1)

(a)	(i)	($E_K = ½ mv^2$ =) 0.5 × 68 × 16^2 ✓ = **8700** or 8704 (J) ✓	**7**
	(ii)	($\Delta E_P = mg\Delta h$ =) 68 × 9.8(1) × 12 ✓ = **8000** or 8005 (J) ✓	
	(iii)	any **three** from gain of kinetic energy **>** loss of potential energy ✓ (because) cyclist does work ✓ energy is wasted (on the cyclist and cycle) due to air resistance or friction or transferred to thermal/heat ✓ KE = GPE + W – energy 'loss' ✓ (owtte) energy wasted (= 8000 + 2400 - 8700) = 1700 (J) ✓	
(b)	(i)	(u = 16 m s^{-1}, s = 160 m, v = 0, rearranging $s = ½ (u + v) t$ gives) 160 = ½ × 16 × t or $t = \frac{2s}{(u+v)}$ or correct alternative $\frac{2\times160}{16}$ (gets 2 marks) ✓ = 20 s ✓	**6**
	(ii)	acceleration a = ($\frac{v-u}{t}$ =) $\frac{(0-16)}{20}$ ecf (b) (i) ✓ = (-) **0.80** (m s^{-2}) resultant force $F = ma$ = 68 × (-) 0.80 ✓ = (-) 54 (N) ✓ or 54.4 or (work done by horizontal force = loss of kinetic energy work done = force × distance gives) force = $\frac{\text{(loss of kinetic) energy}}{\text{distance}}$ ✓ = $\frac{8700\text{J}}{160\text{m}}$ ecf (a) (i) ✓ = 54 (N) ✓	
		Total	**13**

2)

a		8300 x 9.81 OR = 81423 ✓ (8300 x 9.81 sin 25) = 3.4 x 10^4 (N) ✓ (34 411 N) ecf from first line unless g not used msin25 gets zero	2		Penalize use of g=10 here only (35 077 N) Allow 9.8 in any question **Correct answer only, gets both marks for all two mark questions**
b	i	($E_k = ½mv^2$) = ½ x 8300 x 56^2 ✓ = 1.3 x10^7 (J) ✓ (13 014 400) allow use of 8300 only	2		In general: Penalise transcription errors and rounding errors in answers

b	ii	*mgh* = KE (13 014 400) for *mgh* allow GPE or E_p OR 13 014 400 / 81 423 ✓ h = 160 (m) ✓ (159.8) ecf 1bi	2		Allow use of suvat approach
c	i	(work done) by friction \ drag \ air resistance \ resistive forces ✓ (Energy converted) to internal \ thermal energy ✓	2		Allow 'heat'
c	ii	0.87 x (8300 x 9.81 x 140 = 9 917 000) OR $v = \sqrt{\left[\frac{2 \times (9\,917\,000)}{8300}\right]}$ ✓ = 49 (= 48.88 ms^{-1}) ✓	2		87% of energy for 140m or 160m only for first mark. Use of 160 (52.26) and/or incorrect or no % (52.4) gets max 1 provided working is shown. **Do not credit suvat approaches here.**
		Total	10		

3)

(a)	(i)	$(m = \rho V) = 1.2 \times 3.5 \times 10^5$ must be seen ✓ 4.2×10^5 (kg) seen ✓	**2**
(a)	(ii)	$(E_k = \frac{1}{2} mv^2) = \frac{1}{2} \times 4.2 \times 10^5 \times 11^2$ ✓ 2.5 or 2.4×10^7 (J) ✓ (25.4 or 24.2 MJ)	**2**
(a)	(iii)	$\frac{10 \times 10^6}{2.54 \times 10^7}$ ✓ allow ecf from (a)(ii) 39 to 41.6 (%) ✓ allow ecf from (a)(ii) unless percentage is greater than 100	**2**
(b)		**advantages**, any one: wind has: no fuel cost/causes no air pollution/no CO_2/is renewable ✓ **disadvantages**, any one from: wind: varies/is intermittent/unreliable/causes visual pollution/noise/danger to birds/has a high capital cost/high 'start up' cost/requires changes to National Grid need ✓ allow 'unpredictable'	**2**
		Total	**8**

4)

a	i	($s = ½(u+v)\ t$) $t = 2s/v$ ✓ (correct rearrangement, either symbols or values) (= 100/6.7) = 15 ✓ (s) (14.925) or alternative correct approach	**2**
a	ii	($KE = 1/2mv^2 = ½ \times 83 \times 6.7^2$) = 1900 ✓ (1862.9 J) **2 sf** ✓	**2**
a	iii	GPE = 83 × 9.81 × 3.0 ✓ penalise use of 10, allow 9.8 = 2400 (2443 J) ✓ do not allow 2500 (2490) for use of g = 10	**2**
b	i	5300 + 3700 (or 9000 seen) **or** – 2443 – 1863 (or (–) 4306 seen) ✓ = 4700 (J) ✓ (4694) ecf from parts aii & aiii	**2**
b	ii	mention of friction and appropriate location given ✓ mention of **air** resistance (or drag) ✓ do not allow energy losses or friction within the motor do not allow energy losses from the cyclist must give a **cause** not just eg 'heat loss in tyres'	**2**
		Total	**10**

5)

1	a		$(Ep = mg\Delta h)$ = 65 × 9.81× 54 ✓ = 3.44×10^4 = 3.4×10^4 (J) ✓ (34433)	2	max 1 if g =10 used (35100 J) Correct answer gains both marks
1	b		$v = \sqrt{\frac{2Ep}{m}}$ OR $v = \sqrt{\frac{2\times34433}{65}}$ ✓ = 33 (32.55 ms^{-1}) ✓ ecf 1(a) OR correct use of $v^2 = 2\,g\,s$	2	allow 32 (32.3) for the use of 34000 allow 32.6 don't penalise g=10 (32.863)
1	c		$(s = 1/2\ gt^2$ or other kinematics equation) $t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2\times54}{9.81}}$ ✓ = 3.318 = 3.3 (s) ✓ ecf from 1(b) if speed used	2	With use of g= 9.8 or 9.81or 10 and/or various suvat equations, expect range 3.2 to 3.4 s. No penalty for using g= 10 here.
1	d		(all G)PE (lost) is transferred to KE no (GP)E transferred to 'heat' / 'thermal' / internal energy **OR** ✓ (therefore) $mg\Delta h = \frac{1}{2}mv^2$ ✓ mass cancels ✓	3	Must imply that all GPE is transferred to KE. E.g. accept 'loss of GPE is gain in KE' but not: 'loses GPE and gains KE. Accept 'm's crossed out
			total	9	

6)

a		$(s = \frac{1}{2}(u + v)t)$ $u = \frac{2s}{t}$ - v **OR** substitution in above equation **OR** $u = \frac{2\times1.5}{0.43}$ - 5.0 ✓ = 6.9767 – 5.0 ✓ = 2.0 ✓ (1.98 ms^{-1})	3	Correct answer with no working gets 2 out of three. Full credit for use of gsin25 = acceleration down slope. This yields answer 3.22 ms^{-1} Allow 1sf answer (2).
b	i	(F = 75 × 9.81 ×) sin25 (°)✓ = 310 (311, 310.94) (N) ✓	2	use of g = 10 not penalised here 'sin25' on its own Use of g=10 yields 317 Allow cos65
b	ii	$W = Fs$ = 311× 2.0 = 620 (622 J) ✓ ecf (2bi) × 2.0	1	
c		Idea that GPE is ultimately transferred to: internal (energy) /'heat'/ 'thermal' (energy in the surroundings) ✓ Correct reference to a named resistive force: friction / drag / air resistance ✓ All GPE becomes 'heat', etc **OR** no (overall) increase in KE **OR** reference to work done against or by a resistive force ✓	3	Allow transfer of GPE to KE and then to 'thermal' etc Do not allow reference to 'sound' on its own Don't accept implication that a resistive force is a form of energy Do not allow references to loss of body heat. Allow: '(GPE) not converted to KE'
		total	**9**	