

Polymerisation

Question Paper 7

| | |
|-------------------|-----------------------|
| Level | International A Level |
| Subject | Chemistry |
| Exam Board | CIE |
| Topic | Polymerisation |
| Sub-Topic | |
| Paper Type | Theory |
| Booklet | Question Paper 7 |

Time Allowed: 78 minutes

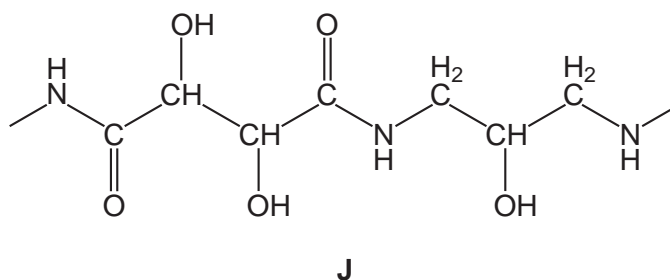
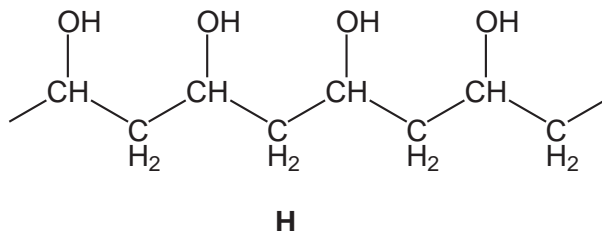
Score: /65

Percentage: /100

Grade Boundaries:

| A* | A | B | C | D | E | U |
|------|-------|-----|-------|-------|-----|------|
| >85% | 77.5% | 70% | 62.5% | 57.5% | 45% | <45% |

- 1 Hydrophilic polymers find important uses in the manufacture of contact lenses and wound dressings. Their chemical structures allow them to bond with water molecules, which keeps them soft and flexible. Sections of two hydrophilic polymers are shown below.



- (a) What type of polymerisation has produced
- (i) polymer **H**?
- (ii) polymer **J**? [2]
- (b) What type of attractions might occur between these polymers and molecules of water? [1]
- (c) Chains of polymer **H** can be 'cross-linked', i.e. joined together, by reaction with a small bifunctional molecule.
- (i) Which one of the following molecules would be most suitable for such cross-linking?

(place a tick in one box only)

| | |
|--|--------------------------|
| HOCH ₂ CH ₂ OH | <input type="checkbox"/> |
| H ₂ NCH ₂ CH ₂ NH ₂ | <input type="checkbox"/> |
| HOCH ₂ CH ₂ CO ₂ H | <input type="checkbox"/> |
| HO ₂ CCH ₂ CH ₂ CO ₂ H | <input type="checkbox"/> |
| H ₂ NCH ₂ CH ₂ CO ₂ H | <input type="checkbox"/> |

- (ii) What type of bond would be formed during the cross-linking?

..... [2]

- (d) (i) Suggest the reagents and conditions needed to hydrolyse polymer **J** into its monomers.

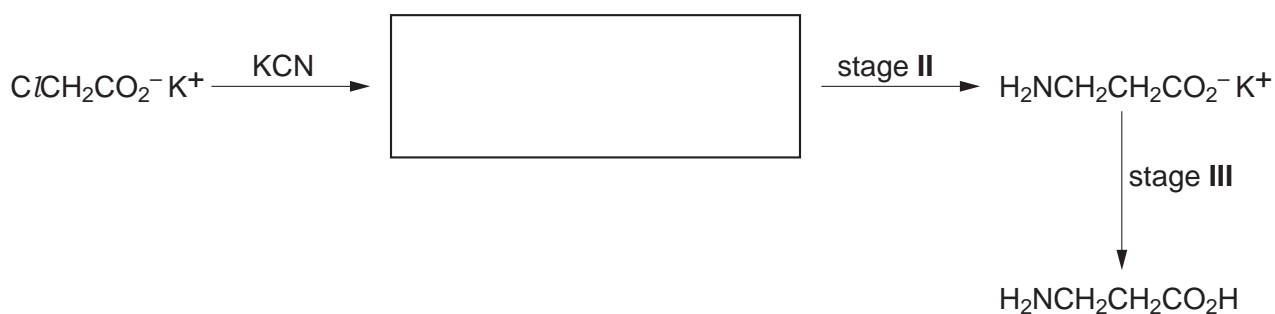
.....

- (ii) Draw the structural formulae of the two products of this hydrolysis reaction.

.....

[3]

- (e) The last compound in the list in (c)(i) above is 3-aminopropanoic acid. This can be made from potassium chloroethanoate by the following 3-stage route.



- (i) In the box above write the structure of the intermediate in this route.
- (ii) Suggest reagents and conditions for

stage II

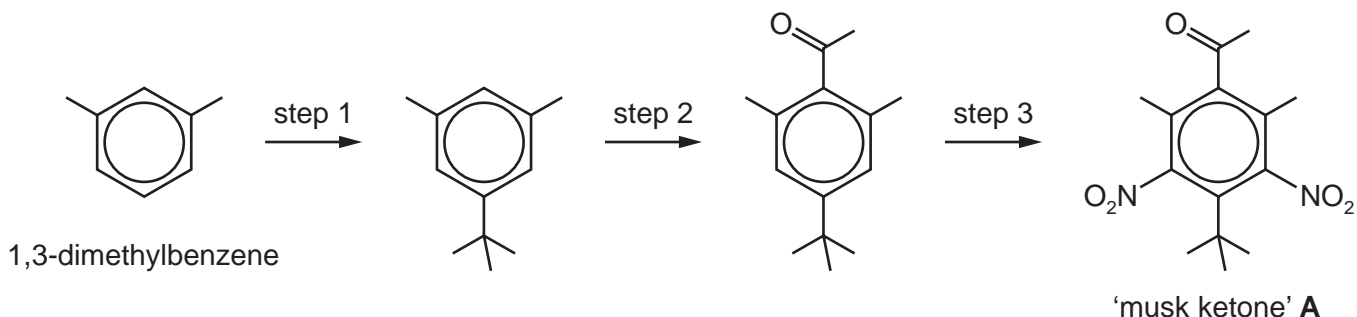
stage III

[3]

[Total: 11]

2 1,3-dimethylbenzene is a useful starting material for several commercially important compounds.

(a) The artificial ‘musk ketone’, **A**, is a perfume agent added to many cosmetics and detergents. It is made from 1,3-dimethylbenzene by the following route.



(i) The only by-product of step 2 is HCl.

Suggest the reagent that was used in this step.

..... [1]

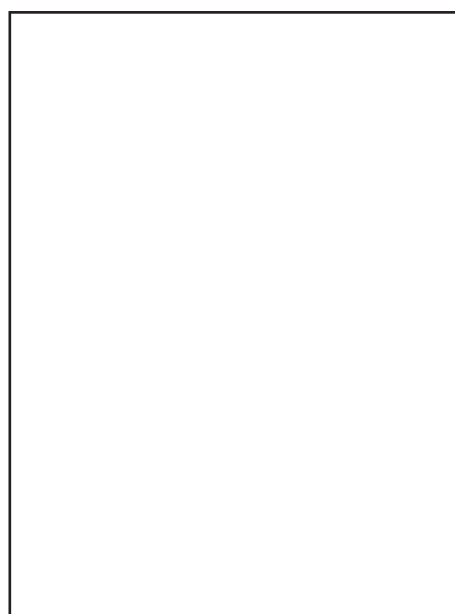
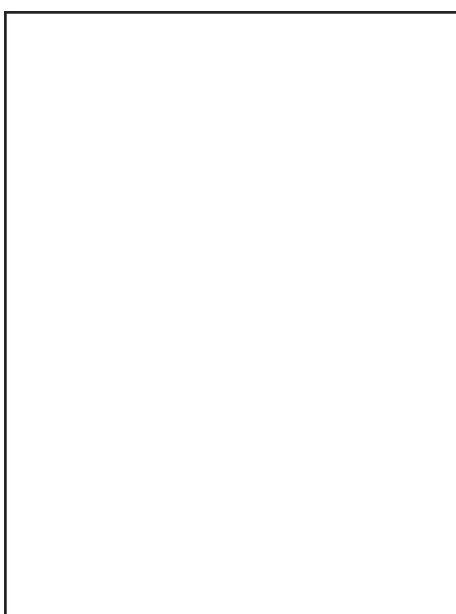
(ii) Suggest the *type of reaction* that is occurring during both step 2 and step 3.

..... [1]

(iii) State the reagents and conditions needed for step 3.

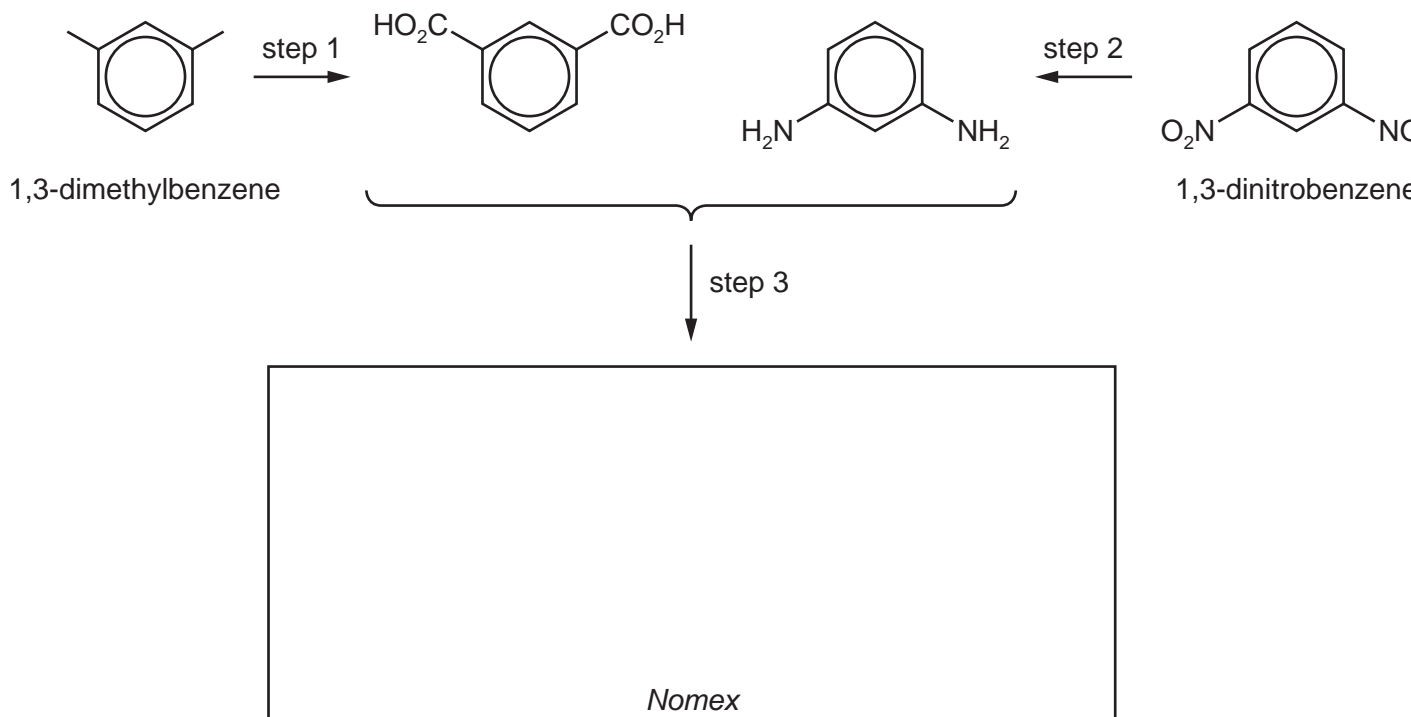
..... [1]

(iv) Suggest the structures of the two products formed when **A** is reacted with alkaline aqueous iodine.



[2]

- (b) 1,3-dimethylbenzene is also a starting material for the synthesis of the polymer *Nomex*, used in fireproof protective clothing worn by firefighters, military pilots and racing car drivers. The polymer is made from 1,3-dimethylbenzene and 1,3-dinitrobenzene by the following route.

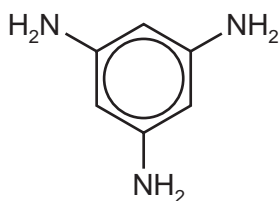


- (i) Draw the structure of one repeat unit of *Nomex* in the box above. [1]
- (ii) What type of polymer is *Nomex*? [1]

- (iii) Suggest the by-product formed during step 3. [1]

- (iv) Suggest reagents and conditions for step 2. [1]

- (v) Suggest how and why the properties of the polymer might change if some of the diamine monomer were replaced with 1,3,5-triaminobenzene.



1,3,5-triaminobenzene

..... [1]

- 3 (a) The table shows the structures of four amino acids found in proteins in the human body.

Complete the table by indicating the type of tertiary interaction each side-chain is most likely to have when its amino acid is present in a protein chain.

| amino acid | structure | type of interaction |
|------------|---|---------------------|
| alanine | $\text{H}_2\text{NCH}(\text{CH}_3)\text{CO}_2\text{H}$ | |
| cysteine | $\text{H}_2\text{NCH}(\text{CH}_2\text{SH})\text{CO}_2\text{H}$ | |
| lysine | $\text{H}_2\text{NCH}((\text{CH}_2)_4\text{NH}_2)\text{CO}_2\text{H}$ | |
| serine | $\text{H}_2\text{NCH}(\text{CH}_2\text{OH})\text{CO}_2\text{H}$ | |

[3]

- (b) Metal ions play an important role in the biochemistry of the human body. For each of the following metal ions, outline one of the places in the body it can be found and its main role there.

iron

.....

.....

potassium

.....

.....

zinc

.....

.....

[3]

(c) Many chemical reactions at a cellular level require energy in order to take place. This energy is largely provided by the breakdown of one particular compound.

(i) Write an equation showing the breakdown of this compound.

.....

(ii) What type of chemical reaction is this?

.....

[2]

(d) Cystic fibrosis is a genetic disease caused by a mutation in the DNA sequence resulting in the production of a faulty version of an important protein which acts as an ion pump in the cell membrane. This pump controls the flow of ions into and out of cells. People with the faulty protein show two major symptoms.

- water is retained in cells in the lungs resulting in the formation of a thick, sticky mucous outside the cells;
- their sweat is very salty.

Based on the information given for people with cystic fibrosis,

(i) suggest which ions are involved in the ion flow,

.....

.....

(ii) suggest and explain what type of bonding might result in thick or sticky mucous.

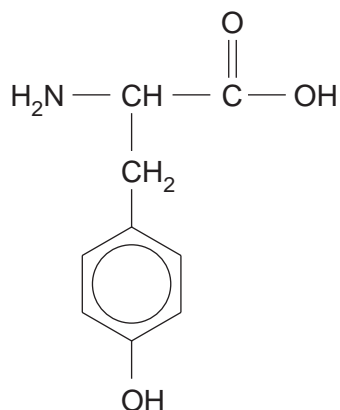
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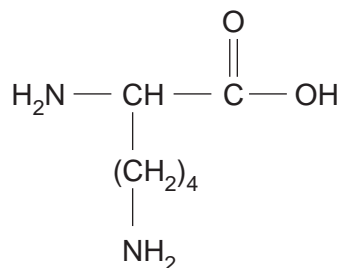
[2]

[Total: 10]

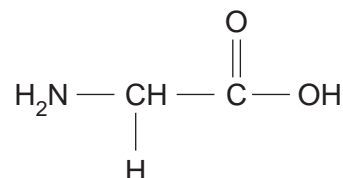
4 The amino acids tyrosine, lysine and glycine are constituents of many proteins.



tyrosine



lysine



glycine

(a) State the reagents and conditions you could use to break proteins down into amino acids.

..... [2]

(b) Draw a ring around each chiral centre in the above molecules. [1]

(c) In aqueous solution amino acids exist as zwitterions. Draw the zwitterionic structure of glycine.

..... [1]

(d) For each of the following reactions, draw the structure of the organic compound formed.

(i) glycine + excess NaOH(aq)

.....

(ii) tyrosine + excess NaOH(aq)

.....

(iii) lysine + excess HCl(aq)

.....

(iv) tyrosine + excess Br₂(aq)

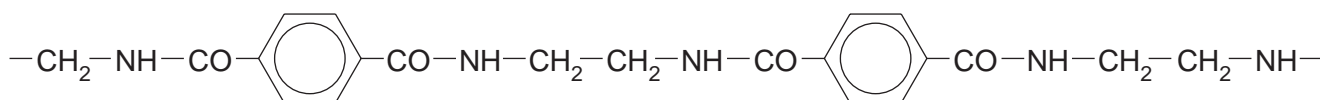
.....

[5]

(e) Draw the structural formula of a tripeptide formed from **all three** of these amino acids, showing clearly the peptide bonds.

..... [2]

(f) The formula of part of the chain of a synthetic polyamide is shown below.



(i) Identify the repeat unit of the polymer by drawing square brackets around it on the above formula.

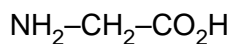
(ii) Draw the structures of the **two** monomers from which the polymer could be made.

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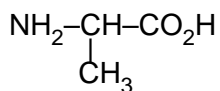
[3]

[Total: 14]

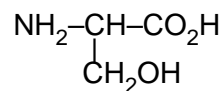
- 5 Much research has been carried out in recent years investigating the exact structure of silk. The silk of a spider's web is at least five times as strong as steel, and twice as elastic as nylon. A silk fibre is composed of many identical protein chains, which are mainly made from the amino acids glycine, alanine and serine, with smaller amounts of four other amino acids.



glycine



alanine



serine

- (a) Amino acids can exist as zwitterions. Draw the zwitterionic structure for glycine.

[1]

- (b) Amino acids can act as acids or bases. Write equations to show:

- (i) the reaction between alanine and $\text{HCl}(\text{aq})$,

.....

- (ii) the reaction between serine and $\text{NaOH}(\text{aq})$.

.....

[2]

- (c) Draw the structural formula of a portion of the silk protein, showing three amino acid residues. Label a peptide bond on your structure.

[3]

- (d) What *type* of polymer is silk protein?

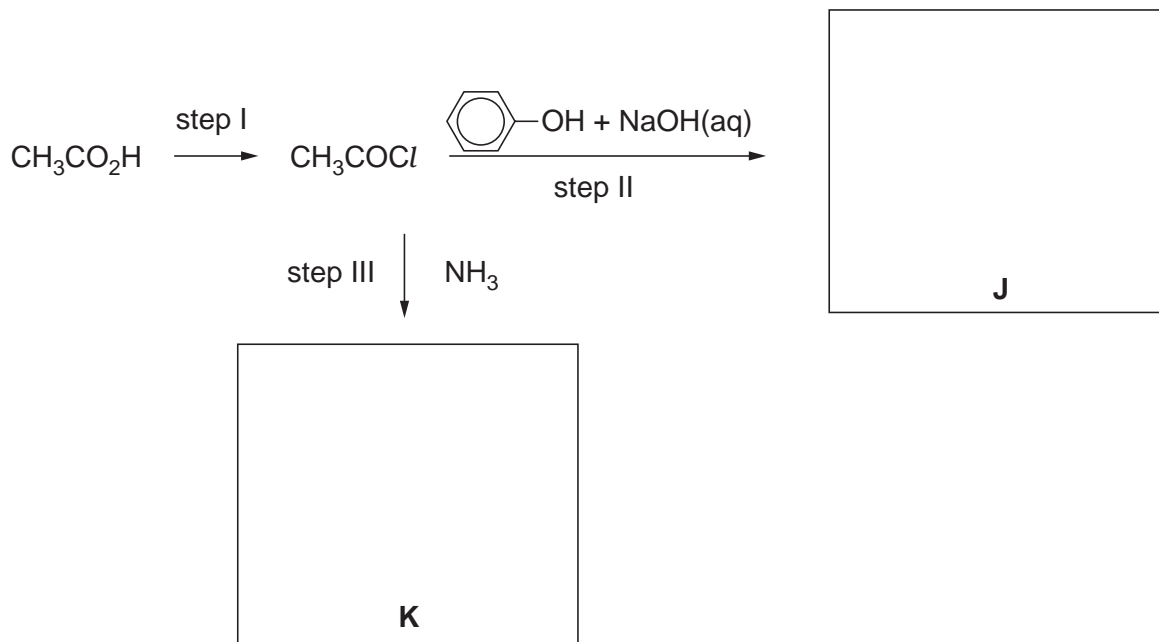
.....[1]

- (e) The M_r of a silk protein molecule is about 600,000. Assuming it is made from equal amounts of the above three amino acids, calculate the average number of amino acid residues in the protein chain. [M_r (glycine) = 75; M_r (alanine) = 89; M_r (serine) = 105]

number of residues = [3]

[Total: 10]

- 6 (a) Acyl chlorides are useful intermediates for making various acid derivatives. The following reaction scheme shows some of the reactions of ethanoyl chloride.



- (i) Suggest a reagent for step I.

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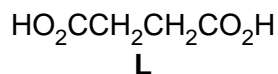
- (ii) Write an equation showing the reaction between phenol and NaOH(aq), the reagents in step II.

.....

- (iii) Draw the structural formulae of products **J** and **K** in the boxes above.

[4]

- (b) The diacid **L** occurs naturally and is used as a food additive to enhance the acidic flavour in some fruit drinks.



When the diacyl chloride of **L** is reacted with $\text{HOCH}_2\text{CH}_2\text{OH}$, a polymer is formed.

- (i) What type of polymerisation is occurring here?

.....

- (ii) Write an equation showing the reaction between **one** mole of the diacyl chloride of **L** and **two** moles of $\text{HOCH}_2\text{CH}_2\text{OH}$.

[3]

- (c) The following formula represents a section of another polymer.



- (i) What type of polymer is this?

.....

- (ii) Draw the structural formula of each of the monomers that make up this polymer.

[3]

[Total : 10]