M.Sc. PHYSICS
SECOND SEMESTER
ATOMIC, MOLECULAR & LASER PHYSICS
MPH-204

Duration: 3 Hrs. **Marks: 70**

{ Part : A (Objective) = 20
Part : B (Descriptive) = 50 }

[PART-B : Descriptive]

Duration: 2 Hrs. 40 Mins. **Marks: 50**

[Answer question no. One (1) & any four (4) from the rest]

1. What are the different types of coupling schemes of orbital and spin angular momenta? Explain with various diagrams and give examples of each. (2+6+2=10)

2. What do you mean by normal Zeeman effect? Deduce the expression of Zeeman shift.
If the normal Zeeman components of 500 nm spectral line are 0.116 nm apart in a magnetic field of 1.0T, then calculate the value of 'e/m' of electron. (2+5+3=10)

3. What do you mean by Doppler effect? Explain how Doppler effect contributes to the breadth of the spectral line.
Calculate Doppler broadening at 1200°C for Argon ion transition at 488 nm. (2+6+2=10)

4. What are the drawbacks of the harmonic oscillator model of a diatomic molecule? How these drawbacks are removed by introducing anharonicity? Write down the expression of the vibrational energy of an anharmonic diatomic molecule. Deduce the expression for the frequency of fundamental, first order and second order overtones and first hot band transition. Give the expression of Morse potential. (2+1+2+4+1=10)

5. Explain the quantum theory of Raman effect to calculate the frequencies of Stokes and anti-Stokes lines. Why classical theory is not sufficient to explain Raman effect? Describe the rotational Raman spectra of 16O2 molecule and write the frequencies of first Stokes and first anti-Stokes lines. What do you mean by polaizability ellipsoid? (2+1+4+1+1=10)

6. Explain briefly the characteristics of a laser which distinguish them from ordinary light. What do you mean by Spontaneous and Stimulated emissions? Explain the principle of population inversion. (6+2+2=10)

7. Explain briefly the construction and operation of He-Ne laser. State the function of Brewster's windows in He-Ne laser. (8+2=10)

8. What is holography? State the basic principle of holography and explain the briefly the steps of its construction. (1+1+8=10)

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[PART-A : Objective]

Choose the correct answer from the following: **1×20=20**

1. Diffused spectral line is emitted by
   a. H_2 b. Na c. Cd d. Hg

2. The number of vibrational modes of CO_2 molecule common in both Raman and IR is
   a. Zero b. One c. Two d. Three

3. The rotational constant of $^{14}N_2$ is 2 cm^{-1}. If the wave number of incident radiation in a Raman spectrometer is 20487 cm^{-1}, the wave number of first Stokes lines (in cm^{-1}) of $^{14}N_2$ is
   a. 20475 b. 20499 c. 20479 d. 20495

4. Rotational energy level with even value of J is missing for the molecule
   a. O_2 b. N_2 c. H_2 d. D_2

5. The nucleus which do not exhibit NMR spectra is
   a. ^{11}B b. ^{18}O c. ^{31}P d. ^{35}Cl

6. The numbers of fine structure line of H_α line is
   a. 3 b. 5 c. 4 d. 6

7. The electronic state not allowed for He atom is
   a. $2\,^3S$ b. $1\,^3S$ c. $2\,^3P$ d. $2\,^1P$

8. The energy state which lie deepest is
   a. $^1P_1$ b. $^3P_0$ c. $^3P_1$ d. $^3P_2$

9. The value 'm' in the expression of wave number of diffuse series of alkali metal $(2, u_P) \leftarrow (m, u_D)$ is given by
   a. $m \geq 1$ b. $m \geq 2$ c. $m \geq 3$ d. $m \geq 4$

10. If reduced mass is doubled then the vibrational frequency is
    a. increased by a factor $\sqrt{2}$ b. increased by a factor 2
    c. decreased by a factor 2 d. unchanged

11. The spacing between the rotational spectral lines of HF is 40 cm^{-1}. The corresponding spacing between rotational line in DF molecule is
    a. 30 cm^{-1}
    b. 7.5 cm^{-1}
    c. 20 cm^{-1}
    d. 60 cm^{-1}

12. The selection rule for P and R branches of rotational fine structure in vibrational transition are respectively
    a. $\Delta J = +1$ & -1
    b. $\Delta J = 0$ & $+1$
    c. $\Delta J = -1$ & $+1$
    d. $\Delta J = -1$ & 0

13. The angular spread $\Delta\theta$ of the far field beam of a laser of wavelength 'λ' is related to the aperture diameter 'd' by
    a. $\Delta\theta = \frac{\lambda}{d^2}$
    b. $\Delta\theta = \frac{\lambda^2}{d}$
    c. $\Delta\theta = \frac{\lambda}{d}$
    d. $\Delta\theta = \frac{d}{\lambda}$

14. If the relative band width of light sources is $\xi = \frac{\Delta\vartheta}{\vartheta_0}$, (where $\Delta\vartheta$ is line-width and ϑ_0 is central frequency), then the condition for absolute monochromaticity is
    a. $\Delta\vartheta = 1$
    b. $\Delta\vartheta = -1$
    c. $\Delta\vartheta = \infty$
    d. $\Delta\vartheta = 0$

15. The ratio of Einstein's A and B coefficient of transitions in energy levels is given by
    a. $\frac{A}{B} = \frac{\hbar\omega}{\pi^2 c^3}$
    b. $\frac{A}{B} = \frac{\hbar\omega}{\pi c}$
    c. $\frac{A}{B} = \frac{\pi^2 c^3}{\hbar\omega}$
    d. $\frac{A}{B} = 0$

16. Resonant frequency of an open resonator is given by
    a. $\omega = \frac{C\pi q}{L\eta}$
    b. $\omega = \frac{C\eta q}{\pi L}$
    c. $\omega = \frac{L\eta}{C\pi q}$
    d. $\omega = \frac{Cq}{\pi\eta L}$ (the terms have their usual meaning)

17. In He-Ne laser, the aim of keeping Ne pressure much below that of He is to
    a. get continuous wave laser oscillation
    b. stop energy transfer from Ne to He
    c. both (a) and (b)
    d. none of these

18. Brewster windows are used in He-Ne laser system to reduce the
    a. polarization loss
    b. reflection loss
    c. refraction loss
    d. bending loss

19. Quality factor of a laser cavity (Q) is related to the line width of the laser ($\Delta\omega$) as
    a. $Q = \frac{\omega}{\Delta\omega}$
    b. $Q = \frac{\Delta\omega}{\omega}$
    c. $Q = \omega.\Delta\omega$
    d. $Q = exp\left(-\frac{\omega}{\Delta\omega}\right)$

20. Holographic process records the
    a. reflected light
    b. refracted light
    c. inverted light
    d. none of above

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UNIVERSITY OF SCIENCE & TECHNOLOGY, MEGHALAYA

Question Paper CUM Answer Sheet

[PART (A) : OBJECTIVE]

Serial no. of the main Answer sheet

Course : .....

Semester : ..... Roll No : .....

Enrollment No : ..... Course code : .....

Course Title : .....

Session : 2016-17 Date : .....

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Instructions / Guidelines

- The paper contains twenty (20) / ten (10) questions.
- The student shall write the answer in the box where it is provided.
- The student shall not overwrite / erase any answer and no mark shall be given for such act.
- Hand over the question paper cum answer sheet (Objective) within the allotted time (20 minutes / 10 minutes) to the invigilator.

Full Marks	Marks Obtained	Remarks
20		

Scrutinizer's Signature *Examiner's Signature* *Invigilator's Signature*