WEST BENGAL STATE UNIVERSITY

B.Sc. Honours Part-III Examination, 2020

PHYSICS

PAPER-PHSA-VI

Time Allotted: 2 Hours | Full Marks: 50

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

UNIT-VIA

1. Answer any ***five*** questions from the following: 3×5 = 15

(a) A radioactive substance disintegrate for a time equal to its average life. Calculate the fraction of the original substance disintegrated.

(b) A GM-counter has a 'dead time' $400\,\mu s$. What are the true counting rates when the observed rates are (i) 100/minute, (ii) 1000/minute?

(c) Consider the decay $n \to p + e^- + \bar{\nu}$. Show that both baryon and lepton numbers are conserved in this process.

(d) A cyclotron in which the magnetic flux density is 1.4 Wb/m^2, is employed to accelerate protons. How rapidly should the electric field between the dees be reversed? (Mass of the proton $= 1.67 \times 10^{-27}$ kg and the charge $= 1.6 \times 10^{-19}$ C)

(e) Why linear accelerator is not suitable to very high energy?

(f) What is electron storage ring (ESR)? What is the order of magnitude of pressure required in this system in the storage mode?

(g) Write two similarities between the characteristics of liquid drop and nucleus.

(h) Nuclear forces are charge independent — Explain.

Answer any *one* question from the following 10×1 = 10

2. (a) Prove that the Coulomb potential energy of a nucleus of charge +*Ze* and radius *R* is given by $E_C = -\frac{3}{5}\frac{(Ze)^2}{4\pi\varepsilon_0 R}$. 3

(b) What is 'tunnel effect' in connection with α-particle decay? 3

(c) To what minimum distance will an α-particle with kinetic energy 0.4 MeV approach a stationary Pb nucleus in an head on collision? 2

(d) Explain the origin of the fine structure in α-decay. 2

3. (a) What are magic numbers? 4
   (b) Give four evidences in favour of magic numbers. 4
   (c) Obtain the spin and parity of $_{13}Al^{27}$. 2

4. (a) Why does a free neutron does not decay into an electron-positron pair? 2
   (b) What is meant by a 'hyperon'? 2
   (c) The isospin, baryon number and strangeness of a particle are given by $I=0,\ B=+1$ and $S=-3$. Find the electric charge of the particle. 2
   (d) Identify the type of the following interaction from the conservation laws: 2

   $$\Sigma^0 \rightarrow \Lambda^0 + \gamma \quad (\text{life time } \leq 10^{-14}\text{ s})$$

   (e) Name a reaction in which parity is not conserved. Which class of interaction does this reaction belong to? 2

5. (a) Draw and discuss the energy spectrum curve of β-decay. What is 'end point energy'? 2+1
   (b) What are the difficulties in explaining the observed β-ray spectrum? How are the difficulties removed with the help of the 'neutrino hypotheses'? 2+3
   (c) What is pair production? 2

6. (a) What is meant by 'delayed neutrons' in a nuclear reactor? Why are they so important in the control of a nuclear reactor? 2+3
   (b) Explain the principle of action of a Scintillation Counter. Why is it called a 'Spectroscope'? 3+2

7. (a) What is the 'plateau region' of a GM counter? 2
   (b) A GM counter operates at 1 KV and has a wire of diameter 0.2 mm. The radius of the cathode is 20 mm and the tube has a guaranteed life time of 10^9 counts. What is the magnitude of maximum radial field? 3
   (c) Show that for a fixed magnetic field, the kinetic energy of a particle in the cyclotron is proportional to the square of the orbit radius. 3
   (d) A cyclotron accelerates deuterons to 12 MeV energy. What will be the energy of the α particles obtained from the instruments? 2

UNIT-VI B

8. Answer any ***five*** questions from the following: 3×5 = 15
   (a) Derive Bragg's relation from Laue's equations.
   (b) What is 'lattice'? How many types of Bravais lattice are there?
   (c) Show that in a cubic crystal, the distance between adjacent planes with Miller indices (h, k, l) is given by $d_{hkl} = \dfrac{a}{\sqrt{h^2+k^2+l^2}}$, where '$a$' is the lattice constant.

(d) What is Pauli Paramagnetism?

(e) Why do some materials exhibit only electronic polarization? Give examples.

(f) What is the physical significance of the hysteresis plot in magnetic or dielectric materials?

(g) Explain briefly the concepts of phase and coherence in laser optics.

(h) State the properties of optical fiber along with their applications.

Answer any *one* question from the following 10×1 = 10

9. (a) (i) Give a brief account on crystalline and amorphous solids. 2+2

(ii) Can we do X-ray analysis for amorphous solids? Explain in brief.

(b) (i) Is there any relation between reciprocal lattice and k-space? Explain with example. 2+2

(ii) The reciprocal of a bcc is an fcc lattice — True or False? — Explain.

(c) What is the interplanar spacing between two adjacent parallel planes in a cubic lattice? 2

10. (a) Draw E-K graphs for free electrons and electrons in solids. What is effective mass? 2+2

(b) What is ionic polarizability? 1

(c) The crystal of sodium chloride has static dielectric constant of 5.6 and optical index of refraction 1.5. Calculate the percentage of ionic polarizability. 3

(d) The relative permittivity of germanium is 16. The edge length of the conventional cubic cell for germanium lattice is 5.65×10^{-10} m. Calculate the electronic polarizability of germanium atoms. 2

11. (a) Using free electron theory, derive an expression for electrical conductivity of a metal in terms of Fermi velocity and mean free path of electrons. 4

(b) Distinguish between good conductors, semi-conductors and insulators. 3

(c) The conductivity of a metal decreases with rise of temperature, whereas the conductivity of a semiconductor increases with increase of temperature. Explain both the cases clearly giving appropriate examples. 2

(d) Why semi-conductor acts as an insulator at 0 K? 1

12. (a) (i) State the types of paramagnetism along with their properties. 3+3+2

(ii) Discuss the classical theory of paramagnetism.

(iii) What was the modification proposed by Weiss?

(b) The saturation magnetisation of iron is 1.75×10^{6} amp/met. Assume that the iron has a body-centered cubic structure with an edge-length of 2.87 Å. Find the average number of Bohr magnetons contributed to the saturation magnetisation per atom. 2

13.(a) Establish relation among Einstein's *A* and *B* coefficients. 3

(b) A laser beam of wavelength 740 nm has coherence time 4×10^{-5} sec. Deduce the order of magnitude of its coherence length and spectral half width. 2

(c) What is holography? Describe the process of recording and reconstruction of a hologram. 1+4

14.(a) What is an optical fibre? What are different types of losses in optical fibre? 1+2

(b) What is the essential difference between a 'step index' and a 'graded index' type optical fibre? Draw their index profiles and path of light rays through them. 1+2+2

(c) An optical fibre of length 150 m has input power of 10 μW and output power 9 μW. Compute the loss in decibels per kilometers. 2

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