2022

(May/June)

PHYSICS

(Elective/Honours)

(Atomic, Nuclear and Solid-State Physics)

[PHY04 (T)]

Marks : 56

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer Question No. **1** and *any* **four** from the rest

1. *(a)* What is half-life of a radioactive material? A radioactive sample has its half-life equal to 60 days. Calculate *(i)* its decay constant, *(ii)* its mean life and *(iii)* the time required for $\frac{3}{4}$ of the original number of atoms to disintegrate. 4

(b) Calculate the *(i)* ionization potential and *(ii)* first excitation potential of the hydrogen atom.

Given, $\hbar c = 197{\cdot}3$ MeV fm, $\frac{e^2}{4\pi\varepsilon_0} = 1{\cdot}44$,

$m = 938$ MeV/c^2. 4

(c) If the magnetization and flux density of a magnetic material be 3200 A/m and 0·005 Wb/m^2, calculate the susceptibility and relative permeability of the material. 4

2. (a) Describe Millikan's oil-drop method for the determination of electronic charge. 6

(b) Discuss the construction of Bainbridge mass-spectrograph. 3

(c) Using Pauli's exclusion principle, show that the maximum number of electrons that can be accommodated in any state of principal quantum number n is $2n^2$. 2

3. (a) State Moseley's law. Discuss how it has been utilized in removing some of the defects of periodic table. 1+2=3

(b) What is Compton effect? Obtain an expression for the Compton shift using non-relativistic mechanics only. 1+4=5

(c) What is population inversion in laser? Explain why laser action cannot occur without population inversion between atomic levels. 1+2=3

4. (a) Explain the principle of working and theory of a betatron. 2+3=5

(b) Explain the source of stellar energy and estimate the energy obtained therein. 3

(c) Explain the property of east-west effect of cosmic rays. 3

5. (a) What is meant by pair production? What is the maximum energy requirement of the agent causing the phenomenon? 3

(b) Explain the principle of action of scintillation counter. Describe their usefulness in the study of nuclear radiation. 2+2=4

(c) Explain the terms 'multiplication factor' and 'chain reaction' in nuclear fission. 2+2=4

6. (a) What is controlled nuclear chain reaction? Describe how this can be achieved in a nuclear reactor indicating the function of each part of the reactor. 1+4=5

(b) Explain briefly the important features of the shell model of nuclei. What are its limitations? 2+2=4

(c) What are the broad classifications of elementary particles? Mention which of them take part in strong or weak interaction. 2

7. (a) What do you understand by packing fraction of a crystal? Calculate the packing fraction for a face-centred cubic (f.c.c.) structure. 1+3=4

(b) Derive the expression for the inter-planar spacing of the set of (hkl) planes of a cubic lattice. 4

(c) Explain the distinction among conductors, semiconductors and insulators in terms of band gap. 3

8. (a) Discuss the experimental evidence on the occurrence of superconductivity in metals and alloys. 3

(b) What is magnetic susceptibility? Mention any two points to distinguish among diamagnetic, paramagnetic and ferromagnetic materials. 1+3=4

(c) What is Meissner effect? Distinguish between type I and type II super-conductors. 1+3=4

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