

Polymers

Student Learning Outcomes

After studying this chapter, students will be able to:

- Define polymers as large molecules built up from many smaller molecules called monomers.
- Identify the repeating units and / or linkages in addition polymers and in condensation polymers.
- Deduce the structure or repeating unit of a condensation polymer from given monomers and vice versa, limited to:
 - a. polyamides from a dicarboxylic acid and a diamine
 - b. polyesters from a dicarboxylic acid and a diol.
- Describe the differences between addition and condensation polymerization.
- State that plastics are made from polymers.
- Describe how the properties of plastics have implications for their disposal.
- Describe the environmental challenges. caused by plastics, limited to:
 - o disposal in landfill sites
 - o accumulation in oceans
 - o formation of toxic gases from burning
- Describe the structure of:
 - o nylon, a polyamide
 - o PET, a polyester The full name for PET, polyethylene terephthalate, is not required.
- State that PET can be converted back into monomers and repolymerised
- Outline the importance of polymers in the textile industry. (Examples for polymers being used may be given along with their specific properties).





Polymers or macromolecules are extremely large molecules which are formed by linking together a very large number of simple molecular units called monomers. The process of formation of a polymer from a monomer is called polymerization. Carbohydrates, proteins and nucleic acids are the everyday examples of polymers which exist naturally. Whereas plastics, synthetic fibers, and natural rubber are the examples of man-made polymers. One of the most significant changes which has occurred throughout the world, has been the gradual replacement of metals, wood and cotton with man-made synthetic polymers. Polymers are important in our daily life due to their high strength, flexibility and resistance to heat and chemicals. These properties make them useful for a wide range of applications.

26.1 Types of Polymers

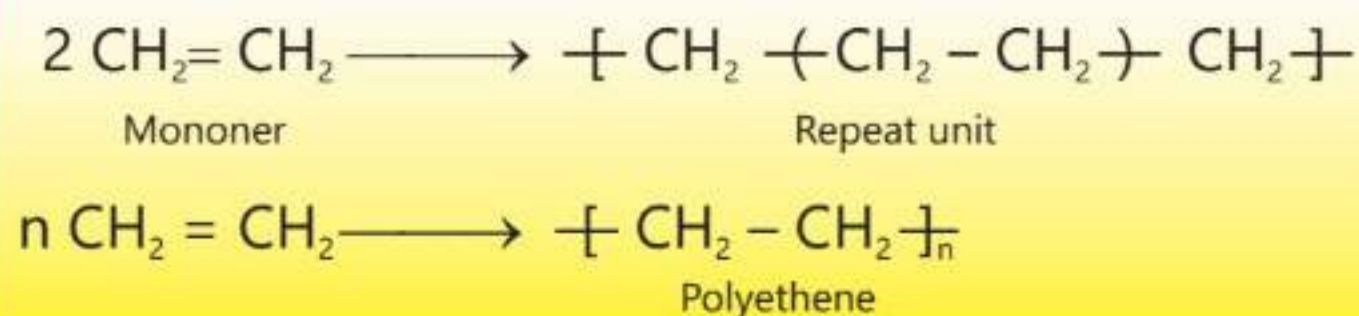
There are two main types of polymers.

- a) Addition Polymers
- b) Condensation Polymers

(a) Addition Polymers

Addition polymers are formed when monomer molecules containing a double bond combine together through a covalent bond to give a very large molecule. For example, a large number of ethene molecules add together to give one very big molecule which is called polyethene or polythene. During this reaction, the C=C double bond in ethene breaks down to allow ethene molecules to join together. Polymerization reactions usually take place at high pressure and in the presence of a catalyst.

In addition polymerization, no molecule is eliminated and no by-product is formed.



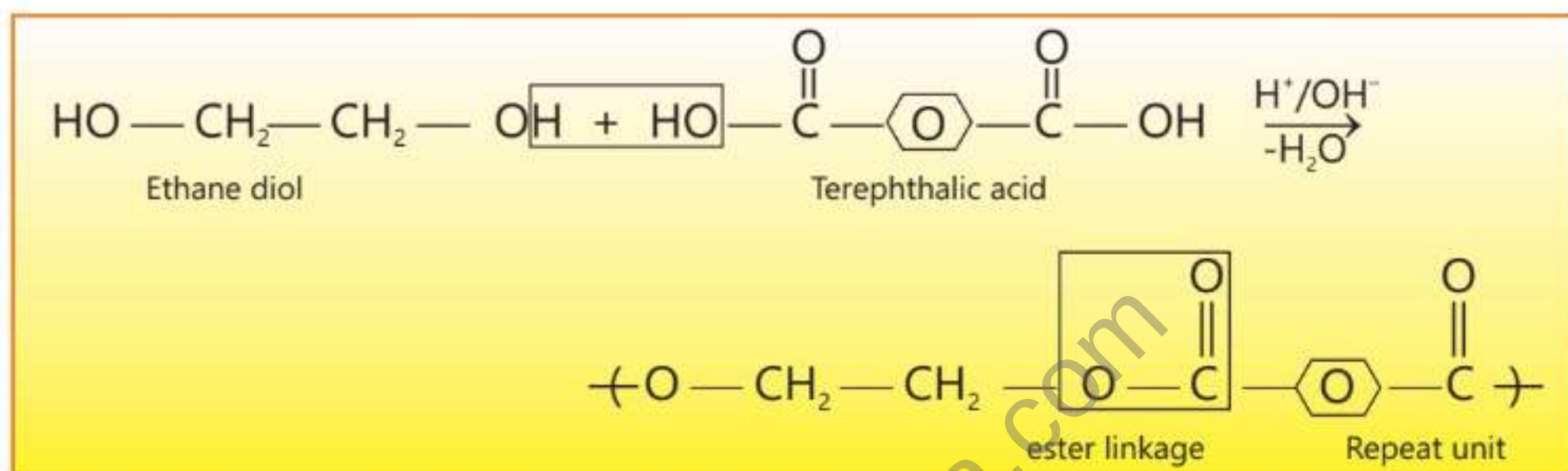
26.1 Quick Check!

- Give an example of a commercial product which is formed using polyethene.
- Write three properties of synthetic polymers.

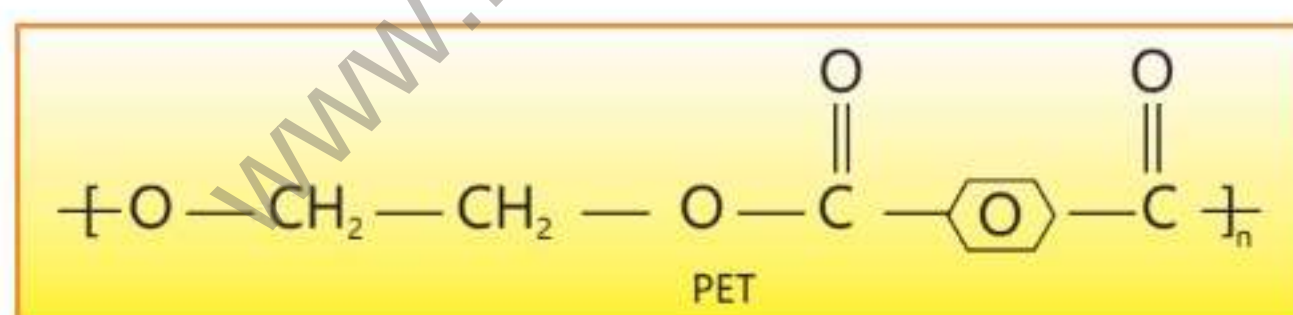


(b) Condensation Polymers

A condensation polymer is formed when two different molecules containing two different functional groups react together with the elimination of a small molecule like H_2O , HCl and NH_3 etc. The reaction takes place in the presence of an acid or a base. For example, ethane diol reacts with a dicarboxylic acid (terephthalic acid) to give a polymer called Polyethylene Terephthalate (PET). The carboxyl group present in terephthalic acid reacts with the hydroxyl group of the diol to give an ester linkage.

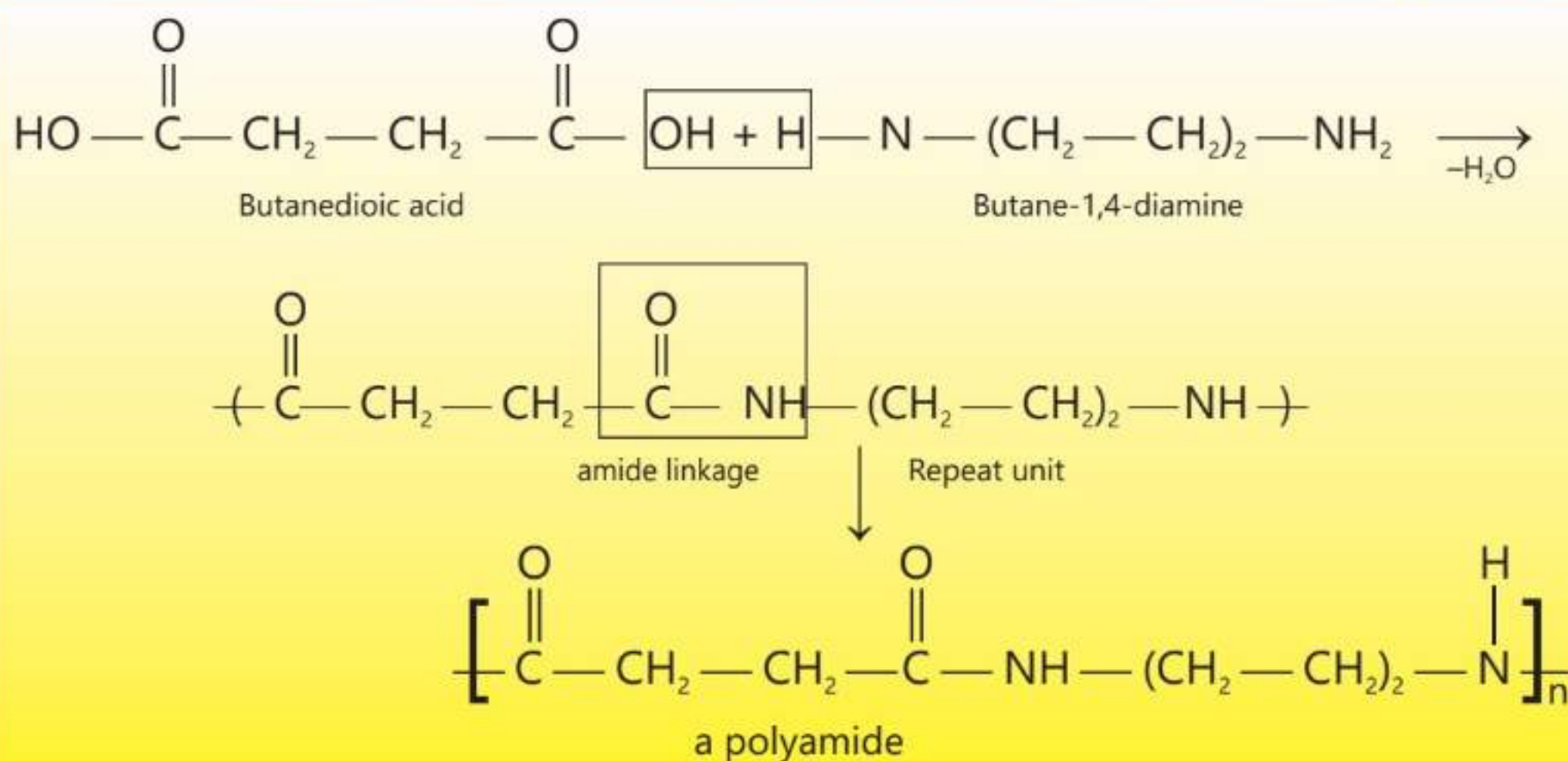


This product is called a repeat unit. Since the functional groups are present at both ends of the resulting molecule, the polymerization process continues at both ends to give a very big molecule, which is represented by the following structure.



PET can be recycled by chemically breaking down to the monomer units. Chemical recycling can be done through heating the polymer in the absence of oxygen.

Another condensation polymer, a polyamide, is formed when butanedioic acid reacts with a diamine. Each $-\text{COOH}$ group of the dicarboxylic acid reacts with each $-\text{NH}_2$ group present in diamine to form an amide linkage. A water molecule is lost during the condensation reaction. The repeat unit thus formed is then converted into a polymer.



26.2 Quick Check!

- How an ester linkage between two monomers is formed?
- How does condensation polymerization occur?

Interesting Information!

Properties of polymers can be changed through careful control of their chemical structure and composition enabling their use in highly specific application like non-stick coating (Teflon).



Differences between Addition and Condensation Polymerizations.

Addition Polymerization	Condensation Polymerization
A single monomer is used which should have a double or a triple bond.	This polymerization takes place between two monomers. The monomer molecules have two functional groups present one on each end of the molecule.
It involves an addition reaction and only a single product is formed.	It involves the condensation between two monomers with the elimination of a small molecule like H ₂ O, HCl or NH ₃ .
The molecular mass of the product polymer can be found by adding the molecular masses of all the monomers used.	The molecular mass of the polymer cannot be found by adding the molecular masses of all the monomers.



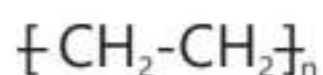


Addition Polymerization	Condensation Polymerization
The polymer formed contains only the single bonds along the polymer backbone chain.	The polymer formed contains a specific linkage, e.g. ester linkage or amide linkage.
Examples of addition polymers are polyethene, polystyrene, polyvinylchloride (PVC), etc.	Examples of condensation polymers are polyester, nylon, bakelite, etc.

26.2 Structure of Monomer from Polymer

Addition Polymer

- Write down the structure of addition polymer.



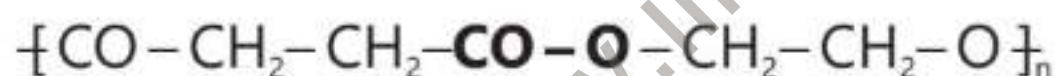
- Identify the repeating unit in the polymer. Remove the brackets, the extended bonds from each side and the subscript n. Change the single bond to a double bond.



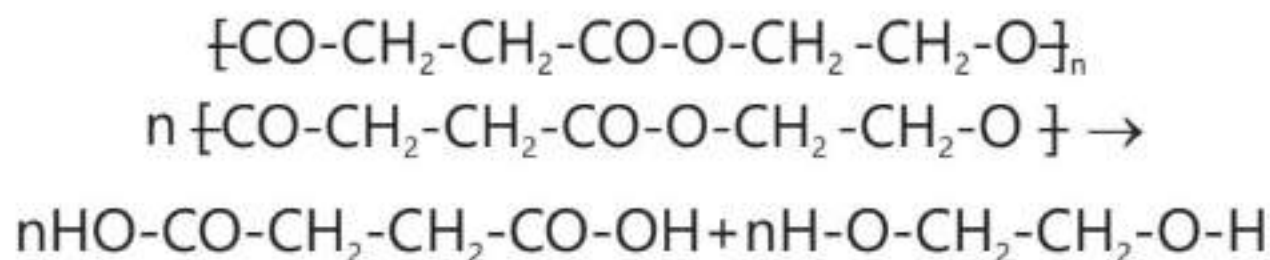
Condensation Polymer

26.1 Example:

- Write down the structure of a condensation polymer, polyester.



- Identify the repeating unit in the polymer. Remove the brackets, the extended bonds at both the ends and the subscript n. Break the bond between CO and O of the ester linkage. Add OH to the each end of the dicarboxylic acid monomer. Add H to each end of the diol monomer.



26.2 Example:

- Write down the structure of a condensation polymer, a polyamide.

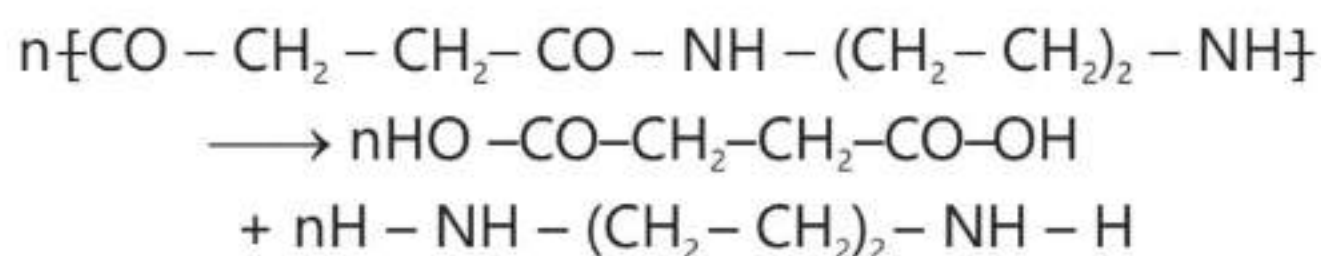


- Identify the repeating unit in the polymer. Remove the brackets, remove the extended linkage at both the ends and subscript n. Break the bond between the CO and NH of the amide linkage. Add OH to the each end of dicarboxylic acid





monomer. Add H to each end of the diamine monomer.



26.3 Quick Check!

- What do you understand by the term repeating unit?
- Draw the structure of a polyamide linkage.

Interesting Information!

By varying the type and proportion of monomers, chemists can make such polymers which show specific properties, such as flexibility, strength and thermal stability to meet specific application requirements.

26.3 Plastics

Polymerization of monomers like ethylene, propylene and styrene gives polyethylene (PE), polypropylene (PP) and polystyrene (PS) respectively. All these polymers are a few examples of compounds called Plastics. These plastics are used to make all types of carry-home food containers, eg, soft drink bottles, water bottles, juice bottles etc. They are also used to manufacture shopping bags, kitchen-wares, buckets, tables, chairs, food wrappers, cups and plates etc. Plastics are light weight, flexible and durable. They can be easily moulded into solid objects of almost any desired shape. All these properties have led to their widespread use in almost any sphere of our daily life. Starting from early 20th century millions of tons of plastics are made every year (Figure 26.1).



Figure 26.1: Plastic products

26.4 Importance of Polymers in Textile Industry

Polymers which are used in the textile industry are called synthetic fibers. Examples of synthetic fibers are nylon, polyester, rayon, acrylic etc. The





properties of synthetic fibers which enable them to be used in textile industry are as follows:

1. They are cheaper in cost than natural fibers like cotton and silk.
2. They are stronger and more durable than natural fiber.
3. They do not shrink.
4. They resist wrinkling.
5. They are light weight and quick drying.
6. They are moth and insect resistant.



Figure 26.2: Plastic in textile

The polyesters and nylon are the two common polymers which account for 69% of all the material used in clothing industry worldwide. Polyester is an important fiber for its strength and resistance to shrinking. It is commonly used in sportswear and hosiery. Acrylic is light weight, soft and provides warmth (Figure 26.2).

26.5 Adverse Effects of Plastics

Unlike other materials, plastics do not undergo biodegradation. When articles made of plastics are discarded, they can take upto 1000 years to break down. This fact has led to build up of huge amounts of plastics in the environment. Accumulation of such a huge amount of different articles made of plastics has caused widespread environmental problems. Plastic pollution is found almost everywhere on lands, in air and in all the water bodies: rivers, ponds, lakes, seas and oceans. This pollution has reached to an extremely alarming level and has led to cause serious health problems.

Discarded plastic articles we put in the bins are disposed of through burning, dumping in the landfill, thrown in the drains from where they make their



Figure 26.3: Plastic pollution





way to rivers and oceans. Burning of discarded plastic articles in town, creates a hazardous environmental condition because this releases dangerous gases in air (Figure 26.3).

Interesting Information!

Polymers can be 3D printed using a variety of techniques. These techniques involve layer-by-layer deposition of the polymer material to create three-dimensional objects.

EXERCISE

A Multiple Choice Questions

Choose and tick the correct answer from the given choices.

1. Which of the following polymer is a synthetic polymer:

- | | |
|----------------|---------------|
| (a) Starch | (b) Cellulose |
| (c) Animal fat | (d) Polyester |

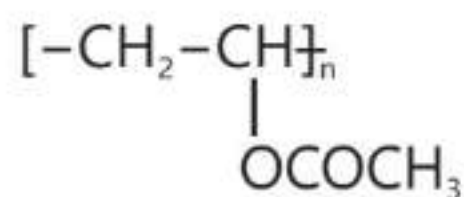
2. Which polymer has an amide linkage:

- | | |
|----------------|-----------------|
| (a) Polyester | (b) Polyamide |
| (c) Polyethene | (d) Polystyrene |

3. Identify an ester linkage:

- | | |
|--|---|
| (a) $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{R}$ | (b) $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}$ |
| (c) $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{NH}-\text{R}$ | (d) $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}-\text{R}$ |

4. The structure of the monomer of the following polymer is:



- | | |
|--|--|
| (a) $\text{CH}_2=\text{CH}_2$ | (b) $\text{CH}_2=\text{CH}_2-\text{CH}_3$ |
| (c) $\text{CH}_2=\text{CH}-\text{OCOCH}_3$ | (d) $\text{CH}_2=\text{CH}-\text{CO}-\text{O}-\text{CH}_3$ |

5. Which of the following polymers can be recycled?

- | | |
|---------|-----------------|
| (a) PET | (b) Polystyrene |
| (c) PVC | (d) Epoxy |

6. Which of the following polymers is biodegradable?

- | | |
|---------------|---------------|
| (a) Polyamide | (b) Polyester |
| (c) Starch | (d) PET |





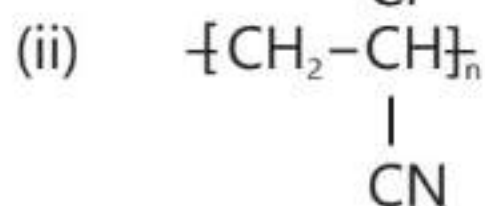
7. Which of the following polymers is obtained by condensation polymerization?
- | | |
|------------------------|-----------------|
| (a) Polyvinyl chloride | (b) Polystyrene |
| (c) Polyamide | (d) Polyethene |

B Short Answer Questions

- 26.1. Give two examples each of addition polymers and condensation polymers.
- 26.2. How polymers are useful for us?
- 26.3. How synthetic fibers are different from natural fibers?
- 26.4. Are natural polymers hazardous for the environment? Explain why?
- 26.5. Draw the structures of the following polymers.
- | |
|-------------------|
| (a) Polypropylene |
| (b) Polystyrene |

C Constructed Response Questions

- 26.1. Why is it dangerous to burn discarded articles made of plastics?
- 26.2. Why is it not advisable to dump discarded synthetic articles in oceans?
- 26.3. What is the role of catalyst in addition polymerization?
- 26.4. Deduce the monomer from the following addition polymers.



D Descriptive Questions

- 26.1. How is PET formed? Can you recycle this polymer?
- 26.2. Differentiate between addition and condensation polymerizations.
- 26.3. Write down reactions alongwith the conditions to prepare polyamide and polyester.
- 26.4. Describe the role of synthetic polymers in the textile industry.
- 26.5. Describe the effects of synthetic polymers on the environment.



Pairing Scheme / Instructions for Preparation of Exam Paper of Chemistry for Class-10

ESSENTIAL INSTRUCTIONS FOR PAPER SETTERS

The paper of Chemistry (General) for class 10 will consist of 60 marks. Timing of the paper will be two hours. The paper will be made as per following details:

Objective:

Q-1:

12 Multiple Choice Questions

$$1 \times 12 = 12$$

The detail is as follows:

Chapter	14	15	16	17	18	19	20	21	22	23	24	26
No. of Short Questions	1	1	1	1	1	1	1	1	1	1	1	1

Subjective:

Q-2:

Part-I:

5 short answer questions have to be answered out of 8.

$$2 \times 5 = 10$$

The detail is as follows:

Chapter	14	15	16	17	18
No. of Short Questions	2	1	1	2	2

Q-3:

Five (5) short answer questions have to be answered out of Eight (8). The detail is as follows:

$$2 \times 5 = 10$$

Chapter	19	20	21	22
No. of Short Questions	2	2	2	2

Q-4:

Five (5) short answer questions have to be answered out of Eight (8). The detail is as follows:

$$2 \times 5 = 10$$

Chapter	23	24	25	26
No. of Short Questions	2	2	2	2

Subjective:

This section will contain three detailed questions bifurcated in two-part **a & b** (carrying 5 & 4 marks each) and students have to attempt 2 questions The detail is as follows:

$$2 \times 9 = 18$$

Part-II:

Q-5:

Chapter	14	15
Part	a	b

Q-6:

Chapter	20	22
Part	a	b

Q-7:

Chapter	23	25
Part	a	b





MODEL PAPER OF CHEMISTRY FOR CLASS-10

Objective Type

Max. Marks: 12

Time allowed: 15 Min.

کل نمبر: 12

وقت: 15 منٹ

Note: Four possible answers A, B, C and D to each question are given. The choice which you think is correct, fill that circle with marker or pen ink in the answer-book. Cutting or filling two or more circles will result in zero mark in that question.

نوٹ: ہر سوال کے چار ممکنہ جوابات A، B، C اور D دیے گئے ہیں۔ جو انتخاب آپ کے خیال میں درست ہے، اس سوال کے سامنے والے دائرے کو مار کر یا پین کی سیاہی سے بھریں۔ دو یا دو سے زیادہ دائروں کو کاٹنے یا بھرنے کی صورت میں جواب غلط تصور ہوگا۔

Q.1. Select the correct answer.

(1×12=12)

1- درست جواب کا انتخاب کریں۔

- (i) Which gas will diffuse at the fastest rate? کون سی گیس سب سے زیادہ تیز ڈیفیوژ ہوگی۔
 (a) HCl (b) SO₂ (c) H₂S (d) CO₂
- (ii) Volume occupied by 15 moles of ammonia gas at RTP پر 15 مولز کا والیوم RTP کے 15 مولز کا والیوم
 (a) 224 dm³ (b) 160 dm³
 (c) 360 dm³ (d) 265 dm³
- (iii) Which of the following metal is the highest in the electrochemical series? الیکٹروکیمیکل سیریز میں کون سی میٹل کی پوزیشن سب سے اوپر ہے؟
 (a) Tin ٹن (b) Iron آئرن
 (c) Magnesium میگنیشیم (d) Zinc زنک
- (iv) The shape of the crystal of NaCl is: سوڈیم کلورائیڈ کے کرسٹل کی شکل و صورت ہے:
 (a) Cubic کیوبک (b) Hexagonal ہیکزگونل
 (c) Rhombic رومبک (d) Trigonal ٹرائیگونل
- (v) The oxide that is neutral in character: ایک ایسا آکسائیڈ جس کی خاصیت نیوٹرل ہے:
 (a) Al₂O₃ (b) SO₂ (c) CO₂ (d) NO
- (vi) The pH of distilled water is: ڈسٹلڈ واٹر کی pH ہے:
 (a) 6.5 (b) 8.5 (c) 7 (d) 7.5
- (vii) Select the general formula of alkyne family. الکائین فیملی کا جنرل فارمولا بتائیں:
 (a) C_nH_{2n+1} (b) C_nH_{2n} (c) C_nH_{2n-1} (d) C_nH_{2n-2}
- (viii) Which of the following is not used as a fuel? مندرجہ ذیل میں سے کون سا بطور ایندھن استعمال نہیں ہوتا:
 (a) LPG ایل۔ پی۔ جی (b) CNG سی۔ این۔ جی
 (c) Diesel ڈیزل (d) Asphalt اسفالٹ
- (ix) Which of the following acids is present in apple? سیب میں درج ذیل میں سے کون سا ایسڈ موجود ہوتا ہے:
 (a) Citric acid سٹرک ایسڈ (b) Tartaric acid ٹارٹارک ایسڈ
 (c) Acetic acid ایسٹک ایسڈ (d) Malic acid میلک ایسڈ
- (x) If the reactants possess an energy higher than the activation energy, then the reaction will be: اگر ری ایکشنز کی انرجی ایکٹیویشن انرجی سے زیادہ ہو تو ری ایکشن کیسے وقوع پذیر ہوگا؟
 (a) Slow سست (b) Fast تیز
 (c) Not affected اثر نہیں ہوگا (d) Instantaneous فوری





- (xi) Which polymer can be recycled? (xi) درج ذیل میں کونسا پولیمر ری سائیکل کیا جاسکتا ہے؟
 (a) PET پی۔ای۔ٹی (b) Polystyrene پولی سٹائرین
 (c) PVC پی۔وی۔سی (d) Epoxy ایپوکسی
 (xii) Which catalyst other than H_3PO_4 can also be used for hydration of alkenes. (xii) H_3PO_4 کے علاوہ کون سا کیٹالسٹ الکینز کی ہائیڈریشن کے لیے استعمال کیا جاسکتا ہے؟
 (a) NaOH (b) H_2SO_4
 (c) CH_3COOH (d) Ni

Subjective Type (Part I)

Time allowed: 1:45 Hrs.

Max. Marks: 30

Q. 2: Write short answers to any five (05) questions:

کوئی سے پانچ (5) سوالات کے مختصر جوابات لکھیے:

- (i) Is condensation an endothermic process? (i) کیا کنڈن سیشن حرارت جذب کرنے والا عمل ہے؟
 (ii) Why ice melts when the pressure is exerted on it? (ii) جب برف پر دباؤ بڑھایا جاتا ہے تو وہ کیوں پگھلتی ہے؟
 (iii) Why is percentage yield important? (iii) پرنسٹیج ییلڈ کیوں اہم ہے؟
 (iv) What are the main objectives of electroplating? (iv) الیکٹروپلیٹنگ کے بنیادی مقاصد کیا ہیں؟
 (v) Give any two features of the catalytic action of an enzyme. (v) کسی انزائم کے بطور کیٹالسٹ عمل کرنے کی کوئی سی دو خصوصیات بتائیں۔
 (vi) From where do molecules get energy to attain higher energy state? (vi) ہائر انرجی سٹیٹ حاصل کرنے کے لیے مالیکیولز انرجی کہاں سے حاصل کرتے ہیں؟
 (vii) Name two insoluble carbonates. (vii) کوئی سے دو نا حل پذیر کاربونیٹس کے نام بتائیں۔
 (viii) What is crystal lattice? (viii) کرسٹل لیٹس کسے کہتے ہیں؟

Q. 3: Write short answers to any five (05) questions:

کوئی سے پانچ (5) سوالات کے مختصر جوابات لکھیے:

- (i) How nitrogen is obtained from air? (i) نائٹروجن ہوا سے کیسے حاصل کی جاتی ہے؟
 (ii) How fossil fuels produce SO_2 ? (ii) فوسل فیولز SO_2 کیسے پیدا کرتے ہیں؟
 (iii) What is trachoma disease? (iii) ٹراکوما کون سی بیماری ہے؟
 (iv) What is the difference between sedimentation and filtration? (iv) سیڈیمینٹیشن اور فلٹریشن میں کیا فرق ہے؟
 (v) Define structural isomerism. (v) سٹرکچرل آئسومرزم کی تعریف کریں۔
 (vi) Write down the structural formula of Butan-2-ol. (vi) بیوٹین-2-اول کا سٹرکچرل فارمولہ تحریر کریں۔
 (vii) How an alkene can be identified? (vii) الکیئن کو کیسے شناخت کیا جاتا ہے؟
 (viii) Why is oxyacetylene flam so hot? (viii) آکسی ایسیٹائلین شعلہ بہت گرم کیوں ہوتا ہے؟





Q. 4: Write short answers to any five (05) questions:

کوئی سے پانچ (5) سوالات کے مختصر جوابات لکھیے:

- (i) Give any two disadvantages of fermentation reaction. (i) فرمٹیشن ری ایکشن کے دو نقصانات بتائیں۔
- (ii) How ethanol is prepared from ethene? (ii) اتھنول سے ایٹھانول کیسے تیار کی جاتی ہے؟
- (iii) What is esterification reaction? (iii) ایسٹریفیکیشن ری ایکشن کسے کہتے ہیں؟
- (iv) How does ethanol react with propanoic acid? (iv) ایٹھانول، پروپینوئک ایسڈ کے ساتھ کیسے ری ایکشن کرتا ہے؟
- (v) What is the role of enzyme in our body? (v) ہمارے جسم میں انزائمز کیا کردار ادا کرتے ہیں؟
- (vi) What is glycoside linkage? (vi) گلائکوسائیڈک لنکیج کسے کہتے ہیں؟
- (vii) What is the role of catalyst in addition polymerization? (vii) ایڈیشن پولیمرائزیشن میں کیٹالسٹ کیا کردار ادا کرتا ہے؟
- (viii) How does condensation polymerization reaction occur? (viii) کنڈنسیشن پولیمرائزیشن ری ایکشن کیسے وقوع پذیر ہوتا ہے؟

Subjective Type (Part II)

نوٹ: کوئی سے دو سوالات کے جوابات لکھیے۔ **Note: Attempt any two questions.**

- Q5:** (a) Differentiate between evaporation and boiling. (5) ایوپوریشن اور بوائیٹنگ میں فرق واضح کریں۔
- (b) How would you identify the limiting reactant in a chemical reaction? (4) ایک کیمیکل ری ایکشن میں لیملٹنگ ری ایکٹنٹ کو کس طرح شناخت کیا جاسکتا ہے؟
- Q6:** (a) What is fertilizer? Mention the essential qualities of a good fertilizer. (5) کھاد کسے کہتے ہیں؟ اچھی کھاد کی اہم خصوصیات کا ذکر کریں۔
- (b) Describe two methods of preparation for ethene. (4) اتھین کی تیاری کے لیے دو طریقے بیان کریں۔
- Q7:** (a) Describe the applications of ethanol in pharmaceutical and cosmetic industries. (5) فارماسیوٹیکل اور کاسمیٹک انڈسٹری میں اتھنول کے استعمال کی وضاحت کریں۔
- (b) What are carbohydrates? Describe their classification with examples. (4) کاربوہائیڈریٹس کسے کہتے ہیں؟ مثالوں کے ساتھ اس کی کلاسیفیکیشن کی وضاحت کریں۔

