

Ph.D. ENTRANCE EXAMINATION, APRIL 2022

NANOSCIENCE AND TECHNOLOGY

Time : Two Hours

Maximum : 100 Marks

Section I (Objective Questions)

Answer any 25, no negative marks.

1. The capacitance of a parallel plate capacitor is C . If a dielectric slab of thickness equal to one-fourth of the plate separation and dielectric constant K is inserted between the plates, then the capacitance becomes :

(a) $KC/2(K+1)$.	(b) $2KC/K+1$.
(c) $5KC/4K+1$.	(d) $KC/3K+1$.
2. The co-efficient of coupling between two air core coils depends on :

(a) Self-inductance of two coils only.
(b) Mutual inductance between two coils only.
(c) Mutual inductance and self-inductance of two coils.
(d) None of the above.
3. There are three Rods A, B, C of equal length L at same temperature. Their co-efficient of linear expansion are $\alpha_a, \alpha_b, \alpha_c$ respectively. If the temperature of all rods is increased by $\theta^\circ \text{C}$ and co-efficient of linear expansion is like $\alpha_b > \alpha_a > \alpha_c$. Then what will be the final order of length of rod :

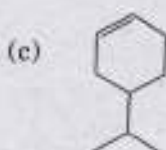
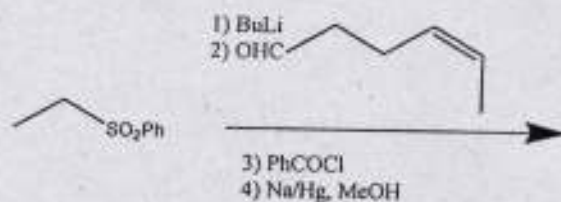
(a) $L_c > L_b > L_a$.	(b) $L_b = L_a = L_c$.
(c) $L_a > L_b > L_c$.	(d) $L_b > L_a > L_c$.

Turn over

4. What is the spectral region of the spectral lines emitted by the excited H-atom due to the transition from $n' = 4$ to $n = 2$?
- (a) UV. (b) Visible.
(c) Near IR. (d) IR.
5. What is the dielectric strength of mica ?
- (a) 200 MV/m. (b) 118 MV/m.
(c) 3 MV/m. (d) 1012 MV/m.
6. Bromination of (E)-2-butenedioic acid gives :
- (a) (2R, 3S)-2,3-dibromosuccinic acid.
(b) (2R, 3R)-2,3-dibromosuccinic acid.
(c) A mixture of (2R, 3S)-and (2S, 3S)-2,3-dibromosuccinic acid.
(d) (2S, 3S)-2,3-dibromosuccinic.
7. The time dependent Schrödinger equation is :
- (a) $\left(-\hbar^2/2m \nabla^2 + v\right) \Psi = E\Psi$. (b) $H\Psi = -\hbar/i \partial\Psi/\partial t$.
(c) $\left(-\hbar^2/2m \nabla^2 + v(x)\right)$. (d) $H\Psi = -\hbar/I \partial\Psi/\partial t$.
8. Which of the following materials is used for the generation of ultrasonic waves by using magnetostriction effect ?
- (a) Ferromagnetic material. (b) Paramagnetic material.
(c) Diamagnetic material. (d) Both paramagnetic and diamagnetic material.
9. Liquefied petroleum gas is mainly composed of _____.
- (a) Methane and ethane. (b) Ethane and propane.
(c) Propane and butane. (d) Butane and hexane.

10. Raoult's law is expressed by _____.
- (a) $P_0 - P/P_0 = X_2$. (b) $P - P_0/P_0 = X_2$.
(c) $P - P_0/P = X_2$. (d) $P - P_0/P_0 = X$.
11. Helmholtz model represents _____ model.
- (a) Diffused layer.
(b) Gibb's free energy.
(c) Fixed layer.
(d) Partially fixed and diffused.
12. The migration of positively charged colloidal particles, under an electrical field, toward the cathode is _____.
- (a) Electrophoresis. (b) Electro-osmosis.
(c) Sedimentation. (d) Electro-dialysis.
13. The unit for activation of energy is _____.
- (a) kJ mol^{-1} . (b) kJ K^{-1} .
(c) $\text{kJ K}^{-1} \text{mol}^{-1}$. (d) kJ R^{-1} .
14. Potassium crystalline in bcc structure the co-ordination number of potassium metal is _____.
- (a) 3. (b) 8.
(c) 7. (d) 5.
15. Which of the following defects results in the decrease density of crystal ?
- (a) Interstitial defect. (b) Impurity defect.
(c) Frenkel defect. (d) Schottky defect.

16. The major product in the following transformation is :



17. Oxymercuration-demercuration reaction of 1-methylcyclohexene gives :

- (a) Cis-2-methylcyclohexanol.
- (b) Trans-2-methylcyclohexanol.
- (c) 1-methylcyclohexanol.
- (d) Mixture of cis and trans-2-methylcyclohexanol.

18. Identify the smallest alkane which can form a ring structure (cycloalkane) ?

- (a) Cyclomethane.
- (b) Methane.
- (c) Cyclopropane.
- (d) Propane.

19. Value of critical current density (J_c) in a superconductor depends upon :

- (a) Temperature.
- (b) Magnetic field strength.
- (c) Silsbee effect.
- (d) Both (a) and (b).

20. The electronic polarisability α_e of a monoatomic gas atom is :

- (a) $4\pi\epsilon_0$. (b) $4\pi\epsilon_0 R$.
(c) $4\pi\epsilon_0 R^3$. (d) $4\pi\epsilon_0 R^2$.

21. On the basis of band theory of solids the semiconductors have :

- (a) A partly filled valence band and totally empty conduction, band.
(b) A completely filled valence band a totally empty conduction band and a very wide forbidden band.
(c) A completely filled valence band a partially filled conduction band and a narrow forbidden band.
(d) A partly filled valence band a totally empty conduction band and a wide forbidden band.

22. A certain stress applied to an elastic material produces a certain strain in it. If the elastic limit is not exceeded the energy gained per unit volume of the material is given by :

- (a) Stress/strain. (b) (stress/-strain).
(c) Stress $\times$ strain. (d) (Stress/strain).

23. Among the following materials which material has highest dielectric strength :

- (a) Glass. (b) Rubber.
(c) Polystyrene. (d) Porcelain.

24. According to Gauss law, the electric field due to infinitely long this charged wire varies as _____ ?

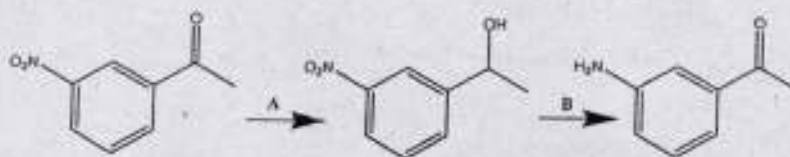
- (a) r^2 . (b) r .
(c) r^{-1} . (d) r^{-2} .

25. Materials in superconducting state have the property of :

- (a) Absorbing magnetic field. (b) Repelling magnetic field.
(c) Absorbing electric field. (d) Repelling electric field

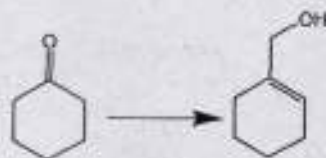
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26. The appropriate reagents A and B in the following reaction sequences are :



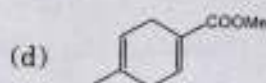
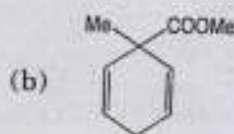
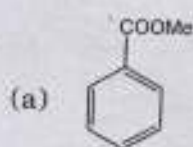
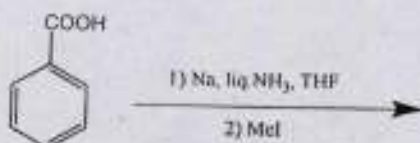
- (a) $A = \text{LiAlH}_4$; $B = \text{Sn/HCl}$.
- (b) $A = \text{NaBH}_4$; $B = \text{Sn/HCl}$.
- (c) $A = \text{Sn/HCl}$; $B = \text{LiAlH}_4$.
- (d) $A = \text{Sn/HCl}$; $B = \text{NaBH}_4$.
27. The other name for branched chain alkanes is _____.
- (a) Paraffins. (b) Neoparaffins.
- (c) Isoparaffins. (d) Naphthenes.
28. An example for Lewis acid is :
- (a) BF_3 . (b) CaO .
- (c) CO_2 . (d) None of the above.
29. According to Werner's theory, how many types of valencies do metal complexes have ?
- (a) One. (b) Two.
- (c) Three. (d) None of the above.
30. An atom differs from its ion in which among the following ?
- (a) Mass number. (b) Atomic number.
- (c) Neutrons. (d) Number of protons.

31. The correct reagent combination / reaction sequence for effecting the following conversion is :



- (a) a) $\text{Me}_3\text{SiCH}_2\text{OMe}$, n-BuLi; b) H_3O^+ ; c) NaBH_4 , MeOH.
 (b) a) $\text{Ph}_3\text{P}^+\text{CH}_2\text{OMeCl}^-$, n-BuLi; b) H_3O^+ ; c) NaBH_4 , MeOH.
 (c) a) NH_2NHTs ; b) NaOEt ; c) ClCOOEt .
 (d) a) NH_2NHTs ; b) 2 equiv. n-BuLi; c) HCHO .
32. A 2nd order reaction has a rate constant of $k = 1.9 \times 10^{-11} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$ at 25°C and activation energy of $E = 106 \text{ kJ mol}^{-1}$. Calculate the rate constant if the temperature is raised from 25°C to 35°C :
- (a) $7.6 \times 10^{-11} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$.
 (b) $2.8 \times 10^{-10} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$.
 (c) $8.8 \times 10^{-7} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$.
 (d) $5.2 \times 10^{-5} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$.
33. Which compound is a secondary alcohol ?
- (a) Butan-1-ol. (b) Butan-2-ol.
 (c) Isobutyl alcohol. (d) 2-methylpropan-2-ol.
34. What is the necessary number of intensive variables for defining the state of hydrogen gas pressurized in a cylinder ?
- (a) p alone. (b) p and T.
 (c) p, T and concentration. (d) None of the above.

35. The major product in the following reaction will be :



36. For an aqueous solution, transmission % was measured to be $T\% = 13.3\%$ by a spectrophotometer. What is the absorbance of the solution ?

(a) 0.570.

(b) 0.876.

(c) 0.273.

(d) 0.133.

37. Cyclohexyl benzyl ether when reacted with hydrogen in the presence of 10 % palladium on charcoal generates a mixture of :

(a) Cyclohexanol and benzyl alcohol. (b) Cyclohexanol and toluene.

(c) Cyclohexane and benzyl alcohol. (d) Cyclohexane and toluene.

38. In which of the following Bravais lattices not all axial angles are right angles :

(a) Rhombohedral.

(b) Tetragonal.

(c) Orthorhombic.

(d) Cubic.

39. In the X-ray diffraction of a set of crystal planes having interatomic distance which is equal to 0.18 nm. The first order reflection is found to be at an angle of 38° .

The wavelength of X-ray is $(\sin 38^\circ = 0.62)$.

- (a) 0.0374 nm. (b) 0.02223.
(c) 0.23332 nm. (d) 0.2232 nm.

40. $[P^2, X] =$

- (a) $2i\hbar P$. (b) $2\hbar P$.
(c) $-2i\hbar P$. (d) $-2\hbar P$.

41. Mobility of the electron is :

- (a) Flow of electron per unit electric field.
(b) Reciprocal of conductivity.
(c) Average electron drift velocity per unit electric field.
(d) None of these.

42. The maximum radius of the interstitial sphere that can just fit into the void between the body centered atom of bcc structure is :

- (a) $r \left[\left(\frac{2}{\sqrt{3}} \right) - 1 \right]$. (b) $r \left[\left(\frac{\sqrt{3}}{2} \right) - 1 \right]$.
(c) $r \left[\sqrt{3} - 1 \right]$. (d) $r \left[\sqrt{2} - 1 \right]$.

43. A dielectric material must be :

- (a) Resistor. (b) Insulator.
(c) Good conductor. (d) Semiconductor.

44. In a ferroelectric material, as the applied electric field is gradually reduced to zero, the polarization still left known as :
- (a) Coercive polarization. (b) Remanent polarization.
(c) Zero polarization. (d) Positive polarization.
45. At very high temperature, the mean free path and collision time of an electron in a metal is :
- (a) T^2 . (b) $1/T^2$.
(c) $1/T$. (d) Independent of temperature.
46. When the electric field interacts with the magnetic field that is known as _____ field.
- (a) Electric. (b) Magnetic.
(c) Electromagnetic. (d) None of the above.
47. The spacing between principal planes of NaCl crystal is 2.82 Å. It is found that first order Bragg reflection occurs at an angle of 10° . What is the wavelength of X-rays ?
- (a) 0.98 Å. (b) 0.99 Å.
(c) 2.82 Å. (d) 10.52 Å.
48. The unit of dipole moment / unit volume is :
- (a) Coulomb/metre. (b) Coulomb/metre².
(c) Coulomb/metre³. (d) Coulomb.
49. In electrophilic aromatic substitution reactions, nitro group is meta-directing, because the nitro group :
- (a) Increases electron density at meta position.
(b) Increases electron density at ortho and para positions.
(c) Decreases electron density at meta position.
(d) Decreases electron density at ortho and para positions.

50. The reduction of but-2-yne to trans-but-2-ene can be brought about by :

- (a) H_2/PtO_2 (b) Lindlar catalyst.
(c) LiAlH_4 (d) $\text{Li}/\text{liquid NH}_3$.

(50 × 1 = 50 marks)

Section II

Answer any five in detail, no negative marks.

1. Derive packing factor of simple cubic crystal, body centred cubic crystal, face centred cubic crystal, hexagonal and diamond cubic structure.
2. Explain the chemical kinetics of first order chemical reactions.
3. Derive Bragg's law of X-ray diffraction in terms of reciprocal lattice vector.
4. Explain Kronig Penny model for the periodic potential with the help of one-dimensional Schrödinger equation.
5. With which type of spectroscopy would one observe the pure rotation spectrum of H_2 ? If the bond length of H_2 is 0.07417 nm, what would be the spacing of the lines in the spectrum?
6. Derive Clausius-Mossotti relation for a solid dielectric.
7. (a) Write short notes on Hoffmann degradation and Cope elimination.
(b) Discuss the generation and structure of nitrenes.
8. Solve one electron time independent Schrödinger equation for a constant potential.
9. How many normal modes of vibration are possible for the following molecules : HBr , O_2 , OCS (linear), SO_2 (bent), BCl_3 , $\text{HC}=\text{CH}$, CH_4 , CH_3I , C_6H_6 .
10. Write down the following naming reactions :
 - a) Sandmeyer Reaction.
 - b) Gatterman Reaction.
 - c) Balz-Schiemann Reaction.
 - d) Finkelstein Reaction.

(5 × 10 = 50 marks)