1	**The only correct answer is D (*W*)** A is not correct because upthrust is equal to the weight of liquid displaced B is not correct because upthrust is equal to the weight of liquid displaced C is not correct because upthrust is equal to the weight of liquid displaced	**1**

3	**The only correct answer is B** because Upthrust is equal to weight of sphere (2.5 N). Weight of displaced water if half sphere submerged = 2.5 N Weight of displaced water if all of sphere submerged = 5.0 N Total upwards force acting on sphere when completely submerged = 5.0 N Total downwards force on sphere if completely submerged (and stationary) = 5.0 N *F* must be equal to 2.5 N **A** *is not the correct answer as F = 2.5 N* **C** *is not the correct answer as F = 2.5 N* **D** *is not the correct answer as F = 2.5 N*	**(1)**

7	**B decreased by $(2.4 \times 10^{-5}) \times (1000) \times (9.81)$**	**1**
	Incorrect Answers: A – this is just the mass of the displaced water C – the reading will decrease and not increase due to the upthrust acting upwards on the object by the weight, and not the mass, of the displaced water (upthrust) D – the reading will decrease and not increase due to the upthrust acting upwards on the object	

Question Number	Answer		Additional Guidance	Mark
17(a)	Calculates volume of one lifting bag	**(1)**	Example calculation $V_{bag} = \frac{4}{3} \times \pi \times \left(\frac{0.5\text{ m}}{2}\right)^3 = 0.0654\text{ m}^3$ $V_{box} = 1.1\text{ m} \times 0.5\text{ m} \times 0.25\text{ m} = 0.138\text{ m}^3$ $V_{total} = 2 \times 0.0654\text{ m}^3 + 0.138\text{ m}^3 = 0.269\text{ m}^3$ $m_{displaced\ water} = 1020\text{ kg m}^{-3} \times 0.269\text{ m}^3 = 274\text{ kg}$ $W_{displaced\ water} = 274\text{ kg} \times 9.81\text{ N kg}^{-1} = 2690\text{ N}$ 2690 (N) > 2500 N so the box will be lifted	**6**
	Calculates volume of box	**(1)**		
	Use of $\rho = \frac{m}{V}$	**(1)**		
	Use of $W = mg$	**(1)**		
	Total upthrust = 2700 N	**(1)**		
	Comparison of calculated upthrust with 2500 N and consistent conclusion	**(1)**		
17(b)(i)	Calculates resultant of weight and upthrust	**(1)**	Example calculation $F = 4.77 \times 10^{-4}\text{ N} - 1.82 \times 10^{-6}\text{ N} = 4.752 \times 10^{-4}\text{ N}$ $v = \frac{4.752 \times 10^{-4}\text{ N}}{6 \times \pi \times 8.60 \times 10^{-4}\text{ Pa s} \times 2.25 \times 10^{-3}\text{ m}} = 13.03\text{ m s}^{-1}$	**3**
	Use of $F = 6\pi\eta rv$	**(1)**		
	Terminal velocity = 13.0 m s^{-1}	**(1)**		

17(b)(ii)	Any two from • The bubble may not move at a low speed • The bubble may not be spherical • The bubble may not experience laminar flow **Or** flow may be turbulent • The temperature/viscosity may change (as the bubble rises) • The volume/radius may change (as the bubble rises)	**(1)** **(1)** **(1)** **(1)** **(1)**	Ignore the bubble may not be small	**2**
	Total for question 17			**11**

Question Number	Answer		Mark
13(a)	Distance $P = D - h$ Distance $Q = D$	**(1)** **(1)**	**2**
***13(b)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** **Max 5** A statement or description of tension = weight – upthrust (+ drag) (Initially) tension constant as upthrust is constant **Or** (Initially) the graph is flat as upthrust is constant in water The speed is slow/constant in water so friction is constant/negligible As the cylinder moves through the surface of the water the volume/weight/mass of displaced water decreases The tension increases because the upthrust decreases **Or** the tension increases as the upthrust is proportional to submerged volume (Once above the water the) tension greater/constant as tension = weight **Or** (Once above the water the) tension greater/constant as upthrust is negligible/small Accept symbols for tension, weight and upthrust but symbols must be defined if QWC awarded	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question 13		**7**

Question Number	Answer		Mark
19(a)	• Upthrust/U upwards • Tension/T upwards • Weight/W/mg downwards (-1 for each extra force over three, -1 if any arrow does not touch the dot, -1 if any arrow is not close to vertical. Accept a single line up with two labelled arrowheads.)	(1) (1) (1)	**(3)**
19(b)(i)	• Water exerts upward force on sphere. **Or** Water exerts an upthrust on the sphere. • Sphere exerts a downwards/opposite force on water by Newton's Third Law. • Extra downward force on water (increases reading on balance).	(1) (1) (1)	**(3)**

19(b)(ii)	• Mass of displaced water = 150 g (1) • Use of $V = m/\rho$ for water with $\rho = 1\,000$ kg m^{-3} (150 ml) (1) • Use of $m = \rho V$ for sphere WITH $\rho = 2\,000$ kg m^{-3} (1) • $m = 0.30$ kg (1) Example of calculation Increase in weight of water = force of ball on water = upthrust on ball Mass of displaced water = 465 g – 315 g = 150 g Volume of sphere = $\frac{0.150\ \text{kg} \times \cancel{g}}{1000\ \text{kg m}^{-3} \times \cancel{g}} = 1.5 \times 10^{-4}$ m^3 Mass of sphere = 2000 kg m^{-3} × 1.5×10^{-4}	**(4)**
19(b)(iii)	• Upthrust less in oil **or** weight of displaced oil less **or** downward force of sphere on oil less (1) • (Therefore increase in) balance reading less (than for water). (1) (MP2 dependent on MP1)	**(2)**
	Total for question 19	**12**