II.9 Polymers

Civil Services 2016–2026: **24** parts, **230** marks · IFoS 2016–2025: **39** parts, **305** marks

Syllabus. Organic polymers: polyethylene, polystyrene, polyvinyl chloride, teflon, nylon, terylene, synthetic and natural rubber.

Marks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
CSE	20	10	40	10	10	30	15	15	15	25	40
IFoS	35	30	65	30	30	20	20	25	20	30	

How to use this chapter. Read every question once and mark the ones that repeat. Pick three, write them by hand against the clock (about 7 minutes for 10 marks), then compare with the model answers on vkcscience.com.

2026

CSE 2026 · Q6(b) Nylons, combustion of polyethylene, polystyrene, Teflon and PVC [20 marks]

(i) How are nylon 6 and nylon 6,6 prepared?
(ii) If 20 g of polyethylene was completely burnt in the presence of excess air, how many moles of CO_2 will be produced?
(iii) Why is polystyrene brittle in nature, while polyethylene is flexible? Explain.
(iv) Why is Teflon chemically inert, while PVC is reactive at high temperatures? Explain.

CSE 2026 · Q6(c) Natural rubber and gutta-percha; nucleic acids [20 marks]

(i) How do the physical properties of natural rubber differ from gutta-percha? Explain. Also write the structures of both the polymers.
(ii) What are nucleic acids? Give a schematic diagram for the primary structure of a nucleic acid.

2025

CSE 2025 · Q4(a) Molecular weight of poly(p-hydroxybenzoic acid); Structure of the polymer; Precursor of natural rubber [15 marks]

(i) After polymerization of *p*-hydroxybenzoic acid, IR analysis shows 0·2% unreacted —COOH. Calculate the molecular weight of the polymer and categorize it. [7]
(ii) Write the structure of the polymer formed when *p*-hydroxybenzoic acid is polymerized. [3]
(iii) What is the precursor of the main component of natural rubber? Draw the structures of both monomer and polymer. [5]

CSE 2025 · Q4(b)(i) Nylon 6 and nylon 6,6 compared [5 marks]

(i) Compare the salient properties of Nylon 6 and Nylon 6,6. [5]

CSE 2025 · Q4(b)(ii) Preparing syndiotactic polystyrene [5 marks]

(ii) How would you prepare syndiotactic polystyrene? [5]

IFoS 2025 · Q6(c)(i) Number- and weight-average molar masses [10 marks]

(i) What will be the number average and weight average molecular weight of a sample of propylene oligomer that consists of 5 mol of pentamer and 10 mol of hexamer? 10

IFoS 2025 · Q7(a) Polyphosphazene formation and solubility; Preparation and branching of silicones [20 marks]

(i) Propose the chemical reaction for synthesis of polyphosphonitrilic chloride. The freshly prepared polyphosphonitric chlorides are soluble in chloroform but insoluble in petroleum. Why? 10

(ii) Propose the mechanism for synthesis of silicones from dialkyl dichlorosilane. How is chain branching introduced in silicones? 10

2024

CSE 2024 · Q6(a) Benzoyl peroxide-initiated polymerisation of ethylene; Atactic, syndiotactic and isotactic polystyrene [15 marks]

(i) Explain the various steps involved in benzoyl peroxide-initiated polymerization of ethylene to give polyethylene. [10]

(ii) Predict the physical properties of atactic, syndiotactic and isotactic polystyrenes based on their structure. [5]

IFoS 2024 · Q5(a) Weight-average molecular mass [5 marks]

Calculate $\overline{M}_w$ for a polydispersed polymer having three fractions with molecular weights and mass % as follows:

Molecular weight	:	200000	50000	100000
Mass %	:	50	20	30

where $\overline{M}_w$ is average molecular weight of the polymer.

IFoS 2024 · Q6(b) Living anionic polymerization; Silicone structure and stability [15 marks]

(i) What is living polymer? Explain the reaction mechanism by taking example of a reaction of monomer styrene with BuLi. 10

(ii) Give the representative structure of silicone. Comment on its stability. 5

2023

CSE 2023 · Q5(c) Acetylene to neoprene; why rubber perishes in air [10 marks]

(i) Identify A and B. The polymerisation of the rearranged product of B, unaided by any catalyst, gives rise to a 'synthetic rubber'. Name this rubber along with its structural formula.

$$2\,CH{\equiv}CH \xrightarrow[NH_4Cl]{Cu_2Cl_2} A \xrightarrow{HCl} B$$

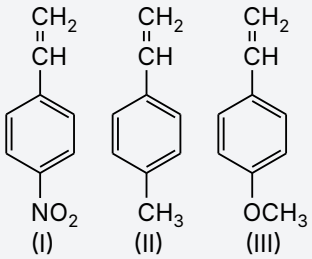
(ii) When rubber balls and other objects made of rubber are exposed to the air for long periods of time, they turn brittle and crack. This does not happen to objects made of polyethylene. Explain.

CSE 2023 · Q6(b)(ii) Tacticity: isotactic, syndiotactic and atactic polymers [5 marks]

(ii) What is meant by 'Tacticity' of a polymer? Distinguish among isotactic, syndiotactic and atactic polymers.*5*

IFoS 2023 · Q5(a) Substituent effects on anionic propagation [5 marks]

List the following groups of monomers in order of decreasing ability to undergo anionic polymerization and give suitable justification.



IFoS 2023 · Q7(b) Sequential anionic polymerization [5 marks]

Complete the following reactions sequence:

$$Ph-CH=CH_2 \xrightarrow[THF]{\text{n-BuLi}} A \xrightarrow{CH_2=CH-CH=CH_2} B \xrightarrow{ROH} C$$

IFoS 2023 · Q7(c) Neoprene and chloroprene [5 marks]

Write the structure of neoprene and its monomer precursor which gives the former by use of Zeigler-Natta catalyst.

IFoS 2023 · Q7(d) Why polymers have average molar masses [5 marks]

Why is the weight average molecular weight and the number average molecular weight used in polymer chemistry rather than simply measuring molecular weight? Explain.

IFoS 2023 · Q8(d) Average repeat-unit mass of a terpolymer [5 marks]

A terpolymer is prepared from vinyl monomers A, B and C; the molecular weight of the repeat units are 104, 184 and 128, respectively. A particular polymerisation procedure yields a product with the empirical formula $A_{3.55}B_{2.20}C_{1.00}$. Calculate the average unit weight of the polymer.

2022

CSE 2022 · Q6(b) Polypropylene by Ziegler–Natta catalysis; Perlon (nylon-6) from ε-caprolactam [15 marks]

(i) How will you synthesize polypropylene (PP) by using Ziegler-Natta catalysis? Discuss the mechanism and its advantages over conventional polymerization.

(ii) How is Perlon synthesized from ε-Caprolactam? Give the mechanism of the reaction.

IFoS 2022 · Q5(b) Stopping radical styrene polymerization [5 marks]

Polystyrene is largely used thermoplastic material. For preparation of polystyrene, monomers of styrene are polymerized in the presence of BPO. After attainment of desired molar mass, the living polymer is subjected to react with DPPH to become dead polymer. Explain the above process of conversion of living polymer to dead polymer through chemical reactions.

IFoS 2022 · Q6(a) Epoxy resins [10 marks]

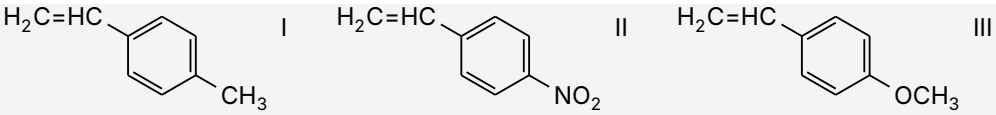
In local hardware stores, now-a-days epoxy resins are commonly sold. What are these? Give one method of preparation of epoxy resin. Write three uses of it.

IFoS 2022 · Q6(b) Polymer end-group analysis [5 marks]

What is group analysis method of determination of molar mass of polymers? Which spectroscopic technique is used in this quantitative estimation method?

2021

CSE 2021 · Q5(b) Three para-substituted styrenes in anionic polymerisation; Structures and configurations of natural and synthetic rubber [10 marks]

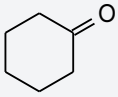
(i) 

Arrange the above monomers in order of decreasing ability to undergo anionic polymerization.

(ii) Draw the structures of synthetic rubber and natural rubber and discuss their configurations.

CSE 2021 · Q7(a) A, B and C in two polymer-forming sequences [20 marks]

I. $C_6H_5-CH=CH_2$ (excess) $\xrightarrow{\text{n-BuLi}}$ A $\xrightarrow{\text{1,3-butadiene}}$ B $\xrightarrow{H_2O}$ C

II.  $\xrightarrow{NH_2OH}$ A $\xrightarrow{55\%\ H_2SO_4}$ B $\xrightarrow{\Delta}$ C

Complete the above reaction sequence by writing the structures of A, B and C.

IFoS 2021 · Q1(e) Natural rubber and polyethylene [5 marks]

Write the monomer unit of natural rubber. How can natural rubber and polyethene be identified by IR spectroscopy?

IFoS 2021 · Q6(b)(ii) End-group content of polystyrene [5 marks]

(ii) Calculate the end group content (weight fraction) of polystyrene of molecular weight 1,50,000 g mol^{-1} assuming that the phenyl group constitutes both the end groups of an average polymer molecule. 5

IFoS 2021 · Q6(c)(ii) Terylene from p-xylene [5 marks]

(ii) Write the synthesis of terylene starting from p-xylene. Mention the IR bands of the functional groups having lower percentage of transmittance. 5

IFoS 2021 · Q6(e) Acid equivalent of nylon-6,6 [5 marks]

Calculate the acid equivalent of nylon-6,6 whose average degree of polymerization is 440.

2020

CSE 2020 · Q5(a) Tetrafluoroethylene from methane; uses of PTFE [10 marks]

How will you prepare building block of the polymer PTFE starting with CH_4 (g)? List the applications of PTFE.

IFoS 2020 · Q5(a) Average molecular weights of polymers; Z-average molar mass [5 marks]

What is the need for average molecular weight of polymer? Describe different types of average molecular weights. What is Z-average molar mass?

IFoS 2020 · Q6(a) Molecular weight of a protein from sedimentation and diffusion (Svedberg) [10 marks]

A protein has a sedimentation coefficient value of $3{\cdot}12 \times 10^{-13}$ sec in water. Its diffusion coefficient is found to be $8{\cdot}2 \times 10^{-7}$ cm^2/sec. Both the values have been corrected for 20 °C in water. The partial specific volume of protein is 0·735 and density of water at 20 °C is 0·9982. Determine the molecular weight of the protein.

IFoS 2020 · Q7(a) Viscosity of macromolecular solutions; intrinsic viscosity and molecular weight [5 marks]

Discuss the effect of macromolecules on the viscosity of a solution. Describe the relation between intrinsic viscosity and molecular weight of polymer.

IFoS 2020 · Q8(a) Light scattering for molar mass; the Zimm plot [10 marks]

Describe light scattering method for determination of molar mass of macromolecules. Also discuss the significance of Zimm plot.

2019

CSE 2019 · Q8(c)(i) Monomers of PS, LDPE, PP, PMMA and Buna-S [10 marks]

Name the monomers of the following polymers:
(1) PS (2) LDPE (3) PP (4) PMMA (5) Buna-S

IFoS 2019 · Q5(a) Osmotic pressure of 0.001 M sugar solution [5 marks]

A very dilute solution, 0·001 *M* sugar in water, is separated from pure water by an osmotic membrane. What osmotic pressure develops in atm at 25 °C?

IFoS 2019 · Q5(c) Molar mass of polyisobutylene from intrinsic viscosity [5 marks]

Calculate the molar mass of a polyisobutylene in CCl_4 solutions at 30 °C. Given $K = 2{\cdot}6\times10^{-4}$ dL/g, $a = 0{\cdot}70$ and intrinsic viscosity $[\eta] = 43$ dL/g.

IFoS 2019 · Q8(a) M̄n = M̄w for a protein mixture [10 marks]

Show that $\overline{M}_n = \overline{M}_w$ of the protein solution, when an equal number of protein mixtures containing—
Haemoglobin = 15·5 kg/mol
Ribonuclease = 13·7 kg/mol
Myoglobin = 17·2 kg/mol
are available.

IFoS 2019 · Q8(b) Odd one out among Terylene, Teflon, polyethene, styrene; monomers of nylon-6,6 [10 marks]

(i) Predict the odd one among the following:
Terylene, Teflon, Polyethene, Styrene
Justify giving suitable explanation. 5
(ii) Write the reactants with their structures to produce Nylon-66. 5

2018

CSE 2018 · Q2(d) Syntheses of nylon 66, Teflon and Terylene [15 marks]

Give the synthetic schemes including reaction conditions for the preparation of the following polymers from their monomers :
(i) Nylon 66 (ii) Teflon (iii) Terylene

CSE 2018 · Q5(c) HDPE and LDPE: production, properties, uses [10 marks]

Distinguish between HDPE and LDPE with reference to their mode of production and physical properties. Mention any two applications for each.

CSE 2018 · Q7(d) Radical chain polymerisation of vinyl chloride with benzoyl peroxide [15 marks]

Explain the mechanism of free radical chain polymerization of vinyl chloride using benzoyl peroxide as an initiator.

IFoS 2018 · Q5(a) Number-average molecular weight from three fractions [5 marks]

Calculate $\overline{M}_n$ of a polymer consisting of three fractions with molecular weights 1×10^5, 2×10^5 and 3×10^5. The mole fractions are found to be 0·1, 0·5 and 0·4 respectively.

IFoS 2018 · Q5(b) Information from a Zimm plot [5 marks]

Zimmer plot constructed from light scattering results on polymer solutions, provides useful information. Justify your answer.

IFoS 2018 · Q5(c) Molecular weight of polystyrene from intrinsic viscosity [5 marks]

Determine the molecular weight of a polystyrene sample. Given a = 0·60, K = $1{\cdot}6\times10^{-4}$ dL/g and limiting viscosity number η = 0·4 dL/g.

IFoS 2018 · Q6(a) Teflon and LDPE; vulcanisation; proteins monodisperse; threshold molecular weight [20 marks]

Give reasons for the following: 5×4=20
(i) Teflon is an inert polymer, while LDPE is a branched polymer.
(ii) Natural rubber on masticating with about 30% sulphur becomes a hard plastic.
(iii) Proteins are considered as monodispersed polymers.
(iv) Threshold molecular weight of polyethylene is higher than that for nylons.

IFoS 2018 · Q7(b) Light scattering, end-group analysis, osmometry; nylon-6,6 versus 6,10 [20 marks]

Justify your answers for the following statements: 5×4=20
(i) Light scattering is a highly useful technique for the determination of molecular weight of a polymer.
(ii) The determination of molecular weight by end-group analysis of a polymer is carried out only if the number of determinable groups of molecules is known.
(iii) Osmometric method is preferred over viscosity method for the determination of molecular weight of a polymer.
(iv) Softening temperature of nylon 6,6 is higher than that of nylon 6,10.

IFoS 2018 · Q8(c) Polystyrene from benzene and its properties [10 marks]

Sketch the chemical reactions in the preparation of polystyrene starting from benzene and list a few important properties.

2017

CSE 2017 · Q7(d) Natural rubber, polystyrene, Teflon; terylene and PVC [10 marks]

Write structures of repeating units of natural rubber, polystyrene and teflon. How will you prepare terylene and PVC?

IFoS 2017 · Q6(b) Cross-linking; preparation of polyvinyl alcohol [10 marks]

What is cross-linking in the context of polymers? Suggest one method for obtaining polyvinyl alcohol.

IFoS 2017 · Q6(d) Borazine; Ziegler–Natta catalysis [10 marks]

(i) What is borazine? Why is it called 'Inorganic benzene'? 5

(ii) What is Zeigler-Natta catalysis? What is the active form of this catalyst? 5

IFoS 2017 · Q8(a) Molecular weight of polymers from viscosity [10 marks]

Write a short note on 'Determination of molecular weight by viscosity measurements'.

2016

CSE 2016 · Q6(c) Nylon-6,6 and Terylene: repeating units and manufacture [10 marks]

Write the structures of repeating units of Nylon-6,6 and Terylene. How are they prepared?

CSE 2016 · Q7(c) Synthetic rubbers: Buna-S and neoprene [10 marks]

Give any two types of synthetic rubber and write the preparation of monomeric units.

IFoS 2016 · Q5(a) Monomers of Teflon and Bakelite; addition or condensation [5 marks]

Write the names of monomers of the following polymers and classify them as addition or condensation polymers :

(i) Teflon (ii) Bakelite

IFoS 2016 · Q6(a) Number-average and weight-average molecular weight [10 marks]

Calculate $\overline{M}_n$ and $\overline{M}_w$ for a polymer that consists of 10% by weight of a macromolecule of molecular weight 10,000 and 90% by weight of a macromolecule with molecular weight 1,00,000.

IFoS 2016 · Q6(b) Viscosity-average molecular weight with an Ostwald viscometer [10 marks]

How will you determine the molecular weight of a polymer solution using Ostwald viscometer ?

IFoS 2016 · Q6(c) True or false: polymer statements [10 marks]

State whether *true* or *false*. If false, give the correct statement. 2×5=10

(i) Polyvinyl alcohol can be prepared by polymerization of vinyl alcohol.

(ii) CH_4 can be polymerized.

(iii) C_2H_2 and aniline cannot be polymerized.

(iv) Polymers have sharp melting point.

(v) Ziegler-Natta catalyst is used for the preparation of syndiotactic polymer.