

# POLYTECHNIC TRB - PHYSICS, RASIPURAM

## MODEL QUESTION PAPER - 19

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1. The trace of an antisymmetric matrix is :

- (A) real
- (B) zero
- (C) pure imaginary
- (D) unity

2. What is the volume of a parallelepiped spanned by the vectors :

$$(\hat{i} + \hat{j}), (\hat{j} + \hat{k}), (\hat{k} + \hat{i}) ?$$

- (A) zero
- (B) 1
- (C) 2
- (D) 3

3. In an X-ray diffraction experiment the incident radiation has a linewidth of 0.1%. Assuming ideal situation what will be the angular width  $\delta\theta$  of a diffraction line at a scattering angle of  $\pi/2$  ?

- (A) 0.001 rad
- (B) 0.01 rad
- (C) 0.005 rad
- (D) 0.002 rad

4. An experiment involves measurement of two random variables A and B. The measurement error in A is 0.1% and that in B is 0.2%. The error in measurement of (A + B) will then be :

- (A) 0.1%
- (B) 0.2%
- (C) 0.03%
- (D) 0.0225%

5. The step function

$$\theta(u) = \begin{cases} 1 & u > 0 \\ 0 & u < 0 \end{cases}$$

is given by the integral

$$\frac{1}{2\pi i} \oint_C \frac{e^{izu}}{z} dz$$

when the contour  $C$  is :

- (A) circle of radius  $a$  with origin as centre
- (B) a semicircle comprising real axis and half the arc of circle above the real axis
- (C) a semicircle as in (B) above but avoiding the origin by indenting the real axis by a semicircle of radius  $\epsilon$  above the real axis
- (D) a semicircle comprising the imaginary axis and an infinite arc of circle on the right side of origin

6. The value of  $\nabla(r^2)$  is :

- (A)  $\hat{r}$
- (B)  $2\hat{r}$
- (C)  $2|\hat{r}|$
- (D) zero

7. The value of  $\nabla^2(1/r)$  is :

- (A)  $-1/r^2$
- (B)  $-4\pi\delta(r)$
- (C)  $4\pi$
- (D) zero

8. If  $A$  is an antisymmetric matrix of odd order  $n$ , then the determinant of  $A$  is :

- (A) positive real number
- (B) negative real number
- (C) zero
- (D) real number  $(-1)^{(n+1)/2}$

9. Band structure in crystalline structure is due to :
- (A) finite mass of electrons
- (B) periodic nature of potential
- (C) uniform density of the solid
- (D) spherically symmetric nature of the potential
10. The ground state energy of a particle in infinite square well is 1 eV. If four particles obeying Bose-Einstein statistics are kept in this well, then the ground state energy will be :
- (A) 30 eV
- (B) 10 eV
- (C) 4 eV
- (D) 1/4 eV
11. The maximal set of commuting observables for a system in spherically symmetric potential is given by :
- (A)  $H, L^2, L_z$
- (B)  $H, L_x, L_y, L_z$
- (C)  $p^2, L^2, L_z$
- (D)  $L^2, L_z$
12. Which of the following is *not* a consequence of Heisenberg's uncertainty principle ?
- (A) Absence of electrons in atomic nuclei
- (B) Extra stability of benzene molecule
- (C) Repulsive part of van der Waals' interaction
- (D) Antisymmetric nature of wave function of electrons

13. The stationary eigenfunction for Hamiltonian of a particle of mass  $m$  in one-dimensional potential  $V(x)$  is given to be :

$$\psi(x) = A \exp(-bx^2/2),$$

where  $A$  and  $b$  are real positive constants. It follows that :

- (A)  $V(x) = \text{constant}$   
 (B)  $V(x) \propto 1/x$   
 (C)  $V(x) \propto x^2$   
 (D)  $V(x) \propto x^3$
14. If the  $\phi$  dependent part of an eigenfunction of an electron in a hydrogen atom  $e^{2i\phi}$ , then the minimum principal and minimum orbital angular momentum quantum numbers  $n$  and  $l$  respectively for this eigenfunction will be :
- (A)  $n = 3, l = 2$   
 (B)  $n = 2, l = 2$   
 (C)  $n = 2, l = 1$   
 (D)  $n = 1, l = 2$

15. The wave function of a particle moving in one-dimensional time independent potential  $V(x)$  is represented by  $\psi(x) = e^{-iax + b}$ , where  $a$  and  $b$  are real constants. This means that the potential  $V(x)$  is of the form :

(A)  $V(x) \propto x$

(B)  $V(x) \propto x^2$

(C)  $V(x) = \text{constant}$

(D)  $V(x) = e^{-ax} + b$

16. The eigenvalues of a Hermitian operator must be :
- (A) Complex  
 (B) Real  
 (C) Positive  
 (D) Negative

17. If the  $Q$  factor of a coil which is  $W_0L/R$  is measured as a function of frequency, then :
- (A) the plot between  $Q$  and frequency is linear
  - (B) the value of  $Q$  initially decreases with increase in frequency and afterwards increases with increase in frequency
  - (C) the value of  $Q$  initially increases with increase in frequency and afterwards decreases with increase in frequency
  - (D) the  $Q$  factor remains constant irrespective of the value of frequency
18. In a Millikan oil drop experiment, one of the drop falls at speed  $V$  without field and rises at speed  $2V$  with field  $E$  applied. If the field is made  $E/2$ , the drop will :
- (A) fall with speed  $V/4$
  - (B) rise with speed  $V/2$
  - (C) rise with speed  $3V/2$
  - (D) remain steady
19. It is required to operate a proportional counter with a maximum radial field of  $10^7 \text{ Vm}^{-1}$ . The applied voltage required if the radii of the wire and tube are 0.002 cm and 1 cm respectively is :
- (A)  $10^7$  Volts
  - (B) 1242 Volts
  - (C)  $1242 \times 10^7$  Volts
  - (D) 12 Volts
20. A pressure sensor measures the systolic blood pressure of a human body which is 120 mm of Hg. It means :
- (A) Pressure is only 120 mm of Hg
  - (B) Pressure is 120 mm of Hg above atmospheric pressure
  - (C) Pressure is 120 mm of Hg below atmospheric pressure
  - (D) It is noway related to atmospheric pressure

21. In an individual thermistor, the variation of resistance with temperature is :

- (A) Negative temperature coefficient and non-linear
- (B) Negative temperature coefficient and linear
- (C) Positive temperature coefficient and non-linear
- (D) Positive temperature coefficient and linear

22. If a given signal consists of frequencies from 1 to 100 Hz. If the band limit frequencies for an amplifier are  $F_1 = 1$  Hz,  $F_2 = 50$  Hz



After amplification which of the portion of the signal is affected more.

- (A) P
- (B) T
- (C) R
- (D) All

23. Formula for decibel is given as :

$$\text{decibels} = 10 \log$$

If values of decibel is equal to zero then :

- (A) Value of  $P_2$  is zero
- (B) Value of  $P_2$  is greater than  $P_1$
- (C) Value of  $P_1$  is ten times that of  $P_2$
- (D) Value of  $P_1$  is equal to value of  $P_2$

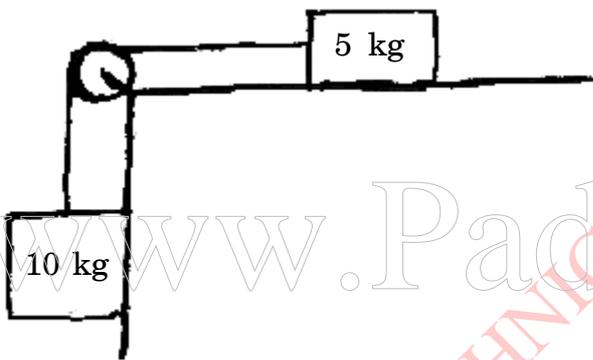
24. If a signal is averaged 'N' times the signal to noise ratio improves by :

- (A)  $N^2$  times
- (B) N times
- (C)  $\sqrt{N}$  times
- (D)  $\frac{\sqrt{N}}{2}$  times

25. A cylindrical can filled with water to a height of 40 cm has on its side two small holes of equal area, one at height of 10 cm and the other at a height of 30 cm. At the initial time, what is the ratio of the mass of water flowing per second through the lower hole to that flowing through the upper hole ?

- (A) 3
- (B)  $\sqrt{3}$
- (C)  $\sqrt{5}$
- (D) 5

26. In the figure a frictionless, massless pulley is fixed to the edge of a frictionless table. The two blocks of mass 10 kg and 5 kg are connected by a weightless string passing over the pulley. Is the tension in the string :
- (A) Greater than  
 (B) Less than  
 (C) Equal to  
 (D) Square of
- the tension it would be if the 5 kg block was glued down.



27. A circular disc is rotating about its centre in the horizontal plane. A razor blade is balanced on edge in a groove along a radius of the wheel. If the blade is pulled along the radius toward the centre of the wheel, will it tend to fall :
- (A) In the direction of rotation  
 (B) Opposite to the direction of rotation  
 (C) On both sides with equal probability  
 (D) In either in or opposite to the direction of rotation depending on the frictional force between the edge and the disc

28. Imagine the radius of the earth shrinking by 1%, its mass remaining the same. Then its kinetic energy of rotation :

- (A) decreases by 2%  
 (B) increases by 2%  
 (C) increases by 1%  
 (D) decreases by 1%

29. A uniform thin rod of mass  $M$  and length  $L$  hangs from a frictionless pivot and is connected at the bottom by a spring to the wall as shown. The spring constant is  $K$ . Then the period of motion, is a function of :

- (A)  $M$  and  $K$   
 (B)  $K$  and  $L$   
 (C)  $M$  and  $L$   
 (D)  $M$ ,  $K$  and  $L$

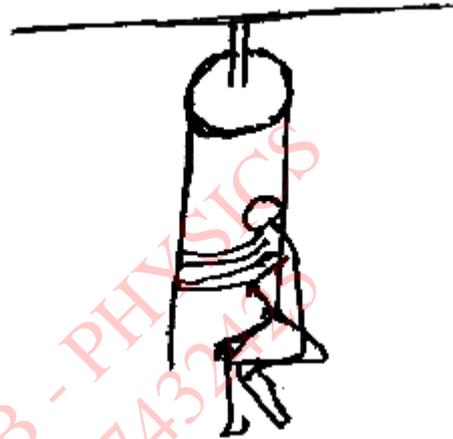
30. What is the ratio of the mass of the sun to the mass of the earth to one significant figure ?

- (A)  $1 \times 10^9$
- (B)  $3 \times 10^5$
- (C)  $7 \times 10^7$
- (D)  $9 \times 10^{11}$

31. Two persons of equal weights are hanging by their hands from the ends of a rope hung over a frictionless pulley. They begin to climb. One person can climb twice the speed of the other (with respect to the rope). Who gets to the top first ?

- (A) faster climber
- (B) slower climber
- (C) get there together
- (D) indeterminate

32. The man in the figure weighs 150 kg. He sits in a sling and pulls himself slowly up by means of a rope one a pulley. With what force he must pull ?



- (A) 150g
- (B) 100g
- (C) 75g
- (D) 50g

$g$  : constant acceleration due to gravity on earth surface.

33. A point charge  $q$  is placed at the origin. The flux of the electric field that passes through a square described by the vertices  $(0, 0, 1)$ ,  $(1, 0, 1)$ ,  $(1, 1, 1)$  and  $(0, 1, 1)$  is :

- (A)  $\frac{q}{\epsilon_0}$
- (B)  $\frac{q}{3\epsilon_0}$
- (C)  $\frac{q}{6\epsilon_0}$
- (D)  $\frac{q}{24\epsilon_0}$

34. In a constant electric field  $\vec{E}$ , the electric displacement vector  $\vec{D}$  in a certain dielectric medium is found to be given by  $\vec{D} = 2.1 \epsilon_0 \vec{E}$ . This implies that the dielectric medium is :

- (A) linear and isotropic
- (B) linear and unisotropic
- (C) non-linear and isotropic
- (D) non-linear and unisotropic

35. The electric potential in a region of space is given by  $V = V_0 e^{-bx^2}$ , where  $V_0$  and  $b$  are constants. The volume charge density in this region is :

- (A) 0
- (B)  $2b\epsilon_0 xV$
- (C)  $-2b\epsilon_0 xV$
- (D)  $2b\epsilon_0(1 - 2ax^2)V$

36. The Poynting vector

$$\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$$

has the dimension of :

- (A) energy
- (B) energy/area
- (C) power
- (D) power/area

37. Which of the following equations implies that magnetic monopole does *not* exist ?

- (A)  $\nabla \times \vec{E} = \vec{0}$
- (B)  $\nabla \cdot \vec{B} = 0$
- (C)  $\nabla \times \vec{B} = \mu_0 \vec{J}$
- (D)  $\nabla \cdot \vec{J} + \frac{\partial \rho}{\partial t} = 0$

38. The energy stored by an inductor is in the form of :

- (A) electric field
- (B) magnetic field
- (C) heat energy
- (D) electrostatic potential energy

39. A constant current is flowing through a cylindrical wire. Then the Poynting vector at the surface of the cylindrical wire :

- (A) is in the direction of the current
- (B) is in the radially outward direction
- (C) is in the radially inward direction
- (D) has zero magnitude

40. A charged particle  $q$  is kept at center of a mettalic spherical shell. The magnitudes of the electric fields inside the shell and outside the shell are given by :

- (A)  $0, \frac{q}{4\pi\epsilon_0 r^2}$  respectively
- (B)  $\frac{q}{4\pi\epsilon_0 r^2}, 0$  respectively
- (C)  $\frac{q}{4\pi\epsilon_0 r^2}, \frac{q}{4\pi\epsilon_0 r^2}$  respectively
- (D)  $\frac{q}{4\pi\epsilon_0 r}, \frac{q}{4\pi\epsilon_0 r}$  respectively

( $r$  denotes the distance from the center)

41. Considering Hydrogen ( $H_2$ ) and Helium (He) as classical ideal Maxwell-Boltzmann gas, the ratio of root mean square speeds of  $H_2$  molecules to that of He atoms at the same temperature  $T$  is :

(A) 2

(B)  $\sqrt{2}$

(C)  $\sqrt{\frac{1}{2}}$

(D)  $\frac{1}{2}$

42. The molar specific heat of conduction electrons at 300 K is :

(A)  $\gg \frac{3}{2} R$

(B)  $\frac{3}{2} R$

(C)  $\ll \frac{3}{2} R$

(D)  $R$

Here  $R$  is the gas constant.

43. Two identical particles are to be distributed over 3 energy levels. Treating the particles as distinguishable Maxwell-Boltzmann particles, the number of ways in which the particles can be distributed is :
- (A) 9  
(B) 6  
(C) 3  
(D) 8
44. A system of N identical independent three dimensional harmonic oscillators vibrating with the same frequency  $\omega$ . The system is contact with a heat reservoir at temperature T. Treating the oscillators as classical, the molar specific heat of the system is :
- (A)  $\frac{3}{2}R$   
(B)  $3NK$   
(C)  $\sqrt{\frac{3}{2}}R$   
(D)  $3R$
45. A system has a relaxation time of the order of a millisecond. A quasistatic process on this system can be carried out on the time scale of the order of :
- (A) 0.001 s  
(B) 0.1 s  
(C) 0.0001 s  
(D) 1  $\mu$ s
46. Let  $\bar{E}$  be the mean kinetic energy and V be the volume of a classical ideal gas. The pressure of the gas is numerically equal to :
- (A)  $\frac{2}{3} \frac{\bar{E}}{V}$   
(B)  $\frac{1}{3} \frac{\bar{E}}{V}$   
(C)  $\frac{3}{2} \frac{\bar{E}}{V}$   
(D)  $\frac{1}{2} \frac{\bar{E}}{V}$

47. In an adiabatic expansion of an ideal monatomic gas using Joule-Thompson effect :

- (A) Cooling effect is produced
- (B) Heating effect is produced
- (C) Neither heating nor cooling effect is produced
- (D) Supercooling effect is produced

48. Which of the following thermodynamic relations is *incorrect* ?

(A)  $P = -\left(\frac{\partial F}{\partial V}\right)_T$

(B)  $T = \left(\frac{\partial G}{\partial T}\right)_P$

(C)  $S = -\left(\frac{\partial F}{\partial T}\right)_V$

(D)  $P = -\left(\frac{\partial U}{\partial V}\right)_S$

Here P, V, T are the pressure, volume and temperature, and F, G, S, U are the Helmholtz Free energy, Gibbs' free energy, entropy and average energy respectively.

49. The equation of state of an ideal gas in the extreme relativistic approximation is given by :

(A)  $PV = \frac{2}{3}U$

(B)  $PV = \frac{5}{2}U$

(C)  $PV = \frac{1}{3}U$

(D)  $PV = \frac{2}{5}U$

50. The operator corresponding

$\vec{r} \cdot \vec{p} - \vec{p} \cdot \vec{r}$  in quantum

mechanics is :

(A)  $i\hbar$

(B) zero

(C)  $3i\hbar$

(D)  $(\partial/\partial x + \partial/\partial y + \partial/\partial z)$