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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	

Q3.

Question Number	Acceptable Answers	Additional guidance	Mark
(i)	• Focus image of distant/far object on to a screen (1) • Measure distance from lens to screen (1) **Or** • Use parallel rays of light (1) • Measure distance from lens to the point where the rays converge (1)	MP2 dependent on MP1	2
(ii)	• Greater refraction (1) • To converge (parallel) rays at a point closer to the lens (1)		2
(iii)	• Photograph 2 has a greater magnification (1) • so v is greater (1) • since u is constant (1) • So f is greater (1) • Hence photograph 2 taken with lens of focal length 200 mm (1)	MP5 dependent on MP2 and MP4	5

Q4.

Question Number	Acceptable answers		Additional guidance	Mark
(i)	• Use of $\ln 2 = \lambda t_{1/2}$ • $\lambda = 4.92 \times 10^{-18}$ (s^{-1})	(1) (1)	Example of calculation $\lambda = \ln 2 / 1.41 \times 10^{17}$ s $= 4.92 \times 10^{-18}$ s^{-1}	2
(ii)	• Calculate rate = counts / time • Subtract background radiation • Use of $A = -\lambda N$ • Calculates $N \times$ atomic mass • Calculates percentage by mass • Answer = 0.17% (ecf for λ from (a)(i))	(1) (1) (1) (1) (1) (1)	Example of calculation background rate = 525 / (10 × 60) s = 0.875 s^{-1} vase count rate = 3623 / (5 × 60) s = 12.077 s^{-1} corrected rate = 11.2 s^{-1} for whole vase = 11.2 s^{-1} × 0.0177 m^2 / 6.36 × 10^{-5} m^2 = 3117 s^{-1} N = 3117 / 4.91 × 10^{-18} s^{-1} = 6.348 × 10^{20} Mass = 6.348 × 10^{20} × 238 × 1.66 × 10^{-27} kg = 2.51 × 10^{-4} kg Percentage = 2.51 × 10^{-4} kg × 100 / 0.149 = 0.17 %	6
(iii)	Max 2 from: • Alpha particles could have been absorbed by the glass • Alpha particles will be emitted in all directions, not just towards the detector • Some alpha particles could have been detected from other parts of the vase • The count could include radiation from decay products • Some alpha particles could be absorbed by the GM tube window	(1) (1) (1) (1) (1)		2

Q5.

Question Number	Acceptable Answers		Additional guidance	Mark
(i)	• Use of $v = \frac{s}{t}$ • Use of $V = \frac{4}{3}\pi r^3$ • Use of $v = \frac{Vg(\rho_s - \rho_l)}{6\pi r\eta}$ • η =1.8 Pa s	(1) (1) (1) (1)	Example of Calculation $v = \frac{0.5}{3.9} = 0.13\ (\mathrm{m\ s^{-1}})$ $\eta = \frac{\frac{4}{3}\pi(4 \times 10^{-3})^3 \times 9.81 \times (7800 - 1300)}{6\pi \times 4 \times 10^{-3} \times 0.13} = 1.8\ \mathrm{Pa\ s}$ Accept kg $m^{-1}s^{-1}$ / N s m^{-2}	4

Question Number	Acceptable Answers	Additional guidance	Mark
(ii)	5cm (no mark) • Laminar flow **Or** less/no turbulent flow (1) • So Stoke's law applies **Or** sphere falls at a more constant rate (1)	Accept wider for 5.0 cm	**2**

Q6.

Question Number	Answer	Mark
(i)	(Stokes' law is only for) small (solid) spheres **Or**(Stokes' law is only for) laminar flow **Or** there is turbulent flow (1) Additional/less drag due to the bubbles having a non-stationary surface **Or** Stokes' law cannot be applied to a gas bubble because they have a non-stationary surface **Or** sides of container too close to bubbles **Or** volume/shape changes as it rises (1)	**2**
* (ii)	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) **Either: Resultant forces method 4 marks** Measure the diameter/radius of the sphere (from the photograph) (1) Use of $4\pi r^3/3$ to find the volume of the sphere (1) Use $V\rho g$ to find the upthrust / weight of the bubble (1) Drag = upthrust – weight (1) **Or: Stokes' law method 2 marks** Measure the diameter/radius of the sphere (from the photograph) (1) Calculate the (terminal) velocity using $v = s/t$ **and** substitute into $F = 6\pi r\eta v$ (1)	**4**

Q7.

Question Number	Acceptable Answers	Additional guidance	Mark
(i)	• Recognises resultant force on raindrop = 0 **Or** Uses W=F(+U) (1) • Use of $F = 6\pi\eta rv$ (1) • Use of U = weight of air displaced **Or** $U = \frac{4}{3}\rho_a \pi r^3 g$ **Or** $U = \rho_a V g$ and $V = \frac{4}{3}\pi r^3$ **Or** $U = mg$ and $\rho = \frac{m}{V}$ and $V = \frac{4}{3}\pi r^3$ **Or** states upthrust is negligible (1) • 1.7 m s^{-1} (1)	<u>Example of Calculation</u> W=F+U $F = 6\pi \times 1.3 \times 10^{-5}\text{Nm}^{-2} \times 1.0 \times 10^{-4} \times v = (2.45 \times 10^{-8}\ v)$ (N) $U = 1.225 \text{ kg m}^{-3} \times \frac{4}{3}\pi(0.0001 \text{ m})^3 \times 9.81 \text{m s}^{-2} = 4.9 \times 10^{-11}$ (N) $v = \frac{4.1\times10^{-8}\text{ N} - 4.9\times10^{-11}\text{ N}}{2.45\times10^{-8}} = 1.7 \text{ m s}^{-1}$	4

(ii)	turbulent flow (1) (so) Stokes law does not apply (1)		2

Q8.

Question Number	Acceptable Answers	Additional guidance	Mark
	• See drag = $6\pi r\eta v$ **(1)** • see Upthrust $= \rho_l V g$ **(1)** • see weight of sphere = $\rho_s V g$ **(1)**	Accept F or D for drag Do not accept $U = \rho_s V g$ for MP2 Accept ρ_f for ρ_l <u>Example of Calculation</u> At terminal velocity: Weight =Drag + Upthrust Therefore $m_s g = 6\pi r\eta v + m_l g$ $\rho_s V g = 6\pi r\eta v + \rho_l V g$ Rearranging $v = \frac{\rho_s V g - \rho_l V g}{6\pi r\eta}$ $v = \frac{Vg(\rho_s - \rho_l)}{6\pi r\eta}$	3

Q9.

Question Number	Acceptable Answers	Additional guidance	Mark
(i)	• Use of $v = \frac{s}{t}$ (1) • Use of $V = \frac{4}{3}\pi r^3$ (1) • Use of $v = \frac{Vg(\rho_s - \rho_l)}{6\pi r\eta}$ (1) • $\eta = 1.1$ (Pa s) (1)	<u>Example of Calculation</u> $\eta = \dfrac{\frac{4}{3}\pi\left(\frac{7.0\times10^{-3}\ \mathrm{m}}{2}\right)^3 \times 9.81\ \mathrm{m\ s^{-2}} \times (7800 - 1430)\mathrm{kg\ m^{-3}}}{6\pi \times \frac{7.0\times10^{-3}\mathrm{m}}{2} \times \frac{0.8\ \mathrm{m}}{5.3\ \mathrm{s}}}$ $\eta = 1.13$ Pa s	4
(ii)	• With the large sphere the speed will be greater so Stokes' law won't apply (1) • The flow is turbulent or not laminar (1)		2
(iii)	Any one • Can eliminate human reaction time • Can playback to measure <u>time</u> more accurately • Can check that terminal velocity is reached (1)		1

Q10.

Question Number	Answer	Additional Guidance	Mark
	• Use of $F = 6\pi\eta rv$ (1) • Use of $U = mg$ **and** $\rho = \frac{m}{V}$ (1) **and** $V = \frac{4}{3}\pi r^3$ • Recognises $W = F + U$ (1) • Use of $v = \frac{s}{t}$ (1) **Either** • $t = 1.7 \times 10^7$ s (1) • comparison with 6 months and conclusion consistent with their answer **Or** • $s = 3.3 - 3.6$ m (1) • comparison with 4 m and conclusion consistent with their answer	<u>Example of calculation</u> $F = 6\pi \times 1.0 \times 10^{-3}\ \mathrm{kg\ m^{-1}\ s^{-1}} \times 2.5 \times 10^{-7}\ \mathrm{m} \times v$ $V = \frac{4}{3}\pi(2.5 \times 10^{-7}\ \mathrm{m})^3 = 6.5 \times 10^{-20}\ \mathrm{m^3}$ $U = \rho_w Vg = 1000\ \mathrm{kg\ m^{-3}} \times 6.5 \times 10^{-20}\ \mathrm{m^3} \times 9.81\ \mathrm{m\ s^{-1}}$ $U = 6.4 \times 10^{-16}$ N $W = 2650\ \mathrm{kg\ m^{-3}} \times 6.5 \times 10^{-20}\ \mathrm{m^3} \times 9.81\ \mathrm{m\ s^{-1}}$ $W = 1.7 \times 10^{-15}$ N $F = 1.7 \times 10^{-15}\ \mathrm{N} - 6.4 \times 10^{-16}\ \mathrm{N}$ $F = 1.1 \times 10^{-15}$ N $v = \frac{1.1 \times 10^{-15}\ \mathrm{N}}{6\pi \times 1.0 \times 10^{-3}\mathrm{kg\ m^{-1}s^{-1}} \times 2.5 \times 10^{-7}\ \mathrm{m}}$ $v = 2.3 \times 10^{-7}\ \mathrm{m\ s^{-1}}$ $t = \frac{4\ \mathrm{m}}{2.3 \times 10^{-7}\ \mathrm{m\ s^{-1}}} = 1.7 \times 10^7$ s t =197 days which is 6.6 months accept 1 month = 28 to 31 days giving t = 6.3 to 7.0 months	**6**