18 When water vapour in the atmosphere cools it condenses, forming tiny drops of water. These drops increase in size by colliding with each other and fall back to the ground as rain.

(a) As a raindrop falls through the air it eventually reaches its terminal velocity. The upthrust on the raindrop can be considered to be negligible.

(i) Explain what is meant by the terminal velocity of the raindrop. Your answer should include a free-body force diagram for the raindrop when terminal velocity has been reached.

(4)

(ii) The air resistance F acting on a raindrop travelling at a velocity v, can be determined using the expression

$$F = 0.45\rho A v^2$$

where A is the cross-sectional area of the raindrop and ρ is the density of the air.

Calculate the terminal velocity of a spherical raindrop of radius 2.0×10^{-3} m.

density of air = $1.2\,\text{kg}\,\text{m}^{-3}$
density of rainwater = $1.0 \times 10^{3}\,\text{kg}\,\text{m}^{-3}$

(4)

Terminal velocity = ...

(b) Some plants have adapted to high rainfall by having a specialised shape and waxy leaves. This allows rain to slide down a leaf and off the end as a series of drops.

(i) A drop of water slides off a leaf as shown.

Add to the diagram to show the position of the drop at regular intervals of time. The first two positions have been drawn for you.

(2)

(ii) Water falls from a leaf at a steady rate of five drops per second.

As each drop reaches the ground, there are four drops above it in the air.

Calculate the height of the leaf from the ground. It can be assumed that the drop at the highest position has just left the leaf.

(3)

Height of leaf = ...

(Total for Question 18 = 13 marks)