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GATE 2027

Textile Engineering and Fibre Science

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GATE-2027

Textile Engineering and Fibre Science

CONTENTS

Points to Remember

Conversion Tool

1. 1 inch = 2.54 cm
2. 1 yard = 0.91 m
3. 1 Pound (lbs) = 0.453 kg [453.6 g]
4. 1 θns = 28.34 g
5. 30 cm = 12 inches (" = inches)
6. 1 feet = 12" = 30 cm
7. 1 yard = 3 feet = 36 "
8. 1 metre = 39.7" [∴ 1m > 1 yd]
9. 1 kg = 1000 g = 2.2046 lbs
10. 1 hank = 840 yds
11. 1 cm = 10 mm
12. 1 m = 100 cm = 1000 mm
13. 1 yard = 0.914 m [91.44 cm]
14. 1 lea = 120 yds
15. 7 lea = 1 hank = 840 yds [768 m]
16. 1 Pound = 16, ons = 7000 grains
17. 1gm = 15.432 grains
18. 1 penny = 24 grains
19. 1 m = 1.04 yds
20. 100 m = 109 yds
21. 1 Tonne = 1000 kg
22. 1 qunital = 100 kg

Direct System

1. Tex → wt in gms of 1000 m
2. Denier → wt in gms of 9000 m
3. Decitex → wt in gms of 10,000 m

Indirect

1. Ne (English count) → No. of hanks of all 840 yds long in 1 pound
2. Nm (Metrics count) → no. of Kilometer lengths per kilogram
3. Nw (Worsted count) → no. of hanks of all 560 yds long in 1 pound

Basic

1. $\text{Tex} = \frac{590.5}{\text{Ne}}$ & $\text{Denier} = \frac{5315}{\text{Ne}}$
2. Denier = 9 Tex = 0.9 d tex
3. $\text{Tex} = \frac{0.111}{\text{denier}} = 0.1$ d tex
4. $\text{Decitex} = \frac{1.111}{\text{denier}} = 10$ tex
5. Ne = Nf × 1.81

   Nm = Ne × 1.69

   Nw = Ne × 1.5

   $\text{Ne} = \frac{\text{Nm}}{1.69}$ [micronaire → micrograms per inch]
6. $\text{Tex} = \text{den} \times 0.11 = \frac{1000}{\text{Nm}} = \frac{\text{mic}}{25.4}$
7. dtex = 0.394 × micronaire
8. Denier = 0.354 × micronaire

Important Points to Keep in Mind

1. Optimum TPI (Twist per inch) = TM $\sqrt{\text{Ne}}$

   TM (Twist multiplier) → 3.6 to 4 for knitting

   TM → 4 to 4.5 for (weaving)
2. CF yarn → Stwisted, Twist ∠ α = 30°

   R/F yarn → z twisted, twist ∠ α = 20°
3. CSP = Breaking load in pounds x count of yarn Ne

   CSP = Count strength product (bundle strength)

4. RKM (Resleins kilometer)

- Breaking length in kms
- Length of yarn which will break at its own lengths.

5. Plain weave

- Thinnest light weight fabric known as muslin
- Thickest and the heaviest fabric such as canvas cloths

6. Total Draft

TD = break draft × main draft

$$TD = \frac{\text{Texfed}}{\text{tex delivered}} \quad T.D. = \frac{\text{Hank delivered}}{\text{Hank feed}}$$

$$TD = \frac{\text{Delivery roller surface speed}}{\text{Feed roller surface speed}}$$

7. Speeds

Sizing speed → 100 m/min practical spd 150 m/min maxm

warping speed → 1000 m/min

In modern warping m/c [benniger]

Speed → 1200 -1400 m/min

Sizing speed → 100 m/min practical speed 150 m/min max^{m}

8. Weaves as per strength

Twill > Matt > Diamond > Plain > Sateen

9. Cationic (+) Ve, anionic (–) ve,

Exothermic → external heat energy

endothermic → internal heat energy

10. Main draft = Actual draft × $\frac{100 - w}{100}$

❑❑❑

CONTENTS

Points to Remember (Short Notes)

Fibers

1. Nylon 6 polymer = $C_6H_{11}ON$
2. Repeat unit of polyethylene terephthalate (PET) = $C_{10}H_8O_4$
3. DGT, Diglycol terephthalate = $C_{12}H_{14}O_6$
4. Polypropylene = $[C_3H_6]_n$
5. Polyethylene = $[C_2H_4]_n$
6. Polystyrene = $[C_2H_3(C_6H_5)]_n$
7. Polyvinylchloride = C_2H_3Cl
8. Polytetrafluoroethylene = C_2F_4
9. Polyacrylonitrile = C_3H_3N
10. Hexamethylene diamine = $C_6H_{16}N_2$
11. Adipic acid = $C_6H_{10}O_4$
12. Nylon 66 Polymer = $C_6H_{16}N_2$
13. Cellulose = $C_6H_{10}O_5$
14. Viscose Rayon = $C_6H_9O_4$–ONa

Degree of Crystallinity

1. By Volume

$$X_v = \frac{d - da}{dc - da}$$

X_v = degree of crystallinity by volume

d = density fof sample

da = fully amorphous components

dc = fully crystalline component

2. By specific volume

$$X_m = \frac{V_a - v}{V_a - V_c}$$

X_m = Degree of crystallinity of mass

v = Specific volume of the sample

V_a = Specific volume of the fully amorphous componenet

V_c = Specific volume of the fully crystalline componenet

3. $\because$ $$X_m = \frac{dc}{da} \times \frac{d - da}{dc - da} \times 100$$

Relation between 1] & 2]

4. By using enthalpy (H)

$$X_{cal} = \frac{H_a - H}{H_a - H_c}$$

H = Enthalpy of the sample

H_a = Enthalpy of amorphous component

H_c = Enthalpy of crystalline component

X_{cal} = Degree of crystallinity of partially crystalline sample

5. By weight

$$X_m = \frac{P_c(P_s - P_a)}{P_s(P_c - P_a)} \times 100$$

P_s= density of a specimen for which the present crystallinity is to be determined.

P_a= density of the completely amorphous polymer.

P_c= Density of the completely crystalline polymer

Synthetic Fibres

1. Drawing

$$\text{Draw ratio} = \frac{\text{Feed roller velocity}}{\text{Delivery roller velocity}}$$

$$= \frac{O/P}{I/P}$$

The meter is drawn in the solid state to about 1.1 times to 30 times of its original length

2. Throughput speed

$$= \frac{wt}{mt} \times \text{take up speed} \times \frac{1}{\text{density}} \text{ cm}^3/\text{min}$$

wt = Weight and mt = meter

Change in temperature by 1°C changes throughput rate by 5% +ve or –ve.

3. Void volume fraction %

$$= \frac{\text{Denstiy fo void free fibre} - \text{Density determiend}}{\text{Denstiy of void free fibre}} \times 100$$

4. $\%\ \text{Porosity} = 1 - \frac{\text{Volume of fibre}}{\text{Volume of yarn}}$

5. $\text{Airflow rate} = \frac{1}{\text{Specific surface}}$

6. $\text{Denier of fiber} = \frac{\pi d^2}{4} \times 9 \times 10^5 \times \delta \times 10^{-8}$

δ = Density of fiber

d = Dia of fiber in micron

7. $\bar{M}_n < \bar{M}_v < \bar{M}_w$

$\bar{M}_n$ = molecular wt on no. basis

$\bar{M}_v$ = molecular wt on viscosity basis

$\bar{M}_w$ = molecular wt on wt

8. $\frac{1}{2} < \frac{T_g}{T_m} < \frac{2}{3}$

$T_g = \frac{1}{2} T_m$ (Symmetrical polymers)

$T_g = \frac{2}{3} T_m$

(asymmetrical polymers)

$T_g \rightarrow \beta$ transition - glass transition

$T_m \rightarrow \alpha$ transition temp. - melting temperature

9. Birefringence

$\Delta n = n'' - n'$

n'' = refractive index in parallel direction

n' = refractive index in perpendicular direction

10. Optical orientation factor

$f' = \frac{\Delta n}{\Delta n'} = 0.5\ [3\cos^2\theta - 1]$

Δn = experimental value

$\Delta n'$ = perfectly oriented sample

θ = the avg $\angle$ of orientation of the chain molecules

Synthetic Fibres Properities

- Nylon 6, Nylon 66, arcylic, viscose & PET, length to breadth ratio excess of 2000 : 1
- In all the above fibers titanium dioxide is used as delustering agent
- All having circular cross-section and glass rod magnified appearance
- Standard moisture regains, viscose –11%, Acrylic – 1.5%, Nylon – 4% * PET – 0.4 %
- Olefin, PP, carbon craphite, glass fibers has no moisture regain or content.

Fibers	Polymers	Monomers	Catalyst	Spinning technology	Density gm/c	DP*	T_g	T_m	Crystallinity %
Nylon 6 1938	Polycaprolac tum	Cyclic caprolactum	Water	Melt	1.14	200	50	250	65 - 85
Nylon66	Polyhexamethy lene diamide	Hexamethylene diamine adipic acid		Melt	1.13	50-80	50	270	65 - 85
Acrylic 1948	Poly acrylonitrile	8.5% wt of acrtylonitule	[Artificial wool]	Dry/wet	1.16	2000			70-80
Viscose	Artifical silk		Carbondi sulfide	Solution	1.49	175			35-40
Polyester 1953	Polyethylene Terapthalate	Ethylene glycol Terepthalic acid [Dimethyl]	Antimony trioxide & antimony triacetate	Melt	1.38	115-140	69	264	65-85
Polypro-pylene	Propylene homo 8 copoly mer	Propylene	Ziegler Natta catalyst	Melt	0.91		– 13	–	
Kevlar	Aromatic Polyamide	Terephthaloyl chloride & P-pheryleredia mine		Dry-jet wet (solvent spinning)	1.45		50 0		

* DP = Degree of Polymerisation

Blowroom/Carding

1. % Cleaning efficiency

$$= \frac{\text{Trash \% in processed fiber}}{\text{Trash \% in raw cotton}} \times 100$$

2. Openess Index

$$= \left[\frac{\text{Volume of fibers}}{\text{Weight of fibers}}\right] \times \text{Specific gravity of fiber}$$

3. Specific gravity of blend

$$= \frac{[SG_1 \times \%\text{ in blend}] + [SG_2 \times \%\text{ in blend}]}{100}$$

4. Beats per inch

$$= \frac{\text{Beater rpm} \times \text{no. of arms}}{\text{feed roller rpm} \times \pi \times \text{feed roller dia inches}}$$

5. TPM (Twist per meter)

$$= \frac{\text{Rotational speed of twisting device (rpm)}}{\text{yarn delivery spd (m/min)}}$$

6. $Cy = \frac{1}{2}[\sec\alpha + 1]$ & $Ry = \left(\frac{\text{Sec } \alpha - 1}{\text{sec } \alpha + 1}\right)$

$\alpha \rightarrow$ twist angle

$Cy = 1 + Ry$

$Cy \rightarrow$ Contraction factor $(1 - \infty)$

$Ry \rightarrow$ Retraction factor (0–1)

7. $\text{Draft} = \frac{\text{Stretched length}}{\text{initial length}}$

$$= \frac{\text{initial count (tex)}}{\text{final Count (tex)}}$$

8. Intensity of opening

$$I_{(mg)} = \frac{P \times 10^6}{60 \times n_b \times N}$$

$P \rightarrow$ Production rate (kg/h)

$n_b \rightarrow$ beater speed (rpm)

$N \rightarrow$ no. of strikers

9. No. of fibers (nf)

$$= \frac{I \times 10^5}{L_f \times T_f}$$

$L_f \rightarrow$ Average fiber length (cm)

$T_f \rightarrow$ Average fiber linear density (mtex)

1 CHAPTER

Natural Fibres

1. Which of the following is a leaf fibre

(a) Ramie (b) Banana (c) Flax (d) Sisal

[1 Mark : GATE-2001]

2. In Bombyx mori silk, 80 - 85% of fibroin is composed of the following amino acids

(a) Glycine, Tyrosine and Aspartic acid

(b) Serine, Tyrosine and Aspartic acid

(c) Glycine, Alaninfe, and Serine

(d) Tyrosine, Aspartic acid and Serine

[1 Mark : GATE-2001]

3. Extensibility in natural 'cellulosic fibres such as cotton, jute, coir, etc. depends primarily upon

(a) Presence and extent of convolutions

(b) Spiral angle of the fibrils

(c) Amount of noncellulosic material

(d) Arrangement of ultimates

[2 Mark : GATE-2001]

4. Which of the following statements is not correct with respect to differences between silk and wool

(a) Silk is highly sensitive to alkali while wool is not

(b) Silk is smooth while wool has scales on the surface

(c) Silk is mostly composed of a few amino acids while wool has many more

(d) Silk has higher crystallinity than wool

[2 Mark : GATE-2001]

5. List and explain the main structural factors that affect moisture regain in cellulosic fibres.

[2 Mark : GATE-2001]

NOTES

NOTES

12. Explain the following

(i) Silk and wool both are natural polyamide fibres. Why wool shows higher elongation and higher moisture regain?

(ii) Alkali resistance of silk is higher than that of wool.

[3+2 = 5 Marks : GATE-2002]

13. Explain how the tenacity of cotton / polyester blended yarn changes with blend ratio.

[5 Marks : GATE-2002]

13. Which of the following is a multi-cellular fibre?

(a) Cotton (b) Flax

(c) Silk (d) Cuprammonium Rayon

[1 Mark : GATE-2003]

14. Amongst the following fibres, the highest initial modulus is demonstrated by

(a) Cotton (b) Wool (c) POY polyester (d) Jute

[1 Mark : GATE-2003]

16. Lyocel is a

(a) Protein fibre (b) Cellulosic fibre

(c) Polyamide fibre (d) Polyester fibre

[1 Mark : GATE-2003]

17. Which fibre is most difficult to be opened out?

(a) Cotton (b) Viscose rayon (c) Polyester (d) Acrylic

[1 Mark : GATE-2003]

18. High elastic recovery of wool is predominantly a result of

(a) Cystine linkages

(b) $\alpha - \beta$ transformation

(c) Deformation of amorphous regions

(d) Percent crystallinity

[2 Marks : GATE-2004]

19. "Matching" exercises. Choose the correct one amongst the alternatives (a), (b), (c) and (d)

List-I	**List-II**
A. Polyester	**1.** Smells like burning paper in flame
B. Silk	**2.** Melts and fuses away from flame
C. Viscose rayon	**3.** Dissolves in metacresol at 75°C
D. Cotton	**4.** Smells like burning hair in flame
	5. Triangular cross-section
	6. Serrated cross-section

Codes:	**A**	**B**	**C**	**D**
(a)	2	4	6	5
(b)	2	5	1	4
(c)	3	6	4	1
(d)	3	4	6	1

[2 Marks : GATE-2004]

55. The fibre which does NOT contain 1,4-glycosidic bonds is

(a) Polynosic (b) Lyocell (c) Silk (d) Ramie

[1 Mark : GATE-2025]

56. Amongst the following, the correct statement(s) for regenerated cellulosic fibres is/are

(a) Degree of polymerization of Lyocell is higher than that of viscose

(b) Degree of crystallinity of Lyocell is lower than that of viscose

(c) Spinning dope of Lyocell is an aqueous solution

(d) Wet strength of Lyocell is lower than that of viscose

[2 Mark : GATE-2025]

57. Amongst the following, the fibre which contains lignin is _____.

(a) cotton (b) wool (c) silk (d) jute

[1 Mark : GATE-2026]

58. Which of the following features is/are related to a wool fibre?

(a) Cuticle (b) Amide linkages

(c) Cortex (d) Ester linkages

[2 Mark : GATE-2026]

❑❑❑

NOTES

ANSWERS AND EXPLANATIONS

1. ***Ans. (d)***

Sisal, other leaf fibres are abaca, henequen, manila, phoruium tenax etc.

2. ***Ans. (c)***

The Bombyx mori silk, 80 - 85% of fibroin is composed of the amino acids, glycine, Alaninfe, and serine.

3. ***Ans. (b)***

More spiral angle → More extension.

4. ***Ans. (a)***

Silk is highly sensitive to alkali while wool is not.

5. ***Ans. (*)***

6. ***Ans. (*)***

7. ***Ans. (*)***

8. ***Ans. (a)***

9. ***Ans. (c)***

- Density of PET → 1.38 gm/cc
- Density of cotton → 1.54 gm/cc

10. ***Ans. (b)***

Fibres in the order of decreasing breaking extension :

Wool > Silk > Cotton > Hemp

11. ***Ans. (b)***

12. ***Ans. (*)***

13. ***Ans. (*)***

14. ***Ans. (b)***

15. ***Ans. (d)***

16. ***Ans. (b)***

17. ***Ans. (a)***

18. ***Ans. (b)***

19. ***Ans. (d)***

- Polyester → Dissolves in metacresol at 75°C
- Silk → Smells like burning hair in flame.
- Viscose rayon → Serrated cross-section.
- Cotton → Smells like burning paper in flame.

20. ***Ans. (d)***

21. ***Ans. (d)***

22. ***Ans. (d)***

The context of bast fibres, an ultimate refers to the largest possible bundle of cells.

23. ***Ans. (d)***

24. ***Ans. (b)***

- ***Milling*** → Subjecting the wool to randomization by mechnical action
- ***Felting*** → Differential friction effect caused by the scales on the fibre surface
- ***Setting Shrinkage*** → Realignment of intra- and intermolecular interactions
- ***Relaxation Shrinkage*** → Release of stresses and strains introduced into the garments during manufacture

25. ***Ans. (d)***

Breaking extension of wool → 20 – 40%

Breaking extension of cotton → 6 – 8%

Breaking extension of flax → 3 – 4%

Breaking extension of jute → 1 – 2%

26. ***Ans. (c)***

27. ***Ans. (c)***

- Viscose rayon → Serrated cross-section
- Jute → Unicellular
- Wet-spun acrylic fibre → Cationic dyeable
- Cotton → Kidney shaped cross-section

28. ***Ans. (d)***

The treatment involves masking scales by coating polyether followed by cross linking wurlan process is used to make wool shrink resistant.

29. ***Ans. (b)***

Jute, flax and ramie fibres belong to Bast family.

2 CHAPTER

Synthetic Fibres

NOTES

1. An ionic comonomer to the extent of 5 - 10% is normally added in preparation of acrylic fibres in order to

(a) Regulate the coagulation process during solution spinning

(b) Improve thermal stability

(c) Improve thermal insulation

(d) Improve dyeability and moisture regain

[2 Mark : GATE-2001]

2. What would happen to the mechanical properties of a man-made fibre if its fine structure is improved, for example making it fibrillar compared to micellar

(a) Tenacity increases while extensibility decreases

(b) Tenacity decreases while extensibility increases

(c) Both tenacity and extensibility increase

(d) Both tenacity and extensibility decrease

[2 Mark : GATE-2001]

3. (i) Give the names and chemical structure of the monomers used in synthesis of poly(ethylene terephthalate) i.e. PET.

(ii) PET is polymerized in two steps, what type of intermediate product is obtained after the 1st step? Give chemical representation of the product.

(iii) What is done to obtain high molecular weight PET at the end of the polymerization?

[1+2+2= 5 Marks : GATE-2001]

4. Explain how the following process steps contribute to better spinnability of viscose

(i) Ageing

(ii) Ripening

[2+3 = 5 Marks : GATE-2001]

5. (i) Why polyester is more prone to static charge generation?

(ii) What is the basic principle involved to impart anti-static finish to polyester?

(iii) Write a brief note on the process to impart anti-static finish to polyester based on principle of surface itching.

[1+1+3= 5 Mark : GATE-2001]

NOTES

6. Which one of the following fibres does not dissolve in concentrated sulphuric acid

(a) Acrylic (b) Polypropylene (c) Polyester (d) Cotton

[1 Mark : GATE-2002]

7. Melting point (Tm) of PET is

(a) More than that of acrylic

(b) More than that of polyethylene

(c) Less than that of polypropylene

(d) Equal to that of Nylon 6

[1 Mark : GATE-2002]

8. Which one of the following fibres is most resistant to attack by micro-organisms

(a) Cotton (b) Wool (c) Jute (d) Acrylic

[1 Mark : GATE-2002]

9. The rate of crystallization of unoriented PET spun yarn

(a) Is maximum near its glass transition temperature (Tg)

(b) Is maximum near its melting temperature (Tm)

(c) Is maximum at a temperature between Tg and Tm

(d) Increases with increases in temperature from Tg to Tm

[2 Marks : GATE-2002]

10. During the production of viscose rayon, write the chemical reactions that take place during

(i) Steeping

(ii) Xanthation

(iii) Regeneration

[1+1+1 = 3 Marks : GATE-2002]

11. Why $ZnSO_4$ is used in the coagulation /regeneration bath for producing viscose rayon from cellulose xanthate. How does the presence of Zn^{++} ions in the bath, change the morphology of gel fibre?

[2 Marks : GATE-2002]

12. In the context of acrylic fibre,

(i) Name the two preferred polymerization methods for production of acrylic fibre.

(ii) Mention one advantage and one disadvantage of the above two techniques.

(iii) Write the chemical structure of one neutral co-monomer used for acrylic fibre production.

[1+3+1 = 5 Marks : GATE-2002]

59. In a comber, the component that rotates both in the forward and backward directions is

(a) Nipper (b) Top comb (c) Cylinder comb (d) Detaching roller

[1 Mark : GATE-2022]

60. Yarn that has helically twisted fibres at the core and belts/wrappers on the surface is

(a) Ring yarn (b) Rotor yarn (c) Compact yarn (d) Air-vortex yarn

[1 Mark : GATE-2022]

61. A yarn is unravelled from a woven fabric specimen of 1 m × 1 m size. If the length of the straightened yarn is 1.1 m, then the crimp percentage (in integer) is_____.

[1 Mark : GATE-2022]

62. In the amorphous phase, polymer chains prefer to be in a random coil conformation to

(a) Maximize entropy (b) Maximize enthalpy

(c) Minimize entropy(d) Minimize enthalpy

[1 Mark : GATE-2023]

63. Copolymers are present in

(a) Nylon 6 fibre (b) Nylon 66 fibre

(c) Acrylic fibre (d) PET fibre

[1 Mark : GATE-2023]

64. Consider the following statements regarding Nylon 6 production from caprolactam using water as a catalyst.

P The first reaction involving ring-opening of caprolactam with water is an endothermic reaction

Q Increase in water concentration during the polycondensation results in a higher molecular weight polymer

R The polycondensation is an irreversible reaction

S Increase in temperature during the polycondensation results in a lower molecular weight polymer

The correct combination of TRUE statements is

(a) P and Q (b) Q and R (c) R and S (d) S and P

[2 Marks : GATE-2023]

65. Amongst the following polymers, the one with the lowest glass transition temperature is

(a) Polyethylene (b) Polypropylene

(c) Polystyrene (d) Poly(ethylene terephthalate)

[1 Mark : GATE-2024]

NOTES

ANSWERS AND EXPLANATIONS

1. ***Ans. (d)***

The extent of 5 - 10% is normally added in preparation of acrylic fibres in order to improve dyeability and moisture regain.

2. ***Ans. (a)***

The tenacity increases while extensibility decreases when its fine structure is improved, for example making it fibrillar compared to micellar.

3. ***Ans. (*)***

4. ***Ans. (*)***

5. ***Ans. (*)***

6. ***Ans. (b)***

The polypropylene dissolves in m-xylene.

7. ***Ans. (b)***

- Melting temperature of Nylon6 = 220°C.
- Melting temperature of PET = 260°C.
- Melting temperature of Polyethylene = 120 – 180°C.
- Melting temperature of polypropylene = 160°C.

8. ***Ans. (d)***

The acrylic fibres is most resistant to attack by micro-organisms among the fibres.

9. ***Ans. (d)***

10. ***Ans. (*)***

Production of viscose rayon

1. Steeping

$$\underset{\substack{(1000)\\ \text{Glucose}}}{\text{Cell}} - OH + \underset{(17-19\%)}{NaOH} \rightarrow \underset{\text{Soda cellulose}}{\text{Cell} - ONa} + H_2O$$

2. Xanthation

$$\text{Cell} - ONa + CS_2 \rightarrow \underset{\text{Sodium cellulose xanthate}}{\text{Cell} - \overset{\overset{S}{\|}}{OC} - S} - Na$$

3. Regeneration

Spinning of viscose involve recovery of cellulose from cellulose xanthate by an acid decomposition reaction.

$$\text{Cell} - \overset{\overset{S}{\|}}{OC} - S - Na + \underset{(8-10\%)}{H_2SO_4} \rightarrow \underset{\text{Glucose}}{\text{Cell} - OH} + CS_2 + Na_2SO_4\,(270)$$

11. ***Ans. (*)***

Aliphatic amines, in presence of zinc salts slow down coagulation rate and there by molecules can be oriented (streching) easily before satisfying to get higher strength.

12. ***Ans. (*)***

1. Suspension polymerisation and solution polymerisation are two preferred polymerization method for production of acrylic fibre.
2. Advantage of Suspension polymerization
   - Ready to control heat of polymerisation
   - Suspension of the polymer may be directly usable.

Disadvantage of Suspension polymerization.

- It is only applicable for the water-insoluble monomer.
- Continmous agitation is requited.

Advantage of Soulation polymerization

- Better heat control

Disadvantage of Solution polymerisation.

- Removal of the diluent from the polymer.

3. Co-monomer used for acrylic fibre production.

MA (methylacrylate) $\rightarrow CH_2 = CH - CO - OCH_3$

MMA (methylmetha acrylate) $\rightarrow$

$$CH_2 = \underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}} - CO - OCH_3$$

13. ***Ans. (*)***

DGT is diethyleneglycol terephthalate

Formation of DGT is necessary step because, it gives uniform monomer for polycondensation. and the reaction is fast. Less side reactions and better thermal stability of melt.

3 CHAPTER

Fibre Manufacturing

NOTES

1. During the degumming of silk, serecin is preferentially hydrolyzed compared to fibroin because serecin is

(a) Amorphous and hydrophilic (b) Crystalline and unoriented
(c) Hydrophobic (d) Highly oriented

[1 Mark : GATE-2003]

2. "Matching" exercises. Choose the correct one amongst the alternatives (a), (b), (c) and (d)

List-I	List-II
A. Linen	**1.** Unicellular fibre
B. Polyester	**2.** Dissolves in acetone
C. Polyacrylonitrile	**3.** Dissolves in formic acid
D. Nylon	**4.** Cationic dyes
	5. DMT
	6. Bast fibre

Codes:	**A**	**B**	**C**	**D**
(a)	6	5	4	3
(b)	1	5	4	3
(c)	1	2	3	4
(d)	2	1	4	6

[2 Marks : GATE-2003]

3. "Matching" exercises. Choose the correct one amongst the alternatives (a), (b), (c) and (d)

List-I	List-II
A. Polyester	**1.** Addition polymerization
B. Polypropylene	**2.** Melt spun
C. Polyacrylonitrile	**3.** Ziegler Natta
D. Modacrylic	**4.** Condensation polymerization
	5. Halogen containing co-polymer
	6. Hydrophilic

Codes:	**A**	**B**	**C**	**D**
(a)	4	2	1	3
(b)	2	6	3	1
(c)	2	6	4	1
(d)	4	3	1	5

[2 Marks : GATE-2003]

NOTES

16. There are three major unit operations in the polymerization of nylon 6, i.e., ring opening, polyaddition, and polycondensation. Consider the following statements and choose the correct set of answers.

P. Water is added during ring opening

Q. Water is added during polyaddition

R. Water is released during polycondensation

S. Water dissolves polycaprolactam

(a) P, Q, R (b) P, R, S (c) P, R (d) R, S

[2 Marks : GATE-2006]

17. In the manufacture of PET, the principal compound/s involved during polycondensation step is/are

(a) MEG (monoethylene glycol) and DMT (dimethyl terphthalate)

(b) EG (ethylene glycol) and PTA (purified terphthalate)

(c) DBT (dibutyl terphthalate)

(d) DOT (diethylenglycol terphthalate)

[2 Marks : GATE-2006]

18. The solution viscosity of a batch of nylon 6 chips was found to be lower compared to that of the production average. From among the following, choose the correct set of statements with respect to this batch.

P. Acid dye uptake of the resultant fibre would be higher.

Q. The ratio of carboxylic to amino groups would increase significantly.

R. Melt flow index would decrease significantly

S. Throughput rate would increase if the melt spinning conditions are kept the same

(a) P, S (b) P, Q (c) P, R (d) Q, R

[2 Marks : GATE-2006]

19. Poly-condensation reaction typically occurs due to the presence of

(a) One functional group (b) Two functional groups

(c) Low temperature (d) Addition of a compound

[1 Mark : GATE-2007]

20. Nylon 6 polymer is produced from caprolactum. The catalyst used in the process is

(a) Magnesium Acetate (b) Cobalt Acetate

(c) Acetic acid (d) Water

[2 Marks : GATE-2007]

21. Match the elements of List-I and List-II and choose the correct answer from amongst (a), (b), (c), and (d)

List-I	List-II
A. Polyester fibres	**1.** Melt spinning
B. Acrylic fibres	**2.** Dry spinning
C. Nylon fibres	**3.** Wet spinning
D. Viscose rayon fibres	**4.** Xanthation
	5. Drawing
	6. Coagulation

Codes:	**A**	**B**	**C**	**D**
(a)	4	2	1	6
(b)	1	3	5	4
(c)	5	6	4	5
(d)	6	5	2	3

[2 Marks : GATE-2007]

22. Mixing of two polymer melts yields

(a) Block copolymers (b) Random copolymers

(c) Alternate copolymers (d) Polymer blends

[1 Mark : GATE-2008]

23. In the context of application of spin finish to synthetic fibres, the INCORRECT statement among the following is

(a) Spin finish dissipates static charge

(b) Spin finish reduces fibre breakage in carding

(c) Spin finish reduces the stiffness of the fibre

(d) Spin finish reduces nep generation tendency in fibres

[1 Mark : GATE-2008]

24. Which of the following is a suitable catalyst during polycondensation of PET

(a) Triphenyl phosphite (b) Trisnonyl phenyl phosphite

(c) Diphenyl terephthalate (d) Antimony trioxide

[2 Marks : GATE-2008]

25. Choose the correct alternative for the following assertion-reason pair,

Assertion (A) : In a wet spinning process, the counter diffusion of solvent and nonsolvent are essential in the coagulation bath for fibre formation.

Reason (R) : This ensures a constant diameter of the gel fibre.

(a) A is wrong, R is correct (b) A is correct, R is wrong

(c) A is wrong, R is wrong (d) A is correct, R is correct

[2 Marks : GATE-2008]

NOTES

NOTES

50. In the production of PET, diglycol terephthalate (DGT) is an intermediate, Taking the atomic weights of H = 1, C = 12, O = 16, the molecular weight of DGT is _____

[2 Marks : GATE-2020][

51. The technique used for producing viscose rayon is

(a) Melt spinning (b) Wet spinning

(c) Dry spinning (d) Dry-jet wet spinning

[1 Mark : GATE-2021]

52. Assume that there is no compression of roving during winding and each coil of a layer is placed directly over the coil of the previous layer. A full roving bobbin consisting of 50 layers of roving is wound on an empty bobbin of 60 mm diameter. If the diameter of the roving is 1 mm, then the diameter (mm) of the full bobbin (in integer) is _____.

[1 Mark : GATE-2022]

53. A PET sample with 40 % crystallinity shows only a melting endotherm in the first heating cycle of DSC with a melting enthalpy of 50 J/g. The degree of crystallinity (%) of another PET sample which also shows only a melting endotherm but with a melting enthalpy of 80 J/g is (in integer) _____.

[1 Mark : GATE-2023]

54. Amongst the following fibre forming polymers, the one which is synthesised by chain growth polymerisation is

(a) Poly(ethylene terephthalate) (b) Nylon 6,6

(c) Polyacrylonitrile (d) Poly(p-phenylene terephthalamide)

[1 Mark : GATE-2024]

55. ***This Question is MSQ.***

Polymer melt flowing through a capillary exhibits die-swell. The correct statement(s), amongst the following, is/are

(a) Die-swell is due to entropic effect

(b) Die-swell is dependent on capillary length

(c) Die-swell is independent of processing temperature

(d) Die-swell is dependent on shear rate

[2 Marks : GATE-2024]

56. Three melt-spun fibre samples A, B and C produced from same polymer under different conditions are found to have densities 1.10 g/cm^3, 1.15 g/cm^3 and 1.20 g/cm^3, respectively. If the mass fraction based degree of crystallinity (x_c) of A and C is 0.45 and 0.75, respectively, then x_c for B (rounded off to 2 decimal places) is _____.

[2 Marks : GATE-2024]

ANSWERS AND EXPLANATIONS

1. ***Ans. (a)***

During the degumming of silk, serecin is preferentially hydrolyzed compared to fibroin because serecin is amorphous and hydrophilic.

2. ***Ans. (a)***

- Linen → Bast fibre
- Polyester → DMT
- Polyacrylonitrile → Cationic dyes
- Nylon → Dissolves in formic acid

3. ***Ans. (d)***

- Polyester → Condensation polymerization
- Polypropylene → Ziegler Natta
- Polyacrylonitrile → Addition polymerization
- Modacrylic → Halogen containing co-polymer

4. ***Ans. (b)***

Water is added to caprolactam during the polymerization of nylon 6. Its primary role is that of a Catalyst.

5. ***Ans. (c)***

6. ***Ans. (c)***

7. ***Ans. (d)***

- Nylon 6, 6 → Adipic acid
- Acrylic → Solution spinning
- Polyester → Codensation polymerization
- Nylon 6 → Caprolactum

8. ***Ans. (c)***

9. ***Ans. (c)***

10. ***Ans. (b)***

11. ***Ans. (d)***

12. ***Ans. (a)***

13. ***Ans. (a)***

14. ***Ans. (d)***

15. ***Ans. (c)***

16. ***Ans. (c)***

There are three major unit operations in the polymerization of nylon 6, i.e., ring opening, polyaddition, and polycondensation :

- Water is added during ring opening
- Water is released during polycondensation
- Water dissolves polycaprolactam

17. ***Ans. (d)***

18. ***Ans. (d)***

19. ***Ans. (b)***

The poly-condensation reaction typically occurs due to the presence of two functional groups.

20. ***Ans. (d)***

21. ***Ans. (b)***

- Polyester fibres → Melt spinning
- Acrylic fibres → Wet spinning
- Nylon fibres → Drawing
- Viscose rayon fibres → Xanthation

22. ***Ans. (d)***

23. ***Ans. (c)***

In the context of application of spin finish to synthetic fibres, the spin finish reduces the stiffness of the fibre.

24. ***Ans. (d)***

The antimony trioxide is a suitable catalyst during polycondensation of PET.

25. ***Ans. (b)***

26. ***Ans. (b)***

Fibres produced via. solution spinning are viscose and acrylic. Polyamide and polyester are spun in melt spinning.

27. ***Ans. (c)***

Draw ratio (D.R.)

$$= \frac{l_2}{l_1} = \frac{20}{5} = 4$$

28. ***Ans. (b)***

The coagulation bath requires acid for regeneration of cellulose in the context of viscose fibre production.