M.Sc.-I/Physics-104C/18

M.Sc. 1st Semester Examination, 2018

PHYSICS

Course Title : Atomic Spectroscopy & Nuclear Physics-I

Paper : PHYS104C

Course ID : 12454

Time: 2 Hours **Full Marks: 40**

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Unit – I

1. Answer *any three* of the following: 2×3=6

(a) Find the L, S, J quantum numbers corresponding to the ground state electronic configuration of Boron (z = 5). 2

(b) What is Paschen-Back effect? 2

(c) Find the Lande-g-factor for $^3D_3$. 2

(d) Calculate the diameter of first Bohr orbit of hydrogen atom. 2

(e) What is the difference between ortho- and para-Heliam? 2

2. Answer *any two* questions: 4×2=8

(a) What is the main difference between normal and anomalous Zeeman effect? Write your comment about parallel and perpendicular observation of Zeeman Spectroscopy. 2½+1½=4

(b) What do you mean by 'Population Inversion' in a laser system? A laser beam of wavelength 740 nm has coherence time 4×10^{-5}s. Deduce the order of magnitude of its coherence length and spectral half width. 2+2=4

(c) The quantum numbers of two electrons in a two valence electrons atom are

$n_1 = 6,\ l_1 = 3, s_1 = \frac{1}{2}$

$n_2 = 5,\ l_2 = 1,\ s_2 = \frac{1}{2}$

(i) Assuming L–S coupling, find the possible values of L and hence of J.

(ii) Assuming j–j coupling, find the possible value of J. 2+2=4

(d) Establish the relation

$$(\sigma.\vec{A})(\sigma.\vec{B}) = \vec{A}.\vec{B} + i\sigma\,(\vec{A}\times\vec{B})$$

Where σ being the Pauli matrice and $\vec{A}$ and $\vec{B}$ are arbitrary operators. 4

3. Answer *any one* of the following: 6×1=6

(a) What do you mean by fine structure of hydrogen atom? Find out the relativistic correction to energy levels of hydrogen atom. 1+5=6

(b) What is Auger effect? A beam of electron enters a uniform magnetic field of 1.2 Tesla. Calculate, the energy difference between electrons whose spins are parallel and antiparallel to the field. 2+4=6

Unit – II

1. Answer *any three* of the following: 2×3=6

(a) Find the binding energy for $^{2}\mathrm{He}_{4}$, $M(\,{}_{2}He^{4}) = 4.0026\,u$

(b) Why are the most stable nuclei found in the region near A = 60?

(c) Define iso-spin quantum number.

(d) What are the significations of magic numbers?

(e) The neutron although a neutral particle possesses a negative magnetic moment. Why?

2. Answer *any two* of the following: 4×2=8

(a) Calculate binding energies of the following isobars and their binding energy per nucleon: $^{28}\mathrm{Ni}_{64} = 63{\cdot}9280$; $^{29}\mathrm{Cu}_{64} = 63{\cdot}9298$; $^{30}\mathrm{Zn}_{64} = 63{\cdot}9292$. Assume, $\mathrm{M_n} = 1{\cdot}009$ amu and $\mathrm{M_p} = 1{\cdot}008$ amu. 4

(b) Why are nuclei with all the combinations of Z and N for a given A value do not exists in nature? 4

(c) Find out the total scattering cross section for a low energy $n - p$ (s-wave) scattering assuming a square well potential. 4

(d) Explain with suitable diagram, the principle of operation of a Tandem accelerator. 4

3. Answer *any one* of the following: 6×1=6

(a) On the basis of the extreme single particle shell model, what would be the expected ground state spectroscopic configuration of the following nuclei:

$^{11}\mathrm{C}_{6}$, $^{45}\mathrm{Sc}_{21}$, $^{61}\mathrm{Ni}_{28}$, $^{73}\mathrm{Ge}_{32}$, $^{109}\mathrm{In}_{49}$, $^{181}\mathrm{Ta}_{73}$, $^{203}\mathrm{Tl}_{81}$, $^{241}\mathrm{Am}_{95}$? 6

(b) (i) Show that for a spherical charge distribution, the charge form factor is given by,

$F(q) = \frac{4\pi}{q}\int_0^\infty p(r)\sin(qr)dr$, where the symbols have their usual meaning.

(ii) Show that the deuteron spends more time outside the nuclear range, in comparison to the inside the range. 3+3=6

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