C : MATERIALS SCIENCE

Q. 1 – Q. 9 carry one mark each.

Q.1   Arrange the following elements in order of increasing melting point:
(P) gallium   (Q) tungsten   (R) aluminium   (S) gold

(A) P < R< Q < S
(B) S < P < R < Q
(C) P < R < S < Q
(D) R < S < Q < P

Q.2   When the atoms in a solid are separated by their equilibrium distance,

A) the potential energy of the solid is lowest
B) the force of attraction between the atoms is maximum
C) the force of repulsion between the atoms is zero
D) the potential energy of the solid is zero

Q.3   To which of the following category of materials does Teflon (PTFE) belong?

(A) Thermosets   (B) Thermoplastics   (C) Elastomers   (D) Block copolymers

Q.4   Which of the following statements is TRUE about the glass transition temperature (T_g)?

(A) T_g appears below the melting temperature in a perfectly crystalline material
(B) Upon heating through T_g, heat capacity remains constant but the thermal expansion coefficient changes
(C) Upon heating through T_g, heat capacity changes but the thermal expansion coefficient remains the same
(D) Upon heating through T_g, both the heat capacity and thermal expansion coefficient change

Q.5   The slope of a graph of $\log_e$(conductivity) versus 1/T (where T is the temperature) for an intrinsic semiconductor with energy gap E_g, is

(A) $E_g/2k$ (B) $-E_g/2k$ (C) E_g/k (D) $-E_g/k$

Q.6   Which is NOT a ceramic forming process?

(A) extrusion   (B) slip casting   (C) forging   (D) tape casting

Q.7   Which of the following is NOT a soft magnetic material?

(A) Iron-silicon steel
(B) Nickel zinc ferrite
(C) Nickel iron alloy
(D) Alnico

Q.8   The eutectic reaction is
[Note: S – solid; L– liquid]

(A) $S_1 \rightleftharpoons S_2 + S_3$
(B) $L \rightleftharpoons S_1 + S_2$
(C) $L_1 + S_1 \rightleftharpoons L_2 + S_2$
(D) $L_1 + S_1 \rightleftharpoons S_2 + S_3$

Q.9   Vacancies play an important role in

(A) deformation twinning
(B) self diffusion
(C) strain hardening
(D) cross-slip

Q. 10 – Q. 22 carry two marks each.

Q.10   Match the techniques listed in Column I with the characteristics of the materials measured in
Column II.

Column I   **Column II**
P. DSC   1. Density of states
Q. XRD   2. Glass transition temperature
R. STM   3. Cathodoluminescence
S. SEM   4. Crystal structure
                                                  5. Thermal expansion coefficient

(A) P-2, Q-3, R-4, S-1
(B) P-5, Q-4, R-5, S-1
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-5, R-4, S-2

Q.11   The mass of an electron would increase _____ times its original mass if it travels at 96%
of the speed of light.

Q.12   With increasing temperature from $15^{o}C$ in winter to $45^{o}C$ in summer, the length of an iron rail track
increases by 0.05 cm. Calculate the original length of the iron rail track in cm. (linear thermal
expansion coefficient of iron is $11.0 \times 10^{-6} K^{-1}$)

Q.13   What is the thickness (in μm) of a germanium crystal layer that would be required for absorbing
80% of the incident radiation whose wavelength is 1.3 μm? The absorption coefficient (α) of
germanium at 1.3 μm is $3.3 \times 10^{5} m^{-1}$.

Q.14   A 1 kg sacrificial anode of Mg (atomic weight: 24.31 amu) is attached to the base of a ship. If the
anode lasts for 60 days, what is the average corrosion current (in Amperes) during that period?

Q.15   A capacitor has a 0.075 cm thick $BaTiO_3$ dielectric with a dielectric constant of 2000 and an
electrode area of 0.2 cm^2. What is the capacitance of this capacitor in nF?

Q.16   A hot pressed ceramic composite material consists of 30 volume % SiC whiskers in an Al_2O_3
matrix. The measured bulk density of this composite is 3.65 g cm^{-3}. If the theoretical density of SiC
is 3.22 g cm^{-3} and that of Al_2O_3 is 3.95 g cm^{-3}, estimate the porosity (%) of the composite, assuming
that the linear rule of mixtures is valid in this case.

Q.17   Match the technical ceramics listed in Column I with their common applications listed in Column II

Column I   **Column II**
P. Y-doped ZrO_2 1. Lasers
Q. UO_2 2. Turbine engine
R. Si_3N_4 3. Integrated circuit substrate
S. AlN   4. Oxygen sensor
T. Cr doped Al_2O_3 5. Nuclear fuel
                                                         6. Thermistor

(A) P-6, Q-4, R-5, S-1, T-3
(B) P-4, Q-5, R-2, S-3, T-1
(C) P-3, Q-1, R-2, S-6, T-5
(D) P-1, Q-4, R-5, S-2, T-1

Q.18   Creep in metals is defined as

(A) the maximum energy a solid can absorb elastically
(B) the maximum energy a solid can absorb by plastic deformation
(C) the stress at which plastic deformation starts
(D) slow plastic deformation due to diffusion of atoms usually at high temperature (T > half the melting point)

Q.19   Calculate the planar density of the (100) plane in an fcc crystal given that R is the atomic radius of the element.

(A) $0.25\ R^2$ (B) $0.25/R^2$ (C) $1/R^2$ (D) $4/R^2$

Q.20   The diffusion coefficient of copper atoms in aluminium is found to be 1.28×10^{-22} m^2s^{-1} at T=400K and 5.75×10^{-19} m^2s^{-1} at T=500K. Find the temperature (in Kelvin) at which the value of the diffusion coefficient is 10^{-16} m^2s^{-1}

Q.21   Calculate the density of copper in kg m^{-3} given that copper has an fcc lattice with a lattice parameter of 0.365 nm. Copper has an atomic weight of 63.54 amu.

Q.22   What would be the maximum number of electron-hole pairs that can be generated using a silicon detector irradiated by x-ray of energy 1.54 keV. The band gap of silicon is 1.1 eV.

END OF THE QUESTION PAPER