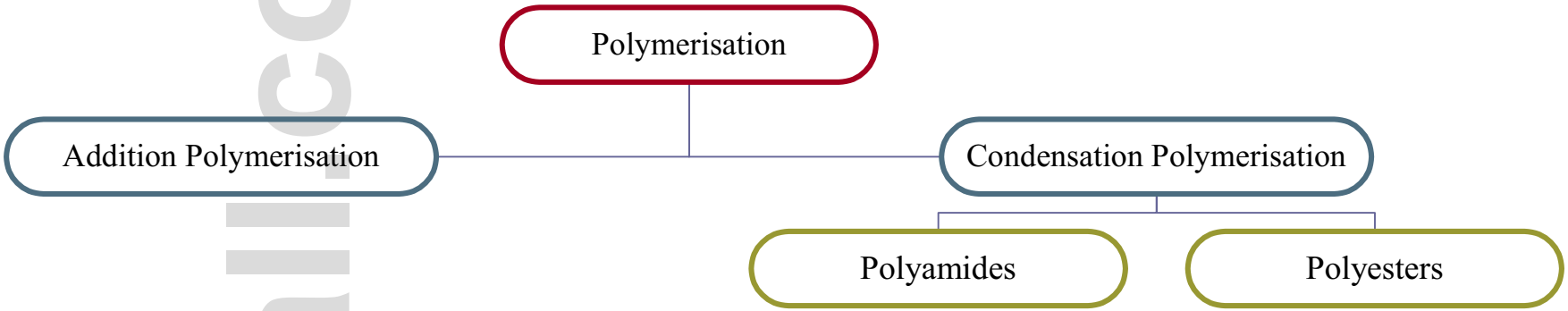
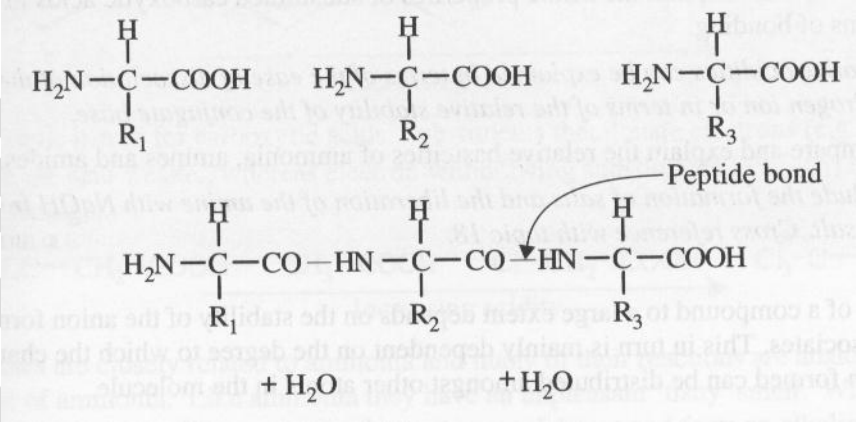
General Overview



Addition Polymerisation	Monomers containing double bonds undergo an addition reaction.
Condensation Polymerisation	Two different functional groups are required and for each new bond formed between the monomer units, a small molecule is eliminated.
Polyamides	Amine group bonds with carboxylic acid group to form an amide linkage, example: nylon.
Polyesters	Alcohols bond with carboxylic acid to form an ester. Example: Terylene.

Peptides & Proteins:

Are formed of 2-amino acids that react in the presence of bond carboxylic acid and amine function groups. For example:



Determining the properties of polymers:

Chain Length	The greater the average chain length, the greater are the intermolecular forces and hence the higher the strength and melting point.
Intermolecular Forces (IMFA's)	The stronger the IMFA's, the higher the strength and the melting point of the polymer.
Branching	A straight chain polymer can pack closer together. The presence of branches limits how close polymer chains can come to each other, thus lowering IMFA's, leading to lower density and melting point.
Cross-linking	The greater the cross-linking between the chains, the more rigid the polymer.

Types of Plastic

Type	Formation Reaction	Explanation
Thermoplastic	Addition Reactions	Plastics keep shape on cooling, but can be reheated and re-molded.
Thermosetting	Condensation Reactions	Plastics can be molded when heated, but due to substantial cross-linking, they cannot be re-molded once cooled.

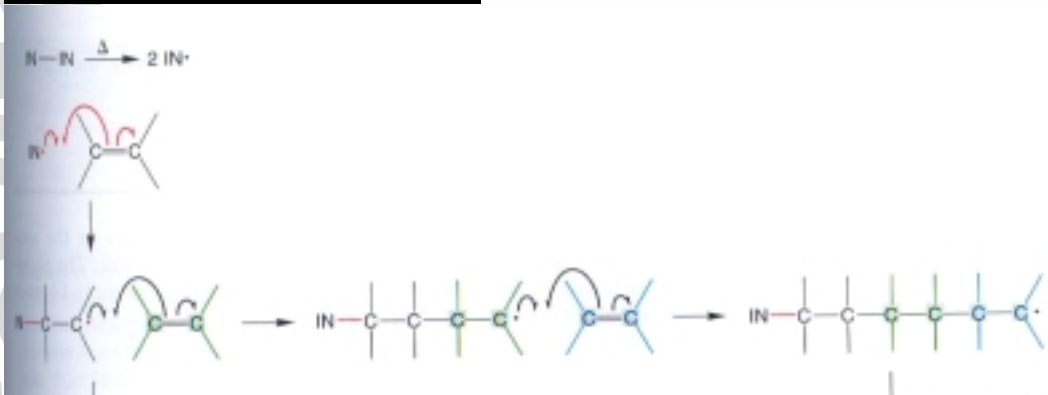
Polymerisation Review **Brett Anderson**

Properties and uses of some plastics

Properties and uses of some plastics

Polymer	Type of plastic	Properties	Uses
Polyethene $(-CH_2-CH_2-)_n$	Thermoplastic; becomes soft and melts on heating; can be moulded, excellent insulators; unreactive.	(a) Low density polymer, low melting point (~100°C). (b) High density polymer, high tensile strength, higher melting point (~140°C).	(a) Packaging material, plastic bags etc. (b) Plastic Chairs, tables, rigid bottles etc.
Polyurethane foams	Thermosetting can be made flexible by adding a blowing agent. Produce toxic vapours in fires.	(a) Flexible polyurethane foams have low strength and low density. (b) Rigid polyurethanes have higher tensile strength and density.	(a) Materials for furniture etc. (b) Insulators in building panels etc.
Polyvinyl chloride (PVC)	Thermoplastic polymer with wide range of physical properties; plasticizers added which make it more flexible	(a) Flexible PVC has low tensile strength and density. (b) Rigid PVC has higher density and strength.	(a) Raincoats, handbags, shower curtains, etc. (b) Pipes, tiles, rigid bottles, etc.
Phenol-methanal plastics	Cross-linked by covalent bonding.	Chemically inert; electrical and thermal insulators; non-flammable; high density, high strength.	Electric switches, electronic casings, utensil handles, etc.

Example: Addition Polymerization



Some Monomers and Polymers

Table 10.2 Some Monomers and Polymers

Monomer	Polymer Formula	Name	Monomer	Polymer Formula	Name
$H_2C{=}CH_2$ Ethylene	$(CH_2)_n$	Polyethylene, polymethylene	$F_2C{=}CF_2$ Tetrafluoroethylene	$(CF_2)_n$	Poly(tetrafluoro-ethylene), Teflon
Styrene	$-(CH_2-CH)_n-$	Polystyrene	$H_2C{=}CHCl$ Vinyl chloride	$-(CH-CH_2)_n-$ (Cl)	Poly(vinyl chloride)
			$H_2C{=}CHCOOCH_3$ Methyl acrylate	$-(CH-CH_2)_n-$ ($COOCH_3$)	Polyacrylate

Polymer Review Questions

1. **A plastic wrap has the following structural unit:** $\left[\begin{array}{cccc} H & & Cl & \\ | & & | & \\ -C & - & C & - \\ | & & | & \\ H & & Cl & \end{array}\right]_n$ **Draw a structure for the monomer and name it.**

   $CH_2 = CCl_2$
   1,1 - dichloroethene

2. **Define Polymer.**
   A long chain molecule that is composed of thousands of simple repeating units (monomers).

3. **What is the common structural feature of monomers that form addition polymers? Give an example of a common addition polymers.**
   Monomers that form addition polymers are always unsaturated, during the reaction the double bonds ($\pi + 246kJ$) break. They open to form strong σ bonds (-348KJ/mol). Ex: Polyethene.

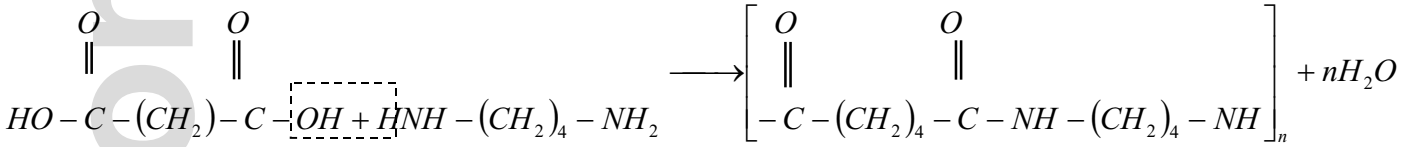
4. **What is necessary for an addition polymerization reaction to occur?**
   Requires an initiator such as O_2 or peroxide that has been converted to a free radical, (condensation reaction requires at least 2 different monomers that have functional groups at both ends of the molecule).

5. **Write formulas to represent the polymers formed from the following monomers.**

$HC_2 = CH_2$	$\left[-CH_2 - CH_2\right]_n$
$H_2C = CHCl$	$\left[-CH_2 - CHCl-\right]_n$
$HC_2 = CF_2$	$\left[-H_2C - CF_2-\right]_n$
$(CH_3)CH = CH(CH_3)$	$\left[-CH_3CH - CHCH_3\right]_n$

6. Distinguish between an addition polymer and a condensation polymer.

An addition polymer forms when simple unsaturated monomers join together by breaking open the π-bond. Condensation polymers form when each monomer loses an atom or groups of atoms from each end of the molecule, and new linkages form between the remaining parts of the monomer units. The smaller molecules usually eliminated include H_2O, NH_3, CH_3OH and HCl.
For example:

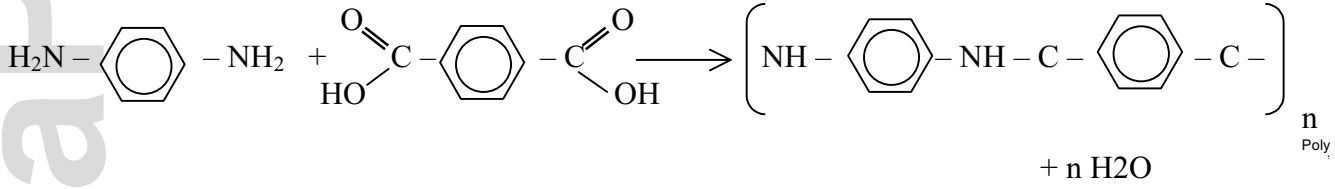


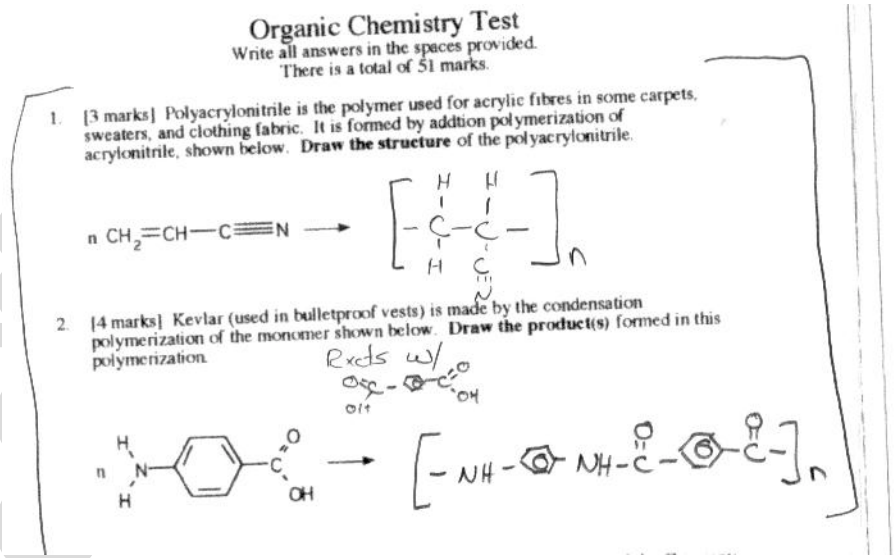
The product is polyhexamethylene adipamide. (nylon-6,6)
This is a copolymer: formed by the union of two or more different kinds of monomers.

7. What type of polymer will form during the reaction of a diol and a dicarboxylic acid?

Polyester.

8. Write the reaction for the formation of reaction for Kevlar. It is a condensation reaction between 1,4-diaminobenzene and 1,4-benzoic acid.





Organic Chemistry Test

Write all answers in the spaces provided.
There is a total of 51 marks.

1. [3 marks] Polyacrylonitrile is the polymer used for acrylic fibres in some carpets, sweaters, and clothing fabric. It is formed by addtion polymerization of acrylonitrile, shown below. **Draw the structure** of the polyacrylonitrile.

$n\ CH_2{=}CH{-}C{\equiv}N \longrightarrow$

2. [4 marks] Kevlar (used in bulletproof vests) is made by the condensation polymerization of the monomer shown below. **Draw the product(s)** formed in this polymerization.

Rxds w/

Practice Questions

1. The proper term used to describe a polymer made by combining large numbers of identical monomers is which of the following?

a. natural polymer
b. addition polymer
c. thermoset polymer
d. Condensation polymer
e. Thermoplastic polymer

2. The primary structure of a protein involves which of the following?

a. Van der Waals forces
b. hydrogen bonds
c. hydrophilic forces
d. peptide bonds
e. Disulfide bonds

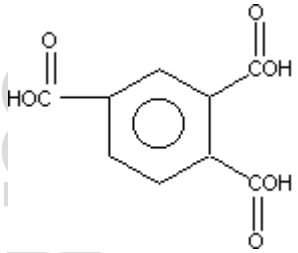
3. Which one of the following statements is incorrect?

a. nylon polymers consist of diamine and dicarboxylic acid monomers
b. hydrogen bonding provides great strength to Kevlar
c. polyesters consist of dialcohol and dicarboxylic acid monomers
d. isoprene (rubber) is a condensation polymer
e. disulfide bonds add strength in rubber

4. All amino acids contain at least one amino group and at least one of which of the following?

a. carboxylic acid
d. carbon ring

6. The polymer Torlon is used in automotive engines as a plastic replacement for steel parts. It is produced from the monomers.



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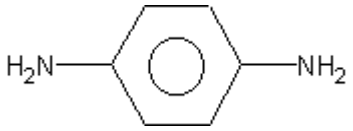
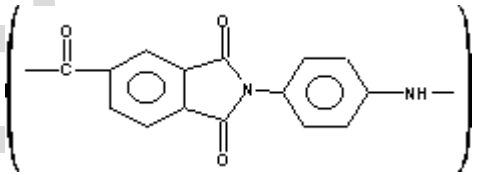
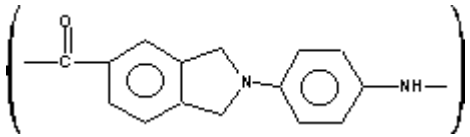


What is the formula of Torlon?

a.



c.



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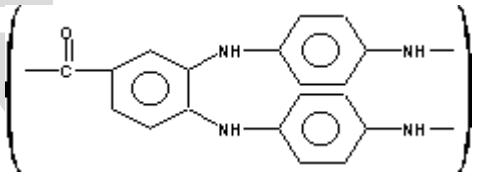

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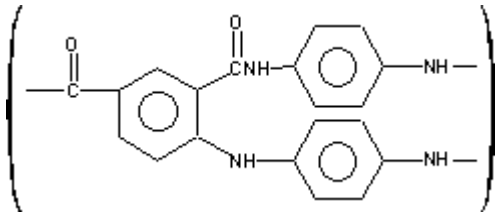
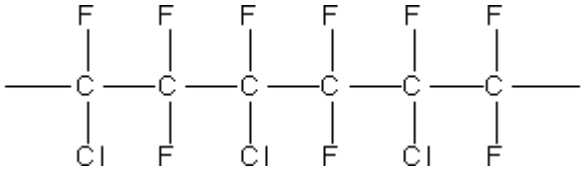
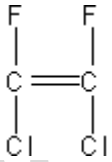


7. What is the monomer for the polymer Kel-F shown below?



a.



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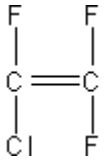


b.

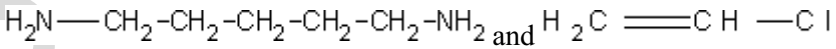
d.

8. Latex paint consists of several components. Use your knowledge of polymers to determine which of these compounds is most likely a polymer.

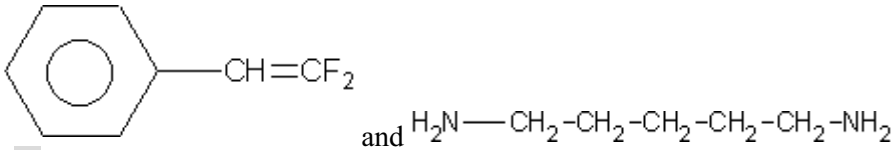
a. a colored pigment
b. a volatile solvent that evaporates
c. a binder hardens to form a continuos film
d. an emulsifier to keep the paint mixed

9. Which one of the following contains compounds from which a condensation polymer can be produced?

a.



b.



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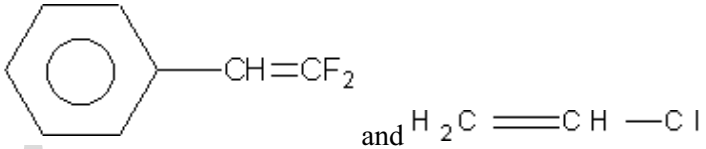

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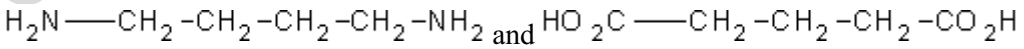
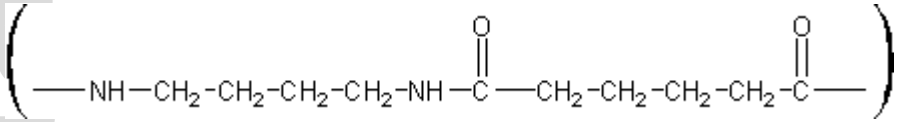
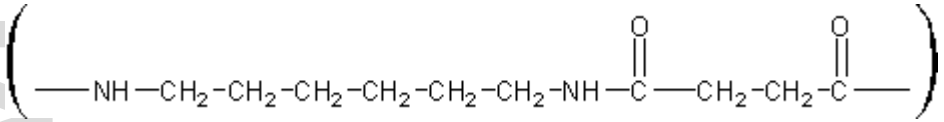


10. Which of the following polymers is Nylon 6,4?

a.



b.



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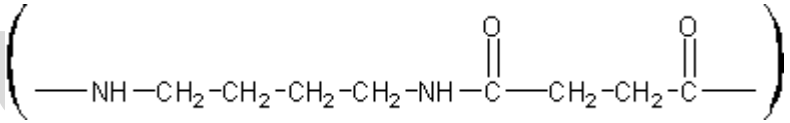
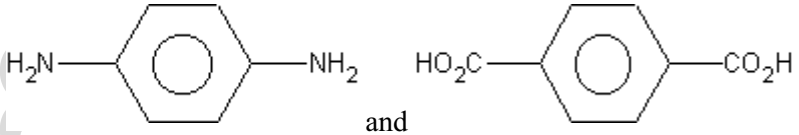


d.

Complete the following:

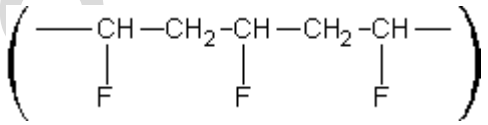
1. Kevlar, a strong polymer used in bullet proof vests, is made by the following condensation of monomers:



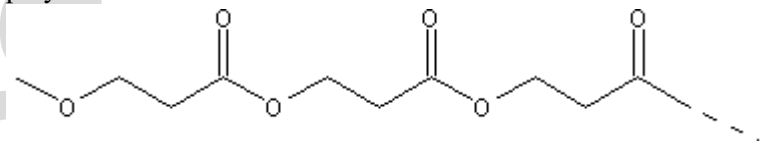
and

The structure of the polymer Kevlar is _____.

2. The monomer that must be used to produce the polymer given below is _____.



3. The polymer with the structure given below is classified as a(n) _____ polymer.



4. Protein molecules are composed of amino acids held together by _____ functional group.

5. The last stage of the addition polymerization reaction when two unpaired electron ends combine is called _____.

6. Why does the rubber in an elastic band easily stretch, whereas the rubber on the soles of shoes does not?

Answers

Multiple Choice

1B 2D 3D 4A 5A 6A 7C 8C 9D 10 B

Completion

3.Addition 4. Amide 5.termination