

- 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 $a = 3.5 \text{ \AA}$. If the material is irradiated using X-rays of wavelength $\lambda = 1.54056 \text{ \AA}$, 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 KCl at 300°C under equilibrium condition will be: [2020 - XE]
- Given:
 Activation energy for the formation of Schottky defect = $250 \text{ kJ} \cdot \text{mol}^{-1}$
 Avogadro number = $6.023 \times 10^{23} \text{ mol}^{-1}$
 Universal Gas Constant = $8.314 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
- a) 1.21×10^{18}
 b) 1.52×10^{16}

c) 9.75

d) 2.42×10^{12}

- 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 $P(n) \leq \frac{1}{2}$ 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 (E_g) 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^3 in pure form. At temperature $T = 300$ K, the shift in Fermi energy upon doping with respect to intrinsic Fermi level of pure Si will be _____ eV (with appropriate sign and round-off to two decimal places).
Intrinsic carrier concentration of Si, n_i , is given as:

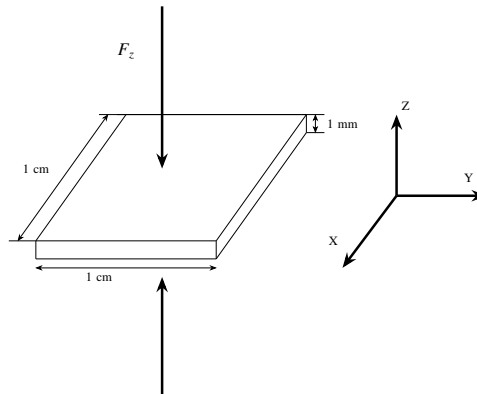
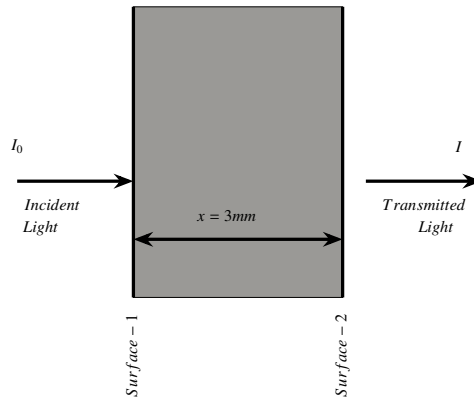
$$n_i = 2 \left(\frac{2\pi m k_B T}{h^2} \right)^{3/2} \exp \left(-\frac{E_g}{2k_B T} \right)$$

Given:

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

[2020 - XE]

- 8) The schematic diagram shows the light of intensity I_0 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, $\alpha = 10^3 \text{ m}^{-1}$ and $R = 0.05$. [2020 - XE]
- 9) Fe_3O_4 (also represented as $\text{FeO} \cdot \text{Fe}_2\text{O}_3$) is a FCC structured inverse spinel (AB_2O_4) 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 Fe_3O_4 per formula unit in terms of Bohr magnetons (μ_B) will be _____ μ_B . Ignore contribution from orbital magnetic moments. [2020 - XE]
- 10) A piezoelectric ceramic with piezoelectric coefficient (d_{zz}) value of $100 \times 10^{-12} \text{ C} \cdot \text{N}^{-1}$ 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_0) is $8.85 \times 10^{-12} \text{ F} \cdot \text{m}^{-1}$. [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)	$\rho(\text{g} \cdot \text{cm}^{-3})$
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 cm^2)) 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). [2020 - XE]

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

erf(z)	z
0.56	0.55
0.60	0.60
0.64	0.65
0.68	0.70