TEST SERIES CSIR-NET/JRF DEC. 2018

BOOKLET SERIES F

FULL LENGTH TEST - II

Paper Code 05

Test Type: TEST SERIES

PHYSICAL SCIENCES

Duration: 3:00 Hours

Date: 08-12-2018

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.

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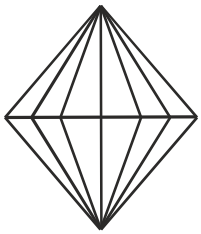
PART-A

1. Anup is standing facing the North side. He goes 30 metres forward and then he turns left and goes for 5 metres. He then turns to his right and goes for 25 metres and finally turns to his right side and continues to walk. Which direction is he facing now ?
(a) East (b) West (c) North (d) South

2. Count total number of triangles in the figure given



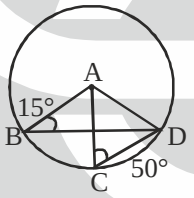
(a) 42 (b) 48 (c) 50 (d) 56

3. A circular wire has a diameter of 14 cm. If it is cut and a square is made of the wire then what is the area of the square formed ?
(a) 144 sq. cm (b) 49 sq. cm (c) 196 sq. cm (d) 121 sq. cm

4. In how many ways a committee of 5 members can be formed from 6 executives and 5 technicians consisting of 3 executives and 2 technicians ?
(a) 120 (b) 200 (c) 150 (d) 300

5. A right circular cone is devided in two parts of equal height. What is the ratio of the volume of upper part to the lower part ?
(a) 7 : 1 (b) 1 : 7 (c) 3 : 5 (d) 2 : 5

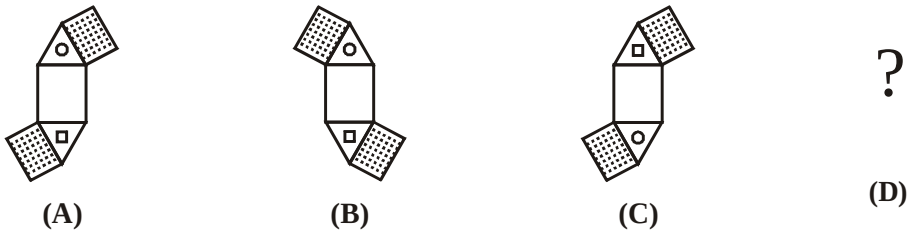
6. In the below figure A is the centre of the circle and $\angle ACD = 50°$, and $\angle ABD = 15°$, then $\angle BAC = ?$

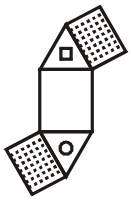
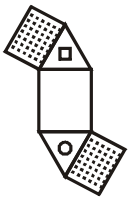
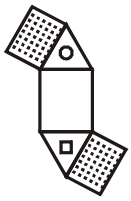
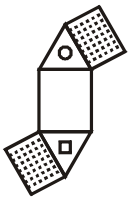


(a) 100° (b) 70° (c) 80° (d) 75°

7. Pointing to a Photograph of Ram, Vimal said, "The father of his sister is the husband of my wife's mother". How is vimal related to Ram.
(a) Brother in law (b) Son in law (c) Cousin (d) Father

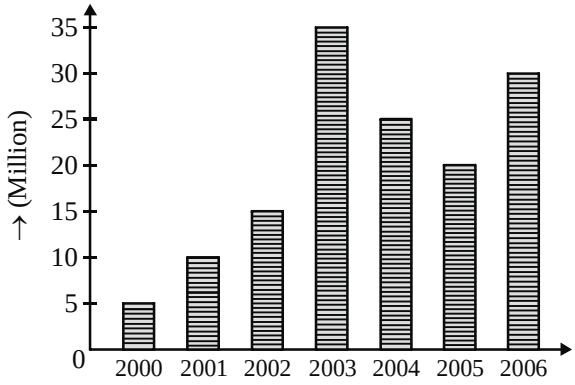
8. Find the next figure "D"



(a)  (b)  (c)  (d) 

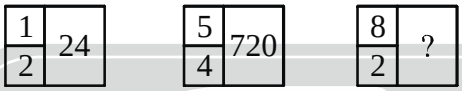
9. If in a certain code 'TEACHER' is coded 'UGDGMKY' , then what will be the code for 'STUDENT'
(a) TVXHJAT (b) SUXHJTT (c) TVXHJTA (d) RUYHJTA

10. Below is given a graph which represents, revenue of a bank in million from year 2000 to 2006. By how much percent revenue increased in 2006 as compared to average revenue over the years ?



(a) 55 % (b) 60 % (c) 75 % (d) 50 %

11. Based on the pattern followed in (I) and (II), find out what should come in place of question mark (?) in (III) ?



(I) (II) (III)

(a) 900 (b) 990 (c) 100 (d) 984

12. $2^{16} - 1$ is not divisible by which of the following ?

(a) 17 (b) 5 (c) 3 (d) 11

13. Amit and Barun completes a work in 10 days, Barun and Christine does the same work in 5 days, where Christine and Amit does the work in 6 days. In how many days working together they can complete the work?

(a) 5 days (b) $3\frac{2}{7}$ days (c) $4\frac{2}{7}$ days (d) $5\frac{2}{3}$ days

14. If 1st january is friday in 2017, then what is the day on 2nd january 2018 ?
(a) Saturday (b) Sunday (c) Monday (d) Tuesday

15. How many kg of rice costing ` 8 per kg should be mixed with 40 kg rice costing 5 : 40 per kg to gain a profit of 20 % by selling the mixture at ` 7. 20 per kg ?
(a) 10 (b) 12 (c) 14 (d) 15

16. If $\frac{1}{b-a}+\frac{1}{b-c}=\frac{1}{a}+\frac{1}{c}$, then a, b, c are in
(a) AP (b) GP (c) HP (d) None of these

17. A train running at a speed of 54 km/hr reaches the destination 10 min late the same train running at a speed of 72 km per hour reaches 20 min earlier. What is the distance that the train covers ?
(a) 92 km (b) 108 km (c) 216 km (d) 432 km

18. A box contains 8 green balls and 6 red balls. Balls are picked from the box in random. What is the minimum number of balls to the picked to ensure that at least two green balls or two red balls have been picked.
(a) 3 (b) 14 (c) 8 (d) 6

19. Random errors associated with the measurement of P and Q are 4% and 3% respectively. What is the percentage random error in P/Q ?
(a) 1 % (b) 7 % (c) $\sqrt{12}$ % (d) 5 %

20. In each of the following pair of words hides a numbers. Based on these numbers you have to arrange them in ascending order and to choose the correct order ?

(1) Smooth reel (2) Valiant wonder (3) Small toner
(4) Wifi venture (5) Haze road

(a) 3, 5, 2, 4, 1 (b) 5, 3, 2, 1, 4 (c) 5, 2, 3, 1, 4 (d) 5, 3, 2, 4, 1

PART-B

21. A particle of rest mass m_0 initially at rest is subjected to a constant force. After travelling a distance x its speed becomes $\frac{3c}{5}$. Then kinetic energy of the particle after travelling distance $2x$ is

(a) $2m_0c^2$ (b) $\frac{m_0c^2}{2}$ (c) $\frac{10m_0c^2}{3}$ (d) $\frac{5m_0c^2}{2}$

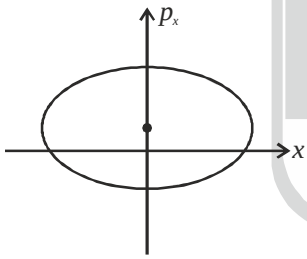
22. A rectangular plate of sides 'a' and 'b' and mass M is rotated about its diagonal with angular speed ω. Angular momentum of the plate is

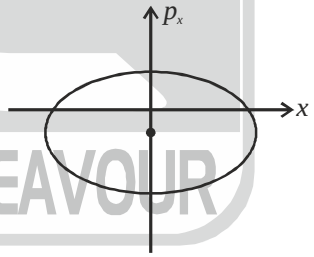
(a) $\frac{Mab\omega}{12}$ (b) $\frac{M(a^2+b^2)\omega}{12}$ (c) $\frac{Ma^2b^2\omega}{6(a^2+b^2)}$ (d) $\frac{Ma^2b^2\omega}{12(a^2+b^2)}$

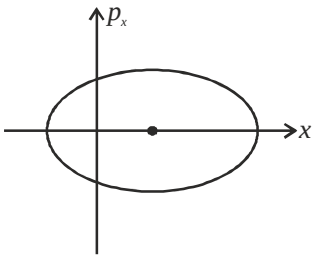
23. Lagrangian of a particle is $L=\frac{1}{3}\dot{x}^2-x^3+x^2$. If the particle is released at $x=1$ then its speed at $x=\frac{2}{3}$ will be

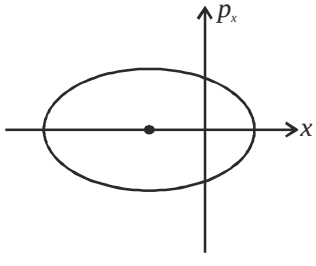
(a) $\frac{2}{3}$ (b) 1 (c) $\frac{1}{3}$ (d) $\frac{1}{2}$

24. Lagrangian of a particle is $L=\frac{1}{2}m\dot{x}^2-K\dot{x}-\frac{1}{2}Kx^2$. Phase space trajectory of the particle is given as

(a) 

(b) 

(c) 

(d) 

25. Consider three operators $\hat{A},\hat{B}$ and $\hat{C}$ such that, $\hat{A}=\hat{\sigma}_x\,\hat{\sigma}_y, \hat{B}=\hat{\sigma}_y\hat{\sigma}_z, \hat{C}=\hat{\sigma}_z\hat{\sigma}_x$, then the value of commutator $\left[\hat{A}\hat{B},\hat{C}\hat{A}\right]$ is equal to

(a) $2i\hat{\sigma}_x$ (b) $2i\hat{\sigma}_y$ (c) $i\hat{\sigma}_x$ (d) None of these

26. Consider the following function and curve in the complex argand plane:

$$f(z)=\frac{\sinh(z)\cdot e^{z}}{z^{5}};\quad c:\frac{(x-1)^{2}}{9}+\frac{(y+1)^{2}}{16}=1$$

Which of the following statements is correct?

(a) $z = 0$ is a 5th order pole and $\oint_c f(z)dz=\frac{4\pi i}{3}$

(b) $z = 0$ is a 4th order pole and $\oint_c f(z)dz=\frac{4\pi i}{3}$

(c) $z = 0$ is a 5th order pole and $\oint_c f(z)dz=\frac{2\pi i}{3}$

(d) $z = 0$ is a 4th order pole and $\oint_c f(z)dz=\frac{2\pi i}{3}$

27. In an oil refinery, a storage tank contains 2000 gallon of gasoline that initially has 100kg of an additive dissolve in it. In preparation winter weather, gasoline containing 2kg of additive per gallon, is pumped into the tank at a rate 40 gallon/min. The well mixed solution is then pumped out at a rate 45 gallon/min. Which of the following equation describes the rate of change of the amount of additive in the tank w.r.t. time t?

(a) $\frac{dy}{dt}+\frac{45}{2000-5t}y=80$ (b) $\frac{dy}{dt}+\frac{45}{2000-5t}=40$

(c) $\frac{dy}{dt}=2000-5t$ (d) $\frac{dy}{dt}=y-(2000-5t)$

28. 10 electrons are placed in a 3-D harmonic oscillator with a potential of the form,

$$V(\vec{r})=\frac{k}{2}\left(x^{2}+2y^{2}+4z^{2}\right)\quad [k \text{ is a constant}]$$

The ground state energy of the system is E_e. If the electrons are replaced by Higgs and the ground state energy is found to be E_g, $\frac{E_e}{E_g}$ is equal to

(a) $\sqrt{\frac{m_e}{m_g}}$ (b) $\frac{23+4\sqrt{2}}{15}\sqrt{\frac{m_g}{m_e}}$ (c) 1 (d) $\frac{23-4\sqrt{2}}{15}\sqrt{\frac{m_e}{m_g}}$

[**Note:** m_e and m_g are electron and Higgs masses, respectively]

29. The *s*-wave and *p*-wave phase shifts, when a beam of particles of energy 12 MeV is scattered by a target are 60° and 30° respectively. When the energy is changed, the values of *s* and *p* wave phase shifts become 90° and 60°, respectively. If the scattering cross-section remain unchanged, the energy of the changed beam is,

(a) 12 MeV (b) 26 MeV (c) 48 MeV (d) 24 MeV

30. A particle of mass *m* is in an attractive delta function potential of the form

$$V(x) = -\alpha\delta(x) \qquad [\alpha > 0]$$

The ground state energy of the system, estimated using the trial normalized wave function

$$\psi(x) = \begin{cases} \frac{1}{\sqrt{a}}\cos\frac{\pi x}{2a} & ; \quad |x| \le a \\ 0 & ; \quad |x| > 0 \end{cases}$$

is,

(a) $-\frac{m\alpha^2}{\hbar^2\pi}$ (b) $-\frac{m\alpha^2}{\hbar^2\pi^2}$ (c) $-\frac{2m\alpha^2}{\hbar^2\pi}$ (d) $-\frac{2m\alpha^2}{\hbar^2\pi^2}$

31. Suppose the following information is known about a 3×3 matrix A

$A\begin{bmatrix}1\\2\\1\end{bmatrix} = 6\begin{bmatrix}1\\2\\1\end{bmatrix}$, $A\begin{bmatrix}1\\-1\\1\end{bmatrix} = 3\begin{bmatrix}1\\-1\\1\end{bmatrix}$; $A\begin{bmatrix}2\\-1\\0\end{bmatrix} = 3\begin{bmatrix}1\\-1\\1\end{bmatrix}$. Then eigenvalues of *A* are

(a) 6, 3, 3 (b) 6, 3, 0 (c) 6, 1, 3 (d) None of these

32. The finish times for marathan runners during a race is normally distributed with a mean of 195 minutes and a standard deviation of 25 minutes. What is the probability that a runner wil complete the marathan within 170 minute

(a) 0.1600 (b) 0.2401 (c) 0.02301 (d) 0.2610

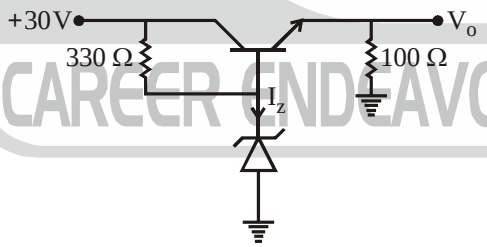
33. Minimum number of two input NAND gate to design function $f = x\bar{y}z$ is ?

(a) 4 (b) 5 (c) 6 (d) 7

34. $(21)_3 = \sqrt{(100)_x}$, the value of *x* = ... ?

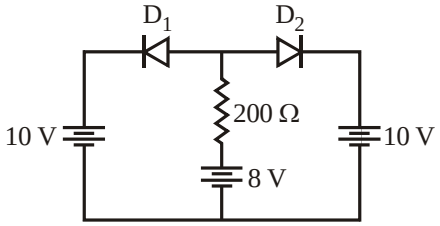
(a) 5 (b) 6 (c) 7 (d) None of these

35. For circuit shown in figure, the transistor has $\beta = 40$, $V_{BE} = 0.7\,V$ and voltage across zener diode is 15 V. The current (in mA) through the zener diode is ?



(a) 39 mA (b) 42 mA (d) 46 mA (d) 38 mA

36. For circuit shown assume ideal diode with zero forward resistance, zero forward voltage drop. The current through the diode D_2 in mA is ?



(a) 0 mA (b) 10 mA (c) 15 mA (d) 20 mA

37. In a setup two chamber 1 and 2 are enclosed by a thermally insulated material. Chamber 1 contains an ideal gas at 100 atm. Chamber 2 is completely evacuated. The two chambers are separated by a breakable seal before the seal is broken, the temperature of the chamber 1 is $T_{1,\,initial}$. Then the seal is broken, and the gas is allowed to rush the chamber 2. The volume of chamber 2 is 100 times the volume of chamber 1. When the pressure in the two chambers becomes equal and their respective temperature is $T_{1.final}$ and $T_{2.final}$. Which of the following statements is true?

(a) $T_{1.\,final} = T_{2.\,final} = T_{1.initial}$ (b) $T_{1.\,final} = T_{2.\,final} < T_{1.initial}$

(c) $T_{2.\,final} < T_{1.\,final} = T_{1.initial}$ (d) $T_{2.\,final} > T_{1.\,final}, T_{1.\,final} = T_{1.initial}$

38. The equation for a real gas is given by

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

If P_c, V_c and T_c represent critical pressure, critical volume and critical temperature respectively, the value of vander Waal's constant *a* and *b*, respectively, are

(a) $\frac{27}{64}\frac{R^2T_c^2}{P_c}, \frac{8RT_c}{P_c}$ (b) $\frac{64}{27}\frac{R^2T_c^2}{P_c}, \frac{8RT_c}{P_c}$ (c) $\frac{27}{64}\frac{R^2T_c^2}{P_c}, \frac{RT_c}{8P_c}$ (d) $\frac{64}{27}\frac{R^2T_c^2}{P_c}, \frac{RT_c}{8P_c}$

39. An isolated blackbody expands into vacuum from an initial volume V_0 to a final volume $2V_0$. If the initial temperature of the blackbody is T_0, the final temperature will be

(a) $16T_0$ (b) $\frac{T_0}{2^{1/4}}$ (c) $8T_0$ (d) $\frac{T_0}{2^{1/3}}$

40. A charge Q is split into two parts *q* and *Q–q*. The value of *q* for which the repulsive force will be maximum between them, when they placed at a given distance apart, is

(a) $q = \frac{Q}{3}$ (b) $q = \frac{Q}{4}$ (c) $q = \frac{Q}{2}$ (d) $q = \frac{2Q}{3}$

41. Consider a thin rod with its one end at *z* = 0 and the other end at $z = \ell$. Its charge density is given by $\rho(z) = \alpha\left(z - \frac{\ell}{2}\right)$ for $0 \le z \le \ell$. Area of cross-section of the rod is *A*. The electrostatics field at point far away from the origin is proportional to

(a) r^{-5} (b) r^{-4} (c) r^{-3} (d) r^{-2}

42. A conducting sphere of radius *a* is surrounded by a thick spherical metallic shell having inner and outer radius 2*a* and 4*a* respectively. The outer shell is isolated and initially uncharged. Charge +*Q* is placed on the inner sphere. The capacitance of the system is

(a) $4\pi\varepsilon_0 a$ (b) $16\pi\varepsilon_0 a$ (c) $\frac{16\pi\varepsilon_0 a}{3}$ (d) $\frac{4}{3}\pi\varepsilon_0 a$

43. A long wire has a circular cross-section with radius *a*. The current density in the wire is $J(r) = J_0\left(\frac{a^2 - r^2}{a^2}\right)$ where *r* is the distance from the axis. The value of *r* for which the magnetic field will be maximum is

(a) *r* = 0 (b) *r* = *a* (c) $r = \sqrt{\frac{2}{3}}\,a$ (d) $r = \frac{a}{2}$

44. When a linear polarized light is incident on the interface of air and dielectric medium at angle 60° the transmitted light make angle 30° with the normal. Now, if we replace linear polarized light by a circular polarized and is incident at an angle 45°. Then,
(a) Reflected light will be linear polarized light.
(b) Transmitted light will be linear polarized light.
(c) Both reflected and transmitted light will be elliptical polarized light.
(d) Reflected light will be linearly polarized but transmitted light will be elliptical polarized light.

45. A beam of particles each of mass m and energy $\frac{\pi^2\hbar^2}{2mL^2}$, is incident from left on the following potential barrier.

$$V(x)=\begin{cases}0 & for\ x<0\\ \frac{\pi^2\hbar^2}{2mL^2} & for\ 0\le x\le L\\ 0 & for\ x>L\end{cases}$$

The transmission coefficient T will be approximated

(a) $\left(1+\frac{\pi^2}{2}\right)^{-1}$ (b) $\left(1+\frac{\pi^2}{4}\right)^{-1}$ (c) $\left(1+\frac{2}{\pi^2}\right)^{-1}$ (d) $\left(1+\frac{4}{\pi^2}\right)^{-1}$

PART-C

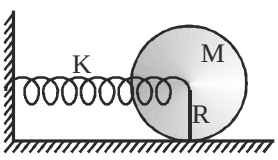
46. A particle moves in one dimensional potential $V(x)=\frac{(x-2)^2}{2}$. Which of the following statements is not correct.
(a) Motion of particle S.H.M.
(b) If amplitude of oscillation is doubled then time period becomes half
(c) If energy of particle is 2 then amplitude of oscillation is 2
(d) Phase space trajectory of particle is ellipse

47. A particle of mass m and angular momentum l has Lagrangian $L=\frac{1}{2}mr^2-\frac{l^2}{2mr^2}+\frac{K}{r}$. If energy of the particle is zero then minimum value of r is

(a) $\frac{l^2}{mK}$ (b) $\frac{2l^2}{mK}$ (c) $\frac{l^2}{2mK}$ (d) 0

48. In figure shown center of disc is attached to a rigid support with a light spring of force constant K. If the disc rolls without slipping then time period of oscillation will be

(a) $2\pi\sqrt{\frac{M}{K}}$ (b) $2\pi\sqrt{\frac{2M}{K}}$



(c) $2\pi\sqrt{\frac{3M}{2K}}$ (d) $2\pi\sqrt{\frac{M}{2K}}$

49. Given the generating function of legendre polynomials $P_n(x)$

$$\left(1-2xt+t^2\right)^{-1/2}=\sum_{n=0}^{\infty}P_n(x)t^n \quad \left[|t|<1\right]$$

The term $P'_{2n+1}(0)$ can be expressed as

(a) $(2n-1)P_{2n}(0)$ (b) $(2n+1)P_{2n}(0)$ (c) $-(2n-1)P_{2n}(0)$ (d) $-(2n+1)P_{2n}(0)$

50. Consider the following function:

$$f(t)=\begin{cases}\cos t & for \quad |t|\le\dfrac{\pi}{2}\\ 0 & for \quad |t|\ge\dfrac{\pi}{2}\end{cases}$$

The fourier transform $\left[\tilde{f}(\omega)=\dfrac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}f(t)e^{-i\omega t}dt\right]$ of $f(t)$ will be

(a) $\tilde{f}(\omega)=\dfrac{1}{\sqrt{2\pi}}\dfrac{\cos\frac{\omega\pi}{2}}{1-\omega^2}$

(b) $\tilde{f}(\omega)=\sqrt{\dfrac{2}{\pi}}\dfrac{\cos\frac{\omega\pi}{2}}{1-\omega^2}$

(c) $\tilde{f}(\omega)=\dfrac{1}{\sqrt{2\pi}}\dfrac{\cos\frac{\omega\pi}{2}}{1-\omega^2}$ for $\omega\neq\pm1$

$=\dfrac{\sqrt{2\pi}}{4}$ for $\omega=\pm1$

(d) $\tilde{f}(\omega)=\sqrt{\dfrac{2}{\pi}}\dfrac{\cos\frac{\omega\pi}{2}}{1-\omega^2}$ for $\omega\neq\pm1$

$=\dfrac{\sqrt{2\pi}}{2}$ for $\omega=\pm1$

51. The wavefunction of an electron in a hydrogen atom is given by

$$\psi_{2s}(\vec{r})=\frac{1}{4\sqrt{2\pi a_0^3}}\left(2-\frac{r}{a_0}\right)e^{-\frac{r}{2a_0}} \quad \left[a_0 \text{ is the Bohr radius}\right]$$

The magnitude of average electric dipole moment of the hydrogen atom will be

(a) $4e\,a_0$ (b) $5e\,a_0$ (c) $6e\,a_0$ (d) $2e\,a_0$

52. Consider a particle in 1-D system with a symmetric potential energy , wave function of the particle of the lowest two normalized eigenstates are $|\psi_0\rangle$ and $|\psi_1\rangle$ respectively. If $|\psi\rangle=a|\psi_0\rangle+b|\psi_1\rangle$ [*a,b* are real constants] is a normalized state and $\hat{P}|\psi\rangle$ is orthogonal to $|\psi\rangle$ which is the correct option?

[$\hat{P}$ is the parity operator]

(a) $a=\dfrac{1}{\sqrt{2}},b=-\dfrac{1}{\sqrt{2}}$ (b) $a=\dfrac{1}{\sqrt{3}},b=\sqrt{\dfrac{2}{3}}$ (c) $a=\dfrac{1}{2},b=\dfrac{\sqrt{3}}{2}$ (d) $a=\dfrac{\sqrt{3}}{2},b=\dfrac{1}{2}$

53. Consider a particle of mass *m* under a potential of the form

$$V(x)=\frac{2\hbar^2k^2}{m}x^2\left[-\infty\le x\le\infty\right]$$ [where *k* is a constant of appropriate dimension]

The values of *n* for which

$\psi_n(x)=A_nx^n\,e^{-kx^2}$, where A_n is the normalization constant for the n^{th} state will be an energy eigenstate of the system are

(a) $n=0,1$ (b) $n=1,2$ (c) $n=0,2$ (d) $n=2,4$

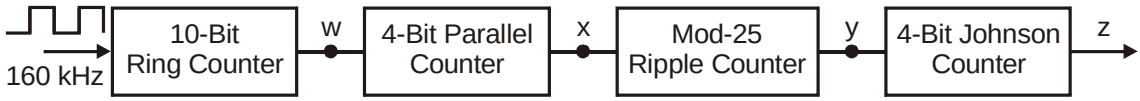
54. A constant perturbation of the form $H' = by^2$ is applied on an isotropic 3-D harmoninc oscillator of frequency 'ω'. The first order correction to ground state energy of a particle of mass *m*.

[Ground state wave function of the oscillator is , $\psi_0(\vec{r}) = \left(\frac{m\omega}{\pi\hbar}\right)^{3/4} e^{-\frac{m\omega r^2}{2\hbar}}$]

$$\left[\textbf{Given}: \int \sin^4 x dx = \frac{3x}{8} - \frac{1}{4}\sin 2x + \frac{1}{32}\sin 4x + c \text{ and } \int_0^\infty x^{2n} e^{-ax^2} dx = \frac{1}{2}\frac{\Gamma\left(n+\frac{1}{2}\right)}{a^{n+\frac{1}{2}}}\right]$$

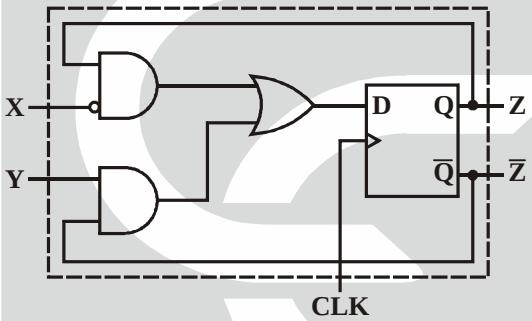
(a) $\frac{3\pi b}{64}\left(\frac{m\omega}{\hbar}\right)^{-1}$ (b) $\frac{9\pi b}{64}\left(\frac{m\omega}{\hbar}\right)^{-1}$ (c) $\frac{9\pi b}{4}\left(\frac{m\omega}{\hbar}\right)^{-1}$ (d) $\frac{3\pi b}{4}\left(\frac{m\omega}{\hbar}\right)^{-1}$

55. The frequency of the pulse at z in the network shown in figure below is



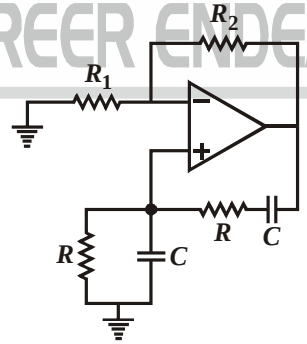
(a) 10 Hz (b) 160 Hz (c) 40 Hz (d) 5 Hz

56. A sequential circuit using D-flip-flop and logic gates is shown below where X and Y are the inputs and Z is the output. The circuit is



(a) S-R FF with inputs X = R and Y = S (b) S-R FF with inputs X = S and Y = R
(c) J-K FF with inputs X = J and Y = K (d) J-K FF with inputs X = K and Y = J

57. In the following circuit minimum required value of R_2/R_1 to sustain oscillation is



(a) 1.5 (b) 1 (c) 2 (d) 4

58. 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) $AT + BT^3$

59. The first order XRD from (100) planes, in fcc solid, is observed at 120°. If wavelength of incident X-ray is 1.5 Å, the lattice constant of solid is

(a) $\sqrt{3}\ Å$ (b) $\frac{\sqrt{3}}{2}\ Å$ (c) $\frac{1}{2}\ Å$ (d) 1Å

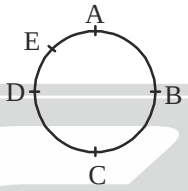
60. The tight binding energy dispersion relation for electrons in an fcc crystal is given as

$$E(k) = -\alpha - 4\beta\left[\cos\left(\frac{k_x a}{2}\right)\cos\left(\frac{k_y a}{2}\right) + \cos\left(\frac{k_y a}{2}\right)\cdot\cos\left(\frac{k_z a}{2}\right) + \cos\left(\frac{k_z a}{2}\right)\cdot\cos\left(\frac{k_x a}{2}\right)\right]$$

Where a is lattice constant and $\alpha > 0$. The effective mass (m^*) at $\left(\frac{2\pi}{a}, 0, 0\right)$ is

(a) $-\frac{\hbar^2}{\beta a^2}$ (b) $\frac{\hbar^2}{2\beta a^2}$ (c) $-\frac{\hbar^2}{4\beta a^2}$ (d) $-\frac{\hbar^2}{2\beta a^2}$

61. Five students ABCDE are sitting in a circle at equidistant as shown in the following figure.



Student A has a book in the beginning. She passes the book to the student on her left or the student on her right with equal probability. What is the probability that the book come back to student A, if the book is being exchanged 5 times?

(a) $\frac{1}{16}$ (b) $\frac{3}{16}$ (c) $\frac{1}{32}$ (d) $\frac{3}{32}$

62. A rod of length 1m with insulated side is initially at a uniform temperature u_0. Its ends are suddenly coded to 0°C and are kept at that temperature. Find the temperature $u(x,t)$ by solving the heat equation.

$$k\frac{\partial^2 u}{\partial x^2} = \frac{\partial u}{\partial t}$$

subjected to boundary conditions $u(0,t) = u(1,t) = 0$ for all t and the initial condition $u(x,0) = u_0,\ 0 < x < 1$.

(a) $\sum_{n=1,3,5,.....}^{\infty} \frac{4}{n\pi}\sin(n\pi x)e^{-c_n^2 t}$ (b) $\sum_{n=1,2,3,4.....}^{\infty} \frac{4}{n\pi}\sin(n\pi x)e^{-c_n^2 t}$

(c) $\sum_{n=2,4,6,.....}^{\infty} \frac{4}{n\pi}\sin(n\pi x)e^{-c_n^2 t}$ (d) None of these

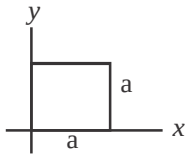
63. Given the initial value problem, $\frac{dy}{dx} = 1 - 0.25y + 0.2x$, with $y(0) = 1$. Then the value of $y(1)$ using Euler's method is [Given: step size $h = 0.5$]

(a) 1.650 (b) 1.750 (c) 0.650 (d) 0.750

64. A real gas expands isobarically and reversibly in an adiabatic container. Which of the following thermodynamic potential gets minimized?

(a) Helmholtz free energy (b) Gibbs free energy
(c) Enthalpy (d) Internal energy

65. In the figure shown below, there exists a non-uniform time varying magnetic field $\vec{B} = bx^3t\hat{z}$ and a square loop of side *a* lies in the first quadrant. The *e.m.f* induced in the loop is,



(a) $\frac{-ba^5}{2}$ (b) $\frac{-ba^5}{16}$ (c) $\frac{-ba^5}{4}$ (d) $\frac{-ba^5}{8}$

66. 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) $2\mu_o Ia$

67. A plane electromagnetic wave is propageting in non-magnetic, isotropic, dielectric medium is given by

$$\vec{E} = \left(A\hat{x} + \hat{z}\right)\cos\left(10^9 t - 4x + 4\sqrt{3}\, z\right)$$

The refractive index (n) of the medium is

(a) 4.2 (b) 2.0 (c) 2.4 (d) 1.5

68. Imagine the universe to be a spherical cavity with a radius *r* and impenetrable walls. If the universe contains *N* electrons, the fermi momentum of the electrons at absolute zero is

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

69. A system has two fermions. If each fermions can have any value of energy out of three given levels $-\varepsilon$, 0 and ε. If the system is in thermal equilibrium at temperature *T*. The average energy of the system is given by (where, $\beta = \frac{1}{k_B T}$)

(a) $\frac{-2\varepsilon \sinh \beta\varepsilon}{1+2\cosh \beta\varepsilon}$ (b) $\frac{2\varepsilon \sinh \beta\varepsilon}{1+2\cosh \beta\varepsilon}$ (c) $\frac{-2\varepsilon \sinh \beta\varepsilon}{1-2\cosh \beta\varepsilon}$ (d) $\frac{2\varepsilon \sinh \beta\varepsilon}{1-2\cosh \beta\varepsilon}$

70. Consider the following statements

(P) The ground state term for the configuration $2p^1 3p^1$ in L-S coupling is $^3D_1$.

(Q) If total angular momentum quantum numbers for ground state of ^7N and ^9F are J_1 and J_2 are respectively, then the ratio J_1/J_2 is equal to 3.

(R) The number of transitions from $^3P \rightarrow {}^3S$ in Anomalous Zeeman effect are 18

(S) The Lande g factor for the term $^3P_1$ is $\frac{3}{2}$

Which of the following statements are correct?

(a) Only P and S (b) P, R and S (c) All P, Q, R and S (d) Only P, Q and R

71. A particular laser cavity has length of 24 cm and refractive index of active medium is equal to 1. If the output mode number is 400000, then the wavelength of the laser light is

(a) 3.2 m (b) 2.4 mm (c) 1.2μm (d) 3.2 nm

72. In a vibrational spectra, if the fundamental band of H^1Cl^{35} lies at wavelength λ, then the wavelength of the corresponding band of H^2Cl^{35} is

(a) 1.4 λ (b) 1.8 λ (c) 0.82 λ (d) 2.1 λ

73. Match the following reactions with the type of interaction

Column-I	**Column-II**
(P) $\pi^- + P \rightarrow \Sigma^+ + k^-$	(I) Strong
(Q) $\pi^+ + P \rightarrow P + P + \bar{n}$	(II) Electromagnetic
(R) $\Sigma^+ \rightarrow \Lambda^0 + k^+$	(III) Weak
(S) $\bar{n} \rightarrow \bar{P} + e^+ + \nu_e$	(IV) Forbidden

(a) P-I, Q-I, R-III, S-III (b) P-I, Q-II, R-IV, S-IV
(c) P-IV, Q-I, R-IV, S-III (d) P-II, Q-II, R-III, S-IV

74. From semi-empirical formula, binding energy is given by $B = a_1 A - a_2 A^{2/3} - a_3 z^2 A^{-1/3} - a_4 \left(A - 2z\right)^2 A^{-1} \pm \delta$.

If $a_1 = 14.1\, MeV$, $a_2 = 13.0\, MeV$, $a_3 = 0.58\, MeV$, $a_4 = 19.3\, MeV$, the value of z for most stable nuclei for A = 88 is

(a) 37 (b) 38 (c) 39 (d) 40

75. The β^+-decay reation is given as

$$_{12}Mg^{23} \rightarrow {}_{11}Na^{23} + \beta^+ + \nu_e$$

If atomic mass of Mg^{2+} is 23.0002 amu and of Na^{23} is 22.99618 amu and kinetic energy of emitted β^+ particle is 1.22 MeV, then the kinetic energy of the emitted ν_e is

(a) 1.22 MeV (b) 1.5 MeV (c) 2.72 MeV (d) 0.35 MeV

space for rough work

Physical Sciences (CSIR-NET/JRF)

Test Series- (F)

Date: 08-12-2018

ANSWER KEY

PART-A

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

PART-B

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

PART-C

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