R1062

Sub. Code
542201

M.Sc. DEGREE EXAMINATION, APRIL – 2024

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. Arrange the elements P, As, S, and Cl in the increasing order of their ionization energy (CO1, K1)

   (a) P < As < S < Cl

   (b) Cl < As < S < P

   (c) P < S < As < Cl

   (d) As < P < S < Cl

2. Hydrogen bonding is an example of ———— (CO1, K1)

   (a) Covalent bonding

   (b) non-covalent bonding

   (c) ionic bonding

   (d) Metallic bonding

3. The band gap of germanium at room temperature is ———— (CO2, K1)

(a) 0.67 eV (b) 1.1 eV

(c) 1.21 eV (d) 0.84 eV

4. Which among the following is not an example for semiconductor (CO2, K4)

(a) Si (b) Ge

(c) Mn (d) GaAs

5. In the sp3 Carbon, the arrangement is tetrahedral with a bond angle of ———— (CO3, K1)

(a) 120° (b) 109.5°

(c) 180° (d) 90°

6. Which among the following is an example of viscoelastic polymer? (CO3, K5)

(a) Thermoset (b) thermoplastic

(c) Elastomers (d) monomers

7. The surface electronic properties affected by differences in work function are ———— (CO4, K2)

(a) thermionic emission

(b) photoemission

(c) thermionic emission and photoemission

(d) none of the above

8. ———————— is the force that resists motion when the surface of one object comes into contact with the surface of another (CO4, K5)

(a) Friction

(b) Surface activation

(c) Surface passivation

(d) Surface phonons

9. The quality of the grown crystals is affected by ———————— (CO5, K3)

(a) heating rate

(b) cooling rate

(c) both heating and cooling rate

(d) neither heating or cooling rate

10. Which among the following is/are example for metal processing (CO5, K6)

(a) casting (b) forging

(c) welding (d) all the above

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

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

11. (a) Describe in detail about covalent bond, metallic bond and Vander Waals bond. (CO1, K1)

Or

(b) How ionic bonding is different from hydrogen bonding? (CO1, K1)

12. (a) What are the characteristic properties of semiconductors? (CO2, K1)

Or

(b) Describe about electrical conductivity and mobility. (CO2, K4)

13. (a) Classify various types of polymers based of structure and geometry. (CO3, K1)

Or

(b) Compare polymeric ionic conductors with piezoelectric polymers. (CO3, K5)

14. (a) Distinguish between ideal surfaces and real surfaces. (CO4, K2)

Or

(b) What are the importance of anodization and surface passivation? (CO4, K5)

15. (a) Explain the role of catalysts in the synthesis of polymers. (CO5, K3)

Or

(b) Explain in detail the various types of metal processing. (CO5, K6)

Part C (5 × 8 = 40)

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

16. (a) Describe in detail about mixed-covalent bonding, ionicity, cohesive energy, ionization energy. (CO1, K1)

Or

(b) Explain about the importance of electron affinity, electronegativity and bonding in multielement crystals. (CO1, K1)

17. (a) Classify different types of semiconductors and alloys and write the applications of semiconductors. (CO2, K1)

Or

(b) Explain in detail about dynamics of electron motion, quantum confinement, doping, and defects. (CO2, K4)

18. (a) Describe in detail about liquid crystals and the types of polymer crystal models. (CO3, K1)

Or

(b) Examine the importance of viscolelasticity and thermal properties of polymers in various applications. (CO3, K5)

19. (a) Compare thermonic emission, field emission and photo emission. (CO4, K2)

Or

(b) Describe in detail about plasmons dispersion force and various types of surface modification processes. (CO4, K5)

20. (a) Describe the various methods used to synthesis and processing of ceramics and glasses. (CO5, K3)

Or

(b) Give a brief note on synthesis of steels, processing of stainless steels, sol-gel synthesis method and synthesis of carbon nanotubes. (CO5, K6)

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R1063

Sub. Code
542202

M.Sc. DEGREE EXAMINATION, APRIL – 2024

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 objective questions by choosing the correct option.

1. Thermal analysis is defined as _____ (CO1, K1)
   (a) Measurement of concentration of materials as a function of temperature
   (b) Measurement of solubility of materials as a function of temperature
   (c) Measurement of physical properties as a function of temperature
   (d) Measurement of line positions of crystals as a function of temperature

2. Which of the following parameters can be used, using the DSC and DTA cells? (CO1, K1)
   (a) Catalytic properties of enzyme
   (b) Elasticity of crystals
   (c) Enthalpy of substances
   (d) Line positions of phases

3. The resolution of SEM ———— with decreases electron beam probe size. (CO2, K2)

(a) Increases

(b) Decreases

(c) Innermost

(d) Outermost

4. Tungsten is widely used as filament material because of (CO2, K2)

(a) Higher melting point

(b) Lower melting point

(c) Higher brightness

(d) Higher flexibility

5. Which of the following microscope is used for studying Bio films? (CO3, K3)

(a) Fluorescence microscope

(b) Confocal Microscope

(c) Interference microscope

(d) Bright Field microscope

6. The main microscope lens that focuses the image is (CO3, K3)

(a) Ocular (b) Base

(c) Objective (d) Binocular

7. Four Probe method use for measuring ———— (CO4, K2)

(a) Capacitance (b) Inductance

(c) Resistance (d) Impedance

8. In Hall effect electron placed in magnetic field, it experiences ———— force proportional to strength of field. (CO4, K2)

(a) Lenz (b) Faradays

(c) Lorentz (d) Gauss

9. How is the wavelength controlled in an FTIR spectrometer? (CO5, K6)

(a) By a Michelson Interferometer

(b) By a computer

(c) By a laser

(d) By calibration with a standard sample

10. In NMR spectroscopy sample nuclei is irradiated with ————. (CO5, K6)

(a) Microwaves (b) Radio waves

(c) Cosmic rays (d) Ultraviolet rays

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

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

11. (a) Tabulate the various factors that influence differential thermal analysis (DTA). (CO1, K1)

Or

(b) List out the advantages and disadvantages of Differential scanning calorimetry (DSC). (CO1, K1)

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

Or

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

13. (a) Examine about the EDAX operation with clear illustration. (CO3, K3)

Or

(b) Write the steps for the sample preparation for electron microscopy studies like SEM and TEM. (CO3, K3)

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

Or

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

15. (a) Describe Stoke's lines and anti-Stoke's lines in Raman 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) Explain the working of Thermo-gravimetric analysis (TGA) with a neat diagram. (CO1, K1)

Or

(b) Describe the Differential scanning calorimetry characterization with its principle. (CO1, K1)

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

Or

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

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

Or

(b) Give an elaborate explanation of the different modes of operation in AFM. (CO3, K3)

19. (a) Explain the photoluminescence process with its spectroscopy 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 HNMR spectroscopy. (CO5, K6)

Or

(b) Explain the instrumentation and basic operation of ESR. (CO5, K6)

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R1064

Sub. Code
542203

M.Sc. DEGREE EXAMINATION, APRIL – 2024

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. Two wave functions $\psi_m(x)$ and $\psi_n(x)$ are orthogonal if (CO1, K2)

(a) $\int \psi_m(x)\,\psi_n(x)dx = 0$

(b) $\int \psi_m^*(x)\,\psi_n(x)dx = 0$

(c) $\int \psi_m(x)\,\psi_n(x)dx = 1$

(d) $\int \psi_m^*(x)\,\psi_n(x)dx = 1$

2. The one-dimensional 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) $-\frac{d^2\psi}{dx}\frac{\hbar^2}{2m} = i\hbar\frac{d\psi}{dt}$

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

3. A harmonic oscillator is in ground state. Where is the probability density maximum? (CO2, K2)

(a) at $x = a/2$ (b) at $x = a$

(c) at $x = 0$ (d) at $x = 2a$

4. The ground state of linear harmonic oscillator is(CO2, K4)

(a) Trigonometric function

(b) Gaussian function

(c) Hyperbolic function

(d) Bessel function

5. The wave function of which orbital is spherically symmetric? (CO3, K4)

(a) p_x (b) p_y

(c) d_{xy} (d) s

6. The potential $V(r)$ for hydrogen atom problem is (CO3, K4)

(a) kZe^2/r (b) $-kZe^2/r$

(c) $-kZe^2/r^2$ (d) kZe^2/r^2

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 S – sub cell state, the corresponding values of 1 and m are? (CO4, K2)

(a) $1 = 0, m = 0$ (b) $1 = 1, m = -1, 0, 1$

(c) $1 = 1, m = \frac{1}{2}, -\frac{1}{2}$ (d) $1 = 2, m = -2, -1, 0, 1, 2$

9. Anti-bonding molecular orbitals are produced by (CO5, K6)

(a) Constructive interaction of atomic orbitals

(b) Destructive interaction of atomic orbitals

(c) The overlap of the atomic orbitals of two negative ions

(d) None of these

10. The filling of molecular orbital takes place according to _____ (CO5, K6)

(a) The Aufbau principle

(b) Pauli Exclusion Principle

(c) Hund's rule of maximum multiplicity

(d) All the mentioned above

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

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

11. (a) What is linear operator? Prove that product of two linear operator is a linear operator. (CO1, K2)

Or

(b) Explain the orthogonality function in detail. (CO1, K2)

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

Or

(b) Explain anharmonic oscillator and write down its significance. (CO2, K4)

13. (a) Outline the types of quantum numbers in detail. (CO3, K4)

Or

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

14. (a) Evaluate the commutators : (CO4, K2)

(i) $\left[\hat{x}, \hat{p_x}\right]$

(ii) $\left[\hat{x}, \hat{p_x^2}\right]$.

Or

(b) Explain Pauli's exclusion principle. Give its importance. (CO4, K6)

15. (a) Outline the Heitler-London wave functions for hydrogen molecule. What are singlet and triplet states of hydrogen? (CO5, K6)

Or

(b) Sketch the molecular orbital formation in ethylene and butadiene. (CO5, K6)

Part C (5 × 8 = 40)

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

16. (a) Summaries the postulates of quantum mechanics in detail. (CO1, K2)

Or

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

17. (a) Write Schrodinger's equation for a particle in a box and determine the expression for energy Eigen values and Eigen functions. (CO2, K2)

Or

(b) Derive the Schrodinger's wave equation for a one-dimensional harmonic oscillator and deduce its Eigen value. (CO2, K4)

18. (a) Solve the angular 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) Explain LS and JJ coupling in detail. (CO4, K2)

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

Or

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

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R1065	Sub. Code
	542204

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Second Semester

Materials Science

CRYSTAL GROWTH

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

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

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

1. What does the classical theory of nucleation primarily focus on? (CO1, K1)

   (a) Statistical analysis of nuclei formation

   (b) Thermodynamic aspects of nucleus formation

   (c) Kinetic processes during nucleation

   (d) Energy release during nucleation

2. The nucleation rate is dependent on: (CO1, K1)

   (a) Temperature only

   (b) Pressure only

   (c) Both temperature and pressure

   (d) None of the above

3. What aspect of crystal growth does the Temkin model neglect? (CO2, K2)

(a) Atmospheric nucleation

(b) Two-dimensional nucleation

(c) Surface diffusion

(d) Nucleation in a vacuum

4. What is the main focus of the Temkin model of crystal growth? (CO2, K2)

(a) Atmospheric nucleation

(b) Two-dimensional nucleation

(c) Surface diffusion

(d) Solution of diffusion equations

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. In the context of crystal growth, what is the significance of the Czochralski method? (CO3, K3)

(a) Controlled pulling technique

(b) Controlled solidification in a temperature gradient

(c) Controlled fluid flow analysis

(d) Controlled impurity removal

7. What is the primary purpose of the Accelerated Crucible Rotation Technique (ACRT) in solution growth? (CO4, K4)

(a) Minimizing supersaturation

(b) Enhancing crystal nucleation

(c) Accelerating crystal growth

(d) Controlling gel formation

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. What is the primary mechanism involved in Physical Vapour Transport (PVT)? (CO5, K2)

(a) Diffusion (b) Convection

(c) Radiation (d) Conduction

10. Which epitaxial growth technique is based on the use of chloride compounds? (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) Examine nucleation and how primary nucleation is different from secondary? (CO1, K2)

Or

(b) Explain in detail about energy of formation of nucleus. (CO1, K2)

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

Or

(b) Explain the fundamental concepts and principles behind the Two-Dimensional Nucleation Theory in crystal growth. (CO2, K2)

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

Or

(b) How to grow a good quality GaAs single crystal using diboron trioxide solution in LEC? (CO3, K5)

14. (a) Write in detail about the measurement the supersaturation with clear diagrams. (CO4, K2)

Or

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

15. (a) Explain briefly about Liquid Phase Epitaxy. (CO5, K6)

Or

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

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

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

16. (a) Write in detail about Gibbs Thomson equation for vapor and explain the modified Thomson's equation for melt. (CO 1, 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. Discuss the role of atmospheric nucleation in natural processes. (CO2, K2)

18. (a) With a neat illustration, interpret about Bridgman crystal pulling method. Also explain the role of crucible shapes on it. (CO3, K3)

Or

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

19. (a) Explain in detail about crystal Growth in gel with necessary diagrams. (CO4, K4)

Or

(b) With neat diagram, examine the crystal growth by 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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R1066

Sub. Code
542507

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Second Semester

Materials Science

Elective – MOLECULAR SPECTROSCOPY

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

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

1. Einstein's photoelectric effect can be well understood by assuming ———— nature of the light. (CO2, K5)

   (a) Wave (b) Particle

   (c) Reflection (d) Scattering

2. The total number of normal modes for a linear AB molecule are ————. (CO2, K3)

   (a) 5 (b) 6

   (c) 3 (d) 1

3. Raman Spectroscopy based on the phenomena of light. (CO4, K5)

   (a) Absorption

   (b) Emission

   (c) Excitation

   (d) Scattering

4. The reduced mass of the home-diatomic (atomic mass of m) molecule is (CO2, K2)

(a) $\frac{m}{2}$ (b) m

(c) $\frac{m}{3}$ (d) 0

5. The selection rule for the vibrational transition is governed by the difference in vibrational quantum number (Δv). The value of (Δv) ————————. (CO2, K3)

(a) 0 (b) ±1

(c) ±2 (d) 0, ±1

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

(a) N_2 (b) O_2

(c) H_2O (d) Br_2

7. The ^1H isotope of hydrogen is NMR active because it has ———————— nuclear spin. (CO5, K5)

(a) Non-zero (b) Zero

(c) Negative (d) Infinite

8. The hybridization of CO_2 molecule is (CO1, K1)

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

(c) sp (d) sp^4

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

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

(c) sp (d) sp^4

10. A material responds in ESR spectroscopy because it bars (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** the questions not more than 500 words each.

11. (a) Write down the postulates of VBT. Predict the Geometry of XeF_4. (CO1, K1)

Or

(b) Sketch the molecular orbital diagram of O_2 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 its' significance in Spectroscopy. (CO2, K5)

Or

(b) Describe fundamental absorption, first overtone, and second overtone in the context of vibrational Spectroscopy. (CO3, K3)

14. (a) Why are Stokes lines more intense than Anti-Stokes lines in Raman scattering? Briefly describe Raleigh scattering. (CO4, K4)

Or

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

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

Or

(b) State the principle of ESR spectroscopy. Discuss its application with an appropriate example. (CO5, K6)

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

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

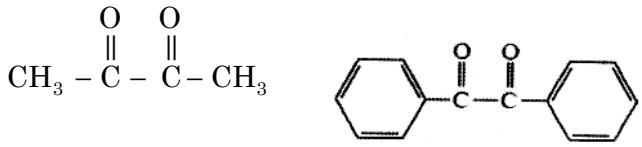
16. (a) Draw Lewis dot structures and predict the molecular geometry of the following species.

(i) PF_5 (ii) XeF_6 (iii) ClO_2^- (iv) SF_6. (CO1, K1) [4 × 2]

Or

(b) Arrange the order of the vibrational frequencies (C=O) for the following compounds. Justify your answer. (CO2, K3) [2]

(i)



(ii) Draw an orbital overlap diagram of Acetylene, Ethylene and Acetonitrile molecules by using VBT. (CO1, K1) [6]

17. (a) If the IR spectrum of $H^{79}Br$ exhibited an intense line at 2630 cm^{-2} calculate the force constant (k) and zero-point energy. (CO2, K3)

Or

(b) Calculate the atomic weight of ^{13}C with the help of the following microwave spectroscopic data. Explain how this will affect their rotational energy levels. Rotational constants for ^{12}CO and ^{13}CO were observed to be 1.92118 and 1.83669 cm^{-1} respectively. Atomic weight for ^{16}O and ^{12}C can be taken as 15.9994 and 12.0000, respectively. (CO2, K2)

18. (a) (i) Draw the fundamental vibrations of the H_2O molecule and assign their symmetries. (CO2, K3) [3]

(ii) Define Doppler, collisional and natural broadening. (CO2, K4) [5]

Or

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

(ii) The following spectroscopic data are available. Predict the molecule's geometry (type AX_2) with proper justification. (CO2, K4) [5]

Wave number (cm^{-1})	Infrared	Raman
1361	Active (PQR)	Active (Depolarized)
1151	Active (PQR)	Active (Polarized)
519	Active (PQR)	Active (Polarized)

19. (a) Describe the classical and quantum treatment of Raman Scattering. (CO2, K4) [8]

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 interactions between spin and magnetic field. What is Larmor frequency? (CO5, K5) [6+2]

Or

(b) (i) What is the Mutual exclusion principle? (CO4, K4) [2]

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

(iii) What is the Franck-Condon Principle? (CO3, K4) [2]

(iv) What is the Stark effect? (CO2, K6) [2]

———————