

EduTrend Contents

W4C · BIOLOGY & LIFE SCIENCES · HIGH SCHOOL

# Enzymes at Work

## How do temperature and pH affect catalase activity?

Ages 15–18 | Level: Advanced | 75 minutes | Pairs · up to 24 | Activity 05

Inside: activity at a glance · step-by-step session plan · facilitator notes · 3 student worksheets · assessment checklist

ACTIVITY 05 · AT A GLANCE

# Enzymes at Work

Students investigate the enzyme catalase, which breaks down hydrogen peroxide into water and oxygen. Pairs measure the rate of oxygen production at different temperatures or pH values, calculate initial rates, plot graphs and explain the optimum and the effect of denaturation. The activity develops quantitative practical skills and understanding of enzyme action.

## Learning outcomes

By the end of the session students can:

- measure the rate of an enzyme-controlled reaction;
- control variables and take repeat readings;
- calculate and plot rates of reaction;
- explain optimum conditions and denaturation using enzyme structure.

**KEY WORDS**

enzyme · catalase · substrate · active site · optimum · denature · rate

**CURRICULUM LINKS**

Biology: enzymes, proteins, metabolism. Chemistry: rates and catalysts. Maths: gradients and graphs.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| **QUESTION** | **PREDICT** | **PLAN** | **OBSERVE** | **RECORD** | **EXPLAIN** |
| What do we want to know? | What will happen? | Keep it fair | Look closely | Measure and note | What does it show? |

## Materials (per pair)

- Potato cylinders or yeast suspension
- Hydrogen peroxide solution (up to 3%)
- Boiling tube with bung and delivery tube, or gas syringe
- Water baths at 10, 20, 30, 40, 50 and 60 °C, or pH buffers
- Measuring cylinder in a trough, stopwatch
- Worksheets 1, 2 and 3

## Before the session

- Prepare water baths or buffer solutions.
- Cut potato cylinders of equal size or make yeast suspension.
- Check hydrogen peroxide concentration.
- Set up one demonstration apparatus.
- Plan which pair tests which condition for class data.

**SAFETY**

Goggles on. Hydrogen peroxide is an irritant: wipe spills and wash skin. Take care with hot water baths.

ACTIVITY 05 · SESSION PLAN

# Step by step

Timings are for 75 minutes. Assign temperatures or pH values across pairs so that the class builds a complete data set.

| Time | What happens | Say or ask |
|---|---|---|
| **0–10 min Hook** | Drop potato into hydrogen peroxide in a boiling tube. Foam rises. What is happening? | *"What is the gas? Where did it come from?"* |
| **10–20 min Plan** | Pairs identify variables and write a method on Worksheet 1. | *"How will you keep the enzyme amount the same?"* |
| **20–50 min Measure** | Pairs equilibrate reactants in the water bath, mix and record gas volume every 30 seconds for 3 minutes, then repeat. | *"Why leave the tubes in the bath first?"* |
| **50–60 min Calculate** | Pairs calculate the initial rate from the first 60 seconds and share results. | *"Why use the initial rate?"* |
| **60–70 min Graph** | Plot rate against temperature or pH using class data. | *"Where is the optimum? What happens above it?"* |
| **70–75 min Explain** | Discuss active site shape and denaturation. | |

**CHALLENGE CARD (print or copy onto the board)**

Find the optimum temperature (or pH) for potato catalase to within 10 °C (or 1 pH unit). Justify your answer with a graph and state your uncertainty.

ACTIVITY 05 · FACILITATOR NOTES

# The biology in brief

Enzymes are biological catalysts made of protein. Each has an active site with a specific shape into which its substrate fits. Catalase breaks down hydrogen peroxide, a harmful by-product of metabolism, into water and oxygen: 2 H2O2 gives 2 H2O + O2.

Increasing temperature increases the kinetic energy of molecules, so enzyme and substrate collide more often and rate rises. Above the optimum, bonds holding the protein's shape break, the active site changes and the enzyme is denatured, so the rate falls sharply. Changes in pH alter charges on the active site, so each enzyme also has an optimum pH.

## Common ideas to listen for

- "Enzymes are killed by heat." Enzymes are not alive; they are denatured.
- "The enzyme is used up." Enzymes are not changed by the reaction.
- "The graph peak is the only important point." The shape either side reveals the mechanism.

## Adapting the activity

**Support**

Measure foam height in a measuring cylinder instead of gas volume, and test three temperatures.

**Stretch**

Investigate substrate concentration and explain the levelling off in terms of saturated active sites.

WORKSHEET 1

# Plan

Name: _____ Class: _____ Date: _____

Complete before you start.

## Variables

| Variable | Details |
|---|---|
| Independent | |
| Dependent | |
| Control 1 | |
| Control 2 | |
| Control 3 | |

## Prediction with reason

WORKSHEET 2

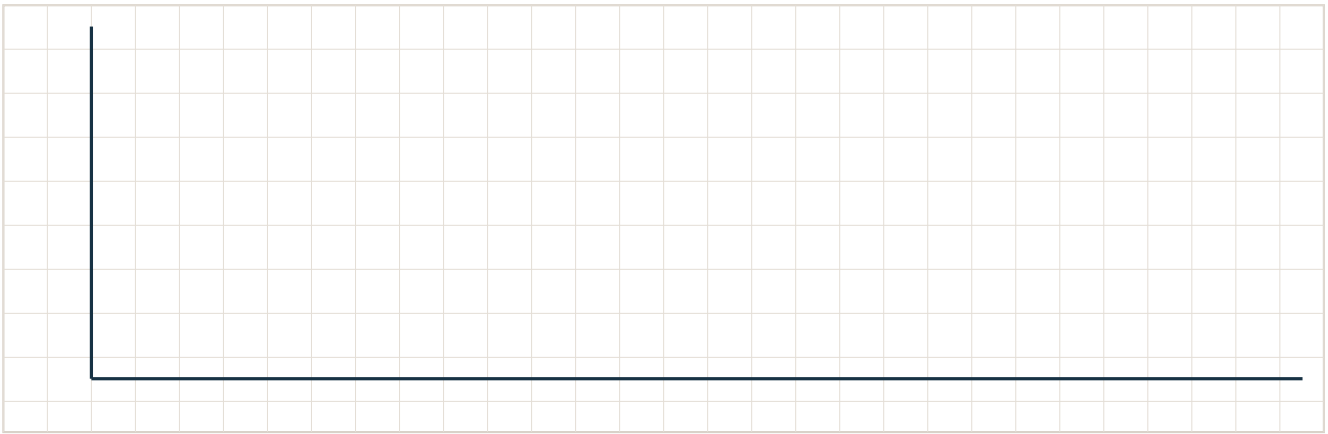
# Results

Record gas volume ($cm^3$) every 30 seconds.

## Data

| Time (s) | Trial 1 | Trial 2 | Mean |
|---|---|---|---|
| 30 | | | |
| 60 | | | |
| 90 | | | |
| 120 | | | |
| 150 | | | |
| 180 | | | |

## Rate graph (class data)



y-axis: initial rate ($cm^3$ per min)

x-axis: temperature (°C) or pH

WORKSHEET 3

# Explain and evaluate

Use the terms active site, substrate, collisions and denature.

## Explain the shape of your graph

## Two improvements to the method

FOR THE TEACHER

# Assessment checklist

Use during the session. One sheet covers up to eight students; copy as needed.

| Student | Controls variables | Calculates rates correctly | Explains with enzyme structure |
|---|---|---|---|
| | | | |
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| | | | |

Suggested codes: W = working towards · E = expected · G = greater depth

**ABOUT THIS ACTIVITY**

Enzymes at Work is a sample activity from the EduTrend Contents W4C Biology & Life Sciences programme (high school, level: advanced). Every activity in the programme follows the same format: a practical challenge, a clear session plan, facilitator notes and ready-to-print worksheets, so that teachers, club leaders and parents can run it without extra preparation.

**Full 15-, 20- and 32-week programmes are available from EduStore at edutrend.org.**

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