

**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 terephthalate)
(C)	Vulcanized polybutadiene
(D)	High density polyethylene



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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)	$R_P < R_G < R_I$



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

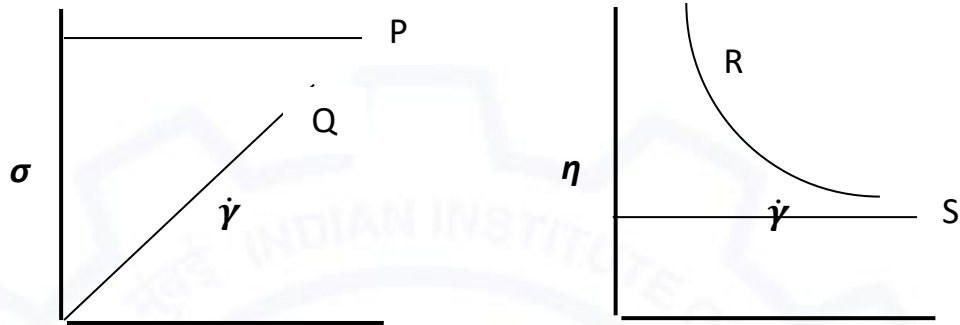
Q. 10	Match the Additive to its Function.	
	Additive	Function
	P. Tritolyl phosphate	1. Coupling Agent
	Q. Triethoxy vinyl silane	2. Antioxidant
	R. Azoisobutyronitrile	3. Plasticizer
	S. 4-Methyl-2,6-di-t-butyl phenol	4. Blowing Agent
(A)	P-3, Q-2, R-1, S-4	
(B)	P-3, Q-1, R-4, S-2	
(C)	P-4, Q-1, R-3, 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, $R = 8.3\text{ J K}^{-1}\text{ mol}^{-1}$, and the monomer molecular weight is 104 g/mol . The molecular weight between entanglements (<i>rounded off to the nearest integer</i>) 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 (<i>rounded off to one decimal place</i>) 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, $\Delta p = 0$). The extruder has a screw diameter, $D = 5\text{ cm}$, a channel depth, $H = 0.4\text{ cm}$, distance between flights, $W = 1\text{ cm}$, and a helix angle, $\theta = 20^\circ$. Assume the value of $\pi = 3.14$. The volumetric flow rate (<i>rounded off to 2 decimal places</i>) is _____ cm^3/s .
Q. 16	At 215°C , the viscosity of a polystyrene of molecular weight $250 \times 10^3\text{ g/mol}$ is $8.0 \times 10^3\text{ Pa.s}$. The critical molecular weight of polystyrene, $M_c = 35 \times 10^3\text{ g/mol}$. For a similar polystyrene of molecular weight $500 \times 10^3\text{ g/mol}$, the viscosity (<i>rounded off to nearest integer</i>) will be _____ $\times 10^3\text{ Pa.s}$.
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 (<i>rounded off to 3 decimal places</i>) 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 (<i>rounded off to 2 decimal places</i>) 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 (<i>rounded off to the nearest integer</i>) is _____.
Q. 20	A polymer is synthesized from 2 moles of terephthalic acid (molecular weight of the repeat unit, $(-\text{OCC}_6\text{H}_4\text{CO}-)$, is 132 g/mol), 1 mol of ethylene glycol (molecular weight of the repeat unit, $(-\text{OCH}_2\text{CH}_2\text{O}-)$, is 60 g/mol), and 1 mol of butylene glycol (molecular weight of the repeat unit, $(-\text{O}(\text{CH}_2)_4\text{O}-)$, is 88 g/mol). The reaction is terminated at 99% conversion of the acid. The number averaged molecular weight, \bar{M}_n (<i>rounded off to the nearest integer</i>) 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 (<i>rounded off to the nearest integer</i>) 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 $\lambda = 1.542 \text{ \AA}$. The position of the (002) peak, which was found initially at a Bragg angle of 37.50° at $\sigma = 0$ MPa shifted to 37.45° at $\sigma = 160$ MPa. Assuming elastic deformation, the strain (<i>rounded off to three decimal places</i>) in the sample along the direction of applied stress is _____ $\times 10^{-3}$.

END OF THE QUESTION PAPER