Ph.D. Programme in Materials Science

Model Question Paper

RESEARCH APTITUDE ASSESSMENT TEST

Time : 2 Hours **Max. Marks : 75**

I. Part A: Multiple Choice Questions - 30 marks

Choose the correct Response, viz., A, B, C, D or E for the Questions from 1 - 30 which carry ONE mark each. Please NOTE that an **incorrect response** will attract **negative marking**. (For Multiple Choice questions with 5 options, ¼th mark will be deducted for an incorrect answer.)

Questions 1-10 carry ONE mark each

1. For a particle in an infinite potential well, let $\psi_n(x)$ be the wave function. In the middle of the well, the probability density vanishes for

   (A) The ground state only (n=1)
   (B) States of even n (n=2, 4, 6,…)
   (C) States of odd n (n=1, 3, 5,…)
   (D) All states (n=1, 2, 3,…)
   (E) All states except the ground state

   (___)

2. The fraction of nonreflected radiation that is transmitted through a 10-mm thickness of a transparent material is 0.90. If the thickness is increased to 20 mm, the fraction of light that will be transmitted is

   (A) 0.81 (B) 0.61 (C) 0.51 (D) 0.45 (E) 0.75

   (___)

3. The SI unit of dielectric displacement is

   (A) m (B) ratio (C) C/m^2 (D) $kg\text{-}m/s^2\text{-}C$ (E) $kg\text{-}m^2/s^2\text{-}C$

   (___)

4. Which of the following treatment(s) can increase the electrical conductivity of silicon?
   (i) heating, (ii) doping with arsenic, (iii) doping with aluminium, (iv) exposure to light

   (A) Only (i)
   (B) Only (i) and (ii)

(C) Only (i), (ii) and (iv) (D) All (i), (ii), (iii) and (iv)
(D) None of the above

(___)

5. $MgAl_2O_4$ is an example of _____ structure

(A) Perovskite (B) Inverse spinel (C) Spinel
(D) Pyrochlore (E) None of the above

(___)

6. The contrast obtained in scanning electron microscope using back scattered electrons depends on

(A) Atomic number of the specimen material
(B) Accelerating voltage of the microscope
(C) Working distance in the microscope
(D) Type of the electron emitter in the microscope
(E) None of the above

(___)

7. BaTiO3 is a well-known piezoelectric materials with Tc at about 120°C. It has notable phase transition at four different temperature ranges (T < -90°C; -90°C < T< 5°C; 5°C < T <120°C; T>120°C). What will be its crystal structure at T > 130°C?

(A) Octahedral to tetragonal
(B) Tetragonal to Cubic
(C) Cubic to Rhombohedral
(D) Rhombohedral to tetragonal
(E) None of the above

(___)

8. to 10. …..

Questions 11-20 carry TWO marks each

11. A particle of mass *m* has wave function $\psi(x,t) = e^{i\omega t}(\alpha\ coskx + \beta\ sinkx)$. The probability current density is

(A) 0 (B) $\frac{\hbar k}{m}$ (C) $\frac{\hbar k}{2m}(|\alpha|^2 + |\beta|^2)$
(D) $\frac{\hbar k}{m}(|\alpha|^2 - |\beta|^2)$ (E) $\frac{\hbar k}{2mi}(\alpha^*\beta - \beta^*\alpha)$

(___)

12. Given specific heat of tungsten is 0.032 cal/g-K. The amount of heat that must be supplied to 250 g of tungsten to raise its temperature from 25 ^{0}C to 650 ^{0}C is

(A) 4500 cal (B) 6500 cal (C) 5000 cal
(D) 5500 cal (E) 6000 cal

(___)

13. Which of the following statement(s) is/are true
(i) All piezoelectric materials are necessarily ferroelectric
(ii) All ferroelectric materials are necessarily piezoelectric
(iii) All pyroelectric materials are necessarily piezoelectric
(iv) All pyroelectric materials are necessarily ferroelectric

(A) (i) and (ii) (B) (ii) and (iii) (C) (i) and (iv)
(D) (ii) and (iv) (E) All statements are false

(___)

14. A zinc rod immersed in an acid solution loses 25mg during 12 hr of exposure. The equivalent current flowing during corrosion is (in mA)___ . Atomic weight of zinc is 65.4 g/mol.

(A) 0.85 (B) 1.7 (C) 2.5 (D) 3.4 (E) 4.5

(___)

15. The donor concentration in a sample of *n*-type silicon is increased by a factor of 100. The shift in the position of the Fermi level at 300K, assuming the sample to be non degenerate is ___ *meV.*

(A) 10 (B) 100 (C) 115 (D) 150 (E) 200

(___)

16. to 20. ….

Part - B

(45 Marks)

II. Write any NINE questions from the following in the sheets provided with the question paper. Each question carries FIVE marks.

1. Discuss the various factors which have to be considered when choosing a substrate for thin film growth.

2. Describe the Czochralski technique for growing single crystals using a schematic diagram. What are its advantages and disadvantages?

3. Explain how light scattering can be used to characterize powder samples.

4. The room-temperature electrical conductivity of intrinsic silicon is 4 x 10^{-4} $(\Omega\text{-m})^{-1}$. An extrinsic n-type silicon material is desired having a room temperature conductivity of 150 $(\Omega\text{-m})^{-1}$. Specify a donor impurity type that may be used as well as its concentration in atom percent to yield these electrical characteristics. Assume that the electrical and hole mobilities are the same as for the intrinsic material, and that at room temperature the donor impurities are exhausted. (Note: mobility of electron in Si = 0.14 $m^2/V\text{-s}$, density of Si = 2.33 g/cm^3, molecular weight of Si = 28.09 g/mol).

5. Calculate the saturation magnetization and the saturation flux density for nickel, which has a density of 8.90 g/cm^3. (Note: Net magnetic moment per atom = 0.60 μ_B, molecular weight of Ni = 58.71 g/mol).

6. to 12. …..

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