

M.Sc. 3rd Semester Examination, 2019

PHYSICS

*(Molecular Spectroscopy and Laser Physics/
Nuclear Physics-I)*

PAPER – PHS-302.1+ 302.2

Full Marks : 40

Time : 2 hours

The figures in the right hand margin indicate marks

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

Illustrate the answers wherever necessary

**Write the answers to questions of each
Paper in separate books**

PHS-302.1

(Molecular Spectroscopy and Laser Physics)

[Marks : 20]

(Turn Over)

1. Answer any *two* questions of the following : 2×2

(a) What is meant by vibrational coarse structure ?

(b) A particular molecule is known to undergo electronic spectroscopic transition between the ground state and excited state, its lifetime in excited state is 10 second . Calculate the approximate uncertainty in the excited energy level and width of the associated spectral lines in Hz [$h = 6.626 \times 10^{-34}$ J].

(c) What do you mean by hot bands of lines ? Why are they called so ?

(d) A diatomic molecule has the anharmonicity constant $x_e = 0.01$ and anharmonic oscillation frequency 1000 cm^{-1} . What will be its zero-point energy ?

2. Answer any *two* questions : 4×2

(a) Show that the gain constant (α) is always negative for a two level laser system.

- (b) Derive the expression for quality factor of a laser resonator ?
- (c) Explain what is meant by Fortrat diagram. Draw Fortrat diagram assuming $B' < B''$ where B' is the rotational constant in the excited state and B'' is the rotational constant in the ground state. Draw Fortrat Diagram when $B' > B''$.
- (d) Compare the energy levels of rigid and non-rigid di-atomic molecules by drawing the energy level diagram and selection rules.

3. Answer any *one* question : 8 × 1

- (a) (i) What is the average period of rotation of HCl molecule if it is in the $J = 1$ state ? The internuclear distance of HCl is 0.1274 nm. Given the mass of hydrogen and chlorine atom are 1.673×10^{-27} kg and 58×10^{-27} kg respectively.
- (ii) Three consecutive lines in the rotational spectrum of a diatomic molecule are

observed at 84.544 , 101.355 and 118.112 cm^{-1} . Assign these lines to their appropriate $J'' - J'$ transitions and deduce values of B and D . 4 + 4

- (b) Explain in details how the intensity vary for progression corresponding to Vibrational-electronic transition in a diatomic molecule? Find an expression of maximum vibrational quantum number for transition close to dissociation of atoms. Show the rotational fine structure of electronic-vibrational transition. 3 + 1 + 4

UNIT – PHS-302.2

(*Nuclear Physics-I*)

[*Marks : 20*]

4. Answer any *two* questions : 2 × 2

- (a) Why the magnetic moment due to electron is not account in Rabi's method ?

- (b) "Measurement of the quadruple moment of nucleus is a test of the shell theory"—Justify.
- (c) How can you conclude that a heavy nuclide of mass no. $A \geq 150$ is energetically unstable against α -decay?
- (d) State the important uses of Mösbauer effect.

5. Answer any *two* questions: 4 × 2

- (a) (i) What do you mean by the nuclear isomerism?
- (ii) The nuclide Am^{241} emits six groups of α -particles, with kinetic energies of 5.534 MeV, 5.500 MeV, 5.477 MeV, 5.435 MeV, 5.378 MeV and 5.311 MeV, respectively. Gamma-rays are found, with energies of 0.0264 MeV, 0.0332 MeV, 0.0435 MeV, 0.0555 MeV, 0.0596 MeV, 0.103 MeV, and 0.159 MeV. Construct a decay scheme based on these data. ^{1 + 3}

(b) (i) Write briefly the working principle of the momentum filter of a double focussing mass-spectrometer.

(ii) Prove that the contribution of coulomb energy in the semi-empirical mass formula of a heavy nucleus of mass no. A and proton no. z is in the form

$$a_c (z^2 / A^{1/3}),$$

where $a_c = a$ constant.

2 + 2

(c) ${}^{77}\text{As}$ has an isomeric state $9/2^-$ of energy 475 keV, which undergoes radiative transition to $3/2^-$ ground state and $3/2^-$ excited state of energy 265 keV. Two γ -rays of energies 265 keV and 210 keV are observed. State the nature of the transitions and estimate their relative intensities.

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(d) What are the expected types of gamma ray transitions between the following states of odd A nuclei : $g_{9/2} \longrightarrow p_{1/2}$, $f_{5/2} \longrightarrow p_{3/2}$, $h_{11/2} \longrightarrow d_{5/2}$, and $h_{11/2} \longrightarrow d_{3/2}$.

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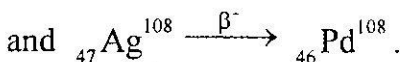
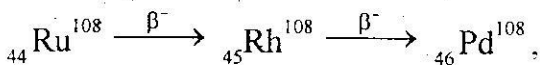
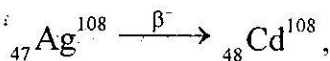
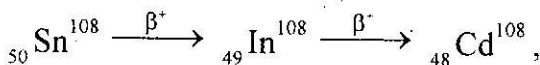
6. Answer any *one* question :

8 × 1

(a) (i) Discuss the basic principle of the Rabi's method for determination of the magnetic moment of nuclei.

(ii) Graphically show the transitions of the following even A (108) isobaric nuclei with parabolic presentation :

5 + 3



(b) (i) What energy must be imparted to an α -particle to force it into the nucleus of ${}^{235}\text{U}$ ($r_0 = 1.2$ fm).

- (ii) Following Fermi's theory of β -decay, find out the probability per unit time for the emission of β^- -particles (electrons) in the momentum range p_e and $p_e + dp_e$. 2 + 6
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