Higher Chemistry: Unit 2 – Nature's Chemistry

Part D – Proteins

Lesson 2 – Protein Digestion and Function

Learning Outcomes

By the end of this lesson you should know:

1. How proteins can be broken down back to amino acids.
2. The function of proteins in our bodies
3. How proteins are sensitive to temperature

Success Criteria

You will have been successful in this lesson if you:

1. Read and learn the notes given
2. Watch the links provided
3. Complete questions provided
4. Complete and submit the homework assigned by your class teacher.
5. EXTENSION: There is a further reading section to help you gain more depth of understanding for this section. There are also suggested questions for you to try from the blue book of revision questions.

If you have any questions about the content of this lesson, you should ask your class teacher either through your class MS team or via email. The teams will be monitored through the week and someone will get back to you as soon as they can.

Links to Prior Knowledge

You may wish to revise the following to help you understand this lesson:

Higher chemistry – Amino Acids and Protein Formation

You may wish to have a copy of the data booklet handy for this lesson. Download or print a copy of the Higher Chemistry Data Booklet from MS Teams or the SQA website - https://www.sqa.org.uk/sqa/files_ccc/ChemistryDataBooklet_NewH_AH-Sep2016.pdf

Notes - you should either copy, print or save the notes below.

You will receive a paper copy of these notes when we return to school.

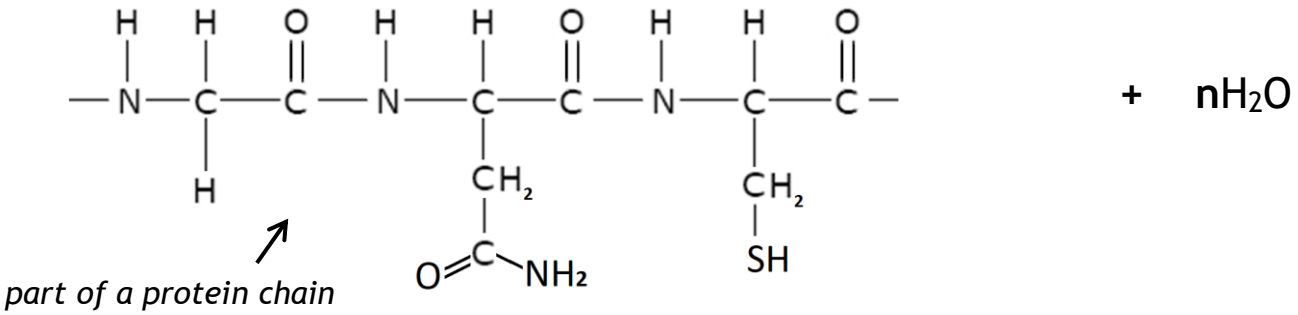
Protein Digestion and Function

Click here for a PowerPoint with voice recording from Ms Hastie for this lesson

Protein Digestion

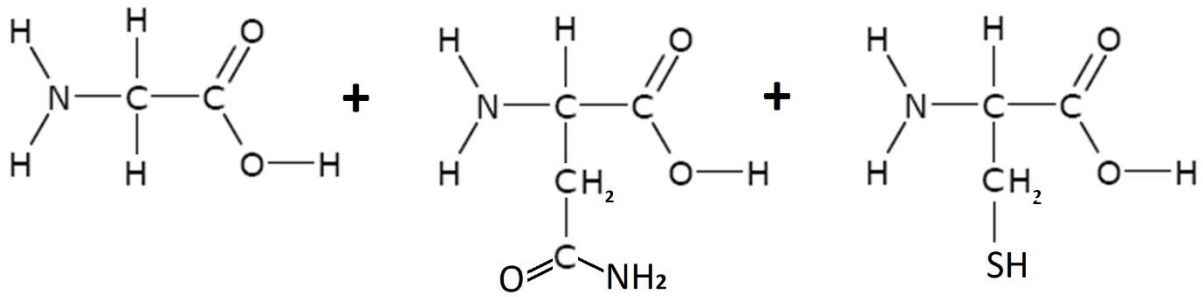
When we eat, our bodies break down protein chains back into amino acids. This process is known as **hydrolysis** (reverse of condensation).

Digestion of proteins occurs in the stomach and requires **enzymes** for the reaction to go ahead.



part of a protein chain

hydrolysis reaction



amino acids formed on hydrolysis of the protein

TASK - Draw a protein chain like the one above and break it up back into the amino acids. Highlight the amino and carboxyl functional groups formed in the products.

WATCH - (3 mins) https://www.twigscotland.com/film/food-basics-proteins-1381/

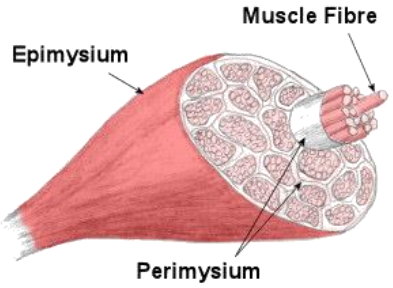
A short clip about proteins

Protein Function

Depending on the amino acid sequence, each protein has a specific function in the body.

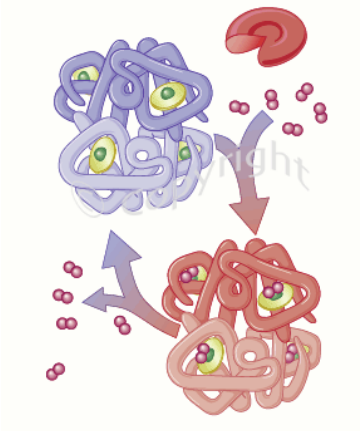
These can be divided into two categories:

1. **Structural Proteins**



The major structural materials of animal tissue are made of proteins. **Structural proteins** are long and thin and make up the major structural materials of animal tissue, eg skin, muscle, hair.

2. **Regulatory proteins**



Proteins are also involved in **the maintenance and regulation of life processes**. These include hormones, antibodies and enzymes.

Enzymes are proteins which act as biological catalysts.

WATCH - (1 min) https://www.twigscotland.com/film/glossary/enzyme-413/

Short animation about enzymes

Protein Structure

Each protein consists of a long chain of amino acids, typically between 50 and 2000 amino acids long. The long chain wraps itself **into large 3D shapes** to suit its function. Within proteins, the long-chain molecules form spirals, sheets, or other complex shapes. The chains are held in **these forms by intermolecular bonding between the side chains** of the constituent amino acids. For example, hydrogen bonds.

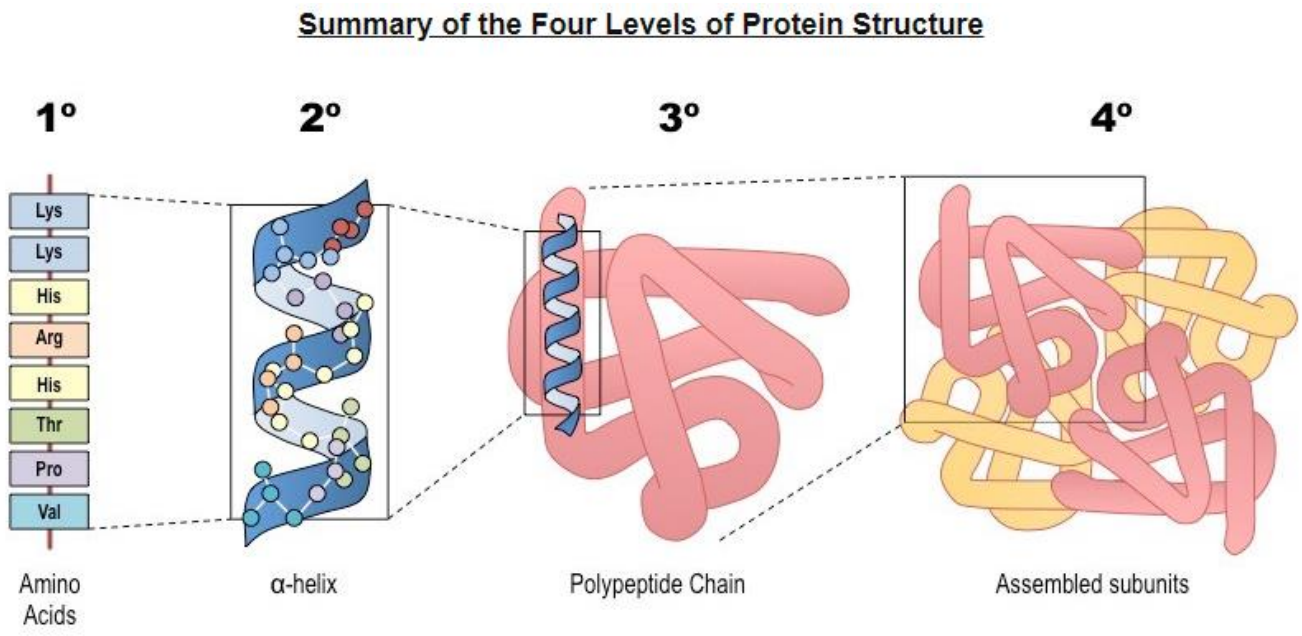


Image from https://ib.bioninja.com.au/higher-level/topic-7-nucleic-acids/73-translation/protein-structure.html

Denaturing Proteins

When proteins are heated, during cooking, these **intermolecular bonds are broken** allowing the proteins to **change shape** (denature). These changes alter the texture of foods.

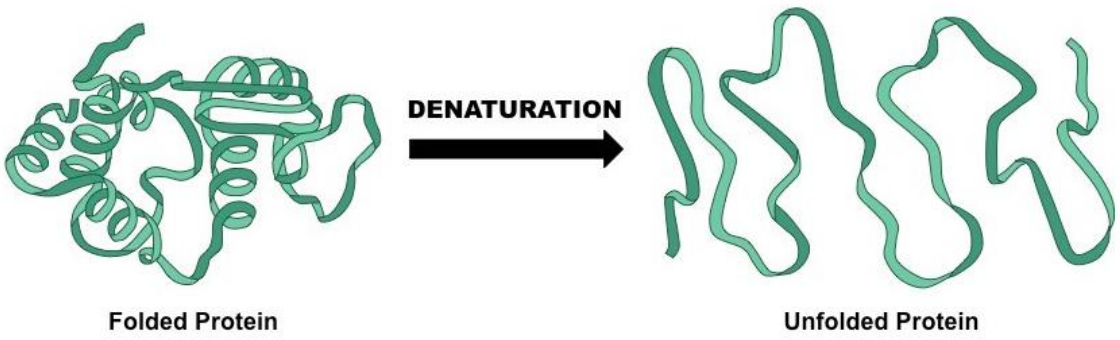
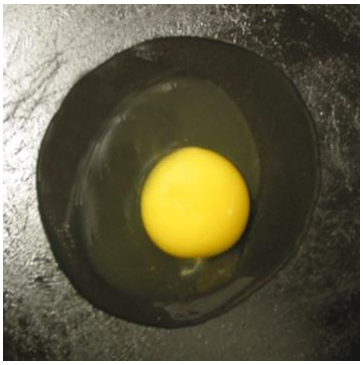


Image from https://ib.bioninja.com.au/standard-level/topic-2-molecular-biology/24-proteins/denaturation.html

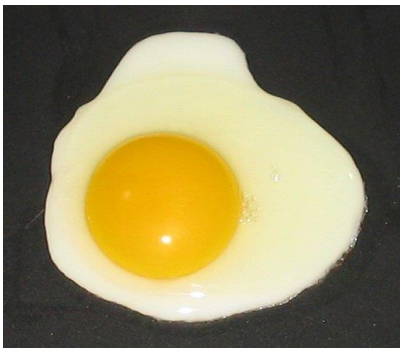
When you cook protein-rich foods such as meat, fish or eggs, they often change colour and texture. The change is irreversible.



raw egg

The intermolecular bonds in the protein break, causing the 3D shape to unravel, denaturing the protein.

HEAT



cooked egg

Denaturing also affects the **function of the protein**. This is why enzymes have an optimum temperature and **don't work above certain temperatures**. The graph shows enzyme activity as the temperature is increased.

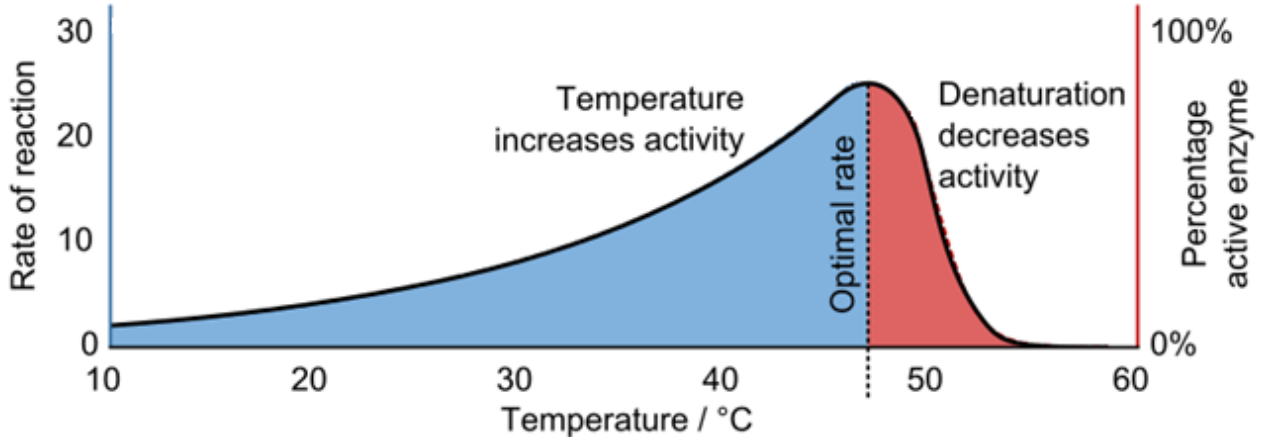
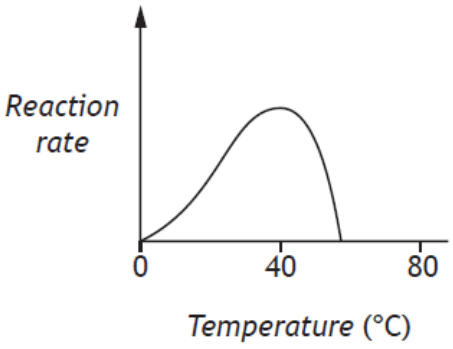


image from https://commons.wikimedia.org/w/index.php?curid=47436421

The graph shows that enzymes are **denatured at high temperatures**.

This shape of graph is often called a "bell-shaped curve" due to its round shape. A second example is on the right:



WATCH - (2 mins) https://www.twigscotland.com/film/factpack-enzymes-1048/

Short clip about enzymes

SUMMARY

1. During digestion, enzyme hydrolysis of protein produces amino acids.
2. The structural formulae of amino acids obtained from the hydrolysis of a protein can be drawn given the structure of a section of the protein.
3. Proteins which fulfil different roles in the body are formed by linking together differing sequences of amino acids.
4. Within proteins, the long-chain molecules form spirals, sheets, or other complex shapes. The chains are held in these forms by intermolecular bonding between the side chains of the constituent amino acids. When proteins are heated, these intermolecular bonds are broken, allowing the proteins to change shape (denature). The denaturing of proteins in foods causes the texture to change when it is cooked.
5. Proteins are the major structural materials of animal tissue and are also involved in the maintenance and regulation of life processes. Enzymes are proteins which act as biological catalysts.

Learning Outcomes

You should now know:

1. How proteins can be broken down back to amino acids.
2. The function of proteins in our bodies
3. How proteins are sensitive to temperature

Further Reading

To learn more about proteins, try the following online resources:

BBC Bitesize: https://www.bbc.co.uk/bitesize/guides/zswqq6f/revision/1

Read page 1-3 and try the test

Scholar: Log in through GLOW

Higher Chemistry → Nature's chemistry → 7. Proteins

Read through the exercises 7.4-7.6 and try the end of topic test

Evans2 chem web: https://www.evans2chemweb.co.uk/login/index.php#

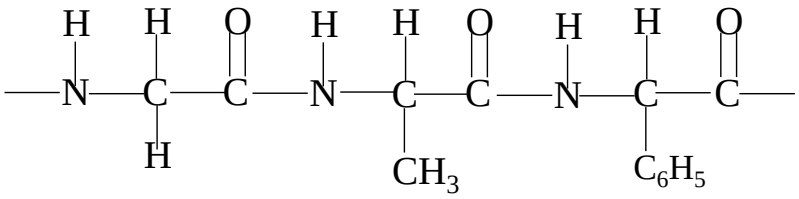
Username: snhs password: giffnock

Select any teacher → revision material → CfE Higher → Unit 2: Nature's Chemistry → Proteins

Check your understanding - Answers the questions below in you class jotter

2.15 Breaking Proteins (i)

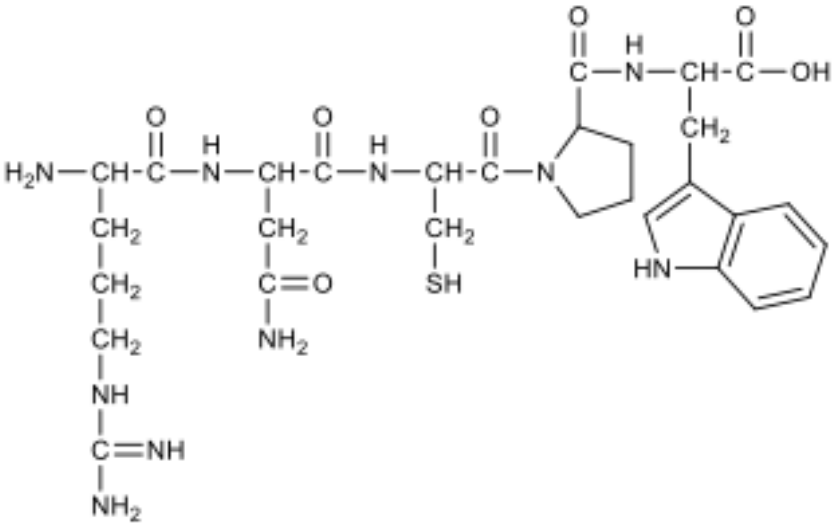
1. The diagram below shows part of a protein molecule that is produced when 3 different amino acids react together:



a) In the stomach, proteins are broken down into amino acids. What name is given to this reaction?

b) Draw the structural formula of the amino acids produced when this protein is broken down.

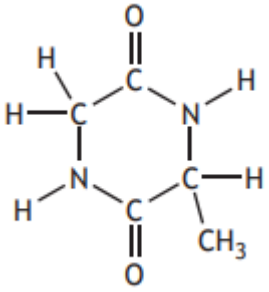
2. The molecule below is known as a peptide:



a) Draw the structure of a peptide link.

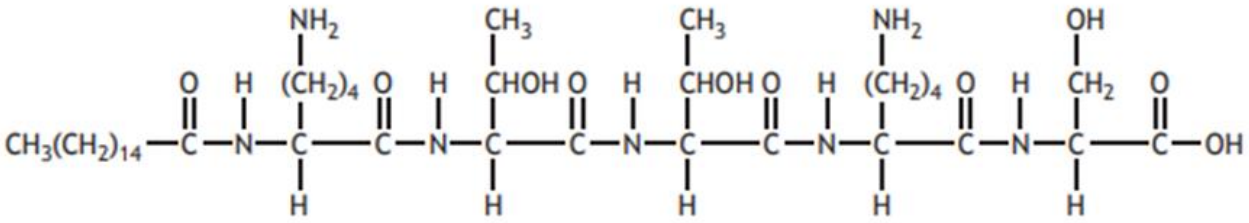
b) How many different amino acids have reacted to produce this molecule?

3. Draw a structural formula for one of the amino acids that would be formed on complete hydrolysis of the molecule shown.



2.16 Breaking Proteins (ii)

1. The molecule below is used in face creams:



It is produced by reacting palmitic acid ($CH_3(CH_2)_{14}COOH$ with **3 different** amino acids.

a) Draw the structural formula of the 3 different amino acids.

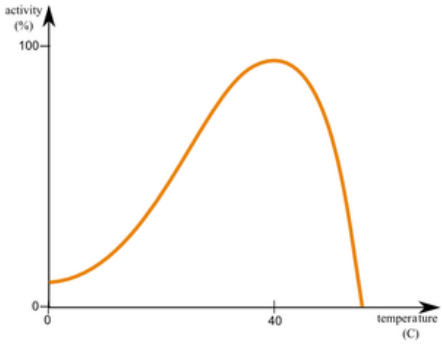
b) Only **1 molecule** of the amino acid, serine is used in the reaction. What is the molecular formula of serine?

2. The hydrolysis of proteins in the body involves the use of enzymes like pepsin which is present in the stomach.

a) Define a hydrolysis reaction.

b) What is an enzyme?

c) The graph below shows how the rate changes with temperature for a reaction using an enzyme:



Why does the rate of reaction decrease above approximately 40°C?

3. Chicken, beef and pork have a high protein content. When they are cooked the proteins become denatured and the texture of the meat changes.

Explain fully what happens when a protein becomes denatured.

ANSWERS TO EXERCISES WILL BE POSTED ON WEDNESDAY FOR YOU TO CHECK YOUR WORK

EXTENSION WORK

For more practise questions for proteins, use your Revision Questions for Higher Chemistry "Blue book"

Proteins page 47 Q3-6

HOMEWORK

You should now complete "**Homework 4 - Proteins**" in your homework jotter, or the back of your class jotter if you don't have your homework jotter at home with you.

Take a picture of your homework answers and submitted them to your class teacher by **1pm on Friday 12th February.** Your teacher will let you know how to submit this and will give you feedback on this homework.

A copy of the homework is on the next pages.

Homework 4 - Proteins

1. The monomers used to construct enzyme molecules are

A amino acids
B alcohols
C esters
D fatty acids

2. Which type of bond is broken when a protein is denatured?

A Ionic
B Polar covalent
C Hydrogen
D Non-polar covalent

3. Which of the following pairs of molecules could be formed by hydrolysis of a protein?

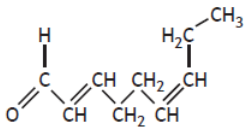
A $HOOC-CH_2-COOH$ $HOCH_2-CH_2-CH_2OH$

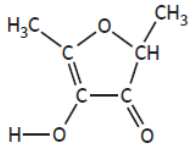
B $HOOC-CH_2-COOH$ $H_2N-\underset{\displaystyle CH_3}{\underset{|}{CH}}-NH_2$

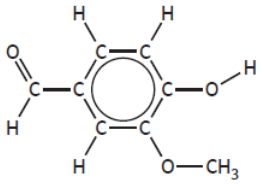
C $HOOC-CH_2-CH_2OH$ $HOOC-CH_2-CH_2OH$

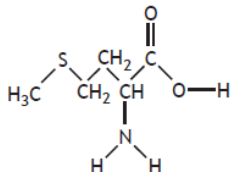
D $HOOC-CH_2-NH_2$ $HOOC-\underset{\displaystyle CH_3}{\underset{|}{CH}}-NH_2$

4. Which of the following flavour molecules would be most likely to be retained in the food when the food is cooked in water?

A 

C 

B 

D 

5. What term is used to describe the amino acids that the body cannot make itself?

A Alpha
B Complex
C Essential
D Dietary

6. A tripeptide, X, has the structure

$$H_2N-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CONH-CH_2-CONH-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-COOH$$

Partial hydrolysis of X yields a mixture of dipeptides. Which of the following dipeptides could be produced on hydrolysing X?

A $H_2N-CH_2-CONH-\underset{\displaystyle CH_3}{\underset{|}{CH}}-COOH$

B $H_2N-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CONH-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-COOH$

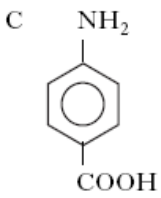
C $H_2N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-CONH-CH_2-COOH$

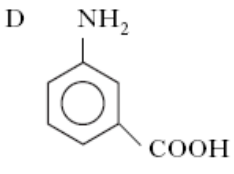
D $H_2N-CH_2-CONH-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-COOH$

7. In α-amino acids the amino group is on the carbon adjacent to the acid group. Which of the following is an α-amino acid?

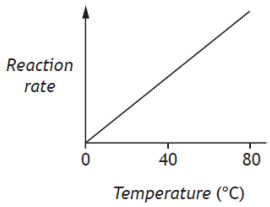
A $CH_3-\underset{\displaystyle CH_2-NH_2}{\underset{|}{CH}}-COOH$

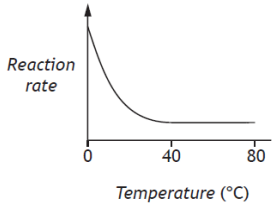
B $CH_2-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH$ (SH on CH_2)

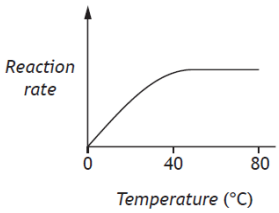
C 

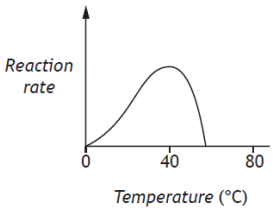
D 

8. The rate of hydrolysis of protein, using an enzyme, was studied at different temperatures. Which of the following graphs would be obtained?

A 

B 

C 

D 

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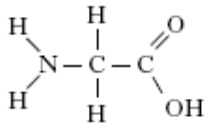
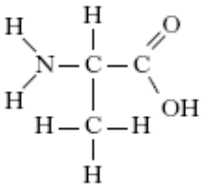
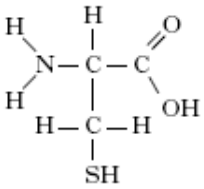
9. Keratin is a protein found in hair. The hydrolysis of keratin produces 3 different monomers of the type shown below.


glycine


alanine


cysteine

(a) What name is given to monomers like glycine, alanine and cysteine? (1)

(b) Cysteine and alanine can reacted together to form a dipeptide

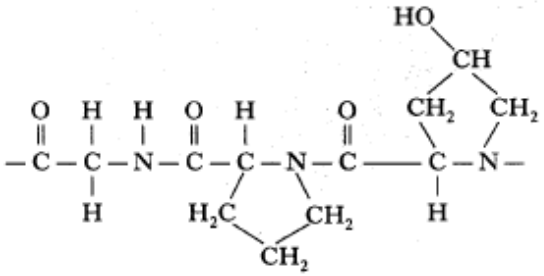
(i) Draw the molecule formed when cysteine and alanine react. (1)

(ii) Name the type of reaction that has taken place. (1)

(c) Draw the molecule of glycine. Circle and name each functional group in glycine. (1)

(d) What is meant by a "hydrolysis" reaction? (1)

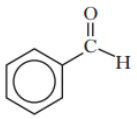
(e) Glycine, along with another two molecules can combine to make another protein, collagen, shown below.

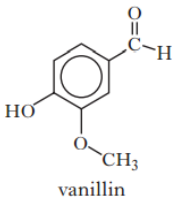


(i) Draw structural formula for the two other monomers (not glycine) formed on hydrolysis of the molecule above. (2)

(ii) Name the link which holds the monomers together in a protein. (1)

10. Benzaldehyde and vanillin are examples of flavour molecules.


benzaldehyde


vanillin

(a) Name a functional group present in both benzaldehyde and vanillin. (1)

(b) Which of the molecules would you expect to be more soluble in water? (1)

(c) Which of the molecules would you expect to be more volatile? (1)

Total = 20