QK21/MSCPHY/04

**MSc (Physics)-III$^{rd}$ Semester**
MID TERM EXAMINATION- September-2022
**MSPH-217: Characterization Techniques**

Max. Time - 1:30 Hrs

Max. Marks- 25

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|---|
| **1. All questions are compulsory.** |
| **2. Assume suitable missing data, if any.** |

1[a]. Why X-ray Diffraction (XRD) and scanning electron microscope is used to characterize the materials in place of ordinary light and optical microscope (SEM)? [2] (CO1)

[b]. Distinguish between characteristic and continuous radiations of X-rays, which type of X-rays is used for material characterizations. [2] (CO2)

[c]. Calculate the velocity and kinetic energy of electrons which strike the target of an X-ray tube operated at 35 kV. Determine the maximum energy per quantum of x- radiation emitted and the short wavelength limit ($\lambda_{swl}$) of the spectrum. [2] (CO1)

[d]. Drawing a pattern of X –ray peak Intensity *vs* diffraction angle. Show all the information can be extracted from peak width. [2] (CO1)

2[a]. Briefly explain, among scanning electron microscope (SEM) and transmission electron microscope (TEM) which is closer to supplement the characterizations performed by XRD. Why copper (Cu) may not be used as filament to eject electrons in SEM and TEM? [3] (CO3)

[b]. Write the Kanaya- Okayama (KO) depth penetration relation and hence estimate the surface information from nano to micro level as obtained at 0.5 KV, 5 KV, 15 KV and 30 KV voltages used in SEM. [2] (CO3)

3[a]. What are secondary electrons (SE) in SEM? Distinguish between SE1 and SE2 with proper atomic diagrams. [3] (CO3)

[b]. How many electrons per second can directed at the given area of specimen in SEM, for a beam of e's generated by thermionic emission at high temperature of 2700 K and applied potential 40 kV? if the work function of filament material is 4.5 eV. [2] (CO3)

4[a]. What are the information can be deduced from Imaging and Diffraction modes in TEM. Draw a ray/schematic diagram for TEM and explains the working principle of TEM. Draw patterns for single crystal and polycrystal observed in terms of SAED patterns. [4] (CO3)

[b]. Explain atomic and unit cell scatterings. Assuming proper fractional atomic positions of simple cubic (SC) cell, find out the structure factor in mixed and unmixed state. [3] (CO1)

*Total No. of Pages: 2*

THIRD SEMESTER

END SEMESTER EXAMINATION

*Roll No.* 2K21/MSCPHY/04

**M.SC. [PHYSICS]**

**(November, 2022)**

**MSPH-217**

# CHARACTERIZATION TECHNIQUES

Time: 3:00 Hours

Max. Marks: 50

Note: Answer Any **FIVE** questions. **Question No. 1** is Compulsory. Assume suitable missing data, if any

**1. Answer all the questions.** [2 x 5]

[a]. Explain Bragg's law? Derive the Bragg's formula: $2d\sin\theta = n\lambda$. (CO1)

[b]. Determine the frequency and energy of CuKα ($\lambda = 0.15418\ nm$) and FeKα ($\lambda = 0.19373\ nm$). (CO1)

[c]. Briefly, explain energy dispersive X- rays (EDX) spectroscopy. How EDX is beneficial for characterization of materials? (CO2)

[d]. Draw SEAD patterns of single crystalline, polycrystalline and amorphous solids by TEM/ HR-TEM. (CO4)

[e]. What is the difference between IR and FTIR? Why KBr material is used as binder for sample preparation in FTIR? (CO3)

2[a]. Define 'multiplicity' and 'structure factor'. Assuming proper fractional atomic positions of 'body centered cubic' cell, find out the structure factor in mixed and unmixed state of intensity. (CO1) [5]

[b]. Explain the basic principle and instrumentation of X-ray Photo Electron Spectroscopy. Write the different characteristics studied/ analyzed by XPS. (CO3)[5]

3[a]. Discuss working and principle of FTIR. Consider a FTIR pattern of any compound and show finger print and characteristic regions in it and explain. Write the wavenumbers of C-O, C-C and C=O stretches. (CO3) [7]

PHY/04

[b]. A microscope consists of a 5X objective and a 20X ocular. The distance between the lenses is 15 cm. (a) Determine the overall magnification if the eye is relaxed (b) determine the focal length of the ocular lens (c) the focal length of the objective lens. (CO4) [3]

4[a]. Discuss about secondary electron (SE), backscattered electron (BSE) and X-rays ejection and their applications in material characterization for a scanning electron microscope (SEM). Distinguish between SEM and FE-SEM. (CO4) [7]

[b]. An electron beam of brightness, $10^{10}$ $Am^{-2}sr^{-1}$ is focused to a spot of diameter 100 nm at the specimen. What is the current density within the spot and what is the dose rate in electrons per square nm per second? Take the convergence angle to be 0.04 radians. (CO2) [3]

5[a]. Discuss about contact and non contact mode of Atomic force microscope (AFM). Using force – distance curve, explain the cantilever and tip interaction with the specimen to measure adhesion force using AFM. (CO4) [7]

[b]. Define Peizo sensitivity in AFM, if a cantilever travels a distance of 40 nm during adhesion force measurement for a deflection of 5 V signal, calculate the sensitivity of Peizo crystal. (CO2) [3]

6[a].Explain the principle, working and application of thermal gravimetric technique (TGA). Write any example for multiple transition with weight losses and signify the transition process. (CO5) [7]

[b]. A mixture of $CaCO_3$ and CaO is analyzed using TGA technique. TGA curve of the sample indicates that there is a mass change from 145.3 mg to 115.4 mg between 500–900 °C. Calculate the percentage of $CaCO_3$ in the sample. (CO5) [3]

7. Discuss briefly any ***FOUR***. [5X4]

[a]. Magnetic force microscopy (MFM) (CO4)

[b]. Deep level transient spectroscopy (DLTS) (CO3)

[c]. Bright field optical microscopy (BFOM) (CO4)

[d]. Differential thermal analysis (DTA) (CO5)

[e]. Atomic absorption spectroscopy (AAS) (CO3)

[f]. Differential scanning calorimetry (DSC) (CO5)

*Total Number of Page: 02*

Roll. No 2K21/MSCPHY/04

**III SEMESTER**
**M.Sc. (PHYSICS)**
**END SEMESTER EXAMINATION** **Nov/Dec-2022**

**MSPH203: Nuclear and Particle Physics**

***Time: 3 Hours*** ***Max. Marks: 50***

*Note: Answer All questions.*
*Assume suitable missing data, if any*

Q1. Explain the fundamental characteristics of Nuclear Forces? Which of the nuclear phenomenon happens due to disintegration of the atomic nucleus? Determine the minimum energy (in MeV) needed to remove just one proton from the nucleus C. (Let the mass of a proton be 1.0078 u, the mass of C be 12.0000 u, and the mass of B be 11.0093 u.) 5 [CO:1,2]

Q2. i) Explain the importance of the use of beam of particles (Electrons or protons) in the field of nuclear physics? Use energy methods to calculate the distance of the closest approach for a head-on collision between an alpha particle with an initial energy of 0.5 MeV and a gold nucleus ($^{197}$Au) at rest. 5 [CO:2]

ii) Explain the term: Binding energy per nucleon in view of the stability of nuclei. Give an example of a compound which has a doubly magic number nucleus? Explain semi-empirical mass formula with significance of various terms in terms of their gravity. 5 [CO:1,2]

Q3. Starting from assumptions, mention various achievements and failures of shell model and its implications for the heavier and lighter nuclei and its structure with examples? 5 [CO:2]

Q4. Explain the following: 20 [CO:1, 2,3]

Nuclear Scattering Processes, Controlled thermonuclear Reactions, Nuclear Spin and Nuclear decay, Nuclear Magnetic Dipole moment, Environmental effects of Nuclear Power, Different types of Nuclear Reactions, Main Components of Nuclear Reactor and its working, Role of particle physics in astronomy

Q 5. i) Explain the difference among alpha, beta and gamma decay with examples? If radiation is dangerous then why do we use it? Why do Nuclear Reactions Release Tremendous Amounts of Energy? 5 [CO:3, 4]

ii) Does fusion produce radioactive waste the same way as fission does? Explain? Illustrate the difference between fusion and fission reactions? Can fusion cause a nuclear accident? Justify with examples? 5 [CO:3, 4]

Total Number of Page 2
3rd SEMESTER
**END SEMESTER EXAMINATION**

Roll. No. 2K21/MSCPHY/04
**M.Sc. (PHYSICS)**
Nov/Dec-2022

**MSPH201: Atomic and Molecular Physics**

*Time: 03:00 Hours* *Max. Marks: 50*

*Note: Answer All questions*
*Assume suitable missing data, if any*

## Part A (Atomic Physics)

Q1.

(a) What is Zeeman Effect? How it can be understood on quantum mechanical basis? Obtain an expression for Zeeman splitting of atomic energy levels in a magnetic field B. Explain the magnetic splitting of sodium D-lines. [5][CO#2]

(b) What is spin-orbit interaction? Calculate the energy shift due to spin-orbit interaction term in H-like system. Discuss the significance of this shift in relation to the fine structure of hydrogen spectral lines. [5][CO#1]

(c) Compute the field gradient of a 0.5 m long Stern- Gerlach magnet that would produce a 1 mm separation at the end of the magnet between the two components of a beam of silver atoms emitted from an oven at 960 °C. The magnetic dipole moment of silver is due to a single $l = 0$ electron, just as for hydrogen. (Boltzmann constant $k = 1.38 \times 10^{-23}$ K). [5][CO#2]

Q2. State Bohr's postulates and deduce an expression for the allowed energies of the hydrogen atom. Show an energy level diagram for the observed transitions. What are the limitations of Bohr's theory? [5][CO#1]

OR

Derive an expression for Larmor precessional frequency. What is its importance? A beam of electrons enters a uniform magnetic field of flux density 1.2 Tesla. Calculate the energy difference between electrons whose spins are parallel and antiparallel to the field. [5][CO#2]

Q3. Write Short Notes on any **Two** of the following

(a) Vector-atom model [2.5][CO#1]
(b) Lamb Shift [2.5][CO#1]
(c) Stark effect [2.5][CO#2,3]

## Part B (Molecular Physics)

Q4. Attempt any **Five** of the following. All parts carry equal marks. [15][CO#3,4,5]

(a) Explain Kasha's rule with a suitable schematic diagram.
(b) Discuss Predissociation.
(c) Discuss Fortrat diagram.
(d) In CO the J =0 $\rightarrow$J=1 absorption line occurs at a frequency of $1.15 \times 10^{11}$ Hz. What is the bond length of CO molecule?
(e) Discuss all the factors affecting the intensities of rotational spectral lines, including the role of isotopic substitution.
(f) The force constant of the bond in CO molecule is 1870 N $m^{-1}$. Calculate the frequency of vibration of the molecule and the spacing between its vibrational energy levels in eV. Given that the reduced mass of CO=$1.14\times10^{-26}$ kg, h=$6.63\times10^{-34}$ J s and 1eV=$1.6\times10^{-19}$ J.
(g) If the fundamental band of $H^1Cl^{35}$ lies at 3.46 μm (micron), calculate the wavelength of the corresponding band of $H^2Cl^{37}$.

Q5. Answer the following:
(a) The carbon monoxide (CO) molecule has a bond length $R$ of 0.113 nm and masses of the $^{12}C$ and $^{16}O$ atoms are $1.99\times10^{-26}$ kg and $2.66\times10^{-26}$ kg, respectively. Find (i) the energy and (ii) the angular velocity of the CO molecule when it is in its lowest rotational state. [5][CO#5]
(b) Derive energy/frequency expression of a diatomic vibrating rotator considering the concept of Born-Oppenheimer approximation and obtain the transitions between the rotational-vibrational energy levels, i.e., the vibration-rotation spectrum. [5][CO#5]

*Total Number of Page 1*
*III SEMESTER*
**MID SEMESTER EXAMINATION**

Roll. No. 2K21/MSCPH/04
M.Sc. **(PHYSICS)**
September-2022

**MSPH203: Nuclear and Particle Physics**

*Time: 1:30 Hours* *Max. Marks: 25*

*Note: Answer All questions.*
*Assume suitable missing data, if any*

Q1. Calculate the momentum of a neutron having de Broglie wavelength of 5 fm. Calculate the energy of electron at rest? Calculate the average binding energy per nucleon of $^4$He nucleus. Given $m_{He}$= 4.002643 amu, $m_p$= 1.007825 amu, $m_n$= 1.008665 amu. 2.5 [CO:1]

Q2. i) What is amu? Nuclear forces are of short range. Explain? Why the number of neutrons tends to exceed the number of protons in stable nuclei? 2.5 [CO:2]

ii) Show that nuclear density is same for all the nuclei? Why are even-even nuclei most stable? Explain the terms: Binding Energy, Binding energy per nucleon, packing fraction, Mass defect? 2.5 [CO:1]

Q3. i) What is semi-empirical mass formula? Explain the significance of various terms? 5 [CO:2]

ii) What was the need of various nuclear models? Starting from assumptions discuss the achievements and failures of shell model? 2.5 [CO:2]

Q4. Explain the following: 10 [CO:1, 2]

i) Two experimental evidences of magic numbers (Shell model)

ii) Nuclear Spin

iii) Nuclear Magnetic Dipole moment

iv) Parity

*Total Number of Page 1*
*3rd SEMESTER*
**MID SEMESTER EXAMINATION**

Roll. No. 2K21/MSCPH/04
**M.Sc. (PHYSICS)**
September-2022

**MSPH201: Atomic and Molecular Physics**

*Time: 1:30 Hours* *Max. Marks: 25*

*Note: Answer All questions.*
*Assume suitable missing data, if any*

## Part A (Atomic Physics)

Q1. Answer the following:

(a) Explain why spectral lines of the Balmer series are not observed in the absorption of terrestrial sources, but have been observed in the absorption spectra of some stars. 2.5 [CO:1]

(b) A muon ($\mu^-$) (charge -e, mass=207 $m_e$) from cosmic rays is trapped by a proton to form a hydrogen-like atom. Calculate the longest wavelength of the spectral line (in the analogue of the Lyman series) of such an atom. 2.5 [CO:1]

Q2. Answer the following:

(a) Discuss how the Stern-Gerlach experiment explains space quantization and electron spin. What will be observed if we replace a beam of neutral silver atom with a hydrogen atom? 2.5 [CO:2]

(b) Consider the states in which $l=4$ and $s=1/2$. Calculate the angle between $\vec{J}$ and the +z-axis for the state with the largest possible $j$ and largest possible $m_j$. 2.5 [CO:1]

(c) Determine the possible terms of a one-electron atom corresponding to n=3 and compute the angle between $\vec{L}$ and $\vec{S}$ vectors for the term $^2F_{5/2}$. 2.5 [CO:2]

## Part B (Molecular Physics)

Q3. Answer the following:

(a) Describe the frequency regions and their origin. Also, discuss the interaction of radiation with matter in the microwave and infrared regions. 2.5 [CO:4]

(b) Sketch a diagram of spectrophotometer and Spectrofluorometer and discuss their necessary optical and electronic components. 2.5 [CO:3]

Q4. Discuss the following:

(a) Emission with Jablonski diagram, quantum yield and fluorescence lifetime with mathematical expressions. 2.5 [CO:4]

(b) Bathochromic shift, hypsochromic shift, hyperchromic and hypochromic effects with suitable examples. 2.5[CO:5]

(c) Franck-Condon principle with suitable examples. 2.5 [CO:4]

Total No. of Pages:01

Roll No 2K21/MSPHY/04

SEVENTH SEMESTER

**B.Tech. (EP)**

## MID SEMESTER EXAMINATION *September-2022*

### EP-427 Advanced Materials for Photonic Devices

*Time: 1:30 Hours* *Max. Marks : 25*

**Note :** All questions are Compulsory.
All questions carry equal marks
Assume suitable missing data, if any.

1. (a) Write any two important features of Miller indices? Construct $(0\ \bar{1}\ 1)$ plane within a cubic unit cell. [3][CO 1]

   (b) Classify various types of interatomic and intermolecular bonds in crystals. [2][CO1]

2. Define Glass according to ASTM. Draw a Volume-Temperature diagram for a glass forming liquid and explain the formation of glass and the crystal from the liquid in detail. [5][CO 1]

3. (a) Describe the components used to prepare a glass with suitable examples. [3][CO 1]

   (b) Explain the stochiometric calculation for synthesis of 3.0 gm of a $LiMn_2O_4$ material by solid state route using the precursors/ raw materials: $Li_2CO_3$ and $MnO_2$ for Li, and Mn content, respectively. [2][CO1]

4. (a) Explain Top-down and Bottom-up approach of materials synthesis with proper diagram. [3][CO 2]

   (b) Write name of glass formation theories and explain the empirical observations of Zachariasen's rules for glass formation for oxide materials. [2][CO 1]

5. List any four synthesis routes of semiconducting/ photonic materials. Discuss all steps of material synthesis by sol-gel technique. How aerogel and xerogel are different? [5][CO 2]

*Total No. of Pages:01*

*Roll No.* 2K21/MSC414/04

SEVENTH SEMESTER

**B.Tech. (EP)**

**END SEMESTER EXAMINATION** ***Nov/Dec-2022***

**EP-427: Advanced Materials for Photonic Devices**

*Time: 3:00 Hours* *Max. Marks : 50*

| Note : | Answer any FIVE questions.<br>Assume suitable missing data, if any. |
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1. Write short notes on the following with example: [4×2.5= **10**][CO1 &4]
   (a) Atomic Packing Factor (b) Van der Waals bond
   (c) Electric and Magnetic dipole transitions
   (d) Radiative and non-radiative relaxations
2. (a) An element of atomic weight 60 has density 6.23 gm/cc. What is the radius of its atom if it has FCC structure? **[4]** [CO1]
   (b) Describe construction and working of any rare earth laser. **[6]** [CO5]
3. (a) What are Lanthanides and describe the significant properties of Lanthanides. **[4]**[CO4]
   (b) What is phosphor converted w-LED and give an example. Describe the basic principles and approaches to generate white light. **[6]**[CO5]
4. (a) Discuss synthesis procedure to prepare any phosphor using solid state reaction method. **[3]**[CO2]
   (b) What is structure factor? Assuming the proper atomic positions in a body centered cubic (bcc) unit cell, estimate the structure factor for both the mixed and unmixed states. **[4]**[CO3]
   (c) In a powder diffraction pattern, the size of crystallite (t) is observed 50 nm at an angle of diffraction ($\theta$), $30^0$ for the X-ray beam of wavelength ($\lambda$), 0.1540 nm. Find out the full width at half maxima (FWHM), $\beta$ for the peak in degree. **[3]**[CO2]
5. (a) Write down the characteristic information deduced from scanning electron microscope (SEM) for materials. How SEM is different is from optical microscopy? **[3]**[CO3]
   (b) Discuss the working principle of scanning electron microscope (SEM) with suitable diagram. Write any two applications of SEM. **[7]**[CO3]
6. (a) List the thermal analysis techniques used for material characterization. Write difference between differential thermal analysis (DTA) and differential scanning calorimetry (DSC). **[3]** [CO3]
   (b) Describe working principle of thermo-gravimetric analysis (TGA). Write any two applications of TGA. **[7]**[CO3]

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*Total No. of Pages:1* *Roll No.* 2K21/MSCPHY/...

**FOURTH SEMESTER**
**M.Sc.**
**END SEMESTER EXAMINATION (May 2023)**
**MSPH-204 Space & Atmospheric Sciences**

*Time: 3:00 Hours* *Max. Marks: 50*

**Note:** Answer ALL five questions
All questions carry equal marks
Assume suitable missing data, if any.

1. What is an automatic weather station and explain the measurement of different meteorological parameters using automatic weather station. What are the advantages of automatic weather station?
(10 M)(CO2)

2. Discuss the needs for upper air observations along with various techniques available to explore the structure of the upper air.
(10 M)(CO2)

3. Explain the basic principles of radiosonde. What are the thermo dynamical parameters? Discuss their importance.
(10 M)(CO3)

4. What are trace gases? Explain various natural mechanisms and anthropogenic causes responsible for trace gases production. Explain the adverse effects of trace gases on human beings, animals and agriculture.
(10 M)(CO4)

5. Explain in detailed the mechanism of production of tropospheric Ozone. Write its effect on various things in troposphere. Explain the role of Ozone in stratosphere and its depletion and consequences of its depletion in stratosphere.
(10 M)(CO5)

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Total No. of Pages 2

Roll No. 2K21/MSCPHY/04

Fourth SEMESTER **M.Sc (Physics)**

**END SEMESTER EXAMINATION** *(May-2023)*

**MSPH-202 Advanced Semiconductor Devices**

*Time: 3.0 Hours* *Max. Marks: 50*

**Note :** Attempt any Five questions.
All questions carry equal marks.
Assume suitable missing data, if any.

1. **(a)** What are the limitations of conventional tubes at microwave frequencies? Explain with schematic diagram. **[5][CO-1,4,5]**

**(b)** What is the Reflex Klystron? Prove that the maximum electronic efficiency of reflex klystron is 22.7%. **[5][CO-1,4,5]**

2. **(a)** What is a Travelling Wave Tube (TWT)? With the aid of a schematic diagram, explain about the helical slow-wave structure. **[5][CO-1,4,5]**

**(b)** Explain 'Mode Jumping' in a cavity magnetron. What remedial steps can be taken to prevent the same? **[5][CO-1,4,5]**

3. **(a)** Explain the J-E characteristics of Gunn diode with the help of two valley model theory. **[5][CO-1,4,5]**

**(b)** Explain, working principle of MOCVD technique. **[5][CO-4,5]**

4. **(a)** Explain the with diagram working principle P-N junction. Discuss forward and reverse biasing of P-N junction diode. **[5][CO-1,2,4,5]**

**(b)** Explain with reference to Zener diode characteristic curve the following:

(i) $I_{ZK}$ (ii) $I_{ZT}$ (iii) $Z_z$ **[5][CO-1,2,4,5]**

5. (a) With suitable diagram, explain working principle of photodiode. **[5][CO-1,2,4,5]**

(b) Differentiate between semiconductor and Quantum Well Laser (QWL). Explain why, light is propagate only in active layer in QWL. **[5][CO-1,2,4,5]**

6. (a) With suitable diagram, explain work function, electron affinity, acceptor, and donor and Fermi level in semiconductor. **[5][CO-1,2,4,5**

(b) Differentiate between ferroelectric, degenerate and non-degenerate semiconductors. **[5][CO-1,2,4,5]**

7. Write short notes on **any two**. **[10][CO-1,4,5]**

(a) Application and working principle of charge couple device (CCD)

(b) Density of states for 3D material

(c) SAW and integrated devices

*Total no. of Pages 02*

*Roll no* 244 MSCPH4/45

**Third Semester**
**M.Sc. (Physics)**

**END TERM EXAMINATION** **November 2022**

**MSPH 215 Plasma Physics**

**Time : 3:00 Hours** **Max. Marks : 50**

**Note :** Attempt all the Questions.
All Questions carry equal Marks
Assume Suitable missing date, if any

Q.1. Explain the construction and working of Q-Machine in a dusty plasma. How can you measure the plasma parameters (electron density and temperature) using Langmuir probe techniques? [10][CO#1]

**Or**

What is the magnetic moment in plasma? Show that for a diamagnetic case the magnetic moment is given by $\vec{\mu} = -\frac{W_\perp}{B^2}\vec{B}$, where $W_\perp$ is the transverse kinetic energy of the particle. [10] [CO#1]

Q.2. What are the electrostatic ion –cyclotron waves? An ion beam of density $n_{ob}$, velocity $\overline{v_{ob}} \| \hat{z}$, charge (+e) and mass $m_b$ is propagating through a plasma of electron density $n_{oe}$, electron temperature $T_e$, ion density $n_{i0}$, ion mass $m_i$, ion temperature $T_i \approx 0$ immersed in a static magnetic field $\overline{B_o} \| \hat{z}$. Show that the growth rate of the unstable mode is given by

$$\gamma = \left(\frac{\omega_{pb}^2 \alpha_1}{2}\right)^{1/3}, \alpha_1 = \frac{kc_s}{\left(1+\frac{k^2c^2}{\omega_{pi}^2}\right)^{1/2}}$$

[10] [CO#2]

**Or**

Show that the dispersion relation for electrostatic waves in a magnetized plasma is given by

$$\varepsilon = 1 - \frac{\omega_p^2}{\omega^2}\frac{k_z^2}{k^2} - \frac{\omega_p^2}{\omega^2-\omega_c^2}\frac{k_x^2}{k^2} - \frac{\omega_{pi}^2}{\omega^2}\frac{k_z^2}{k^2} - \frac{\omega_{pi}^2}{\omega^2-\omega_i^2}\frac{k_x^2}{k^2} = 0$$

[10] [CO#2]

Q. 3. What is kelvin Helmholtz Instabilities (KHI)? For a fully ionized plasma in the presence of magnetic field, show that the instability occurs if

$$k > \frac{\gamma}{\beta}\left[1 + \frac{\Lambda^2}{(\gamma/\beta)^2}\right].$$

[10] [CO#3]

Q.4. What is the distribution function f? Solve the Vlasov equation for an isotropic plasma ($B_s$ =0) and obtain $\varepsilon = 1 + \chi_e + \chi_i$ , where

[10] [CO#4]

$$\chi_e = \frac{2\omega_{pe}^2}{k^2 v_{th}^2}\left[1 + \frac{\omega}{kv_{th}} Z\left(\omega / kv_{th}\right)\right] \quad \text{and} \quad \chi_e = \frac{2\omega_{pi}^2}{k^2 v_{thi}^2}\left[1 + \frac{\omega}{kv_{thi}} Z\left(\omega / kv_{thi}\right)\right]$$

Q.5. What is Free Electron Laser (FEL)? Explain the physical mechanism using schematic diagram. Show that the growth rate of the FEL instability is given by

$$\Gamma = \left(\frac{v_{o\perp}^2}{c^2}\frac{\omega_{pb}^2 k_w c}{\gamma_0^3}\right)^{1/3}\frac{\sqrt{3}}{2}$$

[10] [CO#5]

Or

What is Cerenkov free electron laser (CFEL)? Explain the physical mechanism using suitable schematic diagram. [10] [CO#5]

*Total Number of Page 1*

Roll. No. 16

*3rd SEMESTER*

**M.Sc. (PHYSICS)**

**MID SEMESTER EXAMINATION**

September-2022

**MSPH201: Atomic and Molecular Physics**

*Time: 1:30 Hours*

*Max. Marks: 25*

*Note: Answer All questions.*
*Assume suitable missing data, if any*

## Part A (Atomic Physics)

Q1. Answer the following:

(a) Explain why spectral lines of the Balmer series are not observed in the absorption of terrestrial sources, but have been observed in the absorption spectra of some stars. 2.5 [CO:1]

(b) A muon ($\mu^-$) (charge -e, mass=207 $m_e$) from cosmic rays is trapped by a proton to form a hydrogen-like atom. Calculate the longest wavelength of the spectral line (in the analogue of the Lyman series) of such an atom. 2.5 [CO:1]

Q2. Answer the following:

(a) Discuss how the Stern-Gerlach experiment explains space quantization and electron spin. What will be observed if we replace a beam of neutral silver atom with a hydrogen atom? 2.5 [CO:2]

(b) Consider the states in which $l=4$ and $s=1/2$. Calculate the angle between $\vec{j}$ and the +z-axis for the state with the largest possible $j$ and largest possible $m_j$. 2.5 [CO:1]

(c) Determine the possible terms of a one-electron atom corresponding to n=3 and compute the angle between $\vec{L}$ and $\vec{S}$ vectors for the term $^2F_{5/2}$. 2.5 [CO:2]

## Part B (Molecular Physics)

Q3. Answer the following:

(a) Describe the frequency regions and their origin. Also, discuss the interaction of radiation with matter in the microwave and infrared regions. 2.5 [CO:4]

(b) Sketch a diagram of spectrophotometer and Spectrofluorometer and discuss their necessary optical and electronic components. 2.5 [CO:3]

Q4. Discuss the following:

(a) Emission with Jablonski diagram, quantum yield and fluorescence lifetime with mathematical expressions. 2.5 [CO:4]

(b) Bathochromic shift, hypsochromic shift, hyperchromic and hypochromic effects with suitable examples. 2.5[CO:5]

(c) Franck-Condon principle with suitable examples. 2.5 [CO:4]