# PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

# CSIR NET Physics - Dec 2016 - Full Paper

Complete question paper with answer key

**75 questions . Answer key included**

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**Q1. [Dec 2016] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

The random errors associated with the measurement of $P$ and $Q$ are $10\%$ and $2\%$, respectively. What is the percentage random error in $P/Q$ ?

1. 12.0
2. 9.8
3. 8.0
4. 10.2

**Q2. [Dec 2016] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

In how many distinguishable ways can the letters of the word CHANCE be arranged?

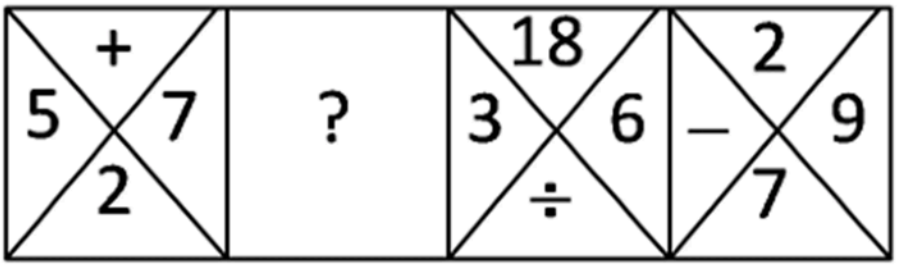
1. 120
2. 720
3. 360
4. 240

**Q3. [Dec 2016] . 2.0 marks**

General Aptitude > Reasoning

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

Find out the missing pattern.




1. 


2. 


3. 


4. 

**Q4. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

Seeds when soaked in water gain about 20% by weight and 10% by volume. By what factor does the density increase?

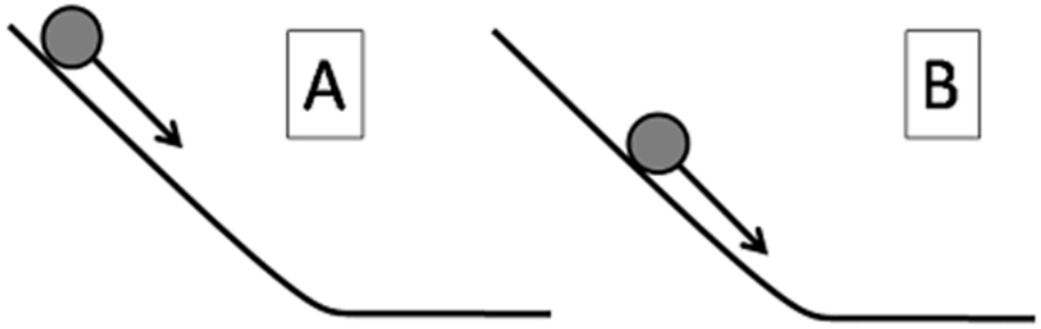
1. 1.20
2. 1.10
3. 1.11
4. 1.09

**Q5. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

Retarding frictional force, $f$, on a moving ball, is proportional to its velocity, $V$. Two identical balls roll down identical slopes (A & B) from different heights. Compare the retarding forces and the velocities of the balls at the bases of the slopes.




1. $f_A > f_B; V_A > V_B$
2. $f_A > f_B; V_B > V_A$
3. $f_B > f_A; V_B > V_A$
4. $f_B > f_A; V_A > V_B$

**Q6. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

Two cockroaches of the same species have the same thickness but different lengths and widths. Their ability to survive in oxygen deficient environments will be compromised if

1. their thickness increases, and the rest of the size remains the same.

2. their thickness remains unchanged, but their length increases.

3. their thickness remains unchanged, but their width decreases.

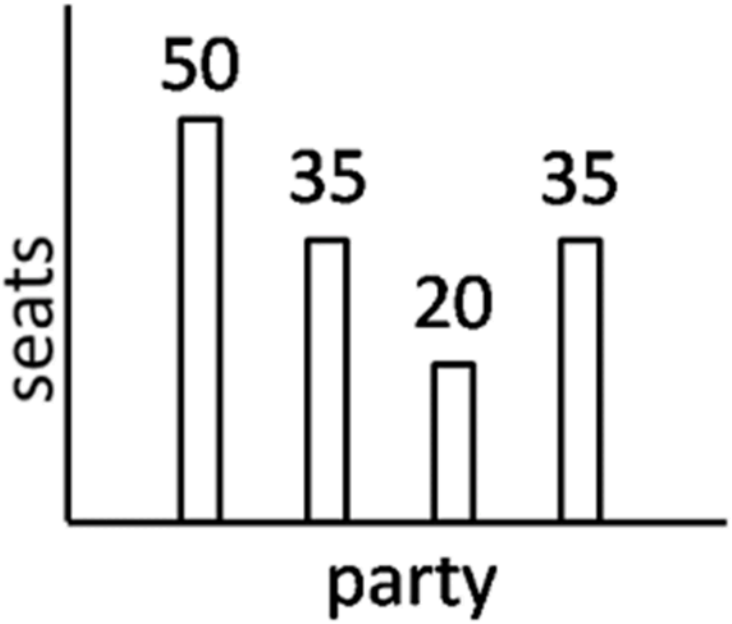
4. their thickness decreases, but the rest of the size remains unchanged.

**Q7. [Dec 2016] . 2.0 marks**

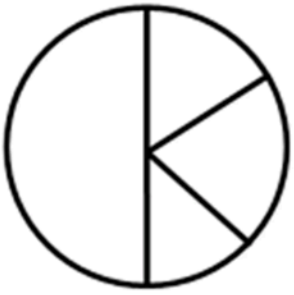
General Aptitude > Data Analysis

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

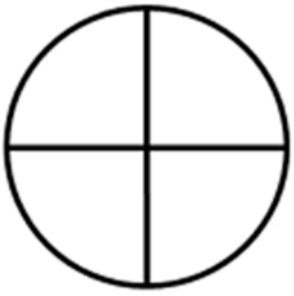
The bar chart shows number of seats won by four political parties in a state legislative assembly.




Which of the following pie-charts correctly depicts this information?

1. 

2. 

3. 

4. 

**Q8. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

Intravenous (IV) fluid has to be administered to a child of 12 kg with dehydration, at a dose of 20 mg of fluid per kg of body weight, in 1 hour. What should be the drip rate (in drops/min) of IV fluid?

(1 mg = 20 drops)

1. 7

2. 80

3. 120

4. 4

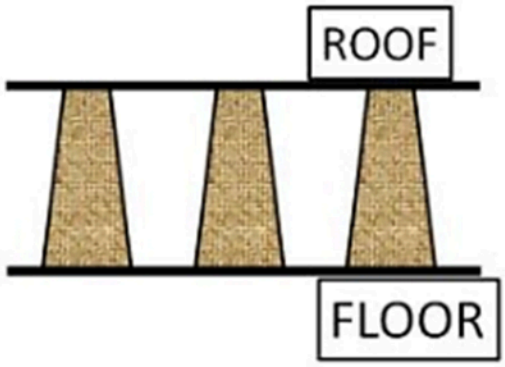
**Q9. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

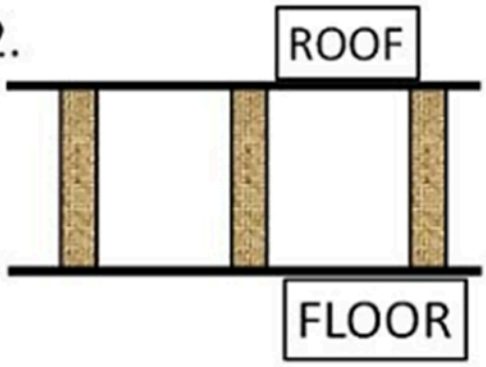
| CSIR NET | 2016 Dec | 2M |
|---|---|---|

A hall with a high roof is supported by an array of identical columns such that, to a person lying on the floor and looking at the ceiling, the columns appear parallel to each other. Which of the following designs conforms to this?

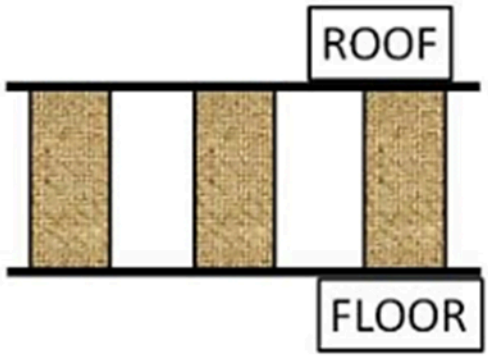
1.



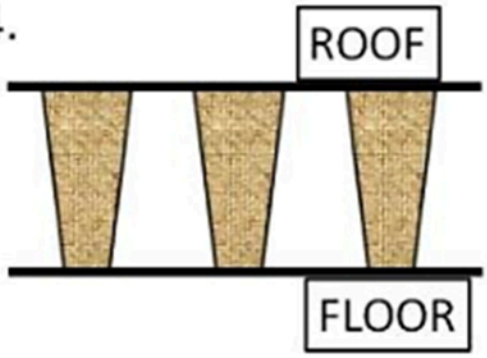

2.




3.




4.

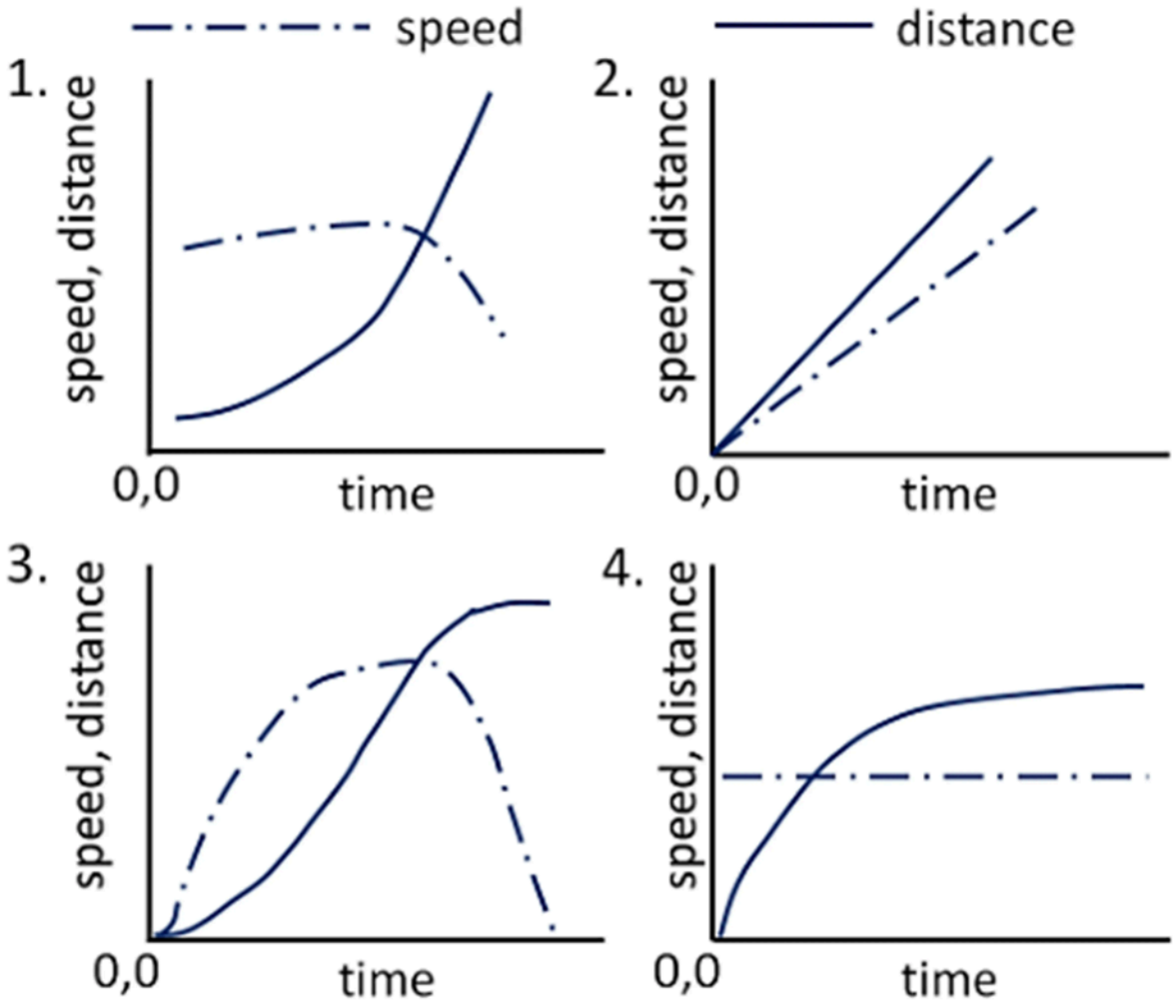


**Q10. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

Which of the following graphs correctly shows the speed and the corresponding distance covered by an object moving along a straight line?



**Q11. [Dec 2016] . 2.0 marks**

General Aptitude > Geometry

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

A normal TV screen has a width to height ratio of 4:3, while a high definition TV screen has a ratio of 16:9. What is the approximate ratio of their diagonals, if the heights of the two types of screens are the same?

1. 5: 9
2. 5:18
3. 5: 15
4. 5: 6

**Q12. [Dec 2016] . 2.0 marks**

General Aptitude > Geometry

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

Comparing numerical values, which of the following is different from the rest?

1. The ratio of the circumference of a circle to its diameter.
2. The sum of the three angles of a plane triangle expressed in radians.
3. 22/7.
4. The net volume of a hemisphere of unit radius, and a cone of unit radius and unit height.

**Q13. [Dec 2016] . 2.0 marks**

General Aptitude > Geometry

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

A river is 4.1 km wide. A bridge built across it has 1/7 of its length on one bank and 1/8 of its length on the other bank. What is the total length of the bridge?

1. 5.1 km
2. 4.9 km
3. 5.6 km
4. 5.4 km

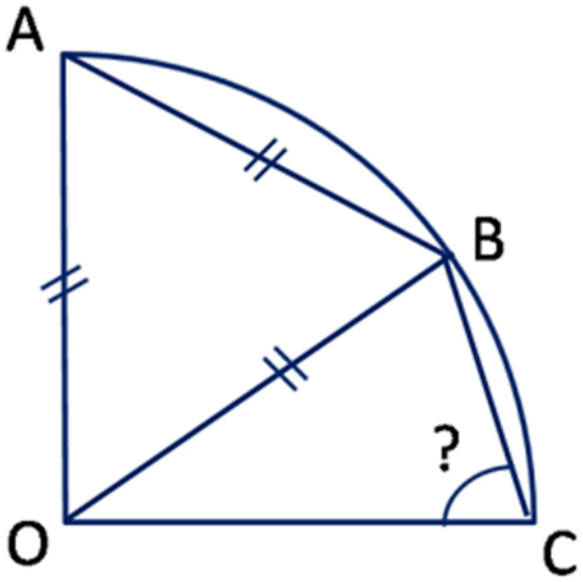
**Q14. [Dec 2016] . 2.0 marks**

General Aptitude > Geometry

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

OA, OB, and OC are radii of the quarter circle shown in the figure. AB is also equal to the radius.

What is angle OCB?




1. 60°
2. 75°
3. 55°
4. 65°

**Q15. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

Two iron spheres of radii 12 cm and 1 cm are melted and fused. Two new spheres are made without any loss of iron. Their possible radii could be

1. 9 and 4 cm
2. 9 and 10 cm
3. 8 and 5 cm
4. 2 and 11 cm

**Q16. [Dec 2016] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

A man buys alcohol at Rs. 75/cL, adds water, and sells it at Rs.75/cL making a profit of 50%. What is the ratio of alcohol to water?

1. 2:1
2. 1:2
3. 3:2
4. 2:3

**Q17. [Dec 2016] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

The sum of digits of a two-digit number is 9. If the fraction formed by taking 9 less than the number as numerator and 9 more than the number as denominator is 3/4, what is the number?

1. 36
2. 63
3. 45
4. 54

**Q18. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

The distance between X and Y is 1000 km . A person flies from X at 8 AM local time and reaches Y at 10 AM local time. He flies back after a halt of 4 hours at Y and reaches X at 4 PM local time on the same day. What is his average speed for the duration he is in the air?

1. 500 km/hour
2. 250 km/hour
3. 750 km/hour
4. cannot be calculated with the given information

**Q19. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

If a person travels $x\%$ faster than normal, he reaches $y$ minutes earlier than normal. What is his normal time of travel?

1. $\left(\frac{100}{x}+1\right) y$ minutes
2. $\left(\frac{x}{100}+1\right) y$ minutes
3. $\left(\frac{y}{100}+1\right) x$ minutes
4. $\left(\frac{100}{y}+1\right) x$ minutes

**Q20. [Dec 2016] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2016 Dec | 2M |
|---|---|---|

$A$ and $B$ walk up an escalator one step at a time, while the escalator itself moves up at a constant speed. A walks twice as fast as B. A reaches the top in 40 steps and $B$ in 30 steps. How many steps of the escalator can be seen when it is not moving?

1. 30

2. 40

3. 50

4. 60

**Q21. [Dec 2016] . 3.5 marks**

Mathematical Physics > Probability

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

Consider two radioactive atoms, each of which has a decay rate of 1 per year. The probability that at least one of them decays in the first two years is

1. $\frac{1}{4}$
2. $\frac{3}{4}$
3. $1 - e^{-4}$
4. $(1 - e^{-2})^2$

**Q22. [Dec 2016] . 3.5 marks**

Mathematical Physics > Fourier Transform

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The Fourier transform $\int_{-\infty}^{\infty} dx f(x) e^{ikx}$ of the function $f(x) = \frac{1}{x^2+2}$ is

1. $\sqrt{2}\pi e^{-\sqrt{2}|k|}$
2. $\sqrt{2}\pi e^{-\sqrt{2}k}$
3. $\frac{\pi}{\sqrt{2}} e^{-\sqrt{2}k}$
4. $\frac{\pi}{\sqrt{2}} e^{-\sqrt{2}|k|}$

**Q23. [Dec 2016] . 3.5 marks**

Classical Mechanics > Basic Mechanics

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

A ball of mass $m$ is dropped from a tall building with zero initial velocity. In addition to gravity, the ball experiences a damping force of the form $-\gamma v$, where $v$ is its instantaneous velocity and $\gamma$ is a constant. Given the values $m = 10\ \text{kg}, \gamma = 10\ \text{kg/s}$, and $g \approx 10\ \text{m/s}^2$, the distance travelled (in metres) in time $t$ in seconds, is

1. $10(t + 1 - e^{-t})$
2. $10(t - 1 + e^{-t})$
3. $5t^2 - (1 - e^{t})$
4. $5t^2$

**Q24. [Dec 2016] . 3.5 marks**

Mathematical Physics > Matrices and Linear Algebra

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The matrix $M = \begin{pmatrix} 1 & 3 & 2 \\ 3 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ satisfies the equation

1. $M^3 - M^2 - 10M + 12I = 0$
2. $M^3 + M^2 - 12M + 10I = 0$
3. $M^3 - M^2 - 10M + 10I = 0$
4. $M^3 + M^2 - 10M + 10I = 0$

**Q25. [Dec 2016] . 3.5 marks**

Mathematical Physics > Laplace transform

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The Laplace transform of

$$f(t) = \begin{cases} \frac{t}{T}, & 0 < t < T \\ 1 & t > T \end{cases}$$ is

1. $-(1 - e^{-sT})/s^2T$
2. $(1 - e^{-sT})/s^2T$
3. $(1 + e^{-sT})/s^2T$
4. $(1 - e^{sT})/s^2T$

**Q26. [Dec 2016] . 3.5 marks**

Classical Mechanics > Special theory of relativity

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

A relativistic particle moves with a constant velocity $v$ with respect to the laboratory frame. In time $\tau$, measured in the rest frame of the particle, the distance that it travels in the laboratory frame is

1. $v\tau$
2. $\frac{c\tau}{\sqrt{1-\frac{v^2}{c^2}}}$
3. $v\tau\sqrt{1-\frac{v^2}{c^2}}$
4. $\frac{v\tau}{\sqrt{1-\frac{v^2}{c^2}}}$

**Q27. [Dec 2016] . 3.5 marks**

Classical Mechanics > Poisson brackets

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

A particle in two dimensions is in a potential $V(x, y) = x + 2y$. Which of the following (apart from the total energy of the particle) is also a constant of motion?

1. $p_y - 2p_x$
2. $p_x - 2p_y$
3. $p_x + 2p_y$
4. $p_y + 2p_x$

**Q28. [Dec 2016] . 3.5 marks**

Classical Mechanics > Lagrangian and Hamiltonian

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The dynamics of a particle governed by the Lagrangian $L = \frac{1}{2}m\dot{x}^2 - \frac{1}{2}kx^2 - kx\dot{x}t$ describes

1. an undamped simple harmonic oscillator
2. a damped harmonic oscillator with a time varying damping factor
3. an undamped harmonic oscillator with a time dependent frequency
4. a free particle

**Q29. [Dec 2016] . 3.5 marks**

Classical Mechanics > Oscillations

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The parabolic coordinates $(\xi, \eta)$ are related to the Cartesian coordinates $(x, y)$ by $x = \xi\eta$ and $y = \frac{1}{2}(\xi^2 - \eta^2)$. The Lagrangian of a two-dimensional simple harmonic oscillator of mass $m$ and angular frequency $\omega$ is

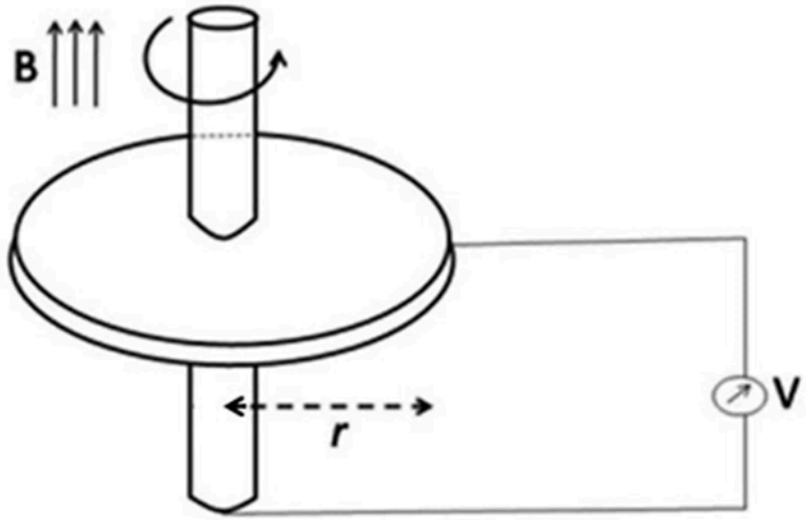
1. $\frac{1}{2}m\left[\dot{\xi}^2 + \dot{\eta}^2 - \omega^2(\xi^2 + \eta^2)\right]$
2. $\frac{1}{2}m(\xi^2 + \eta^2)\left[(\dot{\xi}^2 + \dot{\eta}^2) - \frac{1}{4}\omega^2(\xi^2 + \eta^2)\right]$
3. $\frac{1}{2}m(\xi^2 + \eta^2)\left(\dot{\xi}^2 + \dot{\eta}^2 - \frac{1}{2}\omega^2\xi\eta\right)$
4. $\frac{1}{2}m(\xi^2 + \eta^2)\left(\dot{\xi}^2 + \dot{\eta}^2 - \frac{1}{4}\omega^2\right)$

**Q30. [Dec 2016] . 3.5 marks**

Electromagnetism > Electrodynamics

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

A conducting circular disc of radius $r$ and resistivity $\rho$ rotates with an angular velocity $\omega$ in a magnetic field $B$ perpendicular to it. A voltmeter is connected as shown in the figure below.




Assuming its internal resistance to be infinite, the reading on the voltmeter

1. depends on $\omega, B, r$ and $\rho$
2. depends on $\omega, B$ and $r$, but not on $\rho$
3. is zero because the flux through the loop is not changing
4. is zero because a current flows in the direction of $B$

**Q31. [Dec 2016] . 3.5 marks**

Electromagnetism > Electrostatics

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The charge per unit length of a circular wire of radius $a$ in the $xy$-plane, with its centre at the origin, is $\lambda = \lambda_0 \cos\theta$, where $\lambda_0$ is a constant and the angle $\theta$ is measured from the positive $x$-axis. The electric field at the centre of the circle is

1. $\vec{E} = -\frac{\lambda_0}{4\epsilon_0 a}\hat{\imath}$
2. $\vec{E} = \frac{\lambda_0}{4\epsilon_0 a}\hat{\imath}$
3. $\vec{E} = -\frac{\lambda_0}{4\epsilon_0 a}\hat{\jmath}$
4. $\vec{E} = \frac{\lambda_0}{4\pi\epsilon_0 a}\hat{k}$

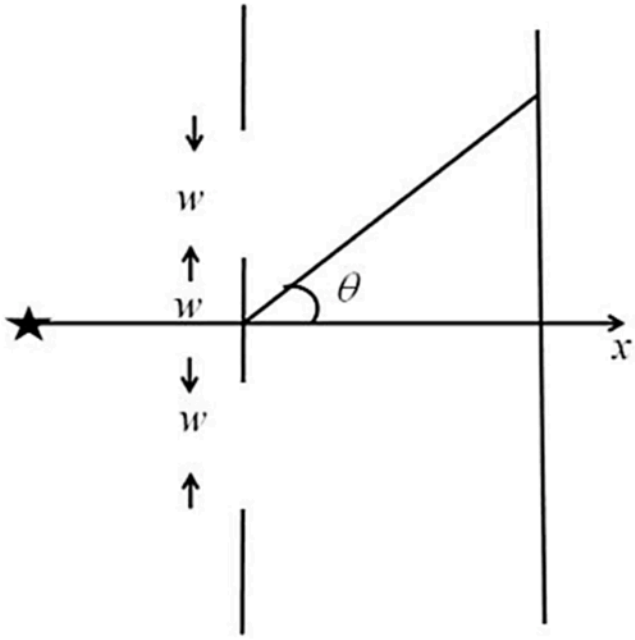
**Q32. [Dec 2016] . 3.5 marks**

Optics > Interference and diffraction

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

A screen has two slits, each of width $w$, with their centres at a distance $2w$ apart. It is illuminated by a monochromatic plane wave travelling along the $x$-axis. The intensity of the interference pattern, measured on a distant screen, at an angle $\theta = n\lambda/w$ to the $x$-axis is

1. zero for $n = 1,2,3 \ldots$
2. maximum for $n = 1,2,3 \ldots$
3. maximum for $n = \frac{1}{2}, \frac{3}{2}, \frac{5}{2} \ldots$
4. zero for $n = 0$ only



**Q33. [Dec 2016] . 3.5 marks**

Optics > Polarization

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The electric field of an electromagnetic wave is $\vec{E}(z,t) = E_0\cos(kz+\omega t)\hat{\imath} + 2E_0\sin(kz+\omega t)\hat{\jmath}$ , where $\omega$ and $k$ are positive constants. This represents

1. a linearly polarised wave travelling in the positive z-direction
2. a circularly polarised wave travelling in the negative $z$-direction
3. an elliptically polarised wave travelling in the negative $z$-direction
4. an unpolarised wave travelling in the positive z-direction

**Q34. [Dec 2016] . 3.5 marks**

Quantum Mechanics > Basic Quantum Mechanics

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

Consider the two lowest normalized energy eigenfunctions $\psi_0(x)$ and $\psi_1(x)$ of a one dimensional system. They satisfy $\psi_0(x) = \psi_0^*(x)$ and $\psi_1(x) = \alpha \frac{d\psi_0}{dx}$, where $\alpha$ is a real constant. The expectation value of the momentum operator in the state $\psi_1$ is

1. $-\frac{\hbar}{\alpha^2}$
2. 0
3. $\frac{\hbar}{\alpha^2}$
4. $\frac{2\hbar}{\alpha^2}$

**Q35. [Dec 2016] . 3.5 marks**

Quantum Mechanics > Basic Quantum Mechanics

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

Consider the operator $a = x + \frac{d}{dx}$ acting on smooth functions of $x$. The commutator $[a, \cos x]$ is

1. $-\sin x$
2. $\cos x$
3. $-\cos x$
4. 0

**Q36. [Dec 2016] . 3.5 marks**

Quantum Mechanics > Quantum Harmonic Oscillator

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

Let $a = \frac{1}{\sqrt{2}}(x + ip)$ and $a^\dagger = \frac{1}{\sqrt{2}}(x - ip)$ be the lowering and raising operators of a simple harmonic oscillator in units where the mass, angular frequency and $\hbar$ have been set to unity. If $|0\rangle$ is the ground state of the oscillator and $\lambda$ is a complex constant, the expectation value of $\langle\psi|x|\psi\rangle$ in the state $|\psi\rangle = \exp\left(\lambda a^\dagger - \lambda^* a\right)|0\rangle$, is

1. $|\lambda|$
2. $\sqrt{|\lambda|^2 + \frac{1}{|\lambda|^2}}$
3. $\frac{1}{\sqrt{2}i}(\lambda - \lambda^*)$
4. $\frac{1}{\sqrt{2}}(\lambda + \lambda^*)$

**Q37. [Dec 2016] . 3.5 marks**

Electromagnetism > Potential Formulation

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

Consider the operator $\vec{\pi} = \vec{p} - q\vec{A}$, where $\vec{p}$ is the momentum operator, $\vec{A} = (A_x, A_y, A_z)$ is the vector potential and $q$ denotes the electric charge. If $\vec{B} = (B_x, B_y, B_z)$ denotes the magnetic field, the $z$-component of the vector operator $\vec{\pi} \times \vec{\pi}$ is

1. $iq\hbar B_z + q(A_x p_y - A_y p_x)$
2. $-iq\hbar B_z - q(A_x p_y - A_y p_x)$
3. $-iq\hbar B_z$
4. $iq\hbar B_Z$

**Q38. [Dec 2016] . 3.5 marks**

Statistical Mechanics > Microcanonical Ensemble

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

Consider a gas of $N$ classical particles in a two-dimensional square box of side $L$. If the total energy of the gas is $E$, the entropy (apart from an additive constant) is

1. $Nk_B \ln\left(\frac{L^2 E}{N}\right)$
2. $Nk_B \ln\left(\frac{LE}{N}\right)$
3. $2Nk_B \ln\left(\frac{L\sqrt{E}}{N}\right)$
4. $L^2 k_B \ln\left(\frac{E}{N}\right)$

**Q39. [Dec 2016] . 3.5 marks**

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

Consider a continuous time random walk. If a step has taken place at time $t = 0$, the probability that the next step takes place between $t$ and $t + dt$ is given by $btdt$, where $b$ is a constant. What is the average time between successive steps?

1. $\sqrt{\frac{2\pi}{b}}$
2. $\sqrt{\frac{\pi}{b}}$
3. $\frac{1}{2}\sqrt{\frac{\pi}{b}}$
4. $\sqrt{\frac{\pi}{2b}}$

**Q40. [Dec 2016] . 3.5 marks**

Statistical Mechanics > Canonical Ensemble

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The partition function of a two-level system governed by the Hamiltonian $H = \begin{bmatrix} \gamma & -\delta \\ -\delta & -\gamma \end{bmatrix}$ is

1. $2\sinh\left(\beta\sqrt{\gamma^2+\delta^2}\right)$
2. $2\cosh\left(\beta\sqrt{\gamma^2+\delta^2}\right)$
3. $\frac{1}{2}\left[\cosh\left(\beta\sqrt{\gamma^2+\delta^2}\right)+\sinh\left(\beta\sqrt{\gamma^2+\delta^2}\right)\right]$
4. $\frac{1}{2}\left[\cosh\left(\beta\sqrt{\gamma^2+\delta^2}\right)-\sinh\left(\beta\sqrt{\gamma^2+\delta^2}\right)\right]$

**Q41. [Dec 2016] . 3.5 marks**

Thermodynamics > Kinetic theory of Gases

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

A silica particle of radius $0.1\mu$ m is put in a container of water at $T = 300$ K. The densities of silica and water are $2000\ \mathrm{kg/m^3}$ and $1000\ \mathrm{kg/m^3}$, respectively. Due to thermal fluctuations, the particle is not always at the bottom of the container. The average height of the particle above the base of the container is approximately

*1.* $10^{-3}$ m

2. $3 \times 10^{-4}$ m

*3.* $10^{-4}$ m

4. $5 \times 10^{-5}$ m

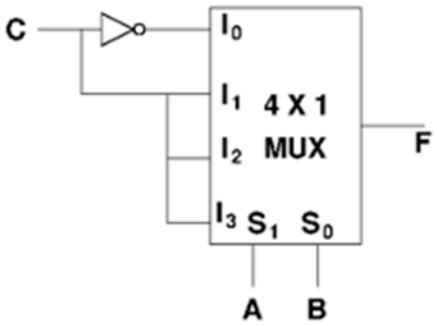
**Q42. [Dec 2016] . 3.5 marks**

Electronics > Flip flops/Counters/Registers/microcontroller etc.

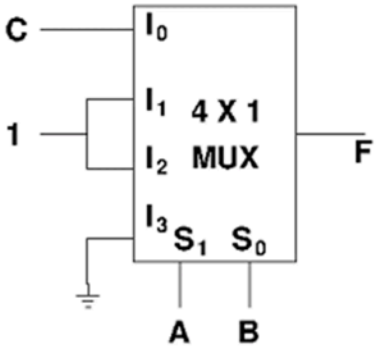
| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

Which of the following circuits implements the Boolean function $F(A,B,C) = \sum(1,2,4,6)$ ?

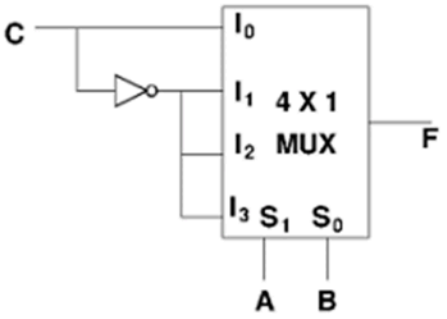
1.



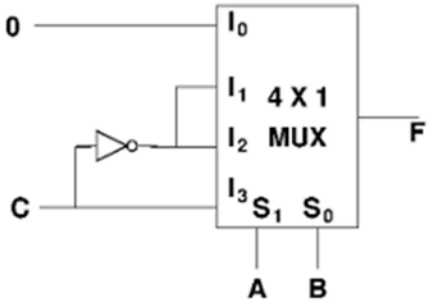

3.




2.




4.



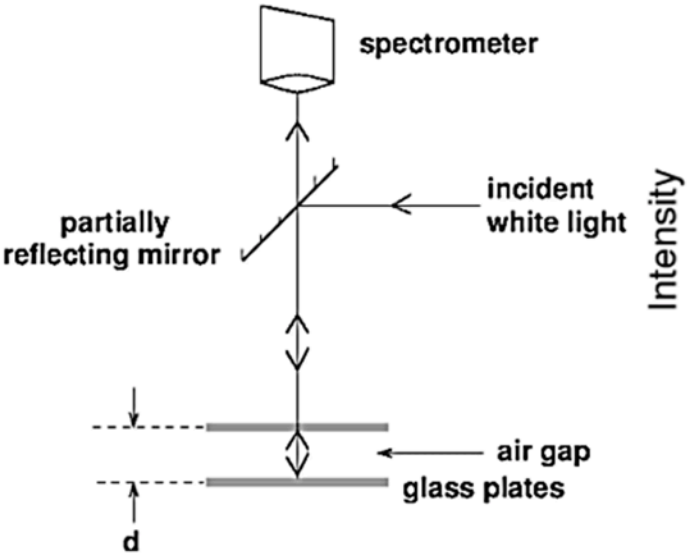
**Q43. [Dec 2016] . 3.5 marks**

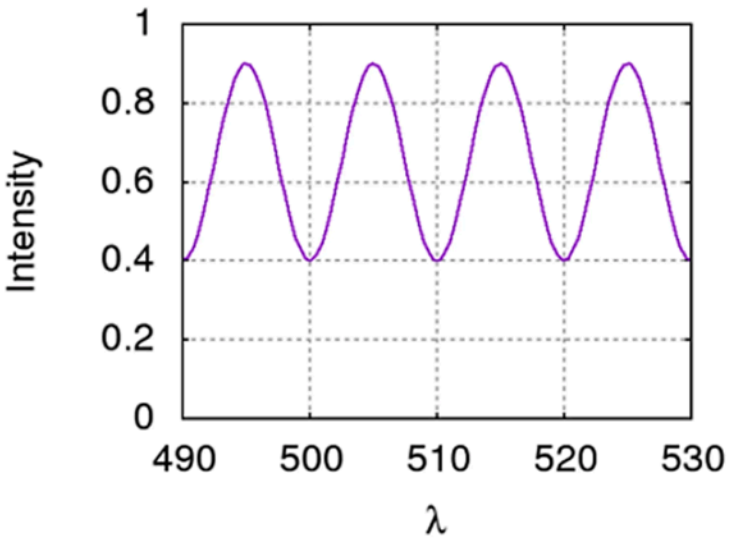
Optics > Interference and diffraction

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

A pair of parallel glass plates separated by a distance $d$ is illuminated by white light as shown in the figure below. Also shown is the graph of the intensity of the reflected light $I$ as a function of the wavelength $\lambda$ recorded by a spectrometer.

Assuming that the interference takes place only between light reflected by the bottom surface of the top plate and the top surface of bottom plate, the distance $d$ is closest to




1. $12\mu$ m
2. $24\mu$ m
3. $60\mu$ m
4. $120\mu$ m

**Q44. [Dec 2016] . 3.5 marks**

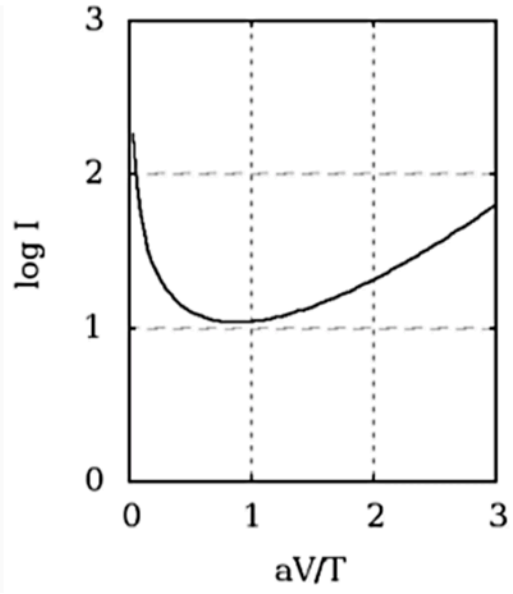
Electronics > Basic Electronics

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

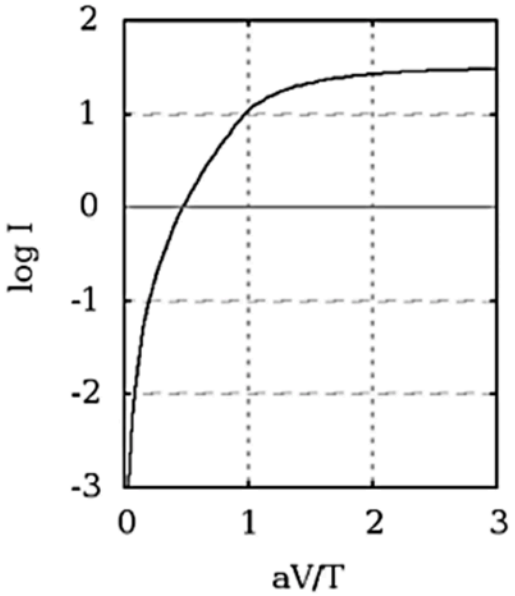
The $I-V$ characteristics of a device is

$I = I_s\left[\exp\left(\frac{aV}{T}\right) - 1\right]$, where $T$ is the temperature and $a$ and $I_S$ are constants independent of $T$ and $V$. Which one of the following plots is correct for a fixed applied voltage $V$ ?

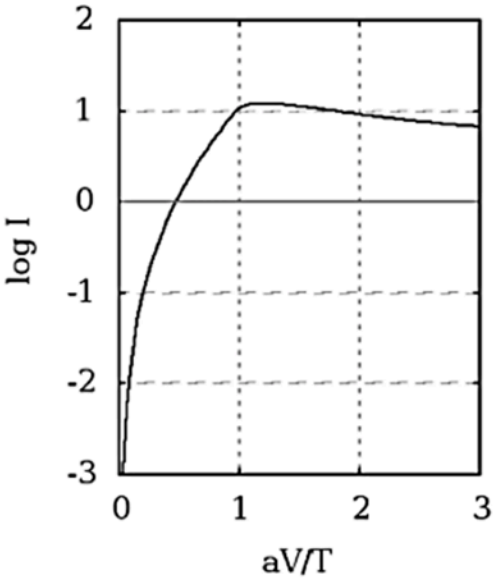
1.



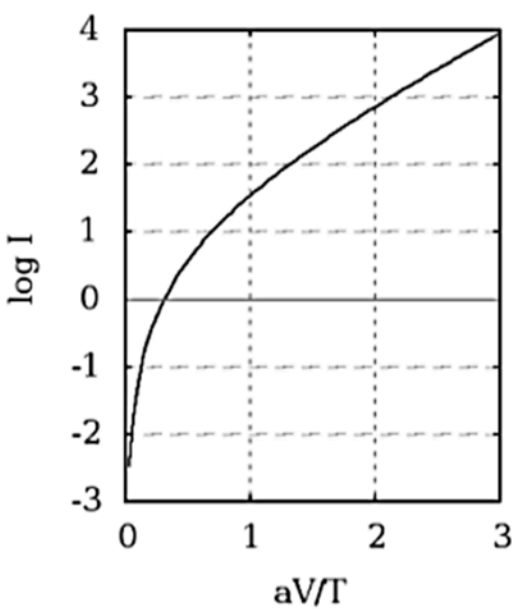

3.




2.




4.



**Q45. [Dec 2016] . 3.5 marks**

Electronics > Diodes

| CSIR NET | 2016 Dec | 3.5M |
|---|---|---|

The active medium in a blue LED (light emitting diode) is a $Ga_xIn_{1-x}N$ alloy. The band gaps of GaN and InN are 3.5 eV and 1.5 eV respectively. If the band gap of $Ga_xIn_{1-x}N$ varies approximately linearly with $x$, the value of $x$ required for the emission of blue light of wavelength 400 nm is (take $hc \approx 1200\text{eV} - \text{nm}$)

1. 0.95
2. 0.75
3. 0.50
4. 0.33

**Q46. [Dec 2016] . 5.0 marks**

Mathematical Physics > Basic Mathematics

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A stable asymptotic solution of the equation $x_{n+1} = 1 + \frac{3}{1+x_n}$ is $x = 2$. If we take $x_n = 2 + \epsilon_n$ and $x_{n+1} = 2 + \epsilon_{n+1}$, where $\epsilon_n$ and $\epsilon_{n+1}$ are both small, the ratio $\epsilon_{n+1}/\epsilon_n$ is approximately

1. $-\frac{1}{2}$
2. $-\frac{1}{4}$
3. $-\frac{1}{3}$
4. $-\frac{2}{3}$

**Q47. [Dec 2016] . 5.0 marks**

Mathematical Physics > Group Theory

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

The $2 \times 2$ identity matrix $I$ and the Pauli matrices $\sigma^x, \sigma^y, \sigma^z$ do not form a group under matrix multiplication. The minimum number of $2 \times 2$ matrices, which includes these four matrices, and form a group (under matrix multiplication) is

1. 20
2. 8
3. 12
4. 16

**Q48. [Dec 2016] . 5.0 marks**

Mathematical Physics > Numerical Methods

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Given the values $\sin 45^\circ = 0.7071$, $\sin 50^\circ = 0.7660$, $\sin 55^\circ = 0.8192$ and $\sin 60^\circ = 0.8660$, the approximate value of $\sin 52^\circ$, computed by Newton's forward difference method, is

1. 0.804
2. 0.776
3. 0.788
4. 0.798

**Q49. [Dec 2016] . 5.0 marks**

Mathematical Physics > Partial Differential Equations

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Let $f(x,t)$ be a solution of the heat equation $\frac{\partial f}{\partial t} = D\frac{\partial^2 f}{\partial x^2}$ in one dimension. The initial condition at $t = 0$ is $f(x,0) = e^{-x^2}$ for $-\infty < x < \infty$. Then for all $t > 0, f(x,t)$ is given by [Useful integral: $\int_{-\infty}^{\infty} dx e^{-\alpha x^2} = \sqrt{\pi/\alpha}$.]

1. $\frac{1}{\sqrt{1+Dt}} e^{-\frac{x^2}{1+Dt}}$
2. $\frac{1}{\sqrt{1+2Dt}} e^{-\frac{x^2}{1+2Dt}}$
3. $\frac{1}{\sqrt{1+4Dt}} e^{-\frac{x^2}{1+4Dt}}$
4. $e^{-\frac{x^2}{1+Dt}}$

**Q50. [Dec 2016] . 5.0 marks**

Classical Mechanics > Basic Mechanics

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

After a perfectly elastic collision of two identical balls, one of which was initially at rest, the velocities of both the balls are nonzero. The angle $\theta$ between the final velocities (in the lab frame) is

1. $\theta = \frac{\pi}{2}$
2. $\theta = \pi$
3. $0 < \theta \leq \frac{\pi}{2}$
4. $\frac{\pi}{2} < \theta \leq \pi$

**Q51. [Dec 2016] . 5.0 marks**

Classical Mechanics > Central forces

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Consider circular orbits in a central force potential $V(r) = -\frac{k}{r^n}$, where $k > 0$ and $0 < n < 2$. If the time period of a circular orbit of radius $R$ is $T_1$ and that of radius $2R$ is $T_2$, then $T_2/T_1$ is

1. $2^{\frac{n}{2}}$
2. $2^{\frac{2}{3}n}$
3. $2^{\frac{n}{2}+1}$
4. $2^n$

**Q52. [Dec 2016] . 5.0 marks**

Classical Mechanics > Special theory of relativity

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Consider a radioactive nucleus that is travelling at a speed $c/2$ with respect to the lab frame. It emits $\gamma$-rays of frequency $v_0$ in its rest frame. There is a stationary detector (which is not on the path of the nucleus) in the lab. If a $\gamma$-ray photon is emitted when the nucleus is closest to the detector, its observed frequency at the detector is

1. $\frac{\sqrt{3}}{2}v_0$
2. $\frac{1}{\sqrt{3}}v_0$
3. $\frac{1}{\sqrt{2}}v_0$
4. $\sqrt{\frac{2}{3}}v_0$

**Q53. [Dec 2016] . 5.0 marks**

Electromagnetism > Electrostatics

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Suppose that free charges are present in a material of dielectric constant $\epsilon = 10$ and resistivity $\rho = 10^{11}\Omega - \mathrm{m}$. Using Ohm's law and the equation of continuity for charge, the time required for the charge density inside the material to decay by $1/e$ is closest to

1. $10^{-6}$ s
2. $10^{6}$ s
3. $10^{12}$ s
4. 10 s

**Q54. [Dec 2016] . 5.0 marks**

Electromagnetism > Radiations

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A particle with charge $-q$ moves with a uniform angular velocity $\omega$ in a circular orbit of radius $a$ in the $xy$-plane, around a fixed charge $+q$, which is at the centre of the orbit at ( 0,0,0 ). Let the intensity of radiation at the point $(0,0,R)$ be $I_1$ and at $(2R,0,0)$ be $I_2$. The ratio $I_2/I_1$, for $R \gg a$, is

1. 4
2. $\frac{1}{4}$
3. $\frac{1}{8}$
4. 8

**Q55. [Dec 2016] . 5.0 marks**

Electromagnetism > Electrodynamics

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A parallel plate capacitor is formed by two circular conducting plates of radius $a$ separated by a distance $d$, where $d \ll a$. It is being slowly charged by a current that is nearly constant. At an instant when the current is $I$, the magnetic induction between the plates at a distance $a/2$ from the centre of the plate, is

1. $\frac{\mu_0 I}{\pi a}$
2. $\frac{\mu_0 I}{2\pi a}$
3. $\frac{\mu_0 I}{a}$
4. $\frac{\mu_0 I}{4\pi a}$

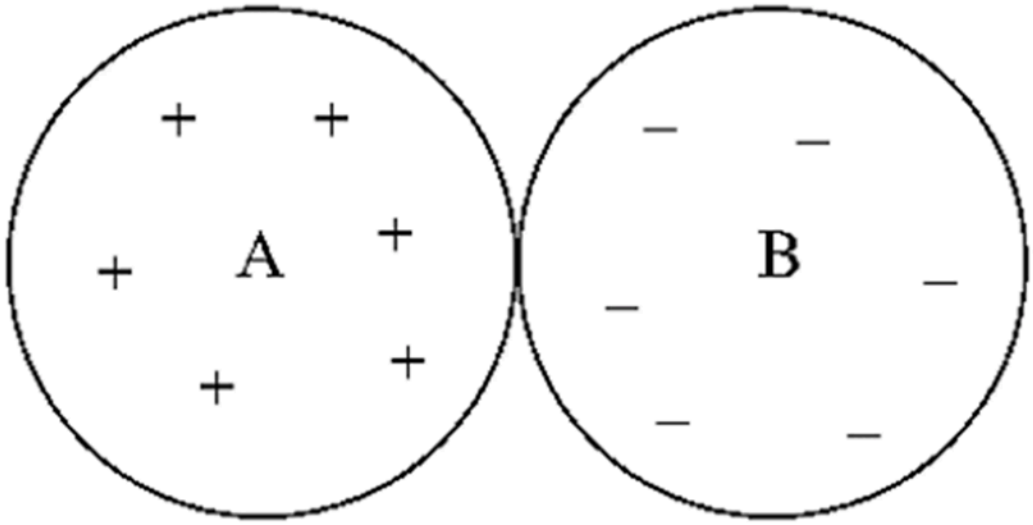
**Q56. [Dec 2016] . 5.0 marks**

Electromagnetism > Electrostatics

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Two uniformly charged insulating solid spheres A and B , both of radius $a$, carry total charges $+Q$ and $-Q$, respectively. The spheres are placed touching each other as shown in the figure. If the potential at the centre of the sphere A is $V_A$ and that at the centre of B is $V_B$, then the difference $V_A - V_B$ is

1. $\frac{Q}{4\pi\varepsilon_0 a}$
2. $\frac{-Q}{2\pi\varepsilon_0 a}$
3. $\frac{Q}{2\pi\varepsilon_0 a}$
4. $\frac{-Q}{4\pi\varepsilon_0 a}$



**Q57. [Dec 2016] . 5.0 marks**

Quantum Mechanics > Scattering theory

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A particle is scattered by a central potential $V(r) = V_0 r e^{-\mu r}$, where $V_0$ and $\mu$ are positive constants. If the momentum transfer $\vec{q}$ is such that $q = |\vec{q}| \gg \mu$, the scattering cross-section in the Born approximation, as $q \to \infty$, depends on $q$ as

[You may use $\int x^n e^{ax} dx = \frac{d^n}{da^n} \int 1 \; e^{ax} dx$ ]

1. $q^{-8}$
2. $q^{-2}$
3. $q^{2}$
4. $q^{6}$

**Q58. [Dec 2016] . 5.0 marks**

Quantum Mechanics > Dirac delta potential

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A particle in one dimension is in a potential $V(x) = A\delta(x-a)$ . Its wavefunction $\psi(x)$ is continuous everywhere. The discontinuity in $\frac{d\psi}{dx}$ at $x = a$ is

1. $\frac{2m}{\hbar^2}A\psi(a)$
2. $A(\psi(a) - \psi(-a))$
3. $\frac{\hbar^2}{2m}A$
4. 0

**Q59. [Dec 2016] . 5.0 marks**

Quantum Mechanics > KG and Dirac equation

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

The dynamics of a free relativistic particle of mass $m$ is governed by the Dirac Hamiltonian

$H = c\vec{\alpha} \cdot \vec{p} + \beta mc^2$, where $\vec{p}$ is the momentum operator and $\vec{\alpha} = (\alpha_x, \alpha_y, \alpha_z)$ and $\beta$ are four $4 \times 4$ Dirac matrices. The acceleration operator can be expressed as

1. $\frac{2ic}{\hbar}(c\vec{p} - \vec{\alpha}H)$
2. $2ic^2\vec{\alpha}\beta$
3. $\frac{ic}{\hbar}H\vec{\alpha}$
4. $-\frac{2ic}{\hbar}(c\vec{p} + \vec{\alpha}H)$

**Q60. [Dec 2016] . 5.0 marks**

Quantum Mechanics > Pertubation theory

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A particle of charge $q$ in one dimension is in a simple harmonic potential with angular frequency $\omega$. It is subjected to a time dependent electric field $E(t) = Ae^{-(t/\tau)^2}$, where $A$ and $\tau$ are positive constants and $\omega\tau \gg 1$. If in the distant past $t \to -\infty$ the particle was in its ground state, the probability that it will be in the first excited state as $t \to +\infty$ is proportional to

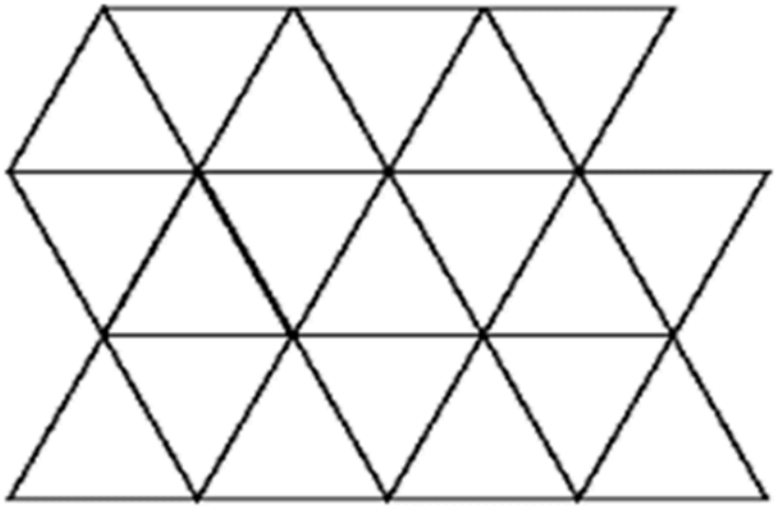
1. $e^{-\frac{1}{2}(\omega\tau)^2}$
2. $e^{\frac{1}{2}(\omega\tau)^2}$
3. 0
4. $\frac{1}{(\omega\tau)^2}$

**Q61. [Dec 2016] . 5.0 marks**

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Consider a random walk on an infinite twodimensional triangular lattice, a part of which is shown in the figure below. If the probabilities of moving to any of the nearest neighbour sites are equal, what is the probability that the walker returns to the starting position at the end of exactly three steps?



1. $\frac{1}{36}$
2. $\frac{1}{216}$
3. $\frac{1}{18}$
4. $\frac{1}{12}$

**Q62. [Dec 2016] . 5.0 marks**

Statistical Mechanics > Canonical Ensemble

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

An atom has a non-degenerate ground-state and a doubly-degenerate excited state. The energy difference between the two states is $\varepsilon$. The specific heat at very low temperatures ( $\beta\varepsilon \gg 1$ ) is given by

1. $k_B(\beta\varepsilon)$
2. $k_B e^{-\beta\varepsilon}$
3. $2k_B(\beta\varepsilon)^2 e^{-\beta\varepsilon}$
4. $k_B$

**Q63. [Dec 2016] . 5.0 marks**

Statistical Mechanics > Quantum Statistical Mechanics

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

The electrons in graphene can be thought of as a two-dimensional gas with a linear energy-momentum relation $E = |\vec{p}|v$, where $\vec{p} = (p_x, p_y)$ and $v$ is a constant. If $\rho$ is the number of electrons per unit area, the energy per unit area is proportional to

1. $\rho^{3/2}$
2. $\rho$
3. $\rho^{1/3}$
4. $\rho^{2}$

**Q64. [Dec 2016] . 5.0 marks**

Electronics > OPAMP

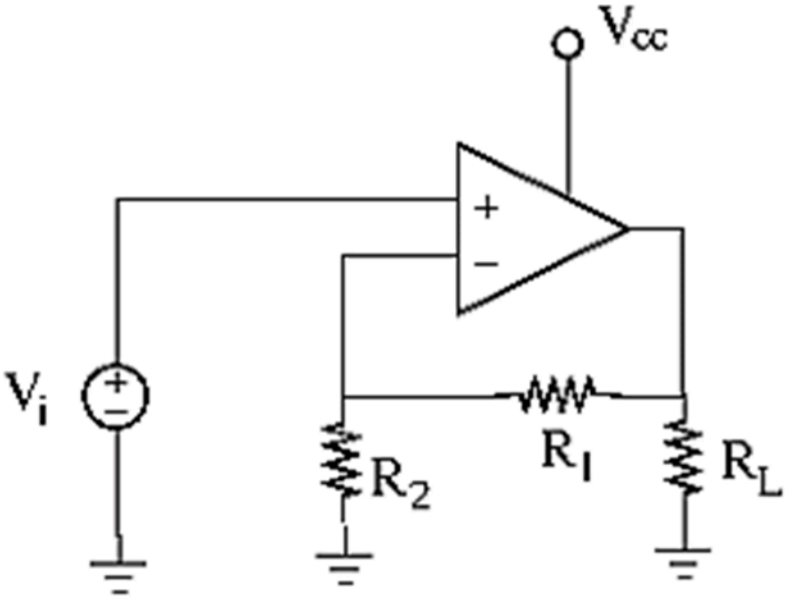
| CSIR NET | 2016 Dec | 5M |
|---|---|---|

In the circuit below, the input voltage $V_i$ is $2\ V$,

$V_{cc} = 16\ \text{V}, R_2 = 2\text{k}\Omega$ and $R_L = 10\text{k}\Omega$.

The value of $R_1$ required to deliver 10 mW of power across $R_L$ is

1. $12\text{k}\Omega$
2. $4\text{k}\Omega$
3. $8\text{k}\Omega$
4. $14\text{k}\Omega$



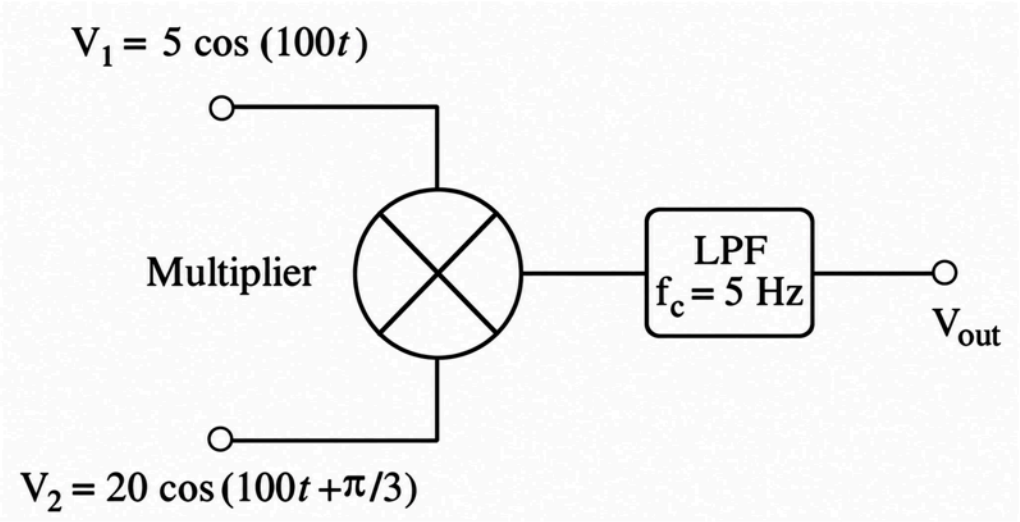
**Q65. [Dec 2016] . 5.0 marks**

Electronics > Instruments

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Two sinusoidal signals are sent to an analog multiplier of scale factor $1\,\mathrm{V}^{-1}$ followed by a low pass filter (LPF). If the roll-off frequency of the LPF is $f_c = 5$ Hz , the output voltage $V_{\text{out}}$ is

1. 5 V
2. 25 V
3. 100 V
4. 50 V



**Q66. [Dec 2016] . 5.0 marks**

Electronics > "Errors , curve fitting and data analysis"

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

The resistance of a sample is measured as a function of temperature, and the data are shown below.

| $T(^\circ\mathrm{C})$ | 2 | 4 | 6 | 8 |
|---|---|---|---|---|
| $R(\Omega)$ | 90 | 105 | 110 | 115 |

The slope of $R$ vs $T$ graph, using a linear least-squares fit to the data, will be

1. $6\Omega/\circ C$
2. $4\Omega/\circ C$
3. $2\Omega/\circ C$
4. $8\Omega/\circ C$

**Q67. [Dec 2016] . 5.0 marks**

Solid State Physics > Tight binding model

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Consider a one-dimensional chain of atoms with lattice constant $a$. The energy of an electron with wave-vector $k$ is $\epsilon(k) = \mu - \gamma\cos(ka)$, where $\mu$ and $\gamma$ are constants. If an electric field $E$ is applied in the positive $x$-direction, the time dependent velocity of an electron is (In the following $B$ is the constant)

1. proportional to $\cos\left(B - \frac{eE}{\hbar}at\right)$
2. proportional to $E$
3. independent of $E$
4. proportional to $\sin\left(B - \frac{eE}{\hbar}at\right)$

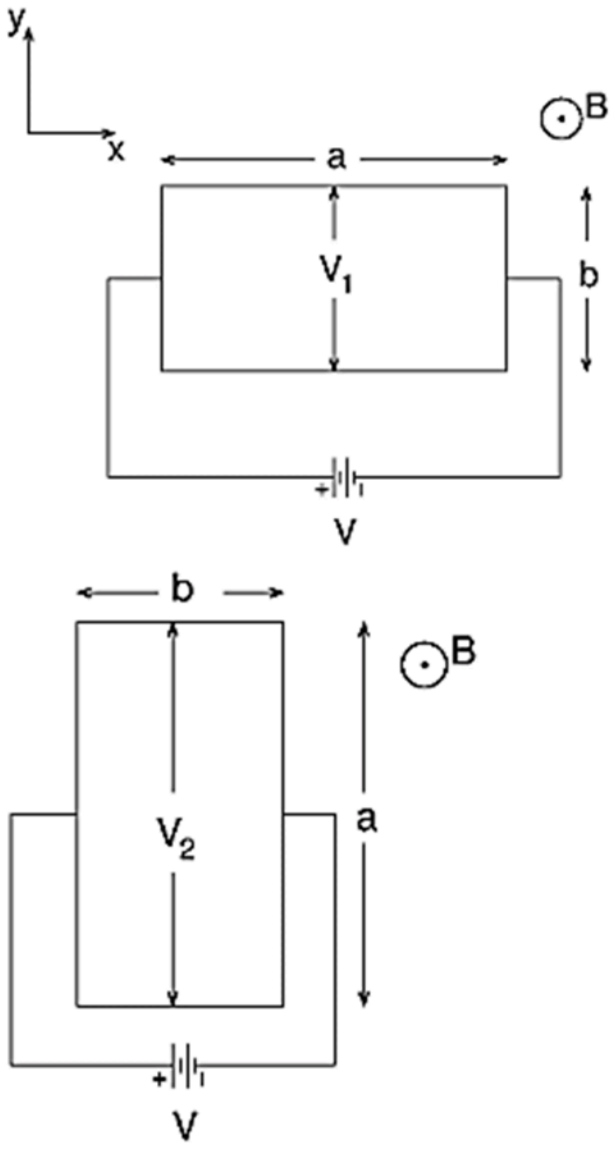
**Q68. [Dec 2016] . 5.0 marks**

Solid State Physics > Hall effect

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A thin rectangular conducting plate of length $a$ and width $b$ is placed in the $xy$-plane in two different orientations, as shown in the figures below. In both cases a magnetic field $B$ is applied in the $z$-direction and a current flows in the $x$ direction due to the applied voltage $V$. If the Hall voltage across the $y$-direction in the two cases satisfy $V_2 = 2V_1$, the ratio $a:b$ must be

1. $1:2$
2. $1:\sqrt{2}$
3. 2:1
4. $\sqrt{2}:1$



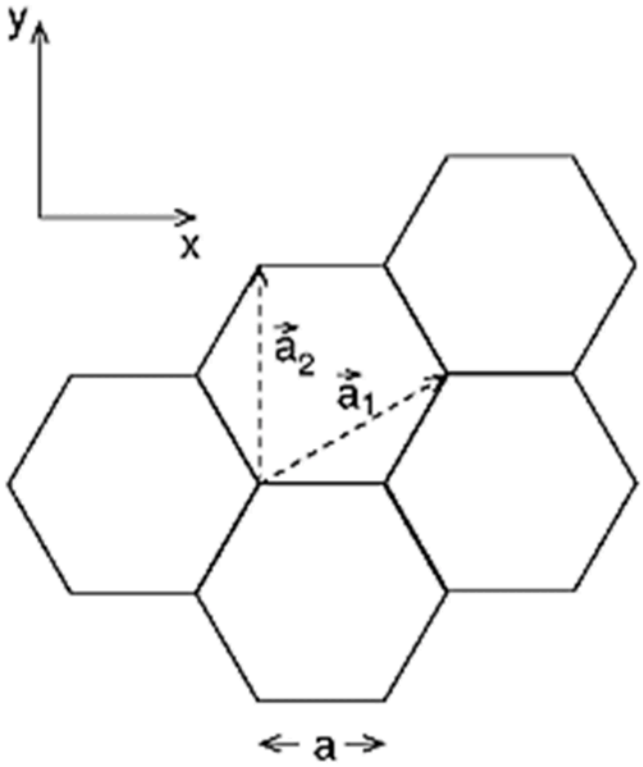
**Q69. [Dec 2016] . 5.0 marks**

Solid State Physics > Crystallography

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Consider a hexagonal lattice with basis vectors as shown in the figure below. If the lattice spacing is $a = 1$, the reciprocal lattice vectors are

1. $\left(\frac{4\pi}{3}, 0\right), \left(-\frac{2\pi}{3}, \frac{2\pi}{\sqrt{3}}\right)$
2. $\left(\frac{4\pi}{3}, 0\right), \left(\frac{2\pi}{3}, \frac{2\pi}{\sqrt{3}}\right)$
3. $\left(0, \frac{4\pi}{\sqrt{3}}\right), \left(\pi, \frac{2\pi}{\sqrt{3}}\right)$
4. $\left(\frac{2\pi}{3}, \frac{2\pi}{\sqrt{3}}\right), \left(-2\pi, \frac{2\pi}{\sqrt{3}}\right)$



**Q70. [Dec 2016] . 5.0 marks**

Atomic and Molecular Physics > "LS, JJ and other interactions"

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

In the $L-S$ coupling scheme, the terms arising from two non-equivalent $p$-electrons are

1. $^3\mathrm{S}, {}^1\mathrm{P}, {}^3\mathrm{P}, {}^1\mathrm{D}, {}^3\mathrm{D}$
2. $^1S, {}^3S, {}^1P, {}^1D$
3. $^1S, {}^3S, {}^3P, {}^3D$
4. $^1S, {}^3S, {}^1P, {}^3P, {}^1D, {}^3D$

**Q71. [Dec 2016] . 5.0 marks**

Atomic and Molecular Physics > "LS, JJ and other interactions"

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

The total spin of a hydrogen atom is due to the contribution of the spins of the electron and the proton. In the high temperature limit, the ratio of the number of atoms in the spin-1 state to the number in the spin-0 state is

1. 2
2. 3
3. $1/2$
4. $1/3$

**Q72. [Dec 2016] . 5.0 marks**

Atomic and Molecular Physics > Lasers

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A two level system in a thermal (black body) environment can decay from the excited state by both spontaneous and thermally stimulated emission. At room temperature ( 300 K ), the frequency below which thermal emission dominates over spontaneous emission is nearest to

*1.* $10^{13}$ Hz

*2.* $10^{8}$ Hz

*3.* $10^{5}$ Hz

*4.* $10^{11}$ Hz

**Q73. [Dec 2016] . 5.0 marks**

Nuclear and Particle Physics > Nuclear properties

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

What should be the minimum energy of a photon for it to split an $\alpha$-particle at rest into a tritium and a proton?

(The masses of $^4_2\mathrm{He}$, $^3_1\mathrm{H}$ and $^1_1\mathrm{H}$ are 4.0026 amu, 3.0161 amu and 1.0073 amu, respectively, and $1\mathrm{amu} \approx 938\mathrm{MeV}$.)

1. 32.2 MeV
2. 3 MeV
3. 19.3 MeV
4. $931.5\mathrm{MeV}$

**Q74. [Dec 2016] . 5.0 marks**

Nuclear and Particle Physics > Particle physics

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

Which of the following reaction(s) is/are allowed by the conservation laws?

(i) $\pi^+ + n \rightarrow \Lambda^0 + K^+$

(ii) $\pi^- + p \rightarrow \Lambda^0 + K^0$

1. both (i) and (ii)
2. only (i)
3. only (ii)
4. neither (i) nor (ii)

**Q75. [Dec 2016] . 5.0 marks**

Nuclear and Particle Physics > Particle physics

| CSIR NET | 2016 Dec | 5M |
|---|---|---|

A particle, which is a composite state of three quarks $u, d$ and $s$, has electric charge, spin and strangeness respectively, equal to

1. $1, \frac{1}{2}, -1$
2. $0, 0, -1$
3. $0, \frac{1}{2}, -1$
4. $-1, -\frac{1}{2}, +1$

# Answer Key

75 questions . Subject and topic for quick revision

| Q. No | Subject | Topic | Answer |
|---|---|---|---|
| Q1 | General Aptitude | Mathematical Analysis | **4** |
| Q2 | General Aptitude | Mathematical Analysis | **3** |
| Q3 | General Aptitude | Reasoning | **1** |
| Q4 | General Aptitude | Basic Physics | **4** |
| Q5 | General Aptitude | Basic Physics | **1** |
| Q6 | General Aptitude | Basic Physics | **1** |
| Q7 | General Aptitude | Data Analysis | **2** |
| Q8 | General Aptitude | Basic Physics | **2** |
| Q9 | General Aptitude | Basic Physics | **1** |
| Q10 | General Aptitude | Basic Physics | **3** |
| Q11 | General Aptitude | Geometry | **4** |
| Q12 | General Aptitude | Geometry | **3** |
| Q13 | General Aptitude | Geometry | **3** |
| Q14 | General Aptitude | Geometry | **2** |
| Q15 | General Aptitude | Basic Physics | **2** |
| Q16 | General Aptitude | Mathematical Analysis | **1** |
| Q17 | General Aptitude | Mathematical Analysis | **2** |
| Q18 | General Aptitude | Basic Physics | **1** |
| Q19 | General Aptitude | Basic Physics | **1** |
| Q20 | General Aptitude | Basic Physics | **4** |
| Q21 | Mathematical Physics | Probability | **3** |
| Q22 | Mathematical Physics | Fourier Transform | **4** |
| Q23 | Classical Mechanics | Basic Mechanics | **2** |
| Q24 | Mathematical Physics | Matrices and Linear Algebra | **3** |
| Q25 | Mathematical Physics | Laplace transform | **2** |
| Q26 | Classical Mechanics | Special theory of relativity | **4** |
| Q27 | Classical Mechanics | Poisson brackets | **1** |
| Q28 | Classical Mechanics | Lagrangian and Hamiltonian | **4** |
| Q29 | Classical Mechanics | Oscillations | **2** |
| Q30 | Electromagnetism | Electrodynamics | **2** |
| Q31 | Electromagnetism | Electrostatics | **1** |
| Q32 | Optics | Interference and diffraction | **1** |
| Q33 | Optics | Polarization | **3** |
| Q34 | Quantum Mechanics | Basic Quantum Mechanics | **2** |
| Q35 | Quantum Mechanics | Basic Quantum Mechanics | **1** |
| Q36 | Quantum Mechanics | Quantum Harmonic Oscillator | **4** |
| Q37 | Electromagnetism | Potential Formulation | **4** |
| Q38 | Statistical Mechanics | Microcanonical Ensemble | **3** |
| Q39 | Statistical Mechanics | Random Walk/Brownian motion/Diffusion | **4** |
| Q40 | Statistical Mechanics | Canonical Ensemble | **2** |

# Answer Key (cont.)

| Q. No | Subject | Topic | Answer |
|---|---|---|---|
| Q41 | Thermodynamics | Kinetic theory of Gases | **3** |
| Q42 | Electronics | Flip flops/Counters/Registers/microcontroller etc. | **2** |
| Q43 | Optics | Interference and diffraction | **1** |
| Q44 | Electronics | Basic Electronics | **4** |
| Q45 | Electronics | Diodes | **2** |
| Q46 | Mathematical Physics | Basic Mathematics | **3** |
| Q47 | Mathematical Physics | Group Theory | **4** |
| Q48 | Mathematical Physics | Numerical Methods | **3** |
| Q49 | Mathematical Physics | Partial Differential Equations | **3** |
| Q50 | Classical Mechanics | Basic Mechanics | **1** |
| Q51 | Classical Mechanics | Central forces | **3** |
| Q52 | Classical Mechanics | Special theory of relativity | **1** |
| Q53 | Electromagnetism | Electrostatics | **4** |
| Q54 | Electromagnetism | Radiations | **3** |
| Q55 | Electromagnetism | Electrodynamics | **4** |
| Q56 | Electromagnetism | Electrostatics | **3** |
| Q57 | Quantum Mechanics | Scattering theory | **1** |
| Q58 | Quantum Mechanics | Dirac delta potential | **1** |
| Q59 | Quantum Mechanics | KG and Dirac equation | **1** |
| Q60 | Quantum Mechanics | Pertubation theory | **1** |
| Q61 | Statistical Mechanics | Random Walk/Brownian motion/Diffusion | **3** |
| Q62 | Statistical Mechanics | Canonical Ensemble | **3** |
| Q63 | Statistical Mechanics | Quantum Statistical Mechanics | **1** |
| Q64 | Electronics | OPAMP | **3** |
| Q65 | Electronics | Instruments | **2** |
| Q66 | Electronics | "Errors , curve fitting and data analysis" | **2** |
| Q67 | Solid State Physics | Tight binding model | **1 or 4** |
| Q68 | Solid State Physics | Hall effect | **4** |
| Q69 | Solid State Physics | Crystallography | **1** |
| Q70 | Atomic and Molecular Physics | "LS, JJ and other interactions" | **4** |
| Q71 | Atomic and Molecular Physics | "LS, JJ and other interactions" | **2** |
| Q72 | Atomic and Molecular Physics | Lasers | **1** |
| Q73 | Nuclear and Particle Physics | Nuclear properties | **1** |
| Q74 | Nuclear and Particle Physics | Particle physics | **1** |
| Q75 | Nuclear and Particle Physics | Particle physics | **3** |

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