Name: ____

Forces and Motion 2

Mark Scheme

Date:

Time:

Total marks available:

Total marks achieved: ______

Mark Scheme

Q1.

Question Number	Answer	Mark
	C	1

Q2.

Question Number	Acceptable answers		Additional guidance	Mark
	• Initial acceleration due to a resultant force	**(1)**		3
	• Decreasing acceleration as resistive forces increase **Or** Decreasing acceleration as resultant force decreases	**(1)**	Accept reference to gradient of graph for acceleration for MP2 & MP3.	
	• No acceleration as resultant force is zero **Or** constant velocity as resultant force is zero	**(1)**	Accept terminal velocity for constant velocity	

Q3.

Question Number	Answer		Mark
(a)	This can be marked in terms of the train either initially stationary or moving with constant speed. State N1in terms of ΣF =/> 0 e.g. An unbalanced/net/resultant/total/ΣF force of zero gives constant speed/velocity/motion (the friction between floor and feet) accelerate the feet **Or** (friction between floor and feet) creates an unbalanced/net/resultant/total force on feet the train accelerates but the man continues travelling at the original/constant speed **Or** the top half has no (resultant) force as the train accelerates **Or** the man's speed relative to the train is lower **Or** (All of the) man needs to accelerate at the same rate as the train	 (1) (1) (1)	3
* (b)	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) Man pulls (backward) on the support Due to N3 the support exerts a (opposite) force on the man This force is a resultant/unbalanced/net force on man Due to N1/N2 the man will accelerate With the same acceleration/speed/velocity as the train	 (1) (1) (1) (1) (1)	5
	Total for question		**8**

Q4.

Question Number	Answer		Mark
(a) (i)	Each row of the table contains a suitable method. One mark for each column, do not allow a mix and match of methods (rows)	(1) (1) (1) (1)	

Distance measured with the metre rule	**<u>Corresponding</u> time**	**<u>Correct</u> use of measurements referred to in columns 1 and 2**	**To calculate g use:** (formula/expression seen)
Record the position on the **rule** for each frame	Time between frames	Plot distance against t^2	g = 2 x gradient
Measure distance between (successive) frames against a metre **rule**	Time between frames	Calculate the speed each frame using distance /time and plot against time	g = gradient
Use metre **rule** to measure: (total) distance ball falls through **Or** height from which the ball was dropped (e.g. 1 m)	Number of frames × time between frame **Or** total time of journey recorded/found	Use of: $s = ut + ½ at^2$ **Or** $s = ½ at^2$ **Or** $s = ½ gt^2$	$g = 2s/t^2$ **Or** Re-arrange $s = ½ gt^2$ substituting in s and t to find g.
Measure distance between frames (at beginning and) end of drop using the **rule**	Time between frames known and count frames **Or** if stated $u = 0$ then time for ball to fall and the time between frames.	Use speed = $Δs/Δt$ to find their final velocity using correct time interval [may take u as 0]	$g = (v-u)/t$ **Or** $a = (v-u)/t$
Record the position on the **rule** each frame	Time between frames	Calculate the speed each frame using d/t and plot a graph of v^2 against s.	Gradient/2 = acceleration

Accept metre stick or ruler in place of metre rule
(The candidate may refer to the acceleration of free fall as '*a*' or 'g')

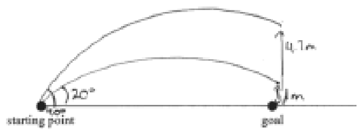
(a) (ii)	Ball may be released between 1st and 2nd images (so times used all too long because they include a short time before it is dropped) **Or** ball released before the 1st image so u is not 0 **Or** the ruler is not vertical/straight **Or** the idea that the camera has not been calibrated correctly i.e. runs too fast/slow **Or** the idea that there is a parallax error from camera to object (Parallax alone is insufficient) (Do not award a mark for air resistance)	(1)	1
(b)	Small / dense / streamlined shape / smooth surface / shiny Correct explanation, e.g.: Small surface area– minimise drag Dense – weight > upthrust **Or** weight > drag Streamlined /aerodynamic– minimise drag **Or** ensure laminar flow Smooth surface – minimise drag **Or** ensure laminar flow Shiny – easy to see on the recording Small – easier to read scale (precisely) (Sphere is not acceptable for a property but statement such as 'sphere to minimise drag' can score 2nd mark)	(1) (1)	2
(c)	Advantage Explanation (to score both marks the explanation must be linked to the advantage. Accept reverse arguments. Human error is not sufficient for reaction time).	(1) (1)	2

Advantage	Explanation
No reaction time	Reduces uncertainties **Or** (time recorded) more precise/accurate
Can be paused /stopped to take readings.	Measurements taken at exact times **Or** positions against rule recorded more accurately. **Or** velocities can be calculated frame by frame (more readings
Allows repeated playback **Or** rewinding	Allows values to be checked/confirmed **Or** values obtained are more reliable

Q5.

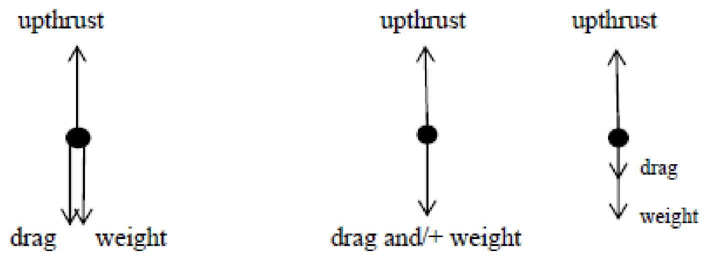
Question Number	Answer		Mark
(a)	Same (downwards) acceleration **Or** acceleration = g (accept constant acceleration)	(1)	1
(b)(i)	The ball is in contact with the floor (accept the ball bounces)	(1)	1
(b) (ii)	Lower gradient **Or** the lines would be not be as steep	(1)	1
(c)	Use of equation(s) of motion to find s **Or** use of distance = area under the graph **Or** use of GPE = KE s = 1.1 m – 1.4 m <u>Example of calculation</u> $(4.7 \text{ m s}^{-1})^2 = (0 \text{ m s}^{-1})^2 + (2 \times 9.81 \text{ m s}^{-2} \times s)$ s = 1.13 m	(1) (1)	2
(d)(i)	Use of KE = ½ mv^2 KE = 1.1 – 1.3 (J) (no ue) <u>Example of calculation</u> KE = ½ × 0.40 kg × $(2.4 \text{ m s}^{-1})^2$ = 1.15 J	(1) (1)	2
(d)(ii)	Use of GPE = KE h = 0.27 m – 0.32 m (ecf from 16(d)(i)) (If area under graph or an equation of motion is used e.g. $h = \frac{(u+v)t}{2}$ or $v^2 = u^2 + 2as$ only MP2 can be scored) <u>Example of calculation</u> $h = \frac{1.2 \text{ J}}{0.4 \text{ kg} \times 9.81 \text{ Nkg}^{-1}}$ h= 0.31 m	(1) (1)	2
(e)	(Elastic potential) energy transferred to thermal energy **Or** energy dissipated as heat	(1)	1
	Total for question		10

Q6.

Question Number	Answer		Mark
(a)(i)	The ball has bounced **Or** the ball would be below initial height **Or** the ball has landed before reaching the goal **Or** the ball has hit the ground	**(1)**	**1**
(a)(ii)	Correct shape of at least one trajectory, starting at the kick and ending at/beyond the goal Range/position of the higher angle > range/position of lower angle ball seen with paths labelled Example of response scoring 2 marks 	**(1)** **(1)**	**2**

(b) (i)	Use of (u_H) = u cos15 **Or** u sin75 **Or** see 25(.1) m s^{-1} Use of $u = s/t$ to calculate the time to the goal **Or** see 0.44 s Use of (u_V) = u sin15 **Or** u cos75 **Or** see 6.7 m s^{-1} Use of $s = ut + ½ at^2$ (a must be negative) s = 2.0 m Use of (value obtained + the 0.22 m (or 0.11 m)) to make a sensible statement as to whether or not the goal will be scored e.g. the top of the ball on reaching the goal 2.23 m. (This is less than 2.4 m and) the goal will be scored (Answer must be consistent with calculated distance. For calculated heights greater than 2.4 m, candidates do not need to refer to radius /diameter but a comparison of heights is needed.) <u>Example of calculation</u> $t = \frac{11\text{ m}}{26\text{ ms}^{-1} \times \cos 15°} = 0.44$ s s = (26 m s^{-1} × sin 15°)(0.44 s) + (½) (–9.81 N kg^{-1})(0.44 s)^2 s = 2.01 m Height of the top of the ball on reaching the goal = 2.01 m + 0.22 m = 2.23 m	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
(b) (ii)	Air resistance is in the opposite direction to the ball's motion **Or** air resistance adds a backwards force **Or** work is done against air resistance The ball will decelerate (horizontally) **Or** the ball will have a decreasing velocity/speed **Or** the ball will not travel as far **Or** this reduces the maximum height the ball reaches **Or** the ball is in the air for less time **Or** the ball will take longer to reach the goal	**(1)** **(1)**	**2**
	Total for question		**11**

Q7.

Question Number	Answer		Mark
(i)	Weight/W/mg	(1)	
	Upthrust/U	(1)	
	Drag/Friction/Fluid resistance/F/D/V	(1)	3
	(all lines must touch the black dot and should be approximately vertical by eye) (−1 for each additional force)		
			
(ii)	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)		
	Upthrust is greater for the larger bubble	(1)	
	Drag/friction increases	(1)	
	Upthrust increases more than drag **Or** greater (initial) resultant force on bubble **Or** higher terminal velocity **Or** upthrust is related to volume/radius^3 **and** drag related to area/radius$^{(2)}$	(1)	3

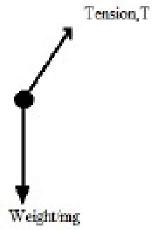
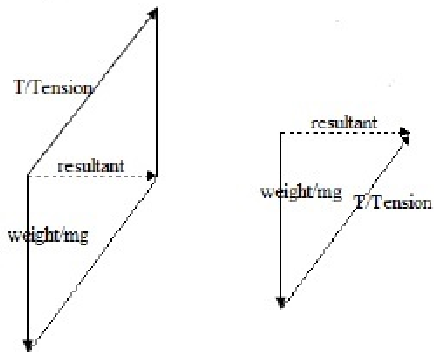
Q8.

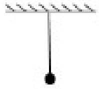
Question Number	Acceptable answers		Additional guidance	Mark
(a)	• use of $\rho = m/V$ **and** $W = mg$ to calculate upthrust	(1)	Example of calculation $m_{displaced} = 1.0 \times 10^3$ kg m^{-3} × 8.0 × 10^{-6} m^{-3} = 8.0 × 10^{-3} kg U = 8.0 × 10^{-3} kg × 9.81 N kg^{-1} = 0.0785 N W = 0.0059 kg × 9.81 N kg^{-1} = 0.0579 N Lid force = 0.0785 N - 0.0579 N = 0.0206 N	
	• use of downward force of lid = upthrust – weight of diver	(1)		
	• downward force of lid = 0.021 (N)	(1)		3

Question Number	Acceptable answers	Additional guidance	Mark
(b)	**Either** • use of force of lid = $V\rho g$ **(1)** • volume of air = 8.0×10^{-6} m^{-3} - their value **(1)** • volume of air = 5.9×10^{-6} (m^3) **(1)** **Or** • use of upthrust on diver = weight of diver **(1)** • use of upthrust = $V\rho g$ **(1)** • volume of air = 5.9×10^{-6} (m^3) **(1)**	<u>Example of calculation</u> volume = 0.0206 N ÷ 9.81 N kg^{-1} ÷ 1.0 × 10^3 kg m^{-3} = 2.1×10^{-6} m^{-3} new volume of air = 8.0×10^{-6} m^{-3} - 2.1×10^{-6} m^{-3} = 5.9×10^{-6} m^3	**3**

Question Number	Acceptable answers	Additional guidance	Mark
(c)	• use of pV = constant **(1)** • $p = 1.4 \times 10^5$ Pa **(1)**	<u>Example of calculation</u> $p_1 \times V_1 = p_2 \times V_2$ $p_2 = 1.01 \times 10^5$ N m^{-2} × 8.0×10^{-6} m^{-3} / 5.9×10^{-6} m^3 $p = 1.37 \times 10^5$ Pa	**2**

Q9.

Question Number		Mark
(a)(i)	Weight (1) (accept *W* or mg or gravitational pull/force) ('gravity' doesn't get the mark) Tension (1) (accept *T*) (Both arrows and labels required for each marking point)  (Arrows must touch mass for marks; ignore any arrows, for correct or incorrect forces, not touching (Minus one from maximum possible mark for each additional force (e.g. resultant, pull) or other arrow (e.g. speed or motion) touching mass)	**2**
(a) (ii)	A triangle or parallelogram with W and T in correct position for vector addition with correct labels and directions. (1) Triangle or parallelogram completed correctly with resultant in correct directions. (1) (Can score 2 marks even if the resultant is not horizontal) e.g. (scores 2 marks) 	**2**

(a)(iii)	$ma/mg = \tan\theta$ **OR** $T\cos\theta = mg$ **and** $T\sin\theta = ma$ (seen or substituted into) $a = 1.2$ (m s^{-2}) <u>Example of calculation</u> $a = \tan 7° \times g = \tan 7° \times 9.81$ m s^{-2} $= 1.2$ m s^{-2}	 (1) (1)	**2**
(b)(i)	Straight down (by eye) 	(1)	**1**
(b)(ii)	To left, angle between string and roof to be less than 83° but not horizontal 	(1)	**1**
(b) (iii)	To right, at any angle except horizontal 	(1)	**1**
(c)	Always has weight **Or** gravitational force **Or** force due to gravity so tension needs a vertical component **Or** Use of the equation $ma/mg = \tan\theta$ Leading to the idea of infinite value of $\tan\theta$ requiring infinite acceleration	(1) (1) (1) (1)	**2**
(d)	Any correct physics answer that uses the concept of the independence of motion at right angles e.g. (to detect movement) in the x,y,z directions/planes/axes **Or** up-down, left-right and forwards-backwards	(1)	**1**
	Total for question		**12**

Q10.

Question Number	Acceptable Answers	Mark
(a)	**Laminar**: Continuous lines, not crossing, below the wing, with at least 2 continuing beyond the wing **(1)** **Turbulent:** swirls, crossing lines, changes of direction greater than 90° **only** above the wing, not necessarily attached to the lines from the left **(1)**	**2**

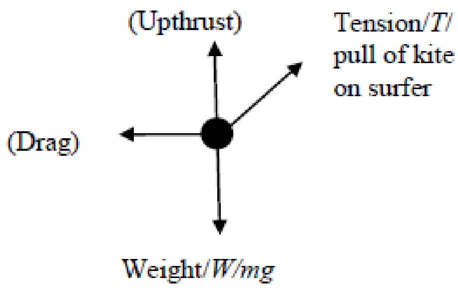
Question Number	Acceptable Answers	Mark
(b)(i)	The idea that a (component of) lift = weight **(1)** See L cos 20° or mg / cos 20° **(1)** L = 0.66 or 0.7 (N) **(1)** <u>Example of calculation</u> Vertical component of lift = weight $L\cos 20° = 0.063 \text{ kg} \times 9.81 \text{ N kg}^{-1}$ L = 0.66 (N)	**3**

Question Number	Acceptable Answers	Mark
(b)(ii)	Find the horizontal component of lift (drag) using trig or Pythagoras **(1)** (L sin 20°, W tan 20°, $\sqrt{L^2 - W^2}$) Use of $F = ma$ **(1)** Acceleration = (−) 3.6 to 3.7 m s^{-2} (ecf) **(1)** <u>Example of calculation</u> $L_{horizontal} = -L\sin 20° = -0.66 \text{ N} \times \sin 20° = -0.226$ (N) $\text{acceleration} = \frac{-0.226 \text{ N}}{0.063 \text{ kg}}$ acceleration = −3.57 m s^{-2}	**3**

Question Number	Acceptable Answers		Mark
(c)(i)	Bird/leg exerts force/push (down) on ground	**(1)**	
	<u>N3</u> ground exerts a force (up) on bird	**(1)**	
	Force ≠ / > weight **Or** there is a resultant/unbalanced force	**(1)**	**4**
	Due to <u>N2 / N1</u> bird accelerates	**(1)**	

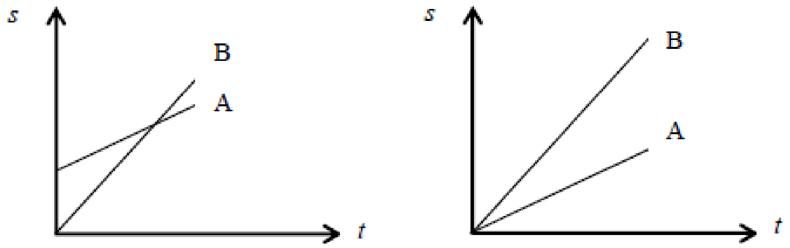
Question Number	Acceptable Answers		Mark
(c)(ii)	Maximum force read from graph = 2.00 N to 2.10 N	**(1)**	
	resultant force = $F - W$ (1.37 N to 1.43 N)	**(1)**	
	Answer = 23 m s^{-2}	**(1)**	**3**
	<u>Example of calculation</u> Maximum force = 2.05 N 2.05 N – (0.063 kg x 9.81 m s^{-2}) = 0.063 kg × a a = 22.7 m s^{-2}		
	Total for question		**15**

Q11.

Question Number	Answer		Mark
(a)(i)	Tension line and arrow correctly drawn and labelled Weight line and arrow correctly drawn and labelled  (Tension can be on either side. If 2 marks have been awarded subtract 1 mark if the drag has been included and is not a horizontal force opposing the tension)	(1) (1)	2
(a)(ii)	Use of correct trig function to find horizontal component of the tension $T_{horizontal}$ = 840 (N) <u>Example of calculation</u> Horizontal component of tension = $T\cos\theta$ $T_{horizontal}$ = 1100 N × cos 40° $T_{horizontal}$ = 843 N	(1) (1)	2
(a)(iii)	$T_{vertical}$ = 1100 sin 40° **Or** $T_{vertical}$ = 707 (N) seen Use of $W = mg$ Use of $mg = U + T_{vertical}$ with a sensible statement discussing what would happen if $T_{vertical}$ = W **Or** $T_{vertical}$ > weight **Or** $T_{vertical}$ < weight e.g. $T_{vertical}$ = W **Or** mass = 72 kg: Upthrust is zero $T_{vertical}$ > weight **Or** mass < 72 kg: Can't have a negative upthrust $T_{vertical}$ < weight **Or** mass > 72 kg : To provide some upthrust <u>Example of calculation</u> $T_{vertical} = T \sin 40°$ (= 707 N) **OR** $mg = U + T_{vertical}$ $mg = U + 707$ N mass = $\frac{707\text{ N}}{9.81\text{ N kg}^{-1}}$ = 72.1 kg	(1) (1) (1)	3

*(b)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** C (1) **Max 3** The horizontal component of the tension in the line produces the forward force acting on the surfer **Or** horizontal component of tension = $T\cos\theta$ (accept $T_{horizontal} = 1100\cos\theta$) (1) As the angle to the horizontal (θ) decreases **Or** As the angle to the vertical (θ) decreases ➔ $T\cos\theta$ increases **Or** the forwards force on the surfer increases **Or** the smallest θ gives the maximum/greatest force (1) Work done increases (1) Power transferred to surfer= $\frac{\text{work done}}{\text{time}}$ has increased hence the power increases **Or** more work done per second on the surfer so the power increases (1)	4
	Total for question	**11**

Q12.

Question Number	Answer	Mark
(i)	Both graphs straight from $t = 0$ (labels not required) (1) Initial gradient of A less than gradient of B (minimum of 1 label required) (1) (The lines do not have to meet i.e. the lines could stop before the meeting point The lines can start anywhere on the displacement axes)  	2
(ii)	Measurement from photographs 0.5 - 0.7 (cm) (1) Use of distance = measurement × 12 (1) Use of speed = distance/time (1) speed = 0.18 – 0.25 m s $^{-1}$ (1) <u>Example of calculation</u> Measurement = 0.55 cm Distance = 0.55×10^{-2} m× 12 = 6.6×10^{-2} m speed = $\frac{6.6 \times 10^{-2}\text{ m}}{0.33\text{ s}}$ speed = 0.20 m s^{-1}	4

Q13.

Question Number	Acceptable Answers	Mark
(a)	As the temperature increases the viscosity decreases **(1)** at a decreasing rate **Or** the rate of decrease is greater at lower temperatures **Or** exponentially **(1)** (do not accept quicker/slower in place of greater/smaller) (a statement that quantities are inversely proportional can score MP1 only)	**2**

Question Number	Acceptable Answers	Mark
(b)(i)	F = N **Or** F = kg m s^{-2} **Or** Pa m^2, r = m and v = ms^{-1} seen **(1)** Pa = N m^{-2} clearly shown **(1)** Example of calculation $\eta = \dfrac{\text{N}}{\text{m} \times \text{m s}^{-1}} = \text{N m}^{-2}\text{ s} = \text{Pa s}$	**2**

Question Number	Acceptable Answers	Mark
(b)(ii)	Reading from graph of viscosity: 1.09 to 1.13 ($\times 10^{-3}$)(Pa s) **(1)** Use of $F = mg$ **and** $F = 6\pi r\eta v$ **Or** use of $mg = 6\pi r\eta v$ **(1)** v =3.7 to 3.8 (m s^{-1}) (must be at least 2 sig figs) **(1)** Example of calculation $v = \dfrac{4.0\times10^{-6}\text{ kg}\times9.81\text{ N kg}^{-1}}{6\times\pi\times5.0\times10^{-4}\text{ m}\times1.11\times10^{-3}\text{ Pa s}}$ v = 3.75 (m s^{-1})	**3**

Question Number	Acceptable Answers	Mark
*(c)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** **Max 3** Viscosity of biodiesel is high **Or** viscosity of biodiesel higher than diesel **Or** viscosity of biodiesel needs reducing **(1)** Freezing point of biodiesel is high **Or** freezing point of biodiesel is higher than diesel **(1)** Adding ethanol/blending reduces η/freezing point **Or** adding ethanol/blending makes η/freezing point closer to that for diesel **(1)** Ethanol/ alcohol alone has too low an energy content **(1)**	**3**
	Total for question	**10**

Q14.

Question Number		Mark
(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**
(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**
(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**
(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**
(b) (iv)	Use of Stokes' law equation with velocity either 5.2 m s^{-1} or 6.6 m s^{-1} **(1)** $F = 3.5 \times 10^{-5}$ (N) or 4.5×10^{-5} (N) (no unit error) **(1)** <u>Example of calculation</u> $F = 6\pi\eta rv$ $= 6\pi \times 1.8 \times 10^{-5} \times 2 \times 10^{-2} \times 5.2$ m s^{-1} $= 3.5 \times 10^{-5}$ N	**2**

(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) **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**

Q15.

Question Number	Answer		Mark
(a)(i)	Identifies that the two chocolates on the graph are at different temperatures The greater the temperature of the chocolate, the lower the viscosity	(1) (1)	**2**
(a)(ii)	Marked anywhere vertically above 10^1 Pa s.	(1)	**1**
(b)	Use of drag = upthrust Use of $F = 6\pi r\eta v$ $v = 2.0 \times 10^{-4}\ \text{m s}^{-1}$ <u>Example of calculation</u> $v = \frac{3.7 \times 10^{-5}\ \text{N}}{6 \times \pi \times 1.0 \times 10^{-8}\ \text{m} \times 10\ \text{Pa s}}$ $v = 1.96 \times 10^{-4}\ \text{m s}^{-1}$	(1) (1) (1)	**3**
(c)	**Problem:** Bubbles forming and not rising to the surface to break **Solution:** Reduce the viscosity of the chocolate **Or** heat up the chocolate **Explanation:** The greater the viscosity: the greater the viscous drag **Or** the lower the (terminal) velocity The bubbles rise slower **OR** The lower the viscosity: the lower the viscous drag **Or** the greater the (terminal) velocity The bubbles are able to rise to the top quicker **Or** the bubblies rise to the top in time before the chocolate sets (The 3 marking points can be awarded if seen anywhere within part (c))	 (1) (1) (1) (1) (1)	**3**
	Total for question		**9**