2017

(5th Semester)

PHYSICS

EIGHTH (A) PAPER

(Spectroscopy)

(Revised)

Full Marks : 55

Time : 2½ hours

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. Derive the formula for Rutherford's scattering cross-section. Discuss Rutherford's atomic model and its failure. 4+3=7

Or

Give the postulates of Bohr's theory and derive an expression for the Rydberg constant. Explain why the value of this constant for helium is different than that for hydrogen. 2+4+1=7

2. Discuss Stern-Gerlach experiment. Discuss its importance. What did the experiment establish? 4+2+1=7

Or

What is the physical interpretation of various quantum numbers? What is meant by *L-S* coupling? Deduce the spectral terms which can arise from two non-equivalent *p*-electrons. 3+1+3=7

3. What is Zeeman effect? Derive an expression for normal Zeeman splitting and illustrate with a diagram. Give a point of difference between normal and anomalous Zeeman effect. 2+4+1=7

Or

(a) Considering a three-level laser system, write the laser rate equations. 3

(b) Solve the rate equations under steady-state conditions and derive an expression for the population difference between the first and second energy levels. What is the condition for achieving population inversion? 3+1=4

4. Obtain the expression for the rotational energy of non-rigid diatomic molecule. Write the applicable selection rules. Compare the energy level diagram with that of rigid rotator. 3+1+3=7

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Or

Obtain the expression for the allowed energies for a vibrating molecule treated as a harmonic oscillator. Draw the energy level diagram. Show that the vibrational spectrum consists of a single band. 3+2+2=7

5. *(a)* State and explain Frank-Condon principle. 3

(b) Define the energy level in rotational fine structure of vibrational transition and also explain the significance of *P*, *Q*, *R* branches. 4

Or

(c) What is Raman effect? Give its explanation. What is the difference between Raman spectra with Infrared spectra? 2+3+2=7

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Subject Code : PHY/V/08 (a) (R)

Booklet No. A

Date Stamp .....

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To be filled in by the Candidate

DEGREE 5th Semester
(Arts / Science / Commerce / .....) Exam., **2017**

Subject .....

Paper .....

INSTRUCTIONS TO CANDIDATES

1. **The Booklet No. of this script should be quoted in the answer script meant for descriptive type questions and vice versa.**
2. **This paper should be ANSWERED FIRST and submitted within** *45 minutes* **of the commencement of the Examination.**
3. **While answering the questions of this booklet, any cutting, erasing, over-writing or furnishing more than one answer is prohibited. Any rough work, if required, should be done only on the main Answer Book. Instructions given in each question should be followed for answering that question only.**

To be filled in by the Candidate

DEGREE 5th Semester
(Arts / Science / Commerce / .....) Exam., **2017**

Roll No. .....

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Subject .....

Paper .....

Descriptive Type

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(5th Semester)

PHYSICS

EIGHTH (A) PAPER

(Spectroscopy)

(Revised)

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—A

(*Marks* : 5)

Tick (✓) the correct answer in the brackets provided : 1×5=5

1. In the hydrogen spectrum, the wavelength corresponding to the Balmer series of lines is given by

(a) $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right),\ n = 3,\ 4,\ \ldots$ ( )

(b) $\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right),\ n = 4,\ 5,\ \ldots$ ( )

(c) $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right),\ n = 2,\ 3,\ \ldots$ ( )

(d) $\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n^2}\right),\ n = 5,\ 6,\ \ldots$ ( )

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2. The angle between $\vec{L}$ and $\vec{S}$ vectors, in the vector atom model, is given by

(a) $\cos(\vec{S}, \vec{L}) = \dfrac{J(J+1) + S(S+1) - L(L+1)}{2\sqrt{L(L+1)}\sqrt{S(S+1)}}$ ( )

(b) $\cos(\vec{S}, \vec{L}) = \dfrac{L(L+1) + S(S+1) - J(J+1)}{2\sqrt{L(L+1)}\sqrt{S(S+1)}}$ ( )

(c) $\cos(\vec{S}, \vec{L}) = \dfrac{L(L+1) + J(J+1) - S(S+1)}{2\sqrt{L(L+1)}\sqrt{S(S+1)}}$ ( )

(d) $\cos(\vec{S}, \vec{L}) = \dfrac{L(L+1) + S(S+1) - J(J+1)}{2L(L+1)S(S+1)}$ ( )

3. The X-ray fine structure in X-ray spectra arises due to energy levels

(a) corresponding to different sub-shells of an electronic shell ( )

(b) splitted when the target material is placed in magnetic field ( )

(c) corresponding to spatial quantization of quantum numbers ( )

(d) Both *(b)* and *(c)* ( )

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4. The zero-point energy of a vibrating-diatomic molecule (having ω_{os} hertz as oscillating frequency) is

(a) $\frac{1}{2} h\omega_{os}$ joule ( )

(b) $\frac{1}{4} h\omega_{os}$ joule ( )

(c) $h\omega_{os}$ joule ( )

(d) $\frac{3}{4} h\omega_{os}$ joule ( )

5. Fine structure in molecular spectra are produced by changes in the

(a) rotational levels ( )

(b) vibrational levels ( )

(c) electronic levels ( )

(d) energy levels ( )

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SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. The series limit wavelength of the Balmer series in hydrogen spectrum is 3636 Å. Calculate Rydberg constant in cm^{-1}.

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2. What is spatial quantization? What are the possible number of orientations for $l = 1$ and $l = 2$?

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3. Write a brief note on X-ray fluorescence.

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4. Calculate the intermolecular distance for CO molecules.

(Given $B = 1 \cdot 921 \text{ cm}^{-1}$, $h = 6 \cdot 627 \times 10^{-27}$ erg s

$c = 3 \times 10^{10}$ cm / s, $m_1 = 12$ g, $m_2 = 15 \cdot 9949$ g)

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5. A substance shows a Raman line at 4567 Å when excited by 4358 Å. Deduce the positions of Stokes and anti-Stokes lines for the same substance when excited by 4047 Å radiation.

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