ENTRANCE TEST FOR Ph.D. PROGRAMME, 2023

PHYSICS

Time : Three Hours   Maximum : 100 Marks

Part A

*Answer **all** questions.*
Each question carries 1 mark.

Choose the correct answer from the choices given :

1. Suppose the radius of the earth were to shrink by 1 %, its mass remaining the same, the acceleration due to gravity would :

    (A) Increase by 4 %.   (B) Decrease by 1 %.

    (C) Not change at all.   (D) Increase by 2 %.

2. If the differential cross-section in scattering is equal to a^2, where a is a constant, then the total cross-section will be :

    (A) $a^2/2$.   (B) πa^2.

    (C) $2\pi a^2$.   (D) $4\pi a^2$.

3. The value of the integral $\int_{-\infty}^{\infty} (\delta(x)) e^{ikx} dx$ where k is a constant and $\delta(x)$ is the Dirac delta function is given by :

    (A) Zero.   (B) $\sin k$.

    (C) $\cos k$.   (D) $-ik$.

4. Identify the vector that is perpendicular to both $(\hat{i} + 2\hat{j} - 3\hat{k})$ and $(-\hat{i} + \hat{j} - 2\hat{k})$ from the following :

    (A) $\hat{i} + 3\hat{j} + 2\hat{k}$.   (B) $2\hat{i} + 3\hat{j} + \hat{k}$.

    (C) $-\hat{i} + 5\hat{j} + 3\hat{k}$.   (D) $\hat{i} + \hat{j} + \hat{k}$.

5. A particle thrown upwards from earth's surface reaches a height of 100 m. and returns back. The acceleration of the particle at its highest point of reach has the value :

    (A) Zero.   (B) $g/4$.

    (C) $g/2$.   (D) g.

6. A body of mass m moves in a circular orbit of radius R in a potential : $V_{(r)} = -K/r$, where K is a constant, then its orbital angular momentum about the centre of the circle is :

    (A) 2RKm. ·   (B) $\sqrt{2RKm}$.

    (C) $\sqrt{RKm}$.   (D) RKm.

7. A rigid body consisting of three particles A, B, C is constrained such that A, B are rigidly fixed to be at rest. Which of the following statements correctly describes the behaviour of C ?

    (A) C can move on the surface of a sphere of constant radius.

    (B) C can move the circumference of a circle of constant radius with line joining A, B passing normally through the centre of the circle.

    (C) C can move along the line joining A, B.

    (D) C can move parallel to the line joining A, B.

8. Two masses of value m that are moving towards each other with equal speeds of value 0.6 c collide head on and sticking together form a bigger particle of mass M. Then the value of M is equal to :

    (A) 2 m.   (B) $\dfrac{5}{2}m$.

    (C) $\dfrac{9}{4}m$.   (D) $\dfrac{25}{8}m$.

9. Charge Q is uniformly distributed in a sphere of radius R. The divergence of an electric field $\bar{E} \rho$ inside the spher is (in Gaussian units) :

    (A) $\dfrac{4\pi Q}{R^3}$.   (B) $\dfrac{3Q}{R^3}$.

    (C) $\dfrac{4\pi R^3}{3}$.   (D) $4\pi Q$.

10. Lienard-Wiechert potentials are the :

    (A) Vector potentials due to a moving point charge.

    (B) Scalar potentials due to a moving point charge.

    (C) Vector and scalar potentials due to a static point charge.

    (D) Vector and scalar potentials due to a moving point charge.

11. Electric fields associated with the two electromagnetic waves are in the ratio 3 : 2. Then the energy transported per unit area per unit time by these waves are in the ratio :

   (A) 3 : 2.

   (B) 9 : 4.

   (C) 4 : 9.

   (D) 2 : 3.

12. A 3-dimensional harmonic oscillator is in thermal equilibrium with a heat bath at temperature T. The average total energy of the oscillator is :

   (A) $\frac{1}{2}$ KT.

   (B) 3 KT.

   (C) KT.

   (D) $\frac{3}{2}$ KT.

13. The equation of state of a gas with internal energy U is given by $PV = \frac{1}{3}U$. Then the corresponding equation for an adiabatic process is :

   (A) $PV^{2/3}$ = constant.

   (B) $PV^{1/3}$ = constant.

   (C) $PV^{4/3}$ = constant.

   (D) $PV^{3/5}$ = constant.

14. If a PN junction is formed having a junction potential V_J and a depletion region width W, then

   (A) $V_J \propto W$.

   (B) $V_J \propto W^{1/2}$.

   (C) $V_J \propto W^2$.

   (D) $V_J \propto W^{3/2}$.

15. A photon gas with internal energy U is described by the following equation of state :

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

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

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

   (D) $PV = U$.

16. An op-amp amplifier has a gain of 10 in the inverting configuration and a bandwidth of 1 MHz. At what gain will it have a bandwidth of 10 MHz ?

   (A) 1.

   (B) 20.

   (C) 100.

   (D) 10^5.

17. A square wave of peak to peak amplitude of 500 mV has to be amplified to a peak to peak amplitude of 4 V with a rise time of 3 µs or less. The op-amp used should have a minimum slew rate of :

    (A) 0.5 V/µs.   (B) 0.75 V/µs.

    (C) 0.8 V/µs.   (D) 1.1 V/µs.

18. An ideal differentiator using an op-amp has a high frequency gain above its maximum frequency varying as :

    (A) + 20 db/decade.   (B) − 20 db/decade.

    (C) 10 db/decade.   (D) − 10 db/decade.

19. A first order low-pass filter has a pass band gain of 10 and a cut-off of 10 kHz. The gain of the circuit at 100 kHz in dB is :

    (A) 17 db.   (B) 1.0 db.

    (C) − 20 db.   (D) − 3 db.

20. A weighted resistor network is used as a 4 bit D/A converter. If the current through the LSB resistor is 10 µA, what is the maximum current through the MSB resistor ?

    (A) 40 µA.   (B) 2.5 µA.

    (C) 160 µA.   (D) 80 µA.

21. Most metals used for temperature measurements in the form of a resistance thermometer have :

    (A) Negative resistance characteristic.

    (B) Positive temperature co-efficient of resistance.

    (C) A non-linear resistance variation.

    (D) Negative temperature co-efficient of resistance.

22. Which of the following is not part of a lock-in amplifier ?

    (A) Phase sensitive detector.   (B) Integrator.

    (C) Differentiator.   (D) Small signal amplifier.

23. Heterojunction devices are made up of GaAs and AlGaAs because they have :

    (A) Different bandgap but similar crystal structure.

    (B) Same bandgap and similar crystal structure.

    (C) Same bandgap but different crystal structure.

    (D) Different bandgap and different crystal structure.

24. In the Born-Oppenheimer approximation, the following assumption is made ;

    (A) The nuclei also move in relation to the more fast moving electrons.

    (B) The nuclei move with the same velocity as the fast-moving electrons.

    (C) The nuclei move faster than the fast moving electrons.

    (D) The nuclei remain stationary in relation to the fast moving electrons.

25. In the normal Zeeman effect, the middle spectal line is :

    (A) Circularly polarized.   (B) Elliptically polarized.

    (C) Not polarized.   (D) Plane polarised.

26. One of the following elements shows the doublet spectral features like the alkalies. Identify it from the following :

    (A) Singly ionised Boron.   (B) Singly ionised Aluminium.

    (C) Singly ionised Barium.   (D) Singly ionised Oxygen.

27. The ratio of spontaneous emissions process probability to the stimulated emission probability is proportional to :

    (A) Square root of the transition frequency.

    (B) Reciprocal of the transition frequency.

    (C) Square of the transition frequency.

    (D) Cube of the transition frequency.

28. In a b.c.c. lattice with lattice constant a, the body centered position from the origin is at a distance of :

    (A) $\sqrt{2}\, a$.   (B) $\dfrac{\sqrt{3a}}{2}$.

    (C) $\dfrac{\sqrt{3}}{2}a$.   (D) $\dfrac{\sqrt{3}}{4}a$.

29. In a cubic crystal, the interplanar spacing of (hkl) planes is represented by d_{hkl}. Which of the following is true ?

    (A) $d_{111} > d_{100}$.   (B) $d_{110} > d_{111}$.

    (C) $d_{111} > d_{210}$.   (D) $d_{200} > d_{111}$.

30. Madelung energy is calculated in :

    (A) Inert gas crystals.   (B) Covalent crystals.

    (C) Hydrogen bonded crystals.   (D) Ionic crystals.

31. In a crystalline solid with N number of unit cells, the number of allowed independent phonon modes of a branch is :

    (A) N.

    (B) 2N.

    (C) $\dfrac{N}{2}$.

    (D) N^2.

32. Which of the following is not true ?

A superconductor is characterized by :

    (A) Persistent current.

    (B) Perfect diamagnetism.

    (C) Existence of energy gap.

    (D) Heat capacity linear in temperature.

33. The half life of a radio active sampe is 20 days. This means that :

    (A) The substance completely disintegrates in 40 days.

    (B) The substance completely disintegrates in 80 days.

    (C) 1/8 part of the substance disintegrates in 60 days.

    (D) 7/8 part of the substance disintegrates in 60 days.

34. The function of a moderator in a nuclear reactor is :

    (A) To absorb unwanted neutrons.

    (B) To slowdown the fast neutrons to secure more effective hits on other nuclei.

    (C) To decrease the number of fissile nuclei.

    (D) To increase the number of fissile nuclei.

35. The mass defect of an atom divided by its mass number is known as :

    (A) Binding energy.

    (B) Packing fraction.

    (C) Asymmetric energy.

    (D) Surface energy.

36. The energy dependence of the cross-section of a reaction between two particles close to the resonance energy E is described by :

    (A) Bethe-Bloch formula.

    (B) Breit-Wigner formula.

    (C) Gamow-Teller formula.

    (D) Weizsaker formula.

37. Micro wave spectroscopy is used to get information about :

    (A) Accurate bond length and angles.

    (B) Electric dipole moments.

    (C) Centrifugal distortion constant.

    (D) All of these.

38. In electrodeposition method, which electrode is used to close the current circuit in the electrochemical cell :

    (A) Counter electrode.   (B) Working electrode.

    (C) Reference electrode.   (D) Ground electrode.

39. Which of the following is not a type of modulation scheme in RF systems ?

    (A) Shift Modulation (SM).   (B) Amplitude Modulation (AM).

    (C) Frequency Modulation (FM).   (D) Phase Modulation (PM).

40. The main stages for film formation in spin coatig technique are :

    (A) Deposition, spin up, spin off and pyrolysis.

    (B) Deposition, spin up, spin off and sublimation.

    (C) Deposition, spin up, spin off and evaporation.

    (D) Deposition, spin up, spin off and coating.

41. Which spectroscopy is based on the interaction of light with the chemical bonds within a material ?

    (A) Atomic Absorption Spectroscopy (AAS).

    (B) Raman Spectroscopy.

    (C) Nuclear Magnetic Resonance (NMR) Spectroscopy.

    (D) Flame Spectroscopy.

42. The magnetometer whose working principle is characterized by Lorentz force is termed as :

    (A) Induction magnetometer.

    (B) Magnetic magnetometer.

    (C) Magneto resisitive magnetometer.

    (D) SQUID magnetometer.

43. An OR gate defined in positive logic converts into :

    (A) An AND gate in negative logic. (B) A NAND gate in negative logic.

    (C) A NOR gate in negative logic. (D) A NOT gate in negative logic.

44. Very large input resistance of MOSFET compared to JFET is due to :

    (A) Formation of junction.

    (B) Biasing conditions.

    (C) Formation of capacitor of high dielectric constant.

    (D) Majority carriers.

Turn over

45. Stock and Anti-stock lines are observed in :

    (A) Infrared spectrum.   (B) Fluorescent spectrum.

    (C) Raman spectrum.   (D) Mossbauer spectrum.

46. For a short time after a discharge pulse, there is a time during which the Geiger Muller tube is rendered insensitive and so the tube is temporarily unable to detect the ionizing radiation. The time is called :

    (A) Recovery time.   (B) Relaxation time.

    (C) Dead time.   (D) Discharge time.

47. The geometry associated with Minkoswki space is :

    (A) Parabolic.   (B) Hyperbolic.

    (C) Circular.   (D) Euclidean.

48. Laser printing and Xerox copier works on the principles of :

    (A) Magnetic lensing.   (B) Adsorption.

    (C) Refraction and reflection. (D) Electrostatics.

49. Which law signifies conservation of energy of a thermodynamic system ?

    (A) Zeroth law of thermodynamics.

    (B) First law of thermodynamics.

    (C) Second law of thermodynamics.

    (D) Third law of thermodynamics.

50. The Gamow-Teller selection rules are related to the :

    (A) Beta decay process.   (B) Radiative transition in atoms.

    (C) Dipole selection rules.   (D) Addition of angular momenta of particles.

                                                    (50 × 1 = 50 marks)

Part B

Answer any **ten** *questions.*
Each question carries 5 marks.

51. Describe the various steps involved in a research process.

52. Write a note on "Significance of Research".

53. Write a short note on Research motivation.

54. Explain the qualitative and quantitative research methods.

55. What is the basic structure and components of research report writing ?

56. Discuss the basic component of research paper writing.

57. Discuss the basic methodology used for achieving the research objectives.

58. Write a note on literature review and its purpose.

59. Distinguish between Pure and Applied research.

60. Explain the difference between interview and questionnaire methods.

61. Explain the role of computers in research. Discuss the benefits and limitations of computers.

62. How do you differentiate between primary data and secondary data ?

63. What do you mean by plagiarism ? Explain.

64. What does double-blind mean ? Why is it important ?

(10 × 5 = 50 marks)