IB Biology B1.2 Proteins

Worksheet 03 — Denaturation, pH and temperature

Worksheet	Denaturation, pH and temperature
Recommended time	50–60 minutes
Indicative marks	33
Coverage	Protein function, denaturation, reversible vs irreversible change, enzyme activity in changing environments.
Teacher note	SL questions are included throughout. HL-labelled items can be used for extension, differentiation, or separate HL assessment.

This worksheet examines how temperature and pH affect protein shape and function, with an emphasis on denaturation and the conditions under which renaturation may or may not occur.

Section A — Multiple choice

Choose the best answer for each question. 1 mark each.

1. [SL] Denaturation is best defined as
A. the formation of peptide bonds
B. the loss of normal three-dimensional protein shape and therefore function
C. the hydrolysis of glucose
D. the addition of amino acids to a triglyceride

2. [SL] A protein heated slightly above its optimum temperature may regain function if
A. its peptide bonds have remained intact and it returns to optimum conditions
B. all water is removed
C. the amino acid sequence is rewritten
D. all ionic bonds are permanently broken

3. [SL] An environment that is too acidic or too basic can denature a protein because
A. it adds extra peptide bonds
B. extra charges disrupt normal hydrogen bonding
C. it replaces amino acids with lipids
D. it always breaks all covalent bonds immediately

4. [SL] Which bond type is especially vulnerable when proteins are exposed to above-normal temperature?
A. Peptide bonds only
B. Hydrogen bonds
C. Glycosidic bonds
D. Phosphodiester bonds

5. [HL] Why can denaturation be reversible after mild heating but irreversible after extreme heating?
A. Mild heating may disrupt weaker interactions only, whereas extreme heating may also damage the underlying polypeptide chain
B. Extreme heating always creates new genes
C. Mild heating converts proteins to carbohydrates
D. There is never any reversible denaturation

Section B — Short answer

6. [SL] Explain why loss of protein shape often leads to loss of function. (3 marks)

7. [SL] State two environmental factors highlighted in this topic that can denature proteins. (2 marks)

8. [SL] Distinguish between denaturation and hydrolysis of a protein. (2 marks)

9. [HL] Explain why altered H+ or OH– concentration can interfere with hydrogen bonding patterns within a protein. (4 marks)

Section C — Data response / case study

A student measured the relative activity of an enzyme at different temperatures. The enzyme had an optimum temperature close to 37 °C.

Temperature / °C	20	30	37	45	55	70
Relative activity / %	18	61	100	49	7	0

10a. [SL] Identify the optimum temperature shown by the data. (1 marks)

10b. [SL] Describe the trend in enzyme activity between 20 °C and 55 °C. (2 marks)

10c. [SL] Suggest why some activity remains at 45 °C but none remains at 70 °C. (3 marks)

10d. [HL] Predict whether enzyme molecules tested at 45 °C are more likely to renature successfully than molecules tested at 70 °C if returned to 37 °C. Explain your reasoning. (3 marks)

Section D — Extended response

11. [SL/HL] Explain how pH and temperature can alter protein shape and function, and distinguish between reversible and irreversible outcomes. (8 marks)

Answer key and marking guidance

Use the guidance flexibly. Equivalent scientific wording should receive credit where it is biologically accurate and consistent with the source material.

Section A — Multiple choice answers

Q1	B	Q2	A	Q3	B	Q4	B
Q5	A						

Section B — Short answer guidance

6. [SL] Up to 3 marks for: protein function depends on precise three-dimensional shape; denaturation alters that shape; active/binding sites or structural properties no longer fit their targets or roles correctly.

7. [SL] 1 mark each for temperature and pH.

8. [SL] 1 mark for denaturation changing shape/function; 1 mark for hydrolysis breaking the polymer into smaller units or breaking peptide-linked structure via water-involving reactions.

9. [HL] Award up to 4 marks for stating that added H+ or OH– changes charge distribution, interferes with normal polar interactions, prevents the usual intramolecular hydrogen bonds from forming, and therefore changes conformation.

Section C — Data response guidance

10a. [SL] 1 mark for 37 °C.

10b. [SL] 1 mark for activity increasing from 20 °C to 37 °C; 1 mark for activity decreasing above 37 °C, with a sharp decline by 55 °C.

10c. [SL] Up to 3 marks: at 45 °C only partial denaturation or disruption of weaker bonds has occurred; some functional molecules remain or can still bind substrate; at 70 °C denaturation is extensive and the functional shape is effectively lost.

10d. [HL] 3 marks for predicting better recovery after 45 °C and explaining that milder conditions are more likely to leave the polypeptide chain intact while 70 °C may cause irreversible damage or extensive bond disruption.

Section D — Extended response guidance

11. [SL/HL] Award up to 8 marks for: proteins depend on precise three-dimensional shape; many weak hydrogen bonds help maintain structure; higher temperature increases molecular motion and stresses weak interactions; abnormal pH alters charges and hydrogen bonding; denaturation changes shape and lowers activity; if the amino acid chain remains intact, return to optimum conditions may allow renaturation; if stronger/covalent bonds including peptide-linked integrity are damaged, the change becomes irreversible.