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General Certificate of Education (A-level) January 2013

Physics B: Physics in Context PHYB5

(Specification 2455)

Unit 5: Energy under the microscope

Final



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Question	Part	Sub-part	Marking guidance		Mark	Comment
			Curved line showing compression and labelled B	B1		
1	а		(1, 18) at the other end of the line, labelled or seen	B1		
			Any other legitimate point – eg (1.5, 12) or (1.5, 12)	B1	3	
1	b	i	(a change with) no heat transfer (into or out of the system)	B1	1	
	-					-
1	b	ii	Curve from B ending vertically below A	B1	1	
	-					
1	b	iii	Insulated (to prevent heat transfer) OR fast (to give no time for heat transfer)	B1	1	
1	h	iv.	temperature falls	B1		
I	a	IV	work is done by the gas (as it expands)	B1	2	
1	<u> </u>		n = pV/RT seen in symbols or numbers or substitution into $pV = nRT$	C1		
1	U		1.58 x 10 ⁻² (mol)	A1	2	
	1	1		- 11	1	
2	а	i	Ends with same material as it starts with (C-12)	B1	1	
2	а	ii	Nitrogen / N	B1	1	
2	а	iii	proton – 8 AND nucleon – 15	B1	1	
	-					
2	а	iv	Electron neutrino (not antineutrino)	B1	1	
2	а	v	Encounters electron and annihilates (producing 2 gammas)	B1	1	
2	h		Hotter	B1		
2	b		More massive	B1	2	
			Pd / electric field between the dees	B1		
3	а	i	Exert force on (charged) proton / reference to Eq or Vq/d	B1		
			Pd alternates (so proton is accelerated whichever direction it's going in)	B1	3	

3aiiequates BQV and $m^{1/T}$ involves $v = rw$ and $T = 2\pi/w$ or similar in clear and logical analysisB1 B123aiiiRearranges to give $B = 2\pi fm_{Q}$. OR substitutes into any correct form eg Q Image: Construct the example of the example o							
3 a i involves $v = rw$ and $T = 2\pi/w$ or similar in clear and logical analysis B1 2 3 a iii Rearranges to give $B = 2\pi/m_{Q}$ OR substitutes into any correct form eg C1 </td <td>3</td> <td>2</td> <td></td> <td>equates BQv and mv^2/r</td> <td>B1</td> <td></td> <td></td>	3	2		equates BQv and mv^2/r	B1		
3 a iii Rearranges to give $B = 2\pi Im_{Q}$ OR substitutes into any correct form eg Q Image: Control of the state of the	5	a	11	involves $v = r\omega$ and $T = 2\pi/\omega$ or similar in clear and logical analysis	B1	2	
3 a iii Rearranges to give $B = 2\pi fm_Q^{-1}$ OR substitutes into any correct form eg C1 C1 3 a iii $\frac{2\pi \chi 2.3 \times 1.67 \times 10^{-27}}{1.6 \times 10^{-19}}$ condone power of ten for f C1 A1 2 3 b i Particle must stay inside each electrode for the same length of time B1 A1 2 3 b i Particles are travelling faster (towards the right) B1 B1 2 3 b ii Particles approaching the speed of light B1 B1 3 3 b iii Collision used to create new (massive) particles B1 B1 3 3 b iii Collision used to create new (massive) particles B1 B1 3 4 a i Battery / pacemaker within body B1 B1 3 4 a ii Heart muscle is the resistor in the decay circuit B1 B1 2 4 b i T=1/f or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bi, 4bii and 4biii to be clipped together							
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3 a iii $\frac{2\pi x 2.3x 1.67 x 10^{27}}{1.6 \times 10^{19}}$ condone power of ten for f C1 A1 2 3 b i Particle must stay inside each electrode for the same length of time B1 B1 2 3 b i Particles are travelling faster (towards the right) B1 2 3 b iii Mass increase + mention of relativity Acceleration of particle is reduced Correct reference to relativity equation ANY 3 B1 3 3 b iii Collision used to create new (massive) particles Energy required to produce new matter More ke in proton- proton collision B1 B1 4 a i Battery / pacemaker within body Capacitor discharges through heart muscle Rate appropriate to body demands / can be changed B1 B1 4 a ii Heart muscle is the resistor in the decay circuit B1 2 4 b i T=1/f or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bii it ob eclipped				\overline{Q}			
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3 b ii Particles approaching the speed of light Mass increase + mention of relativity Acceleration of particle is reduced Correct reference to relativity equation B1 ANY 3 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B	3	b	I I	Particles are travelling faster (towards the right)	B1	2	
3 b ii Particles approaching the speed of light Mass increase + mention of relativity Acceleration of particle is reduced Correct reference to relativity equation ANY 3 B1 MAX B1 3 b iii Collision used to create new (massive) particles Energy required to produce new matter More ke in proton- proton collision B1 B1 4 a i Battery / pacemaker within body Capacitor discharges through heart muscle Rate appropriate to body demands / can be changed B1 B1 B1 4 a ii Heart muscle is the resistor in the decay circuit Time constant / <i>RC</i> controls the (time for the discharge and hence) heart rate B1 B1 2			1				
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3 b ii Acceleration of particle is reduced Correct reference to relativity equation ANY 3 B1 3 3 b iii Collision used to create new (massive) particles Energy required to produce new matter More ke in proton- proton collision B1 B1 4 a i Battery / pacemaker within body Capacitor discharges through heart muscle Rate appropriate to body demands / can be changed B1 B1 B1 B1 3 4 a ii Heart muscle is the resistor in the decay circuit Time constant / RC controls the (time for the discharge and hence) heart rate B1 B1 2 4 b i T=1/f or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bi, 4bii and 4biii to be clipped tooether				Mass increase + mention of relativity	B1	MAX	
3 b iii Collision used to create new (massive) particles B1 B1 3 b iiii Collision used to create new (massive) particles B1 B1 4 a i Battery / pacemaker within body Capacitor discharges through heart muscle Rate appropriate to body demands / can be changed B1 B1 B1 4 a ii Heart muscle is the resistor in the decay circuit Time constant / RC controls the (time for the discharge and hence) heart rate B1 2 4 b i T=1/f or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bi, 4bii and 4biii to be clipped together	3	h	ii	Acceleration of particle is reduced	B1	3	
3 b iii Collision used to create new (massive) particles Energy required to produce new matter More ke in proton- proton collision B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B	0	, D		Correct reference to relativity equation ANY 3		Ŭ	
3 b iii Collision used to create new (massive) particles Energy required to produce new matter More ke in proton- proton collision B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B							
3 b iii Collision used to create new (massive) particles Energy required to produce new matter More ke in proton- proton collision B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B			1				1
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4 a i Battery / pacemaker within body Capacitor discharges through heart muscle Rate appropriate to body demands / can be changed B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B	3	b	iii	Energy required to produce new matter	B1		
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4 a i Battery / pacemaker within body Capacitor discharges through heart muscle Rate appropriate to body demands / can be changed B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 4 a ii Heart muscle is the resistor in the decay circuit Time constant / RC controls the (time for the discharge and hence) heart rate B1 B1 2 4 b i T=1/f or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bi, 4bii and 4biii to be clipped together							
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A a ii Heart muscle is the resistor in the decay circuit B1 3 4 a ii Heart muscle is the resistor in the decay circuit B1 2 4 b i T=1/f or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bi, 4bii and 4biii to be clipped together	4	а	i	Capacitor discharges through heart muscle	B1		
4 a ii Heart muscle is the resistor in the decay circuit B1 B1 2 4 b i $T = 1/f$ or $1/0.85$ AND $1/3$ of T eg $1/3x$ 1.18 to give $0.0.392$ (s) B1 1 4bi, 4bii and 4biii to be clipped together				Rate appropriate to body demands / can be changed	B1	3	
4 a ii Heart muscle is the resistor in the decay circuit Time constant / RC controls the (time for the discharge and hence) heart rate B1 B1 2 4 b i T=1/f or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bi, 4bii and 4biii to be clipped together						-	
4 a II Time constant / RC controls the (time for the discharge and hence) heart rate B1 2 4 b i T=1/f or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bii and 4biii to be clipped together				Heart muscle is the resistor in the decay circuit	B1		
4 b i $T=1/f$ or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bi, 4bii and 4biii to be clipped together	4	а	II	Time constant / RC controls the (time for the discharge and hence) heart rate	B1	2	
4 b i $T=1/f$ or 1/0.85 AND 1/3 of T eg 1/3x 1.18 to give 0.0.392 (s) B1 1 4bi, 4bii and 4biii to be clipped together	L	1	1				1
4 b i b i b i b i b i b i b i b i b i b				T = 1/f or 1/0.85 AND 1/3 of T eq 1/3x 1.18 to give 0.0.392 (s)	B1	1	4bi 4bii and 4biii to be clipped
	4	b	i				together

					r	
			$t_{1/2} = 0.693 \text{ RC}$	C1		4bi, 4bii and 4biii to be clipped
			(C-)0 400/0 693x2500	C1		together
			(0-)(0+000)(0000000000000000000000000000		0	logether
			2.3(1) X 10 (F)	AT	3	
4	h					
4	D		OR			
			$V = V_c e^{-t/RC}$			
			$c_{\rm rest}$			
			Contect use of hogs eg in 2 of in(v_0/v) = $t_{1/2}/RC$			
			2.3(1) x 10 ^F)			
			value in the range 4000 Ω to 10 000 Ω	B1		4bi, 4bii and 4biii to be clipped
4	b	iii				together
	Ŭ		change takes, longer or twice as long / time constant is larger or twice the size	D1	2	logothol
				DI	Ζ	
	1			-		
			both sections exponential decay	B1		
			one shown as positive and the other as negative	B1		
4	b	iv	short section has max current of 1.6 mA	B1		
	~		longer section has smaller may current	B1	1	
			chart and an an and an an and an an and an		4	
			short section is 0.4 s and long section is 0.8 s ANY 4			
_			ln2/60 or ln2/2760 or 0.693/60 or 0.693/2760	B1		
5	а	Ì	$251 \times 10^{-4} (s^{-1})$	B1	2	
			2.51 × 10 (3)		2	
	1				1	
			$(dN/dt) = 65 \times 24 \times 10^{\circ}$	C1		
F	0		N = 65 x 24 x 10°/(λ or 2.51 x 10 ⁻⁴) - look for 6.2(2) x 10 ⁻²	C1		
5	a		Divides by 6.0 x 10^{23} (to get number of moles) OR multiplies by 213	C1		
			22 x 10 ⁹ a	A1	4	
				,		
	1	1		04	1	1
			Converts 440 keV to J eg 440 x 10° x $1.6 \times 10^{\circ}$ or 7.04 x 10° seen	01		
5	b	i	Correct sub into $\lambda = hc/E$ condoning power of ten eg <u>6.63 x 10⁻³⁴ x 3 x 10⁸</u>	C1		
			440	A1	3	
			$2.83 \times 10^{-12} \text{ (m)}$		-	
L	1	1		1	1	
		1	-0.23 x 8 = = = =	01	1	
5	b	ii	e condone powers of ten	C1	_	
Ŭ	~		15.9% or 16%	A1	2	

		Divides 8 MeV by 580 keV condoning power of ten eg 8			
5	с	580	C1		
		1.38 x 10 ⁻⁵ (m)	A1	2	
		Points to look for:			
		Damage is caused to cells			
		Radiotherapy can kill tumour/cancer cells			
		Radiotherapy can kill healthy cells			
		Radiotherapy undertaken when therapeutic value is judged to exceed risk			
		How damage is caused			
_		Radiations are ionising			
5	a	Damage to DNA / cell nucleus is particularly important			
		Prevents or distorts reproduction of cell.			
		Comparison of the 2 types of therapy			
		In Targeted, less damage is done to healthy tissue			
		Because isotope is attached to cell, very small doses needed			
		In conventional use, source is outside body			
		Much collateral damage to healthy tissue on route		6	
			1	0	I
		Lises magnetic and electric fields	B1		

	6	а	i	Uses magnetic and electric fields Both fields at right angles to (initial) direction / at right angles to each other Two forces equal and opposite so ion undeviated Eq =Bqv Only for ions of one speed ANY 4	B1 B1 B1 B1	4	
F		1	1		1		

6	а	ii	Fields at right angles to each other <i>B</i> into page and <i>E</i> to right OR <i>B</i> out of page and <i>E</i> to left	M1 A1	2	
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			Uses $Bqv = mv^2/r$ or $r = mv/Bq$	C1		
			one correct substitution with $m = 235$ or 238 or $\Delta m = 3$			
6	b	i	$eg \ 235 \ x \ 1.7 \ x \ 10^{-21} \ x \ 3.5 \ x \ 10^{4}$	C1		
Ũ			1.6 x 10 ⁻¹⁹ x 0.15			
			any correct radius 7.4 mm or 580 mm or 587 mm	C1		
			doubles 7.4 to give 14.8 mm	A1	4	
			- · · · · · · · · · · · · · · · · · · ·		1	
6	b	ii	$eV = \frac{1}{2}mV$	C1		
	-		1530 (V) allow reasonable variations	A1	2	
	•				T	
			$\sqrt{(Qq/4\pi F)}$ OR substitution 2.3 x 10 ⁻¹⁶ = <u>1.6 x 10⁻¹⁹ x 1.6 x 10⁻¹⁹</u>			
			$4\pi r^2$ condone powers of	C1		
6	С	i	10		2	
				C1		
			1 x 10° (m) condone 1 st			
	1		L o o		1	1
6			$\frac{2.3 \times 10^{-2}}{2.3 \times 10^{-27}}$	04		
6	С	Ш	$235 \times 1.7 \times 10$			
			5.9 x 10° (m s) allow reasonable range depending on mass selected	AT	2	
			$a = 1/a^2$ or other legitimate combination of equations of motion	C1	1	
6			$S = \frac{1}{2} at$ of other regulate combination of equations of motion			
0	C		0.04 (III) 2 x 0 84 - 1 7 (m) allow for variations in a 2.0 x10 ⁻⁹ x their a		3	
					5	
			Force is not constant	C1		
6	C	iv	Force or acceleration decreases (rapidly) as ions separate therefore it's an	01		
Ū	0	10	overestimate	A1	2	
L	1	1		,,,	-	1
			Draws appropriate triangle on graph or other mark on graph at ~ 118	B1		
			Change of approx 1 MeV per nucleon is multiplied by 235	B1		
7	а		Multiplies by 1.6 x 10^{-13}	B1		
			Quotes their answer of approx 3.8×10^{-11} to more than 2 sf	B1	4	
<u> </u>						
			(2 x 2.0135) – 4.0026 seen or 0.0244 (u)	C1		
-	L		Multiplies u by 1.7 x 10 ⁻²⁷	C1		
/	a		$E = mc^2$ seen or multiplies by $(3 \times 10^8)^2$	C1		
			3.67 x 10 ⁻¹² J	A1	4	

7	с	Multiplies 3.8×10^{-11} or their 6 (b) by 6×10^{23} attempts to convert to energy per kg by multiplying by 1000/4 or 1000/235 Compares 5.5×10^{14} (J) (Hydrogen) with 9.6×10^{13} (J) (Uranium) in some way eg by stating that the fusion reaction gives more energy (per kg) than the fission or very similar values – must be consequent on some correct analysis	M1 M1 A1	3	
7	d	Availability of fuel easier for fusion Doesn't produce radioactive fission products / no waste management problem	B1 B1	2	