WEST BENGAL STATE UNIVERSITY

B.Sc. Honours Part-III Examination, 2022

PHYSICS

PAPER: PHSA-VI

Time Allotted: 4 Hours | Full Marks: 100

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: 2×5 = 10

   (a) Give four applications of radioisotopes.

   (b) Write down the quark structure of proton and positive pion.

   (c) Why oil sealing is necessary in rotary pump? What degree of vacuum can be obtained by this pump?

   (d) Can electron be accelerated in a cyclotron? — Discuss.

   (e) Why is ${}_6C^{14}$ radioactive while ${}_6C^{12}$ is not?

   (f) In the following radioactive series write down the atomic number and mass number of B, C, D, E.

   $$^{238}_{90}A \xrightarrow{\alpha} B \xrightarrow{\beta^-} C \xrightarrow{\alpha} D \xrightarrow{\beta^-} E$$

   (g) Is the reaction $p \rightarrow n + e + \nu_e$ possible? Give reasons.

   (h) Mention two major types of leak detectors used in vacuum technology.

GROUP-A

Answer any *three* questions from the following 10×3 = 30

2. (a) What do you mean by the 'range' of an α-particle? Write down the empirical relation between 'range' and 'energy' of a α-particle. 1+1

   (b) The range in standard air of α-particles from Ra (half-life = 1622 years) is 3.36 cm and that of α-particles from Po (half-life = 138 days) is 3.85 cm. If the range of α-particles from RaC be 6.97 cm; find the half-life of RaC. 3

   (c) What is 'Pair Production'? 2

   (d) What are 'magic numbers'? Why are they so called? 1+2

3. (a) Define mass defect and binding energy of a nucleus. Draw the curve of binding energy with mass number. 2+1

(b) Using the semi-empirical mass formula find the atomic number of the most stable nucleus for a given mass number A. Hence explain which one is the most stable among $_2He^6$, $_4Be^6$ and $_3Li^6$. Given, $a_c = 0.71$ MeV, $a_n = 22.7$ MeV. 2+1

(c) What are magic numbers? Why are they so called? 2

(d) What is the 'end point energy' related with β decay? 2

4. (a) Let a particle (x) of mass m_x moving along X-axis with kinetic energy K_x collides elastically with a target nucleus (X) of mass M_X at rest. Due to the nuclear reaction, the product nucleus (Y) of mass M_Y is scattered and the product particle (y) of mass m_y is emitted normally with kinetic energy K_y. Show that Q-value of the nuclear reaction is 4

$$Q = K_y\left(1+\frac{m_y}{M_Y}\right) - K_x\left(1-\frac{m_x}{M_Y}\right)$$

(b) Calculate the Q value in MeV of the following reaction and determine the type of reaction 3

$$_1H^3 + _1H^2 \rightarrow _2He^4 + _0n^1$$

Given, $M(_1H^3) = 3.0169982$ amu,

$M(_1H^2) = 2.0147361$ amu

$M(_2He^4) = 4.0038727$ amu

$M(_0n^1) = 1.0089832$ amu.

(c) What is meant by saturation of nuclear force? Which experimental fact indicates saturation of nuclear force? 2+1

5. (a) Find the missing nucleus or particle in each of the following reactions. 2

(i) $_{15}P^{31} + \gamma \rightarrow ? + _0n^1$

(ii) $_{13}Al^{27} + _2He^4 \rightarrow _{15}P^{30} + ?$

(iii) $_{13}Al^{27} + ? \rightarrow _{13}Al^{26} + _1H^3$

(iv) $_{79}Au^{197} + _6C^{12} \rightarrow _{85}At^{205} + ?$

(b) Define 'Hypercharge.' Plot the hypercharge against isospin for the quark triplet. 2+2

(c) Explain why we do not find: 2+2

(i) a baryon with strangeness – 2 and electric charge + 1;

(ii) a meson with strangeness +1 and electric charge –1.

GROUP-B

Answer any *one* question from the following $10\times1 = 10$

6. (a) Explain with a diagram the working principle of a semi-conductor detector. 3+1

(b) Give the operational principle of a GM-counter. 3

(c) Draw the characteristic curve of a GM counter and explain each part of each. 3

7. (a) How does a mercury diffusion pump work? What is the degree of vacuum attainable? 4+1

   (b) Discuss the principle of a Pirani gauge. Write the basic differences of it in comparison to Penning gauge. 3+2

UNIT-VIB

8. Answer any ***five*** questions from the following: 2×5 = 10

   (a) Give one example for each of the following types of bondings— ionic, covalent, metallic and Van der Waals.

   (b) Find the Miller indices for the planes having following intercepts:

   (i) $3a, 3b, 2c$ (ii) $5a, -6b, c,$

   where a, b, c are lattice parameters.

   (c) Define the mobility of a charge carrier. Which one has got a higher mobility— an electron or a hole in an intrinsic semiconductor?

   (d) Define the Hall coefficient of a conductor. What is the significance of its sign?

   (e) What is ionic polarizabilty? Does it depend on temperature?

   (f) Specific heat of a metal at very low temperatures (T) is found to be linear in T. Justify this statement without performing a detailed calculation.

   (g) Mention two important applications of laser.

   (h) Why is a monomode fibre preferred in telecommunication?

GROUP-C

Answer any *three* questions from the following 10×3 = 30

9. (a) Obtain Laue's equation for X-ray diffraction by crystals. Show that these are consistent with Bragg's law. 3+2

   (b) In Powder diffraction experiment with X-rays, the Bragg reflection occurs from a monochromatic cubic crystal with glancing angle θ then show that 2

   $$\sin^2\theta \propto (h^2 + k^2 + l^2)$$

   where (h, k, l) are Miller indices of diffraction plane.

   (c) Prove that the direction $[h, k, l]$ is normal to the plane (h, k, l) for a cubic lattice. 3

10. (a) Kronig-Penney model gives a simplified solution of the form 2+2

   $$P\frac{\sin\alpha a}{\alpha a} + \cos\alpha a = \cos ka \text{, where } \alpha = \sqrt{\frac{2mE}{\hbar}}.$$

   Discuss the nature of energy bands for (i) $P \to 0$

   (ii) $P \to \infty$

   (b) What is Hall-effect? Obtain an expression for the Hall Coefficient for metals. 2+2

   (c) What is the importance of measuring the Hall Coefficient? Will the Hall Coefficient change sign if the direction of applied magnetic field is reversed? 1+1

11.(a) Define Fermi energy. Derive an expression for the Fermi energy of a free electron gas in a metal. 1+3

(b) Estimate the Fermi energy in copper on the assumption that each copper atom contributes one free electron to the electron gas. The density of copper is 8.94×10^3 kg m^{-3} and its atomic mass is 63.5 amu. 4

(c) An insulator has an optical absorption which occurs for all wavelengths shorter than 1800Å. Find the width of the forbidden gas in eV of the insulator. 2

12.(a) The equilibrium separation of two atoms is 2.8 Å and the dissociation energy is 8×10^{-19} J. Calculate the values of A and B if the potential energy be $U(r) = A/r^9 - B/r$, where r is the interatomic separation. 3

(b) Identify the types of bonding in each of the following solids 2

KCl crystal, Diamond, Solid argon and Li-crystal.

(c) Dielectric constant of Si is 12. Number of atoms per unit cell is 8 and the side of the cubic unit cell is 5.43 Å. 3

Find the electronic polarizability of Si-atoms.

(d) The Fermi energy of silver is 5.5 eV. Determine the maximum possible velocity of the conduction electron at the ground state. 2

GROUP-D

Answer any *one* question from the following $10\times1 = 10$

13.(a) What is the difference between the spontaneous and stimulated emission? 2

(b) What is population inversion? 2

(c) Describe the working principle of pulsed ruby laser with schematic diagram. 4

(d) Mention four important applications of Laser. 2

14.(a) What do you mean by attenuation of signal in an optical fibre? Mention the causes. 1+2

(b) Draw the sketches, showing the different light paths through a monomode and a multimode fibre. Why monomode is preferred in telecommunication? 2+2

(c) Consider a optical fibre is of diameter $75\sqrt{2}\,\mu$m. If the core is of refractive index 1.5, find the axial distance travelled by the ray, incident at 30° at the air-fibre interface, between two successive total internal reflections. 3

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

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