Question			Answer	Marks	Guidance
1	a		GPE linked to 'position' / height (in a gravitational field)	B1	**Allow**: GPE linked to an object 'raised' / 'lowered' (on the Earth)
	b	i	$v^2 = u^2 + 2as$ $v^2 = 15^2 + (2 \times 9.81 \times 2.8)$ or $v = \sqrt{280}$ speed = 17 (m s^{-1})	C1 A1	**Allow** other correct methods **Note**: Answer is 16.7 m s^{-1} to 3sf
		ii	(initial energy =) ½ × 0.20 × 16.7^2 or (initial energy =) 0.20 × 9.81 × 2.8 + ½ × 0.20 × 15^2 (final energy =) ½ × 0.20 × 12^2 energy lost = 14 (J)	C1 C1 A1	Possible ecf from **b(i)** **Special case:** 1 mark for 8.1 (J); the difference in the initial KE (½ × 0.20 × 15^2) and the final KE (½ × 0.20 × 12^2)
		iii	change in velocity = 17 + 12 (= 29 m s^{-1}) or 16.7 + 12 (= 28.7 m s^{-1}) *F = ma* force = $0.20 \times \frac{29}{0.065}$ or force = $0.20 \times \frac{28.7}{0.065}$ force = 89 (N) or force = 88 (N)	C1 A1	Possible ecf from **(b)(i)** **Allow** 1 mark for 'force = $0.20 \times \frac{(b)(i) - 12}{0.065}$, calculated with an answer.
			Total	**8**	

Question			Answers	Marks	Guidance
2	(a)		force × distance <u>moved</u> / <u>travelled</u> in the direction of the force	B1	**Allow** force × displacement in direction of force
	(b)		(Work done against friction generates) heat / thermal energy / internal energy	B1	**The term *heat / thermal / internal* to be included and spelled correctly to gain the B1 mark.**
	(c)		1 J (of work done) <u>per</u> second	B1	**Allow** (1 W = 1) J s^{-1} or J/s **Allow** (1) joule<u>s</u> per second **Not** W = 1 J <u>in</u> 1 s **Allow** full credit as long as the definition for the 'watt' is not confused with the definition for 'power' (Examples: • power = rate of work done; W = 1 J s^{-1} ✓ • The rate of work done. It is J per s × • watt = rate of work done, W = 1 J s^{-1} ×)
	(d)	(i)	vertical distance = $(75^2 - 45^2)^{1/2}$ or vertical distance = 60 (m) work done = 5200 × 9.81 × 60 or work done = 3.06×10^6 (J) power = $3.06 \times 10^6/90$ power = 3.4×10^4 (J s^{-1})	C1 C1 A1	 **Allow** 2 marks for an answer of 2.04×10^6 (J s^{-1}); 1.5 used instead of 90 s No credit for [5200 × *g* × 75]/90 or [5200 × *g* × 45]/90
		(ii)	efficiency = $\frac{34}{170} \times 100$ efficiency = 20 %	 B1	 Possible ecf from **(i)**
			Total	**7**	

Question			Answer	Marks	Guidance
3	(a)		power = work done/ time or energy/time or 'rate of work done'	B1	
	(b)		power = KE/time Using $\frac{1}{2}mv^2$ (power =) ½ × 9.7 × 10^5 (kg s^{-1}) × 3.0^2 (power =) 4.365 × 10^6 (W)	C1 C1 A0	**Allow**: 1 mark for a bald answer of 4.37 × 10^6 since this is a 'show' question
	(c)		efficiency = $\frac{1.2}{4.4} \times 100$ efficiency = 27 %	B1	**Note**: Answer to 3 sf is 27.3% if 4.4 × 10^6 is used **Note**: Answer is 27.5% if 4.365 × 10^6 is used **Not**: 0.27
	(d)		(volume per second =) 9.7 × 10^5/1030 or 941.7 mass per second = density × volume per second 9.7 × 10^5 = 1030 × (3.0 × π × r^2) $r^2 = \frac{9.7 \times 10^5}{1030 \times 3\pi}$ radius = 10 (m)	C1 C1 A1	**Allow** any subject **Allow**: 2 marks for 100 (m); answer not square rooted
	(e)	(i)	water has greater density or water has greater mass / KE for the <u>same volume</u>	B1	
		(ii)	Any <u>one</u> from: • Not an eyesore / cannot be seen • Not noisy • Predictable energy (with in and out tides) • Do not occupy space on the land	B1	**Allow** other sensible suggestions
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
4	a		Energy can neither be created nor destroyed (but it can be transformed from one form to another) or Total energy of a closed system remains constant	B1	
	b	i	loss in PE = $0.10 \times 9.81 \times 0.60$ = 0.59 (J) or 0.589 (J)	 B1	
		ii	$v^2 = 2as$ / $v^2 = 2 \times 2.8 \times 0.60$ / $v^2 = 3.36$ $v = \sqrt{2 \times 2.8 \times 0.60}$ or $v = 1.8\underline{33}$ or $v = 1.8\underline{3}$ $v = 1.8$ (m s^{-1})	M1 M1 A0	
		iii	(KE =) $\frac{1}{2}mv^2$ / (KE =) $\frac{1}{2} \times 0.25 \times 1.8^2$ kinetic energy = 0.405 (J) or 0.41 (J)	C1 A1	Possible ecf from **(b)(ii)** **Note**: The answer is 0.42 (J) when 1.83 m s^{-1} is used **Allow:** 1 mark for 0.162 (J) if 0.10 kg mass is used or for 0.567 (J) if 0.35 kg is used
		iv	KE of 0.10 kg mass is not taken into account (AW)	B1	**Not:** 'There is friction'
			Total	**7**	

5	Expected Answers	Marks	Additional Guidance
a	✍work done = force × distance <u>moved</u> / <u>travelled</u> (in direction of force) **The term *distance* / *displacement* to be included and spelled correctly to gain mark**	B1	**Note**: Must have reference to 'distance moved / travelled' **Allow**: 'work done = force × displacement' **Must use tick or cross on Scoris to show if the mark is awarded**
b(i)	<u>gravitational</u> potential ✍ kinetic **The term *kinetic* to be included and spelled correctly to gain the second B1 mark**	B1 B1	**Not**: 'potential' on its own **Note**: Ignore any reference to sound **Must use ticks on Scoris to show where the marks are awarded**
b(ii)	(GPE =) $4000 \times 9.81 \times 110$ / (GPE =) 4.32×10^6 **or** (KE =) $\frac{1}{2} \times 4000 \times 20^2$ / (KE =) 8.0×10^5 Work done = $(4000 \times 9.81 \times 110) - (\frac{1}{2} \times 4000 \times 20^2)$ force = $\frac{3.516 \times 10^6}{510}$ force = 6.9×10^3 (N)	C1 C1 A1	 **Allow**: 2 marks if second line is written or $3.5(16) \times 10^6$ (J) is quoted **Allow**: 3 marks for a bald answer of 6.9×10^3 (N)
	Total	**6**	

Question			Expected Answers	Marks	Additional Guidance
6	(a)		work done = force × distance <u>moved</u> in the direction of the force	M1 A1	**Allow**: 'displacement' instead of 'distance' **Allow**: 1 mark for 'force × distance in the direction of the force' **Not**: work done = energy transfer
	(b)		power = work (done)/time or power = energy/time or power = rate of work done	B1	**Not**: Mixture of quantities and units, e.g: 'energy per second'
	(c)		This is because of heat/thermal energy/friction	B1	**Not**: sound/vibrations
	(d)	(i)	$E_k = \frac{1}{2}mv^2$ / $E_k = \frac{1}{2} \times 810 \times 30^2$ $E_k = 3.645 \times 10^5$ (J) or 3.65×10^5 (J)	C1 A1	**Note**: Bald answer 3.645×10^5 (J) or 3.6×10^5 (J) scores 2/2 marks **Allow**: 1 mark for wrongly rounded answer of 3.7×10^5 (J)
		(ii)	power = $\frac{3.65 \times 10^5}{12}$ power = 3.04×10^4 (W) ≈ 3.0×10^4 (W)	B1	Possible ecf
		(iii) 1.	work done = 500 × 30 work done = 15000 (J s^{-1})	B1	
		2.	'output energy' = $18 \times 46 \times 10^6 \times 0.25$ (= 2.07×10^8 J)	C1	**Allow**: 'input energy' = $18 \times 46 \times 10^6$ (= 8.28×10^8 J)
			total drive time = $\frac{18 \times 46 \times 10^6 \times 0.25}{15000}$ (= 1.38×10^4s)	C1	This C1 mark can also be scored using: 'distance = 2.07×10^8/500' Possible ecf from **iii 1.**
			total drive distance = $1.38 \times 10^4 \times 30$ = 4.1×10^5 (m)	A1	**Allow**: Bald 4.1×10^5 (m) scores 3/3 2/3 for 1.66×10^6 m if 25% efficiency is not used 2/3 if 30 kW from **ii** is used; answer 2.0 or 2.1×10^5 (m)
			Total	**11**	