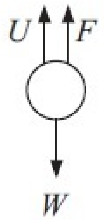
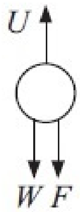
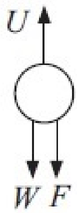
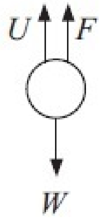
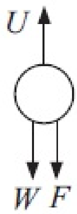
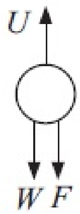
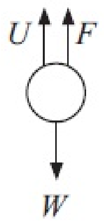
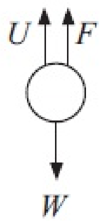
Questions

Q1.

When beer is being brewed it can contain bubbles of gas rising through it as well as solid particles, such as grain particles, falling through it.

Which row of the table correctly shows the forces on a rising gas bubble and a falling solid particle?

F = viscous drag, *U* = upthrust, *W* = weight

	Gas bubble	Solid particle
☒ **A**		
☒ **B**		
☒ **C**		
☒ **D**		

(Total for question = 1 marks)

Q2.

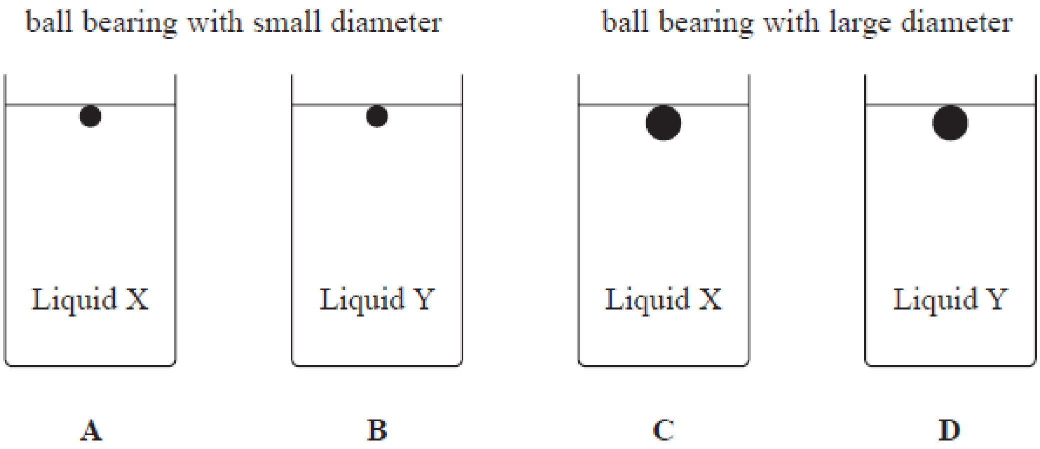
Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer

with a cross ☒.

In a falling-ball method to investigate the viscosity of a liquid, ball bearings with two different diameters are allowed to fall through two different liquids, X and Y.

The viscosity of liquid X is greater than the viscosity of liquid Y.

In which set-up shown below will the ball bearing have the greatest terminal velocity?



☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for question = 1 mark)

Q3.

A camera uses a converging lens to produce an image.

In some cameras, lenses of different focal lengths can be used. A particular camera can use a lens of focal length 50 mm or a lens of focal length 200 mm. Both lenses are made from the same material.

(i) Describe a method to determine an approximate value for the focal length of a converging lens.

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(ii) Explain why the lens with the shorter focal length is thicker at its centre.

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(iii) Both photographs show the same scene photographed from the same position.

Photograph 1

Photograph 2

One photograph was taken using the lens of focal length 50 mm and the other was taken using the lens of focal length 200 mm.

Deduce which lens was used to take photograph 2.

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(Total for question = 9 marks)

Q4.

The photograph shows a vase made of uranium glass. Uranium glass is radioactive.

Uranium glass usually contains a maximum of 2% uranium. Uranium glass made in the early part of the 20th century can contain up to 25% uranium.

A student carried out an investigation to determine the percentage of uranium in the glass.

The student measured the count rate by placing a Geiger Muller (GM) tube against the vase at a single position. This value was used to calculate the decay rate for the whole vase.

(i) Show that the decay constant for uranium is about $5 \times 10^{-18}\ s^{-1}$

half-life of uranium = 1.41×10^{17} s

(2)

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(ii) Calculate the percentage of uranium, by mass, in the glass.

area of GM tube window = $6.36 \times 10^{-5}\ m^2$
surface area of vase = $0.0177\ m^2$
background count rate = 525 counts in 10 minutes
count rate when GM tube next to vase = 3623 counts in 5 minutes
mass of vase = 149 g
mass of uranium atom = 238 u

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Percentage of uranium = ...

(iii) The uranium decays by emitting alpha particles.

Criticise the method used to determine the percentage of uranium in the vase.

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(Total for question = 10 marks)

Q5.

A student carries out an experiment to determine the viscosity of glycerol. She does this by determining the terminal velocity of a steel sphere falling through glycerol.

(i) The student drops a steel sphere with a radius of 4.0 mm into a cylinder of glycerol.

The sphere reaches terminal velocity and takes 3.9 s to fall 0.50 m.

Calculate the viscosity of glycerol.

density of steel = 7800 kg m^{-3}
density of glycerol =1300 kg m^{-3}

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Viscosity of glycerol = ...

(ii) There are two cylinders available for the student to use. One cylinder has a diameter of 1.5 cm and the other has a diameter of 5.0 cm.

State and justify which cylinder the student should use in order to gain a more accurate value for the viscosity of glycerol.

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(Total for question = 6 marks)

Q6.

An exhibit in a science museum requires the observer to use a pump to create air bubbles in a column of liquid. The bubbles then rise through the liquid.

A student wishes to determine the total drag force acting on a bubble.

(i) Explain why it might not be possible to use Stokes' law to calculate the drag force acting on a bubble.

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*(ii) Describe an additional measurement that would need to be taken from the photograph and how it could be used to determine the drag force, assuming that the bubble has reached its terminal velocity.

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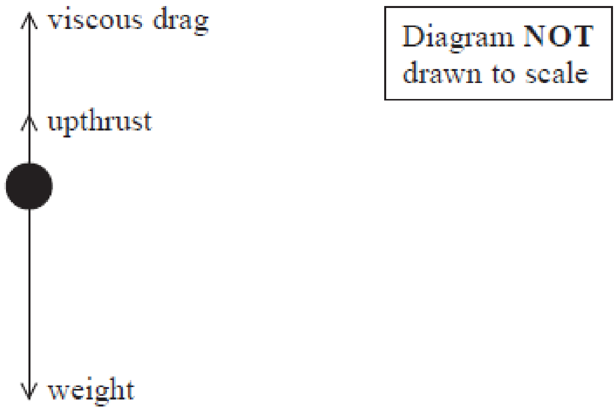
Q7.

Weather stations monitor the position of storm clouds.

(i) A raindrop is falling vertically through the air.

The free-body force diagram shows the forces acting on the raindrop.



The raindrop is travelling at terminal velocity. The raindrop is spherical with a radius of 0.10 mm and a weight of 4.1×10^{-8} N .

Calculate the magnitude of the terminal velocity.

viscosity of air = 1.3×10^{-5} Pa s density of air = 1.2 kg m^{-3}

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Magnitude of terminal velocity = ...

(ii) The value of terminal velocity calculated using the data in (i) is greater than the actual terminal velocity of the raindrop.

Explain why the calculation in (i) may not be valid.

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(Total for question = 6 marks)

Q8.

A student carries out an experiment to determine the viscosity of glycerol. She does this by determining the terminal velocity of a steel sphere falling through glycerol.

The equation shows how the terminal velocity of a solid sphere falling through a liquid depends on the density of both the solid and the liquid.

$$v = \frac{Vg(\rho_s - \rho_l)}{6\pi r\eta}$$

where

ρ_l = density of liquid
ρ_s = density of solid
r = radius of sphere
V = volume of sphere
η = viscosity of liquid
v = terminal velocity

The derivation of the equation for terminal velocity has been started below.
Complete the derivation.

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At terminal velocity: weight of solid sphere = drag + upthrust

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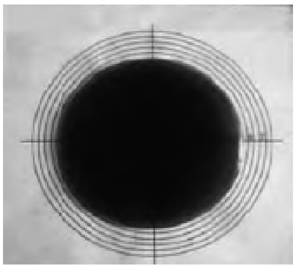
(Total for question = 3 marks)

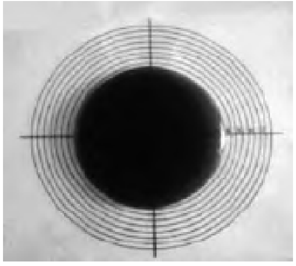
Q9.

The photograph shows an image of two "pancake" volcanoes on the surface of the planet Venus. Scientists believe these types of volcano are formed from lava spreading out in all directions onto a flat landscape.

A student investigated the formation of pancake volcanoes. She observed the flow of a viscous liquid at two different temperatures as it spread out from a central spot. The photographs below show the liquid at both temperatures after it had been flowing for the same length of time.



High temperature test



Low temperature test

The student carried out an experiment to determine the viscosity of the liquid at room temperature. She observed a steel sphere falling through the liquid.

She had the following equipment:

- a long, wide cylindrical tube
- two steel spheres with diameters 7.0 mm and 22.0 mm
- video camera
- metre rule

The student observed the sphere with a diameter of 7.0 mm falling through the liquid. The sphere fell 0.80 m in 5.3 s at a constant velocity.

The viscosity η of the liquid can be calculated using the equation

$$\eta = \frac{Vg(\rho_s - \rho_l)}{6\pi r v}$$

providing Stokes' law applies.

(i) Calculate the viscosity of the liquid.

density of liquid ρ_1 = 1430 kg m^{-3}

density of steel ρ_s = 7800 kg m^{-3}

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Viscosity of liquid = ... Pa s

(ii) If the student had used the larger sphere, the equation would not have produced the correct answer.

Explain why.

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(iii) The student used the video camera to record the sphere falling through the liquid.

State **one** benefit of using the video camera to record the motion of the sphere.

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(Total for question = 7 marks)

Q10.

A seiche is a standing wave that can form on the surface of a lake in strong winds, causing flooding and erosion.

Erosion causes clay particles to be washed into the lake, making the lake cloudy. The lake can remain cloudy to a depth of about 4 m for more than 6 months.

One spherical clay particle has a radius of 2.5×10^{-7} m.

Deduce whether this particle takes more than 6 months to fall 4 m.
You should assume that the water in the lake remains still.

viscosity of water = 1.0×10^{-3} kg m^{-1} s^{-1}
density of water = 1000 kg m^{-3}
density of clay = 2650 kg m^{-3}

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(Total for question = 6 marks)

Mark Scheme

Q1.

Question Number	Answer	Mark
	B	**1**

Q2.

Question Number	Answer	Mark
	D larger ball bearing in liquid with lower viscosity	**1**
	Incorrect Answers: **A** smaller ball bearing in higher viscosity will fall most slowly **B** ball bearing in higher viscosity will fall the more slowly than in lower viscosity **C** smaller ball bearing will fall more slowly than a larger ball bearing	