# TEST SERIES CSIR-NET/JRF June 2017

## BOOKLET SERIES D

**Paper Code 05**

**Test Type: TEST SERIES**

## PHYSICAL SCIENCES

**Duration: 3:00 Hours**

**Date: 05-06-2017**

**Maximum Marks: 200**

**Read the following instructions carefully:**

* Single Paper Test is divided into three Parts.

**Part - A:** This part shall carry 20 questions. The candidate shall be required to answer any 15 questions. Each question shall be of **2 marks.**

**Part - B:** This part shall contain 20 questions covering the topics given in the Part 'B' of syllabus. The candidates are required to answer all questions. Each question shall be of **3.5 Marks.**.

**Part - C:** This part shall contain **25** questions from Part - C of the syllabus. There will be 10 compulsory questions and out of remaining 15 questions , a candidate will be required to answer any 10. Each question shall be of **5 Marks**.

* Darken the appropriate bubbles with HB pencil/Ball Pen to write your answer.
* There will be negative marking @25% for each wrong answer.
* The candidates shall be allowed to carry the Question Paper Booklet after completion of the exam.
* For rough work, blank sheet is attached at the end of test booklet.




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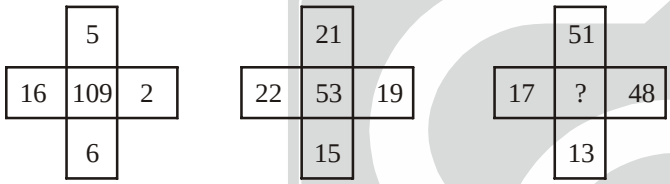
## PART-A

1. Four different electronic devices make a beep after every 30 minutes, 1 hour, $1\frac{1}{2}$ hour and 1 hour 45 minutes respectively. All the devices beeped together at 12 noon. They will again beep together at
   (a) 12 midnight (b) 3 a.m. (c) 6 a.m. (d) 9 a.m.
2. If the digit 12 of a clock is pointing towards east, then in which direction will digit 9 point?
   (a) South (b) West (c) North (d) North-East
3. If every 2 out of 3 readymade shirts need alterations in the collar, every 3 out of 4 need alterations in the sleeves, and every 4 out of 5 need it in the body, how many alterations will be required for 60 shirts?
   (a) 24 (b) 123 (c) 133 (d) 143
4. What is the smallest number of ducks that could swim in this formation two ducks in front of a duck, two ducks behind a duck and a duck between two ducks?
   (a) 3 (b) 5 (c) 7 (d) 9
5. Given that $10^{0.48} = x, 10^{0.70} = y$ and $x^z = y^2$, then the value of $z$ is close to
   (a) 1.45 (b) 1.88 (c) 2.9 (d) 3.7
6. Find the missing number




   (a) 25 (b) 129 (c) 7 (d) 49
7. Madan pays income tax at the rate of 10%. If his income increased by 10% and his tax rate increases to 15%, his net income would increase by Rs. 350. What is Madan's income?
   (a) Rs. 8000 (b) Rs. 10000 (c) Rs. 12000 (d) Rs. 14000
8. If all horses are donkeys, sone donkeys are monkeys and some monkeys are men, then which statement must be true?
   (a) All donkeys are men (b) Some horses may be men
   (c) Some horses are men (d) All horses are also monkeys
9. A man bought apples at the rate of 8 for Rs. 34 and sold them at the rate of 12 for Rs. 57. How many apples should be sold to earn a net profit of Rs. 45?
   (a) 90 (b) 100 (c) 135 (d) 150
10. A can do a certain work in the same time in which B and C together can do it. If A and B together could do it in 10 days and C alone in 50 days, then B alone could do it in
    (a) 15 days (b) 20 days (c) 25 days (d) 30 days
11. A leak in the bottom of a tank can empty the full tank in 8 hours. An inlet pipe fills water at the rate of 6 litres a minute. When the tank is full, the inlet is opened and due to the leak, the tank is empty in 12 hours. How many litres does the cistern hold?
    (a) 7580 (b) 7960 (c) 8290 (d) 8640
12. A is twice as fast as B and B is trice as fast as C is. The journey covered by C in 54 minutes will be covered by B in
    (a) 18 min (b) 27 min (c) 38 min (d) 9 min

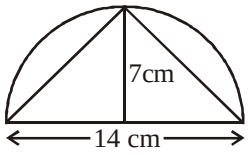
13. A and B walk around a circular track. They start at 8 a.m. from the same point in the opposite directions. A and B walk at a speed of 2 rounds per hour and 3 rounds per hour respectively. How many times shall they cross each other before 9.30 a.m.?

(a) 5 (b) 6 (c) 7 (d) 8

14. A man can row three-quarters of a kilometers against the stream in $11\frac{1}{4}$ minutes. The speed (in km/hr) of the man in still water is

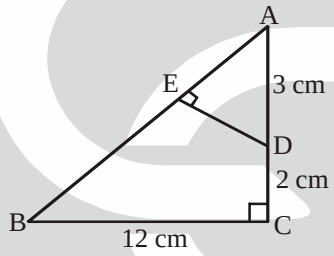
(a) 2 (b) 3 (c) 4 (d) 5

15. The largest triangle is inscribed in a semi-circle of radius 7 cm. Find the area inside the semi-circle which is not occupied by the triangle




(a) 35 sq. cm (b) 56 sq. cm
(c) 21 sq. cm (d) 28 sq. cm

16. In the given figure, $\Delta ABC$ is right angled at C and $DE \perp AB$. Find the length of AE.




(a) $AE = \frac{15}{13}$ cm (b) $AE = \frac{13}{15}$ cm (c) $AE = \frac{11}{13}$ cm (d) $AE = \frac{11}{15}$ cm

17. A rectangular block of metal has dimensions 21 cm, 77 cm and 24 cm. The block has been melted into a sphere. The radius of the sphere is

(a) 21 cm (b) 7 cm (c) 14 cm (d) 28 cm

18. In what ratio must water be mixed with milk to gain $16\frac{2}{3}\%$ on selling the mixture at cost price?

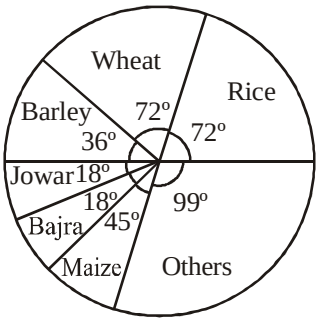
(a) 1:6 (b) 6:1 (c) 2:3 (d) 4:3

19. How many times in a day, the hands of a clock are straight?

(a) 22 (b) 24 (c) 44 (d) 48

**The pie-chart provided below gives the distribution of land (in a village) under various food crops. Study the pie-chart carefully and answer the questions that follow.**

**Distribution of Areas (in acres) Under various Food Crops**




20. Which combination of three crops contribute to 50% of the total area under the food crops?

(a) Wheat, Barley and Jowar (b) Rice, Wheat and Jowar

(c) Rice Wheat and Barley (d) Bajra, Maize and Rice

## PART-B

21. The unnormalized wavefunction of a particle in a spherically symmetric potential, is given by

$$\psi(r,\theta,\varphi) = z^2 f(r) g(\varphi)$$

where $f(r)$ is the function of the radial variable $r$ and $g(\varphi)$ is the function of the angular variable $\varphi$ (Notation have usual meanings). The eigenvalue of the square of the orbital angular momentum of the particle, is

(a) $\frac{\hbar^2}{2}$ (b) $\hbar^2$ (c) $2\hbar^2$ (d) $6\hbar^2$

22. A particle of mass $m$ is moving under the following 3-D potential:

$$V(r) = -c\left[\frac{r}{r_0} + \ell n\left(1 - \frac{r}{r_0}\right)\right]$$

where $c$ and $r_0$ are positive constants of appropriate dimensions. The ground state energy of the particle in $r << r_0$ limit, is

(a) $\frac{1}{2}\sqrt{\frac{c\hbar^2}{mr_0^2}}$ (b) $\frac{3}{2}\sqrt{\frac{c\hbar^2}{mr_0^2}}$ (c) $\frac{1}{2}\sqrt{\frac{c\hbar^2}{2mr_0^2}}$ (d) $\frac{3}{4}\sqrt{\frac{c\hbar^2}{2mr_0^2}}$

23. A particle of mass $m$ is moving under the following 3-D potential:

$$V(x,y,z) = \begin{cases} 0 & \text{for } 0 < x < a, 0 < y < a, 0 < z < a \\ \infty & \text{elsewhere} \end{cases}$$

If the particle is found to be in an eigenstate of energy $\frac{27\pi^2\hbar^2}{2ma^2}$, then degeneracy of the eigenstate is

(a) 2 (b) 3 (c) 4 (d) 6

24. $\hat{x}$ and $\hat{p}_x$ are quantum mechanical operators corresponding to position and momentum respectively. For any positive constant '$a$' the value of $\left[\hat{x}, \cosh\left(\frac{i\hat{p}_x a}{\hbar}\right)\right]$, is

(a) $ia\cosh\left(\frac{i\hat{p}_x a}{\hbar}\right)$ (b) $-a\sinh\left(\frac{i\hat{p}_x a}{\hbar}\right)$ (c) $a\sinh\left(\frac{i\hat{p}_x a}{\hbar}\right)$ (d) $-ia\cosh\left(\frac{i\hat{p}_x a}{\hbar}\right)$

25. Consider a system of three spin-$\frac{1}{2}$ particles, each having z-component of magnetic moment equal to $\pm\mu$. If there is no external magnetic field $(B=0)$, all spin states are of the same energy and are equally accessible. The probability that the z-component of the system is $-\mu$, is

(a) $\frac{1}{8}$ (b) $\frac{3}{8}$ (c) $\frac{3}{4}$ (d) $\frac{1}{4}$

26. The Gibb's free energy for a certain classical system is given by $G(P,T) = k_B T \exp\left[-\frac{AP^2}{(k_B T)}\right]$, where A is an appropriate constant. The specific heat at constant pressure for the system at under the condition $AP^2 << k_B T$ is given by

(a) $\frac{A^2P^4}{k_BT^2}\left[\frac{AP^2}{k_BT}-1\right]$ (b) $\frac{A^2P^4}{k_BT^2}\left[1-\frac{AP^2}{k_BT}\right]$ (c) $\frac{A^2P^4}{k_BT^2}\left[\frac{A^2P^4}{k_B^2T^2}-1\right]$ (d) $\frac{A^2P^4}{k_BT^2}\left[1-\frac{A^2P^4}{k_B^2T^2}\right]$

27. The mean square fluctuation in energy for a system of $N$ independent one dimensional harmonic oscillator with frequency $\omega$, mass m, and subject to a constant gravitational acceleration $g$ along the direction of oscillation and is in thermal contact with heat reservoir at temperature $T$, is given by

(a) $NkT$ (b) $Nk^2T^2$ (c) $Nk^2T^2 - \frac{Nmg^2}{2\omega^2}$ (d) $\sqrt{N}kT - \frac{Nmg^2}{2\omega^2}$

28. Consider $M$ be a matrix of order 3, with trace 3 and determinant 2. If one of the eigenvalues of the matrix $M$ is 1, then eigenvalues of matrix $M^2 - 2I$ will be

(a) $-1, 2(i-1), -2(i+1)$ (b) $-1, 2(i-1), 2(i+1)$

(c) $1, -2(i+1), 2(i+1)$ (d) $1, -2(i+1), 2(i-1)$

29. If a force $\vec{F} = (x+y)\hat{i} + (1-x)\hat{j}$ is applied to a particle, the particle moves around the portion of the curve $9x^2 + 4y^2 = 36$ lying in the 4th quadrant with counter-clockwise rotation. The work done by the force will be

(a) $-5+3\pi$ (b) $5+3\pi$ (c) $5-3\pi$ (d) $-5-3\pi$

30. The Laurrent series expansion of a complex function $f(z)$ about $z=3$ is given as following:

$$f(z) = \frac{1}{2(z-3)^3} - \frac{1}{4(z-3)^2} + \frac{1}{8(z-3)} - \frac{1}{16} + \frac{(z-3)}{32} - \ldots\ldots$$

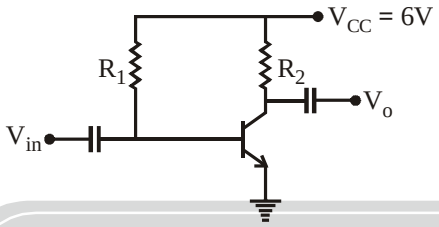
The order of the pole and residue of the function $f(z)$ at $z=2$ are respectively

(a) 3, 1/2 (b) 3, 1/8 (c) 3, -1/8 (d) 1, -1/8

31. A vector $F_i$ and a tensor $F_{jk}$ are related by $F_i = \frac{1}{2} \in_{ijk} F_{jk}$, where $\in_{ijk}$ is the Levi-Civita tensor. The tensor $F_{jk}$ is given by

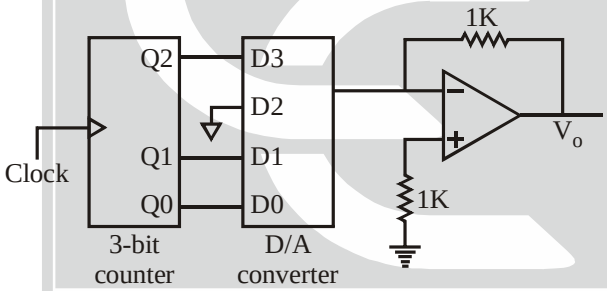
(a) $\begin{bmatrix} 0 & F_3 & F_2 \\ F_3 & 0 & F_1 \\ F_2 & F_1 & 0 \end{bmatrix}$ (b) $\begin{bmatrix} 0 & F_3 & F_2 \\ -F_3 & 0 & F_1 \\ -F_2 & -F_1 & 0 \end{bmatrix}$ (c) $\begin{bmatrix} 0 & F_3 & -F_2 \\ -F_3 & 0 & F_1 \\ F_2 & -F_1 & 0 \end{bmatrix}$ (d) $\begin{bmatrix} 0 & -F_3 & -F_2 \\ F_3 & 0 & F_1 \\ F_2 & -F_1 & 0 \end{bmatrix}$

32. In the amplifier circuit shown in figure, the values of $R_1$ and $R_2$ are such that the transistor is operating at $V_{CE} = 3\,V$ and $I_C = 1.5\,mA$ when its $\beta$ is 150. For transistor with $\beta$ of 200, the operating point $(V_{CE}, I_C)$ is

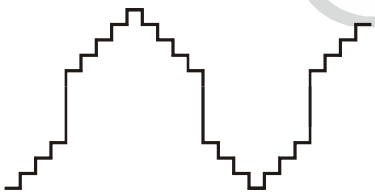


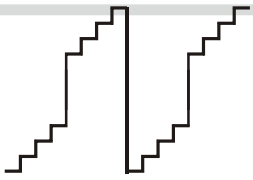

(a) (2V, 2 mA) (b) (3V, 2 mA) (c) (4V, 2 mA) (d) (4V, 1 mA)

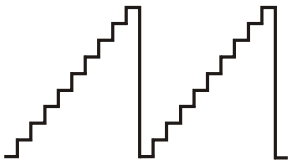
33. A 4-bit D/A converter is connected to a free-running 3-bit UP counter, as shown in the following figure. Which of the following waveforms will be observed at V ?

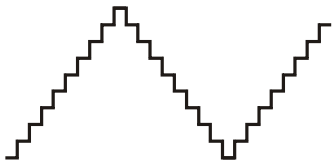



In the figure shown above, the ground has been shown by the symbol ∇

(a) 

(b) 

(c) 

(d) 

34. Consider a particle of *m* whose motion starts from rest in a constant gravitational field. If a resistive force, $kmv^2$, where *v* is the velocity, is encountered, the distance *h* the particle falls in accelerating from $v_0$ to $v_1$ is given by

(a) $\frac{1}{2k} \ell n \left( \frac{g + kv_0^2}{g + kv_1^2} \right)$ (b) $\frac{1}{2k} \ell n \left( \frac{g - kv_0^2}{g - kv_1^2} \right)$ (c) $\frac{1}{2k} \ell n \left( \frac{g + kv_0^2}{g - kv_1^2} \right)$ (d) $\frac{1}{2k} \ell n \left( \frac{g - kv_0^2}{g + kv_1^2} \right)$

35. An electron of rest mass $m_0$ is moving with speed $4c/5$ in $+x$-direction with respect to lab frame. Momentum of electron in another frame which is moving with speed $3c/5$ with respect to lab in $+x$-direction is

(a) $\frac{3m_0 c}{5}$ (b) $\frac{4m_0 c}{3}$ (c) $\frac{3m_0 c}{4}$ (d) 0

36. Lagrangian of a system is $L = \dot{x}^2 - x^2 + x$, if area of phase space trajectory is $\pi$, then energy of the particle is

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

37. A circular loop of radius 'a' and carrying a current 'I' is symmetrically kept inside the hollow cube of side '4a' such that centre of loop coincides with the centre of the cube. The total magnetic flux through the cube is

(a) $8\mu_o Ia$ (b) $4\mu_o Ia$ (c) Zero (d) $2\mu_o Ia$

38. A square loop of side 'a' lies in $x$-$y$ plane. An electromagnetic wave $\vec{E} = E_o\hat{i}\cos\left(\frac{\sqrt{3}}{2}z + \frac{1}{2}y - \omega t\right)$ is propagating in free space. The power crossing through the square is,

(a) $\frac{E_o^2 a^2}{2\mu_o c}$ (b) $\frac{\sqrt{3}E_o^2 a^2}{4\mu_o c}$ (c) $\frac{\sqrt{3}E_o^2 a^2}{2\mu_o c}$ (d) $\frac{E_o^2 a^2}{4\mu_o c}$

39. Consider a transformation of electromagnetic potentials $\vec{A} \to \vec{A}'$, $\phi \to \phi'$ which leaves the electromagnetic fields unchanged. If transformed vector potential is $\vec{A}' = \vec{A} - \frac{A_0 t}{r^2}\hat{r}$, the transformed scalar potential $(\phi')$ is

(a) $\phi + \frac{A_0}{r}$ (b) $\phi + \frac{A_0}{r^2}$ (c) $\phi - \frac{A_0}{r}$ (d) $\phi - \frac{A_0}{r^2}$

40. A sphere of radius R carries a volume charge density $\rho(r) = \beta r^2$, where 'r' is distance from centre and $\beta$ is a constant. The electrostatic potential $(\phi)$ at the centre of sphere is

(a) $\frac{\beta R^4}{4\varepsilon_0}$ (b) $\frac{21\beta R^5}{20\varepsilon_0}$ (c) $\frac{21\beta R^4}{20\varepsilon_0}$ (d) $\frac{\beta R^5}{4\varepsilon_0}$



## PART-C

### COMPULSORY QUESTIONS

41. Consider a particle of mass $m$ that is bouncing vertically and elastically on a reflecting hard floor such that

$$V(z) = \begin{cases} mgz & \text{for } z > 0 \\ \infty & \text{for } z \le 0 \end{cases}$$

where $g$ is the gravitational constant. Using the variational principle with the normalized trial wave function $\psi(x) = 2\sqrt{\eta^3}\, z\, e^{-\eta z}$ (where $\eta$ is the variational parameter), the ground state energy of the particle will be

(a) $\frac{2}{3}\left(\frac{9}{2}\right)^{1/3}\left(\frac{1}{2}mg^2\hbar^2\right)^{1/3}$ (b) $\frac{3}{2}\left(\frac{9}{2}\right)^{1/3}\left(\frac{1}{2}mg^2\hbar^2\right)^{1/3}$ (c) $\frac{3}{2}\left(\frac{9}{2}\right)^{1/3}\left(\frac{1}{4}mg^2\hbar^2\right)^{1/3}$ (d) $\frac{3}{2}\left(\frac{9}{2}\right)^{2/3}\left(mg^2\hbar^2\right)^{1/3}$

42. Consider a system whose initial state $|\psi(0)\rangle$ and Hamiltonian $H$ are given by

$$|\psi(0)\rangle = \frac{1}{5}\begin{pmatrix}3\\0\\4\end{pmatrix} \quad \text{and} \quad H = \begin{bmatrix}3 & 0 & 0\\0 & 0 & 5\\0 & 5 & 0\end{bmatrix}$$

If the measurement of energy is carried out on the system, the probability that it will yield the result +3 units, will be

(a) 0.25 (b) 0.32 (c) 0.36 (d) 0.5

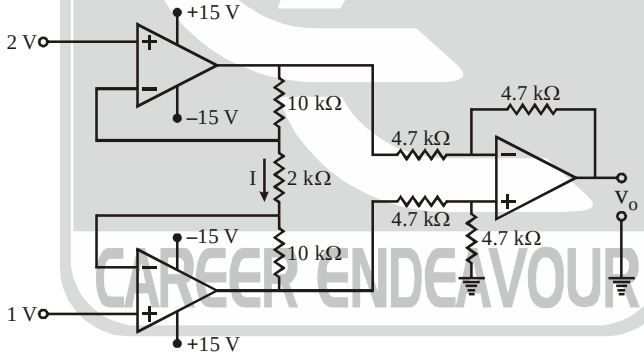
43. A system is characterized by $N$ distinguishable and non interacting atoms in thermal equilibrium with a reservoir at temperature $T$. Each atom can occupy the energy levels $E_n = (n+1)\varepsilon$, $(\varepsilon > 0,\ n = 0,1,2,.....+\infty)$, and the degeneracy of n$^{th}$ level is equal to $g_n = \lambda^n$ with $\lambda$>1 . The average energy of the system is

(a) $\dfrac{\varepsilon}{e^{\varepsilon/kT} - \lambda}$ (b) $\dfrac{N\varepsilon}{e^{\varepsilon/kT} - \lambda}$ (c) $\dfrac{N\varepsilon e^{\varepsilon/kT}}{1 - \lambda e^{-\varepsilon/kT}}$ (d) $\dfrac{N\varepsilon}{1 - \lambda e^{-\varepsilon/kT}}$

44. Suppose $A(t)$ and $B(t)$ are two differentiable functions on $R$ such that $A(t=0) = 2$ and $B(t=0) = 1$. If $A + \dfrac{dB}{dt} = 1$ and $B + \dfrac{dA}{dt} = 1$ for all $t \in [0,1]$. The value of $A$ at $t = \ln 2$ will be

(a) 1/4 (b) 3/2 (c) 5/4 (d) 9/4

45. What is the output voltage $V_o$ of the below circuit ?




(a) –11 V (b) 6 V (c) 11 V (d) – 6 V

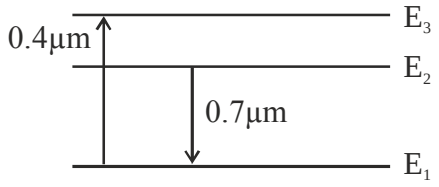
46. A solid cube has mass $M$ and side '$a$'. Moment of inertia of cube about its body diagonal is

(a) $\dfrac{2}{3}Ma^2$ (b) $\dfrac{Ma^2}{6}$ (c) $\dfrac{Ma^2}{12}$ (d) $\dfrac{3Ma^2}{2}$

47. Cut-off frequency $f_c$ for the lowest TE mode of a air-filled rectangular wave guide having cross-section area 1.0×0.75 mm$^2$(approximately)

(a) $1.5\times10^{11}$ *Hz* (b) $2\times10^{11}$ *Hz* (c) $2\times10^{12}$ *Hz* (d) $2.50\times10^{12}$ *Hz*

48. A typical three level laser has pumping rate of $1.5\times10^{19}$ atoms/cm$^3$–sec. All the atoms excited by the 0.4μm radiation decay rapidly to level $E_2$ which has a life time t = 3ms.




The density of atoms in level $E_2$ under steady state condition is:

(a) $1.5\times10^{19}$/cm$^3$ (b) $4.5\times10^{16}$/cm$^3$ (c) $5\times10^{21}$/cm$^3$ (d) $2\times10^{16}$/cm$^3$

49. A Si film is doped with$10^{19}$ P atoms/cm$^3$. Thickness of the film is 1 μm and the current passing through film is 1 mA. The Hall voltage developed in the film, if placed in a perpendicular magnetic field of 1T, is
(a) 1.25 mV (b) 2.5 mV (c) 5.00 mV (d) 0.625 mV

50. The energy of the protons detected at 90º when 2.1 MeV deutrons are incident on 27Al to produce 28Al with an energy difference Q = 5.5 MeV is
(a) 6.32 MeV (b) 8.20 Me (c) 7.19 MeV (d) 11.23 MeV

**ANSWER ANY 10 QUESTIONS OUT OF THE REMAINING 15**

51. Consider a sytem of total angular momentum qunatum number $j=1$ and the corresponding operators $\hat{J}_x, \hat{J}_y, \hat{J}_z$ are given as following:

$$\hat{J}_x=\frac{\hbar}{\sqrt{2}}\begin{bmatrix}0&1&0\\1&0&1\\0&1&0\end{bmatrix},\ \hat{J}_y=\frac{\hbar}{\sqrt{2}}\begin{bmatrix}0&-i&0\\i&0&-i\\0&i&0\end{bmatrix}\ \text{and}\ \hat{J}_z=\hbar\begin{bmatrix}1&0&0\\0&0&0\\0&0&-1\end{bmatrix}$$

When the measurement of $J_x$ is carried out on the system, then it is found to be $-\hbar$. If the measurement of $J_z$ is carried out immediately afterwards, then the uncertainty in $J_z$ will be

(a) $\frac{\hbar}{\sqrt{2}}$ (b) $\frac{\hbar}{2}$ (c) $\frac{\hbar}{4}$ (d) $\frac{\hbar}{\sqrt{3}}$

52. A particle of mass *m* is moving under the following 3-D potential:

$$V(x,y,z)=\begin{cases}0 & \text{for } 0<x<a, 0<y<a, 0<z<a\\ \infty & \text{elsewhere}\end{cases}$$

If a perturbation $V_p=V_0L^3\,\delta\left(x-\frac{a}{4}\right)\delta\left(y-\frac{3a}{4}\right)\delta\left(z-\frac{a}{4}\right)$

is added to it, then the energy eigenvalues of the first excited state (according to first order perturbation theory) will be

(a) $\frac{3\pi^2\hbar^2}{ma^2},\frac{3\pi^2\hbar^2}{ma^2},\frac{3\pi^2\hbar^2}{ma^2}+6V_0$ (b) $\frac{3\pi^2\hbar^2}{ma^2},\frac{3\pi^2\hbar^2}{ma^2},\frac{3\pi^2\hbar^2}{ma^2}-6V_0$

(c) $\frac{3\pi^2\hbar^2}{ma^2},\frac{3\pi^2\hbar^2}{ma^2}+V_0,\frac{3\pi^2\hbar^2}{ma^2}-V_0$ (d) $\frac{3\pi^2\hbar^2}{ma^2}+V_0,\frac{3\pi^2\hbar^2}{ma^2}+V_0,\frac{3\pi^2\hbar^2}{ma^2}-2V_0$

53. The total number of microstates for a system is given by $\Omega(E) = \exp\left[\alpha \frac{E^2}{k_B^2 T^2}\right]$. The entropy $S(E,T)$ and temperature $T(E)$ for the system are respectively given by

(a) $S(E,T) = \frac{\alpha E^2}{k_B^2 T^2}; T(E) = \frac{2\alpha E}{k_B}$ (b) $S(E,T) = \frac{\alpha E^2}{k_B T^2}; T(E) = \frac{\alpha E}{2k_B}$

(c) $S(E,T) = \frac{\alpha E^2}{k_B^2 T^2}; T(E) = \frac{\alpha E}{2k_B}$ (d) $S(E,T) = \frac{\alpha E^2}{k_B T^2}; T(E) = \frac{2\alpha E}{k_B}$

54. Let the unit step function is defined as follows:

$$u(z) = \begin{cases} 0 & \text{when } z < a \\ 1 & \text{when } z \geq a \end{cases} (a \geq 0)$$

The laplace tranform of the function $f(z) = z^2.u(z-3)$ will be

(a) $e^{-s}\left[\frac{2}{s^3} + \frac{9}{s}\right]$ (b) $e^{-s}\left[\frac{2}{s^3} + \frac{6}{s^2} + \frac{9}{s}\right]$ (c) $e^{-3s}\left[\frac{2}{s^3} + \frac{6}{s^2} + \frac{9}{s}\right]$ (d) $e^{-3s}\left[\frac{2}{s^3} - \frac{6}{s^2} + \frac{9}{s}\right]$

55. The circumference of a circle $36\pi$. Contained in that circle is a smaller circle with area $16\pi$. A point is selected at random from inside the larger circle. The probability that the point will also lies in the smaller circle, is

(a) 4/9 (b) 4/81 (c) 16/81 (d) 2/9

56. A particle of mass 3 kg is oscillating about stable equilibrium point of potential $V(x) = \frac{1}{(1+x)^2} + \frac{1}{(1-x)^2}$

angular frequency of small oscillation is

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

57. A particle of mass $\sqrt{3}m$ collides elastically with a particle of mass *m*, which is initially at rest. If in centre of mass frame angle of deflection is 150º then in lab frame the first particle will deflect by

(a) 30º (b) 15º (c) 60º (d) 90º

58. An electromagentic wave is incident normally at air – dielectric interface. The fraction of reflected and transmitted intensities are 0.4 and 0.6, respectively. The refractive index (n) of the dielectric is closest to

(a) 1.5 (b) 2.5 (c) 3.5 (d) 4.5

59. A beam of unpolarized light is incident on a glass plate at an angle of 60º from normal, the reflected light is completely plane polarized. If angle of incidence is 45º, the angle of refraction is:

(a) $\sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (b) $\cos^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (c) $\sin^{-1}\left(\frac{1}{\sqrt{6}}\right)$ (d) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

60. The primitive lattice vectors of a Bravais lattice are given by

$$\vec{a} = \left(\frac{\sqrt{3}}{2}a\hat{x} + \frac{a}{2}\hat{y}\right), \quad \vec{b} = \left(-\frac{\sqrt{3}}{2}a\hat{x} + \frac{a}{2}\hat{y}\right), \quad \vec{c} = c\hat{z}$$

The receiprocal of above lattice and volume of primitive reciprocal unit cell are, respectively

(a) hexagonal, $\frac{16\pi^3}{3\sqrt{3}\,a^2c}$ (b) fcc, $\frac{8\pi^3}{3\sqrt{3}\,a^2c}$

(c) bcc, $\frac{8\pi^3}{3\sqrt{3}\,a^2c}$ (d) hexagonal, $\frac{16\pi^3}{\sqrt{3}\,a^2c}$

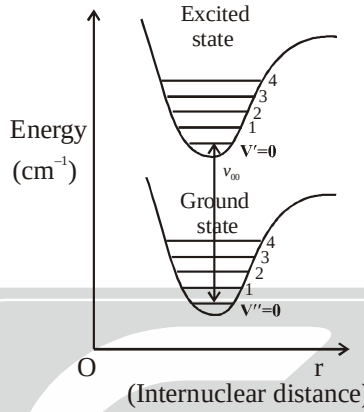
61. The dispersion relation for an unknown Boson particle is given by

$$\omega^2(k) = \omega_0^2\left(3 - \cos k_x a - \cos k_y a - \cos k_z a\right)$$

The specific heat of the particle at low temperature and long wavelength is

(a) AT (b) $BT^3$ (c) $CT^{3/2}$ (d) $AT + BT^3$

62. A vibrational-electronic spectrum of homonuclear molecule is shown in the graph. The dissociation energy in ground state and excited state is 2000 $cm^{-1}$ and 1500 $cm^{-1}$ respectively. If the energy of the dissociated atoms in the excited state exceeds the total energy of dissociated atoms in the ground state by 2200 $cm^{-1}$. The energy ($\nu_{00}$) of $V' = 0 \rightarrow V'' = 0$ transition is:




(a) 2700 $cm^{-1}$ (b) 1700 $cm^{-1}$ (c) 1300 $cm^{-1}$ (d) 5700 $cm^{-1}$

63. The ground state term symbol for Arsenic i.e $^{74}_{33}As$ will be

(a) $^4S_{3/2}$ (b) $^4S_{1/2}$ (c) $^1S_0$ (d) $^4P_{3/2}$

64. A particle X has a width of 158 MeV. The type of interaction by which particle X will be governed is
(a) strong (b) electromagnetic (c) weak (d) insufficient data

65. The quark content of the following particles are:

The beauty hyperon $\Lambda_b = dub$, the charmed meson $D^0 = c\bar{u}$, the beauty mesons, $B^+ = u\bar{b}$, $B^- = \bar{u}b$ and $B^0 = d\bar{b}$. Consider the following statements

(P) In reaction $\pi^- + P \rightarrow D^0 + \Lambda_0 + \pi^+$, charm and beauty quantum numbers are not conserved.

(Q) Reactions $\pi^- + P \rightarrow B^0 + \Lambda_b$ and $\pi^- + P \rightarrow B^+ + \Lambda_b + \pi^-$ are allowed

(R) In reaction $\pi^- + P \rightarrow B^- + \Lambda_b + \pi^+$, beauty quantum number is violated

(S) In reaction $\pi^- + P \rightarrow B^- + B^+$, baryon number is violated

Choose the correct option from the following

(a) Only P, Q and R are correct (b) Only P, R and S are correct

(c) Only Q, R and S are correct (d) All P, Q, R and S are correct.

***Space for rough work***

PHYSICAL SCIENCES
TEST SERIES-D

Date : 05-06-2017

## PART-A

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. (d) | 2. (c) | 3. (c) | 4. (a) | 5. (c) | 6. (a) | 7. (b) |
| 8. (b) | 9. (a) | 10. (c) | 11. (d) | 12. (a) | 13. (c) | 14. (d) |
| 15. (d) | 16. (a) | 17. (a) | 18. (a) | 19. (c) | 20. (c) | |

## PART-B

| | | | | | | |
|---|---|---|---|---|---|---|
| 21. (d) | 22. (c) | 23. (c) | 24. (b) | 25. (b) | 26. (a) | 27. (b) |
| 28. (a) | 29. (c) | 30. (b) | 31. (c) | 32. (a) | 33. (b) | 34. (b) |
| 35. (d) | 36. (c) | 37. (c) | 38. (b) | 39. (c) | 40. (a) | |

## PART-C

| | | | | | | |
|---|---|---|---|---|---|---|
| 41. (b) | 42. (c) | 43. (d) | 44. (d) | 45. (a) | 46. (b) | 47. (a) |
| 48. (b) | 49. (d) | 50. (c) | 51. (a) | 52. (a) | 53. (d) | 54. (c) |
| 55. (c) | 56. (b) | 57. (a) | 58. (d) | 59. (c) | 60. (d) | 61. (b) |
| 62. (a) | 63. (a) | 64. (a) | 65. (d) | | | |