Question Number	Acceptable Answers	Mark
1(a)(i)	Energy = power × time **Or** power = $\frac{\text{energy}}{\text{time}}$ **Or** see 4.2 × 0.4 **(1)** Energy = 1.7 (J) **(1)** Example of calculation Energy = 4.2 W × 0.4 s Energy = 1.68 (J)	**2**

Question Number	Acceptable Answers	Mark
1(a)(ii)	Use of $E_k = ½ mv^2$ **(1)** v = 5.9 / 6.0 ms^{-1} (ecf) **(1)** Example of calculation $v = \sqrt{\frac{2 \times 1.68\,\text{J}}{0.095\,\text{kg}}}$ v = 5.9 m s^{-1}	**2**

Question Number	Acceptable Answers	Mark
1(a)(iii)	Energy is dissipated to heat **Or** work is done against friction **Or** not all the energy becomes kinetic energy **Or** air resistance on car **Or** friction between car/wheels/pin and track **Or** resistance in motor **(1)**	**1**

Question Number	Acceptable Answers	Mark
1(b)	No resistant force is acting on the car **(1)** (do not credit use of external force) (Car) continues moving: in a straight line **Or** in same direction **Or** with same velocity. **(1)**	**2**
	Total for question 14	**7**

Question Number	Acceptable Answers	Mark
2(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
2(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 $L\cos 20^{o} = 0.063 \text{ kg} \times 9.81 \text{ N kg}^{-1}$ L = 0.66 (N)	**3**

Question Number	Acceptable Answers	Mark
2(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> $L_{\text{horizontal}} = -L\sin 20 = -0.66 \text{ N} \times \sin 20 = -0.226$ (N) $\text{acceleration} = \frac{-0.226 \text{ N}}{0.063 \text{ kg}}$ acceleration = −3.57 m s^{-2}	**3**

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

Question Number	Acceptable Answers		Mark
2(c)(ii)	Maximum force read from graph = 2.00 N to 2.10 N	**(1)**	**3**
	resultant force = $F - W$ (1.37 N to 1.43 N)	**(1)**	
	Answer = 23 m s^{-2}	**(1)**	
	Example of calculation 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 18		**15**

Question Number	Answer	Mark
3 (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)**
3 (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)**
3 (c)	State a relevant variable to control <u>Temperature</u>	**(1)**
	Total for question 14	**6**

Question Number	Answer	Mark
4(a)	Explain the meaning of the terms: Ductile – can be made/drawn into wires / shows significant/large/lots of plastic deformation / large plastic region Brittle - shatters when subject to impact / sudden force fails/breaks/cracks with little or no plastic deformation / breaks just beyond elastic limit / breaks just beyond limit of proportionality / breaks under stress due to propagation of cracks	**(1)** **(1)**
4(b)	Calculate the mass that would produce this load. Use of $W = mg$ Correct answer (3600 kg) <u>Example of calculation</u> $W = mg$ m = 35 000 N / 9.81 N kg^{-1} = 3570 kg	**(1)** **(1)**
	Total for question 15	**4**

Question Number	Answer		Mark
5(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**
5(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**
5(b)(i)	**Either** 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 17		**8**

Question Number	Answer	Mark
6(a) (i)	Show that the resultant upward force at the moment it is released is about 200 N Use of density x volume **(1)** Use of mass x *g* **(1)** Correct answer [215 (N) to at least 2 sf] **(1) [no ue]** <u>Example of calculation</u> Mass of displaced air = density x volume = 1.2 kg m^{-3} x 2830 m^3 = 3396 kg upthrust = weight of displaced air = 3396 kg x 9.81 N kg^{-1} = 33 315 N resultant force = 33 315 N – 33 100 N = 215 N [If candidate starts from difference in densities, apply mark scheme in the same way.]	**(3)**
6(a) (ii)	Find the initial upward acceleration Use of $F = ma$ **(1)** Correct answer [0.06 m s^{-2}] **(1)** <u>Example of calculation</u> $F = ma$ a = 215 N / 3370 kg = 0.064 m s^{-2} [Use of 200 N gives 0.059 m s^{-2}]	**(2)**
6(a) (iii)	Justify that effect of air resistance is negligible Use of Stokes' law equation, $F = 6\pi\eta rv$ **(1)** Find viscous drag (6.0 x 10^{-3} (N)) **(1) (no ue)** Relevant comment, e.g. **very** small **in comparison** to other forces (not just "small")/ **much** small**er** than other forces (not just smaller) **(1)** <u>Example of calculation</u> $F = 6\pi\eta rv$ F = 6 x π x 1.8 x 10^{-5} kg m^{-1} s^{-1} x 8.8 m x 2 m s^{-1} = 6.0 x 10^{-3} N This is very much less than upthrust and so is negligible	**(3)**
6(b)	Add labelled arrows Correctly show weight (W, mg), upthrust (U), and viscous drag /drag/friction/air resistance (V, F, D) 3 correct = 2, 2 correct = 1 [4 labels, max 1 for 3 correct forces, zero for 2 correct forces, 5 labels or more = zero] [Forces do not need to be co-linear. Accept two correct labels on the same arrow. Accept buoyancy force for upthrust]	**max (2)**

	[Do not accept 'gravity']	
6(c)	Explain why this density change limits the height to which the balloon will rise. Mass/weight of displaced air decreases / upthrust decreases / density of air in balloon eventually equals density of surrounding air [accept density greater than surrounding air] **(1)** Net upward force would decrease / no resultant upward force / no more upwards acceleration **(1)**	**(2)**
	Total for question	**12**

Question Number	Answer	Mark
7(a)	Calculate the resistive forces State component of $T = T \cos \theta$ (1) Correct answer [1120 N] (1) **Example of calculation** $T = T \cos \theta$ = 1150 N x cos 12° = 1125 N Therefore resistive forces = 1125 N	**2**
7(b)	Calculate the work done on the boat by the horse Use of $\Delta W = F\Delta s$ (1) Correct answer [558 000 J] (1) [ecf] **Example of calculation** $\Delta W = F\Delta s$ = 1125 N x 500 m =560 000 J	**2**
7(c)	Explain using a longer rope Longer rope → smaller angle (1) cos theta then larger / need smaller force (for same component acting on boat) (1)	**2**
	Total for question	**6**