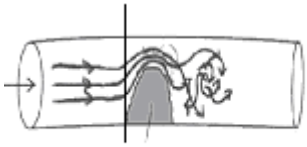
Question Number		Mark
1(a)	Graph does not have a zero gradient **Or** Graph does not shows constant velocity **Or** the velocity is constantly changing **Or** Graph always shows an acceleration (or deceleration) **Or** Graph not horizontal/ flat **Or** Graph not parallel to the time/x-axis **(1)** (Accept 'line/gradient/tangent' in place of 'graph')	**1**
1(b) (i)	Use of gradient of tangent **(1)** a = 6.5 to 7.4 (m s^{-2}) (conditional mark) **(1)** (Check graph to make sure that the values have been read accurately from the graph, misreading from the graph will only score 1 mark even if the answer falls in the above range) <u>Example of calculation</u> Acceleration = $\frac{8.0\text{m} - 1.2\text{m}}{1.0\text{s}}$ Acceleration = 6.8 m s^{-2}	**2**
1(b)(ii)	Use of $F = ma$ **(1)** F = 0.016 to 0.018(N) (ecf acceleration from (b)(i)) **(1)** <u>Example of calculation</u> F = 6.9 m s^{-2} × 0.0024 kg = 0.017 N	**2**
1 (b) (iii)	Use of W = mg **(1)** Drag = 0.006 to 0.008(N) (ecf) **(1)** <u>Example of calculation</u> W = 0.0024 kg ×9.81 N kg^{-1} = 0.0235 N 0.017 = 0.0235 – drag Drag = 0.0065 N	**2**
1 (b) (iv)	Use of Stokes' law equation with velocity either 5.2 m s^{-1} or 6.6 m s^{-1} **(1)** F = 3.5 × 10^{-5} (N) or 4.5 × 10^{-5} (N) (no unit error) **(1)** <u>Example of calculation</u> $F = 6\pi\eta rv$ = 6π × 1.8 × 10^{-5} × 2 × 10^{-2} × 5.2 m s^{-1} = 3.5 × 10^{-5} N	**2**

1 (c)(i)	Correctly identifies a region of laminar flow and region of turbulent flow **(1)**	
1 (c)(ii)	the idea that there is turbulent flow **Or** ball is moving fast **Or** this is a large sphere **Or** Statement about Stokes law force for laminar flow only **Or** Stoke's law assumes that the ball is moving slowly (which this is not) **Or** Stoke's law is for a small sphere (and the hollow ball is large) **(1)** **Or** A large amount of eddies increases the drag	**1**
1 (d)	**Max 3** Falls with constant acceleration **(1)** At about 0.8 s: the ball bounces **Or** the ball changes direction **(1)** Speed of ball after the bounce is less than the speed before the bounce **(1)** Max height reached at about 1.3 s. **(1)** Accelerations are the same before and after the bounce **(1)**	**3**
	Total for question	**14**

Question Number	Answer	Mark
2(a)(i)	**Laminar:** at least 2 roughly parallel lines before object **(1)** **Turbulent:** lines crossing or showing change in direction of greater than 90^{o}. **(1)** **(Max 1** mark if the laminar flow not shown leading into the turbulent flow.)  Turbulent flow not to start before the oject i.e. to the left of this line 2 marks  1 mark only	**2**
2(a)(ii)	**Laminar flow:** No abrupt change in velocity of flow **OR** no abrupt change in speed or direction of flow (must mention both speed **and** direction) **OR** velocity at a point is constant **OR** flows in layers/flowlines/streamlines **OR** layers do not mix/cross **OR** layers are parallel **(1)** **Turbulent flow:** Mixing of layers/flowlines/streamlines **OR** crossing of layers etc. **OR** contains eddies **OR** contains vortices/whirlpools **OR** abrupt/random changes in speed or direction **(1)**	**2**
2(b)(i)	Greater velocity with lower viscosity **(1)**	
2(b)(ii)	Lower viscosity **(1)** So faster flow **OR** greater velocity **(1)**	**2**
	Total for question	**7**

Question Number	Answer	Mark
3	Complete the diagram Before A = laminar flow – minimum of 2 continuous smooth lines roughly parallel to wing surface which don't cross After A = turbulent flow – lines crossing, eddies, sudden changes in direction, change in direction > 90°, lines disappearing and appearing	**(1)** **(1)**
	Total for question	**2**

Question Number	Answer	Mark
4 (a)	Show that the upthrust is about 8×10^{-4} N Use of mass = density x volume Correct answer for upthrust (= 8.3×10^{-4} (N)) <u>Example of calculation</u> mass of liquid displaced = density x volume = 1300 kg m^{-3} x 6.5×10^{-8} m^3 = 8.45×10^{-5} kg upthrust = 8.45×10^{-5} kg x 9.81 m s^{-2} = 8.3×10^{-4} N	**(1)** **(1)**
4 (b)	Show that the viscosity of the liquid is about 2 kg m^{-1} s^{-1} Correct summary of forces, e.g. V = W - U Use of $F = 6\pi\eta rv$ Correct answer for viscosity (1.8 (kg m^{-1} s^{-1})) <u>Example of calculation</u> Viscous drag = W – U = 4.8×10^{-3} N - 8.3×10^{-4} N = 3.97×10^{-3} N $F = 6\pi\eta rv$ η = 3.97×10^{-3} N / (6 x π x 4.6×10^{-2} m s^{-1} x 2.5×10^{-3} m) = 1.8 kg m^{-1} s^{-1} [Watch out for out of clip answers]	**(1)** **(1)** **(1)**
4 (c)	State a relevant variable to control <u>Temperature</u>	**(1)**
	Total for question	**6**

Question Number	Answer	Mark
5 (a)	Add to the diagram to show the water flow at A_2 and B_2. Laminar at A_2 – minimum 2 lines, approximately straight and parallel, lines mustn't cross (1) Turbulent at B_2 – indicated by lines crossing / change in direction > 90°/ chaotic lines(1)	**2**
5 (b)	Name and describe the type of water flow at A_2 and at B_2. A - laminar flow / streamline flow (1) no abrupt change in (direction or speed of) flow/ flows in straight lines / velocity at any point constant / no mixing of layers [no eddies is not sufficient; smooth is not sufficient; no disruption of lines not sufficient](1) B - turbulent flow (1) mixing of layers / eddies / sudden change in (direction or speed of) flow / velocity at a point not constant (1) [NB - All independent marks]	**4**
	Total for question	**6**

Question Number	Answer	Mark
***6**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** New design: is more streamlined **Or** more curved **Or** more aerodynamic (1) reduces turbulent air flow **Or** fewer eddy currents **Or** increases laminar air flow (1) less (air) resistance/drag/friction (1) less energy transferred to the air (from the lorry) **Or** less work done against (air)resistance **Or** less power/energy/work needs to be supplied to the lorry (to maintain the same speed) (1) Allow converse argument for references to the traditional trailer.	**4**
	Total for Question	**4**

Question Number	Answer		Mark
7(a)(i)	(For upward motion) the upthrust > weight (+drag) **Or** there is a resultant upward force (This is because) greater volume/mass of liquid is displaced (Accept more liquid displaced) Upthrust increases (and mass/weight of wax drop is constant)	(1) (1) (1)	**3**
7(a)(ii)	Upthrust, weight and (viscous) drag identified as the three forces Correct equation e.g. upthrust = weight + drag **Or** upthrust − weight –drag = 0 (Max 1 for undefined symbols used)	(1) (1)	**2**
7(b)	**her** Temperature decreases Density of drop increases Upthrust reduces **Or** Temperature decreases Viscosity (of clear liquid) greater Drag will be greater (at the top)	 (1) (1) (1) (1) (1) (1)	**3**
	Total for question		**8**

Question Number	Answer		Mark
8	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)**		
	As the lava cools, its viscosity increases	**(1)**	
	Rhyolite's viscosity is greater than basalt's	**(1)**	
	Rhyolite flows more slowly than basalt **Or** high viscosity gives low flow rate	**(1)**	
	Basalt flows a long way before solidifying /cooling (so shield shape) **Or** rhyolite flows a short distance before solidifying /cooling (so cone shape)	**(1)**	**4**
	Total for Question		**4**

Question Number	Answer		Mark
9	Viscosity (of the oil) decreases (at higher temperature) Rate of flow increases / Spreads more quickly [Full converse argument about a cold pan. 1 max]	**(1)** **(1)**	**2**
	Total for question		**2**

Question Number	Answer		Mark
10(a)(i)	**Laminar flow** – no abrupt change in direction or speed of flow **or** air flows in layers/flowlines/streamlines **or** no mixing of layers **or** layers remain parallel **or** velocity at a (particular) point remains constant	**(1)**	
	Turbulent flow – mixing of layers **or** contains eddies/vortices **or** abrupt/random changes in speed or direction	**(1)**	**2**
10(a)(ii)	Relative speed of upper surface of ball to air is greater (than at lower surface) **Or** The idea that the direction of movement at the top (due to spin) is opposite to/against (direction of) air flow (converse arguments acceptable)	**(1)**	**1**
10(b)	Force (by ball) on air upwards	**(1)**	
	(Equal and) opposite force (on ball) by air **Or** (Equal and) opposite force acts due to Newton's 3rd law **Or** force of air on ball downwards	**(1)**	**2**
10(c)(i)	Use of $v = s/t$	**(1)**	
	Use of $s = 1/2\ at^2$ to find s or use of correct equation**s** that could lead to the final answer.	**(1)**	
	Distance = 0.037 (m)	**(1)**	**3**
	Example of calculation Time = 2.7 / 31 = 0.087 s $s = 1/2 \times 9.81\ m\ s^{-2} \times (0.087\ s)^2$ = 0.037 (m)		
10(c)(ii)	(Extra) downwards force (on the ball)	**(1)**	
	Greater downwards acceleration	**(1)**	
	Greater distance fallen **Or** drops further(in that time) **Or** needs to drop 15 cm, 4 cm drop not enough	**(1)**	**3**
	Total for question		**11**