TEST SERIES CSIR-NET/JRF JUNE 2019

BOOKLET SERIES E

FULL LENGTH TEST - II

Paper Code 05

Test Type: TEST SERIES

PHYSICAL SCIENCES

Duration: 3:00 Hours

Date: 08-06-2019

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 2**5** 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. In the Botanical garden in Kolkata, there are three watchmen meant to protect the fruits in the campus. However, one day a thief got in without being noticed and stole some fruits. On the way out however, he was confronted by the three watchmen, the first two of whom asked him to part with $1/3^{rd}$ of the fruits and one more. The last asked him to part with 1/5th of the fruits and 4 more. As a result he had no fruits left. What was the number of fruits he had stolen?
(a) 12 (b) 13 (c) 15 (d) None of these

2. There are three persons *A*, *B* and *C* completes 2/3 of a certain job in 6 days. *B* can complete 1/3 of the same job in 8 days and *C* can complete 3/4 of the work in 12 days. All of them work together for 4 days and then *A* and *C* quit. How long will it take for *B* to complete the remaining work alone?
(a) 3.8 days (b) 3.33 days (c) 2.22 days (d) 4.3 days

3. A news paper vendor sells the *A*, *B* and *C* three news papers in equal numbers to 302 persons. Seven get *B* and *C*, tweleve get *A* and *C*, nine get *A* & *B* and 3 get all the three papers. What is the difference of persons who take only *B* and only *C* ?
(a) 2 (b) 3 (c) 4 (d) 5

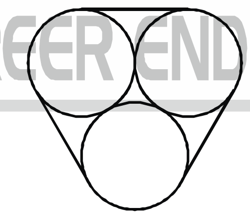
4. *A* purchased an article and sold to *B* at a profit of 20 %, but *B* sold it back to *A* at a loss of 20 %. If on the whole transaction a secured a profit of ` 20, then what is the cost price of the article ?
(a) ` 400 (b) ` 600 (c) ` 440 (d) ` 500

5. If in a certain code language 'INDIA' is coded as 'OJEBJ' and 'DELHI' is coded as 'FEMJI', then in the same language, code for 'TAKEN' is
(a) UZJOF (b) BULOF (c) BUJOF (d) BULFO

6. Amit said to Ram that he has no brothers or sisters, but the man in the photograph is my father's son's son. How is the man in the photograph related to Amit ?
(a) Son (b) Daughter (c) Cousin (d) Nephew

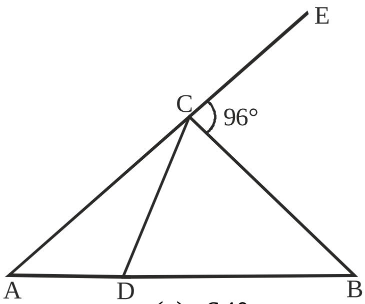
7. Raman cycled 10 km South from his house, turned right and went 5 km and again turned right and cycled 10 km and then turned left and cycled 10 km. How many kilometres will he have to cycle back to reach his house?
(a) 10 km (b) 5 km (c) 20 km (d) 15 km

8. The diagram below represents three circular garbage cans, each of diameter 2 m. The three cans are touching as shown. Find, in metres, the perimeter of the rope encompassing the three cans.



(a) $2\pi + 6$ (b) $3\pi + 4$ (c) $4\pi + 6$ (d) $6\pi + 6$

9. In the figure AD = CD = BC and $\angle BCE = 96°$. How much is $\angle DBC$?



(a) 32° (b) 84° (c) 64° (d) Indeterminate

10. Study the information carefully to answer the question below: A, B, C, D, E and F six persons live on six different floors of a six storey building. Ground floor is numbered as one, first floor as two and six on on the top most floor during six. A, B, C lives in even floors while D, E, F lives in odd floors none of F, B, A, D lives in top most floor B lives in the lowest floor among the even floors. E lives above A and D lives above F. Who lives between A and B ?
(a) D (b) C (c) E (d) F

11. 3 unbiased coins are tossed, what is the probability of getting at least 2 heads ?
(a) 1/3 (b) 1/4 (c) 1/2 (d) 5/8

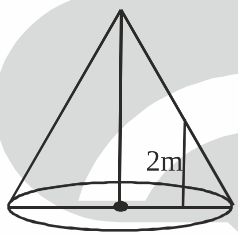
12. **Directions:** In each question below are few statements followed by the conclusions numbered accordingly. You have to take the given statements to be true even if they seem to be at variance from commonly known facts and then decide which of the given conclusions logically follows from the statements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

Statements:
1. All P are Q
2. No Q are R
3. All S are P

Conclusions:
I. Some S are R
II. Some P are R
III. Some P are S
IV. Some Q are P

(a) All follows (b) Only III follows (c) Only IV follows (d) Both III and IV follows

13. The diameter of a right conical tent is 6m. If a pole of length 2m can be fixed up in the tent at half the distance of the radius from the centre of the base and the pole touches the slant height at the mid point, then the area of the canvas required is



(a) 10π (b) 12π (c) 15π (d) 16π

14. If three equal cubes are placed adjacently in a row, then the ratio of the total surface area of the new cuboid to that of the sum of the surface areas of the three cubes will be :
(a) 1 : 3 (b) 5 : 9 (c) 2 : 3 (d) 7 : 9

15. Two medians AD and BE of ΔABC intersect at G at right angle. If AD = 9cm, and BE = 6 cm, then the length of BD (in cm) is
(a) 5 cm (b) 5.5 cm (c) 6 cm (d) 4 cm

16. In a regular polygon of n sides a circumcircle and an incircle are drawn. The area enclosed between the circumcircle and the incircle is 25π cm^2. Find the each side of the regular polygon.
(a) 8 cm (b) 10 cm (c) 12 cm (d) 14 cm

17. At what time (approx) past 5 p.m., the minute hand and hour hand of a correct clock would make a right angle?
(a) 5 : 40 p.m. (b) 5 : 50 p.m. (c) 5 : 55 p.m. (d) 5 : 44 p.m.

18. A ball is dropped from a height of 50 m and each time the ball bounces back 20% of the height from which it was dropped. How much would the ball travel before it rests finally ?
(a) 100 m (b) 60 m (c) 80 m (d) 75 m

19. A mobile tower of height 100 m stands at the top of a tall building. At a point on the ground the angle of elevation of bottom of the tower is 45º, and that of top of tower is 60º. What is the height of the building ?
(a) $100\left(\sqrt{3}+1\right)$ (b) $50\left(\sqrt{3}-1\right)$ (c) $50\left(\sqrt{3}+1\right)$ (d) $50\sqrt{3}$

20. A cubic metre of iron weighing 27000 kg is rolled into a square bar 9 m long. If an exact cube is cut off from the bar, then what will be weight of the bar ?

(a) 270 kg (b) 1000 kg (c) 27 kg (d) 540 kg

PART – B

21. The magnetic field of an unknown mode of a rectangular wave guide of dimensions a×b is given by

$$H_z = H_0 \cos(0.5\pi x) e^{i(kz-\omega t)}, \text{ where } x \text{ and } y \text{ are in cm.}$$

The cut-off wavelength (λ_c) of the mode is :

(a) 2 cm (b) 4 cm (c) 1 cm (d) 8 cm

22. An infinite solenoid of radius R and n turns per unit length carries a time varying current $I(t) = At^2$, with $A \neq 0$. The electric field at a distance $r > R$ is

(a) $-\dfrac{\mu_0 nAtr^2}{2}\hat{\phi}$ (b) $-\dfrac{\mu_0 nAtR^2}{2r}\hat{\phi}$ (c) $-\mu_0 nAtr^2\hat{\phi}$ (d) $-\dfrac{\mu_0 nAtR^2}{r}\hat{\phi}$

23. A steady current I flows down a long cylinderical conductor of radius R. The current density at a distance r from the axis of the conductor is proportional to r. The magnetic field at $r = \dfrac{R}{2}$ is

(a) $B = \dfrac{\mu_0 I}{8\pi R}$ (b) $\dfrac{\mu_0 I}{\pi R}$ (c) $\dfrac{\mu_0 I}{2\pi R}$ (d) $\dfrac{\mu_0 I}{4\pi R}$

24. Consider the following complex integrals:

$$I_1 = \oint_{C_1} \frac{z.\cosh(\pi z)}{z^4 + 5z^2 + 4} dz \text{ and } I_2 = \oint_{C_2} \frac{z.\cosh(\pi z)}{z^4 + 5z^2 + 4} dz$$

where C_1 and C_2 are defined by the equations $C_1 : |z| = 1.5$ and $C_2 : |z| = 2.5$ (both curves are traversed in the clockwise direction). Which of the following statements is CORRECT?

(a) $I_1 = I_2$ (b) $I_1 = 0, I_2 \neq 0$ (c) $I_2 = 2I_1$ (d) $I_1 \neq 0, I_2 = 0$

25. Consider the following differential equation:

$$\frac{d^2y}{dx^2} + 16y = 64x^2$$

with the initial conditions $y(0) = 0, y'(0) = 1$. The value of $y\left(\dfrac{\pi}{2}\right)$ will be

(a) π^2 (b) $\dfrac{1}{2} + \pi^2$ (c) $-\dfrac{1}{2} + \pi^2$ (d) $\dfrac{1}{2} - \pi^2$

26. The eigenvectors of a 3×3 matrix A, corresponding to the eigenvalues 1, 1, 3 are $[1 \quad 0 \quad -1]^T$, $[0 \quad 1 \quad -1]^T$ and $[1 \quad 1 \quad 0]^T$ respectively. The matrix A, will be of the form

(a) $\begin{bmatrix} 0 & 1 & 1 \\ -3 & 4 & 1 \\ 0 & 0 & 1 \end{bmatrix}$ (b) $\begin{bmatrix} -1 & -2 & 1 \\ 4 & 5 & 1 \\ 0 & 0 & 1 \end{bmatrix}$ (c) $\begin{bmatrix} 4 & 1 & 1 \\ -3 & 0 & 1 \\ 0 & 0 & 1 \end{bmatrix}$ (d) $\begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 0 & 0 & 1 \end{bmatrix}$

27. The Fourier transform of the function $f(x)$ is defined as

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

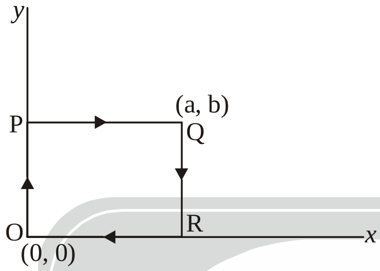
The Fourier transform of the function

$$f(x) = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} \frac{d^{2n+1}}{dx^{2n+1}} [\delta(x)]$$

will be

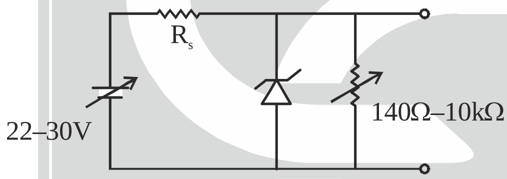
(a) $-i \sinh(k)$ (b) $i \sinh(k)$ (c) $\cosh k$ (d) $i \cosh(k)$

28. An object is moving along the path $O \to P \to Q \to R \to O$ (shown in the figure) under the force field given as following: $F(x, y) = (x^2 - y^2)\hat{i} + 2xy\hat{j}$. The work done by the force field will be



(a) $-2ab^2$ units (b) $2ab^2$ units (c) $-ab^2$ units (d) ab^2 units

29. A zener regulator has an input that may vary from 22 to 30 V. If the regulated output voltage is 12V and load resistance varies from 140 Ω to 10 $k\Omega$. The maximum allowable series resistance is



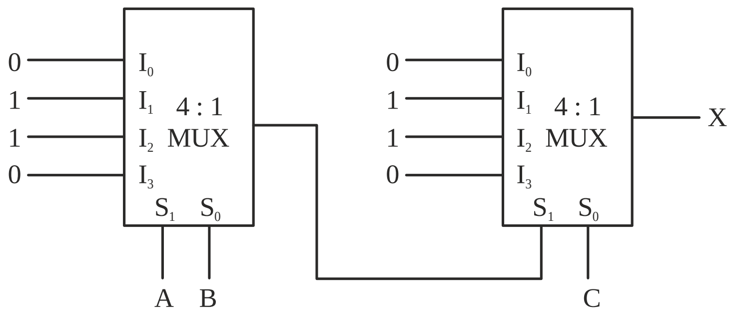
(a) 100 Ω (b) 117 Ω (c) 147 Ω (d) 200 Ω

30. Consider a two-dimensional classical system of N identical non-interacting classical particles in equilibrium at temperature T with Hamiltonian

$H = \frac{p_x^2 + p_y^2}{2m} + (\alpha x^2 + \beta y^4)$, where m is the mass of each particle and α and β are some constant. If x and y both lies from $-\infty$ to $+\infty$, the average energy per particle of the given system is

(a) $\frac{7}{4} k_B T$ (b) $\frac{3}{4} k_B T$ (c) $2k_B T$ (d) $\frac{k_B T}{3}$

31. In the following circuit, X is given by



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

32. The Hamiltonian of a system is described by, $H = H_0\begin{pmatrix} 0 & 1 \\ 4 & 0 \end{pmatrix}$. If a particle is in an eigenstate of an operator $\hat{O} = m\begin{pmatrix} 1 & 0 \\ 0 & 3 \end{pmatrix}$, ($m$ is a constant) with eigenvalue $3m$, the probability of finding $(-2H_0)$ upon measuring energy will be,

(a) 0.2 (b) 0.4 (c) 0.6 (d) 0.8

33. The commutator $\left[L_+ L_- + L_z^2, L_x L_y\right]$ is equal to,

(a) $i\hbar^2\left(L_y^2 + L_x^2\right)$ (b) $i\hbar^2\left(L_y^2 - L_x^2\right)$ (c) $i\hbar^2\left(L_x^2 - L_y^2\right)$ (d) None of these

34. A particle is in a potential of the form $V(x, y, z) = \frac{1}{2}m\omega^2\left(x^2 + 4y^2 + 16z^2\right)$, where m is the mass of the particle and ω is a constant. The degeneracy of the level with energy $E = \frac{19\hbar\omega}{2}$ is

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

35. A particle having energy 16 MeV is incident on a step potential of height 12 MeV. The ratio of transmission probability to reflection probability for this particle will be

(a) 8 : 1 (b) 1 : 8 (c) 4 : 1 (d) 1 : 4

36. The value of a for which the following transformation is canonical:

$$Q = \tan^{-1}\left(\frac{\alpha q}{p}\right), P = \frac{\alpha q^2}{2}\left(1 + \frac{p^2}{\alpha^2 q^2}\right)$$

(a) $\alpha = 2$ (b) $\alpha = 1$ (c) $\alpha = -1$ (d) α can take any value

37. For a particle moving with relativistic speed, its kinetic energy is measured to be α times, its total energy $(0 < \alpha < 1)$. If m and m_0 be the dynamic mass and rest mass of the particle, respectively, then the ratio $\frac{m}{m_0}$ is

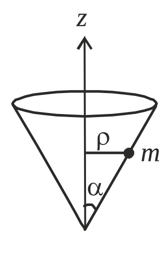
(a) $\frac{1}{1+\alpha}$ (b) $\frac{2}{1-\alpha}$ (c) $1-\alpha$ (d) $\frac{1}{1-\alpha}$

38. A particle moves under the influence of a potential $V(x, y, z) = 4x^5 + 3x^3y^2 + 2x^2y^2z$. The ratio of the average kinetic energy to the total energy is

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

39. A small mass m can slide without friction on the inside of a canonical surface with opening angle α as shown in figure below. The Lagrangian of the particle in cylindrical coordinates ρ, θ and z is given by

$$L = \frac{1}{2}m\left(\dot{\rho}^2\left(1 + \cot^2\alpha\right) + \rho^2\dot{\theta}^2\right) - mg\rho\cot\alpha$$



which among the following quantities is a constant of motion?

(a) $m\left(1 + \cot^2\alpha\right)\dot{\rho}$ (b) $m\rho^2\dot{\theta}$

(c) $m\left(1 - \cot^2\alpha\right)\dot{\rho}$ (d) All of these

40. A body quadruples its momentum when its speed doubles. The length of a rod, with rest length L_0, in the frame of the body moving with initial velocity, is

(a) $\sqrt{\frac{2}{3}}L_0$ (b) $\frac{2}{5}L_0$ (c) $\sqrt{\frac{2}{5}}L_0$ (d) $\frac{2}{\sqrt{5}}L_0$

41. A system, in thermal equilibrium at temperature T, has two identical bosons. Two energy levels $-\varepsilon$ and ε are available to each boson. The average energy of the system when $T \to \infty$ is

(a) -2ε (b) 0 (c) 2ε (d) ∞

42. A system of N non-interacting and localised particles of spin-3/2 is in thermodynamic equilibrium. The entropy of the system is

(a) $4k_B \ln N$ (b) $2k_B \ln N$ (c) $Nk_B \ln 2$ (d) $2Nk_B \ln 2$

43. An ideal gas consisting of rigid diatomic molecules is expanded adiabatically. How many times has the gas to be expanded to reduce the root mean square velocity of the molecules two times?

(a) 32 times (b) 16 times (c) 8 times (d) 4 times

44. The Maxwellian speed distribution function for an ideal gas at temperature T is given by

$$f(v) = 4\pi\left(\frac{m}{2\pi k_B T}\right)^{3/2} v^2 \exp\left(\frac{-mv^2}{2k_B T}\right), 0 < v < \infty$$

where m is the mass of each particle of the gas. The value of the speed v at which the value of the distribution function for the temperature T_0 will be the same as that for the temperature αT_0 is

(a) $\sqrt{\frac{3k_B T_0 \alpha \ln\alpha}{m(\alpha+1)}}$ (b) $\sqrt{\frac{3k_B T_0 \alpha \ln\alpha}{m(\alpha-1)}}$ (c) $\frac{3k_B T_0 \alpha \ln\alpha}{m(\alpha+1)}$ (d) $\frac{3k_B T_0 \alpha \ln\alpha}{m(\alpha-1)}$

45. A random number generator outputs 0 or 1 with probability ratio 3 : 2, every time it is run. After it is run 4 times, the probability of getting 0 atleast 2 times, will be [Assume that the individual runs are independent of each other]

(a) $\frac{513}{625}$ (b) $\frac{609}{625}$ (c) $\frac{529}{625}$ (d) None of these

PART – C

46. The value of the real definite integral:

$$\int_0^{2\pi} \cos^{2n}\theta \, d\theta$$

is

(a) 0 (b) $\frac{1}{2^{2n}}\left[2\pi\binom{2n}{n}\right]$ (c) $\frac{1}{2^{2n}}\left[\pi\binom{2n}{n}\right]$ (d) $\frac{1}{2^{2n}}\left[2\pi\binom{n}{n/2}\right]$

47. Consider a set of polynomials $\{U_1(x), U_2(x), U_3(x), ...\}$ whose generating function relation is given as following:

$$\frac{1}{1-2xt+t^2} = \sum_{n=0}^{\infty} U_n(x)\, t^n$$

Which of the following statements is CORRECT?

(a) $U_n(x) = (-1)^n U_n(x)$ (b) $U_n(-1) = (-1)^n (n+1)$

(c) $U_{2n+1}(0) = 0$ (d) All of the above

48. Interaction between two atoms of copper (Cu) having fcc structure is given by the potential $V(r) = -\frac{A}{r^2} + \frac{B}{r^{10}}$, where $A = \frac{1}{2}\times 10^{-40}$ J-m^2 and $B = \frac{1}{10}\times 10^{-120}$ J-m^{10}, the lattice constant a of Cu is:

(a) 2Å (b) 1 Å (c) 1.40 Å (d) 1.15Å

49. Consider the following data:

$x:$	1	2	4
$f(x):$	1	7	61

Using Lagrange's interpolation technique, one can find $f(3)$ to be

(a) 34 (b) 41 (c) 27 (d) 21

50. The value of the integral $\int_0^1 \frac{1}{2x+3}\,dx$ can be numerically evaluated using Trapezoidal rule with step size 0.5. The maximum possible error (in magnitude), which can occur in this calculation, will be approximately

(a) 2.92×10^{-3} (b) 4.38×10^{-3} (c) 6.17×10^{-3} (d) 8.96×10^{-3}

51. A plane electromagnetic wave propagating in air with $\vec{E} = (8\hat{i} + 6\hat{j} + 5\hat{k})e^{i(\omega t+3x-4y)}$ is incident on a perfectly conducting slab positioned at $x = 0$. The frequency of the wave is (rad/sec)

(a) 1.5×10^{9} (b) 1.5×10^{8} (c) 1.5×10^{10} (d) 3×10^{9}

52. 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 (ϕ') is

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

53. An electron is released at rest from height h and falls under the influence of gravity. The fraction of the potential energy lost to radiation, when it reach to the ground is

(a) $\frac{\mu_0 e^2}{6\pi mc}\sqrt{\frac{g}{h}}$ (b) $\frac{\mu_0 e^2}{6\pi mc}\sqrt{\frac{2g}{h}}$ (c) $\frac{\mu_0 e^2}{6\pi mc}\frac{g}{h}$ (d) $\frac{\mu_0 e^2}{6\pi mc}\left(\frac{2g}{h}\right)$

54. An infinite straight wire carries the current, $I(t) = \begin{cases} 0, & \text{for } t \le 0 \\ I_0, & \text{for } t > 0 \end{cases}$

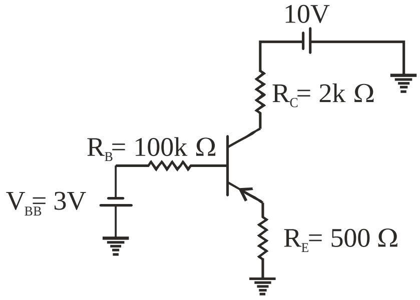
The magnetic vector potential of this current at a distance 's' from the wire is given by

$$\vec{A} = \frac{\mu_0 I_0}{2\pi}\,\ell n\left(\frac{ct + \sqrt{(ct)^2 - s^2}}{s}\right)\hat{z}$$

The magnetic field $(\vec{B})$ at a distance 's' can be represented by:

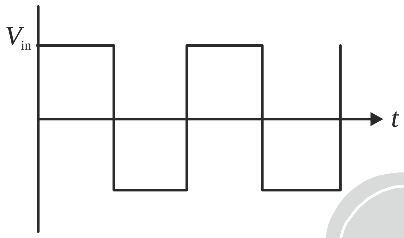
(a) $\frac{\mu_0 I_0 c}{2\pi\sqrt{(ct)^2 - s^2}}\hat{\phi}$ (b) $\frac{\mu_0 I_0 ct}{2\pi s\sqrt{(ct)^2 - s^2}}\hat{\phi}$ (c) $\frac{\mu_0 I_0 ct}{2\pi s\sqrt{(ct)^2 - s^2}}\hat{s}$ (d) $\frac{\mu_0 I_0 c}{2\pi s\sqrt{(ct)^2 - s^2}}\hat{\phi}$

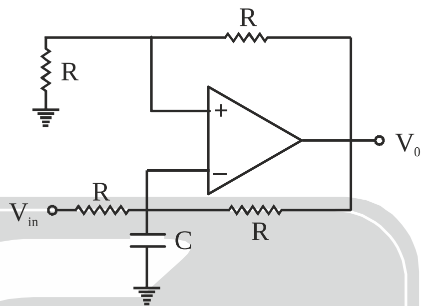
55. Suppose the transistor has $\beta = 100$, $|V_{BE}| = 0.7V$, $|V_{CE\ sat}| = 0.2V$. The transistor is operating in the

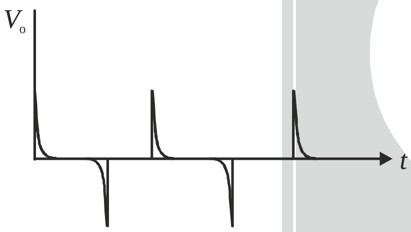


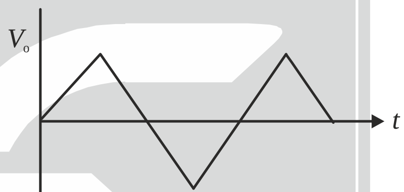
(a) Active region
(b) Saturation region
(c) Cut-off region
(d) Data is not sufficient

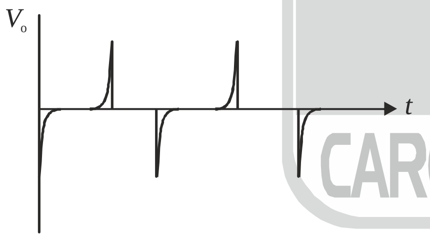
56. Consider the following circuit, which of the following graph will be the best reperesentation of the output





(a)


(b)


(c)


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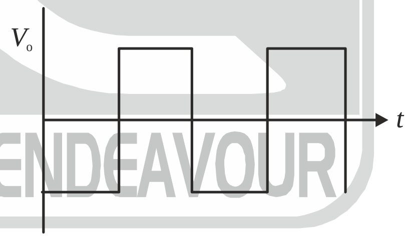
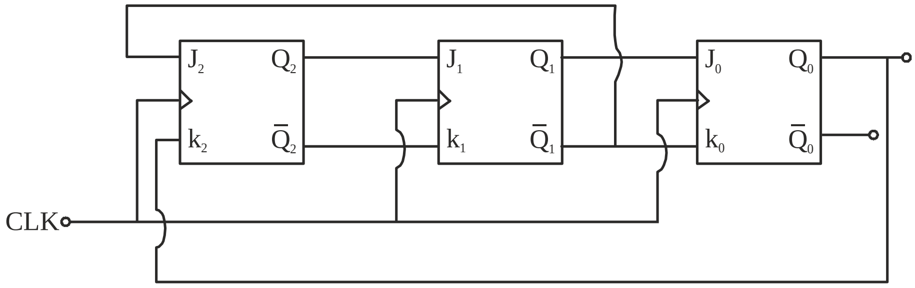


57. The counter shown in the figure has initially $Q_2Q_1Q_0$ = 000, the state of $Q_2Q_1Q_0$ after the first pulse is



(a) 001
(b) 010
(c) 100
(d) 101

58. A low energy particle of mass m is scattered from a potential of the form,

$$V(r)=\begin{cases}-V_0 & \text{for} \quad r<a \\ 0 & \text{for} \quad r>a\end{cases}.$$

Its total scattering cross section considering the lowest non-vanishing order effect will be

(a) $\frac{m^2V_0^2a^6}{9\hbar^4}$ (b) $\frac{4m^2V_0^2a^6}{9\hbar^4}$ (c) $\frac{16\pi m^2V_0^2a^6}{9\hbar^4}$ (d) $\frac{4\pi m^2V_0^2a^6}{3\hbar^4}$

59. A unitary transformation transforms the basis

$$\left\{\begin{pmatrix}1\\0\end{pmatrix},\begin{pmatrix}0\\1\end{pmatrix}\right\} \text{ to } \left\{\frac{1}{\sqrt{2}}\begin{pmatrix}1\\i\end{pmatrix},\frac{1}{\sqrt{2}}\begin{pmatrix}1\\-i\end{pmatrix}\right\}.$$

If a quantum observable was represented in the old basis as $\begin{pmatrix}1 & 0\\0 & -1\end{pmatrix}$, its representation in the new basis will be

(a) $\begin{pmatrix}0 & -i\\i & 0\end{pmatrix}$ (b) $\begin{pmatrix}0 & 1\\1 & 0\end{pmatrix}$ (c) $\begin{pmatrix}1 & 0\\0 & -1\end{pmatrix}$ (d) None of these

60. A particle of mass m is in a potential of the form:

$$V(x)=\begin{cases}\lambda x^2 & ; \quad x\ge 0 \quad (\lambda>0)\\ \infty & ; \quad x<0\end{cases}.$$

If E_1^W is the first excited state energy obtained using WKB approximation and E_1^e is the exact first excited state energy, $E_1^W : E_1^e$ is equal to

(a) $1:1$ (b) $\sqrt{2}:1$ (c) $\sqrt{3}:1$ (d) None of these

61. The normalized wavefunction of a hydrogen atom is given by,

$$\psi(\vec{r})=\frac{1}{\sqrt{32\pi a_0^3}}\left(\frac{r}{a_0}\right)e^{-r/2a_0}\sin\theta\cos\phi$$

where a_0 is the Bohr radius. $\langle L_x^2\rangle$ for this state will be

$$\left[\psi_{2,1,\pm1}=\mp\frac{1}{8\sqrt{\pi a_0^3}}\left(\frac{r}{a_0}\right)e^{-r/2a_0}\sin\theta\, e^{\pm i\phi};\ \{\psi_{n,l,m}\} \text{ are Hydrogen atom eigenstates}\right]$$

(a) 0 (b) $\frac{\hbar^2}{4}$ (c) $\frac{\hbar^2}{2}$ (d) $\hbar^2$

62. A particle of mass m is contrained to move on a curve in the vertical plane defined by the parametric equations

$$y=\ell(1-\cos 2\phi); \quad x=\ell(2\phi+\sin 2\phi)$$

The gravitational force acting in the vertical y-direction. The Hamiltonian of the system is (where, p_ϕ is the cannonical momentum corresponding to the generalised coordinate ϕ)

(a) $\frac{p_\phi^2}{32m\ell^2\cos^2\phi}+2mg\ell\sin^2\phi$ (b) $\frac{p_\phi^2}{8m\ell^2\cos^2\phi}+2mg\ell\sin^2\phi$

(c) $\frac{p_\phi^2}{32m\ell^2\cos^2\phi}+mg\ell\sin^2\phi$ (d) $\frac{p_\phi^2}{8m\ell^2\cos^2\phi}+mg\ell\sin^2\phi$

63. A particle of mass *m* moves under a conservative force with potential energy $V(x)=\frac{cx}{x^2+a^2}$, where *c* and *a* are positive constants. Which among the following statements is correct?
(a) $x = a$ and $x = -a$ are both points of stable equilibrium.
(b) $x = a$ is a point of unstable equilibrium and $x = -a$ is a point of stable equilibrium.
(c) $x = a$ is a point of unstable equilibrium and $x = -a$ is a point of unstable equilibrium.
(d) $x = a$ and $x = -a$ are both points of inflection of this potential.

64. A particle of mass *m* is attached to a force centre by a force which varies inversely as the cube of its distance from the centre. The equations of motion of the particle are (in the following r,θ are plane polar coordinates)

(a) $m\ddot{r}-mr\dot{\theta}^2+\frac{k}{r^3}=0,\ r\ddot{\theta}+2\dot{r}\dot{\theta}=0$. (b) $m\ddot{r}+mr\dot{\theta}^2+\frac{k}{r^3}=0,\ r\ddot{\theta}+2\dot{r}\dot{\theta}=0$

(c) $m\ddot{r}-mr\dot{\theta}^2-\frac{k}{r^3}=0,\ r\ddot{\theta}+2\dot{r}\dot{\theta}=0$ (d) $m\ddot{r}+2mr\dot{\theta}^2-\frac{k}{r^3}=0,\ r\ddot{\theta}+2\dot{r}\dot{\theta}=0$

65. Let us consider a statistical system with N states, with energies $\varepsilon_n = n\varepsilon,\ n = 0,1,....,N-1$. The system is in contact with a reservoir at temperature *T*. The probability that the system is in the state with energy ε_n is

(a) $\frac{e^{n\beta\varepsilon}\left(1-e^{-\beta\varepsilon}\right)}{1-e^{-N\beta\varepsilon}}$ (b) $\frac{e^{-n\beta\varepsilon}\left(1-e^{-\beta\varepsilon}\right)}{1-e^{-N\beta\varepsilon}}$ (c) $\frac{e^{n\beta\varepsilon}\left(1-e^{-\beta\varepsilon}\right)}{1-e^{N\beta\varepsilon}}$ (d) $\frac{e^{-n\beta\varepsilon}\left(1-e^{-\beta\varepsilon}\right)}{1-e^{N\beta\varepsilon}}$

66. The Hamiltonian for a quantum system can be written as

$$\hat{H}=\varepsilon\begin{pmatrix}1&0&1\\0&1&0\\1&0&1\end{pmatrix},\ \varepsilon>0$$

If the system is in thermal equilibrium at temperature *T*, the average energy of the system (in terms of $\beta=\frac{1}{k_BT}$) is

(a) $\varepsilon\left(\frac{e^{\beta\varepsilon}+2}{e^{2\beta\varepsilon}+e^{\beta\varepsilon}+1}\right)$ (b) $\varepsilon\left(\frac{e^{\beta\varepsilon}+1}{e^{2\beta\varepsilon}+e^{\beta\varepsilon}+1}\right)$ (c) $-\varepsilon\left(\frac{e^{\beta\varepsilon}+2}{e^{2\beta\varepsilon}+e^{\beta\varepsilon}+1}\right)$ (d) $-\varepsilon\left(\frac{e^{\beta\varepsilon}+1}{e^{2\beta\varepsilon}+e^{\beta\varepsilon}+1}\right)$

67. Consider a system with three Isings S_1, S_2 and S_3, where each take values ±1, with interaction energy given by

$$E=-J\left(S_1S_2+S_2S_3+S_3S_1\right)$$

where, *J* is the interaction constant. If the system is in thermal equilibrium at temperature *T*, the average energy of the system when $k_BT = J$ is

(a) $3J\left(\frac{e^4+1}{e^4+3}\right)$ (b) $-3J\left(\frac{e^4+1}{e^4+3}\right)$ (c) $3J\left(\frac{e^4-1}{e^4+3}\right)$ (d) $-3J\left(\frac{e^4-1}{e^4+3}\right)$

68. The tight binding energy expression of electron in a two dimensional solid is

$$E\left(k_x,k_y\right)=-4E_0\cos\left(\frac{k_xa}{2}\right)\cos\left(\frac{k_ya}{2}\right)$$

The effective mass (m^*) of electron at the Brillouin zone boundary is

(a) $\frac{\hbar^2}{E_0a^2}$ (b) $\frac{-\hbar^2}{E_0a^2}$ (c) ∞ (d) $\frac{-\hbar^2}{2E_0a^2}$

69. A two dimensional metal has one atom of valency one in a simple rectangular primitive cell $a = 2$Å and $b = 4$Å. The radius of Fermi surface in metal is (in cm^{-1})

(a) 1.25×10^{15} (b) 8.9×10^{7} (c) 6.3×10^{7} (d) 5.0×10^{7}

70. In the L-S coupling scheme, the terms arising from the two equivalent d-electrons are

(a) ${}^1S_0$, ${}^1P_1$, ${}^1D_2$, ${}^1F_3$, ${}^1G_4$, ${}^3S_1$, ${}^3P_{0,1,2}$, ${}^3D_{1,2,3}$, ${}^3F_{2,3,4}$, ${}^3G_{3,4,5}$

(b) ${}^1S_0$, ${}^1P_1$, ${}^1D_2$, ${}^3S_1$, ${}^3P_{0,1,2}$, ${}^3D_{1,2,3}$

(c) ${}^1S_0$, ${}^1D_2$, ${}^1G_4$, ${}^3P_{0,1,2}$, ${}^3F_{2,3,4}$

(d) ${}^1S_0$, ${}^1D_2$, ${}^3P_{0,1,2}$

71. The separation between the energy levels of a two level atom is 4 eV. Suppose that 2×10^{20} atoms are in the ground state and 5×10^{20} atoms are pumped into the excited state just before lasing starts. How much energy will be released in a single laser pulse?

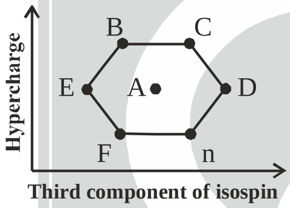
(a) 12 J (b) 24 J (c) 48 J (d) 96 J

72. The ground state spectral term corresponding to the $nd^3\, nf^2\, ns^1$ configuration is

(a) ${}^7K_{11}$ (b) ${}^7K_5$ (c) ${}^7H_{11}$ (d) ${}^7H_5$

73. The elementary particle *n* is placed in a Baryon octet as shown in figure. Which of the following statement is INCORRECT?

(a) In reaction, $\Sigma^0 \to X + \gamma$, the particle X is particle A in figure.



(b) The particles D and E have spin equal to ½, isospin equal to 1 and Baryon number equal to 1.

(c) The particle B and F have Baryon number equal to 1, third component of isospin equal to ½ and even parity.

(d) The particle C and D have charge equal to –1, quark content of C is dss and quark content of D is dss.

74. Consider the following statements.

(P) In reaction, $p + p \to p + p + \pi^0$, if target proton is at rest, rest mass of proton is 938 MeV/c^2 and rest meson of π^0 is 135 MeV/c^2 then the threshold kinetic energy of incident proton is 279.714 MeV.

(Q) In $\propto$ decay reaction ${}_{86}Rn^{222} \to {}_{84}P_0^{218} + {}_2He^4$, if energy released is Q, then the kinetic energy of the emitted α particle is $\dfrac{109}{111}Q$.

Which of the above statements is/are ***CORRECT***?

(a) Only P (b) Only Q (c) Both P and Q (d) Neither P nor Q

75. Consider the following statements.

(P) If a mass X^+ has charm quantum = 1 and bottom quantum number = 1 then quark content of X^+ is $c\bar{b}$

(Q) If a particle is made up of three quarks (qqq) and it has strangeness quantum number = –2, then the possible values of third component of isospin are $\frac{1}{2}$ and $-\frac{1}{2}$

(R) If a particle is made up of a quark and an antiquark $\left(q\bar{q}\right)$ and its strangeness quantum number = 0, then the isospin of the particle is equal to 1.

(S) The quark content of k^+ is $u\bar{s}$, Σ^+ is uss and Ξ^0 is uss.

Which of the following statements are correct?

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

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All the Best for CSIR-NET "16th June 2019" Exam

Space for rough work

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PHYSICAL SCIENCES

TEST SERIES-E

Date : 08-06-2019

ANSWER KEY

PART-A

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

PART-B

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

PART-C

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