Raffles Institution
Year 6 H2 Chemistry 2026
Tutorial 21: Polymers (Suggested Answers)

Self Check Questions

Q1

Ans: C
The monomer of Teflon is $CF_2=CF_2$.

M_r of $CF_2=CF_2 = 2\times12.0 + 4\times19.0 = 100.0$

No. of $CF_2=CF_2$ monomers $= \dfrac{200000}{100.0} = \underline{2000}$

Q2

M_r of one repeating unit
= 2(14.0) + 2(16.0) + 8(12.0) + 14(1.0)
= 170

Since M_r of nylon chain must be between 10 000 and 20 000, let the M_r of nylon chain be 10 030.

Minimum number of repeating units
$= \dfrac{10\,030}{170}$
= 59

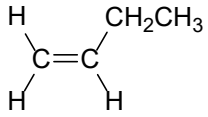
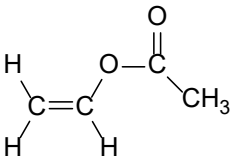
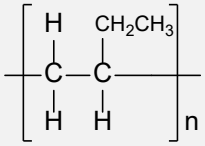
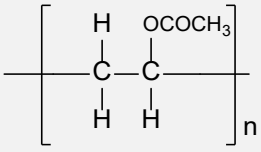
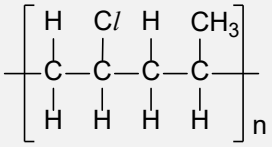
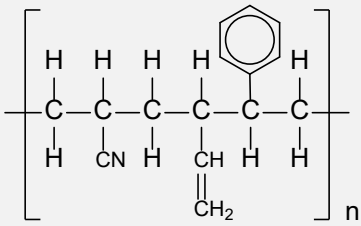
*Note: The minimum number of repeating units cannot be 58 as $M_r = 58 \times 170 = 9860$

Q3

type of polymerisation	addition	condensation
type of monomer	Involves monomers containing C=C double bonds / alkenes (unsaturated compounds)	Involves monomers containing two different functional groups e.g. alcohol, carboxylic acid or amino ($-NH_2$) functional groups. (NOT necessarily need two different monomers)
empirical formula	empirical formula of polymer = empirical formula of monomer	Empirical formula of the condensation polymer is not the same as that of the monomer due to the elimination of a small molecule (H_2O)

Q4

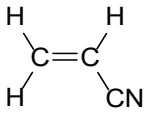
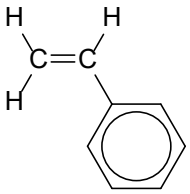
type of reaction addition

(a)	(b)	(c)	(d)
		CH_2=CHCl and CH_2=CH-CH_3	CH_2=CH-CN and CH_2=CH-CH=CH_2 and C_6H_5CH=CH_2 Acrylonitrile Butadiene Styrene, ABS (in this sequence)
			

Q5(a)

addition

Q5(b)

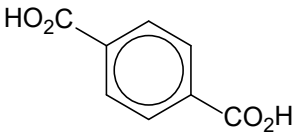
 and 

Practice Questions

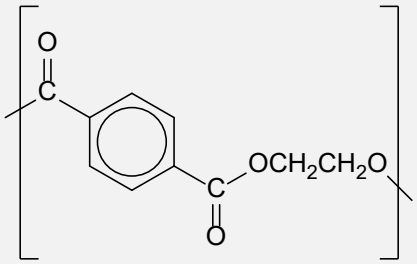
Q6

type of reaction condensation

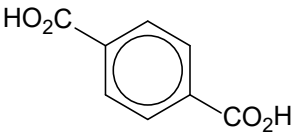
(a)



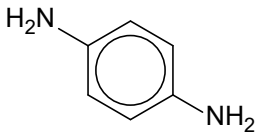
and $HOCH_2CH_2OH$

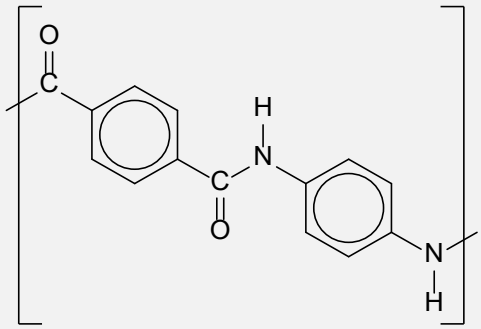


(b)



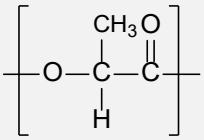
and





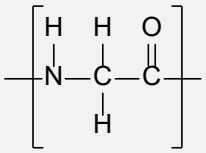
(c)

$CH_3CH(OH)COOH$



(d)

H_2NCH_2COOH

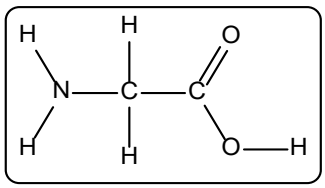


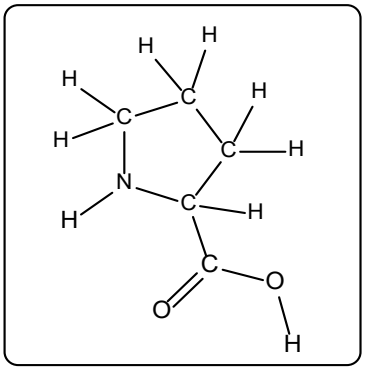
Q7

A

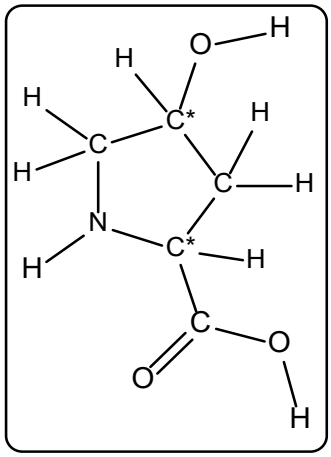
Q8(a)
6 different amino acids

Q8(b)(i)



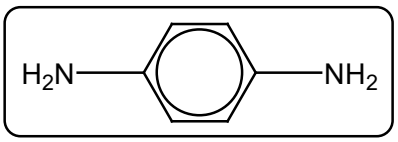


Q8(b)(ii)

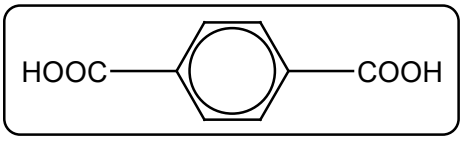


Q8(c)(i)
Any one method:
- Heat with strong acid for several hours
- Heat with strong alkali for several hours

Q8(c)(ii)

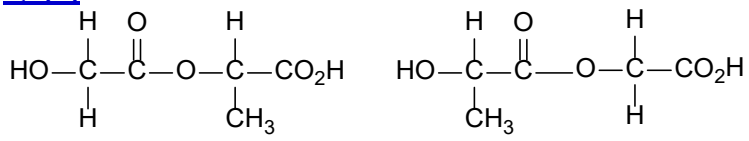


and



Q8(c)(iii)
The monomers of proteins are amino acids that generally have the same general formula of $H_2NCH(R)COOH$ which are naturally occurring while the monomers of Kevlar® are dicarboxylic acids and diamines which are synthetic or man-made.

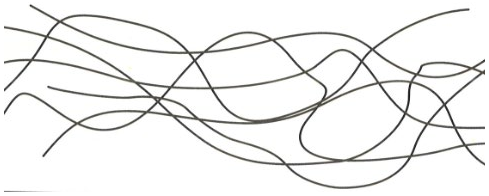
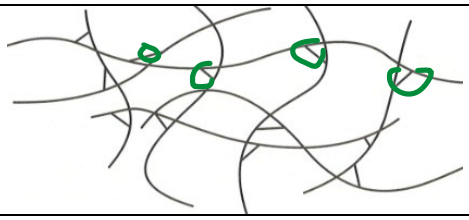
Q8(d)



Q8(e)(i)
Hydrolysis reaction

Q8(e)(ii)
The products of hydrolysis are hydroxyacids that are able to form extensive intermolecular hydrogen bonds with water molecules, enabling them to be soluble in water.

Q9

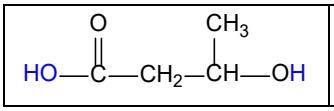
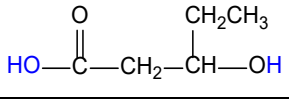
Polymer	**A**	**B**
		
properties	It is hard and rigid at room temperature but soft when heated. It can be melted and molded into shapes that are retained when the polymer is cooled.	It is very hard and rigid and cannot be melted to form a liquid phase. It degrades upon heating.

There are **no cross-links** between the polymer chains in polymer A but there are **cross-links** (which are usually covalent bonds or extensive H-bonds) between the polymer chains in polymer B.

Thermoplastic polymers
- there are extensive intermolecular forces of attraction (such as id-id interactions, pd-pd interactions and hydrogen bonds) between chains so it is hard at room temperature
- chains are not cross-linked, which are formed via stronger covalent bonds
- heating provides the energy to overcome these weaker forces of attraction **between** the individual polymer chains, causing them to **slide** past each other, and the material melts/soften.

In thermoset polymer, although cross-links are mostly covalent bonds, there are examples of cross-links which are hydrogen bonds. Due to the extensiveness of these cross-links, **strong heating** is require to **break the cross-links**, it may result in a polymer not being able to melt and soften and instead **degrade**.

Q10(a)(i)

Q10(a)(ii)
condensation

Q10(a)(iii)
Atom economy of the production of PHBV is 100%. The side product formed is H_2O and it is not a pollutant. Hence all of the product molecules are useful.

Q10(a)(iv)
The ester linkages in PHBV are easily broken/hydrolysed when in contact with acids found in the environment.

Q10(a)(v)
hydrolysis

Q10(a)(vi)
The p–orbital of each carbon atom overlaps side-on with the p–orbitals of its neighbouring C atoms, forming an extended π–electron cloud along the carbon chain.

The electrons found in the extended π–electron cloud are delocalised. These delocalised electrons helps to carry the charges along the carbon chain of the polymer.

Q11(i)
variable 1: dimensions of each sheet
variable 2: shape of the masses used
variable 3: location of the two supports at opposite ends
others: temperature, gravity,

Q11(ii)
gradient from graph = $\frac{\text{amt of bend / °}}{\text{mass / g}}$
Since the polymer has to be strong and a little flexible, it must have small amount of bend for large mass. Thus, the gradient must be small.

Polymer **D** is chosen.
OR: D can withstand largest mass applied, since the line continues to largest value along x-axis
D has some bend shown.

Q11(iii)
Since Polymers **C** and **D** are made from the same hydrocarbon monomer, the monomer is ethene.

Using Fig 5.1, Polymer **C** is LDPE and **D** is HDPE.

Difference in their structures:

Polymer **C** consists of long carbon chains with many branches along the chain. It does not pack well due to branching which also resulted in weaker instantaneous dipole-induced dipole interactions between the chains. Hence, low density.

Polymer **D** consists of long chains joined together in a linear fashion which pack well and resulted in stronger instantaneous dipole-induced dipole interactions between the chains. Hence high density.

Difference in their properties:
Comparing polymer **C** and **D**, polymer **C** shows a larger gradient, thus it has a larger amount of bend for the same mass. Thus, polymer **C** is more flexible and polymer **D** is stronger.