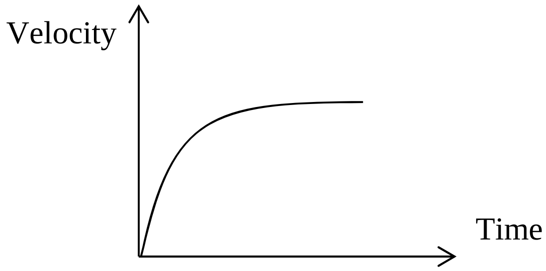
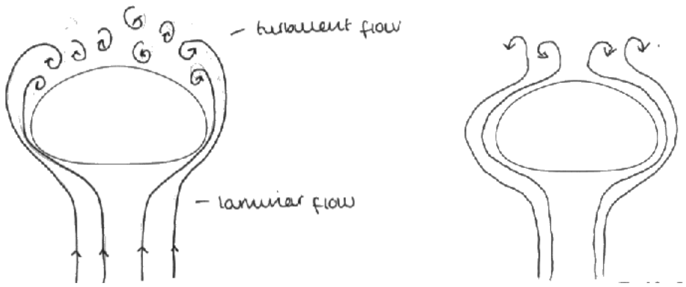
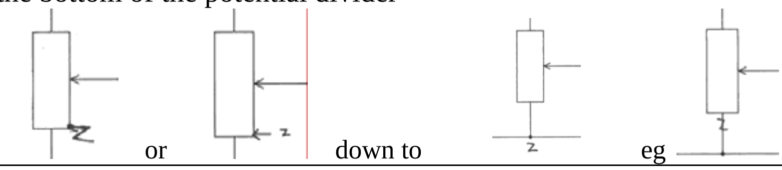
Question Number	Answer	Mark
1(a)(i)	Initially: constant acceleration **(1)** Decreasing acceleration followed by constant velocity **(1)** <u>Example of graph</u> 	**2**
1(a)(ii)	Drag increases with speed (this may be implied following a description of acceleration) **(1)** When drag = weight (− upthrust) **(1)** No resultant force **Or** there is no (further) acceleration **Or** the forces are in equilibrium **(1)**	**3**
1(a)(iii)	Density of air is negligible compared to density of water **Or** mass/weight of air displaced is negligible/tiny compared to the mass/weight of the raindrop **Or** the upthrust is negligible/tiny compared to the mass/weight of the raindrop **(1)**	**1**
1(b)(i)	Use of $v = s/t$ **(1)** $v = 7.1\ \text{m s}^{-1}$ **(1)** <u>Example of calculation</u> $v = \frac{1100\ \text{m}}{2.6\ \text{min} \times 60}$ $v = 7.05\ \text{m s}^{-1}$	**2**
1(b)(ii)	See or use of $\rho V g = 6\pi r \eta v$ **(1)** See $V = \frac{4}{3}\pi r^3$ **and** values substituted into above equation **(1)** $r = 2.4 \times 10^{-4}$ m (ecf from part (b)(i) for terminal velocity) **(1)** <u>Example of calculation</u> Weight of raindrop = $\frac{4}{3} \times \pi \times r^3 \times 1.0 \times 10^3\ \text{kg m}^{-3} \times 9.81\ \text{N kg}^{-1}$ Drag force = $6 \times \pi \times r \times 1.8 \times 10^{-5}\ \text{Pa s} \times v$ $\frac{4}{3}\pi \times r^3 \times 1.0 \times 10^3\ \text{kg m}^{-3} \times 9.81\ \text{N kg}^{-1} = 6 \times \pi \times r \times 1.8 \times 10^{-5}\ \text{Pa s} \times 7.1\ \text{m s}^{-1}$ $r^2 = \frac{9 \times 1.8 \times 10^{-5}\ \text{Pa s} \times 7.1\ \text{m s}^{-1}}{2 \times 1.0 \times 10^3\ \text{kg m}^{-3} \times 9.81\ \text{N kg}^{-1}} = 1.04 \times 10^{-7}$ $r = 2.42 \times 10^{-4}$ m	**3**

1(c)	Laminar air flow around main body of rain drop **(1)** (minimum of 2 lines either side) Some turbulence at the top of the rain drop **(1)** (must not start below the top 1/3rd of the rain drop) (1 mark max for correct drawing of laminar and turbulent flow around the rain drop but upside down. Labels and arrows not required) <u>Example of diagram</u>  		**2**
	Total for Question		**13**

Question Number	Answer	Mark
2(a)(i)	Ammeter and voltmeter both correct **(1)**	**1**
2(a)(ii)	Z at the bottom of the potential divider **(1)** from or down to eg 	**1**
2(b)(i)	Current =0.75 (A) (range 0.74 A – 0.76 A) **(1)** Use of $V = IR$ **(1)** Resistance = 13-14 Ω **(1)** (incorrect current e.g. use of tangent, scores 1 max for use of $V = IR$) <u>Example of calculation</u> $R = \frac{V}{I} = \frac{10\text{ V}}{0.75\text{ A}} = 13.3\Omega$	**3**
***2(b)(ii)**	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) **Max 3** Initially or until about 4 V, I α V/Ohmic conductor **(1)** (Increasing the) <u>current</u> causes heating effect /temperature rise **(1)** Resistance increases OR increases lattice/ion/atoms vibrations **(1)** Rate of increase of current (with potential difference) decreases **(1)**	**3**
2(c)(i)	Reading current values at 4 V of <u>both</u> 0.3 (A) and 0.5 (A) **(1)** (power of 10 error allowed eg 3(A)and 5 (A) seen) Current = 0.8 A **(1)** (allowing for ± 0.1 mm square tolerance, accept range 0.76A to 0.84A)	**2**
2(c)(ii)	p.d. across R = 8 **(1)** $R = \frac{8\text{ V}}{0.8\text{ A}} = 10\ \Omega$ **(1)** (allow ecf from part (c)(i) for the value of I substituted) (accept answers in range 9.52 Ω to 10.53 Ω using range for I)	**2**
2(c)(iii)	Resistance of P greater than resistance of parallel combination **(1)** P will have a greater (share of the) pd **OR** R will have a lower (share of the) pd **(1)** Reading on voltmeter will increase **(1)**	**3**
	Total for question	**15**

Question Number	Answer		Mark
4(a)(i)	Two relevant precautions with reasons, e.g. Ensure that the thermometer and coil are at the same part of the beaker so that the results are not affected by differences in temperature Stir water so that the results are not affected by differences in temperature Check the meter for zero error by connecting a lead across its terminals so there is no systematic error in the resistance measurements Ensure small current so no heating effect in addition to hot water which would make results inaccurate Switch off between readings so no heating effect in addition to hot water which would make results inaccurate Read thermometer at eye level to avoid parallax errors	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**2**
4(a)(ii)	This will ensure that the readings are simultaneous **Or** Higher sampling rate	**(1)**	**1**
4(b) (i)	(The straight line) does not pass through the origin	**(1)**	**1**
4 (b) (ii)	As temperature increase the (lattice) ion/atom vibrations increase (for the same current) electrons will collide more frequently with the vibrating (lattice) ions/atoms More energy dissipated by collisions so (for constant I) greater V required **Or** (constant V gives) lower v and, since $I = nAvq$, I will be lower Since V increases and $R = V/I$, R will increase with temperature **Or** Since I decreases and $R = V/I$, R will increase with temperature	**(1)** **(1)** **(1)** **(1)**	**4**
4(c)	Use of $R = \rho l/A$ Use of correct area in $R = \rho l/A$ length = 0.66 m <u>Example of calculation</u> $l = 12.4\ \Omega \times 5.19 \times 10^{-9}\ \text{m}^2 / 9.71 \times 10^{-8}\ \Omega\ \text{m}$ length = 0.663 m	**(1)** **(1)** **(1)**	**3**

Question Number	Answer		Mark
5(a)(i)	Determines width of at least 9 coils Use of half of their diameter in πr^2 Area = (1.96 to 2.42) × 10^{-7}(m^2) <u>Example of calculation</u> 18 coils = 1.00 cm Diameter = 0.0100 m ÷ 18 = 5.56 × 10^{-4} m Area = π × (5.56 × 10^{-4} ÷ 2)^2 Area = 2.42 × 10^{-7} m^2	**(1)** **(1)** **(1)**	**3**
5(a)(ii)	Use of $R=\rho l/A$ Resistivity magnitude = 4.4 × 10^{-7} (show that value gives 3.7× 10^{-7}) Unit Ωm <u>Example of calculation</u> $\rho=RA\ /\ l$ = 22 Ω x 2.4 × 10^{-7} m^2 / 12 m = 4.4 × 10^{-7} Ωm	**(1)** **(1)** **(1)**	**3**
5(a)(iii)	A sensible response with some detail, e.g. • Avoid difficulty in reading a small scale while holding it and counting turns • it can be enlarged and done more accurately • compare with unravelling and using a micrometer • remains stationary, so easier to measure accurately • you can mark the coils as you go so you don't lose count (treat parallax as neutral and)	**(1)**	**1**
5(b)	Use of ratio of lengths × pd V = 8.2 V <u>Example of calculation</u> V = (7.0 cm / 10.2 cm) × 12 V = 8.2 V	**(1)** **(1)**	**2**
	Total for question		**9**

Question Number	Answer		Mark
6(a)	Resistance of parallel combination much less than resistance of V_1	**(1)**	
	(Therefore) voltage of parallel combination is much less than voltage of V_1	**(1)**	
	Or		
	Identifies current (nearly) zero (because of resistance of V_1 very large)	**(1)**	
	(So) p.d. across 10 Ω is zero by $V = IR$	**(1)**	**2**
	(Credit for each marking point may be obtained by completing a calculation.)		
6(b)	Identifies resistance of parallel combination is 5 MΩ	**(1)**	
	Use of resistors in parallel formula	**(1)**	
	R = 10 MΩ	**(1)**	**3**
	Total for question		**5**