# TEST SERIES CSIR-NET/JRF JUNE 2019

## BOOKLET SERIES D

## FULL LENGTH TEST - I

**Paper Code 05**

**Test Type: TEST SERIES**

## PHYSICAL SCIENCES

**Duration: 3:00 Hours**

**Date: 04-06-2019**

**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 **25** questions covering the topics given in the Part 'B' of syllabus. The candidates are required to answer any 20 questions. Each question shall be of **3.5 Marks.**.

**Part - C:** This part shall contain **30** questions from Part - C of the syllabus. The candidates are required to answer any 20 questions. 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.

## PART – A

1. A thief steals a car at 2.30 p.m. and drives it at 60 kmph. The theft is discovered at 3 p.m. and the owner sets off in another car at 75 kmph. When will he overtake the thief ?
(a) 4.30 p.m. (b) 4.45 p.m. (c) 5 p.m. (d) 5.15 p.m.

2. 6 students A, B, C, D, E, F are to be called for an interview based on their percentage of marks secured in the examination. One who secures the highest marks is called first and next in the decreasing order of their secured marks they are called.
B secured 75 % marks and got a call after C.
F got the call before E.
D was not the last person to get the call as he got 72 % marks.
Two persons are between A and D.
If C got more marks than B, but less than A.
Then who was the second last student to appear in the interview and what could be his possible mark in the examination ?
(a) F, 73 (b) C, 74 (c) F, 71 (d) C, 70

3. In the series given below follows a certain pattern. What should come following the same pattern in place of question mark (?) ?

| | | | | |
|---|---|---|---|---|
| 3 | 7 | 23 | 95 | ? |

(a) 380 (b) 479 (c) 514 (d) 461

4. A and B are brothers, but C is sister of B.
E is father of A and F is mother of B.
If C is married to D, then how is D related to F ?
(a) Uncle (b) Son (c) Grandson (d) Son-in-law

5. A cyclist rides 40 km to the east, then turns north and rides 20 km, again turns left and rides 20 kms. How far is he from the starting point?
(a) 0 km (b) 25 km (c) 20 km (d) 28 km

6. 2 cards are drawn together from a well shuffled pack of 52 cards. What is the probability that either both are black cards or both are queen ?
(a) $\frac{105}{1326}$ (b) $\frac{5}{13}$ (c) $\frac{55}{221}$ (d) $\frac{11}{52}$

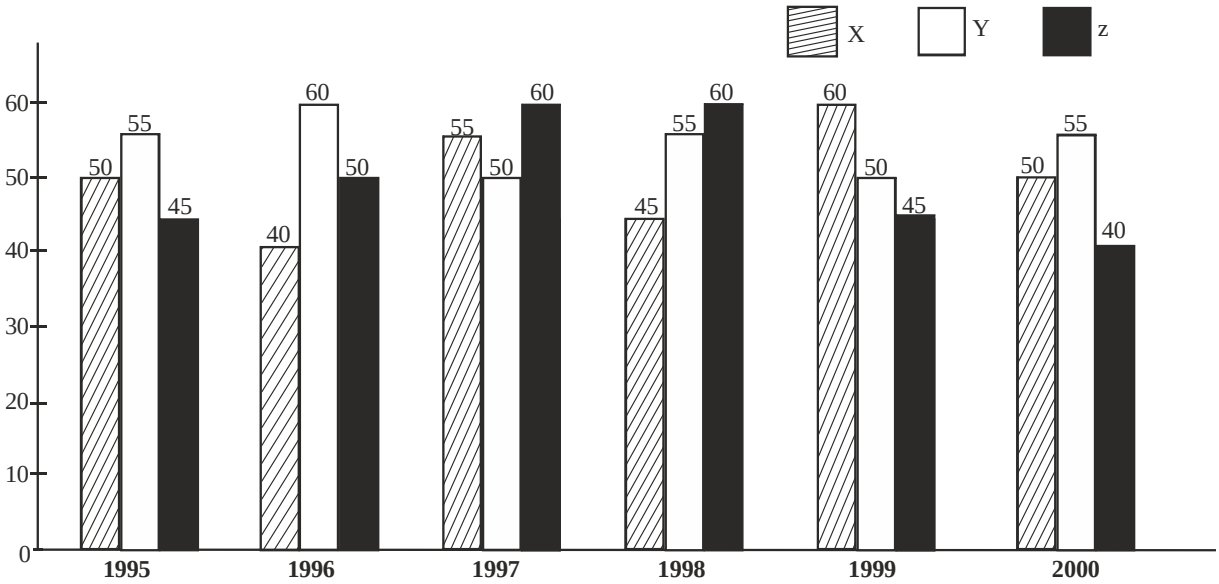
7. **Directions:** In the question below is given few statements followed by the conclusions numbered accordingly. You have to take the given statements to be true even if they seem to be at variance from commonly known facts and then decide which of the given conclusions logically follows from the statements disregarding commonly known facts.

**Statements:**
1. All A are B
2. All C are D
3. All B are C
4. Some A are E

**Conclusions:**
I. All B are A
II. All D are C
III. Some B are E

(a) Only II follows (b) Either I or II follows
(c) Only III follows (d) None follows

8. The sweet cola company prepares drinks of three different flavours –X, Y and Z. The production of the three flavours over a period of six years has been expressed in the bar-graph provided below. Study the graph and answer the question based on it. Production of three different flavour of soft-drinks X,Y, Z by a company over the years (in lakh bottles)




For which of the following years the percentage of rise/fall in production from the previous year is the maximum for the flavour Y ?

(a) 1996 (b) 1997 (c) 1998 (d) 2000

9. In the series given below follows a certain pattern. What should come following the same pattern in place of question mark (?) ?

| | | | | |
|---|---|---|---|---|
| FE | JH | NK | RN | ? |

(a) UV (b) VQ (c) VO (d) VP

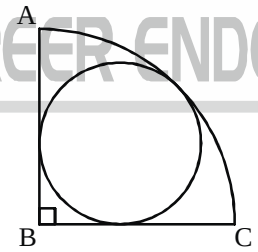
10. A is 3/4 times faster than B. If A gives B a start of 84 m, then how far the winning post has to be so that A and B reaches at the same time ?

(a) 150 (b) 168 (c) 196 (d) 154

11. A watch which gains uniformly, is 5 min. slow at 8 o'clock in the morning on Sunday and is 5 min. 48 sec fast at 8 p.m. on following Sunday. When was it correct?

(a) 8 a.m. Tuesday (b) 7 : 20 p.m. Wednesday
(c) 8 p.m. Thursday (d) 7 : 30 a.m. Wednesday

12. If ABC is a quarter circle and a circle is inscribed in it and if AB = 1 cm, find radius of smaller circle.




(a) $\sqrt{2}-1$ (b) $(\sqrt{2}+1)/2$ (c) $\sqrt{2}-1/2$ (d) $1-2\sqrt{2}$

13. In the given diagram a rope is wound round the outside of a circular drum whose diameter is 70 cm and a bucket is tied to the other end of the rope. Find the number of revoluitons made by the drum if the bucket is raised by 11 m ?

(a) 10 (b) 2.5
(c) 5 (d) 5.5

14. There are 6 pups and 4 cats. In how many ways can they be seated in a row so that no cats sit together ?

(a) $6^4$ (b) 210 (c) 6! × 840 (d) None of these

15. A shopkeeper pruchased 150 identical pieces of calculators at the rate of Rs. 250 each. He spent an amount of Rs. 2500 on transport and packing. He fixed the labelled price of each calculator at Rs. 320. However, he decided to give a discount of 5% on the labelled price.What is the percentage profit earned by him?
(a) 14 % (b) 15 % (c) 16 % (d) 20 %

16. From a bucket containing pure syrup each time 9 litre of syrup is taken out and replaced by water. This process is repeated for two times and the ratio of syrup to the water in the bucket becomes 16:9.What was the initial amount of syrup in the bucket?
(a) Data insufficient (b) 45 litre
(c) 35 litre (d) 25 litre

17. Kolkata-Amritsar superfast express on a specific day, 5 % of the passengers do not like coffee, tea and ice cream and 10 % like all the three items. 20 % like coffee and tea, 25% like coffee and ice-cream. 25 % like ice cream and tea. 55% like coffee, 50% like tea and 50% like ice cream. If total passenger is 400 then the number of passengers who like only coffee is ?
(a) 80 (b) 100 (c) 140 (d) 120

18. What is the angle between hour hand and minute hand of a clock at 7 : 20 p.m.
(a) 90º (b) 100º (c) 95º (d) 105º

19. If the angular diameter of the moon be 30′, m how far from the eye a coin of diameter 4.4 cm be kept to hide the moon?
(a) 252 cm (b) 504 cm (c) 300 cm (d) 500 m

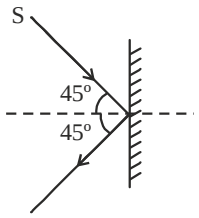
20. A cone of height 9 cm with diameter of its base 18 cm is carved out from a wooden solid sphere of radius 9 cm. The per centage of the wood wasted is :
(a) 25 % (b) 20 % (c) 50 % (d) 75 %

## PART – B

21. The combined frictional and air resistance on a bicyclist has the force $F = aV$, where $V$ is his velocity and $a = 4$ newton-sec/m . The cyclist can generate 600 watts propulsive power. The maximum speed of cyclist on level ground with no wind is approximately equal to
(a) 25 m/s (b) 12.2 m/s (c) 150 m/s (d) 75 m/s

22. A beam of electrons is elastically scattered by a fixed scattering target as shown in figure. Each electron of rest mass $m_0$ has an energy, $E = \frac{5}{3}m_0c^2$ (where $c$ is speed of light) and the beam has a flux of $Q$ electrons per second. The magnitude of force on the scattering target due to the electrons is

(a) $\frac{5}{3}m_0cQ$ (b) $\frac{2\sqrt{2}}{3}m_0cQ$ (c) $\frac{4\sqrt{2}}{3}m_0cQ$ (d) $\frac{4}{3}m_0cQ$




23. Consider the Lagrangian $L = 1 - \sqrt{1-\dot{q}^2} - \frac{q^2}{2}$ of a particle executing oscillations. If $p$ denotes the momentum, then which one of the pair of equations are correct?

(a) $\frac{dq}{dt} = \frac{p}{\sqrt{p^2+1}}, \frac{dp}{dt} = -q$ (b) $\frac{dq}{dt} = \frac{1}{\sqrt{p^2+1}}, \frac{dp}{dt} = q$

(c) $\frac{dq}{dt} = \frac{p}{\sqrt{p^2-1}}, \frac{dp}{dt} = -q$ (d) $\frac{dq}{dt} = \frac{p}{\sqrt{p^2+1}}, \frac{dp}{dt} = \frac{q^2}{2}$

24. A particle of mass $m$ is bound by a linear potential $U = kr$ and it moves in a circular orbit of radius $r_0$. If the particle is slightly disturbed from this circular motion, the frequency of small oscillations, is

(a) $\sqrt{\frac{k}{2mr_0}}$ (b) $\sqrt{\frac{3k}{mr_0}}$ (c) $\sqrt{\frac{k}{mr_0}}$ (d) $\sqrt{\frac{2k}{mr_0}}$

25. For an ideal gas of N molecules, each of mass $m$, the Helmholtz free energy is given by

$$F = -Nk_BT\left[\ell n\left\{\frac{V}{N}\left(\frac{2\pi mk_BT}{h^2}\right)^{3/2}\right\}+1\right]$$

where the symbols have their standard meanings. The nature of the gas is

(a) Monatomic (b) Rigid diatomic (c) Non-rigid diatomic (d) Linear triatomic

26. Consider a one-dimensional quantum linear harmonic oscillator at temperature $T$ and oscillating with frequency $\omega$. If the probability of finding the oscillator in second excited state is half that of finding it in ground state, the temperature $T$ is given by

(a) $\frac{\hbar\omega \ln 2}{k_B}$ (b) $\frac{\hbar\omega \ln 2}{2k_B}$ (c) $\frac{\hbar\omega}{k_B \ln 2}$ (d) $\frac{2\hbar\omega}{k_B \ln 2}$

27. One mole of an ideal gas is compressed from 5L to 2.5L at constant temperature. If R denotes the gas constant, the change in entropy of the gas in the given process is

(a) 0.69 R (b) –0.69 R (c) 0.50 R (d) – 0.50 R

28. Which of the following is not an example of second order phase transition?

(a) Vapourisation of liquid
(b) Normal conductor to superconductor in the absence of magnetic field
(c) Paramagnetism to diamagnetism above Curie point.
(d) Liquid He(I) to liquid He(II)

29. If $L_z$ denotes the z-component of angular momentum, $[L_z, \cos^2\phi]$ will be equal to,

(a) $i\hbar\sin\phi$ (b) $-i\hbar\sin\phi$ (c) $i\hbar\sin 2\phi$ (d) $-i\hbar\sin 2\phi$

30. The root mean-square position for the ground state of a 1-D Harmonic oscillator of frequency $4\omega$ is $x_0$. Its root-mean square momentum will be equal to

(a) $\frac{\hbar}{x_0}$ (b) $\frac{\hbar}{2x_0}$ (c) $\frac{2\hbar}{x_0}$ (d) None of these

31. The energy spectrum for a quantum system is

$E_n = \frac{E_0}{\alpha^n}$, ($\alpha$ is a dimensionless constant that is greater than 1, $n$ = 0, 1, 2, ...)

If expectation value of energy for a normalized state of form,

$\psi = \sum_{n=0}^{\infty}\beta^{n/2}\psi_n$ [$\{\psi_n\}$ are orthonormal basis and $0 < \beta < 1$]

is $\frac{3E_0}{2}$, the relation between $\alpha$ and $\beta$ is

(a) $\alpha = \beta$ (b) $\alpha = 2\beta$ (c) $\alpha = 3\beta$ (d) None of these

32. $\hat{S}_n$ is the component of spin along the vector $(\hat{i}+\hat{j})$. The eigenstate of $\hat{S}_n$ with eignvalue $+\hbar/2$, written in $\hat{S}_z$ basis, will be

(a) $\frac{1}{\sqrt{3}}\begin{pmatrix}1+i\\1\end{pmatrix}$ (b) $\frac{1}{\sqrt{3}}\begin{pmatrix}1-i\\1\end{pmatrix}$ (c) $\frac{1}{2}\begin{pmatrix}1+i\\\sqrt{2}\end{pmatrix}$ (d) $\frac{1}{2}\begin{pmatrix}1-i\\\sqrt{2}\end{pmatrix}$

33. The dynamic resistance of a p-n junction diode is $r_0$ when forward current $I_0$ at room temperature. At the same temperature if forward current is $4I_0$ then the value of the dynamic resistance is

(a) $4r_0$ (b) $2r_0$ (c) $0.5r_0$ (d) $0.25\ r_0$

34. In a transistor the collector to base current with emitter open is 20 μA at room temperature. It is used in CE mode. If the value of $I_B$ = 50μA and β = 100 then the value of collector current $I_C$ is

(a) 5 mA (b) 7.02 mA (c) 10.4 mA (d) 12.3 mA

35. The resolution of an n-bit D/A converter is approximately 0.4% of its full scale range. Then the value of n is

(a) 16 (b) 10 (c) 8 (d) 4

36. The electric field associated with an electromagnetic wave in a lossy dielectric medium is given by

$\vec{E} = \hat{i}30\,\pi e^{-\sqrt{3}x}\, e^{i(x-\omega t)}$ , (where $x$ is measured in meter).

The phase difference between in $\vec{E}$ and $\vec{H}$ fields is

(a) $\frac{\pi}{6}$ (b) $\frac{\pi}{3}$ (c) $\frac{\pi}{4}$ (d) zero

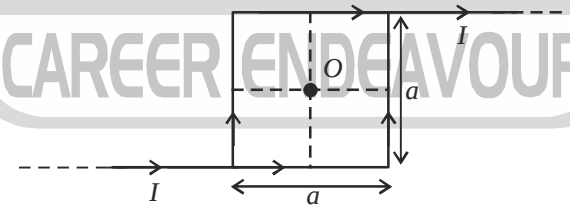
37. The magnetic field associated with an electromagnetic wave in free space is given by

$\vec{B} = \hat{i}B_0\cos(kz-\omega t) + \hat{j}B_0\sin(kz-\omega t)$

The time averaged energy flux density associated with the wave is

(a) $\frac{1}{4}\frac{cB_0^2}{\mu_0}$ (b) $\frac{1}{2}\frac{cB_0^2}{\mu_0}$ (c) $\frac{cB_0^2}{\mu_0}$ (d) zero

38. Consider the following figure as shown below. The value of magnetic field at the centre of the square portion is




(a) $\frac{\mu_0 I}{\pi a}\left(1+\frac{1}{2\sqrt{2}}\right)$ (b) $\frac{\mu_0 I}{\pi a}\left(1-\frac{1}{2\sqrt{2}}\right)$ (c) $\frac{\mu_0 I}{\pi a}$ (d) zero

39. Consider a hemispherical shell of radius $R$ carrying a surface charge density $\sigma = \sigma_0\cos\theta$, where $\theta$ is the usual polar angle. The electric dipole moment about the centre of the hemispherical shell is

(a) $\frac{2\pi}{3}\sigma_0 a^3\hat{k}$ (b) $-\frac{2\pi}{3}\sigma_0 a^3\hat{k}$ (c) $\frac{4\pi}{3}\sigma_0 a^3\hat{k}$ (d) $\frac{2\pi}{3}\sigma_0 a^3\left(\hat{i}+\hat{j}\right)$

40. Suppose, $H_n(x)$ represents the Hermite polynomial of of order '*n*'. Then, the value of the integral

$$\int_0^{\infty} e^{-x^2}\, H_{100}(x)\, H'_{101}(x)\, dx$$

will be

(a) 0 (b) $2^{100}(100!)\sqrt{\pi}$ (c) $2^{100}(101!)\sqrt{\pi}$ (d) $2^{101}(101!)\sqrt{\pi}$

41. The Fourier transform of a function $f(x)$ is defined as following:

$$g(k) = \int_{-\infty}^{\infty} f(x)\, e^{ikx}\, dx$$

If the Fourier Transform of the function

$$f(x) = 1 \quad \text{for } -a < x < a$$
$$= 0 \quad \text{otherwise}$$

is proportional to $\frac{\sin(ka)}{(ka)}$, then the Fourier Transform of the function

$$F(x) = 1 \quad \text{for } 1-a < x < 1+a$$
$$= 0 \quad \text{otherwise}$$

will be proportional to

(a) $e^{ik}\frac{\sin(ka)}{(ka)}$ (b) $e^{-ik}\frac{\sin(ka)}{(ka)}$ (c) $e^{-k}\frac{\sin(ka)}{(ka)}$ (d) $e^{k}\frac{\sin(ka)}{(ka)}$

42. If the complex function $f(x,y) = \left(x^2 + ay^2 - 2xy\right) + i\left(bx^2 - y^2 + 2xy\right)$ is analytic in the entire complex argand plane, then the value of $(a+b)^2$ will be

(a) 4 (b) 0 (c) 2 (d) 1

43. The Hamiltonian of a quantum mechanical system is given as following:

$$H = \begin{pmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{pmatrix}$$

If the energy of the system is measured, then it is found to be $E = -1$ unit . The possibe state of the system can be written as

(a) $\frac{1}{\sqrt{3}}(1 \quad 1 \quad 1)^T$ (b) $\frac{1}{\sqrt{3}}(1 \quad -1 \quad 1)^T$ (c) $(1 \quad 0 \quad 0)^T$ (d) $\frac{1}{\sqrt{2}}(1 \quad -1 \quad 0)^T$

44. If Mr. Modi speaks the truth in 80% of the cases and Mr. Kejriwal speaks truth in 70% of the cases, then the probablity that they will not contradict each other in describing the same event, will be

(a) 0.62 (b) 0.38 (c) 0.56 (d) 0.06

45. If $\int_{-\infty}^{\infty} \frac{dt}{\left(z+t^2\right)} = \frac{\pi}{\sqrt{z}}$, then the value of $\int_{-\infty}^{\infty} \frac{dt}{\left(1+t^2\right)^3}$ is equal to

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

## PART – C

46. A canonical transformation relates the old coordinates $(q, p)$ to the new ones $(Q, P)$ by the relations $Q = \frac{1}{p}$ and $P = qp^2$. The corresponding time-independent generating function is

(a) $-\frac{p}{P^3}$ (b) $\frac{P^2}{p}$ (c) $\frac{P}{p}$ (d) $-pP$

47. A smooth wire has the form of the helix $x = a\cos\theta$, $y = a\sin\theta$, $z = b\theta$, where $\theta$ is a real parameter, and $a$, $b$ are positive constants. The wire is fixed with the axis $Oz$ pointing vertically upwards. A particle of mass $m$ can slide freely on the wire. Taking $\theta$ as generalised coordinate and potential energy as zero in $xy$-plane, the conjugate momentum $p_\theta$ is

(a) $m\left(a^2+b^2\right)\dot{\theta}$ (b) $\frac{1}{2}m\left(a^2+b^2\right)\dot{\theta}$ (c) $m\left(a^2-b^2\right)\dot{\theta}$ (d) $\frac{m}{2}\left(a^2-b^2\right)\dot{\theta}$

48. As measured from lab frame, half life of an unstable particle is 1 micro seconds when it is moving with speed 0.8c. If the same particle moves with speed 0.6c, then its life will be measured to be
(a) 1 μs (b) 2 μs (c) 2.67 μs (d) 0.75 μs

49. A point particle with mass $m$ moves along the $x$-axis under the effect of a conservative force with the following potential

$$V(x) = \begin{cases} \frac{1}{2}m\omega^2\left(x+a\right)^2, & x \le -a \\ 0, & -a < x < a \\ \frac{1}{2}m\omega^2\left(x-a\right)^2, & x \ge a \end{cases}$$

where $a$ is a positive constant. When the system is in contact with a reservoir at temperature $T$, the canonical partition function of the particle is

(a) $2a\left(\frac{2\pi mk_BT}{h^2}\right)^{1/2}$ (b) $\frac{2\pi mk_BT}{h\omega}$

(c) $2a\left(\frac{2\pi mk_BT}{h^2}\right)^{1/2} + \frac{2\pi mk_BT}{h\omega}$ (d) $2a\left(\frac{2\pi mk_BT}{h^2}\right)^{1/2} - \frac{2\pi mk_BT}{h\omega}$

50. A gas of some hypothetical bosons is enclosed in a containter of volume V and temperature T. If the dispersion relation obeyed by the bosons is $E = \alpha\sqrt{p}$, where $\alpha$ is some constant and the chemical potential of the system is zero, the number of bosons in the container varies with temperature as
(a) $T$ (b) $T^2$ (c) $T^4$ (d) $T^6$

51. Consider a particle diffusing in a two dimensional box in some liquid. The diffusing constant of the particle in the liquid is $10^{-2}$ cm$^2$/sec. The standard deviation of the displacement of the particle after 1 sec is
(a) 0.1 cm (b) 0.2 cm (c) 0.3 cm (d) 0.4 cm

52. A Hydrogen atom is in the state,

$$|\psi\rangle = \frac{1}{\sqrt{3}}\left[|\phi_{2,1,0}\rangle + \sqrt{2}|\phi_{2,1,1}\rangle\right]$$

where $\{|\phi_{n,\ell,m}\rangle\}$ are orthonormal eigenstates of the system. The uncertainty in $\hat{L}_x$ for this state will be

(a) $\frac{\hbar}{3}$ (b) $\frac{\sqrt{2}\hbar}{3}$ (c) $\frac{\sqrt{5}\hbar}{3}$ (d) $\frac{\sqrt{7}\hbar}{3}$

53. The value of '$b$' that gives ground state energy of a particle of mass '$m$' in the potential $V(x) = V_0|x|$ ($V_0$ is a constant) estimated using the trial wave function $\psi(x) = Ae^{-bx^2}$; $-\infty < x < \infty$ ($b$ is the variational parameter) will be

$$\left[\text{Given: } \int_{-\infty}^{\infty} x^{2n} e^{-2bx^2} dx = \frac{\boxed{n+\frac{1}{2}}}{(2b)^{n+\frac{1}{2}}}\right]$$

(a) $\left(\frac{2\sqrt{2}V_0 m}{\hbar^2\sqrt{\pi}}\right)^{2/3}$ (b) $\left(\frac{2\sqrt{2}V_0 m}{\hbar^2}\right)^{2/3}$ (c) $\left(\frac{V_0 m}{\hbar^2}\right)^{2/3}$ (d) None of these

54. A particle of mass '$m$' is in the ground state of a 2-D isotropic harmonic oscillator of frequency $\omega$. If a perturbating potential of the from, $H' = \lambda x^4 y^4$ ($\lambda$ is a small constant) is applied, the first order correction to ground state energy will be, $\left[\int_0^{\infty} x^n e^{-\alpha x} dx = \frac{\boxed{n+1}}{\alpha^{n+1}}\right]$

(a) $\frac{9\lambda}{16}\left(\frac{\hbar}{m\omega}\right)^4$ (b) $\frac{9\lambda}{16\pi}\left(\frac{\hbar}{m\omega}\right)^4$ (c) $\frac{3\lambda}{16\pi}\left(\frac{\hbar}{m\omega}\right)^4$ (d) $\frac{3\lambda}{16}\left(\frac{\hbar}{m\omega}\right)^4$

55. A system consists of two spin 1/2 particles designated by '1' and '2'. The commutator, $\left[S_x^{(1)}S_y^{(2)}, S_y^{(1)}S_y^{(2)}\right]$ represented in the standard basis for this system will be

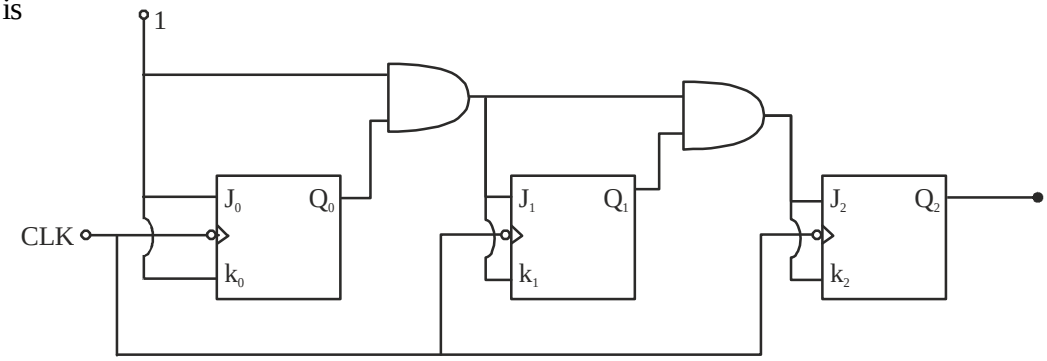
(a) $\frac{i\hbar^3}{4}\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$ (b) $-\frac{i\hbar^3}{4}\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -i & 0 \\ 0 & 0 & 0 & i \end{pmatrix}$

(c) $-\frac{i\hbar^3}{4}\begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & i & 0 \\ 0 & 0 & 0 & -i \end{pmatrix}$ (d) None of these

56. A three variable truth table has a high output of these input conditions: 111, 010, 100 and 110. The Boolean expression corresponding to the logic circuit is

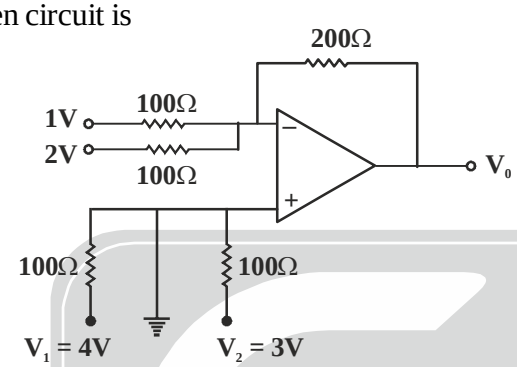
(a) $AB + C$ (b) $AB + (A \odot B)\bar{C}$ (c) $AB + (A \oplus B)\bar{C}$ (d) $(A \odot B)C$

57. Consider the synchronous counter with initial outputs $(Q_2Q_1Q_0 = 100)$. The outputs after three clock pulse is




(a) 010 (b) 011 (c) 111 (d) 000

58. The output of the given circuit is




(a) –6V (b) –5V (c) –3V (d) –4V

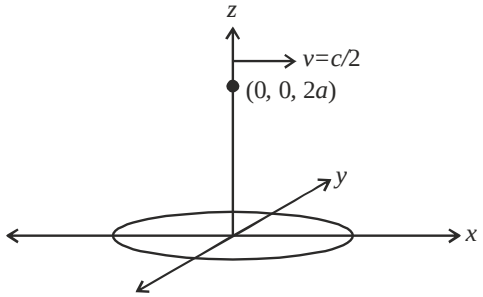
59. In Young's double slit interference experiment, the slits are at a distance $L$ from each other and the screen is at distance $D$ from the slits. If two glass slabs of refractive index $n_1$=3 and $n_2$=2 and thickness $d_1$ and $d_2$ are placed in the path of the two beams. The maximum wavelength of light for which central fringe will be dark

(a) $4d_1 - 2d_2$ (b) $2d_1 - d_2$ (c) $\left(\frac{4d_1 - 2d_2}{3}\right)$ (d) $\left(\frac{2d_1 - d_2}{2}\right)$

60. Consider magneic vector potential $\vec{A}$ and scalar potential $\phi$, which defined the magnetic field $\vec{B}$ and electric field $\vec{E}$. If one adds $\alpha tr^2\hat{r}$ to $\vec{A}$, the function added to $\phi$ such that $\vec{E}$ remains unchanged is

(a) $\frac{\alpha r^2}{2}$ (b) $-\frac{\alpha r^3}{3}$ (c) $-\frac{\alpha r^3}{2}$ (d) $-2\alpha tr$

61. Some amount of charges are uniformly distributed on disc of radius $a$, is placed at rest in $xy$ plane as shown in the figure below. The field due to this disc at (0, 0, 2a) is $\frac{\sigma_0}{\varepsilon_0}\left(1 - \frac{2}{\sqrt{5}}\right)$ in rest frame. If an observer moving with velocity $\frac{c}{2}$ along $x$-axis, he will observe the charge density on the disc is




(a) $\frac{\sqrt{3}\sigma_0}{2}$ (b) $\frac{4\sigma_0}{\sqrt{3}}$ (c) $\sigma_0$ (d) $\frac{2\sigma_0}{\sqrt{3}}$

62. Given magnetic vector potential $\vec{A} = y\cos(ax)\,\hat{x} + (y + e^x)\,\hat{z}$. The current density corresponding to this magnetic vector potential is

(a) $\frac{1}{\mu_0}\left[a\cos(ax)\,\hat{x} + e^x\hat{y}\right]$ (b) $-\frac{1}{\mu_0}\left[a\sin(ax)\,\hat{y} + e^x\hat{z}\right]$

(c) $\frac{1}{\mu_0}e^x\hat{z}$ (d) $-\frac{a}{\mu_0}\sin(ax)\,\hat{y}$

63. Choose the correct option from the following statements.

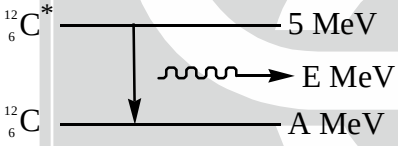
(a) In reaction, $\pi^- + p \to \pi^0 + \Lambda^0$, charge and strangeness number are conserved but baryon number is violated.

(b) In reaction, $\pi^+ + n \to \Lambda^0 + k^+$, charge and baryon number are conserved but strangeness number is violated

(c) In reaction, $\pi^+ + n \to k^0 + k^+$, charge is conserved but baryon number, strangeness number and third component of isospin are violated.

(d) The reaction, $\pi^+ + n \to \Xi^- + k^+ + k^+$ is forbidden.

64. $^{12}_{7}N$ nucleus beta decays to an excited state of $^{12}_{6}C$ i.e. $^{12}_{6}C^*$ as shown in figure which subsequently decays to the ground state with the emission of $\gamma$-photon of E MeV energy. The energy levels of $^{12}_{6}C^*$ and $^{12}_{6}C$ is shown in figure. If the kinetic energy of neutrino is 6 MeV and kinetic energy of emitted beta particle is 6.908 MeV, then the vlaue of A in MeV for energy level of $^{12}_{6}C$ is




[Given: Atomic masses $M\left(^{12}_{7}N\right) = 12.018613\ amu$ and $M\left(^{12}_{6}N\right) = 12.0\ amu$ ]

(a) 0.63 MeV (b) 1.32 MeV (c) 1.58 MeV (d) 3.42 MeV

65. A nucleus X undergoes a first forbidden $\beta$-decay to Y. If the angular momentum (I) and parity (P) denoted by $I^P$ is $\frac{3^+}{2}$ for X, then which of the following is a possible $I^P$. The value of Y by Gammow-Teller selection rule and not by Fermi-selection rule.

(a) $\frac{3^+}{2}$ (b) $\frac{5^-}{2}$ (c) $\frac{7^-}{2}$ (d) $\frac{7^+}{2}$

66. Of the following term symbols of the $nd^2$ atomic configurations, $^1S_0$, $^3P_{0,1,2}$, $^1D_2$, $^3F_{2,3,4}$, $^1G_4$, which is the ground state?

(a) $^3P_0$ (b) $^1G_4$ (c) $^3F_2$ (d) $^3F_4$

67. For a two level system, the population of atoms in the upper and lower levels are $6\times10^{18}$ and $1.4\times10^{18}$ respectively. If the coefficient of stimulated emission is $6\times10^5\ m^3/ws^3$ and the energy density is $4.5\ J/m^3\ Hz$, the rate of stimulated emission will be

(a) $2.4\times10^{25}$ /sec (b) $8.1\times10^{24}$ /sec (c) $3.78\times10^{24}$ /sec (d) $1.62\times10^{25}$ /sec

68. Consider the following differential equation

$$\frac{d^2y}{dt^2}-4\frac{dy}{dt}+8y=3\,\delta(t+2)-2\,\delta(t-1)$$

with initilal conditions $y(0)=0,\ y'(0)=0$. The Laplace Transform of the solution of the differential equation, in the frequency domain, will be

(a) $\frac{3e^{-2s}-2e^{s}}{s^2-4s+8}$ (b) $-\frac{2e^{s}}{s^2-4s+8}$ (c) $\frac{3e^{2s}-2e^{-s}}{s^2-4s+8}$ (d) $\frac{2e^{s}}{s^2-4s+8}$

69. The molecule that will exhibit a pure rotational absorption spectrum out of this

(a) $CH_4$ (b) $CO_2$ (c) $O_2$ (d) $NF_3$

70. Consider the following algebraic equation $x^3=20$, whose exact root is gven to be $x_0=2.714$ (rounded-off upto three decimal places). If we try to find the roots of the equation using Newton Raphson iterative method with initial guess value $x_{in}=3.0$, then the error in the result after first iteration, will be

(a) 0.43% (b) 0.62% (c) 0.96% (d) 1.27%

71. Which of the following statements is CORRECT?

(a) the set of all integers form an abelian group under addition.

(b) the set of all non-zero rational numbers form an abelian group under multiplication.

(c) the set of all $n^{th}$ roots of unity form a finite abelian group of order $n$ under multiplication.

(d) All of the above.

**[NOTE: For an abelian group, $a*b=b*a$ for all $a,b\in G$ ]**

72. Consider the following partial differential equation: $\frac{\partial^2u}{\partial x^2}+\frac{\partial^2u}{\partial y^2}=0$ with the conditions $u(0,y)=u(L,y)=u(x,0)=0,\ u(x,a)=\sin\frac{n\pi x}{L}$. The solution of the equlation will be of the form

(a) $\sin\left(\frac{2n\pi x}{L}\right).\frac{\cosh\left(\frac{n\pi y}{L}\right)}{\cosh\left(\frac{n\pi a}{L}\right)}$ (b) $\sin\left(\frac{2n\pi x}{L}\right).\frac{\sinh\left(\frac{n\pi y}{L}\right)}{\sinh\left(\frac{n\pi a}{L}\right)}$

(c) $\sin\left(\frac{n\pi x}{L}\right).\frac{\cosh\left(\frac{n\pi y}{L}\right)}{\cosh\left(\frac{n\pi a}{L}\right)}$ (d) $\sin\left(\frac{n\pi x}{L}\right).\frac{\sinh\left(\frac{n\pi y}{L}\right)}{\sinh\left(\frac{n\pi a}{L}\right)}$

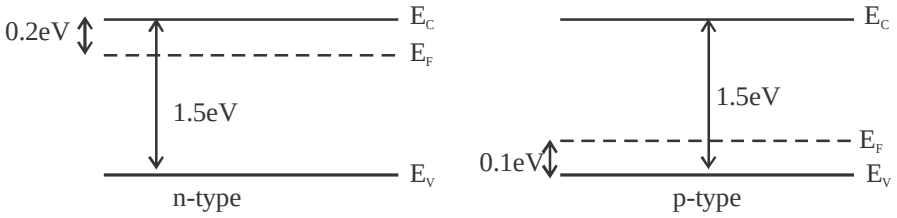
73. The dispersion relation for an electron in a solid is $\omega\ (k)=\omega_0\left(3-\cos k_x a-\cos k_y a-\cos k_z a\right)$. The effective mass (m*) at BZ boundary is

(a) $\frac{\hbar}{\omega_0 a^2}$ (b) $-\frac{\hbar}{\omega_0 a^2}$ (c) $\frac{2\hbar}{\omega_0 a^2}$ (d) $-\frac{2\hbar}{\omega_0 a^2}$

74. X-rays are diffracted from a set of planes with miller indices (110) in NaCl crystal at Bragg angle of 30°. If the lattice parameter (a) of the crystal is 4.2Å, the wavelength $\lambda$ of the X-rays is:

(a) 2.96Å (b) 5.94Å (c) 1.48Å (d) 4.2Å

75. A p-type and n-type semiconductor have energy band diagram as shown in the figure. The p-n junction assume to be constructed from these semiconductors.




The built-in voltage of p-n junction is

(a) 0.3 volt (b) 1.5 volt (c) 1.8 volt (d) 1.2 volt

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**Date : 04-06-2019**

## ANSWER KEY

### PART-A

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

### PART-B

| | | | | | | |
|---|---|---|---|---|---|---|
| 21. (b) | 22. (c) | 23. (a) | 24. (b) | 25. (a) | 26. (d) | 27. (b) |
| 28. (a) | 29. (c) | 30. (b) | 31. (c) | 32. (d) | 33. (d) | 34. (b) |
| 35. (c) | 36. (b) | 37. (c) | 38. (d) | 39. (a) | 40. (c) | 41. (a) |
| 42. (b) | 43. (d) | 44. (a) | 45. (a) | | | |

### PART-C

| | | | | | | |
|---|---|---|---|---|---|---|
| 46. (c) | 47. (a) | 48. (d) | 49. (c) | 50. (d) | 51. (b) | 52. (b) |
| 53. (a) | 54. (a) | 55. (a) | 56. (c) | 57. (c) | 58. (a) | 59. (a) |
| 60. (b) | 61. (b) | 62. (b) | 63. (c) | 64. (c) | 65. (c) | 66. (c) |
| 67. (d) | 68. (b) | 69. (d) | 70. (c) | 71. (d) | 72. (d) | 73. (b) |
| 74. (c) | 75. (d) | | | | | |