Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
	1	(a)	(i)		2	0.1 × 8 (1) 0.8 [kg m/s] (1)			
			(ii)		1	- 0.6 [kg m/s]			+0.6
			(iii)		1	Total momentum before collision = + 0.2 [kg m/s] (**ecf** from parts (i) &(ii) probably giving an answer of +1.4)			
			(iv)		1	Same answer as (iii)			
			(v)		2	$v_B = \frac{0.2}{0.2}$ 2 mark for the numerator (**ecf** from (iv)) 1 mark for the denominator (i.e. 0.2)	If no workings shown: Award 2 marks for an answer of 1 [m/s] Award 2 marks for an answer of 7 [m/s] when **ecf** applied		
		(b)	(i)		2	$t = \frac{(0-8)}{-160}$ 1 mark for the numerator of (0 - 8) **or** (8 - 0) 1 mark for the denominator of -160 **or** 160 respectively	If no workings shown: Award 2 marks for an answer of 0.05 Award 1 mark for an answer of -0.05		
			(ii)		2	Force = 1.6 [N] (1) To the left / opposite [direction to force applied to B] (1)	In the negative vector / velocity direction (for second mark) Accept = -1.6 [N] for both marks Award 1 mark for: force on A is equal and opposite / same size and opposite		Force is backwards / same size
		(c)			3	Before KE = ($\frac{1}{2} \times 0.1\ (8^2)$) +($\frac{1}{2} \times 0.2\ (3^2)$) = 3.2 + 0.9 = 4.1 [J] (1) After KE = 0 +($\frac{1}{2} \times 0.2\ (1^2)$) = 0.1 [J] (1) **ecf** from (a)(v) KE lost = 4.1 – 0.1 = 4.0 [J](1) N.B. **ecf** from (a)(v) gives KE = 0 +($\frac{1}{2} \times 0.2\ (7^2)$) = 4.9 [J] and energy loss = -0.8 [J]	Award mark for correct subtraction where energies are wrong		Final answer of 0.8 from **ecf**s (Award 2 max for KE calculations)
		Total Mark			14				

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
	2	(a)	(i)		1	Gravity **and** radiation / pressure			
			(ii)		1	Forces are balanced / they are balanced	Equal and opposite / forces cancel each other out		The same / equal / because it has a supply of hydrogen / its balanced
		(b)	(i)		1	$^{1}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{0}_{1}\mathrm{e} + {}^{0}_{1}\mathrm{e}$	$4\,{}^{1}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + 2\,{}^{0}_{1}\mathrm{e}$		
			(ii)		3	Four hydrogen [nuclei] / protons join / fuse (1) to form a helium [nucleus] (1) and two positrons (1)	Antielectron instead of positron		Positive electron / react / bond / collide / alpha particle
			(iii)		3	Mass on left hand side = $4 \times 1.00728 = 4.02912$ (1) [Mass on right hand side = 4.00151] Mass defect = 4.02912 **ecf** – 4.00151 = 0.02761 [u] (1) $E = mc^2$ =0.02761 **ecf** $\times 1.66 \times 10^{-27}$ $= 4.58326 \times 10^{-29}$ [kg] (1) $\times (3 \times 10^{8})^2 = 4.12 \times 10^{-12}$ [J] (1) **Alternative solution:** LHS: $4 \times 1.00728 = 4.02912$ (1) 4.02912 **ecf** $\times 1.66 \times 10^{-27} = 6.6883392 \times 10^{-27}$ [kg] **and** RHS: $4.00151 \times 1.66 \times 10^{-27} = 6.6425066 \times 10^{-27}$ [kg] (1) LHS: 6.6883392 **ecf** $\times (3 \times 10^{8})^2 = 6.01950528 \times 10^{-10}$ [J] **and** RHS: $6.6425066 \times (3 \times 10^{8})^2 = 5.97825594 \times 10^{-10}$ [J] (1) Energy loss = $(6.01950528 - 5.97825594) \times 10^{-10}$ J $= 4.12 \times 10^{-12}$ [J] (1)			
		(c)			1	Energy / gamma is released	They annihilate / destroy each other / cancel each other out	An explosion takes place	They neutralise each other
		Total Mark			11				

Question Number				
FT	HT	Sub-section	Mark	Answer
	3		6	**Indicative content:** Conduction in solids occurs because the atoms are regularly positioned and are close together. The atoms in the hot part of the solid vibrate faster than those elsewhere. They pass on their energy to their neighbours by collisions and so the energy travels through the solid. In metals this is improved by free electrons which move at speed from the hot region, colliding with metal ions in the lattice, transferring their energy in the process. Convection occurs in gases because the particles in the hotter region have more energy and push each other further apart in violent collisions. This region becomes less dense and rises above the cooler region setting up a circulating current, transferring thermal energy to all parts of the gas. **5-6 marks** The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. **3-4 marks** The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1-2 marks** The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.
		Total Mark	6	

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
	4	(a)			2	Full core drawn so as to pass inside both coils and labelled <u>IRON CORE</u> (1) Function is to take the magnetic field [from the primary coil] into the secondary coil / linking the <u>magnetic field</u> of primary and secondary coils (1)	To increase the field strength through the secondary coil		A half core drawn or a single line drawn Links the two coils for the 2nd mark
		(b)	(i)		2	As the number of turns on the input coil increases, the output voltage decreases (1) at a decreasing rate (1)	Award 1 mark for negative correlation Award 2 marks for inversely proportional		….in a non-linear way / non-uniform way / reference to the gradient
			(ii)		2	$\frac{400}{60} = \frac{2\,000}{N_2}$ (e.g. using paired values from graph) (1-subs) $N_2 = 2\,000 \times \frac{60}{400} = 300$ (1-ans)			
			(iii)		3	(1-for 120 from graph) $P = VI$ so $I = \frac{480}{120}$ (1-substitution) $I = 4$ [A] (1-manipulation and answer)	480 = 120 × I gets first 2 marks Use of voltage value between 0 – 230 V		
			(iv)		1	Line drawn to the left and always below the line that is given in the question			Any touching of the original line
		Total Mark			10				

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
	5	(a)	(i)		3	Scale added to temperature axis in 10 °C intervals (1) Points ± ½ small square division (1) Best fit straight line with some points either side (1)			
			(ii)		1	Decreases			0 K
			(iii)		1	0 [J]			
		(b)			4	T_1 = 270 K, T_2 = 315 K $p_1 = 3 \times 10^6$, p_2 = ? $p_2 = p_1 \times \frac{T_2}{T_1} = 3 \times 10^6 \times \frac{315}{270}$ (1 – temp conversions) (1 – substitution) $p_2 = 3.5 \times 10^6$ (1- manipulation and answer) Comment which is dependent on their calculation (1) e.g. if correct answer – no danger of explosion stated	$\frac{p_1}{T_1} = \frac{p_2}{T_2}$ $\frac{3 \times 10^6}{-3} = \frac{p_2}{42}$ $p_2 = -42 \times 10^6$ [Pa] No danger of explosion Award: 0 for Kelvin conversion 1 for substitution of - 3 °C 1 for answer **with** negative sign 1 for correct comment based on their answer		
		Total Mark			9				

Question Number								
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
	6	(a)			3	Speed = $\frac{1958\mathbf{(1)}}{240\mathbf{(1)}}$ = 8.1583 / 8.16 [km/s] (1)	8.2 [km/s]		8.15 [km/s]
		(b)			6	**Indicative content:** Similarities: • P and S waves will both arrive at Tokyo and Hawaii. • P waves will always arrive before S waves. Differences: • Tokyo and Hawaii traces will start later than Hong Kong because they have further to travel. Tokyo calculation for arrival of P waves: Time = $\frac{4\,100}{8.16}$ **ecf** = 502.6 s (8.4 min) [so trace starts at 2:36:24] Hawaii Calculation: Time = $\frac{11020}{8.16}$ **ecf** = 1351 s (22.5min) [so trace starts at 2:50:31] • Tokyo trace to have a greater gap (than Hong Kong trace) between P and S waves arriving. Hawaii trace to have an even longer gap between P and S waves arriving. <u>Delay Calculations</u>: From Hong Kong data: Speed of S wave: $\frac{1958}{485}$ = 4.04 km/s Tokyo time for S waves: $\frac{4\,100}{4.04}$ = 1 015.6 [s] [So Tokyo lag time: 1 015.6 – 502.6 = 513 [s]] Hawaii time for S waves: $\frac{11020}{4.04}$ = 2 729 [s] [So Hawaii lag time: 2 729 – 1 351 = 1 378 [s]] Amplitude at Tokyo less than Hong Kong and less still at Hawaii (These figures are within a range of 30 s depending on rounding off.)			

Question Number									
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	6					**5-6 marks** The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. **3-4 marks** The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1-2 marks** The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.			
		(c)			1	The earth in San Francisco may have a different stiffness or different density.	Incorrect change in velocity for a correct property. Waves travel faster in some rocks than others.		Different materials
		Total Mark			10				