Sr. No. 219

ENTRANCE TEST-2023

SCHOOL OF PHYSICAL AND MATHEMATICAL SCIENCE

PHYSICS

Question Booklet Series C

Total Questions : 60
Time Allowed : 70 Minutes

Roll No. : | | | | | | |

Instructions for Candidates :

1. Write your Entrance Test Roll Number in the space provided at the top of this page of Question Booklet and fill up the necessary information in the spaces provided on the OMR Answer Sheet.
2. OMR Answer Sheet has an Original Copy and a Candidate's Copy glued beneath it at the top. While making entries in the Original Copy, candidate should ensure that the two copies are aligned properly so that the entries made in the Original Copy against each item are exactly copied in the Candidate's Copy.
3. All entries in the OMR Answer Sheet, including answers to questions, are to be recorded in the Original Copy only.
4. Choose the correct / most appropriate response for each question among the options A, B, C and D and darken the circle of the appropriate response completely. The incomplete darkened circle is not correctly read by the OMR Scanner and no complaint to this effect shall be entertained.
5. Use only blue/black ball point pen to darken the circle of correct/most appropriate response. In no case gel/ink pen or pencil should be used.
6. Do not darken more than one circle of options for any question. A question with more than one darkened response shall be considered wrong.
7. There will be **'Negative Marking'** for wrong answers. Each wrong answer will lead to the deduction of 0.25 marks from the total score of the candidate.
8. Only those candidates who would obtain positive score in Entrance Test Examination shall be eligible for admission.
9. Do not make any stray mark on the OMR sheet.
10. Calculators and mobiles shall not be permitted inside the examination hall.
11. Rough work, if any, should be done on the blank sheets provided with the question booklet.
12. OMR Answer Sheet must be handled carefully and it should not be folded or mutilated in which case it will not be evaluated.
13. Ensure that your OMR Answer Sheet has been signed by the Invigilator and the candidate himself/ herself.
14. At the end of the examination, hand over the OMR Answer Sheet to the invigilator who will first tear off the original OMR sheet in presence of the Candidate and hand over the Candidate's Copy to the candidate.

SEAL

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1. Which of the following statement is incorrect ?

(A) According to Planck's law exchange of energy between matter and radiation can only take place in bundles of a certain size

(B) According to Planck's law the quantum of energy is directly proportional to its frequency

(C) Radiation pressure is independent of the volume of an enclosure and varies as the fourth power of temperature is direct result of Wien's law

(D) Planck's law explains all the observed results in the entire spectral range for blackbody radiation

2. A blackbody at temperature T emits radiation at a peak wavelength λ. If the temperature of the blackbody becomes 6T, the new peak wavelength is :

(A) $\frac{\lambda}{6}$

(B) $\frac{\lambda}{36}$

(C) $\frac{\lambda}{12}$

(D) $\frac{\lambda}{18}$

3. Two harmonic waves represented by :

$Y_1 = 5 \cos (12t - 13x)m$ and

$Y_2 = 5 \cos (8t - 11x)m$

are superposed to form a wave group. The group velocity of the wave group is :

(A) 1 m/s

(B) 2 m/s

(C) 3 m/s

(D) 4 m/s

4. One-dimensional wave equation is represented by :

(A) $\frac{\partial^2\psi}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2\psi}{\partial^2 t}$

(B) $\frac{\partial^2\psi}{\partial x^2} = \frac{1}{v}\frac{\partial^2\psi}{\partial^2 t}$

(C) $\frac{\partial\psi}{\partial x} = \frac{1}{v^2}\frac{\partial^2\psi}{\partial^2 t}$

(D) $\left(\frac{\partial\psi}{\partial x}\right)^2 = \frac{1}{v^2}\frac{\partial^2\psi}{\partial t^2}$

5. In the Newton's Rings experiment if the incident light consists of two wavelengths 4000 Å and 4002 Å then the distance (from the point of contact) at which the rings will disappear is given by (assume that the radius of curvature of the curved surface is 400 cm) :

(A) 8 cm

(B) 4 cm

(C) 2 cm

(D) 1 cm

6. In the Michelson interferometer arrangement, if one of the mirrors is moved by a distance of 0.08 mm, 250 fringes cross the field of view. The wavelength of monochromatic light used is :

(A) 5400 Å

(B) 6400 Å

(C) 6800 Å

(D) 5800 Å

7. If the intensity distribution produced by a single slit is represented as I_{single}, then the distribution produced by a double slit in Fraunhofer diffraction is given by :

(A) $I_{double} = I_{single} \cos^2\beta$

(B) $I_{double} = 2I_{single} \cos^2\beta$

(C) $I_{double} = 4I_{single} \cos^2\beta$

(D) $I_{double} = I_{single} \cos\beta$

where $\beta = \frac{\pi}{\lambda} d \sin\theta$, and 'd' is the distance between the two slits.

8. For $\lambda = 10 \times 10^{-5}$ cm, the most intense focal point of a zone-plate with raddi, $r_n = 0.2\sqrt{n}$ cm will be at a distance of :

(A) 200 cm

(B) 400 cm

(C) 600 cm

(D) 800 cm

9. The displacement y of a travelling wave in the x-direction is given by :

$$y = 10^{-5} \sin\left(450t - 3x + \frac{\pi}{5}\right) m$$

where x is in meters and t is in seconds, then the speed of the wave motion is :

(A) 450 m/s

(B) 100 m/s

(C) 150 m/s

(D) 300 m/s

10. The ratio of potential energy to the kinetic energy of a body executing SHM when the displacement is equal to one-fourth of the amplitude is :

(A) 1 : 4

(B) 1 : 16

(C) 1 : 32

(D) 1 : 15

11. The photoelectric threshold wavelength for Nickel (work function of Ni = 5 eV) is :

(A) 248 nm

(B) 210 nm

(C) 560 nm

(D) 380 nm

12. The de Broglie wavelength of a tennis ball of mass 140 g after it is slammed across a wall with a speed of 15 m/s is approximately :

(A) 2.7×10^{-33} m

(B) 2.7×10^{-34} m

(C) 3.4×10^{-33} m

(D) 3.1×10^{-34} m

13. The quantum mechanical operator for the momentum of a particle moving in one dimension is given by :

(A) $i\hbar \frac{d}{dx}$

(B) $-i\hbar \frac{d}{dx}$

(C) $i\hbar \frac{d}{dt}$

(D) $i\hbar^2 \frac{d}{dx}$

14. The ground state radial probability density for the Hydrogen atom is proportional to (where a_0 is the Bohr Radius) :

(A) $r e^{\frac{-r}{a_0}}$

(B) $r^2 e^{\frac{-r}{a_0}}$

(C) $r^2 e^{\frac{-2r}{a_0}}$

(D) $r^2 e^{\frac{2r}{a_0}}$

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15. Which of the following statement is incorrect ?

(A) In j–j coupling the spin and orbital angular momentum of each particle add to give a total angular momentum j for that particle, and then J equals the sum of the individual j vectors

(B) In L–S coupling the spins of all the particles and the orbital angular momenta of all the particles add to yield total S and total L, which then add to yield J

(C) In presence of a magnetic field the splitting of the energy levels in the atom gives rise to a splitting of the spectral lines emitted by the atom

(D) Atomic states with different n values but the same j values have slightly different energies because of the interaction of the spin of the electron with its orbital motion

16. Which of the following statement is incorrect ?

(A) There are three generations of leptons, each consisting of a charged lepton and its related neutrino

(B) The photon is the most familiar lepton and is the only one that is stable

(C) Muon is the second-generation lepton with a lifetime of 2.197×10^{-6} s

(D) The tau neutrino is stable and has a weak isospin of 1/2

17. Which of the following set of α-decay chains is possible ?

(A) $4n, (4n-1), (4n-2), (4n-3)$

(B) $4n, (4n+1), (4n+2), (4n+3)$

(C) $4n, (4n+2), (4n+4), (4n+8)$

(D) $4n, (4n-2), (4n-4), (4n-8)$

18. The colour charge of a quark has which of the following possible values ?

(A) Red, blue and green

(B) Yellow, blue and green

(C) Yellow, blue and white

(D) Yellow, white and green

19. The reciprocal lattice corresponding to a direct face-centred cubic lattice is a :

(A) Face-centred lattice

(B) Simple cubic lattice

(C) Body-centred cubic lattice

(D) Hexagonal lattice

20. Choose the incorrect statement :

(A) The heat capacity of most insulators at low temperatures is proportional to the cube of the temperature

(B) The heat capacity of most conductors at low temperatures is proportional to the first power of the temperature

(C) According to the Debye model, the heat capacity of a solid at high temperatures is equal to $3\ Nk_B$, where N is the number of unit cells in the solid

(D) According to the Einstein's model, the heat capacity of a solid at high temperatures is equal to $3Nk_B$, where N is the number of unit cells in the solid

21. In winter, a metal block is cold to touch than a wooden block, although both are at the same temperature. The most appropriate reason is that :

(A) In metals, the heat energy is carried away by phonons only

(B) In metals, the thermal conductivity is only determined by free electrons

(C) In metals, the thermal conductivity is determined by both phonons and free electrons, thereby making the coefficient of thermal conductivity 'K' large

(D) It is because meals have small values of 'K'

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22. Identify the incorrect statement about the tunnel diodes :

(A) Tunnel diodes are capable of very fast operation by using quantum mechanical effects

(B) The positive differential resistance in their operation, allows them to be used as oscillators

(C) In forward-biased tunnel diodes, there is a region in the V-I characteristics where an increase in forward voltage is accompanied by a decrease in forward current

(D) Tunnel diodes are p-n-junctions, where conduction band electron states on the n-side are more or less aligned with valence band hole states on the p-side

23. Which of the following semiconductor parameter can be determined from the knowledge of the Hall Coefficient ?

(A) Fermi level and band gap

(B) Temperature coefficient of resistivity

(C) Mobility and concentration of charge carriers

(D) All the above parameters can be determined

24. In a p-n junction diode, the current due to the majority electron carriers in the n region is given by (where I_o is the current with no bias and V is the forward bias applied) :

(A) $I_o e^{-\frac{eV}{kT}}$

(B) $I_o e^{\frac{eV}{kT}}$

(C) $I_o e^{-\frac{eV^2}{kT}}$

(D) $I_o e^{\frac{eV^2}{kT}}$

25. The ratio of conduction electron concentration (per cm^3) at room temperature of a typical metal (copper) to that of a typical intrinsic semiconductor (germanium) is approximately equal to :

(A) 10^{22}

(B) 10^{18}

(C) 10^{10}

(D) 10^{14}

26. The application of a magnetic field on a semiconductor :

(A) Decreases the resistivity of a semiconductor and produces a decrease in the magnitude of the Hall coefficient

(B) Increase the resistivity of a semiconductor and produces an increase in the magnitude of the Hall coefficient

(C) Decreases the resistivity of a semiconductor and produces an increase in the magnitude of the Hall coefficient

(D) Increases the resistivity of a semiconductor and produces a decrease in the magnitude of the Hall coefficient

27. For using a transistor as an amplifier, the correct option regarding the resistances of base-emitter (RBE) and base-collector (RBC) junctions is :

(A) Very high R_{BE} and very low R_{BC}

(B) Very low R_{BE} and very high R_{BC}

(C) Both R_{BE} and R_{BC} are very low

(D) Both R_{BE} and R_{BC} are very high

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28. Which of the following statements is NOT true ?

(A) For an ideal MOSFET biased in saturation, the magnitude of the small signal current gain for a common drain amplifier is infinite

(B) MOSFET is a voltage-controlled device

(C) When the drain voltage in an n-MOSFET is negative, it operates in inactive region

(D) MOSFET can be used as a voltage-controlled inductor

29. Which of the following statements is correct ?

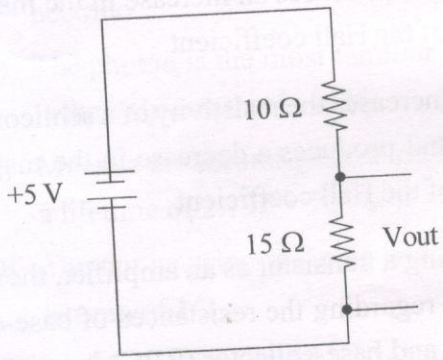
(A) RC coupling is used for power amplification

(B) The frequency response of transformer coupling is excellent

(C) The voltage gain is practically expressed in dB

(D) The final stage of a multistage amplifier uses RC coupling

30. The output voltage of the circuit below is :



(A) 3V

(B) 6V

(C) 9V

(D) 12V

31. Two bodies of masses 3×10^{-24} kg and 6×10^{-25} kg are moving with velocities 0.002c m/s and 0.01c m/s respectively towards each other under a mutually attractive force. The velocity of their centre of mass is (where 'c' is the velocity of light) :

(A) 0.015c m/s

(B) 0.003c m/s

(C) 0 m/s

(D) c m/s

32. A spaceship has a length of 100 m in its rest frame and appears to be 80.0 m to an observer in an earth frame. The relative velocity of the reference frames is :

(A) 0.600c

(B) 0.500c

(C) 0.300c

(D) 0.900c

33. Two relativistic particles with opposite velocities collide head-on and come to rest by sticking with each other. Which of the following quantity is not conserved ?

(A) Total linear momentum

(B) Total energy

(C) Total rest mass

(D) None of the above quantities is conserved

34. Observes in relative motion with speed 'v' are connected by a Lorentz transformation :

(A) $x' = \gamma(x - vt), y' = y, z' = z, t' = t$

(B) $x' = \gamma(x - vt), y' = y, z' = z, t' = \gamma t$

(C) $x' = \gamma(x - vt), y' = y, z' = z, t' = \gamma\left(t - \frac{vx}{c}\right)$

(D) $x' = \gamma(x - vt), y' = y, z' = z, t' = \gamma\left(t - \frac{vx}{c^2}\right)$

35. If we assume that the earth has exact spherical symmetry, then, g at a height h above the surface can be approximately expressed as :

(A) $\left(\frac{GMe}{R_e^2}\right)\left(1+\frac{2h}{R_e}\right)$

(B) $\left(\frac{GMe}{R_e}\right)\left(1-\frac{2h}{R_e}\right)$

(C) $\left(\frac{GMe}{R_e^2}\right)\left(1-\frac{h}{2R_e}\right)$

(D) $\left(\frac{GMe}{R_e^2}\right)\left(1-\frac{2h}{R_e}\right)$

36. A uniform disk of mass M and radius R rolls, without slipping, down a fixed plane inclined at an angle of 45° to the horizontal. The linear acceleration of the disk (in ms^{-2}) is closest to :

(A) 4.6

(B) 4.2

(C) 9.8

(D) 4.9

37. The time period of revolution of an artificial satellite moving around Jupiter in a circular orbit at a distance 'R' from its centre is T. If the same satellite is taken to an orbit of radius 9R around the same planet, the time period would be :

(A) 9T

(B) 27T

(C) T/9

(D) 3T

38. The ratio of the moment of inertia of a spherical shell about a tangent axis to the moment of inertia about its centroidal axis is :

(A) 5/3

(B) 5/2

(C) 7/2

(D) 7/3

39. Which of the following identity is NOT correct ?

(A) $\nabla(fg) = f\nabla g + g\nabla f$

(B) $\nabla\cdot(fA) = f(\nabla\cdot A) + A\cdot(\nabla f)$

(C) $\nabla\times(fA) = f(\nabla\times A) + A\times(\nabla f)$

(D) $\nabla\times(fA) = f(\nabla\times A) - A\times(\nabla f)$

40. Which of the following is a possible electrostatic field ?

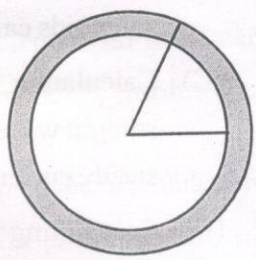
(A) $E = A[xy\hat{i} + 2yz\hat{j} + 3xz\hat{k}]$

(B) $E = A[y^2\hat{i} + (2xy + z^2)\hat{j} + 2yz\hat{k}]$

(C) $E = A[x^2\hat{i} + (2z^2 + xy)\hat{j} + yz\hat{k}]$

(D) $E = A[z^2\hat{i} + (2y + 3xz)\hat{j} + yz\hat{k}]$

41. A thick spherical shell carries charge density $\rho = \frac{k}{r^2}\ (a \le r \le b)$, the electric field in the region $(a < r < b)$ is :



(A) $\left(\frac{k}{\epsilon_0}\right)\left(\frac{r-a}{r^2}\right)\hat{r}$

(B) $\left(\frac{k}{\epsilon_0}\right)\left(\frac{a-r}{r^2}\right)\hat{r}$

(C) $\left(\frac{k}{\epsilon_0}\right)\left(\frac{b-a}{r^2}\right)\hat{r}$

(D) 0

42. The amplitude of a lightly damped harmonic oscillator decreases at the rate of 5% per minute. The loss of energy of the oscillator per minute will be closest to :

(A) 5%

(B) 10%

(C) 15%

(D) 20%

43. A parallel-plate capacitor is filled with an insulating material of dielectric constant K. Then, which of the following statement is NOT true ?

(A) The dielectric material will reduce the electric field inside the capacitor by a factor of 1/K

(B) The dielectric material will increase the electric potential inside the capacitor by a factor of 1/K

(C) The capacitance of the parallel-plate capacitor is increased by a factor of K

(D) The electric field is confined to the spaces between the plates

44. Ampere's law cannot be used for :

(A) Calculating magnetic field due to infinite planes carrying steady currents

(B) Calculating magnetic field due to infinite solenoids carrying steady currents

(C) Calculating magnetic field due to infinite straight wires carrying steady as well as non-steady currents

(D) Calculating magnetic field due to toroid carrying steady currents

45. Choose the correct statement :

(A) The magnetic susceptibility of paramagnetic materials is temperature independent

(B) The magnetic susceptibility of diamagnetic materials is nearly independent of temperature

(C) The magnetic susceptibility of ferromagnetic materials increases with temperature

(D) The magnetic susceptibility of paramagnetic materials increases with temperature

46. Which of the following does not represent the basic equation of Magnetostatics ?

(A) $\nabla \times A = B$

(B) $\nabla \times H = J$

(C) $\nabla \cdot B = 0$

(D) $\nabla \cdot B = |J|$

47. A short cylindrical bar magnet and an identical unmagnetized iron piece are both dropped simultaneously from the tops of two identical, vertical aluminium pipes (of slightly larger diameter and 2 meters long), then :

(A) It takes a fraction of a second for the unmagnetized iron to emerge at the bottom

(B) It takes a fraction of a second for the bar magnet to emerge at the bottom

(C) It takes several seconds for the unmagnetized iron to emerge at the bottom

(D) The bar magnet just hangs near the middle of the aluminium pipe

48. The self-inductance per unit length of a long solenoid, of radius R, carrying n turns per unit length is given by :

(A) $L = \frac{\mu_0 R}{\pi} n$

(B) $L = \mu_0 \pi R^2 n$

(C) $L = \mu_0 \pi R^2 n^2$

(D) $L = \frac{\mu_0 \pi R^2}{n}$

49. The electric field associated with an electromagnetic wave is given by

$$E = (3\hat{k} - \hat{j}) \sin (8x + 4y + z - \alpha t)$$

The value of α is (c is the speed of light) :

(A) c

(B) 3c

(C) 6c

(D) 9c

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50. Which of the following statement is correct ?

(A) Galilean transformation equations can be applied to Maxwell's equations in free space

(B) Maxwell's equations show that electromagnetic waves travel at different speeds in different inertial frames

(C) Maxwell's equations in free space are invariant under Lorentz transformation

(D) Maxwell's equations were able to unify the theories of electromagnetism and thermodynamics

51. The relation between C_p and C_v is given by :

(A) $C_p - C_v = -T\left(\frac{\partial S}{\partial V}\right)_T\left(\frac{\partial V}{\partial T}\right)_P^2$

(B) $C_p - C_v = -T\left(\frac{\partial S}{\partial V}\right)_T\left(\frac{\partial V}{\partial T}\right)_P$

(C) $C_p - C_v = -T\left(\frac{\partial p}{\partial V}\right)_T\left(\frac{\partial S}{\partial T}\right)_P^2$

(D) $C_p - C_v = -T\left(\frac{\partial p}{\partial V}\right)_T\left(\frac{\partial V}{\partial T}\right)_P^2$

52. If 1 mole of an ideal gas is allowed to expand isothermally to 8 times its initial volume, the entropy change in terms of the gas constant R is closest to :

(A) 2

(B) 1

(C) 3

(D) 4

53. The volume expansion coefficient α at constant pressure is given by :

(A) $\alpha = \frac{1}{v}\left(\frac{\partial V}{\partial T}\right)_p$

(B) $\alpha = V\left(\frac{\partial V}{\partial T}\right)_p$

(C) $\alpha = \frac{1}{v}\left(\frac{\partial V}{\partial S}\right)_p$

(D) $\alpha = \frac{1}{v}\left(\frac{\partial S}{\partial T}\right)_p$

54. Which of the following statement is incorrect according to the 3rd law of thermodynamics ?

(A) All expansion coefficients tend to be zero as the temperature approaches absolute zero

(B) As the temperature approaches absolute zero, the susceptibility of a paramagnetic salt increases rapidly

(C) The entropy changes in all reversible isothermal processes tend to zero as the temperature approaches absolute zero

(D) It is not possible to reduce any assembly to the absolute zero of temperature by any process however idealized in a finite number of operations

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55. Which of the following set of differential equations characterises a given hydrostatic system, where dU, dH, dF and dG are changes in internal energy, enthalpy, Helmholtz energy and Gibbs energy respectively ?

(A) $dU = TdS - pdV$
$dH = TdS + Vdp$
$dF = SdT - pdV$
$dG = -SdT + Vdp$

(B) $dU = TdS - pdV$
$dH = TdS + Vdp$
$dF = -SdT - pdV$
$dG = SdT + Vdp$

(C) $dU = TdS - pdV$
$dH = TdS + Vdp$
$dF = -SdT + pdV$
$dG = -SdT + Vdp$

(D) $dU = TdS - pdV$
$dH = TdS + Vdp$
$dF = -SdT - pdV$
$dG = -SdT + Vdp$

56. The mean translational energy per degree of freedom for the molecules of a gas obeying Maxwell's distribution is :

(A) k_BT

(B) $\frac{1}{2}k_BT$

(C) $\frac{3}{2}k_BT$

(D) $2k_BT$

57. The mean free path of an atomic gas obeying Maxwell's distribution of velocities is :

(A) Directly proportional to temperature
(B) Inversely proportional to temperature
(C) Directly proportional to the size of the atoms
(D) Directly proportional to the density of the gas

58. The coefficients of viscosity and diffusion for a gas are $2.31 \times 10^{-6}\,Nsm^{-2}$ and $1.78 \times 10^{-6}\,m^2s^{-1}$, respectively. Given the average molecular speed is $330\ ms^{-1}$, the density and mean free path respectively are :

(A) $1.61\ kg\ m^{-3}$ and $8.32 \times 10^{-8}\ m$
(B) $1.72\ kg\ m^{-3}$ and $6.32 \times 10^{-8}\ m$
(C) $1.29\ kg\ m^{-3}$ and $1.61 \times 10^{-8}\ m$
(D) $1.56\ kg\ m^{-3}$ and $8.32 \times 10^{-8}\ m$

59. At absolute zero, the Fermi-Dirac distribution function $n(\varepsilon)$ is given by :
(Where kB is the Boltzmann constant, T is the temperature and εf is the Fermi energy)

(A) $n(\varepsilon) = \dfrac{1}{\frac{\varepsilon - \varepsilon_f}{e^{k_BT}} + 1}$

(B) $n(\varepsilon) = \dfrac{1}{\frac{\varepsilon - \varepsilon_f}{e^{k_BT}} - 1}$

(C) $n(\varepsilon) = \dfrac{1}{\frac{\varepsilon_f - \varepsilon}{e^{k_BT}} - 1}$

(D) $n(\varepsilon) = \dfrac{1}{\frac{\varepsilon_f - \varepsilon}{e^{k_B}} + 1}$

60. The total number of microstates for a system of 5 indistinguishable particles distributed over four non-degenerate levels of energies $0, \varepsilon, 2\varepsilon, 3\varepsilon$ is :

(A) 120
(B) 625
(C) 1024
(D) 24

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