Question number	Answer	Notes	Marks
1 (a) (i)	GPE = mass x g x height	ACCEPT equivalent rearrangement ACCEPT suitable abbreviations e.g. GPE = mgh ACCEPT 'gravity' or 'gravitional field strength' or 'acceleration due to gravity' for g	1
(ii)	78 x 10 x 5; 3900 (J);		2
(iii)	3900; J / joule;	Accept 4000 J REJECT 'Nm' for 'J' ALLOW kJ only if it matches the value (i.e. 3.9)	2
(b) (i)	efficiency = useful energy output / total energy input	ALLOW 'power' for 'energy'	1

(ii)	in one second –
	useful energy out = (30 x 3900) / 60;
	efficiency = 1950 / 7500;
	0.26 / 26%
		Allow
		useful energy out = (30 x 4000) / 60;
		efficiency = 2000 / 7500;
		0.27 / 27%
		
		CQ on a(ii)
			3

(c)	right general shape reasonably correct proportions / 3kW and 12 kW seen correctly labelled	 ACCEPT "input / waste / useful" or "electrical / kinetic or GPE / waste heat or sound"	3

Question number	Answer	Notes	Marks
2 (a) I	0.45;	no unit penalty	1
ii	Power = current × voltage;	Allow P = I × V and rearrangements	1
iii	Substitution; Evaluation; e.g. 1.5= I x 0.45 I = 3.3 (A) (answer to at least 2 s.f.)	Allow reverse argument yielding 1.35 (W) for 1mark	2
(b) i	conversion of time to seconds; substitution into correct equation (E = I × V × t); evaluation; e.g. time = 7 × 5 × 60 × 60 (= 126 000) E = 3.3 x 9 x 7 x 5 x 60 x 60 3 742 000 (J)	Allow solution in stages i.e. from P=IV and P =E/t Allow for full marks 3 402 000 (J) (from use of 3 A given above) 3 780 000 (J) (from 1.5 x 20 x 7 x 5 x 60 x 60) Allow max of 1 if time not in seconds, e.g. 1040 (J) (from 3.3 x 9 x 7 x 5, time in hours) 62400 (J) (from 3.3 x 9 x 7 x 5 x 60, time in minutes)	3
ii	A description to include electrical; to **light** (and heat);	Reject "electricity" for the first mark Allow chemical to electrical to light for 1 mark only	2
		Total	9

Question number	Answer	Notes	Marks
3 (a)	A (chemical → electrical → kinetic)		1
(b) (i)	KE = ½ x m x v^2 ;		1
(ii)	substitution into correct equation; Calculation; e.g. ½ x 600 x 28^2 ; 240000 (J);	correct answer = 2 marks ACCEPT 235200 (J);	2
(c) (i)	gpe = mass x *g* x height;	ACCEPT GPE = mgh ACCEPT gravitational field strength/acceleration due to gravity for g	1
(ii)	substitution into correct equation; Calculation; e.g. 600 x 10 x 1000 6 000 000 (J) or 6000 k(J) or 6 M(J)	correct answer = 2 marks ALLOW 5 880 000 (from *g* = 9.8)	2
(iii)	EITHER <u>Calculation of energy supplied (by fuel cells)</u> 24 kW x 180 s OR 4 320 000 (J); <u>Comparison with energy required</u> 4 320 000 < 6 000 000; OR <u>Calculation of power required</u> 6 000 000 J ÷ 180 s OR 33.3 kW; <u>Comparision with fuel cells</u> 33.3 kW > 24 kW;	 ALLOW ECF if 6 000 000 not seen ALLOW ECF if 6 000 000 not seen	2

Question number	Answer	Notes	Marks
3 (c) (iv)	use of P= I x V for one cell ; e.g. 30 x 0.6 OR 18(W) calculation; e.g 24 000 ÷ 18 = 1333 (> 1300) OR 1300 x 18 = 23400 (< 24000) ALTERNATIVE Using E= IVt for one cell; e.g. 30 x 0.6 x180 OR 3240(J) calculation; e.g. 4 320 000 ÷ 3240 = 1333 (> 1300) OR 1300 x 3240 = 4 212 000 (< 4 320 000)	First Marking Point can be credited if '18' or '30 x 0.6' seen in calculation	2

Total 11 Marks

Question number	Answer	Notes	Marks
4 (a)	any two from: MP1. reverse the magnet (N into coil); MP2. reverse the connections at the ammeter; MP3. move the magnet out of coil;	ignore all references to • speed of movement • numbers of turns on the coil CARE that candidate does not conflate MP2 and 3 to negate their answer allow for MP2 invert the coil	(2)
(b) (i)	Y= magnet; Z = coil (of wire);		(2)
(ii)	(±)1.6 (V);		(1)
(iii)	reading of time for 1 cycle ; evaluation; e.g. 0.04s 25 (Hz)	no mark for eqn as it is given time can be assumed if f= 1/0.04 seen allow for 1 mark 50, 12.5 (Hz)	(2)
(iv)	C higher higher ;		(1)
(v)	any one from stronger magnet; more turns on the coil;	ignore bigger magnet condone more coils	(1)
(c) (i)	rearrangement of eqn; substitution; evaluation; e.g. work done (energy output) = power x time (=) 3.1 x 290 900 (W)	Accept 899 (W)	(3)
(ii)	$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$	accept standard abbreviations rearrangements with factor of X 100	(1)
(iii)	substitution; rearrangement of eqn; evaluation; e.g. input energy = $\frac{\text{output energy}}{\text{efficiency}}$ = $\frac{899\ (W)}{0.72}$ = 1200 (J)	ECF from ci allow 900 for 899 1245, 1250, 1300 (J)	(3)

Total for Question 4 = 16 marks

Question number	Answer	Notes	Marks
5 (a) (i)	gravitational potential energy = mass x g x height	Allow symbols and rearrangements, e.g. GPE = m x g x h	1
(ii)	Substitution into correct equation; Calculation; e.g. GPE = 2.75 x 10 x 0.61 = 17 (J)	16.8, 16.775, 16.78 (J) allow calculation with g = 9.81 =16.46 (J)	2
(iii)	Any two of- MP1. idea that system is inefficient OR not 100% efficient; MP2. idea that energy is lost / wasted / dissipated ; MP3. explanation /detail of fate of energy; e.g. used when working against {friction / drag / air resistance} as thermal energy to parts of the apparatus or surroundings transferred to surroundings by sound converted into KE as mass fell	condone used / transferred elsewhere Need mention of 'object' Ignore light allow to overcome friction allow heat for thermal energy	2
(iv)	Substitution into correct equation; Calculation; e.g. Energy transferred = 0.46 x 12.7 x 1.3 7.6 (J)	allow answer without working or equation seen (7.5946)	2
(b)	three of the following ideas- MP1. water has (initial) GPE; MP2. KE of (moving) water; MP3. Work done on turbine / generator; MP4. Work done against magnetic force; MP5. Electrical energy/power/current/voltage (produced);	allow KE in turbine / generator	3

Total 10 marks

Question number			Answer	Notes	Marks
6	(a)		Substitution into **correct** equation; Calculation; e.g. 1.3 x 10.3 x 4.7; 63 (J);	No credit for merely quoting the equation as $E = IVt$ is given on p2. 62.9 (J)	2
	(b)	(i)	Work done = force x distance moved (in the direction of the force);	Accept rearrangements and symbols e.g. force = $\frac{\text{work}}{\text{distance}}$ W = F x d F=W/d	1
		(ii)	Substitution into **correct** equation; Calculation; e.g. Work done = 20 x 0.85; 17 (J);		2
		(iii)	Value given in 8(b)(ii);	Allow GP(E)	1
	(c)	(i)	Efficiency = useful energy output divided by total energy input;	Accept efficiency in terms of work or power and percentage e.g. Efficiency = (work out / work in) x 100 %	1
		(ii)	17 divided by 63; 0.27;	Allow ecf answer from b(ii) [or (b)(iii)] divided by answer from (a) Allow 27%	2

Total 9 marks