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General Certificate of Education (A-level)
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Physics B: Physics in Context PHYB5

(Specification 2455)

Unit 5: Energy under the microscope

Final

Mark Scheme

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Question	Part	Sub-part	Marking guidance		Mark	Comment
1	a		Curved line showing compression and labelled B (1, 18) at the other end of the line, labelled or seen Any other legitimate point – eg (1.5, 12) or (1.5, 12)	B1 B1 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	b	iv	temperature falls work is done by the gas (as it expands)	B1 B1	2	
1	c		$n = pV/RT$ seen in symbols or numbers or substitution into $pV = nRT$ 1.58×10^{-2} (mol)	C1 A1	2	
2	a	i	Ends with same material as it starts with (C-12)	B1	1	
2	a	ii	Nitrogen / N	B1	1	
2	a	iii	proton – 8 AND nucleon – 15	B1	1	
2	a	iv	Electron neutrino (not antineutrino)	B1	1	
2	a	v	Encounters electron and annihilates (producing 2 gammas)	B1	1	
2	b		Hotter More massive	B1 B1	2	
3	a	i	Pd / electric field between the dees Exert force on (charged) proton / reference to Eq or Vq/d Pd alternates (so proton is accelerated whichever direction it's going in)	B1 B1 B1	3	

3	a	ii	equates BQv and mv^2/r involves $v = r\omega$ and $T = 2\pi/\omega$ or similar in clear and logical analysis	B1 B1	2	
3	a	iii	Rearranges to give $B = \frac{2\pi fm}{Q}$ OR substitutes into any correct form eg $\frac{2\pi \times 2.3 \times 1.67 \times 10^{-27}}{1.6 \times 10^{-19}}$ condone power of ten for f 1.51(T)	C1 A1	2	
3	b	i	Particle must stay inside each electrode for the same length of time Particles are travelling faster (towards the right)	B1 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 B1 B1	MAX 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	3	
4	a	i	Battery / pacemaker within body Capacitor discharges through heart muscle Rate appropriate to body demands / can be changed	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 together

4	b	ii	$t_{1/2}$ = 0.693 RC (C=)0.400/0.693x2500 2.3(1) x 10^{-4} (F) OR $V = V_0\, e^{-t/RC}$ Correct use of logs eg ln2 or ln(V_o/V) = $t_{1/2}$ / RC 2.3(1) x 10^{-4} (F)	C1 C1 A1	3	4bi, 4bii and 4biii to be clipped together
4	b	iii	value in the range 4000 Ω to 10 000 Ω change takes longer or twice as long / time constant is larger or twice the size	B1 B1	2	4bi, 4bii and 4biii to be clipped together
4	b	iv	both sections exponential decay one shown as positive and the other as negative short section has max current of 1.6 mA longer section has smaller max current short section is 0.4 s and long section is 0.8 s **ANY 4**	B1 B1 B1 B1	4	
5	a	i	ln2/60 or ln2/2760 or 0.693/60 or 0.693/2760 2.51 x 10^{-4} (s^{-1})	B1 B1	2	
5	a	ii	(dN/dt) = 65 x 24 x 10^6 N = 65 x 24 x 10^6 /(λ or 2.51 x 10^{-4}) - look for 6.2(2) x 10^{12} Divides by 6.0 x 10^{23}(to get number of moles) OR multiplies by 213 2.2 x 10^{-9} g	C1 C1 C1 A1	4	
5	b	i	Converts 440 keV to J eg 440 x 10^3 x 1.6 x 10^{-19} or 7.04 x 10^{-14} seen Correct sub into $\lambda = hc/E$ condoning power of ten eg $\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{440}$ 2.83 x10^{-12} (m)	C1 C1 A1	3	
5	b	ii	$e^{-0.23 \times 8}$ condone powers of ten 15.9% or 16%	C1 A1	2	

5	c		Divides 8 MeV by 580 keV condoning power of ten eg $\frac{8}{580}$ 1.38 x 10^{-5} (m)	C1 A1	2	

5	d		Points to look for: <u>Damage is caused to cells</u> Radiotherapy can kill tumour/cancer cells Radiotherapy can kill healthy cells Radiotherapy undertaken when therapeutic value is judged to exceed risk <u>How damage is caused</u> Radiations are ionising Damage to DNA / cell nucleus is particularly important Prevents or distorts reproduction of cell. <u>Comparison of the 2 types of therapy</u> 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 en route		6	

6	a	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	

6	a	ii	Fields at right angles to each other *B* into page and *E* to right OR *B* out of page and *E* to left	M1 A1	2	

6	b	i	Uses $Bqv = mv^2/r$ or $r = mv/Bq$ one correct substitution with m = 235 or 238 or Δm = 3 *eg* $\frac{235 \times 1.7\times10^{-27} \times 3.5 \times 10^{4}}{1.6 \times 10^{-19} \times 0.15}$ any correct radius 7.4 mm or 580 mm or 587 mm doubles 7.4 to give 14.8 mm	C1 C1 C1 A1	4	
6	b	ii	$eV = ½ mv^2$ 1530 (V) allow reasonable variations	C1 A1	2	
6	c	i	√($Qq/4\pi F$) OR substitution $2.3 \times 10^{-16} = \frac{1.6 \times 10^{-19} \times 1.6 \times 10^{-19}}{4\pi r^2}$ condone powers of 10 1×10^{-6} (m) condone 1 sf	C1 C1	2	
6	c	ii	$\frac{2.3 \times 10^{-16}}{235 \times 1.7 \times 10^{-27}}$ 5.9×10^{8} (m s^{-2}) allow reasonable range depending on mass selected	C1 A1	2	
6	c	iii	$s = ½ at^2$ or other legitimate combination of equations of motion 0.84 (m) 2 x 0.84 = 1.7 (m) allow for variations in *a* 2.9×10^{-9} x their *a*	C1 C1 A1	3	
6	c	iv	Force is not constant Force or acceleration decreases (rapidly) as ions separate therefore it's an overestimate	C1 A1	2	
7	a		Draws appropriate triangle on graph or other mark on graph at ~ 118 Change of approx 1 MeV per nucleon is multiplied by 235 Multiplies by 1.6×10^{-13} Quotes their answer of approx 3.8×10^{-11} to more than 2 sf	B1 B1 B1 B1	4	
7	b		(2 x 2.0135) – 4.0026 seen or 0.0244 (u) Multiplies u by 1.7×10^{-27} $E = mc^2$ seen or multiplies by $(3 \times 10^{8})^2$ 3.67×10^{-12}J	C1 C1 C1 A1	4	

7	c		Multiplies 3.8x 10^{-11} or their 6 (b) by 6 x 10^{23} attempts to convert to energy per kg by multiplying by 1000/4 or 1000/235 Compares 5.5x 10^{14} (J) (Hydrogen) with 9.6 x 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	