

- 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 ( $2\theta$ ) corresponding to the fourth reflection will be: [2020 - XE]
- a)  $88.21^\circ$   
 b)  $76.99^\circ$   
 c)  $99.35^\circ$   
 d)  $93.80^\circ$
- 4) The number of Schottky defects per mole of KCl at  $300^\circ\text{C}$  under equilibrium condition will be: [2020 - XE]
- Given:  
 Activation energy for the formation of Schottky defect =  $250 \text{ kJ.mol}^{-1}$   
 Avogadro number =  $6.023 \times 10^{23} \text{ mol}^{-1}$   
 Universal Gas Constant =  $8.314 \text{ J.K}^{-1}.\text{mol}^{-1}$
- a)  $1.21 \times 10^{18}$   
 b)  $1.52 \times 10^{16}$

c) 9.75

d)  $2.42 \times 10^{12}$

- 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  $5 \times 10^{28}$  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:

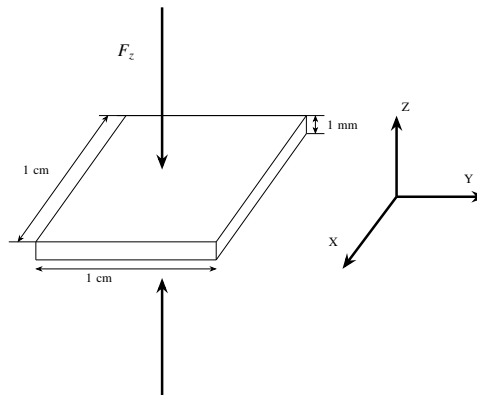
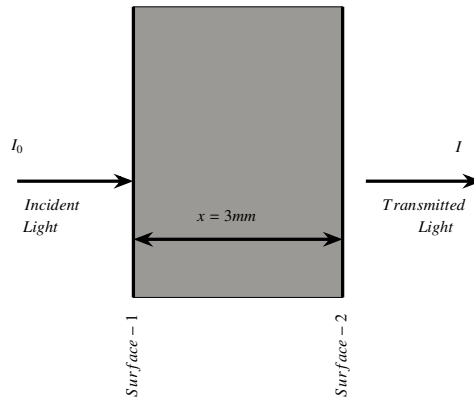
$$n_i = 2 \left( \frac{2\pi m k_B T}{h^2} \right)^{3/2} \exp \left( -\frac{E_g}{2k_B T} \right)$$

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,  $K_B = 1.38 \times 10^{-23} \text{ J.K}^{-1}$
- Planck's constant,  $h = 6.6 \times 10^{-34} \text{ J.s}$

[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,  $\alpha$  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)  $\text{Fe}_3\text{O}_4$  (also represented as  $\text{FeO} \cdot \text{Fe}_2\text{O}_3$ ) is a FCC structured inverse spinel ( $\text{AB}_2\text{O}_4$ ) 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  $\text{Fe}_3\text{O}_4$  per formula unit in terms of Bohr magnetons ( $\mu_B$ ) will be \_\_\_\_\_  $\mu_B$ . Ignore contribution from orbital magnetic moments. [2020 - XE]
- 10) A piezoelectric ceramic with piezoelectric coefficient ( $d_{zz}$ ) value of  $100 \times 10^{-12} \text{ C.N}^{-1}$  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 ( $\epsilon_r$ ) 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 ( $\epsilon_0$ ) is  $8.85 \times 10^{-12} \text{ F.m}^{-1}$ . [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 ( $E/\rho$ ; E: elastic modulus,  $\rho$ : 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)	$\rho(\text{g.cm}^{-3})$
Al	69	2.70
Si	379	2.36

- 12) Isothermal weight gain per unit area ( $\Delta W/A$ , where  $\Delta W$  is the weight gain (in mg) and  $A$  is the area (in  $\text{cm}^2$ )) during oxidation of a metal at  $600^\circ\text{C}$  follows parabolic rate law, where,  $\Delta W/A = 1.0 \text{ mg.cm}^{-2}$  after 100 min of oxidation. The  $\Delta W/A$  after 500 min at  $600^\circ\text{C}$  will be  $\text{mg.cm}^{-2}$  (round-off to two decimal places). [2020 - XE]
- 13) A plain carbon steel sample containing 0.1 wt% carbon is undergoing carburization at  $1100^\circ\text{C}$  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  $6.0 \times 10^{-11} \text{ m}^2.\text{s}^{-1}$  and

<b>erf(z)</b>	<b>z</b>
0.56	0.55
0.60	0.60
0.64	0.65
0.68	0.70