ST. JOSEPH'S COLLEGE (AUTONOMOUS), BENGALURU-27
M.Sc. PHYSICS - III SEMESTER
SEMESTER EXAMINATION: OCTOBER 2021
(Examination conducted in January-March 2022)
PH9220 – ATOMIC AND MOLECULAR PHYSICS

Time- 2 ½ hrs   Max Marks-70

This question paper contains Two printed pages and Two parts

Part A

Answer any FIVE questions. Each question carries 10 marks

[5 x 10 = 50]

1. (a). Compare the normal and anomalous Zeeman effect with a suitable diagram.

   (b). Obtain an expression for Lande 'g' factor. Find the 'g' values for orbital and spin motion.

   [5+5]

2. (a). How are the molecules classified based on the moment of inertia?

   (b). Explain different modes of vibration of CO_2 molecule, are their energy levels the same?

   [6+4]

3. Describe geometric structure factor. Calculate the geometric structure factor for

   (i) simple cubic system,

   (ii) body centred cubic (BCC),

   (iii) face centred cubic (FCC) system.   **[3+7]**

4. (a). With a neat sketch of the energy level diagram, obtain an expression for the rotational energy levels and discuss the allowed transition for a rigid diatomic molecule.

   (b). Diatomic molecules such as CO, HF, HCl will show a rotational spectrum, whereas N_2, O_2, H_2 will not show any rotational spectrum. Why?   **[7+3]**

5. (a). Explain the resonance condition for nuclear magnetic resonance (NMR).

   (b). Describe the construction of NMR spectrometer with block diagram.   **[4+6]**

6. (a). Explain the principle of electron spin resonance (ESR) with the function of magnetic field.

   (b). Explain recoilless emission and absorption of gamma rays.   **[5+5]**

7. Obtain the frequencies for axially symmetric systems. Calculate the energies & frequencies for half integral spin (I=5/2) and illustrate allowed transitions.

Part B

Answer any Four questions. Each question carries 5 marks

[5 x 4 = 20]

8. Calculate the recoil velocity and energy of the free Mossbauer in ^{119}Sn when emitting a γ-ray of frequency 5.76 x 10^{18} Hz. What is the Doppler shift of the γ-ray frequency to an outside observer? Avogadro number is 6.02 x 10^{23} mol^{-1}.

9. Predict and construct the hyperfine structure for hydrogen atom (nuclei of spin I =1/2).

10. By ignoring the rotational fine structure, discuss the appearance of the vibrational coarse structure of spectra.

11. What is Larmor Precession? Derive the frequency of Larmor Precession.

12. Illustrate, with an energy level diagram, Paschen-Back effect for D$_2$ line of sodium. D$_2$ line transition is $3^2P_{3/2} \rightarrow 3^2S_{1/2}$.