-1} (b) 2780 cm^{-1} (c) 2880 cm^{-1} (d) 5668 cm^{-1}

Q: 52. The electric (E) and magnetic (B) field amplitudes associated with an electromagnetic radiation from a point source behave at a distance d from the source as:

(a) E = constant, B = constant (b) $E \propto \frac{1}{d},\ B \propto \frac{1}{d}$

(c) $E \propto \frac{1}{d},\ B \propto \frac{1}{d^2}$ (d) $E \propto \frac{1}{d^3},\ B \propto \frac{1}{d^3}$

Q: 53 Which of the following multipole transitions for spontaneous photon emission by an excited atomic electron occurred through double photon transition?

(a) $2p_{1/2} \to 1s_{1/2}$ (b) $2s_{1/2} \to 1s_{1/2}$

(c) $2d_{1/2} \to 2s_{1/2}$ (d) $3d_{3/2} \to 2p_{1/2}$

Q: 54 Consider the following reactions:

$(i)\ \pi^- + P \to \pi^0 + n$

$(ii)\ \pi^+ \to \mu^+ + \nu_\mu$

$(iii)\ \pi^+ \to \mu^+ + \overline{\nu}_\mu$

$(iv) p + \overline{p} \to \Lambda^0 + \Lambda^0$

Which of the above are allowed?

(a) (i) and (ii) (b) (i) and (iii)

(c) (i), (ii) and (iv) (d) (i), (iii) and (iv)

Q: 55 The free electron model for a metal assumes that the conduction electron can be approximated by a gas of free electrons where the only important parameters for the gas are n, the number density of electrons, and τ, the time between collisions. The resistivity of copper metal is 1.7 x 10^{-6} ohm-cm and the atomic density of copper is 8.5 x 10^{22}atoms/cc. the collision time τ for an electron in copper is.

(a) 1.25 x 10^{-14}sec (b) 2.5 x 10^{-14}sec

(c) 3.5 x 10^{-14}sec (d) 5.0 x 10^{-14}sec

Q56: An air-filled rectangular waveguide of inside dimensions 7×3.5 cm^2, operates in the dominant TE_{10} mode. Then the guided wavelength at 3.5 GHz is

(a) 8.0 cm (b) 11.0 cm

(c) 13.0 cm (d) 15.0 cm

Q57: A particle of rest mass m whose kinetic energy is twice its rest energy collides with a particle of equal mass at rest. The two combine into a single new particle. Using only this information, calculate the rest mass such a new particle would have.

(a) $2m$ (b) $2\sqrt{2}m$

(c) $4m$ (d) $\sqrt{2}m$

Q58: Consider an electron in a box of length L with periodic boundary condition $\psi(x) = \psi(x+L)$. If the electron is in the $\psi_k(x) = \frac{1}{\sqrt{L}} e^{ik,x}$ with energy $\varepsilon_k = \frac{\hbar^2 k^2}{2m}$, what is the correction to its energy, to second order of perturbation theory, when it is subjected to a weak periodic potential $V(x)=V_0 \cos gx$, where g is an integral multiple of the $2\pi/L$?

(a) $V_0^2 \varepsilon_g / \varepsilon_k^2$

(b) $-\frac{mV_0^2}{2\hbar}\left(\frac{1}{g^2+2kg}+\frac{1}{g^2-2kg}\right)$

(c) $V_0^2\left(\varepsilon_k-\varepsilon_g\right)/\varepsilon_g^2$

(d) $V_0^2/\left(\varepsilon_k+\varepsilon_g\right)$

Q: 59 The energy of the band in the Tight Bonding (TB) model is given by

$$E(k) = E_0 - \beta - \gamma \sum_j e^{ik.x_j}$$

Where β and γ are constant, and x_j is the position of the j[th] atom relative to the atom at the origin, the sum goes over the nearest neighbors only. E_0 is the original atomic energy level. γ is known as overlap integral and its value increases with increasing overlap between orbits. For one dimension lattice having lattice constant a and total length L, using the nearest neighbor approximation, the energy dispersion relation is

$$E(k) = E_0 - \beta - 2\gamma \text{ Coska}$$

The density of states of electrons (including spin degeneracy) in the energy band is?

(a) $\frac{L}{\pi\gamma a \sin(ka)}$

(b) $\frac{L}{2\pi\gamma a \sin(ka)}$

(c) $\frac{L}{\pi\gamma a \cos(ka)}$

(d) $\frac{L}{2\pi\gamma a \cos(ka)}$

Q: 60 For each polarization mode in a given propagation direction the dispersion relation ω vs k develops two branches, known as Acoustical (A) and optical (O) branches. For a crystal which has 2 number of atoms in the primitive basis. Which of the following statement is true regarding the number of modes in various classes?. Here L & T means longitudinal & transverse.

(a) It has one LA, one TA, two LO & two TO

(b) It has one LA, two TA, one LO & two TO

(c) It has one LA, two TA, two LO & one TO

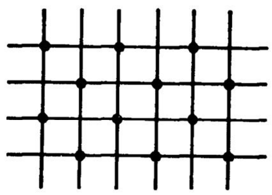
(d) It has two LA, two TA, one LO & two TO

Q: 61 Consider the planes with indices (100) and (001); the lattice is FCC, and these Miller Indices refers to the conventional unit cell. The primitive cell of the FCC is Trigonal. The indices of these planes when referred to the primitive axes of FCC is

(a) (001) and (100)
(b) (011) and (100)
(c) (011) and (101)
(d) (101) and (101)

Q: 62 Figure shows the hypothetical two dimensional crystals consisting of atoms arranged on square grid.

The reciprocal lattice of this lattice is



(a) $\vec{b}_1 = \frac{\pi}{a}(i - j)$ and $\vec{b}_2 = \frac{\pi}{a}(-i + j)$

(b) $\vec{b}_1 = \frac{\pi}{a}(i - j)$ and $\vec{b}_2 = \frac{\pi}{a}(i - j)$

(c) $\vec{b}_1 = \frac{\pi}{a}(-i + j)$ and $\vec{b}_2 = \frac{\pi}{a}(i - j)$

(d) $\vec{b}_1 = \frac{\pi}{a}(i - j)$ and $\vec{b}_2 = \frac{\pi}{a}(i + j)$

Q: 63. Fcc Au (cubic lattice parameter a=4.08Å) has electrical resistivity ρ=2.2μΩcm at room temperature. Using a free-electron model and assuming one valence electron per atom

(A) The fermi energy of the electron at T = 0K is

(a) 3.9eV (b) 4.5eV (c) 5.5eV (d) 6.1eV

(B) The electronic heat capacity per atom at room temperature is

(a) $2.0\times10\text{-}6\text{eV}K^{-1}$ (b) $2.0\times10\text{-}5\text{eV }K^{-1}$

(c) $2.0\times10\text{-}4\text{eV }K^{-1}$ (d) $2.0\times10\text{-}3\text{eV }K^{-1}$

Q: 64 In the NMR spectrum of ethanol ($CH_3CHClCH_2Cl$), the number of spectral lines in the bunch corresponding to CH group is:

(a) 6 (b) 5 (c) 4 (d) 3

Q: 65 A particle is confined into a rigid box at width L one can choose trial wave function $\sqrt{\frac{30}{L^5}}x(L-x)$ then ground state energy for trial function is equal to

(a) Exact value of ground state energy

(b) $\frac{10}{\pi^2}$ times exact value of ground state energy

(c) $\frac{5}{\pi^2}$ times exact value of ground state energy

(d) $\frac{\pi^2}{5}$ times exact value of ground state energy

Q: 66 The exciting line in an experiment is $5460A^0$ and the Stokes line is at $5520A^0$. The wavelength of the anti-stokes line is at

(a) $5401A^0$ (b) $4226A^0$ (c) $6558A^0$ (d) $5725A^0$

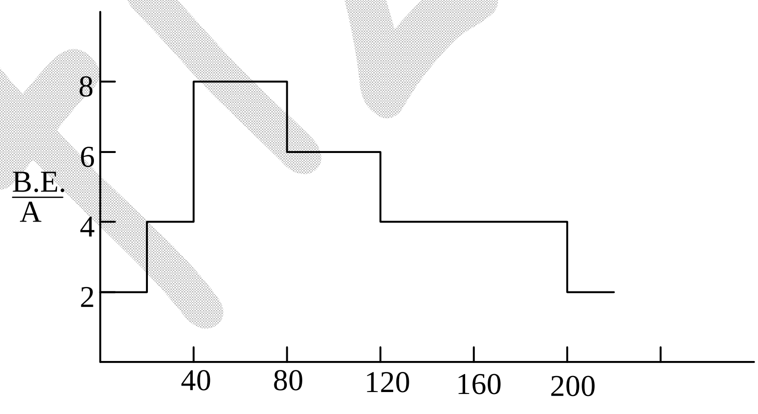
Q: 67 Consider two sets of potential $(\phi, \vec{A})$ and $(\phi', \vec{A}')$, which corresponds to the same electric and magnetic fields. Then which of the following represents the Gauge Transformation :(where symbols have their usual meaning)

(a) $\vec{A}' = \vec{A} + \vec{\nabla}\beta, \quad \phi' = \phi + \frac{\partial \beta}{\partial t}$
(b) $\vec{A}' = \vec{A} - \vec{\nabla}\beta, \quad \phi' = \phi - \frac{\partial \beta}{\partial t}$
(c) $\vec{A}' = \vec{A} + \frac{\partial \beta}{\partial t}, \quad \phi' = \phi - \frac{\partial \beta}{\partial t}$
(d) $\vec{A}' = \vec{A} + \vec{\nabla}\beta, \quad \phi' = \phi - \frac{\partial \beta}{\partial t}$

Q: 68 Consider the CO molecule as a diatomic rigid rotor with a bond length of 1.12Å. The reduced mass of the system is obtained from the atomic masses of C and O. The rotational energies are defined in terms of B (the rotational constant) and J (the rotational quantum number). If ν_1 and ν_2 denote the frequency of the first rotational resonance lines for the molecules $^{12}C^{16}O$ and $^{13}C^{18}O$ respectively, their ratio ν_1/ν_2 is approximately

(a) 1.5
(b) 1.1
(c) 0.9
(d) 1.01

Q: 69 The following histogram represents the binding energy per particle ($B.E./A$) in MeV as a function of the mass number A of a nucleus



A nucleus with mass number A = 180 fissions into two nuclei of equal masses. In the process

(a) 180 MeV of energy is released
(b) 180 MeV of energy is absorbed
(c) 360 MeV of energy is released
(d) 360 MeV of energy is absorbed

Q70: The eigenvectors of matrix

$$A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

(a) $\begin{pmatrix} 0 \\ \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix}, \begin{pmatrix} 0 \\ -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}$

(b) $\begin{pmatrix} 0 \\ -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix}, \begin{pmatrix} 0 \\ \frac{1}{\sqrt{2}} \\ -\frac{1}{\sqrt{2}} \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

(c) $\begin{pmatrix} 0 \\ \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix}, \begin{pmatrix} 0 \\ \frac{1}{\sqrt{2}} \\ -\frac{1}{\sqrt{2}} \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

(d) $\begin{pmatrix} 0 \\ \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix}, \begin{pmatrix} 0 \\ \frac{1}{\sqrt{2}} \\ -\frac{1}{\sqrt{2}} \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

Q71. If a high energetic proton hit a stationary proton target and produce protons and anti proton as

$$p + p = p + p + p + \bar{p}$$

The required minimum kinetic energy of the striking proton to produce the particles of zero velocity in the final state is

(a) 4.2BeV (b) 5.6BeV (c) 6.0BeV (d) 6.6BeV

Q72. The electric field $\vec{E}(\vec{r},t)$ for a circularly polarized electromagnetic wave propagating along the positive z-direction is:

(a) $E_0(\hat{x} + \hat{y})\exp[i(kz - \omega t)]$ (b) $E_0(\hat{x} + i\hat{y})\exp[i(kz - \omega t)]$

(c) $E_0(\hat{x} + i\hat{y})\exp[i(kz + \omega t)]$ (d) $E_0(\hat{x} + \hat{y})\exp[i(kz + \omega t)]$

Q73. Consider a doped semiconductor having the electron and the hole mobilities μ_n and μ_p, respectively. Its intrinsic carrier density is n_i. The hole concentration p for which the conductivity is minimum at a given temperature is

(a) $n_i\sqrt{\frac{\mu_n}{\mu_p}}$ (b) $n_i\sqrt{\frac{\mu_p}{\mu_n}}$

(c) $n_i\frac{\mu_p}{\mu_n}$ (d) $n_i\frac{\mu_n}{\mu_p}$

Q74. (A) Semi-emperical formula for binding energy of a nucleous ${}_ZX^A$ is

$$E_b = a_1A - a_2A^{2/3} - a_3\frac{Z(Z-1)}{A^{1/3}} - a_4\frac{(A-2Z)^2}{A}(\pm,0)\frac{a_5}{A^{1/2}}.$$

Atomic number of most stable isobar of a nucleus of given A is

(a) $Z = \frac{a_3A^{-1/3}+4a_4}{2a_3A^{-1/3}+8a_4A^{-1}}$ (b) $Z = \frac{4a_3A^{-1/3}+a_4}{2a_3A^{-1/3}+8a_4A^{-1}}$

(c) $Z = \frac{a_3A^{-2/3}+4a_4}{2a_3A^{-1/3}+8a_4A^{-1}}$ (d) $Z = \frac{4a_3A^{-2/3}+a_4}{2a_3A^{-1/3}+8a_4A^{-1}}$

(B) Which of the following is a possible spin-parity assignment for spin-parity of ${}^{10}B$

(a) 3^+ (b) 3^- (c) $3/2^{\ +}$ (d) $3/2^{\ -}$

Q75. The quantum mechanical scattering leads a functions

$I(\sigma) = \int_{-\infty}^{\infty}\frac{x\sin x}{x^2-\sigma^2}dx$. The value of I is

(a) $\frac{\pi}{2}$ (b) $\pi\cos\sigma$ (c) $\frac{\pi}{2}\cos\frac{\sigma}{2}$ (d) 0
