Number 16(a) Flow (around sphere must be) laminar Or Flow (around sphere is) not turbulent (1) 1 16(b)(i) Use of upthrust = weight of displaced fluid (1) $U = 5.2 \times 10^{-7} (\text{N})$ (1) 2 Example calculation $U = 5.3 \times 10^{-11} \text{m}^3 \times 998 \text{kg m}^{-3} \times 9.81 \text{N kg}^{-1}$ (1) Use of $V = \frac{4}{3}\pi r^3$ (1) Use of $V = \frac{4}{3}\pi r^3$ (1) Use of $V = 0.12 \text{m s}^{-1}$ Or Required $V = 0.12 \text{m s}^{-1}$ Or Required $V = 0.12 \text{m s}^{-1}$ Or Required $V = 0.4 \times 10^{-9} \text{m}^3$ Or Required $V = 0.4 \times 10^{-9} \text{m}^3$ (1) Valid conclusion by comparison of relevant student values (ccf from (b)(i)) (1) 4 Example calculation $5.3 \times 10^{-11} \text{m}^3 = 2.33 \times 10^{-4} \text{m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{Pa s} \times 2.33 \times 10^{-4} \text{m} \times 3.50 \times 10^{-2} \text{m s}^{-1}$ $= 1.46 \times 10^{-7} \text{N} \neq 5.19 \times 10^{-7} \text{N}$ \therefore Stokes' law does not apply				
16(a) Flow (around sphere must be) laminar Or Flow (around sphere is) not turbulent	Question Number	Answer		Mark
16(b)(i) Use of upthrust = weight of displaced fluid $U = 5.2 \times 10^{-7}$ (N) (1) Example calculation $U = 5.3 \times 10^{-11} \text{m}^3 \times 998 \text{kg m}^{-3} \times 9.81 \text{N kg}^{-1}$ $= 5.19 \times 10^{-7} \text{N}$ 16(b)(ii) Use of $V = \frac{4}{3}\pi r^3$ (1) Use of $F = 6\pi \eta r \nu$ (1) $F = 1.5 \times 10^{-7} \text{N}$ Or Required $v = 0.12 \text{m s}^{-1}$ Or Required $V = 2.4 \times 10^{-9} \text{m}^3$ Or Required $\eta = 3.4 \times 10^{-4} \text{m and } r = 2.3 \times 10^{-4} \text{m}$ Or Required $\eta = 3.4 \times 10^{-3} \text{Pa s}$ (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) 14 Example calculation $5.3 \times 10^{-11} \text{m}^2 = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{Pa s} \times 2.33 \times 10^{-4} \text{m} \times 3.50 \times 10^{-2} \text{m s}^{-1}$ $= 1.46 \times 10^{-7} \text{N} \neq 5.19 \times 10^{-7} \text{N}$ ∴ Stokes' law does not apply		Or	(1)	1
Use of upthrust = weight of displaced fluid $U = 5.2 \times 10^{-7} (\text{N})$ (1) $Example calculation$ $U = 5.3 \times 10^{-11} \text{m}^3 \times 998 \text{kg m}^{-3} \times 9.81 \text{N kg}^{-1}$ $= 5.19 \times 10^{-7} \text{N}$ (1) Use of $V = \frac{4}{3}\pi r^3$ (1) Use of $F = 6\pi \mu r$ Required $v = 0.12 \text{m s}^{-1}$ Or Required $V = 2.4 \times 10^{-9} \text{m}^3$ Or Required $V = 2.4 \times 10^{-9} \text{m}^3$ Or Required $\eta = 3.4 \times 10^{-3} \text{Pa s}$ (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) $Example calculation$		Trow (around sphere is) not turbulent	(1)	1
$\frac{\text{Example calculation}}{U=5.3\times 10^{-11}\text{m}^3\times 998\text{kg m}^{-3}\times 9.81\text{N kg}^{-1}} = 5.19\times 10^{-7}\text{N}$ $16(b)(ii)$ Use of $V=\frac{4}{3}\pi v^3$ (1) Use of $V=\frac{4}{3}\pi v^3$ (1) $V=\frac{4}{3}\pi v^3$ (1) $V=\frac{1}{3}\pi v^3$	16(b)(i)	Use of upthrust = weight of displaced fluid	(1)	
$U = 5.3 \times 10^{-11} \text{m}^3 \times 998 \text{kg m}^{-3} \times 9.81 \text{N kg}^{-1}$ $= 5.19 \times 10^{-7} \text{N}$ Use of $V = \frac{4}{3}\pi r^3$ (1) $Use of F = 6\pi \eta r v$ (1) $F = 1.5 \times 10^{-7} \text{N}$ Or $Required v = 0.12 \text{m s}^{-1}$ Or $Required V = 2.4 \times 10^{-9} \text{m}^3$ Or $Required r = 8.3 \times 10^{-4} \text{m and } r = 2.3 \times 10^{-4} \text{m}$ Or $Required \eta = 3.4 \times 10^{-3} \text{Pa s}$ (1) $Valid conclusion by comparison of relevant student values (ecf from (b)(i))$ (1) $\frac{Example calculation}{5.3 \times 10^{-11} \text{m}^3} = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{Pa s} \times 2.33 \times 10^{-4} \text{m} \times 3.50 \times 10^{-2} \text{m s}^{-1}$ $= 1.46 \times 10^{-7} \text{N} \neq 5.19 \times 10^{-7} \text{N}$ $\therefore \text{Stokes' law does not apply}$		$U = 5.2 \times 10^{-7} (\text{N})$	(1)	2
Use of $V = \frac{4}{3}\pi r^3$ (1) Use of $F = 6\pi\eta rv$ (1) $F = 1.5 \times 10^{-7} \mathrm{N}$ Or Required $v = 0.12 \mathrm{m s^{-1}}$ Or Required $V = 2.4 \times 10^{-9} \mathrm{m}^3$ Or Required $r = 8.3 \times 10^{-4} \mathrm{m}$ and $r = 2.3 \times 10^{-4} \mathrm{m}$ Or Required $\eta = 3.4 \times 10^{-3} \mathrm{Pa} \mathrm{s}$ (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) (1) $\frac{\mathrm{Example calculation}}{5.3 \times 10^{-11} \mathrm{m}^3} = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \mathrm{m}^3}{4\pi}} = 2.33 \times 10^{-4} \mathrm{m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \mathrm{Pa s} \times 2.33 \times 10^{-4} \mathrm{m} \times 3.50 \times 10^{-2} \mathrm{m s^{-1}}$ $= 1.46 \times 10^{-7} \mathrm{N} \neq 5.19 \times 10^{-7} \mathrm{N}$ \therefore Stokes' law does not apply		$U = 5.3 \times 10^{-11} \text{ m}^3 \times 998 \text{ kg m}^{-3} \times 9.81 \text{ N kg}^{-1}$		
Use of $V = \frac{4}{3}\pi r^3$ (1) Use of $F = 6\pi \eta r v$ (1) $F = 1.5 \times 10^{-7} \text{N}$ Or Required $v = 0.12 \text{m s}^{-1}$ Or Required $V = 2.4 \times 10^{-9} \text{m}^3$ Or Required $\eta = 3.4 \times 10^{-4} \text{m}$ and $\eta = 2.3 \times 10^{-4} \text{m}$ Or Required $\eta = 3.4 \times 10^{-3} \text{Pa}$ s (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) (1) $\frac{\text{Example calculation}}{5.3 \times 10^{-11} \text{m}^3} = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{Pa s} \times 2.33 \times 10^{-4} \text{m} \times 3.50 \times 10^{-2} \text{m s}^{-1}$ $= 1.46 \times 10^{-7} \text{N} \neq 5.19 \times 10^{-7} \text{N}$ $\therefore \text{ Stokes' law does not apply}$	16(b)(ii)			
F = 1.5 × 10 ⁻⁷ N Or Required $v = 0.12$ m s ⁻¹ Or Required $V = 2.4 \times 10^{-9}$ m³ Or Required $T = 8.3 \times 10^{-4}$ m and $T = 2.3 \times 10^{-4}$ m Or Required $T = 8.3 \times 10^{-4}$ m and $T = 2.3 \times 10^{-4}$ m Or Required $T = 3.4 \times 10^{-3}$ Pa s (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) (1) Example calculation 5.3 × 10 ⁻¹¹ m³ = $\frac{4}{3}\pi r^3$ $T = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{ m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{ m}$ If Stokes' law applies, $T = U$ $T = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ = 1.46 × 10 ⁻⁷ N ≠ 5.19 × 10 ⁻⁷ N ∴ Stokes' law does not apply		Use of $V = \frac{4}{3}\pi r^3$	(1)	
Or Required $v = 0.12 \text{ m s}^{-1}$ Or Required $V = 2.4 \times 10^{-9} \text{ m}^3$ Or Required $r = 8.3 \times 10^{-4} \text{ m}$ and $r = 2.3 \times 10^{-4} \text{ m}$ Or Required $\eta = 3.4 \times 10^{-3} \text{ Pa s}$ (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) (1) Example calculation $5.3 \times 10^{-11} \text{ m}^3 = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{ m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{ m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$ \therefore Stokes' law does not apply		Use of $F = 6\pi \eta r v$	(1)	
Required $v = 0.12 \text{ m s}^{-1}$ Or Required $V = 2.4 \times 10^{-9} \text{ m}^3$ Or Required $r = 8.3 \times 10^{-4} \text{ m}$ and $r = 2.3 \times 10^{-4} \text{ m}$ Or Required $\eta = 3.4 \times 10^{-3} \text{ Pa s}$ (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) $\frac{\text{Example calculation}}{5.3 \times 10^{-11} \text{ m}^3 = \frac{4}{3} \pi r^3}$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{ m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{ m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$ $\therefore \text{ Stokes' law does not apply}$				
Required $V = 2.4 \times 10^{-9} \text{ m}^3$ Or Required $r = 8.3 \times 10^{-4} \text{ m}$ and $r = 2.3 \times 10^{-4} \text{ m}$ Or Required $\eta = 3.4 \times 10^{-3} \text{ Pa s}$ (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) (1) $\frac{\text{Example calculation}}{5.3 \times 10^{-11} \text{ m}^3 = \frac{4}{3} \pi r^3}$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{ m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{ m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$ \therefore Stokes' law does not apply				
Required $r = 8.3 \times 10^{-4}$ m and $r = 2.3 \times 10^{-4}$ m Or Required $\eta = 3.4 \times 10^{-3}$ Pa s (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) Example calculation $5.3 \times 10^{-11} \text{ m}^3 = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{ m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{ m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$ $\therefore \text{ Stokes' law does not apply}$		Required $V = 2.4 \times 10^{-9} \text{ m}^3$		
Required $\eta = 3.4 \times 10^{-3}$ Pa s (1) Valid conclusion by comparison of relevant student values (ecf from (b)(i)) (1) Example calculation $5.3 \times 10^{-11} \text{ m}^3 = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{ m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{ m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$ $\therefore \text{ Stokes' law does not apply}$		Required $r = 8.3 \times 10^{-4} \text{ m}$ and $r = 2.3 \times 10^{-4} \text{ m}$		
Example calculation $5.3 \times 10^{-11} \text{ m}^3 = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{ m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{ m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$ $\therefore \text{ Stokes' law does not apply}$			(1)	
$5.3 \times 10^{-11} \text{ m}^3 = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11} \text{ m}^3}{4\pi}} = 2.33 \times 10^{-4} \text{ m}$ If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$ $\therefore \text{ Stokes' law does not apply}$		Valid conclusion by comparison of relevant student values (ecf from (b)(i))	(1)	4
If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$ \therefore Stokes' law does not apply		$5.3 \times 10^{-11} \mathrm{m}^3 = \frac{4}{3} \pi r^3$		
		If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4} \text{ Pa s} \times 2.33 \times 10^{-4} \text{ m} \times 3.50 \times 10^{-2} \text{ m s}^{-1}$ $= 1.46 \times 10^{-7} \text{ N} \neq 5.19 \times 10^{-7} \text{ N}$		
Lotal for duestion 16		Total for question 16		7