Decomposition

4.7.2.3 · Ecology · revision notes

How temperature, water and oxygen affect the rate at which microorganisms decay dead material, how gardeners make compost and how biogas generators make methane. It includes the decay of milk required practical, so expect rate calculations and graph work. This subtopic is in GCSE Biology only, not Combined Science.

Key facts

- Faster decay: warm, moist, plenty of oxygen
- Compost = decayed waste used as a natural fertiliser
- Rate of decay = change in mass (or pH) ÷ time
- Lipase: fat → fatty acids + glycerol, so the pH falls
- Too hot → decomposer enzymes denature → decay slows
- Anaerobic decay → methane → fuel (biogas generators)
- Rate from a timed end point = 1 ÷ time

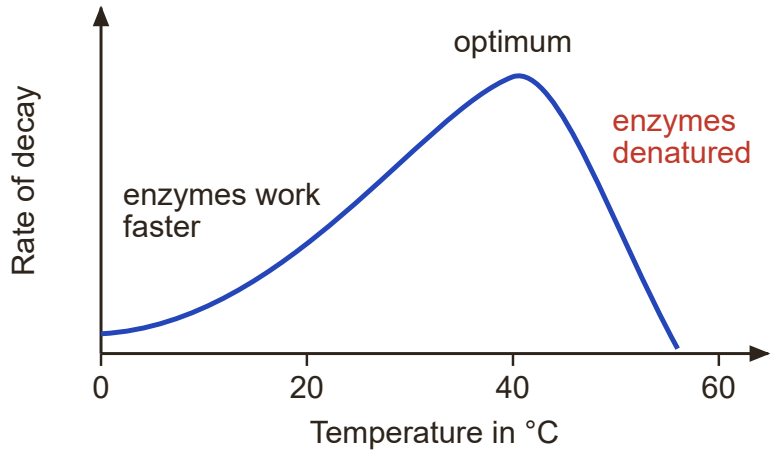
Notes

Decomposers

- Decomposers are microorganisms, such as bacteria and fungi, that break down dead plants, dead animals and waste.
- They secrete enzymes onto the material. The small soluble molecules produced diffuse into their cells.
- Their respiration releases carbon dioxide, and mineral ions are returned to the soil.

Factors affecting the rate of decay

- **Temperature**: warmth speeds up the decomposers' enzyme-controlled reactions, so decay is faster. If it is too hot, the enzymes are denatured and decay slows or stops. Cold slows decay, which is why a fridge keeps food fresh for longer.



Decay speeds up as it gets warmer, until the decomposers' enzymes denature.

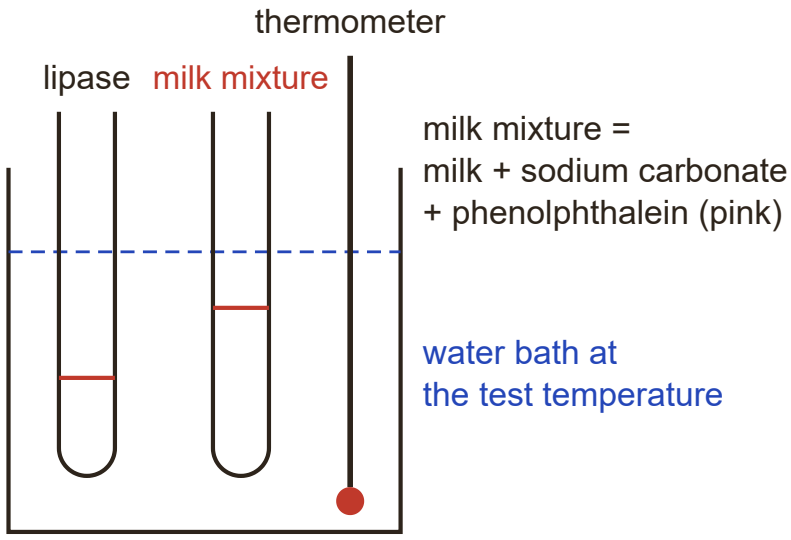
- **Water**: decomposers need moist conditions for their reactions and to digest their food. Dry material decays very slowly.
- **Oxygen**: most decomposers respire aerobically, which releases more energy, so they grow and multiply faster. With little oxygen, decay is slower.

Compost and biogas

- Gardeners and farmers try to give waste the best conditions for rapid decay: warm, moist and with plenty of oxygen (heaps are turned to let air in).
- The finished **compost** is spread on gardens and fields as a natural fertiliser.
- **Anaerobic decay** (decay without oxygen) produces **methane** gas.
- **Biogas generators** use the anaerobic decay of waste, such as animal manure or food waste, to produce methane, which is used as a fuel.

Required practical: decay of milk

- Mix milk, sodium carbonate solution (an alkali) and phenolphthalein indicator. The mixture is pink.
- Add lipase. It breaks down the fat in milk into fatty acids and glycerol, and the fatty acids lower the pH.
- Time how long the pink colour takes to disappear. Use water baths to repeat at different temperatures, warming the milk mixture and the lipase to the test temperature before mixing.



Warm both tubes to the test temperature, mix them and time how long the pink colour takes to go.

- Rate = 1 ÷ time (or 1000 ÷ time). A pH probe gives a clearer end point than judging a colour change by eye.
- From a curve of pH against time, the rate at one time is the gradient of a tangent drawn at that time: change in pH ÷ change in time. Grade 7+ only
- Keep the volumes and concentrations of milk, lipase and sodium carbonate the same.
- Expected result: the time taken gets shorter (the rate rises) as the temperature rises to the optimum, then longer as the lipase is denatured.

How to answer each type of question

Explain how a condition affects the rate of decay — 2 to 3 marks — Grade 5

1. Name the factor and say whether decay speeds up or slows down.
2. Link it to the decomposers: enzymes (temperature), water for reactions (moisture), aerobic respiration (oxygen).
3. Above the optimum temperature, say the enzymes are denatured.

Example. A gardener's compost heap decays faster in summer than in winter. Explain why. (3 marks)

Model answer. It is warmer in summer (1). The enzymes of the decomposers / microorganisms work faster at higher temperatures (1). So the microorganisms digest the waste and grow and reproduce faster, and the waste decays faster (1).

Calculate a rate of decay

2 marks | Grade 5

1. Find the change (start value − end value).
2. Divide by the time taken.
3. Give the units, e.g. g per day.

Example. A bag of leaves had a mass of 480 g. After 40 days its mass was 312 g. Calculate the mean rate of decay in g per day.

Model answer.

480 − 312 = 168 g (1)

168 ÷ 40 = 4.2 g per day (1)

Analyse results from the milk decay practical

2 to 4 marks | Grade 5

1. Use rate = 1000 ÷ time (or 1 ÷ time) as the question tells you.
2. Describe the pattern: the rate rises with temperature up to an optimum, then falls.
3. Explain the fall with denatured enzymes and the active site.

Example. A student timed how long milk containing lipase and phenolphthalein took to lose its pink colour at different temperatures.

Temperature in °C	Time for the pink colour to disappear in s
20	300
30	150
40	80
50	400

(a) Calculate the rate at 40 °C, using rate = 1000 ÷ time. (1 mark)

(b) Explain the result at 50 °C. (2 marks)

Model answer.

(a) 1000 ÷ 80 = 12.5 (1)

(b) The lipase is denatured at 50 °C / its active site changes shape (1), so the fat no longer fits the active site and fatty acids are produced more slowly, so the pH falls more slowly (1).

Explain how compost bins or biogas generators work 3 to 4 marks **Grade 7**

1. Compost: link each feature to warmth, moisture or oxygen for the decomposers.
2. Biogas: there is no oxygen, so decay is anaerobic and methane is produced.
3. Give the use: compost as a fertiliser, methane as a fuel.

Example. Explain why a biogas generator must be sealed, and why it produces gas faster in a warm country. (4 marks)

Model answer. Sealing keeps oxygen out, so the decay is anaerobic (1), and anaerobic decay produces methane (1). At higher temperatures the microorganisms' enzymes work faster (1), so methane is produced faster (1).

Don’t lose marks

- Saying high temperatures 'kill' enzymes. Enzymes are not alive: they are denatured.
- Writing 'biogas' when asked to name the gas. Name methane.
- Forgetting to bring the lipase and the milk mixture to the test temperature before mixing them.
- Leaving out units in rate answers (e.g. g per day).

More tips

Memory tricks

- Decay needs WOW: Warmth, Oxygen, Water.
- No oxygen, methane made: anaerobic decay gives a gas you can burn as fuel.
- Sense check a rate: a decay rate is a positive number describing how fast mass is lost.

Exam technique

- For each factor, name the organisms (decomposers or microorganisms) and the process (enzymes or respiration) in your answer.
- In rate questions, check the time units: hours, days or weeks.
- The colour change is gradual, so a common improvement is to use a pH probe or data logger.

What each grade needs

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

Grade 3 **State what decomposers do**
Microorganisms such as bacteria and fungi break down dead organisms and waste.

Grade 4 **Name the three factors affecting decay rate**
Temperature, water (moisture) and the availability of oxygen.

Grade 5 **Describe how compost and biogas are produced**
Waste decays in warm, moist, well-aerated heaps to make compost; anaerobic decay in a biogas generator makes methane.

Grade 5

Explain how temperature, water and oxygen affect decay

They affect the enzymes and respiration of decomposers, so how fast they break down the material.

Grade 5

Calculate a rate of decay

Divide the change (e.g. in mass or pH) by the time taken, or use 1 ÷ time for a timed end point.

Grade 7

Describe the milk decay required practical

Time how long lipase takes to lower the pH of milk, shown by an indicator changing colour, at different temperatures.

Grade 7

Explain why decay slows at high temperatures

Above the optimum temperature the decomposers' enzymes are denatured, so decay slows down.

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