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 [$h = 6{\cdot}626 \times 10^{-34}$ J].

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

(*d*) A diatomic molecule has the anharmonicity constant $x_e = 0{\cdot}01$ 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*) 77As 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. 4

(*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 $h_{11/2} \longrightarrow d_{3/2}$. 4

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) isoberic nuclei with parabolic presentation : 5 + 3

$${}_{50}Sn^{108} \xrightarrow{\beta^+} {}_{49}In^{108} \xrightarrow{\beta^-} {}_{48}Cd^{108},$$

$${}_{47}Ag^{108} \xrightarrow{\beta^-} {}_{48}Cd^{108},$$

$${}_{44}Ru^{108} \xrightarrow{\beta^-} {}_{45}Rh^{108} \xrightarrow{\beta^-} {}_{46}Pd^{108},$$

and $${}_{47}Ag^{108} \xrightarrow{\beta^-} {}_{46}Pd^{108}.$$

(*b*) (*i*) What energy must be imparted to an α-particle to force if into the nucleus of ^{235}U ($r_0 = 1{\cdot}2$ 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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