R2836

Sub. Code
542201

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Second Semester

Materials Science

MATERIALS CHEMISTRY

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective type questions by choosing the correct option.

1. The bond formed between a metal and a non-metal is called ————. (CO1, K1)

   (a) Covalent Bonding

   (b) Ionic Bonding

   (c) Van der Waals bonding

   (d) Hydrogen Bonding

2. Among the following elements, which has the highest electronegativity (CO1, K1)

   (a) Carbon

   (b) Sulfur

   (c) Fluorine

   (d) Chlorine

3. Which of the following is not a semiconductor? (CO2, K1)

(a) silicon

(b) carbon

(c) sulfur

(d) krypton

4. Brass is an alloy of ————. (CO2, K4)

(a) copper and zinc

(b) carbon and iron

(c) copper and tin

(d) carbon and chromium

5. By which properties can the orientation of molecules in a layer of liquid crystals be changed? (CO3, K1)

(a) Electric field

(b) Heating

(c) Magnetic field

(d) Electromagnetic field

6. An example of a thermosetting polymer is ————. (CO3, K5)

(a) Polythene

(b) Bakelite

(c) Neoprene

(d) PVC

7. Which types of friction is also known as kinetic friction?

(CO4, K2)

(a) Sliding friction

(b) Rolling friction

(c) Fluid friction

(d) Static friction

8. Twin boundaries are which type of crystal defect?

(CO4, K5)

(a) volume defect

(b) surface defect

(c) line defect

(d) point defect

9. Name the first step in the radical polymerization.

(CO5, K3)

(a) Propagation

(b) Initiation

(c) Termination

(d) Hydrolysis

10. What is the purpose of recrystallization? (CO5, K6)

(a) To dissolve crystals

(b) To purify chemicals

(c) To clean crystallizers

(d) Continuous process of crystallization

Part B (5 × 5 = 25)

Answer **all** questions not more than 500 words each.

11. (a) Define ionization energy, electronegativity and electron affinity and compare their trend in the periodic table with examples. (CO1, K1)

Or

(b) Explain the parameters affecting ionization energy, electronegativity and electron affinity. (CO1, K1)

12. (a) Define semiconductors and their band gap structure and briefly explain the applications of semiconductors. (CO2, K1)

Or

(b) List five alloys and their composition and two applications of each. (CO2, K4)

13. (a) Write a short note on liquid crystals, including classifications of liquid crystals, and discuss their potential applications. (CO3, K1)

Or

(b) Write a short note on polymer crystals and structural plastics. (CO3, K5)

14. (a) Define ideal surfaces and real surfaces with examples. (CO4, K2)

Or

(b) Define thermionic emission, photoemission, and field emission. (CO4, K5)

15. (a) What are the different steps involved in crystal growth? Briefly explain the importance of crystal growth over other purification processes. (CO5, K3)

Or

(b) Write a short note on the synthesis and processing of ceramics and glasses. (CO5, K6)

Part C $(5 \times 8 = 40)$

Answer **all** the questions not more than 1000 words each.

16. (a) Explain the different types of bonding with examples and compare their strengths. (CO1, K1)

Or

(b) Write an essay on a summary of atomic properties and parameters. (CO1, K1)

17. (a) Give an elaborate account on the dynamics of electron motion and quantum confinement. (CO2, K1)

Or

(b) Describe defects and the importance of doping. (CO2, K4)

18. (a) Give an elaborate account on the thermal and mechanical properties of polymers. (CO3, K1)

Or

(b) Explain in detail about various types of photoresists and its applications. (CO3, K5)

19. (a) Describe how the surface defects and surface modifications will affect the electronic properties of surfaces. (CO4, K2)

Or

(b) Explain in detail about plasmons dispersion force and friction. (CO4, K5)

20. (a) Describe the issues related to synthesis and processing with an emphasis on thermodynamic, chemical effects and kinetic effects. (CO5, K3)

Or

(b) Explain in detail about the sol-gel synthesis and polymer synthesis. (C05, K6)

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R2837

Sub. Code
542202

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Second Semester

Materials Science

CHARACTERISATION OF MATERIALS

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following by choosing the correct option.

1. DTA can be used for which of the following process? (CO1, K1)
   (a) Line positions of the crystals
   (b) Mechanical properties of the crystals
   (c) Phase diagrams
   (d) Catalytic properties of enzymes

2. In the application of DTA and DSC which of the following parameters is measured for the glasses? (CO1, K1)
   (a) Concentration of the glass
   (b) Solubility of the glass
   (c) Cooling temperature
   (d) Transition temperature

3. The surfaces of non-metallic samples can be studied by (CO2, K2)
   (a) STM (b) AFM
   (c) STEM (d) SPM

4. The secondary electrons radiated back in the scanning microscope is collected by? (CO2, K2)
   (a) specimen (b) anode
   (c) vacuum chamber (d) cathode

5. A microscope that uses light rays to produce a dark image against a bright background is known as a (CO3, K3)

(a) Dark field microscope
(b) Bright field microscope
(c) Phase contrast microscope
(d) Electron microscope

6. Confocal microscopy relies on a ———————— beam. (CO3, K3)

(a) Light (b) Laser
(c) Electron (d) Proton

7. Identify application which is not suitable with Four Probe method. (CO4, K2)

(a) Remote sensing area
(b) Fuel cell bipolar plate
(c) Resistance thermometers
(d) Inductance controlling

8. Vander Pauw measurement use for ———————— measurement. (CO4, K2)

(a) Resistivity (b) Inductance
(c) Capacitance (d) Conductance

9. In what region of the spectrum does infrared radiation occur? (CO5, K6)

(a) At the low-energy end
(b) Between the visible and ultraviolet regions
(c) Between the visible and microwave regions
(d) Between the visible and x-ray regions

10. In NMR spectrum, the nuclei in the field resonate at (CO5, K6)

(a) High frequency
(b) Low frequency
(c) It is constant throughout the spectrum
(d) It does not depend on chemical shift

Part B $(5 \times 5 = 25)$

Answer **all** the questions not more than 500 words each.

11. (a) Discuss various modes and principle of operation of differential thermal Analysis. (CO1, K1)

Or

(b) Write the advantages and applications of Differential scanning calorimetry (DSC). (CO1, K1)

12. (a) Explain in detail about the dark field microscopy and its applications. (CO2, K2)

Or

(b) Write the working principle of confocal microscopy. (CO2, K6)

13. (a) Examine the Scanning probe microscopy operation with a clear illustration. (CO3, K3)

Or

(b) Discuss the various advantages and limitations of Transmission Electron Microscopy (TEM). (CO3, K3)

14. (a) Compare the Hall effect and four probe based on resistance measurements. (CO4, K2)

Or

(b) Explain the emission process with a clear illustration. (CO4, K2)

15. (a) Describe the operation of FTIR Spectroscopy. (CO5, K6)

Or

(b) Explain the UV–visible spectroscopy with its instrumentation diagram. (CO5, K6)

Part C (5 × 8 = 40)

Answer **all** the questions not more than 1000 words each.

16. (a) Discuss about the Thermogravimetric analysis (TGA) with a neat diagram. (CO1, K1)

Or

(b) Explain the working principle of Differential scanning calorimetry characterization. (CO1, K1)

17. (a) Examine about the Bright field microscopy techniques. (CO2, K2)

Or

(b) Clearly explain the operation of fluorescence microscopy with diagram. (CO2, K2)

18. (a) With a schematic diagram explain the mechanism of image formation in TEM. (CO3, K3)

Or

(b) Define Tunnelling and Give an elaborate explanation of the operation of STM. (CO3, K3)

19. (a) Explain the electroluminescence process with its diagram. (CO4, K2)

Or

(b) Give a detailed account of the electrochemical studies and clearly illustrate the C–V techniques. (CO4, K2)

20. (a) Give a clear explanation of the instrumentation of NQR spectroscopy. (CO5, K6)

Or

(b) Describe the operation of ESR and evaluate the spin resonance properties. (CO5, K6)

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R2838

Sub. Code
542203

M.Sc. DEGREE EXAMINATION, APRIL – 2025.

Second Semester

Materials Science

QUANTUM MECHANICS

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective type questions by choosing the correct option.

1. The time dependent Schrodinger's equation is ————————. (CO1, K2)

(a) $-\frac{d^2\psi}{dx^2}\frac{\hbar^2}{2m} = i\hbar\frac{d\psi}{dt}$ (b) $-\frac{d\psi}{dx}\frac{\hbar^2}{2m} = i\hbar\frac{d\psi}{dt}$

(c) $-\frac{d^2\psi}{dt^2}\frac{\hbar^2}{2m} = i\hbar\frac{d\psi}{dx}$ (d) $-\frac{d\psi}{dt}\frac{\hbar^2}{2m} = i\hbar\frac{d\psi}{dt}$

2. The operator corresponding to the energy in one-dimension is (CO1, K2)

(a) $E = i\hbar\partial/\partial t$ (b) $E = -i\hbar\partial/\partial t$

(c) $E = i\hbar\partial/\partial x$ (d) $E = -i\hbar\partial/\partial x$

3. The ground state energy of a harmonic oscillator with angular frequency ω is ————————. (CO2, K2)

(a) $\frac{1}{2}\hbar\omega$ (b) $3/2\hbar\omega$

(c) $5/2\hbar\omega$ (d) $\hbar\omega$

4. A free particle has (CO2, K4)

(a) Definite energy but indefinite momentum

(b) Definite momentum but indefinite energy

(c) Definite energy and definite momentum

(d) Indefinite energy and indefinite momentum

5. The energy of hydrogen atom depends on (CO3, K4)

(a) l (b) m

(c) n (d) l and m

6. The variation principle is particularly effective when estimating the energy of (CO3, K4)

(a) The highest state of any symmetry

(b) The lowest state of any symmetry

(c) Any state of symmetry

(d) Both the highest and lowest state of symmetry

7. The commutation relations of position and momentum operator is (CO4, K2)

(a) $[x,-i\hbar\, d/dx]=i\hbar$ (b) $[x,-i\hbar\, d/dy]=i\hbar$

(c) $[x,-i\hbar\, d/dz]=i\hbar$ (d) $[x,-i\hbar\, d/dx]=0$

8. In LS coupling often occurs in ————————. (CO4, K2)

(a) All atoms

(b) Lighter atoms

(c) Heavier atoms

(d) Occurs only in nuclei

9. The combination of two atomic orbitals results in the formation of two molecular orbitals namely ————————. (CO5, K6)

(a) One bonding and one non-bonding orbital

(b) Two bonding orbitals

(c) Two non-bonding orbitals

(d) Two bonding and non-bonding orbitals

10. In molecular orbital theory, the stability increases, as the energy ————————. (CO5, K6)

(a) Increases

(b) Decreases

(c) Does not change

(d) Increases and then decreases

Part B (5 × 5 = 25)

Answer **all** questions not more than 500 words each.

11. (a) What is Hermitian operator? Explain its properties. (CO1, K2)

Or

(b) Outline the failures of classical mechanics in detail. (CO1, K2)

12. (a) Explain Bohr's correspondence principle in detail. (CO2, K2)

Or

(b) Deduce the energy Eigen value for a particle in a one-dimensional box. (CO2, K4)

13. (a) Explain in detail about (CO3, K4)

(i) principal quantum number (n),

(ii) azimuthal quantum number (l) and magnetic quantum number (m).

Or

(b) Illustrate the types of approximation methods to solve the ground state energy of multi-electron atoms. (CO3, K4)

14. (a) Evaluate the commentators (CO4, K2)

(i) $[\hat{x}, \hat{p}_x]$

(ii) $[\hat{x}, \hat{p}_x^2]$

Or

(b) Explain the LS coupling in detail. (CO4, K6)

15. (a) What is LCAO approximation? List the conditions to be satisfied by the contributing atomic orbitals to generate an effective molecular orbital. (CO5, K6)

Or

(b) Explain the valence bond method of Heitler and London (CO5, K6)

Part C ($5 \times 8 = 40$)

Answer **all** questions not more than 1,000 words each.

16. (a) What is the need for quantum mechanics? Elaborate in detail. (CO1, K2)

Or

(b) Derive the time independent Schrodinger' s wave equation and explain its physical significance. (CO1, K2)

17. (a) Solve the Schrodinger's wave equation for a rigid rotor and deduce the expression for rotational constant and bond length. (CO2, K2)

Or

(b) Derive the Schrodinger's wave equation for a free particle. (CO2, K4)

18. (a) Solve the radial part of Schrodinger's equation for the hydrogen atom and obtain its eigen values. (CO3, K4)

Or

(b) Outline the variation method used for obtaining approximate value of the ground state energy of a system. (CO3, K4)

19. (a) Prove the following commutation relations: (CO4, K2)

(i) $\left[L_x, L_y\right] = i\hbar L_z$

(ii) $\left[L^2, L_x\right] = 0$.

Or

(b) Construct the Slater determinant for helium atom. (CO4, K2)

20. (a) Outline the molecular orbital method for hydrogen molecule. (CO5, K6)

Or

(b) Illustrate the Huckel molecular orbital method for ethylene molecule. (CO5, K6)

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R2839	Sub. Code
	542204

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Second Semester

Materials Science

CRYSTAL GROWTH

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following questions by choosing the correct option.

1. Which type of nucleation involves the formation of a nucleus in a different phase from the existing material? (CO1, K1)

   (a) Homogeneous nucleation

   (b) Heterogeneous nucleation

   (c) Classical nucleation

   (d) Kinetic nucleation

2. Which theory of nucleation considers the role of statistical fluctuations in the formation of nuclei? (CO1, K1)

   (a) Classical theory

   (b) Thermodynamic theory

   (c) Statistical theory

   (d) Kinetic theory

3. Atmospheric nucleation is concerned with crystal growth that occurs (CO2, K2)

(a) In a controlled laboratory environment

(b) Exclusively on the surface

(c) Under the influence of external atmospheric conditions

(d) In a vacuum

4. The solution of the BCF surface diffusion equation is essential for understanding (CO2, K2)

(a) Atmospheric nucleation

(b) Two-dimensional nucleation

(c) Crystal growth through surface diffusion

(d) Limitations of the Temkin model

5. Which method is commonly used for starting materials and purification in crystal growth? (CO3, K3)

(a) Bridgman method

(b) Czochralski method

(c) Verneuil method

(d) Zone melting

6. Which method of crystal growth involves the controlled solidification of a melt in a temperature gradient? (CO3, K3)

(a) Bridgman method

(b) Czochralski method

(c) Verneuil method

(d) Zone melting

7. Which technique is specifically used for the growth of biological crystals? (CO4, K4)

(a) Hydrothermal technique

(b) Sol-gel growth

(c) Growth of biological crystals

(d) High-temperature solution growth

8. What is a characteristic of the hydrothermal technique for crystal growth? (CO4, K4)

(a) Low-pressure conditions

(b) Gelatinous matrix as a medium

(c) Use of an electric field

(d) High-temperature and high-pressure conditions

9. In chemical vapor transport, what is transported to facilitate the growth of crystals. (C05, K2)

(a) Solid Precursor

(b) Liquid Precursor

(c) Gaseous Precursor

(d) Plasma Precursor

10. Which epitaxial growth technique is known for its high precision and control over layer thickness (CO5, K2)

(a) Liquid Phase Epitaxy

(b) Molecular Beam Epitaxy

(c) Vapour Phase Epitaxy

(d) Chemical Beam Epitaxy

Part B (5 × 5 = 25)

Answer **all** questions not more than 500 words each.

11. (a) Write in detail about Gibbs Thomson equation for vapour and also explain the modified Thomson's equation for melt. (CO1, K2)

Or

(b) Explain in detail about statistical theory of nucleation. (CO1, K2)

12. (a) Describe the main elements of Temkin's Crystal Growth Model. Discuss how this model contributes to our understanding of crystal growth processes. (CO2, K2)

Or

(b) Describe the basic ideas and tenets of the two-dimensional nucleation theory of crystal development. (CO2, K2)

13. (a) List the advantages of growing crystals by melt method. Discuss the working principle involving the growth of crystal by Czochralski pulling technique. (CO3, K3)

Or

(b) Draw the sketch of Verneuil growth apparatus and explain its operational principle. (CO3, K5)

14. (a) What is supersaturation? Derive the expression for coefficient of supersaturation. (CO4, K2)

Or

(b) With neat diagram, explain the growth of crystals by low temperature solution growth methods. (CO4, K4)

15. (a) Briefly discuss about the principle, advantages and disadvantages of Liquid phase epitaxy. (CO5, K6)

Or

(b) Explain briefly about physical vapor transport. (CO5, K6)

Part C $(5 \times 8 = 40)$

Answer **all** questions not more than 1000 words each.

16. (a) What is nucleation? Explain primary and secondary nucleation. (CO1, K2)

Or

(b) Outline the free energy change for the formation of the spherical and cap shaped nucleus. (CO1, K1)

17. (a) Examine the BCF (Burton-Cabrera-Frank) Surface Diffusion Theory in the context of crystal growth. Elaborate on the key principles and mechanisms proposed by this theory. (CO2, K2)

Or

(b) Describe the conditions and factors that lead to nucleation events in the atmosphere. Explain the role of atmospheric nucleation in natural processes. (CO2, K2)

18. (a) Explain the Bridgman crystal pulling method using a clear illustration. Describe how crucible forms affect it as well. (CO3, K3)

Or

(b) Describe Zone melting technique for crystal growth. Give principle and techniques for multi zone refining methods. (CO3, K5)

19. (a) Define gel growth method. Explain in detail about the procedure for preparation of silicon gel. (CO4, K4)

Or

(b) Compare the merits and demerits of low temperature solution growth methods. (CO4, K4)

20. (a) Explain in detail about the method which uses transport agent and its different temperature profiles. (CO5, K6)

Or

(b) Compare the physical vapor deposition and chemical vapor deposition methods. (CO5, K6)

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R2840

Sub. Code
542507

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Second Semester

Materials Science

Elective – MOLECULAR SPECTROSCOPY

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** questions by choosing the correct option.

1. From the principle of wave-particle duality, the concept of wave is valid for a particle with relatively _____. (CO2, K5)

   (a) Low molecular weight

   (b) High molecular weight

   (c) Extremely high molecular weight

   (d) None of them

2. The total number of stretching vibrations for a nonlinear AB_3 molecule can be estimated to be _____. (CO2, K3)

   (a) 5

   (b) 6

   (c) 3

   (d) None of (a), (b) and (c) are true

3. Raman spectroscopy based on the phenomena of light _____. (CO4, K4)

(a) Absorption (b) Emission

(c) Excitation (d) Scattering

4. Spin multiplicity of the stable $3P^4$ electronic configuration is equal to _____. (CO1, K2)

(a) 3 (b) 2

(c) 1 (d) 0

5. The energy difference between two successive vibrational energy levels is equal to _____. (CO2, K3)

(a) $0.5hv$ (b) hv

(c) $2hv$ (d) $3hv$

6. Which of the following molecules is microwave inactive? (CO2, K2)

(a) N_2 (b) HCl

(c) H_2O (d) NH_3

7. The ^{12}C isotope of carbon is NMR inactive because it has _____ nuclear spin. (CO5, K5)

(a) Non-zero (b) Zero

(c) Negative (d) Infinite

8. The hybridization of NH_3 molecule is _____. (CO1, K1)

(a) sp^2 (b) sp^3

(c) sp (d) sp^4

9. The hybridization of the Acetylene molecule is _____. (CO1, K1)

(a) sp^2 (b) sp^3

(c) sp (d) sp^4

10. A material responds in ESR spectroscopy because it exhibits _____. (CO5, K6)

(a) Free radical with an unpaired electron

(b) A pair of electrons

(c) Negative charge

(d) Can't say anything

Part B $(5 \times 5 = 25)$

Answer **all** questions not more than 500 words each.

11. (a) Write down the postulates of VBT. What is the geometry of PF_5? (CO1, K1)

Or

(b) Sketch the molecular orbital diagram of CO with appropriate energy levels. (CO1, K1)

12. (a) State the difference between Rigid and Non-rigid rotor models with an appropriate energy diagram. (CO2, K2)

Or

(b) Why is background correction necessary for error-free data acquisition by a single-beam spectrophotometer? (CO2, K3)

13. (a) Define transition moment integral and explain it's significance in spectroscopy. (CO2, K5)

Or

(b) Define 'hot band' in vibrational spectroscopy. Why is it named 'hot'? (CO3, K3)

14. (a) During electronic excitation, vibrational and rotational transitions will also take place. Comment and justify the statement. (CO4, K4)

Or

(b) Which factors are responsible for the variation of spectral intensity? (CO4, K4)

15. (a) Define chemical shift for NMR spectroscopic analysis. Which molecule is used as a reference for determining chemical shifts? Justify your answer. (CO5, K5)

Or

(b) How can you differentiate Prussian blue and Turnbull's blue with the help of Mössbauer spectroscopy? (CO2, K6)

Part C ($5 \times 8 = 40$)

Answer **all** questions not more than 1000 words each.

16. (a) Write Lewis dot structures and predict the molecular geometry of the following species. (CO1, K1)

(i) BF_3

(ii) XeF_4

(iii) ClO_2^-

(iv) XeF_2

Or

(b) (i) Show that an oscillating electric dipole became a source of electromagnetic waves. (3)
(CO1, K1)

(ii) Assuming $M-X$ as a diatomic molecule, show that the moment of inertia (I) of the molecule can be expressed as, $I=\mu\times r^2$, where $\mu=\frac{m_M\times m_X}{m_M m_X}$ and r =equilibrium bond length of the molecule. (5)
(CO4, K4)

17. (a) Show that rotational spectral lines are equispaced for a rigid rotor model. (CO2, K2)

Or

(b) Describe the classical and quantum treatment of Raman Scattering. (CO2, K4)

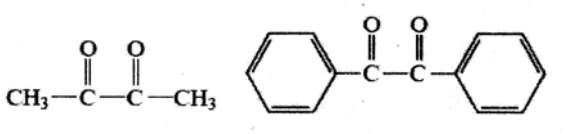
18. (a) (i) Predict the total number of normal modes or vibrational frequencies of the benzene (C_6H_6) molecule. Calculate the number of stretching and bending vibrations. (1+1+1)
(CO2, K3)

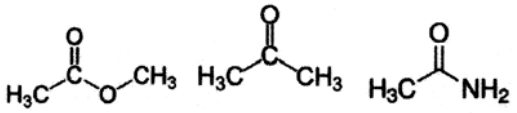
(ii) The following spectroscopic data are available. Predict the molecule's geometry (type A_2B) with proper justification. (5)
(CO2, K4)

Frequency (cm^{-1})	FTIR	Raman
589	√ (PQR)	×
1285	√ (PR)	√ (Polarized)
2234	√ (PR)	√ (depolarized)

Or

(b) Arrange the order of the vibrational frequencies (C=O) for the following compounds. Justify your answer. (CO2, K3)

(i)  (2)

(ii) 
(A) (B) (C) (6)

19. (a) (i) What is the Mutual exclusion principle? (2)
(CO4, K4)

(ii) What is the Born-Oppenheimer approximation? (2)
(CO3, K4)

(iii) What is the Franck-Condon Principle? (2)
(CO3, K3)

(iv) Why does the light interact with matter? (2)
(CO5, K5)

Or

(b) Describe the principle of multiphoton absorption. Discuss the advantages and application of multiphoton absorption spectroscopy.
(CO4, K4)

20. (a) Describe the principle of Mossbauer spectroscopy.
(CO2, K6)

Or

(b) Describe the principle of interactions between spin and magnetic field. What is Larmor frequency?
(6 + 2)
(CO5, K5)

———————