2019

PHYSICS

(Major)

Paper : 5.2

(Atomic Physics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option of any *seven* of the following : 1×7=7

(a) Which of the following lines mostly appears in the absorption spectra of hydrogen?

(i) Lyman

(ii) Paschen

(iii) Pfund

(iv) Brackett

(b) Rutherford's α-particle scattering experiment gave experimental information about

(i) the charge of α-particle

(ii) the size of the atom

(iii) the size of the nucleus

(iv) None of the above

(c) Which of the following transitions gives rise to most intense line?

(i) $\Delta L = -1,\ \Delta J = +1$

(ii) $\Delta L = -1,\ \Delta J = 0$

(iii) $\Delta L = -1,\ \Delta J = -1$

(iv) $\Delta L = +1,\ \Delta J = 0$

(d) The value of 'Bohr magneton' is

(i) 0

(ii) $9 \cdot 27 \times 10^{-24}$ A-m

(iii) $9 \cdot 27 \times 10^{-24}$ A-m^2

(iv) $4 \cdot 63 \times 10^{-24}$ A-m^2

(e) X-ray is produced when transition takes place

(i) in the innermost orbit

(ii) in the outermost orbit

(iii) in the nuclear transition

(iv) All of the above

(f) Which of the following is not true about Raman scattering?

(i) Most of the Raman lines are strongly polarized

(ii) Raman spectrum is the characteristic of the scattering substance

(iii) Stokes lines have greater wavelength than the original line

(iv) Anti-Stokes lines are more intense than the Stokes lines

(g) The maximum possible energy of electron in hydrogen atom is

(i) 13·6 eV

(ii) – 13·6 eV

(iii) 0 eV

(iv) 1 eV

(h) Compton wavelength is given by

(i) $\frac{h}{m_0 c}$ (ii) $\frac{2h}{m_0 c}$

(iii) $\frac{3h}{m_0 c}$ (iv) $\frac{2h}{m_0 v}$

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

(a) The series limit wavelength of Balmer series in hydrogen spectrum is 3646 Å. Calculate Rydberg constant for hydrogen atom.

(b) Calculate the two possible orientations of spin vector S with respect to a magnetic field B.

(c) Why is $^4D_{1/2}$ term not split in a magnetic field?

(d) Calculate the minimum voltage that must be applied to an X-ray tube to produce X-ray photons of wavelength 0·1 Å.

(e) What is the distance of closest approach when a 5·0 MeV proton approaches a gold nucleus?

(Continued)

3. Answer the following questions :

(a) Write three prominent observations of Rutherford's α-particle scattering experiment. What is impact parameter? How does the scattering depend on the thickness of the foil? 3+1+1=5

(b) Calculate the possible orientations of the total angular momentum vector J corresponding to $j = 3/2$ with respect to a magnetic field along z-axis. 5

Or

Write the values of quantum numbers l, s and j corresponding to each of the following one electron terms :

$^2P_{1/2}$, $^2D_{3/2}$ and $^2S_{1/2}$

Is $^2D_{1/2}$ a possible term? Why? 3+1+1=5

(c) Describe quantum theory of Raman effect. How can one explain the existence of centre of symmetry of CO_2 molecule using Raman and infrared spectrum? 3+2=5

Or

What are continuous and characteristics X-rays? Why are X-rays used to study the crystal structure? What are K_β and M_α lines? 2+1+1+1=5

(Turn Over)

4. Answer the following questions :

(a) Explain space quantization and electron spin hypothesis. Describe, in brief, how Stern-Gerlach experiment explained the existence of electron spin. 4+4+2=10

Or

Derive an expression for the Larmor precessional frequency. What is its importance? Calculate the magnitude of spin magnetic dipole moment of an electron in terms of Bohr magneton. 5+2+3=10

(b) Discuss Sommerfeld's relativistic correction. What is fine structure constant? Explain the fine structure of H_α line with the help of Sommerfeld's theory. Draw the two possible electron orbits for $n = 2$ according to Sommerfeld's theory. 4+1+3+2=10

Or

Describe the construction of Bainbridge's mass spectrograph with a clean diagram. Show that the radius r of the ion path is linearly proportional to the ion mass M for the same ionic charge q in Bainbridge's mass spectrograph. Explain how isotopes can be detected with the help of Aston's mass spectrograph. 3+4+3=10

(Continued)

(c) State and explain Moseley's law of X-rays. Show how it has been used in removing some of the defects in the periodic table. The K_α line from molybdenum has a wavelength of 0·7078 Å. Calculate the wavelength of K_α line of copper. Atomic numbers of molybdenum and copper are 42 and 29, respectively. 4+3+3=10

Or

Write explanatory notes on the following : 5+5=10

(i) Rayleigh scattering and color of sky

(ii) Pauli's exclusion principle

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