# Answers to Workbook exercises Chapter 5

## Exercise 5.1 Writing enzyme questions

Look for questions that are very clear, biologically correct and that have unambiguous answers.

## Exercise 5.2 Lipase experiment

a fats (lipids)

b fatty acids and glycerol

c Fatty acids are produced, which are acids and therefore have pH below 7.

d

| Tube | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Temp / °C | 20 | 20 | 0 | 40 | 100 |
| Milk added? | no | yes | yes | yes | yes |
| pH at: | | | | | |
| 0 min | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| 2 min | 7.0 | 6.8 | 7.0 | 6.7 | 7.0 |
| 4 min | 7.0 | 6.7 | 7.0 | 6.55 | 7.0 |
| 6 min | 7.0 | 6.6 | 7.0 | 6.3 | 7.0 |
| 8 min | 7.0 | 6.6 | 6.9 | 6.2 | 7.0 |
| 10 min | 7.0 | 6.5 | 6.9 | 6.2 | 7.0 |

e There was no milk, so no fat, so no fatty acids were made.

f The high temperature denatured the lipase molecules, so there was no digestion of fats and no fatty acids were made.

g These tubes differed only in their temperature. Lipase acts more rapidly at 20 °C than at 0 °C because its molecules (and those of its substrate) are moving round faster and therefore collisions between enzyme and substrate molecules happen more frequently and with more energy. This means the rate of reaction is faster at 20 °C than at 0 °C.

h 40 °C is certainly the temperature at which the enzyme worked fastest in this experiment, but the optimum could actually be somewhere either side of this – either a bit below or anywhere between 40 °C and 100 °C.

i The experiment could be repeated, to obtain another set of results, to see if these matched the first ones. Alternatively (or as well) three tubes could be set up for each temperature, and a mean calculated. To find a more precise value of the optimum temperature, more temperatures need to be tested on either side of 40 °C – say 35 °C, 45 °C, 50 °C and so on. Once these results have been found, the temperature range can be narrowed down even more to keep moving in closer and closer to the optimum temperature.

j Take equal volumes of cow's and goat's milk. Add equal volumes of lipase to both samples. Keep the tubes at 40°C for five minutes.

Measure the pH every two minutes.

Repeat the experiment three times, and calculate the mean pH for cow's milk and mean pH for goat's milk at each time interval.

The milk in which the pH drops faster is the one that contained most fat.

## Exercise 5.3 Finding the optimum pH for amylase

a pH

b 1 to 14 (a narrower range would be acceptable)

c Using buffer solutions. Tubes could be set up using buffers for pH 1, 2 and so on.

d The volume and concentration of starch solution used should be kept constant. Do this by making up one lot of starch solution, keeping it well mixed, and measuring volumes using a syringe

or other calibrated instrument. The volume and concentration of amylase solution should also be kept constant – do this as for the starch solution. The temperatures of all solutions too need to be kept constant – use water baths.

e The time taken for the starch to disappear should be measured. Take samples from the mixtures of amylase and starch at timed intervals (for example, every minute); place them on a tile and add iodine solution. Record the colour. The time at which the sample does not go black with iodine solution is the time to record.

f Measure equal volumes of starch solution into six tubes. Add equal volumes of different buffer solutions, for pH 1, 3, 5, 7, 9 and 11, to each tube. Stand the tubes in a water bath at a known temperature (for example, 30 °C). Measure equal volumes of amylase solution, and add them to the starch mixtures. Use a clean glass rod to take samples from each tube (a different glass rod for each, wiped clean between samples) and place them on a tile. Add iodine solution and record the colour obtained.

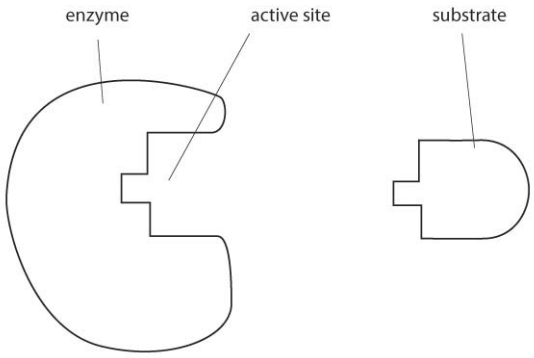
g Look for columns or rows for the pH and the time taken for the brown colour to disappear. In this case, the values written in the table would be times in minutes. Students may also like to show the colour each time a sample was tested, in which case the results table should also have columns or rows with headings for the time intervals. The results written in the table would then be colours.

h The sketch graph should have an *x*-axis labelled 'pH', and a *y*-axis labelled 'Time taken for starch to disappear / minutes'. The line should begin high at the lowest pHs, drop down to pH 7.5 and then rise again.

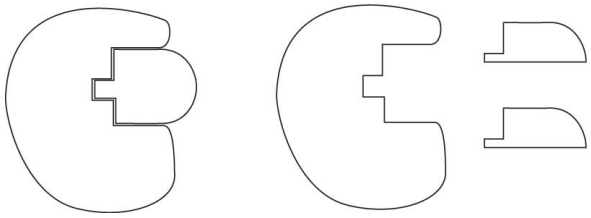
## Exercise 5.4 How enzymes work

S

a




b



c i Each type of enzyme has an active site of a specific shape. It can only bind with a substrate whose shape is complementary to this.

ii The molecules of the enzyme and the substrate move faster at higher temperatures, so collide with each other more frequently.

iii Above its optimum temperature, an enzyme molecule loses its shape (becomes denatured), so the substrate cannot fit into its active site.