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(CBCS)

(4th Semester)

PHYSICS

FOURTH PAPER

(Atomic, Nuclear Physics–I and Solid-State Physics–I)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. If an electron in a hydrogen atom jumps from the third orbit to the second orbit, it emits a photon of wavelength . When it jumps from the fourth orbit to the third orbit, the corresponding wavelength of the photon will be

(a) $\frac{16}{25}$ ( )

(b) $\frac{9}{16}$ ( )

(c) $\frac{20}{7}$ ( )

(d) $\frac{20}{13}$ ( )

2. The Compton effect can be explained on the basis of

(a) wave nature of light ( )

(b) ray optics ( )

(c) wave optics ( )

(d) quantum theory of light ( )

3. The electron emitted in the radioactive decay process originates from

(a) inner orbits of atom ( )

(b) free electrons existing inside the nucleus ( )

(c) photons escaping from the nucleus ( )

(d) decay of a neutron inside the nucleus ( )

4. If the nucleus $^{27}_{13}Al$ has a nuclear radius of 3·6 fm, then the nuclear radius of $^{125}_{52}Te$ will be

(a) 9·6 fm ( )

(b) 6·0 fm ( )

(c) 4·8 fm ( )

(d) 12·0 fm ( )

5. The coordination number of f.c.c. structure is

(a) 6 ( )

(b) 12 ( )

(c) 4 ( )

(d) 8 ( )

6. Miller indices of the plane parallel to *Y* and *Z*-axes are

(a) (0 1 0) ( )

(b) (0 0 1) ( )

(c) (1 1 1) ( )

(d) (1 0 0) ( )

7. In Bragg's experiment of diffraction by crystals using X-rays of wavelength Å, the glancing angle of the first-order spectrum is 30°. The lattice spacing is

(a) 0·282 Å ( )

(b) 0·141 Å ( )

(c) 1·41 Å ( )

(d) 2·82 Å ( )

8. The Madelung constant for a one-dimensional lattice chain is

(a) $2 \log_e 2$ ( )

(b) $\log_e 2$ ( )

(c) $\log_{10} 2$ ( )

(d) $2 \log_{10} 2$ ( )

9. As the temperature approaches absolute zero, the specific heat of solids approaches

(a) infinity ( )

(b) zero ( )

(c) any value between zero and infinity ( )

(d) –1 ( )

10. The Wiedemann-Franz law is given by (symbols have their usual meanings)

(a) $\frac{k}{} \quad T^{1}$ ( )

(b) $\frac{}{k} \quad T$ ( )

(c) $\frac{k}{} \quad T$ ( )

(d) $\frac{k}{} \quad T^{2}$ ( )

(SECTION : B—SHORT ANSWER)

(*Marks* : 15)

Answer the following questions : 3×5=15

UNIT—I

1. State Moseley's law and mention its importance.

OR

2. How are continuous X-rays produced? What is the relation between minimum wavelength of X-rays produced and the voltage applied across the X-ray tube?

UNIT—II

3. Define mean life and decay constant of a radioactive element. Write a relation between them.

OR

4. Define nuclear fission and nuclear fusion with an example of each.

UNIT—III

5. Define space lattice and basis in the description of crystal structure. Write the relation between crystal structure, lattice and basis.

OR

6. How many atoms are there in a unit cell of diamond? Find the distance between two nearest diamond atoms if the lattice constant is 3·56 Å.

UNIT—IV

7. What is reciprocal lattice vector? Write Bragg's diffraction condition in terms of reciprocal lattice vector $\vec{G}$.

OR

8. The energy of two particles in the field of each other is given by

$$U(r) \quad \frac{}{r} \quad \frac{}{r^8}$$

where and are constants and r is the distance between the centre of the two particles. At what separation between them will they form a stable compound?

UNIT—V

9. Enlist the salient features of Einstein's theory of specific heat of solids. How is it different from the classical theory?

OR

10. Define Fermi energy, Fermi level and Fermi temperature.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following questions : 10×5=50

UNIT—I

1. *(a)* What is a mass spectrograph? Give the construction and working of Aston's mass spectrograph. 1+3+3=7

(b) In an experiment for positive ray analysis with Thomson's method, singly ionized and doubly ionized particles form two identical parabolas when magnetic fields are 5 Wb/m^2 and 7·5 Wb/m^2 respectively. Compare the masses of the particles, assuming the electric fields to be the same. 3

OR

2. *(a)* On the basis of Bohr's atomic model, derive an expression for the total energy of an electron in the nth orbit of hydrogen atom. What does negative value of this energy signify? 6+1=7

(b) Explain why the spectrum of hydrogen atom has many lines, although a hydrogen atom contains only one electron. Name the series of hydrogen spectrum lying in the ultraviolet region. 2+1=3

UNIT—II

3. *(a)* Define half-life of a radioactive element and derive an expression for it. If a radioactive substance is placed in a vacuum, what will be the effect on its half-life? 1+5+1=7

(b) The half-life of a radioactive substance is 10 minutes. If initially there are 600 nuclei in the substance, find the time taken to disintegrate 450 nuclei. 3

OR

4. *(a)* What is the origin of an alpha particle emitted in the radioactive decay process? Explain proton-proton cycle as a source of stellar energy. 1+3=4

(b) Define binding energy of a nucleus. Explain how the concept of binding energy is related to the stability of atomic nucleus. 1+3=4

(c) The binding energy per nucleon for C^{12} is 7·68 MeV and that of C^{13} is 7·47 MeV. Calculate the energy required to remove a neutron from C^{13}. 2

UNIT—III

5. *(a)* What do you mean by a symmetry operation? Explain the following terms : 1+2+2+2=7

(i) Plane of symmetry

(ii) Axis of symmetry

(iii) Centre of symmetry

(b) Calculate the packing fraction in face-centred cubic lattice. 3

OR

6. *(a)* What are point groups and space groups? Give their numbers for two- and three-dimensional lattices. 2+2=4

(b) Prove that five-fold rotation axis is not permissible with a crystalline lattice. 4

(c) Find the interplanar spacing of the planes (111) in a simple cubic lattice of lattice constant a. 2

UNIT—IV

7. *(a)* Deduce Bragg's law of X-ray diffraction in crystals. Explain why X-rays are used in the analysis of crystals. 4+1=5

(b) What is reciprocal lattice? Prove that the volume of the reciprocal lattice is inversely proportional to the volume of a unit cell of direct lattice. 1+4=5

OR

8. *(a)* Show that the distance between the intercepts of adjacent (hkl) planes on the $\vec{a}$, $\vec{b}$ and $\vec{c}$ crystallographic axes are $\frac{a}{h}$, $\frac{b}{k}$ and $\frac{c}{l}$ respectively. 5

(b) What are ionic, covalent, van der Waals' and metallic bonding? Explain them with examples. 5

UNIT—V

9. *(a)* Discuss Einstein's theory of specific heat and also discuss its failures in solid. 5

(b) Discuss Debye T^3 law of specific heat. 5

OR

10. *(a)* State and explain free electron model (classical model). 3

(b) Deduce the expression for electrical conductivity from free electron model. 7

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