

PROGRAMME: PhD – PHYSICAL SCIENCES STREAM

Duration: 120 Minutes

Total Marks: 100

(Select the most appropriate answer; Each question carries one mark; There is no negative marking)

- 1) A train running at the speed of 60 km/hr crosses a pole in 9 seconds. What is the length of the train?
a) 120 meters b) 180 meters c) 324 meters d) 150 meters
- 2) The angle of elevation of a ladder leaning against a wall is 60° and the foot of the ladder is 4.6 m away from the wall. The length of the ladder is:
a) 2.3 m b) 4.6 m c) 7.8 m d) 9.2 m
- 3) A sum of money at simple interest amounts to Rs. 815 in 3 years and to Rs. 854 in 4 years. The sum is:
a) Rs. 650/- b) Rs. 690/- c) Rs. 698/- d) Rs. 700/-
- 4) Alfred buys an old scooter for Rs. 4700 and spends Rs. 800 on its repairs. If he sells the scooter for Rs. 5800, his gain percent is:
a) 4.57% b) 5.45% c) 10% d) 12%
- 5) A fruit seller had some apples. He sells 40% apples and still has 420 apples. Originally, he had
a) 588 apples b) 600 apples c) 672 apples d) 700 apples
- 6) Today is Monday. After 61 days, it will be
a) Wednesday b) Saturday c) Tuesday d) Thursday
- 7) The average monthly income of P and Q is Rs. 5050. The average monthly income of Q and R is Rs. 6250 and the average monthly income of P and R is Rs. 5200. The monthly income of P in rupees is:
a) 3500 b) 4000 c) 4050 d) 5000
- 8) Which one of the following is not a prime number?
a) 31 b) 61 c) 71 d) 91
- 9) If $a - b = 3$ and $a^2 + b^2 = 29$, find the value of ab .
a) 10 b) 12 c) 15 d) 18

10) A bag contains 2 red, 3 green and 2 blue balls. Two balls are drawn at random. What is the probability that none of the balls drawn is blue?

- a) $10/21$ b) $11/21$ c) $2/7$ d) $5/7$

11) An accurate clock shows 8 o'clock in the morning. Through how many degrees will the hour hand rotate when the clock shows 2 o'clock in the afternoon?

- a) 144° b) 150° c) 168° d) 180°

12) Find the statement that must be true according to the given information:

Sheela is twelve years old. For three years, she has been asking her parents for a dog. Her parents have told her that they believe a dog would not be happy in an apartment, but they have given her permission to have a bird. Sheela has not yet decided what kind of bird she would like to have.

- a) Sheela's parents like birds better than they like dogs
b) Sheela does not like birds.
c) Sheela and her parents live in an apartment
d) Sheela and her parents would like to move

13) Odometer is to mileage as compass is to

- a) Speed b) Hiking c) Needle d) Direction

14) Optimist is to *cheerful* as pessimist is to

- a) Gloomy b) Mean c) Petty d) Helpful

15) **Statement: Unemployment allowance should be given to all unemployed Indian youth above 18 years of age.**

Assumptions:

I) There are unemployed youth in India who needs monetary support.

II) The government has sufficient funds to provide allowance to all unemployed youth.

- a) Only assumption I is implicit
b) Only assumption II is implicit
c) Either I or II is implicit
d) Neither I nor II is implicit

16) **Statements:** All mangoes are golden in colour. No golden-coloured things are cheap.

Conclusions:

1) All mangoes are cheap.

2) Golden-coloured mangoes are not cheap.

- a) Only conclusion I follows
b) Only conclusion II follows
c) Either I or II follows
d) Neither I nor II follows

17) Look at this series: 7, 10, 8, 11, 9, 12, What number should come next?

- a) 7 b) 10 c) 12 d) 13

18) The words in the bottom row are related in the same way as the words in the top row. For each item, find the word that completes the bottom row of words.

Candle Lamp Floodlight
Hut Cottage ???

- a) Tent b) City c) Dwelling d) House

19) Apple Fruit Supermarket
Novel Book ???

- a) Vegetable b) Magazine c) Bookstore d) Shopping

20) Here are some words translated from an artificial language.

gorblflur means fan belt

pixngorbl means ceiling fan

arthtusl means tile roof

Which word could mean "ceiling tile"?

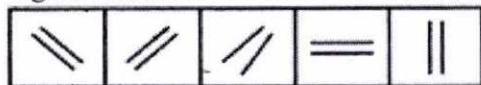
- a) gorbltusl b) flurgorbl c) arthflur d) pixnarth

21) A word is underlined followed by four answer choices. You will choose the word that is a necessary part of the underlined word

Book

- a) Fiction b) Pages c) Pictures d) Learning

22) Choose the figure which is different from the rest.



(1) (2) (3) (4) (5)

- a) 1 b) 2 c) 3 d) 4

23) Choose the figure which is different from the rest.



(1) (2) (3) (4) (5)

- a) 5 b) 2 c) 3 d) 1

24) Choose the alternative which closely resembles the mirror image of the given combination.

TARAIN1014A

(1) AƆ101NIARAL

(2) A101ƆNIARAT

(3) A101ƆTARAIN

(4) AƆ101NIARAT

a) 1

b) 2

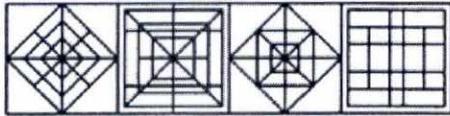
c) 3

d) 4

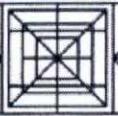
25) Find out the alternative figure which contains figure (X) as its part.



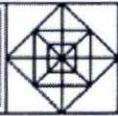
(X)



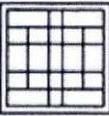
(1)



(2)



(3)



(4)

a) 1

b) 2

c) 3

d) 4

26) Identify the figure that completes the pattern



(X)



(1)



(2)



(3)



(4)

a) 1

b) 2

c) 3

d) 4

27) Find the correctly spelt word.

a) Efficient

b) Treatment

c) Beterment

d) Employd

28) Find the correctly spelt word.

a) Ommineous

b) Omineous

c) Ominous

d) Omenous

29) The study of ancient societies is known as

a) Anthropology

b) Archaeology

c) History

d) Ethnology

30) List of the business or subjects to be considered at a meeting is termed as

a) Schedule

b) Timetable

c) Agenda

d) Plan

31) Which of phrases given below each sentence should replace the phrase printed in *italics* type to make it grammatically correct?

The small child does whatever his father *was done*.

a) has done

b) did

c) does

d) had done

32) The man *to who I sold* my house was a cheat.
a) to whom I sell b) to who I sell c) who was sold to d) to whom I sold

33) From the given alternatives, choose the one which best expresses the given sentence in Indirect/Direct speech.

"If you don't keep quiet I shall shoot you", he said to her in a calm voice.

- a) He warned her to shoot if she didn't keep quiet calmly.
- b) He said calmly that I shall shoot you if you don't be quiet.
- c) He warned her calmly that he would shoot her if she didn't keep quiet.
- d) Calmly he warned her that be quiet or else he will have to shoot her

34) Pick out the most effective word from the given words to fill in the blank to make the sentence meaningfully complete.

Fate smiles those who untiringly grapple with stark realities of life

- a) with b) over c) on d) round

35) If you smuggle goods into the country, they may be by the customs authority.

- a) Possessed b) Punished c) Confiscated d) Fined

36) Joule is the unit of

- a) Temperature b) Pressure c) Energy d) Heat

37) For which of the following disciplines is Nobel Prize awarded?

- a) Physics and Chemistry
- b) Physiology or Medicine
- c) Literature, Peace and Economics
- d) All of the above

38) Professor Amartya Sen is famous in which of the fields?

- a) Biochemistry b) Electronics c) Economics d) Geology

39) What is the name of the CalTech seismologist who invented the scale used to measure the magnitude of earthquakes?

- a) Charles Richter b) Hiram Walker c) Giuseppe Mercalli d) Joshua Rumble

40) Sometimes computers are connected to a UPS system. What does UPS mean?

- a) United Parcel Service
- b) Uniform Product Support
- c) Under Paneling Storage
- d) Uninterruptable Power Supply

- 41) The potential which exhibits the dependence of the potentials on the velocity of the particle is known as
- Scalar potential
 - Vector potential
 - Lienard- Wiechar potential
 - Retarded potential
- 42) The de-Broglie hypothesis is associated with
- Wave nature of electron only
 - Wave nature of protons only
 - Wave nature of radiation
 - Wave nature of all material particles
- 43) In case of H- atom, the total degeneracy of the state of specified m is given by
- $N = n(2L+1)$
 - $N = n^2$
 - $N = (l+1)$
 - $N = 2L+1$
- 44) Zeeman effect is
- The change in energy levels of an atom when it is placed in a uniform external magnetic field.
 - The change in energy levels of an atom when placed in a non-uniform external field
 - The change in energy levels of an atom when placed in an external electric field
 - The change in energy levels of an atom when placed in a non- uniform electric field.
- 45) Scattering cross section for Coulomb potential using Born approximation is directly proportional to
- $\sin^4\theta$
 - $\cos^4\theta$
 - $\operatorname{Cosec}^4\theta$
 - $\operatorname{Cosec}^4\theta/2$
- 46) Particle having spin 0 are described by
- The Klein-Gorden equation
 - The Dirac equation
 - The Pauli equation
 - The Proca equation
- 47) The internal energy E of a system is given by $E = sb^3/VN$, where b is a constant and other symbols have their usual meaning. The temperature of the system is equal to
- bs^2/VN
 - $3bs^2/VN$
 - BS^3/V^2N
 - $(S/N)^2$
- 48) If the number density of a free electron gas in three-dimensions is increased eight times, its Fermi temperature will
- Increase by a factor 4
 - Decrease by a factor of 4
 - Increase by a factor of 8
 - Decrease by a factor of 8

49) Gas molecules of mass m are confined in a cylinder of radius R and height L (with $R \gg L$) kept vertically in the Earth's gravitational field. The average energy of the gas at low temperatures (such that $mg \gg K_B T$) is given by

- a) $Nk_B T/2$ b) $3Nk_B T/2$ c) $2Nk_B T$ d) $5Nk_B T/2$

50) The spin orbital interaction in an atom is given by $H = a.L.S$, where L and S denote the orbital and spin angular momenta, respectively of the electron. The splitting between the levels ${}^2P_{3/2}$ and ${}^2P_{1/2}$ is

- a) $3/2 * a\hbar^2$ b) $1/2 * a\hbar^2$ c) $3a\hbar^2$ d) $5/2 * a\hbar^2$

51) The number of ways in which N identical bosons can be distributed in two energy levels is

- a) $N+1$ b) $N(N-1)/2$ c) $N(N+1)/2$ d) N

52) A circular ring rotates about the axis passing through its center and perpendicular to its plane. Each point on it moves with a speed $c/2$, where c is the speed of light in vacuum. The relative velocity between any two diametrically opposite points on the ring is

- a) $2c/5$ b) $c/2$ c) $4c/5$ d) C

53) The total spin-angular momentum of a system of three free electrons is

- a) $S_{tot} = 1/2$ and $S_{tot} = 3/2$
 b) $S_{tot} = 1/2$ only
 c) $S_{tot} = 3/2$ only
 d) $S_{tot} = 0$ and $S_{tot} = 1$

54) The Hall Effect is used to measure

- a) Type of semiconductor
 b) Determination of carrier concentrations
 c) Determination of mobility
 d) All the above

55) A certain non-inverting amplifier has an R_i of $1.0 \text{ k}\Omega$ and R_F of $100 \text{ k}\Omega$. The closed loop gain is

- a) 100000 b) 1000 c) 101 d) 100

56) At high temperature, entropy of a spin half system is equal to

- a) Nk b) $Nk \ln 2$ c) $Nk/2$ d) $2Nk$

57) The magnitude of frictional force acting on the disc is

- a) ma b) μmg c) $ma/2$ d) zero

58) The kinetic energy of the body is twice its rest mass energy. What is the ratio of relativistic mass to rest mass of the body?

- a) 3 b) 1 c) $1/2$ d) 2

59) In a Ruby laser, population inversion is achieved by applying

- a) Magnetic field.
 b) Electronic field

- c) Both electric field and magnetic field
d) Optical pumping
- 60) An infinitely long closely wound solenoid carries a sinusoidally varying current. The induced electric field is
a) Zero every where
b) Non-zero inside and zero outside the solenoid
c) Non-zero inside as well as outside the solenoid
d) Zero inside and non-zero outside the solenoid
- 61) The dominant mode in a rectangular waveguide is TE_0 because this mode has
a) No attenuation
b) No cut off
c) No magnetic field component
d) The highest cut off wavelength
- 62) According to Schrodinger, a particle is equivalent to a
a) Wave packet
b) Single wave
c) Light wave
d) None
- 63) For a wave function $\psi(r,\theta)=A_f(n)\cos\theta$ value of quantum number l is
a) 1 b) 0 c) 2 d) 3
- 64) The barn is equal to
a) 10^{-20} cm^2 b) 10^{-24} cm^2 c) 10^{-28} cm^2 d) 10^{-30} cm^2
- 65) The equation of the plane that is tangent to the surface $xyz=8$ at the point (1,2,4) is
a) $x+2y+4z=12$
b) $4x+2y+z=12$
c) $x+4y+2z=0$
d) $x+y+z=7$
- 66) Bose condensation occurs in liquid He^4 kept at ambient pressure at 2.17K. At which temperature will Bose condensation occur in He^4 in gaseous state, the density of which is 1000 times smaller than that of liquid He^4 ?
a) 2.17mK b) 21.7mK c) 21.7 μ K d) 2.17 μ K
- 67) The commutator $[x^2, p^2]$ is
a) $2ihxp$ b) $2ih(xp+px)$ c) $2ihpx$ d) $2ih(xp-px)$
- 68) Let $y(x)$ be a continuous real function in the range 0 and 2π , satisfying the inhomogeneous differential equation $\sin x \cdot d^2y/dx^2 = \delta(x-\pi/2)$. The value of dy/dx at the point $x = \pi/2$.
a) Is continuous
b) Has a discontinuity of 3
c) Has a discontinuity of 1/3
d) Has a discontinuity of 1

69) A Carnot engine operates between a heat source at 500 K and a heat sink at 300 K. The temperature of the source is increased by 20 K. In order that the efficiency of the engine remain unchanged, the temperature of the sink should be changed by

- a) 20K b) 12K c) -12K d) -20K

70) Two particles come towards each other with a speed of $0.7c$, with respect to the laboratory. What is their relative speed?

- a) $0.9c$ b) $0.94c$ c) c d) Zero

71) Which of these is conserved as well as invariant?

- a) Energy b) Rest mass c) Charge d) Momentum

72) A point charge q induces some charge on an infinite plane conducting surface when placed at a distance r from that plane which is also grounded, the charge induced on the surface

- a) q/r b) q c) $-q$ d) $-q/r$

73) When a monoatomic gas atom is placed in a uniform electric field E , the resulting induced dipole moment is proportional to

- a) E b) E^2 c) E^3 d) Independent of E

74) Matter waves are

- a) Longitudinal
b) Electromagnetic
c) Always travel with the speed of light
d) Show diffraction

75) If potential is symmetric, then the wave function of a particle will be

- a) Symmetric
b) Antisymmetric
c) Either symmetric or antisymmetric
d) Neither symmetric nor antisymmetric

76) The Slater determinant can be used to describe

- a) Symmetric eigen function
b) Antisymmetric eigen function
c) Both symmetric and antisymmetric eigen functions
d) None of the above

77) A particle in one dimension moves under the influence of a potential $V(x) = ax^6$, where a is a real constant. For large n , the quantized energy level E_n depends on n as

- a) $E_n \sim n^3$ b) $E_n \sim n^{4/3}$ c) $E_n \sim n^{6/5}$ d) $E_n \sim n^{3/2}$

78) The minimum energy of an electron (the rest mass of which is 0.5 MeV) that can emit Cherenkov radiation while passing through water (of refractive index 1.5) is approximately

- a) 1.0 MeV b) 3.0 MeV c) 0.6 MeV d) 0.5 MeV

- 79) Which of the following quantities is Lorentz invariant?
 a) $|\mathbf{E} \times \mathbf{B}|^2$ b) $|\mathbf{E}|^2 - |\mathbf{B}|^2$ c) $|\mathbf{E}|^2 + |\mathbf{B}|^2$ d) $|\mathbf{E}|^2 |\mathbf{B}|^2$
- 80) The magnetic field at a distance R from a long straight wire carrying a steady current I is proportional to
 a) IR b) I/R^2 c) I^2/R^2 d) I/R
- 81) The ground state energy of the hydrogen atom is -13.6 eV. The energy of the second excited state is
 a) -12.2 eV b) -6.8 eV c) -1.5 eV d) -4.5 eV
- 82) The number of fundamental modes of vibrations of CO₂ molecule is
 a) Four: two are raman active and two are infrared active
 b) Four: one is raman active and three are infrared active
 c) three: one is raman active and two are infrared active
 d) three: two are raman active and one is infrared active
- 83) The mean internal energy of a one-dimensional harmonic oscillator in equilibrium with a heat bath of temperature T is
 a) $1/2 * k_B T$ b) $k_B T$ c) $3/2 * k_B T$ d) $3 k_B T$
- 84) The work done by the frictional force at the instant of pure rolling
 a) $\mu mg a t^2 / 2$
 b) $\mu mg a t^2$
 c) $\mu mg (a t^2 / \alpha)$
 d) zero
- 85) Distance of a planet from the earth is 0.8 light years. An astronaut starts from the earth at $t=0$ with a constant speed of 0.8 c towards the planet. What is the reading of planet's clock at the instant?
 a) 10 years b) 12.4 years c) 6 years d) 8 years
- 86) In an electromagnetic wave, the direction of the magnetic induction \vec{B} is
 a) Parallel to electric field \vec{E}
 b) Perpendicular to the electric field \vec{E}
 c) Antiparallel to the Poynting's vector \vec{S}
 d) Random
- 87) Commutator of two no-commuting Hermitian operator is
 a) Hermitian
 b) Anti-Hermitian
 c) Neither
 d) Either Hermitian or anti- Hermitian
- 88) For scattering on a hard sphere of radius R, in classical physics the differential scattering cross section is given by
 a) πR^2 b) $\pi R^2 / 2$ c) $R^2 / 2$ d) $R^2 / 4$

89) The equation of the first excited quantum state of the particle in the two dimensional potential $V(x,y) = \frac{1}{2} m \omega^2 (x^2 + 4y^2)$ is

- a) $2\hbar\omega$ b) $3\hbar\omega$ c) $3/2\hbar\omega$ d) $5/2\hbar\omega$

90) A laser operating at 500 nm is used to excite a molecule. If the stoke line is observed at 700cm^{-1} , the approximate positions of the stokes and anti-stokes lines are

- a) 481.5nm and 520nm
 b) 481.5nm and 500nm
 c) 500nm and 520nm
 d) 500nm and 600nm

91) The energy required to create a lattice vacancy in a crystal is equal to 1 e.V. The ratio of the number densities of vacancies $n(1200\text{K})/n(300\text{K})$. when the crystal is at equilibrium at 1200 K and 300 K, respectively, is approximately

- a) $\text{Exp}(-30)$ b) $\text{Exp}(-15)$ c) $\text{Exp}(15)$ d) $\text{Exp}(30)$

92) Let $u(x,y) = x + 1/2(x^2 - y^2)$ be the real part of an analytic function $f(z)$ of the complex variable $z = x + iy$. The imaginary part of $f(z)$ is

- a) $y + xy$ b) xy c) y d) $y^2 - x^2$

93) The activity of radioactive sample is defined as ΛN , where Λ is the decay constant and N is the number of atoms. In an experiment, the activity of the sample $^{55}_{24}\text{Cr}$ was found to change as

| | | | | | |
|-----------------------------|------|------|------|------|------|
| After(min) | 0 | 5 | 10 | 15 | 20 |
| $\Lambda N(\text{m-curie})$ | 19.2 | 7.13 | 2.65 | 0.99 | 0.37 |

The half-life of $^{55}_{24}\text{Cr}$ is

- a) 5.08 min b) 3.52 min c) 3.57 min d) 5.16 min

94) A piece of semiconducting material is introduced into a circuit. If the temperature of the material is raised, the circuit current will

- a) Increases b) Remain the same c) Decreases d) Ceases to flow

95) Relative mechanics reduces to non-relativistic mechanics in the limit

- a) $c \longrightarrow 0$
 b) $c \longrightarrow \infty$
 c) $v \longrightarrow c$
 d) None of the above

96) Which of these is neither conserved nor invariant?

- a) Velocity b) Momentum c) Charge d) Energy

97) A transmission line whose characteristic is a resistance

- a) Must be lossless line
 b) Must be a distortion less line
 c) May not be distortion less line
 d) None of the above

98) For a wave function $\psi(r,\theta) = A f(n) \cos\theta$ value of quantum number m is

- a) 0 b) 1 c) 2 d) 3

99) Consider the transition of liquid water to steam as water boils at a temperature of 100°C under the pressure of 1 atmosphere. Which one of the following does not change discontinuously at the transition?

- a) The Gibbs free energy
- b) enthalpy
- c) The entropy
- d) The specific volume

100) The excitations of three-dimensional solid are bosonic in nature with their frequency ω and wave number k are related by $\omega \propto k^2$ in the large wavelength limit. If the chemical potential is zero, the behavior of the specific heat of the system at low temperature is proportional to

- a) $T^{1/2}$
- b) T
- c) $T^{3/2}$
- d) T^3

PHYSICAL SCIENCES (41-100) STREAM

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|----|---|----|---|-----|---|
| 1 | D | 35 | C | 69 | B |
| 2 | D | 36 | C | 70 | B |
| 3 | C | 37 | D | 71 | C |
| 4 | B | 38 | C | 72 | C |
| 5 | D | 39 | A | 73 | A |
| 6 | B | 40 | D | 74 | D |
| 7 | B | 41 | C | 75 | A |
| 8 | D | 42 | D | 76 | B |
| 9 | A | 43 | A | 77 | D |
| 10 | A | 44 | A | 78 | C |
| 11 | D | 45 | D | 79 | B |
| 12 | C | 46 | A | 80 | D |
| 13 | D | 47 | B | 81 | C |
| 14 | A | 48 | A | 82 | D |
| 15 | A | 49 | D | 83 | B |
| 16 | B | 50 | C | 84 | D |
| 17 | B | 51 | C | 85 | A |
| 18 | D | 52 | C | 86 | B |
| 19 | C | 53 | A | 87 | B |
| 20 | D | 54 | D | 88 | D |
| 21 | B | 55 | C | 89 | C |
| 22 | C | 56 | B | 90 | A |
| 23 | B | 57 | C | 91 | C |
| 24 | D | 58 | A | 92 | B |
| 25 | D | 59 | D | 93 | B |
| 26 | C | 60 | B | 94 | A |
| 27 | A | 61 | D | 95 | A |
| 28 | C | 62 | A | 96 | A |
| 29 | B | 63 | A | 97 | C |
| 30 | C | 64 | B | 98 | B |
| 31 | C | 65 | B | 99 | A |
| 32 | D | 66 | B | 100 | C |
| 33 | C | 67 | D | | |
| 34 | C | 68 | A | | |


(MAWAJ KOMATH)