

Reg. No.: .....

Date of Examination.....

Time: Two Hours

Maximum: 100 Marks

**Department of Nanoscience and Technology**

**UNIVERSITY OF CALICUT**

**Ph.D. Entrance Examination – Model Question Paper (2023-24 Admissions)**

**Instructions to Candidates**

- Candidates are provided with a Question Booklet and an Optical Marker Reader (OMR) answer sheet to mark the responses. Write the Register number and Date of the examination in the space provided on the top of this booklet. Read carefully all the instructions given in the OMR sheet.
- This question booklet contains two sections with 50 multiple choice questions in Section A (2 marks each) and 10 descriptive type questions in Section B (10 marks each). **Answer any 25 questions from SECTION A and any five questions from SECTION B.** No negative marks for the wrong answer.

**SECTION-A**

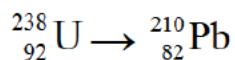
1. The number of lattice points in a primitive cell are
  - (a) 1
  - (b)  $\frac{1}{2}$
  - (c) 2
  - (d)  $\frac{3}{2}$
2. Which of the following metals crystallises in FCC structure?
  - (a) Aluminium
  - (b) Zinc
  - (c) Sodium
  - (d) Caesium Chloride
3. Classify the following unit cell into proper crystal system:  $a= 1.08 \text{ nm}$ ,  $b= 0.947\text{nm}$ ,  $c= 0.52 \text{ nm}$  and  $\alpha= 41^\circ$ ,  $\beta= 82^\circ$ ,  $\gamma= 95^\circ$ 
  - (a) Orthorombhic
  - (b) (b) Monoclinic
  - (c) (c) Triclinic
  - (d) (d) Hexagonal
4. The de Broglie wavelength associated with an electron of mass  $m$  and accelerated by a potential  $V$  is
  - (a)  $\frac{h}{\sqrt{2meV}}$

- (b) (b)  $\frac{\sqrt{2meV}}{h}$
- (c) (c)  $\frac{h}{meV}$
- (d) (d)  $\frac{h}{2meV}$
5. Which of the following statements is correct?
- X-rays are electromagnetic radiation of long wavelength
  - X-rays produced in a gas tube are different from those in Coolidge tube
  - The wavelength of the scattered X-rays by a material is longer than that of the incident beam
  - X-ray spectral lines are produced when fast moving electrons are retarded by a material
6. If  $E_1$  is the energy of the electron in the lowest energy state of a one-dimensional potential box of side 'a' and  $E_2$  is the energy of the electron in the energy state just above the lowest state of a three-dimensional cubical box of side '2a', find  $E_1/E_2$
- 1/2
  - 2/3
  - 1/4
  - 2
7. The forbidden energy gap of carbon in diamond structure is
- 0.7 eV
  - 1 eV
  - 0.01 eV
  - none of these
8. Einstein's theory concludes that at lower temperature the specific heat
- Drops linearly with increase of temperature
  - Drops linearly with decrease of temperature
  - Drops exponentially with decrease of temperature
  - Remains constant
9. A superconducting material when placed in a magnetic field will
- Attract the magnetic field towards its centre
  - Repel all the magnetic lines of forces passing through it
  - Attract the magnetic field but transfer it into a concentrated one
  - Not influence the magnetic field
10. Magnetic susceptibility has the dimension of
- Wb/m<sup>2</sup>
  - Wb/m
  - amp/m
  - dimensionless
11. Each ferromagnetic material has a characteristics temperature above which its properties are vitally different from those below it. This temperature is called
- Demagnetization temperature
  - Curie Temperature
  - Transition temperature
  - Faraday's Temperature
12. The dependance of the mobility of charge carriers in a semiconductor is given by
- $\mu \propto 1/T$


- (b)  $\mu \propto 1/T^{3/2}$
  - (c)  $\mu \propto T^{3/2}$
  - (d)  $\mu \propto T^2$
13. If  $e$ ,  $\mu$  and  $n$  respectively represent the charge, mobility and concentration of electrons, then the electrical conductivity of the metal is given by
- (a)  $n/\mu e$
  - (b)  $\mu e/n$
  - (c)  $ne$
  - (d)  $ne\mu$
14. The dipole moment per unit volume of a solid is the sum of all the individual dipole moments and is called
- (a) Polarization of the solid
  - (b) Permittivity of the solid
  - (c) Electrostatic moment
  - (d) None of these
15. Piezoelectric effect is the production of electricity by
- (a) Chemical effect
  - (b) varying field
  - (c) temperature
  - (d) pressure
16. Calculate the Zero-point energy for a particle in an infinite potential well for an electron confined to a 1 nm atom.
- (a)  $3.9 \times 10^{-20}$  J
  - (b)  $4.9 \times 10^{-20}$  J
  - (c)  $5.9 \times 10^{-20}$  J
  - (d)  $6.9 \times 10^{-20}$  J
17. For a particle in a box, the potential is maximum at  $x =$
- (a)  $L$
  - (b)  $2L$
  - (c)  $L/2$
  - (d)  $L/4$
18. Inversion of pyramidal structure of ammonia can be explained by
- (a) Variation theorem
  - (b) Spherical harmonics
  - (c) Quantum mechanical tunneling
  - (d) Hybridization
19. Which is the odd one?
- (a) MM
  - (b) SE
  - (c) DFT
  - (d) Ab initio
20. According to variation theorem, the energy of a trial function is always
- (a) Zero
  - (b) Lower than the exact energy
  - (c) Higher than the exact energy

- (d) None of the above
21. The anti-symmetry of a wave function can be explained by:
- Plank's quantum hypothesis
  - Pauli's exclusion principle
  - Heisenberg uncertainty principle
  - Wein's law
22. Hamiltonian operator in stationary perturbation theory is:
- time independent
  - time dependent
  - velocity dependent
  - velocity independent
23. If the vibrational frequencies of a molecule contains imaginary numbers, then the molecule will corresponds to
- Stable conformer
  - Transition state
  - Local minima
  - Global minima
24. The selection rule which can be applied to trans-N<sub>2</sub>F<sub>2</sub> is
- Spin selection rule
  - Laporte selection rule
  - Orbital selection rule
  - Both a and b
25. 1 HF = ----- amu
- 1
  - 4.184
  - 27.21
  - 10
26. The combination of symmetry operations  $C_3^2\sigma_v''$  on a pyramidal molecule like NH<sub>3</sub> is equivalent to ....
- $C_3^1$
  - E
  - $\sigma_v'$
  - $\sigma_v''''$
27. The main feature of DFT method is that
- It solves the Schrodinger equation to get the wave function
  - It considers energy as a function of volume
  - It considers energy as a function of density
  - It is the pure theoretical method
28. The most stable conformer is the one which gives the ..... in the potential energy scanning diagram.
- Local minima
  - Global minima
  - Transition state
  - Global maxima
29. AMBER and CCSD are respectively
- SE and DFT methods

- (b) MM and SE methods
  - (c) DFT and Ab initio method
  - (d) MM and Ab initio method
30. WKB approximation is a
- (a) Classical approach
  - (b) Quantum mechanical approach
  - (c) Semi classical approach
  - (d) None of the above
31. The total number of  $\alpha$  and  $\beta$  particles emitted in the following radioactive decay is .....



- (a) 10
  - (b) 11
  - (c) 8
  - (d) None of the above
32. In the EPR spectrum of a methyl radical, the number of lines and their relative intensities, respectively are
- (a) 1 and 1
  - (b) 3 and 1:2:1
  - (c) 4 and 1:2:2:1
  - (d) 4 and 1:3:3:1
33. RNA lacks the nitrogen base of \_\_\_\_\_
- (a) Thymine
  - (b) Cytosine
  - (c) Uracil
  - (d) Adenine
34. In the  ${}^1\text{H}$  NMR spectrum of an organic compound recorded on a 300 MHz instrument, a proton resonates as a quartet at  $\delta$  4.20 ppm. The individual signals of the quartet appear at  $\delta$  4.17, 4.19, 4.21, and 4.23 ppm. The couple constant  $J$  in Hz is .....
- (a) 1
  - (b) 4
  - (c) 6
  - (d) None of the above
35. Based on Wade's rule, the structure-type of  $[\text{B}_5\text{H}_8]^-$
- (a) *closo*
  - (b) *nido*
  - (c) *arachno*
  - (d) *hypho*
36. What is the value of principal quantum number (n) for a 5p orbital
- (a) 5
  - (b) 4
  - (c) 1
  - (d) 0
37. Choose the most appropriate answer. Surface plasmon resonance effect is observed due to:
- (a) Surface area of metal nanoparticles is large

- (b) Metal nanoparticles are conductive
- (c) Collective oscillation of free electrons on surface
- (d) Metal nanoparticles can absorb visible light
38. Higher values of ionization energies of the 5d transition elements are consistent with the
- Relatively smaller penetration
  - Relatively smaller size of their atoms
  - Relatively smaller effective nuclear charge
  - All the above are correct.
39. The bond order for  $N_2$ ,  $O_2$ ,  $N_2^-$ , and  $O_2^-$  varies as
- $N_2 > N_2^- > O_2 > O_2^-$
  - $O_2 > N_2 > O_2^- > N_2^-$
  - $N_2 > O_2 > N_2^- > O_2^-$
  - $N_2^- > N_2 > O_2^- > O_2$
40. The parity labels (u and g) are not given to the MOs of the methane molecule because,
- methane is square planar
  - methane is non-centrosymmetric
  - parity labels are not used for MOs of centrosymmetric molecules
  - parity labels are used only for atomic orbitals.
41. The conjugate base of  $NH_4^+$  is
- $NH_4OH$
  - $NH_3$
  - $OH^-$
  - $NH_2$
42. Coordination number and oxidation state of Cr in  $K_3[Cr(Cr_2O_4)_3]$  are respectively
- 3 and 0
  - 3 and +3
  - 6 and +3
  - 4 and +2
43. Using valence bond theory predict which of the following complex does not have tetrahedral geometry?
- $[Ni(CO)_4]$  (diamagnetic)
  - $[Ni(CN)_4]^{2-}$  (diamagnetic)
  - $[NiCl_4]^{2-}$  (two unpaired electrons)
  - $MnCl_4^-$  (diamagnetic)
44. Which is the most suitable reagent for the following reaction
- 
- $Na/NH_3$  (liq),  $-78^\circ C$
  - $LiAlH_4$
  - $NH_2NH_2$ ,  $OH^-$
  - All the above
45. Arrange the following in increasing order of C-O frequencies

I. CO II. Mo(CO)<sub>3</sub>(NH<sub>3</sub>)<sub>3</sub> III. MO(CO)<sub>6</sub> IV. MO(CO)<sub>3</sub>(PPh<sub>3</sub>)<sub>3</sub>

- (a) IV<III<II<I  
 (b) III<IV<II<I  
 (c) I<II<III<IV  
 (d) I>II>III>IV

46. Which of the following is not aromatic?



47. S<sub>N</sub>1 reaction on optically active substrates mainly gives

- a) Retention in configuration  
 b) Inversion of configuration  
 c) Racemic product  
 d) No product

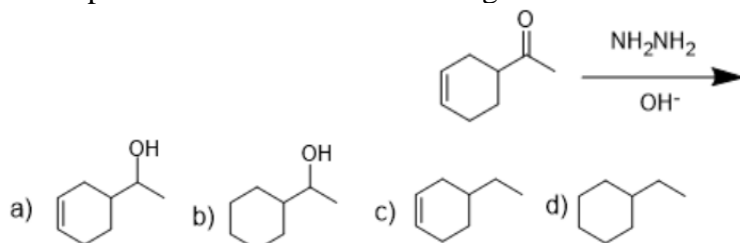
48. In E2 elimination, some compounds follow Hoffmann's rule which means

- a) The double bond goes to the most substituted position  
 b) No double bond is formed  
 c) The compound is resistant to elimination  
 d) The double bond goes mainly toward the least substituted position

49. The absorption at λ<sub>max</sub> 279 nm (ε= 15) in the UV spectrum of acetone is due to

- a) π → π\* transition  
 b) n → π\* transition  
 c) σ → π\* transition  
 d) σ → σ\* transition

50. The product formed in the following reaction is



## SECTION B

- Explain the following terms used in crystallography  
 (i) Crystal Lattice (ii) Unit Cell (iii) Primitive cell (iv) packing factor
- Discuss the Kronig-Penny model for the motion of an electron in a periodic potential. Show the (E-K) graph that materials can be classified into conductors, insulators and semiconductors
- What is superconductivity? Give an account of the occurrence, properties and uses of superconductors

4. Describe the behavior of magnetic substances with reference to their curie points. What are ferromagnetic domains. How is their existence explained?
5. Explain the working of a p-n junction. Discuss forward and reverse biasing of p-n junction diode.
6. Explain quantum mechanical postulates in detail.
7. Explain different photochemical processes by using Jablonsky diagram.
8. Explain Monsanto acetic acid process and Walker's process.
9. Explain Mossbauer spectroscopy by taking iron complexes as examples.
10. Discuss the conformations of butane and cyclohexane.



## **Syllabus covered for the PhD entrance**

### **Nanoscience and Technology**

**Crystal lattice;** X-ray diffraction; lattice parameters; Bravais lattices; Specific heat; Fermi energy; density of states; Band theory of solids; Dielectrics; Superconductivity; Thermal properties of solids; Electromagnetic theory

**Quantum mechanics-**Postulates, approximations, point group, and quantum mechanics of translational motion

**Computational methods-** different methods, basics

**Organic Chemistry-**Chirality, nomenclature, name reactions, Functional transformation, and chemical reactions

**Inorganic and Physical Chemistry-** Transition metals, Organo metallics, inorganic complexes, Chemical Kinetics, Spectroscopy (Mossbauer, Raman, IR, NMR, EPR, UV/Vis)