EE24BTECH11053 - S A Aravind Eswar

1) Read the two statements related to sintering and select the correct option.

Statement-1: Sintering in vacuum leads to improved densification as compared to sintering under ambient (at atmospheric pressure) condition.

Statement-2: Closed pores formed during sintering inhibit full densification. [2020 - XE]

- a) Both Statement-1 and Statement-2 are FALSE
- b) Both Statement-1 and Statement-2 are TRUE
- c) Statement-1 is TRUE but Statement-2 is FALSE
- d) Statement-1 is FALSE but Statement-2 is TRUE
- 2) Select the correct option that appropriately matches the process to the material/product that can be fabricated using them. [2020 XE]

| Process | Material/Product |
|---------------------------------|--------------------------------------|
| (I) Power Processing | (P) Organic Semiconductor thin films |
| (II) Spin coating | (Q) Single crystal silicon |
| (III) Czochralski Process | (R) Poly-silicon |
| (IV) Chemical vapour deposition | (S) Porous bronze bearings |

- a) I-S, II-P, III-R, IV-Q
- b) I-S, II-R, III-Q, IV-P
- c) I-S, II-P, III-Q, IV-R
- d) I-P, II-R, III-Q, IV-S
- 3) Consider a FCC structured metal with lattice parameter a = 3.5 Å. If the material is irradiated using X-rays of wavelength $\lambda = 1.54056$ Å, the Bragg angle (2θ) corresponding to the fourth reflection will be: [2020 XE]
 - a) 88.21°
 - b) 76.99°
 - c) 99.35°
 - d) 93.80°
- 4) The number of Schottky defects per mole of KCI at 300 $^{\circ}C$ under equilibrium condition will be: [2020 XE]

Given:

Activation energy for the formation of Schottky defect = $250 \ kJ \cdot mol^{-1}$ Avogadro number = $6.023 \times 10^2 3 mol^{-1}$

Universal Gas Constant = $8.314J \cdot K^{-1} \cdot mol^{-1}$

- a) 1.21 x 10¹⁸
- b) 1.52 x 10¹⁶

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- c) 9.75
- d) 2.42 x 10¹²
- 5) In an industry, the probability of an accident occurring in a given month is $\frac{1}{100}$ Let P(n) denote the probability that there will be no accident over a period of 'n' months. Assume that the events of individual months are independent of each other. The smallest integer value of 'n' such that $P(n) \le \frac{1}{2}$ is _____ (round off to nearest integer) [2020 - XE]
- 6) For a FCC metal, the ratio of surface energy of {111} surface to {100} surface is (round-off to two decimal places). Assume that only the nearest neighbor broken bonds contribute to the surface energy. [2020 - XE]
- 7) Pure silicon (Si) has a band gap (Eg) of 1.1 eV. This Si is doped with 1 ppm (parts per million) of phosphorus atoms. Si contains 5×10^{28} atoms per m^2 in pure form. At temperature T = 300 K, the shift in Fermi energy upon doping with respect to ____eV (with appropriate intrinsic Fermi level of pure Si will be sign and round-off to two decimal places).

Intrinsic carrier concentration of Si, n_i , is given as:

$$n_i = 2\left(\frac{2\pi m k_B T}{h^2}\right)^{3/2} \exp\left(-\frac{E_g}{2k_B T}\right)$$

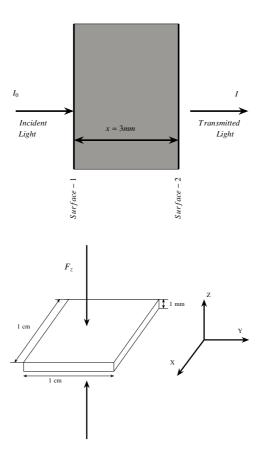
Given:

- Mass of an electron, $m = 9.1 \times 10^{-31} kg$
- Charge of an electron, $e = 1.6 \times 10^{-19} C$
- Boltzmann constant, $K_g = 1.38 \times 10^{-23} J \cdot K^{-1}$ Planck's constant, $h = 6.6 \times 10^{-34} J \cdot s$

[2020 - XE]

- 8) The schematic diagram shows the light of intensity Io incident on a material (shaded grey) of thickness, x, which has an absorption coefficient, α and reflectance, R. The intensity of transmitted light is I. The reflection of light (of a particular wavelength) occurs at both the surfaces (surfaces indicated in the diagram). The transmittance is estimated to be _____ (round-off to three decimal places). Given that for the wavelength used, $\alpha = 10^3 \ m^{-1}$ and R = 0.05. [2020 - XE]
- 9) Fe₃O₄ (also represented as FeO.Fe₂O₃) is a FCC structured inverse spinel (AB₂O₄) material where 1/8 of tetrahedral sites are occupied by half of B cations and 1/2 of the octahedral sites are occupied by remaining B and A cations. The magnetic moments of cations on octahedral sites are antiparallel with respect to those on tetrahedral sites. Atomic number of Fe is 26 and that of O is 8. The saturation magnetic moment of Fe₃O₄ per formula unit in terms of Bohr magnetons (μ_B) will be [2020 - XE] μ_{R} . Ignore contribution from orbital magnetic moments.
- 10) A piezoelectric ceramic with piezoelectric coefficient (d_{zz}) value of 100 x 10⁻¹² $C \cdot N^{-1}$ is subjected to a force, F_z , of 10 N, applied normal to its x-y face, as shown in the figure. If relative dielectric constant (ϵ_r) of the material is 1100, the voltage developed along the z-direction of the sample will be Volts (round-off to two decimal places). Ignore any nonlinear effects.

Given: Permittivity of free space (ϵ_r) is 8.85 x 10^{-12} $F \cdot m^{-1}$. [2020 - XE]



11) Silicon carbide (SiC) particles are added to Aluminum (Al) matrix to fabricate particle reinforced Al-SiC composite. The resulting composite is required to possess specific modulus (E/ρ; E: elastic modulus, ρ: density) three times that of pure Al. Assuming iso-strain condition, the volume fraction of SiC particles in the composite will be (round-off to two decimal places).
[2020 - XE]

| Material | E(GPa) | $\rho(\mathbf{g}\cdot\mathbf{cm}^{-3})$ |
|----------|--------|---|
| Al | 69 | 2.70 |
| Si | 379 | 2.36 |

- 12) Isothermal weight gain per unit area ($\Delta W/A$, where ΔW is the weight gain (in mg) and A is the area (in cm²)) during oxidation of a metal at 600 °C follows parabolic rate law, where, $\Delta W/A = 1.0 \text{ mg} \cdot \text{cm}^2$ after 100 min of oxidation. The $\Delta W/A$ after 500 min at 600 °C will be $\text{mg} \cdot \text{cm}^2$ (round-off to two decimal places). [2020 XE]
- 13) A plain carbon steel sample containing 0.1 wt% carbon is undergoing carburization at 1100 °C in a carbon rich surroundings with fixed carbon content of 1.0 wt% all the time. The carburization time necessary to achieve a carbon concentration of 0.46

wt% at a depth of 5 mm at 1100 °C is _____hour (round off to the nearest integer). _____hour (2020 - XE]

Given: Diffusivity of carbon in iron at 1100 °C is $6.0 \times 10^{-11} \ m^2 \cdot s^{-1}$ and

| erf(z) | Z |
|--------|------|
| 0.56 | 0.55 |
| 0.60 | 0.60 |
| 0.64 | 0.65 |
| 0.68 | 0.70 |