R8416	Sub. Code
	542201

M.Sc. DEGREE EXAMINATION, APRIL – 2023

Second Semester

Materials Science

MATERIALS CHEMISTRY

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** questions.

1. Metallic bonds do not have

   (a) Highly directed bonds

   (b) Mobile valence electrons

   (c) Delocalised electrons

   (d) Overlapping valence orbitals

2. Which group would generally have the lowest first ionization energy?

   (a) Transition Metals

   (b) Alkali Metals

   (c) Noble Gases

   (d) Alkaline Earth Metals

3. If n_p and n_e is the number of holes and electrons respectively in an intrinsic semiconductor then:

(a) $n_p n_e = 1$ (b) $n_p > n_e$

(c) $n_p = n_e$ (d) $n_p < n_e$

4. When the Relative Permeability of a material is much greater than 1, it is called

(a) Diamagnetic

(b) Ferromagnetic

(c) Paramagnetic

(d) Non magnetic

5. Natural rubber is a polymer of

(a) Isoprene (b) Styrene

(c) Ethylene (d) Butadiene

6. An example of elastomer among the following is:

(a) Dacron

(b) Melamine

(c) Vulcanized rubber

(d) Polystyrene

7. When there are no external forces, the shape of a liquid drop is determined by

(a) Surface Tension of the liquid

(b) The density of the liquid

(c) The viscosity of the liquid

(d) The temperature of air only

8. Friction due to fluids is called

(a) force (b) pressure

(c) friction (d) drag

9. What is the effect of high temperatures on material properties?

(a) loss of cohesive strength

(b) increases in stiffness

(c) increase in hardness

(d) gain cohesive strength

10. When are the slip lines observed?

(a) After plastic deformation

(b) Before plastic deformation

(c) After mechanical working

(d) After annealing

Part B (5 × 5 = 25)

Answer **all** questions, choosing either (a) or (b).

11. (a) What effect do hydrogen bonds have on the boiling temperatures of liquids? Explain, and give an example.

Or

(b) Discuss the effect of electron shells on the Ionization energy.

12. (a) Write short note on the electrical conductivity and mobility of semiconductors.

Or

(b) What are compound semiconductors and their alloys with example.

13. (a) What are the general methods to improve the high temperature resistance of polymers?

Or

(b) Why polymers show liquid crystalline behaviour? What are the important properties and applications of LCPs

14. (a) Explain thermionic emission? Explain its applications.

Or

(b) Write short note on

(i) Ideal surface

(ii) Real surface and

(iii) Relaxation

15. (a) Write down the thermodynamic and chemical effects in synthesis and processing of materials.

Or

(b) Explain the role of catalyst in polymer synthesis.

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

Answer any **five** questions.

16. Describe the types of atomic radii and explain them with example. Why is the Van der Waals Radius always greater than the Covalent Radius.

17. Explain the doping, defects and quantum confinement in semiconductors and explain its macroscopic properties.

18. Write a notes on:

(a) Applications of conducting polymers

(b) Piezoelectric polymers

19. What are the surface defects and explain the electronic properties of surfaces.

20. Discuss the crystal growth technique in detail and explain the processing of metals.

21. It requires 5.2 eV, or 120 kcal mole-1, to excite electrons in a diamond crystal from the valence band to the conduction band. What frequency of light is needed to bring about this excitation? What wavelength? What wave number? What part of the electromagnetic spectrum does this correspond to?

22. Explain the application of semiconductors in detail with example.

23. Illustrate with a neat diagram the synthesis of carbon nanotubes.

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R8417	Sub. Code
	542202

M.Sc. DEGREE EXAMINATION, APRIL – 2023

Second Semester

Materials Science

CHARACTERIZATION OF MATERIALS

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the questions.

1. What is the factor that limits the application of this differential thermal analysis method?

   (a) Huge apparatus (b) Insensitivity

   (c) Highly reactive (d) Low growth rate

2. Under conditions of ———— heating, decomposition usually take place in thermogravimetry. Fill up the suitable option from the choices given below

   (a) First order (b) Second order

   (c) Third order (d) Dynamic

3. Resolving power of a microscope is a function of ————

   (a) Wavelength of light used

   (b) Numerical aperture of lens system

   (c) Refractive index

   (d) Wavelength of light used and numerical aperture of lens system

4. In fluorescence microscopy, which of the following performs the function of removing all light except the blue light?

(a) Exciter filter (b) Barrier filter

(c) Dichroic minor (d) Mercury arc lamp

5. Which of the following component of TEM focuses the beam of electrons on the sample?

(a) Ocular lens (b) Condenser lens

(c) Stage (d) Column

6. What is considered a weakness of scanning tunneling microscopy (STM)?

(a) The inability to move and arrange atoms to create a design

(b) The requirement for a conducting surface to work properly

(c) The inability to apply this technology to biology

(d) All of the above

7. Identify condition which is not applicable during Vander Pauw measurement

(a) Homogeneous sample

(b) Less thickness

(c) Less capacitance

(d) Uniform thickness

8. The vital reason for choosing voltammetry instead of other methods

(a) Stability of the method

(b) The method is reliable and sensitive

(c) Simultaneous detection of different species

(d) Wide range of applications

9. The wavelength for far UV region lies ————————

(a) below 200 nm (b) below 400 nm

(c) above 200 nm (d) above 400 nm

10. NMR is the study of the absorption of ———————— by nuclei in a magnetic field.

(a) Radioactive radiation

(b) IR radiation

(c) Radio frequency radiation

(d) Microwaves

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

Answer **all** questions, choosing either (a) or (b).

11. (a) What are the limitations in TGA? How DTA overcome the limitations?

Or

(b) What does a DSC measure? Explain the types of DSC.

12. (a) Write short note on

(i) bright field and

(ii) dark field optical microscopy.

Or

(b) Justify the selection of phase contrast microscopy in biological applications.

13. (a) When an electron beam interacts with the solid sample, sketch the characteristic of electron scattering.

Or

(b) Explain the mode of operations in STM.

14. (a) What is the difference between two probe and four probe method? Justify which of the method is used to measure the resistivity.

Or

(b) Write short note on cyclic voltammogram.

15. (a) Discuss the principle and applications of UV-Vis spectroscopy.

Or

(b) List out the difference between NMR and NQR.

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

Answer any **five** questions.

16. Explain how TGA is used in qualitative and quantitative determinations.

17. Describe the following with suitable examples.

(a) differential interface microscopy

(b) fluorescence microscopy.

18. Discuss the working principle instrumentations, applications and modes of operations in TEM.

19. Briefly describe the working principle instrumentations and applications of Hall probe measurement method.

20. Compare the principle, instrumentation and applications of IR and Raman Spectroscopy.

21. Explain the principle, applications, instrumentation of DSC.

22. Illustrate with neat sketch explain the working principle and instrumentation of EDS.

23. Explain the hyperfine structure of Methyl radical using ESR Spectroscopy.

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R8418	Sub. Code
	542203

M.Sc. DEGREE EXAMINATION, APRIL – 2023

Second Semester

Materials Science

QUANTUM MECHANICS

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the questions.

1. The Eigen value of Hermitian is _____.

   (a) Complex (b) Real

   (c) Imaginary (d) May be real or complex

2. Find the sum of the Eigen values of the of the matrix

$$A = \begin{bmatrix} 3 & 6 & 7 \\ 5 & 4 & 2 \\ 7 & 9 & 1 \end{bmatrix}$$

   (a) 7 (b) 8

   (c) 9 (d) 10

3. The wave function of the particle lies in which region?

   (a) $x > 0$ (b) $x < 0$

   (c) $0 < X < L$ (d) $x > L$

4. The ground state energy of a particle of mass m in a one-dimensional infinite potential well is E_0. If the well breadth is doubled, what is the ground state in terms of E_0.

   (a) E_0 (b) (1/4) E_0

   (c) (1/2) E_0 (d) (3/4) E_0

5. Azimuthal quantum number defines

(a) e/m ratio of electron

(b) Spin of electron

(c) Angular momentum of electron

(d) Magnetic momentum of electron

6. A variational calculation is done with the normalized trial wavefunction $\psi(x)=\frac{\sqrt{15}}{4a^{\frac{5}{2}}}\left(a^2-x^2\right)$ for the one-dimensional potential well $v(x)=\begin{Bmatrix}0, if\ |x|\le a\\ \infty, if\ |x|>a\end{Bmatrix}$, the ground state energy is estimated to be

(a) $\frac{5\hbar^3}{3ma^2}$ (b) $\frac{5\hbar^3}{4ma^2}$

(c) $\frac{3\hbar^3}{5ma^2}$ (d) $\frac{3\hbar^3}{2ma^2}$

7. If the $[x,\ px]=i\hbar$, then the value of $\left[x^2, p_y\right]$ is

(a) 0 (b) $2i\hbar x$

(c) $2i\hbar$ (d) 1

8. $[J_+,\ J]=$

(a) $2\hbar J_z$ (b) $-2\hbar J_z$

(c) $2\hbar J_x$ (d) $2\hbar J_y$

9. When O_2 changes to O_2^-, the electron goes to which of the orbitals?

(a) π orbital (b) σ orbital

(c) π^* orbital (d) σ^* orbital

10. What is the shielding constant experienced by a valence p-electron in the bromine atom?

(a) 28.20 (b) 20.28

(c) 24.20 (d) 20.24

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

Answer **all** the questions, choosing either (a) or (b).

11. (a) Show that $\exp(ikx)$ is an Eigen function of the operator d/dx. Also show that $\exp(kx^2)$ is not an Eigen function of d/dx.

Or

(b) Derive the time independent Schrodinger equation from wave equation.

12. (a) Explain the Bohr's Correspondence principle.

Or

(b) Set up and solve the Schrodinger wave equation for a particle in an infinite one-dimensional box, with potential energy zero inside the box. Normalize the wave function.

13. (a) What is molecular orbital theory? Discuss it mathematically, leading to the derivation of the secular equation.

Or

(b) Use a trial function $e^{-\alpha r}$ and α as a variational parameter to calculate the ground-state energy of a hydrogen atom.

14. (a) Find the value of the operator $\hat{L_x}, \hat{L_y} - \hat{L_y}\hat{L_x}$.

Or

(b) Determine the term symbols for the electron configuration *nsnp*. Which term symbol corresponds to the lowest level?

15. (a) Calculate the Huckel π- electron energies of cyclobutadiene.

Or

(b) Show that $C_1 = C_2$ in the ground state Heitler – London wave function of H_2.

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

Answer any **five** questions.

16. Explain the failures of Classical Mechanics

17. Derive an expression for the energy of the rigid rotor using the Schrodinger wave equation.

18. Using the variation method estimate the ground state energy of the hydrogen atom by choosing the trial function as $\psi(r, \theta, \varphi) = \exp(-br^2)$.

19. Construct the angular momentum matrices for j = 3/2.

20. Illustrate the application of MO theory bonding in hydrogen molecular ion (H^{2+}).

21. Write short notes on

(a) Hermitian and Hamiltonian operators

(b) Eigen Value and Eigen Function

22. Prove that

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

(b) $[J_z, J_+] = \hbar J_+$

23. Explain the LCAO method molecular orbital theory with suitable example.

R8419

Sub. Code
542204

M.Sc. DEGREE EXAMINATION, APRIL – 2023

Second Semester

Materials Science

CRYSTAL GROWTH

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** questions.

1. How does temperature affect the nucleation process?
   (a) When temperature increases the nucleation decreases
   (b) When temperature increases the nucleation increases
   (c) Nucleation is not dependent on Temperature
   (d) When temperature increases the nucleation increases and then decreases

2. Homogenous nucleation is
   (a) The first step of any crystal growth
   (b) Always leads to crystal growth
   (c) A process that can lead to crystal growth
   (d) A process that leads to crystal growth if paired with heterogeneous nucleation

3. One of the most common solvent used for crystallization is
   (a) Water (b) Alcohol
   (c) Normal saline (d) Sulphuric acid

4. The rate of nucleation of a polymer crystal dependent upon:
   (a) The critical free energy barrier
   (b) The mobility of the polymer segments
   (c) The size of the polymer crystallite
   (d) All the above

5. ———————— is used to collected the crystals while using Gooch crucible.
   (a) Force (b) Water bath
   (c) Vacuum pump (d) Centrifuge

6. Which method is used to prepare the single crystals of CaO using plasma torch?
   (a) Stockbarger method
   (b) Zone melting method
   (c) Verneuil flame fusion method
   (d) Bridgman method

7. ———————— is not a method for creating supersaturation?
   (a) Salting in (b) Salting out
   (c) Evaporation (d) Dilution

8. Crystallization of proteins proceeds in ———————— and ———————— steps.
   (a) Solidification and crystallization
   (b) Crystallization and expansion
   (c) Growth and solidification
   (d) Nucleation and growth

9. The source chemicals from which the epitaxial layers are grown are gaseous
   (a) Liquid phase epitaxy
   (b) Vapour phase epitaxy
   (c) Solid phase epitaxy
   (d) All the above

10. Which gas is used for Si epitaxial growth?

(a) SiH_2Cl_2 (b) SiH_2Br_2

(c) SiH_2F_2 (d) SiH_2N_2

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

Answer **all** questions, choosing either (a) or (b).

11. (a) What is the Kinetic theory of nucleation? and discuss the effects of soluble impurities.

Or

(b) Explain the procedure for measuring the induction period employing the conductivity and visual observation methods.

12. (a) Derive the solution for the BCF surface diffusion theory.

Or

(b) Name the four main types of particles present in the atmosphere and explain the atmospheric nucleation.

13. (a) With a neat sketch, outline the experimental procedure for growing crystals by Verneuil technique.

Or

(b) List out the various melt growth techniques and explain the Zone melting in detail.

14. (a) Write a short note on the growth of cholesterol crystals by gel method.

Or

(b) Briefly discuss the principle, advantages and disadvantages of hydrothermal technique.

15. (a) What are the types of epitaxial growth techniques? Explain the importance of substrate selection in the epitaxial growth.

Or

(b) Explain the basic principle and reactor components of metalorganic vapour-phase epitaxy in detail with an example.

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

Answer any **five** questions.

16. What is homogenous nucleation? Explain the Process flow steps involved in the formation of nucleation with a neat sketch.

17. Explain the interface kinetics of Temkins crystallization process and its limitations.

18. Discuss the working principle involved the growth of crystal by Czochralski pulling technique.

19. Describe the experimental conditions for growing crystals by low temperature solution growth and explain the key parameters for optimizing the growth conditions.

20. What is physical vapour deposition? Explain the mechanism of growing single crystals by molecular beam method.

21. Highlight the importance of nucleation and discuss the various stages and kinds of nucleation.

22. Explain the various steps involved in the Melt growth in detail.

23. With suitable diagrams, explain the experimental procedure to grow crystals by chemical reaction methods employing the gel medium.

R8420	Sub. Code
	542507

M.Sc. DEGREE EXAMINATION, APRIL – 2023

Second Semester

Materials Science

MOLECULAR SPECTROSCOPY

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the questions.

1. What's the bond order of Oxygen?

   (a) 3 (b) 2

   (c) 1 (d) 0

2. The relative energies of molecular orbitals in increasing order have been found to be as follows. $(\sigma_{1s}) < (\sigma^*_{1s}) < (\sigma_{2s}) < (\sigma^*_{2s}) < [(\pi_{2py})(\pi_{2pz})] < (\sigma_{2px})$

   $< [(\pi^*_{2py})(\pi^*_{2pz})] < (\sigma^*_{2px})$

   (a) For O_2 to Ne_2 (b) For H_2 to N_2

   (c) For H_2 to Ne_2 (d) For N_2 to Ne_2

3. Which of the following cannot show a vibrational absorption spectrum?

(a) OCS (b) H_2O

(c) CO_2 (d) $CH_2 = CH_2$

4. Which of the following molecule have infrared active vibrations?

(a) NO (b) CH_4

(c) H_2 (d) All of the mentioned

5. The transition zone for Raman spectra is _____

(a) Between vibrational and rotational levels

(b) Between electronic levels

(c) Between magnetic levels of nuclei

(d) Between magnetic levels of unpaired electrons

6. Which of the region of IR spectra appears between (1400-600) cm-1?

(a) Functional group region

(b) Fingerprint region

(c) Low-frequency region

(d) None of the mentioned

7. The correct order of different types of energies is _____

(a) $E_{el} >> E_{vib} >> E_{rot} >> E_{tr}$

(b) $E_{el} >> E_{rot} >> E_{vib} >> E_{rt}$

(c) $E_{el} >> E_{vib} >> E_{tr} >> E_{rot}$

(d) $E_{tr} >> E_{vib} >> E_{rot} >> E_{el}$

8. Total number of vibrations in allyl bromide $CH_2 = CHCH2Br$ are

(a) 18 (b) 21

(c) 14 (d) 16

9. The criteria for electronic spin resonance is _____

(a) Periodic change in polarizability

(b) Spin quantum number of nuclei >0

(c) Presence of unpaired electron in a molecule

(d) Presence of chromophore in a molecule

10. Calculate the ESR frequency of an unpaired electron in a magnetic field of 0.33T given that for a free electron, $g_e = 2$ and $\mu_B = 9.273 \times 10^{-24} JT^{-1}$

(a) 2.3 GHZ (b) 9.00 GHZ

(c) 1.15 GHZ (d) None of these

Part B (5 × 5 = 25)

Answer **all** questions, choosing either (a) or (b).

11. (a) Explain the valance bond theory with an example.

Or

(b) What is the hybridization of (i) sulfur atom in the sulfate iron, SO_4^{2-} and (ii) Ni in $Ni(CO)_4$.

12. (a) State stark effect and explain its application in microwave spectroscopy.

Or

(b) How Raman effect is used in the determination of molecular structure? Which molecule is both IR and Raman active?

13. (a) Obtain the expression for the vibrational frequency of a diatomic molecule.

Or

(b) State and illustrate with suitable potential energy curve the Frank-Condon Principle in the vibronic spectrum of diatomic molecule.

14. (a) What is the purpose of using Raman spectroscopy? Explain the Nonlinear Raman Spectra.

Or

(b) Discuss in detail the multiphoton absorption and its optical limitations.

15. (a) State the principal of NMR and derive Bloch equation.

Or

(b) Explain the principle of ESR. Why does the source have to be from the microwave region for observing ESR.

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

Answer any **five** questions.

16. Describe the molecular orbital theory and draw the MO diagram for O_2.

17. What information about molecular structure can be obtained from an infrared spectrum? Explain with examples.

18. Explain the dissociation and predissociation of vibrational spectra with Morse curve.

19. Briefly explain the Instrumentation of Simulated Raman Scattering and Coherent Anti – Stoke's Raman Scattering

20. Describe the nuclear spin and the splitting of energy levels in a magnetic field.

21. Elucidate the Heitler London theory for Hydrogen molecule.

22. With a neat diagram explain the principle and theory of X-ray spectra in detail

23. Describe according to the nature of bond(M-L), coordination number and structure in Mossbauer spectroscopy.

———————