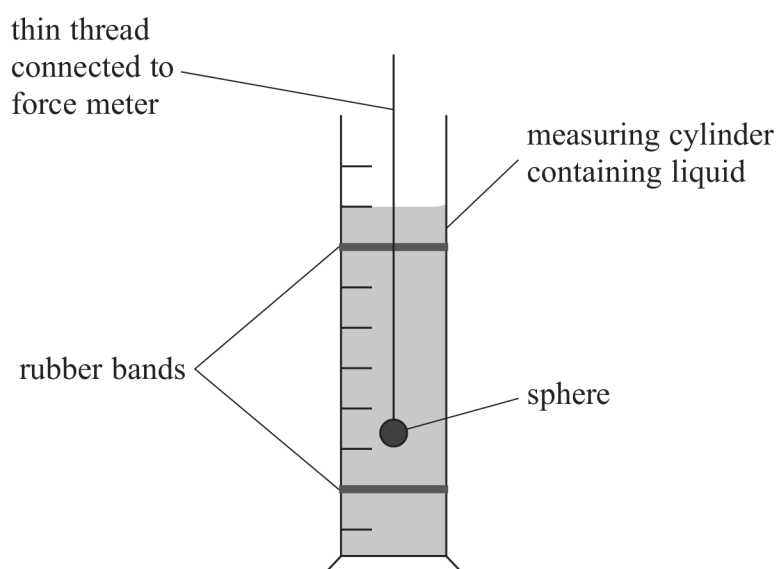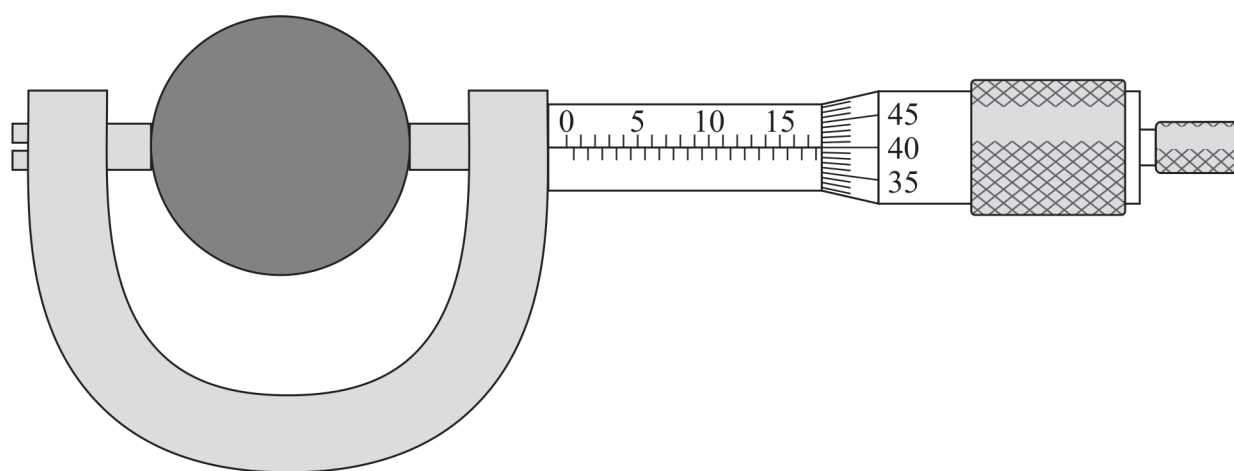**3** A student determined the viscosity of a liquid. The student measured the force required to pull a small sphere upwards through the liquid at a constant speed.

thin thread connected to force meter

measuring cylinder containing liquid

rubber bands

sphere

(a) The student measured the diameter of the sphere using a micrometer.

Calculate the percentage uncertainty in the diameter of the sphere shown on the micrometer.

(3)

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Percentage uncertainty = ...

(b) State one precaution that should be taken before using a micrometer.

(1)

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(c) The student measured the value of force when the sphere was suspended and stationary in the liquid. The force meter used is shown in the photograph.

When the sphere was stationary the reading on the force meter was 0.20 N.

The student then moved the force meter upwards so that the sphere moved at a constant speed of 0.32 m s^{-1}. The reading on the force meter was 0.29 N.

(i) Explain why it was necessary to measure the force when the sphere was stationary and the force when the sphere was moving at constant speed.

(3)

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(ii) Calculate the viscosity η of the liquid.

(3)

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$\eta =$ .... Pa s

(d) The resolution of the force meter was 0.01 N.
The distance moved between the rubber bands was 25.0 cm.
The time measured was 0.78 s.
The percentage uncertainty in the measurement of the diameter was negligible.

Assess which of these measurements was the most significant source of uncertainty in the value of viscosity.

(4)

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(Total for Question 3 = 14 marks)