**19001432**

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**Reg. No.....**

**Name.....**

## M.Sc. DEGREE (C.S.S.) EXAMINATION, APRIL 2019

### Fourth Semester

Faculty of Science

Branch II : Physics—A—Pure Physics

PH 4C 11—ATOMIC AND MOLECULAR PHYSICS

[Common for all]

(2012 Admission onwards)

Time : Three Hours Maximum Weight : 30

### Part A

*Answer any* **six** *questions.*
*Each question carries a weight* 1.

1. What is Lande g-factor ?
2. How does nuclear spin effects the electronic spectrum of an atom ?
3. Explain Hund's rule with an example.
4. Discuss the effect of Isotopic substitution on rotational spectra ?
5. What is centrifugal distortion ? How does it effect the rotational energy of a diatomic molecule.
6. What is Born-Oppenheimer approximation ?
7. Explain hyper Raman effect.
8. What is predissociation ?
9. Obtain the resonance condition in NMR spectroscopy ?
10. What are the factors responsible for the hyperfine structure in ESR spectra ?

(6 × 1 = 6)

### Part B

*Answer any* **four** *questions.*
*Each question carries a weight* 2.

11. Consider a hydrogen atom in the $D_{3/2}$ state (i) Find the possible values of Jz ; (ii) What are the different orientations of the J-vector in space.
12. The bond length of HF molecule is 0.927 nm. (a) What is its moment of inertia ? (ii) What is the value of rotational constant (c) Find the wave numbers of the first four transitions.

**Turn over**

13. The equilibrium vibration frequency of the iodine molecule is 215 $cm^{-1}$ and the anharmonicity constant $x_e$ = 0.003. What is the intensity of the hot band $\nu = 1 - v = 2$ relative to that of the fundamental $\nu = 0 \rightarrow \nu = 1$, if the temperature is 300 k ?

14. In the rotational Raman Spectrum of Hcl, the shifts from the exciting line are represented by

$$\Delta\bar{\upsilon} = (6.24 + 41.6\ J)\ cm^{-1}.$$

Evaluate (i) The rotational constant ; and (ii) bond length of the HCl molecule.

15. The absorption spectrum of $O_2$ shows vibrational structure which becomes a continuum at 56,876 $cm^{-1}$ ; the upper electronic state dissociates into one ground state atom and one excited atom, the excitation energy of which is 15,875 $cm^{-1}$. Estimate the dissociation energy of the ground state of $O_2$ in $KJmol^{-1}$. 1 $cm^{-1}$ = 11.958 J $mol^{-1}$.

16. A Mossbauer nucleus $^{57}Fe$ makes the transition from the excited state of energy 14.4 kev to the ground state. What is its recoil energy and velocity ?

(4 × 2 = 8)

## Part C

*Answer* **all** *questions.*
*Each question carries a weight* 4.

17. (a) Explain in detail the theory of Normal Zeeman effect and anomalous Zeeman effect.

*Or*

(b) Discuss the LS and jj coupling schemes in many electron atoms. Give examples.

18. (a) Explain in detail the rotational spectra produced by symmetric top molecules.

*Or*

(b) Discuss the vibrational spectrum of a diatomic molecule by taking it as an anharmonic oscillator. What are hot bands and overtones of absorption of an anharmonic oscillator.

19. (a) Discuss the theory of rotational fine structure of electronic-vibrational spectra of a diatomic molecule.

*Or*

(b) State the rule of mutual exclusion. Explain structure determination using IR and Raman spectroscopy.

20. (a) Obtain Bloch equations and their steady state solutions in NMR spectroscopy.

*Or*

(b) Give the theory of ESR. Explain in detail the applications of ESR spectroscopy.

(4 × 4 = 16)