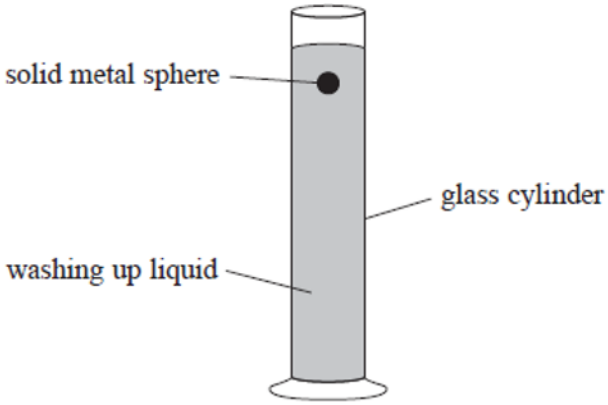
Questions

Q1.

A student carried out an experiment to determine the viscosity of washing up liquid using the apparatus shown.



(a) The student released the sphere at the top of the cylinder and made measurements, using a stopwatch and metre rule, so the terminal velocity of the sphere could be determined.

(i) Describe a method that the student could use to determine an accurate value for the terminal velocity of the sphere. You may add to the diagram above.

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(ii) Explain why the use of a larger sphere would increase the percentage uncertainty in the calculated value of the terminal velocity.

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(b) (i) Complete the free-body force diagram for the sphere when travelling at terminal velocity.

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(ii) The student obtained a value of 0.16 m s^{-1} for the terminal velocity of the sphere.

Calculate the viscosity η of the washing up liquid in Pa s.

radius of sphere = 4.8×10^{-3} m
weight of sphere = 3.5×10^{-2} N
density of washing up liquid = 1.1×10^{3} kg m^{-3}

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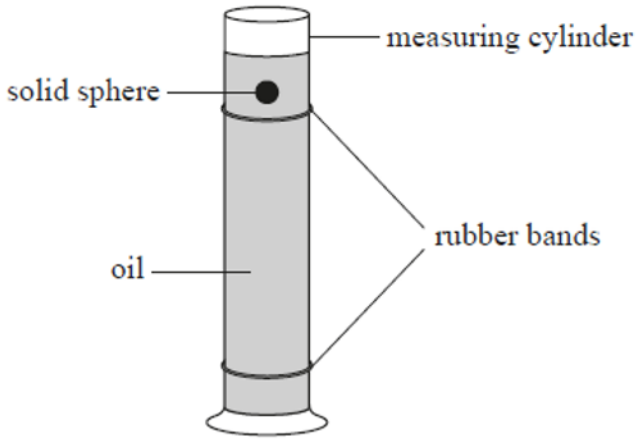
η = ... Pa s

(Total for question = 16 marks)

Q2.

A student carried out an experiment to determine the viscosity of a sample of oil contained in a large measuring cylinder.

A small solid sphere was released just above the surface of the oil and the terminal velocity of the sphere was determined.



(a) Two rubber bands were placed around the cylinder as shown. When the sphere passed the top band a timer was started. The timer was stopped when the sphere passed the bottom band.

(i) Explain why the top rubber band should be placed a short distance below the surface of the oil.

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(ii) Another student suggested using an additional rubber band halfway between the top and bottom rubber bands.

Discuss the benefit of adding the third rubber band.

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(b) The student used the following equation to determine the viscosity η of the oil.

$$\frac{4}{3}\pi r^3 \rho_s g = \frac{4}{3}\pi r^3 \rho_o g + 6\pi r \eta v$$

Where

ρ_s = density of the solid sphere

ρ_o = density of the oil

r = radius of the sphere

v = terminal velocity of the sphere

(i) Which quantity is represented by $\frac{4}{3}\pi r^3 \rho_s g$?

(1)

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(ii) Which quantity is represented by $\frac{4}{3}\pi r^3 \rho_o g$?

(1)

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(iii) Which quantity is represented by $6\pi r \eta v$?

(1)

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(iv) The accepted value for the viscosity of the oil used in this experiment is 41 mPa s at 24 °C.

The student obtained a value of 36 mPa s.

Suggest a possible reason for the student obtaining a lower value for the viscosity than the accepted value.

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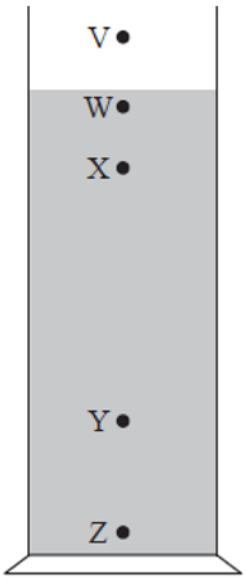
(Total for question = 8 marks)

Q3.

A student determines the terminal velocity of a ball bearing as it falls through oil. He releases the ball bearing at point V and measures the time taken for it to fall a measured distance.



Which two points should he use for the measured distance?

☒ **A** V and Y

☒ **B** W and Y

☒ **C** X and Y

☒ **D** W and Z

(Total for question = 1 mark)

Q4.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A student measured the terminal velocity of different objects as they fell through a liquid. The student used the measurements and Stokes' Law to calculate the viscosity of the liquid.

For which of the following conditions does Stokes' Law apply?

☒ **A** spherical objects and laminar flow

☒ **B** spherical objects and low viscosity

☒ **C** cylindrical objects and laminar flow

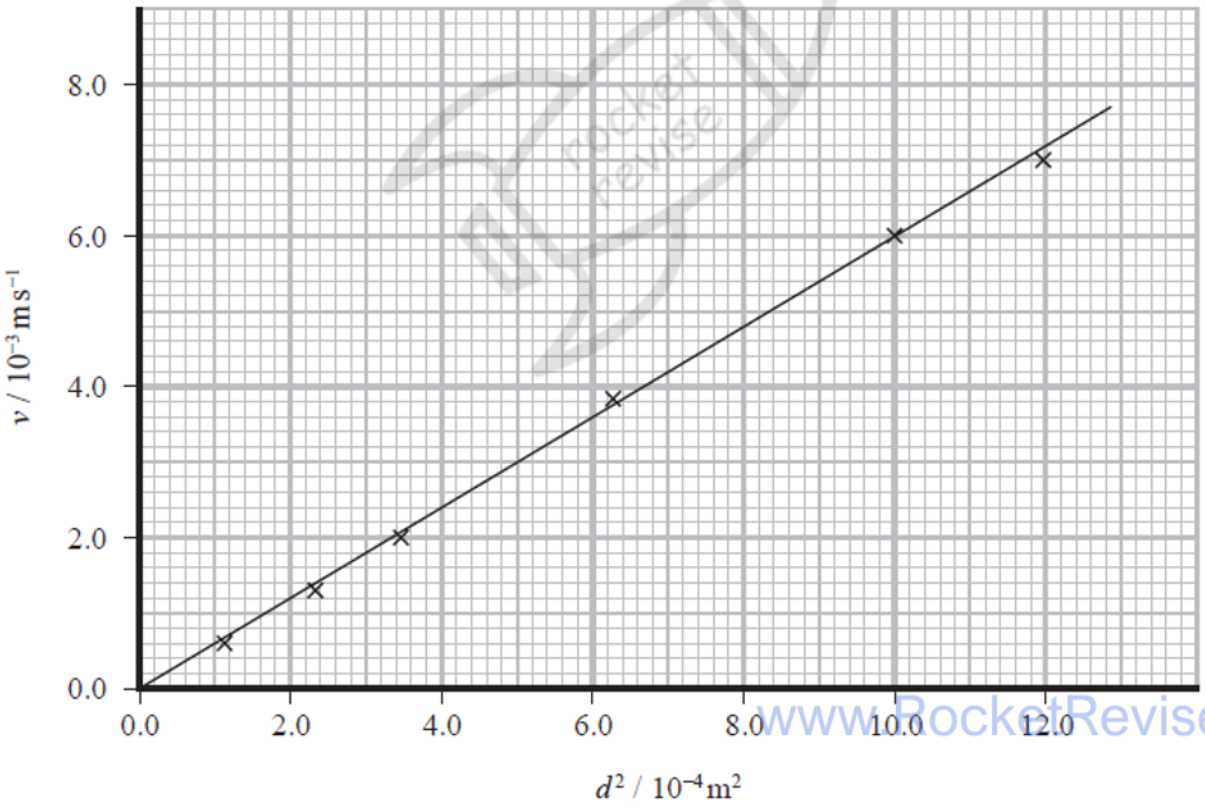
☒ **D** cylindrical objects and low viscosity

(Total for question = 1 mark)

Q5.

A student carried out an experiment to determine the viscosity of a liquid. He measured the terminal velocities v of several different glass spheres of diameter d, as they fell through the liquid.

The student used his measurements to plot the graph of v against d^2 shown below.



(a) Explain what is meant by terminal velocity.

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(b) A glass sphere of diameter 35 mm is travelling through the fluid at terminal velocity.

Show that the drag force on this sphere is about 0.2 N.

density of glass $\rho_g = 2.52 \times 10^3$ kg m^{-3}
density of liquid $\rho_s = 1.43 \times 10^3$ kg m^{-3}

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(c) The student reads in a textbook that if Stokes' law is obeyed

$$v = k\,d^2$$

where k is a constant.

(i) Deduce from the graph whether the flow of liquid around the spheres was laminar.

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(ii) Determine a value for k using the student's graph.

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k = ...

(iii) The constant k is given by

$$k = \frac{(\rho_g - \rho_s)g}{18\eta}$$

where η is the viscosity of the liquid.

Determine a value for η.

density of glass $\rho_g = 2.52 \times 10^3$ kg m^{-3}
density of liquid $\rho_s = 1.43 \times 10^3$ kg m^{-3}

(2)

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η = ...

(Total for question = 15 marks)

Q6.

A student determined the viscosity of a liquid using the falling-ball method.

(a) When the ball is falling at terminal velocity the following equation applies

drag force = weight of ball – upthrust

The density of the liquid was known.

The student used a balance and a digital calliper to make measurements on the ball.

Describe how the student could use her measurements to calculate a value for the drag force acting on the ball.

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(b) When falling through the liquid, the ball reached terminal velocity.

The flow of liquid around the ball was laminar.

Calculate the viscosity of the liquid.

terminal velocity of ball = 5.4×10^{-4} m s^{-1}
radius of ball = 0.50×10^{-2} m
drag force = 1.1×10^{-2} N

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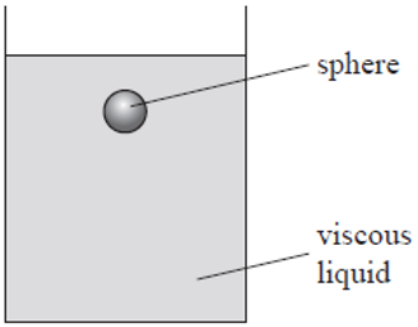
Viscosity of liquid = ...

(Total for question = 6 marks)

Q7.

Answer the question with a cross in the box you think is correct (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

A sphere falls through a viscous liquid as shown.



Which row of the table describes the upthrust and the viscous drag on the sphere as it accelerates downwards?

		Upthrust	Viscous drag
☒	**A**	increasing	increasing
☒	**B**	constant	increasing
☒	**C**	increasing	constant
☒	**D**	constant	constant

(Total for question = 1 mark)

Q8.

A student carried out an experiment using a data logger to record the motion of a ball-bearing as it fell through a liquid.

(a) State the conditions under which Stokes' law applies to an object moving through a fluid.

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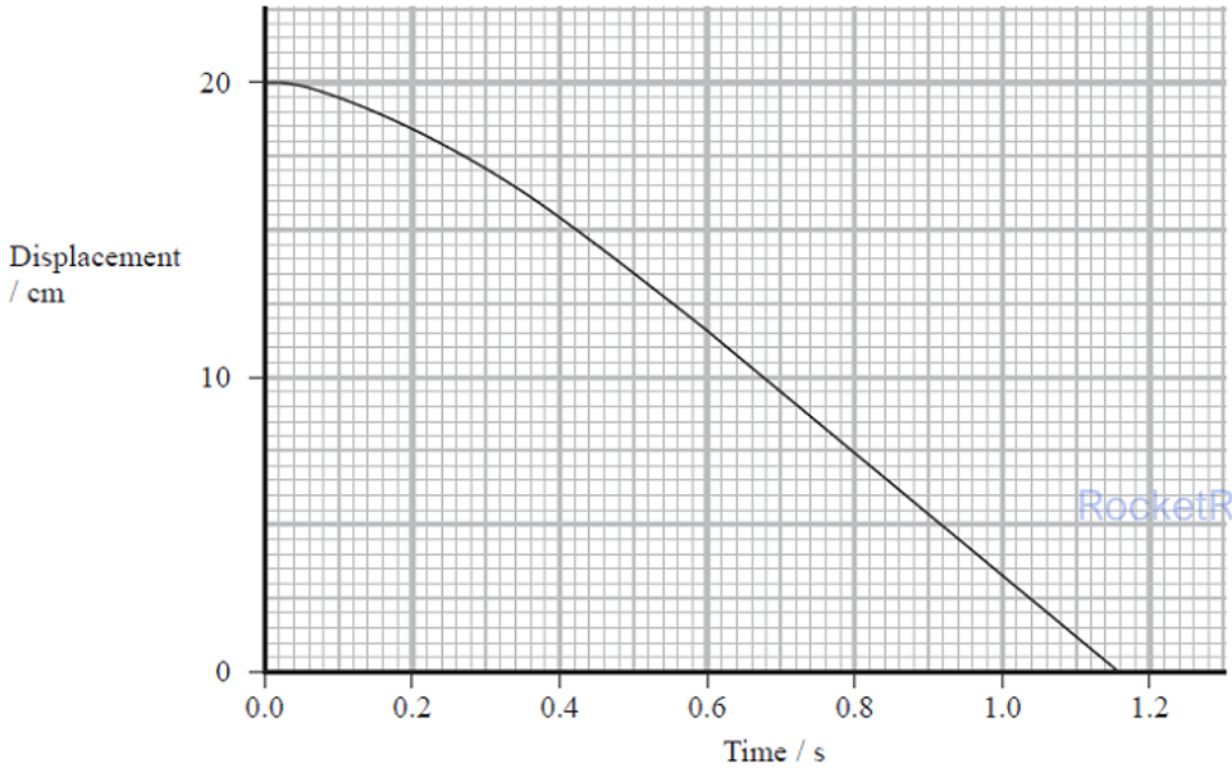
(b) The graph obtained by the student is shown below.



(i) Explain the shape of the graph.

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(ii) The ball-bearing had a diameter of 1.6 mm.

The difference between the upthrust on the ball-bearing and the weight of the ball-bearing is 1.45×10^{-4} N.

Calculate the viscosity of the liquid. Assume that Stokes' law applies.

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Viscosity = ... Pa s

(iii) The student heated the liquid and repeated the experiment.

The ball-bearing took less time to fall a given distance in the liquid when the liquid was at a higher temperature.

Explain why. Assume the density of the liquid is constant.

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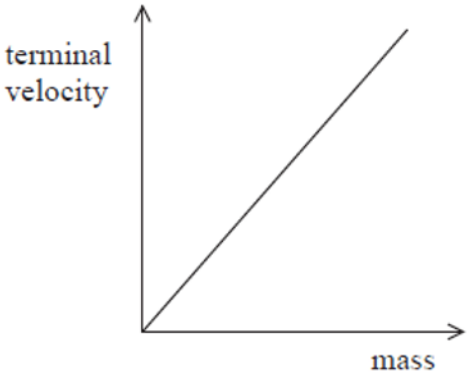
(Total for question = 13 marks)

Q9.

Select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The graph shows how terminal velocity varies with mass for small spheres of equal diameter falling through a viscous liquid.



Which of the following describes the gradient of the graph for a liquid of greater viscosity?

☒ **A** a greater gradient

☒ **B** a smaller gradient

☒ **C** a variable gradient

☒ **D** the same gradient

(Total for question = 1 mark)