Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- rate rises to an optimum (about 40 °C) because molecules have more kinetic energy, so more collisions and enzyme–substrate complexes form
- above the optimum the rate falls quickly
- bonds holding the tertiary structure break, the active site changes shape and the enzyme is denatured

2.2

- H^+ ions affect the charges on R groups / break ionic and hydrogen bonds
- so the shape of the active site changes and fewer substrates bind

2.3

- $V_{\max} = 10$ a.u.
- $K_m = 2.0$ mmol dm^{-3}

3.1

- at low concentration the rate rises in proportion: substrate is the limiting factor
- as concentration rises, more active sites are occupied at any moment
- at high concentration all active sites are occupied, so the rate levels at $V_{\max}$; enzyme concentration now limits

3.2

- more enzyme gives more active sites
- substrate is in excess, so more enzyme–substrate complexes form per second in proportion

3.3

(a) X: at high substrate concentration the rate reaches the same $V_{\max}$

(b) it has a shape similar to the substrate and binds the active site; so fewer active sites are free for substrate / fewer ES complexes

(c) it binds elsewhere on the enzyme, changing the shape of the active site; so the substrate cannot bind, whatever its concentration, and $V_{\max}$ falls

(d) K_m increases

(e) measure rates with a fixed inhibitor concentration over a range of substrate concentrations; if the inhibition is overcome at high substrate concentration (same $V_{\max}$), it is competitive

3.4

(a) any two: the enzyme can be reused; the product is not contaminated with enzyme; more stable to temperature and pH changes; continuous process

(b) the alginate holds the molecule in shape / limits unfolding of its tertiary structure

(c) more lactose remains; because the milk spends less time in contact with the enzyme

3.5

- hexokinase
- its low K_m (high affinity) means it is near $V_{\max}$ even at low glucose concentrations

3.6

- buffer: keeps the pH constant
- water bath: keeps the temperature constant

3.7

(a) more disulfide (or ionic / hydrogen) bonds holding the shape

(b) molecules have little kinetic energy, so few enzyme–substrate collisions

(c) at 95 °C bonds in the tertiary structure break and the active site loses its shape: denatured; at 5 °C the shape is unchanged, the molecules just move slowly, so activity returns on warming