Polymer Science and Engineering (XE-F)

Q.1 - Q.9 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

Q.1	**Linear low density polyethylene (LLDPE) is a copolymer of ethylene and a small fraction of _______.**
(A)	butadiene
(B)	isoprene
(C)	butene
(D)	hexadiene

Q.2	**Binary polymer blends of polypropylene and polyamide 6 are immiscible. From a thermodynamic viewpoint this is due to ___________.**
(A)	low enthalpy of mixing
(B)	high entropy of mixing
(C)	high enthalpy of mixing
(D)	low entropy of mixing

Q.3	**Which one of the following is an elastomer?**
(A)	Polyamide 6,6
(B)	Poly(ethylene terepthalate)
(C)	Vulcanized polybutadiene
(D)	High density polyethylene

Q.4	**Compression moulded isotropic polypropylene film exhibits ________________ in X-ray diffraction analysis.**
(A)	spot pattern
(B)	circular ring pattern
(C)	circular ring and spot pattern
(D)	arc pattern

Q.5	**Which one of the following is an example of a biodegradable polymer?**
(A)	Polyethylene
(B)	Polyamide 6,6
(C)	Polypropylene
(D)	Polylactic acid

Q.6	**Polymer crystals show a range of melting points in contrast to single melting point of crystals of small molecules, because ________.**
(A)	there is an absence of intermolecular interactions
(B)	there is an absence of long range ordering
(C)	the polymer chains are not in thermodynamic equilibrium in a metastable state
(D)	the melting behavior of polymer crystal is independent of sample thermal history

Q.7	**When the rate of cooling is increased during the solidification process, the glass transition temperature of a polymer ______.**
(A)	decreases
(B)	increases
(C)	stays unaltered
(D)	shows a non-monotonic dependence

Q.8	**Equal and opposite forces of a constant magnitude F are applied at the two ends of a thin elastomeric rod, which is held at a temperature T_1 ($T_g < T_1 < T_m$), where T_g and T_m are the glass transition temperature and melting temperature respectively. If the temperature is increased to T_2 ($T_g < T_2 < T_m$ and $T_2 > T_1$), the rod will ______________.**
(A)	expand along the loading direction and the transverse direction
(B)	shrink along the loading direction
(C)	remain dimensionally unaltered
(D)	expand only along the loading direction

Q.9	**The size of a coiled polymer chain in a dilute solution is R_G in a good solvent, R_I in an ideal solvent and R_P in a poor solvent. Select the correct ordering of sizes.**
(A)	$R_G > R_I > R_P$
(B)	$R_G < R_I < R_P$
(C)	$R_P > R_G > R_I$
(D)	$R_P < R_G < R_I$

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

Q. 10 **Match the Additive to its Function.**

Additive	**Function**
P. Tritolyl phosphate	1. Coupling Agent
Q. Triethoxy vinyl silane	2. Antioxidant
R. Azoisobutyronitrile	3. Plasticizer
S. 4-Methyl-2,6-di-t-butyl phenol	4. Blowing Agent

(A) P-3, Q-2, R-1, S-4

(B) P-3, Q-1, R-4, S-2

(C) P-4, Q-1, R-3, S-2

(D) P-1, Q-2, R-4, S-3

Q. 11 **Match the polymer processing operation with respect to its typical range of shear rate.**

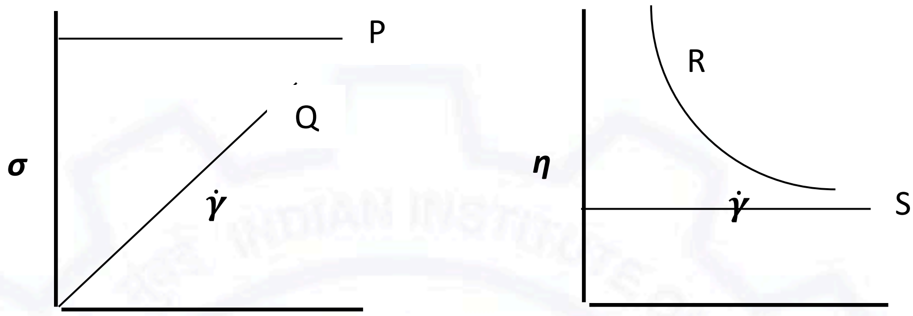
Processing Operation	**Shear rate (s^{-1})**
P. Compression Moulding	1. 1000 - 10000
Q. Extrusion	2. 100 - 1000
R. Calendering	3. 1 - 10
S. Injection Moulding	4. 10 - 100

(A) P-3, Q-4, R-2, S-1

(B) P-1, Q-3, R-2, S-4

(C) P-2, Q-4, R-3, S-1

(D) P-3, Q-2, R-1, S-4

Q. 12	**Shear stress (σ) and shear viscosity (η) are plotted as functions of the shear rate, $\dot{\gamma}$, for idealized "solid-like with yielding (1)" and "liquid-like (2)" materials.**  Associate the shear stress and viscosity plots with the appropriate material responses.
(A)	P-2, Q-1, R-2, S-1
(B)	P-1, Q-2, R-1, S-2
(C)	P-1, Q-2, R-2, S-1
(D)	P-2, Q-1, R-1, S-2

Q. 13 – Q. 22 Numerical Answer Type (NAT), carry TWO marks each (no negative marks).

Q. 13	**The plateau modulus of polystyrene has a value of 0.2×10^6 Pa at 150 °C. Given, the density of polystyrene is 1.05 g/cm^3, the universal gas constant, R = 8.3 J K^{-1} mol^{-1}, and the monomer molecular weight is 104 g/mol. The molecular weight between entanglements (*rounded off to the nearest integer*) of polystyrene chains is ____________ g/mol.**

Q. 14	**A unidirectional composite of epoxy and carbon fiber of 50% by volume is made. The elastic modulus of epoxy and carbon fiber are 3.5 GPa and 350 GPa, respectively. The ratio (*rounded off to one decimal place*) of the modulus of the composite to the matrix modulus is __________.**

Q. 15	**A single screw extruder is operating at a rotational speed of 2 revolutions per second for the extrusion of a Newtonian polymer under open-discharge conditions (in absence of a die, the pressure drop, Δp = 0). The extruder has a screw diameter, D = 5 cm, a channel depth, H = 0.4 cm, distance between flights, W = 1 cm, and a helix angle, θ = 20°. Assume the value of π = 3.14. The volumetric flow rate (*rounded off to 2 decimal places*) is ____________ cm^3/s.**

Q. 16	**At 215 °C, the viscosity of a polystyrene of molecular weight 250×10^3 g/mol is 8.0×10^3 Pa.s. The critical molecular weight of polystyrene, M_c = 35×10^3 g/mol. For a similar polystyrene of molecular weight 500×10^3 g/mol, the viscosity (*rounded off to nearest integer*) will be __________ $\times 10^3$ Pa.s.**

Q. 17	**There are two different PTFE polymer specimens of the following density (ρ) and % crystallinity. For PTFE-specimen-1, ρ is 2.144 g/cm^3 and % crystallinity is 50. For PTFE- specimen-2, ρ is 2.215 g/cm^3 and % crystallinity is 75. Assuming the polymer is pure and defect free, the density (*rounded off to 3 decimal places*) of 100% amorphous PTFE specimen will be _______ g/cm^3.**

Q. 18	**The behavior of a polymer is described by a Maxwell model consisting of a spring element of modulus 10^{10} Pa in series with a dashpot of viscosity 10^{12} Pa.s. In the solid, 50 s after the sudden application of a fixed strain of 1%, the stress (*rounded off to 2 decimal places*) will be _________ $\times 10^7$ Pa.**

Q. 19	**A particular free radical polymerization process yields a polymer with a number averaged degree of polymerization, $\bar{x}_n = 100$. The monomer concentration is doubled and the initiator concentration is increased by four times. Assuming that all rate coefficients and other parameters remain unchanged, the value of $\bar{x}_n$ (*rounded off to the nearest integer*) is ___________.**

Q. 20	**A polymer is synthesized from 2 moles of terephthalic acid (molecular weight of the repeat unit, (-OCC_6H_4CO-), is 132 g/mol), 1 mol of ethylene glycol (molecular weight of the repeat unit, (-OCH_2CH_2O-), is 60 g/mol), and 1 mol of butylene glycol (molecular weight of the repeat unit, (-$O(CH_2)_4O$-), is 88 g/mol). The reaction is terminated at 99% conversion of the acid. The number averaged molecular weight, $\bar{M}_n$ (*rounded off to the nearest integer*) is _________ g/mol.**

Q. 21	**A sample of natural rubber (cis-1,4-polyisoprene) is vulcanized such that one of every 240 chain carbon atoms is cross-linked. The formula unit of the isoprene monomer is C_5H_8 (molecular weight = 68 g/mol). The average molecular weight (*rounded off to the nearest integer*) between cross-links is ___________ g/mol.**

Q. 22	**A sample of an oriented semi-crystalline polymer is subjected to uniaxial tensile stress, σ, in an X-ray diffractometer. The wavelength of X-ray radiation (Cu K_α) is λ = 1.542 Å. The position of the (002) peak, which was found initially at a Bragg angle of 37.50° at σ = 0 MPa shifted to 37.45° at σ = 160 MPa. Assuming elastic deformation, the strain (*rounded off to three decimal places*) in the sample along the direction of applied stress is __________ $\times\ 10^{-3}$.**

END OF THE QUESTION PAPER