Materials Science (XE-C)

Q.1 – Q.7 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

Q.1	**Condition to be satisfied for α and β phases to be in equilibrium in a two-component (A and B) system at constant temperature and pressure is** **(*Given: μ is the chemical potential*)**
(A)	entropy of the system should be maximum
(B)	Gibbs energy of the system should be minimum and $\mu_A^\alpha = \mu_B^\alpha$, $\mu_A^\beta = \mu_B^\beta$
(C)	Gibbs energy of the system should be minimum and $\mu_A^\alpha = \mu_A^\beta$, $\mu_B^\alpha = \mu_B^\beta$
(D)	Helmholtz energy should be minimum

Q.2	**Amino acids react to form peptides and proteins. This process is known as**
(A)	addition polymerization
(B)	nucleophilic substitution
(C)	condensation polymerization
(D)	hydration

Q.3	**The most favoured slip system in face centered cubic metal is**
(A)	(111) [110]
(B)	(110) $[1\bar{1}1]$
(C)	$(11\bar{1})$ [112]
(D)	(111) $[1\bar{1}0]$

Q.4	**The dielectric constant of a material at ultraviolet frequencies is mainly due to**
(A)	dipolar polarizability
(B)	ionic polarizability
(C)	electronic polarizability
(D)	interfacial polarizability

Q.5 Match the different transformations/reactions in **Column I** with the most suitable information in **Column II**.

Column I	**Column II**
(P) Eutectoid reaction	(1) involves no diffusion
(Q) Martensitic transformation	(2) one solid phase transforms into two solid phases
(R) Precipitation reaction	(3) occurs in supersaturated solutions

(A)	P-2; Q-3; R-1
(B)	P-1; Q-2; R-3
(C)	P-2; Q-1; R-3
(D)	P-3; Q-2; R-1

Q.6	**In scanning electron microscopy, the resolution of backscattered electron (BSE) image is poorer compared to that of secondary electron (SE) image, because**
(A)	energy of BSE is lower
(B)	sampling volume of BSE is larger
(C)	yield of BSE is lower
(D)	sampling volume of SE is larger

Q.7	**Which of the following deposition conditions favour the formation of larger grains in thin film?**
(A)	Low deposition rate and low substrate temperature
(B)	Low deposition rate and high substrate temperature
(C)	High deposition rate and low substrate temperature
(D)	High deposition rate and high substrate temperature

Q.8 Multiple Select Question (MSQ), Carry ONE mark each (no negative marks).

Q.8	**A metal has a melting point of 600 °C. By rapid cooling, liquid metal can be made to solidify either at 500 °C or 400 °C or 300 °C. Critical size of the solid nuclei is**
(A)	same for solidification at 400 °C and 500 °C
(B)	smaller for solidification at 400 °C as compared to solidification at 500 °C
(C)	larger for solidification at 400 °C as compared to solidification at 500 °C
(D)	the smallest for solidification at 300 °C

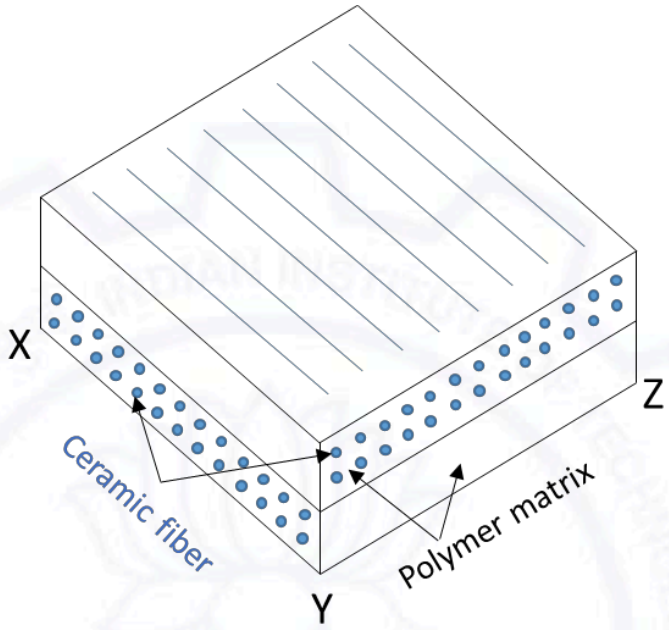
Q.9 Numerical Answer Type (NAT), carry ONE mark each (no negative marks).

Q.9	**A magnet of mass 50 g has a magnetic moment of 4.2×10^{-7} A m^2. The density of the magnet is 7.2 g cm^{-3}. The intensity of magnetization in A m^{-1} is _____ (*round off to 3 decimal places*)**

Q. 10 – Q. 12 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).

Q.10	In the context of scanning electron microscopy, match the information in **Column I** with most appropriate information in **Column II**. **Column I** (P) Secondary electrons (Q) Backscattered electrons (R) Characteristic X-rays (S) Diffracted backscattered electrons **Column II** (1) Crystallographic orientation of grains (2) Failure analysis of fractured surfaces (3) Chemical composition analysis (4) Distinguishing chemically distinct phases
(A)	P-3; Q-2; R-1; S-4
(B)	P-2; Q-4; R-3; S-1
(C)	P-1; Q-3; R-2; S-4
(D)	P-4; Q-2; R-1; S-3

Q.11	Match the heat treatment processes given in **Column I** with the most suitable outcomes in **Column II**. **Column I** (P) Quenching (Q) Annealing (R) Tempering (S) Carburizing **Column II** (1) hardens the steel (2) softens the cold worked steel (3) toughens the steel (4) hardens the surface of steel
(A)	P-3; Q-2; R-1; S-4
(B)	P-2; Q-4; R-3; S-1
(C)	P-1; Q-2; R-3; S-4
(D)	P-1; Q-3; R-4; S-2

Q.12	**A co-joined cross-ply laminate composite, as shown in figure, is distorted upon heating. What are the resultant shapes of edges XY and YZ ?** 
(A)	X — Y, Y ⌣ Z
(B)	X ⌣ Y, Y — Z
(C)	X ⌣ Y, Y ⌢ Z
(D)	X ⌢ Y, Y ⌣ Z

Q. 13 Multiple Select Question (MSQ), Carry TWO marks each (no negative marks).

Q.13	**X-ray diffraction peak broadening enables the estimation of**
(A)	crystallite size of the material
(B)	microstrain in the material
(C)	precise lattice parameter
(D)	residual macrostress acting on the material

Q. 14 – Q. 22 Numerical Answer Type (NAT), carry TWO marks each (no negative marks).

Q.14	**Fe - 10 atom % C austenite (fcc), having no Fe vacancies, has a lattice parameter of 4 Å. The density of austenite in g cm^{-3} is _____ (*round off to 2 decimal places*)** **(*Given: atomic weight of Fe* = 55.8; *atomic weight of C* = 12.0; *Avogadro's number* = 6.023 × 10^{23})**
Q.15	**An element transforms from α to β at 773 K and 1 atm pressure with 912 J mol^{-1} as enthalpy of transformation. The molar volumes of α and β phases are 7.377 cm^3 and 7.317 cm^3, respectively. Assume that the difference in molar volumes of α and β is independent of pressure. The pressure (in atm) required for α to β transformation to occur at 723 K is _____ (*round off to nearest integer*)** **(*Given: 1 atm* = 1.01325 × 10^5 Pa)**
Q.16	**A binary A-B alloy has α and β phases at equilibrium. The ratio of weight percentages (wt.%) of α to β is 4. The wt.% of A in α and β phases is 70 and 20, respectively. The wt.% of B in the alloy is _____ (*round off to nearest integer*)**
Q.17	**During heating, Ti undergoes allotropic transformation from hcp to bcc at 882 °C. The percent volume change accompanying this transformation is _____ (*round off to 1 decimal place*)** **(*Given: atomic weight of Ti* = 47.9; *lattice parameter of bcc Ti* = 0.332 nm; *density of hcp Ti* = 4.51 g cm^{-3}; *Avogadro's number* = 6.023 × 10^{23})**
Q.18	**Vickers hardness test is performed with an indenter of square-base diamond pyramid having an included angle of 136° between the opposite faces of the pyramid. If the applied load is 10 kg and the average length of diagonals of square indentation is 0.5 mm, the Vickers hardness in kg mm^{-2} is_____ (*round off to nearest integer*)**

Q.19	**The drift mobility of electron in an n-type Si crystal doped with 10^{16} cm^{-3} phosphorous atoms is 1350 $cm^2 V^{-1} s^{-1}$. The electrical conductivity in $\Omega^{-1} m^{-1}$ is _____ (*round off to nearest integer*)** **(*Given: Intrinsic charge concentration of Si* = 1.45×10^{10} cm^{-3};** ***Charge of an electron, e* = 1.6×10^{-19} C)**

Q.20	**At 1000 K, the linear thermal expansion coefficients of graphite, parallel and perpendicular to the graphite layers, are 0.8×10^{-6} K^{-1} and 29×10^{-6} K^{-1}, respectively. The percentage increase in the volume of graphite when heated from 900 K to 1100 K is _____ (*round off to 2 decimal places*)**

Q.21	**A certain ceramic has a theoretical density and sintered density of 6.76 g cm^{-3} and 6.60 g cm^{-3}, respectively. The green compact has 18 volume percent porosity. For a sintered cube of side 2 cm, the required side of the cubic green compact in cm is _____ (*round off to 2 decimal places*)**

Q.22	**When a metal (M) is immersed in de-aerated acid electrolyte, it polarizes anodically by 0.4 V. The M/M^{n+} exchange current density is 10^{-5} A m^{-2} and Tafel slope is 0.1 V/decade for the anodic reaction. Assume that corrosion is uniform and, anodic and cathodic reactions are under activation control. The rate of metal dissolution in A m^{-2} is _____ (*round off to 1 decimal place*)**

END OF THE QUESTION PAPER