Amino acids

4.7.3.3 · Organic chemistry · revision notes

Amino acids have two different functional groups, so they can join by condensation polymerisation to make polypeptides and proteins. Higher tier only, and GCSE Chemistry only. Expect questions on glycine, the functional groups, the water lost and the repeating unit of a polypeptide.

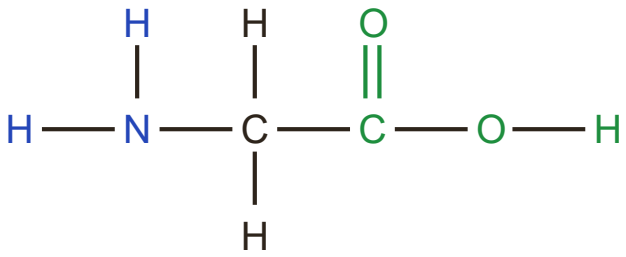
Key facts

- Amino acid: two different functional groups, $–NH_2$ (amine) and –COOH (carboxylic acid)
- Amino acids → polypeptide + water (condensation polymerisation)
- Repeating unit from glycine: $–NH–CH_2–CO–$
- Chain of x amino acids: x − 1 water molecules released
- Glycine: H_2NCH_2COOH
- n H_2NCH_2COOH → $–(HNCH_2CO)_n–$ + n H_2O
- Different amino acids in the same chain → proteins

Notes

Amino acids

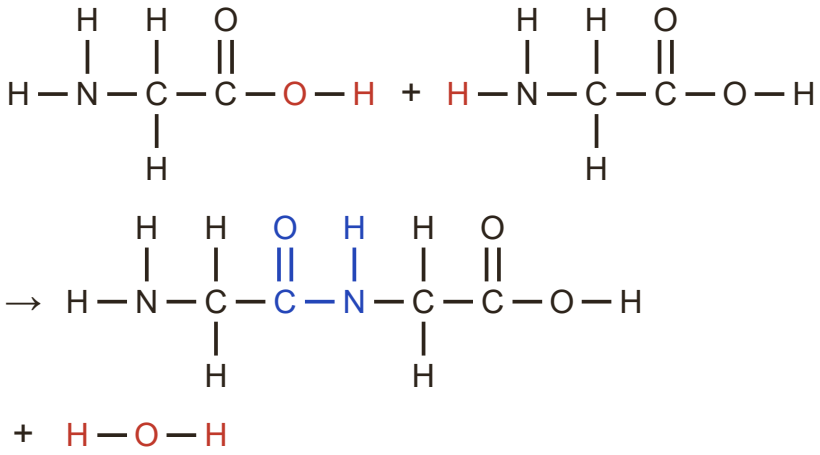
- Amino acids have **two different functional groups** in the same molecule: an **amine** group, $–NH_2$, and a **carboxylic acid** group, –COOH.
- The simplest is **glycine**, H_2NCH_2COOH:



- Other amino acids have a different group in place of one of the H atoms on the middle carbon, e.g. alanine, $H_2NCH(CH_3)COOH$.

Making polypeptides

- Amino acids join by **condensation polymerisation**: the $–NH_2$ group of one molecule reacts with the –COOH group of the next, and a molecule of **water** is lost.
- Each amino acid has both groups, so a single type of amino acid can polymerise on its own. (A polyester needs two different monomers.)
- Glycine forms a **polypeptide**:
  $n\ H_2NCH_2COOH \rightarrow –(HNCH_2CO)_n– + n\ H_2O$
- The repeating unit is $–NH–CH_2–CO–$, where CO is a C=O group. The amino acids are joined by –CO–NH– links.



The –OH of one amino acid and an H of the next (red) leave as water.
The new link –CO–NH– is in blue.

- Each link releases one water molecule, so a chain of 50 amino acids releases 49 water molecules. The equation shows n H_2O because n is very large.

Proteins

- Different amino acids can be combined in the same chain to make **proteins**.
- There are many different amino acids, and they can be joined in any order (sequence), so a huge number of different proteins is possible.
- Proteins are natural polymers whose monomers are amino acids.

How to answer each type of question

Recall: functional groups and products

1 to 4 marks | Grade 6

1. Name both groups: amine ($–NH_2$) and carboxylic acid (–COOH).
2. Amino acids form polypeptides (and proteins) by condensation polymerisation.
3. The small molecule lost is water.

Example. Alanine is an amino acid with the formula $H_2NCH(CH_3)COOH$.

(a) Name the **two** functional groups in alanine.
(b) Many alanine molecules join to form a polymer. Name the type of polymer formed and the other product.

Model answer.

(a) Amine / $–NH_2$ (1); carboxylic acid / –COOH (1)

(b) Polypeptide (1); water (1)

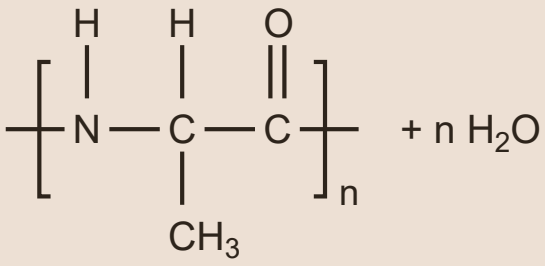
Complete the equation for making a polypeptide

2 to 3 marks | Grade 7

1. Take an H off the $–NH_2$ end and the OH off the –COOH end.
2. Write what is left as the repeating unit, in brackets with n and a bond at each end.
3. Add n H_2O as the other product.

Example. Complete the equation for the polymerisation of alanine.
n $H_2NCH(CH_3)COOH$ → _____ + _____

Model answer.



Repeating unit $–NH–CH(CH_3)–CO–$, with the C=O shown (1)

In brackets with n and a bond at each end: $–(HNCH(CH_3)CO)_n–$ (1)

n H_2O (1)

Explain why amino acids can polymerise on their own 2 marks **Grade 8**

1. Say that an amino acid has two different functional groups that can react with each other.
2. Contrast with polyester monomers, which each have two of the same group, so two different monomers are needed.

Example. Explain why a single type of amino acid can form a polymer, but a polyester needs two different monomers.

Model answer. An amino acid has two different functional groups, $–NH_2$ and –COOH, which can react with each other, so amino acid molecules can join end to end (1). Each polyester monomer has two of the same group (two –OH or two –COOH), so a diol must react with a dicarboxylic acid (1).

Calculate: water lost and relative formula mass of a peptide 2 to 3 marks **Grade 8**

1. Count the links: x amino acids in one chain have x − 1 links.
2. Each link releases one water molecule (M_r = 18).
3. M_r of the peptide = total M_r of the amino acids − (18 × number of links).

Example. Three glycine molecules (M_r = 75) join to form a single chain. M_r of water = 18
(a) How many water molecules are released?
(b) Calculate the relative formula mass of the product.

Model answer.

(a) 2 (1)
(b) 3 × 75 = 225 (1); 225 − (2 × 18) = 189 (1)

Don’t lose marks

- Calling this addition polymerisation. It is condensation, because water is lost.
- Saying amino acids have two of the same functional group. They have two different groups.
- Leaving the whole $–NH_2$ or –COOH in the repeating unit. Take an H off the N and the OH off the C=O carbon.
- Counting one water molecule per amino acid in a short chain. It is one per link.
- Saying proteins are made from one type of amino acid. Proteins combine different amino acids in one chain.

More tips

Memory tricks

- The name gives both groups: AMINO ($–NH_2$) + ACID (–COOH).
- Head to tail: the NH_2 'head' of one amino acid joins the COOH 'tail' of the next, and water is squeezed out.
- Fence-post rule: x amino acids, x − 1 links, x − 1 water molecules.
- Amino acids are like letters: joined in different orders, they make different 'words' (proteins).

Exam technique

- Draw the C=O in the repeating unit clearly; a loosely written 'CO' can be misread.
- If the amino acid has a side group, such as CH_3 in alanine, keep it on the middle carbon in the repeating unit.
- Use the key terms accurately: amino acids form polypeptides by condensation polymerisation; different amino acids in one chain make proteins.
- To find the M_r of the middle section of an amino acid, subtract $–NH_2$ (16) and –COOH (45) from the whole: for glycine, 75 − 61 = 14 (CH_2).

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 6 — **Name the two functional groups in amino acids**
An amine group, $–NH_2$, and a carboxylic acid group, –COOH.

Grade 6 — **State what amino acids polymerise to form**
Polypeptides; different amino acids joined in the same chain make proteins.

Grade 7 — **Explain how amino acids join together**
The $–NH_2$ of one reacts with the –COOH of another, and a water molecule is lost (condensation).

Grade 7 — **Draw the repeating unit of a polypeptide**
For glycine it is $–NH–CH_2–CO–$ (with the C=O shown), in brackets with n.

Grade 8 — **Explain why one amino acid can polymerise alone**
Each molecule has two different groups that react with each other, so no second monomer is needed.

Grade 8 — **Calculate masses and water lost for peptides**
A chain of x amino acids has x − 1 links, so x − 1 water molecules are lost.

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