CAMBRIDGE INTERNATIONAL A LEVEL • PHYSICS 9702

Topical Questions

Unit 23: Nuclear Physics

Past Papers 2021 – 2025

MARK SCHEME 25 Questions

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Question 1 — Mark Scheme

Question	Answer	Marks
12(a)(i)	cannot predict when a particular nucleus will decay **or** cannot predict which nucleus will decay next	**B1**
12(a)(ii)	(decay is) not affected by external (environmental) factors	**B1**
12(b)(i)	$A = A_0 \exp(-\lambda t)$ and so $\ln A = \ln A_0 - \lambda t$ gradient of line = $(-)\lambda$	**C1**
	$\lambda = (36.4 - 35.0) / (20 - 0)$ $(= 0.07(0)\ \text{min}^{-1})$	**C1**
	half-life $= \ln 2 / \lambda$ $= \ln 2 / 0.070$ $= 10$ min	**A1**
	or	
	$A_0 = \exp(-36.4) = 6.43 \times 10^{15}$ (Bq)	**(C1)**
	$A_0 / 2 = 3.21 \times 10^{15}$ (Bq), so $\ln (A_0 / 2) = 35.7$	**(C1)**
	read off half-life = 10 min	**(A1)**
	or	
	(at one half-life,) $\ln A = 36.4 - \ln 2$	**(C1)**
	$= 35.7$	**(C1)**
	read off half-life = 10 min	**(A1)**

9702/42 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** October/November 2021

Question	Answer	Marks
12(b)(ii)	$A = \lambda N$	C1
	N = mass / (nucleon number × u) **or** N = (mass / nucleon number) × N_A	C1
	$\exp(36.4) = (1.17 \times 10^{-3} \times 5.66 \times 10^{-7}) / (\text{nucleon number} \times 1.66 \times 10^{-27})$ **or** $\exp(36.4) = (1.17 \times 10^{-3} \times 5.66 \times 10^{-4} \times 6.02 \times 10^{23}) / \text{nucleon number}$ nucleon number = 62	A1

Question 2 — Mark Scheme

9702/41 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** May/June 2021

Question	Answer	Marks
6(a)	from $x = 0$ to $x = r$: $E = 0$	B1
	from $x = r$ to $x = 3r$: curve with negative gradient of decreasing magnitude passing through (r, E_0)	B1
	line passing through $(2r, E_0 / 4)$ and $(3r, E_0 / 9)$	B1
6(b)	from $p = p_0 / 2$ to $p = p_0$: curve with negative gradient of decreasing magnitude passing through (p_0, λ_0)	B1
	line passing through $(½p_0, 2\lambda_0)$	B1
6(c)	from $t = 0$ to $t = 45$ s: curve with positive gradient of decreasing magnitude starting at (0, 0)	B1
	line passing through $(15, ½N_0)$	B1
	line passing through $(30, 0.75N_0)$ and $(45, 0.88N_0)$	B1

Question 3 — Mark Scheme

5(c)	$1.0T_{½}$ shown at $½N_0$ **and** $2.0T_{½}$ shown at $¼N_0$	**B1**
	line starting at (0, 0) and reaching (T, N_0–N)	**B1**
	line starting at (0, 0) and reaching original curve at ($1.0T_{½}$, $½N_0$)	**B1**

Question 4 — Mark Scheme

Question	Answer	Marks
12(a)	1 not affected by external factors	**B1**
	2 cannot predict when a (particular) nucleus will decay *or* cannot predict which nucleus will decay (next)	**B1**
12(b)(i)	Number of atoms = $\frac{1.0\times10^{-9}}{90\times1.66\times10^{-27}}$ *or* $\frac{1.0\times10^{-9}\times6.02\times10^{23}}{90\times10^{-3}}$ $=6.693\times10^{15}$	**C1**
	$A=\lambda N$ $\lambda=\frac{5.2\times10^{6}}{6.693\times10^{15}}$	**C1**
	$\lambda=7.8\times10^{-10}\ s^{-1}$	**A1**
12(b)(ii)	daughter nucleus is unstable	**B1**

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Question 5 — Mark Scheme

Question	Answer	Marks
9(a)	207, 82 for lead	**B1**
	4, 2 for alpha	**B1**
9(b)(i)	(half-life found as) 0.52 s or correctly read points substituted into $N = N_0 e^{-\lambda t}$ $\lambda = \frac{0.693}{t_{½}}$ $\lambda = \frac{0.693}{0.52}$	**C1**
	λ = **1.3 s^{-1}**	**A1**
9(b)(ii)	$A = \lambda N$ $= 1.3 \times 24 \times 10^{12}$ $= 3.1 \times 10^{13}$ Bq	**A1**
9(b)(iii)	upwards curve of decreasing gradient starting from (0,0)	**B1**
	passes through (0.52, 12) and (1.2, 18.8)	**B1**
9(c)(i)	16×10^{12} and 7.2×10^{12}	**C1**
	$6900 \times 10^3 \times 1.6 \times 10^{-19}$ $(16 \times 10^{12} - 7.2 \times 10^{12}) \times 6900 \times 10^3 \times 1.6 \times 10^{-19}$	**C1**
	= 9.7 J	**A1**

Question	Answer	Marks
9(c)(ii)	lead nuclei have kinetic energy *or* gamma photons are also emitted	**B1**

Question 6 — Mark Scheme

Question	Answer	Marks
8(a)(i)	energy required to separate the nucleons (in the nucleus)	M1
	to infinity	A1
8(a)(ii)	curve starting close to the origin and forming a single peak	B1
	peak shown to left of centre, with steep line on LHS of peak and shallow line on RHS of peak	B1
8(b)(i)	fusion	B1
8(b)(ii)	both particles have low A values **or** both particles are at left-hand end of graph	B1
	He-3 has higher binding energy (per nucleon) than H-2	B1
8(c)	$\Delta m = [(2 \times 2.014102) - (3.016029 + 1.008665)]$ u $(= 0.00351$ u$)$	C1
	$E = \Delta mc^2$	C1
	$= 0.00351 \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$ $(= 5.24 \times 10^{-13}$ J$)$	C1
	1.00 mol of deuterium forms 0.500 mol of helium-3	C1
	total energy $= 0.500 \times 6.02 \times 10^{23} \times 5.24 \times 10^{-13}$ $= 1.58 \times 10^{11}$ J	A1

Question 7 — Mark Scheme

Question	Answer	Marks
10(a)	spontaneous emission of (ionising) radiation	**B1**
	emission from unstable nucleus	**B1**
10(b)(i)	curve with decreasing negative gradient passing through (0, N_0)	**B1**
	curve passing through (T, $0.5N_0$)	**B1**
	curve passing through ($2T$, $0.25N_0$) **and** ($3T$, $0.125N_0$)	**B1**
10(b)(ii)	line through origin with positive gradient	**B1**
	straight line passing through (N_0, A_0)	**B1**
10(c)(i)	activity	**B1**
10(c)(ii)	decay constant	**B1**
10(d)	$N = N_0 \exp(-\ln 2 \times 1.70T / T)$	**C1**
	$N / N_0 = 0.31$	**A1**

Question 8 — Mark Scheme

Question	Answer	Marks
10(a)(i)	cannot predict when a (particular) nucleus will decay **or** cannot predict which nucleus will decay next	**B1**
10(a)(ii)	not affected by external / environmental factors	**B1**
10(b)(i)	line fluctuates **or** trend is a straight line	**B1**
10(b)(ii)	straight line of best fit drawn on Fig. 10.1	**B1**
10(b)(iii)	$M = M_0 \exp(-\lambda t)$ so $\ln M = \ln M_0 - \lambda t$ so gradient = $-\lambda$ (and magnitude of gradient = λ)	**B1**
10(b)(iv)	gradient = (–) (8.0 – 4.8) / (11.6 – 0) (*allow any correct pair of values from Fig. 10.1*)	**C1**
	$\lambda = 0.28\ s^{-1}$	**A1**
10(b)(v)	half-life = 0.693 / λ = 0.693 / 0.28 = 2.5 s	**A1**
10(c)	(for reaction to occur,) energy is released	**B1**
	energy release comes from fall in mass so total mass of products must be less (than mass of carbon-15)	**B1**

Question 9 — Mark Scheme

9702/42 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** February/March 2023

Question	Answer	Marks
8(a)	234, 92 for the uranium nucleus	**B1**
	4, 2 for the alpha particle	**B1**
8(b)(i)	$N_0 = 0.874 / (238 \times 1.66 \times 10^{-27})$ $= 2.21 \times 10^{24}$	**A1**
8(b)(ii)	$A = \lambda N$	**C1**
	$= \frac{\ln 2}{87.7 \times 365 \times 24 \times 3600} \times 2.21 \times 10^{24}$ $= 5.54 \times 10^{14}$ Bq	**A1**
8(b)(iii)	power $= 5.54 \times 10^{14} \times 5.59 \times 10^{6} \times 1.60 \times 10^{-19}$	**C1**
	$= 496$ W	**A1**
8(b)(iv)	$65.3 = 100e^{-\frac{\ln 2}{87.7}t}$	**C1**
	$\ln 0.653 = -(\ln 2 / 87.7)\, t$ $t = 53.9$ years	**A1**
8(c)	advantage: less mass so less energy needed to launch probe	**B1**
	disadvantage: half-life shorter so will not provide power for as long	**B1**

Question 10 — Mark Scheme

9702/41 Cambridge International AS & A Level – Mark Scheme May/June 2023
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Question	Answer	Marks
9(a)	time for activity (of sample) to halve	**B1**
9(b)	sketch: line with positive gradient starting at (0,0) and extending to t = 80 min	**B1**
	exponential curve, extending from t = 0 to t = 80 min, with gradient of steadily decreasing magnitude	**B1**
	line passing through (0,0), (20, 0.5N_0) and (40, 0.75 N_0)	**B1**
9(c)(i)	every (undecayed) nucleus has the same probability of decay	**M1**
	fewer (undecayed) nuclei remaining (with time), so fewer will decay (in a given time interval)	**A1**
9(c)(ii)	• sample emits in all directions but detector only captures emissions in one direction • some emissions are absorbed before reaching detector • some emissions are scattered within the sample • simultaneous arrival of multiple particles only registers once • some particles may reach detector but not cause ionisation *Any two points, 1 mark each*	**B2**
	measured count rate is less than the activity	**B1**

Question 11 — Mark Scheme

Question	Answer	Marks
9(a)	difference between mass of nucleus and (total) mass of nucleons	M1
	when infinitely separated	A1
9(b)(i)	neutron	B1
9(b)(ii)	$E = \Delta m\, c^2$	C1
	Δm = (0.030377 – 0.002388 – 0.009105)u (= 0.018884u)	C1
	energy release = $(0.030377 - 0.002388 - 0.009105) \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2 = 2.8 \times 10^{-12}$ J	A1
9(c)(i)	number of atoms per unit time = $(1.4 \times 10^{28}) / (2.8 \times 10^{-12})$ (= 5.0×10^{39} s^{-1})	C1
	mass of one atom = $4 \times 1.66 \times 10^{-27}$ or $(4 \times 10^{-3}) / (6.02 \times 10^{23})$ (= 6.64×10^{-27} kg)	C1
	mass per unit time = $6.64 \times 10^{-27} \times 5.0 \times 10^{39}$ = 3.3×10^{13} kg s^{-1}	A1
9(c)(ii)	$L = 4\pi\sigma r^2 T^4$ $1.4 \times 10^{28} = 4\pi \times 5.67 \times 10^{-8} \times (2.3 \times 10^9)^2 \times T^4$	C1
	T = 7800 K	A1

Question 12 — Mark Scheme

Question	Answer	Marks
9(a)	(two small) nuclei join together	M1
	to form one larger nucleus	A1
9(b)	line with a peak at $A \approx 56$	B1
	line with steep initial positive gradient on the left of peak and shallower negative gradient at all points to the right of peak and line does not return to 0 binding energy	B1
9(c)(i)	X shown at value of A to the right of the peak	B1
9(c)(ii)	Y shown at value of A close to 1	B1
9(d)	energy from 1 nucleus = $(1.77 \times 10^{13}) / (6.02 \times 10^{23})$ $(= 2.94 \times 10^{-11}\ \text{J})$	C1
	binding energy of Z = $[(1.25 + 1.81) \times 10^{-10}] - 2.94 \times 10^{-11}$ $(= 2.77 \times 10^{-10}\ \text{J})$	C1
	nucleon number of Z = 93 + 139 + 2 – 1 (= 233)	C1
	binding energy per nucleon = $(2.77 \times 10^{-10}) / (233 \times 1.60 \times 10^{-13})$ = 7.43 MeV	A1

Question 13 — Mark Scheme

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Question	Answer	Marks
9(a)(i)	material introduced into the body **and** (position in body) can be detected **or** absorbed by the tissue (being studied)	**B1**
9(a)(ii)	X = β^+ **or** e^+ **and** $P = 1$	**B1**
	$Q = 0$ **and** $R = 18$	**B1**
9(b)(i)	positrons (emitted in the decay) and electrons annihilate	**B1**
	mass of particles becomes energy of gamma photons	**B1**
9(b)(ii)	arrival times of photons are processed	**B1**
	image built up of tracer concentration in the tissue	**B1**
9(c)(i)	$A = \lambda N$ **and** $\lambda = \ln 2 / T$	**C1**
	$N = n \times N_A$	**C1**
	2 photons produced from each decay, so $R_0 = 2 \times \lambda \times n \times N_A$ $R_0 = (2 \ln 2)\, nN_A / T$ *(allow 0.693 for ln 2)*	**A1**
9(c)(ii)	sketch: exponential decay curve from $t = 0$ to $t = 2T$, starting at $(0, R_0)$ and with a negative gradient of continuously decreasing magnitude	**B1**
	line with negative gradient passing through $(T, R_0/2)$ and $(2T, R_0/4)$	**B1**

Question 14 — Mark Scheme

Question	Answer	Marks
8(a)	(minimum) energy required to separate the nucleons (of a nucleus)	M1
	to infinity	A1
8(b)(i)	4	A1

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Question	Answer	Marks
8(b)(ii)	energy = (142 × 8.37) + (90 × 8.72) – (235 × 7.59)	C1
	= 190 MeV	A1
8(b)(iii)	**either** it has too many neutrons (for the number of protons) **or** its neutron to proton ratio is too high	B1
8(b)(iv)	(when t = 6.0 s), $N / N_0 = 1 / 32$	C1
	either $(1 / 32) = \exp(-\ln 2 \times 6.0 / t_{½})$	C1
	$t_{½}$ = 1.2 s	A1
	or $32 / 2^n = 1$ so $n = 5$ (half-lives)	(C1)
	$t_{1/2} = 6.0 / 5$ = 1.2 s	(A1)

Question 15 — Mark Scheme

Question	Answer	Marks
9(a)	time for activity (of sample) to halve	**B1**
9(b)(i)	activity (of X at time *t*)	**B1**
9(b)(ii)	• Y is a stable isotope • total number of nuclei is constant • half-life (of X) is 13.6 s • decay constant (of X) is 0.051 s^{-1} • amount (of X) at $t = 0$ is 0.066 mol • activity (of X) at $t = 0$ is 2.0×10^{21} Bq *Any three points, 1 mark each*	**B3**
9(c)	mass of 1 nucleus = $(7.3 \times 10^{-4}) / (4.0 \times 10^{22})$	**C1**
	nucleon number = mass of nucleus / (1.66×10^{-27})	**C1**
	= $(7.3 \times 10^{-4}) / (4.0 \times 10^{22} \times 1.66 \times 10^{-27})$ = 11 **and** given as an integer	**A1**

Question 16 — Mark Scheme

Question	Answer	Marks
9(a)	energy required to separate (all) the nucleons (in the nucleus)	M1
	to infinity	A1
9(b)(i)	Δm = {[(84 × 1.007276) + (128 × 1.008665)] – 211.942749} (u) (= 1.778 u)	C1
	= 1.778 × 1.66 × 10^{-27} (kg)	C1
	= 2.95 × 10^{-27} kg	A1
9(b)(ii)	$E = (\Delta)mc^2$	C1
	binding energy = 2.95 × 10^{-27} × (3.00 × 10^{8})^2 = 2.66 × 10^{-10} J	A1
9(b)(iii)	binding energy per nucleon = (2.66 × 10^{-10}) / 212 = 1.25 × 10^{-12} J	A1
9(c)(i)	line rising to a single peak that is to the left of the '9' in the Fig. 9.1 label and then continually decreasing	B1
	steep positive gradient on the left of the peak and shallow negative gradient on the right	B1
9(c)(ii)	X shown on the line at a value of *A* that is to the right of the left-hand edge of the '*A*' in the axis label, and to the left of '2' in the 250 label	B1
9(c)(iii)	nucleus formed (as a result of the decay) has a lower nucleon number	B1
	(nucleus formed has a) greater binding energy per nucleon	B1

Question 17 — Mark Scheme

Question	Answer	Marks
9(a)(i)	positron	**B1**
9(a)(ii)	$\lambda = \ln 2 / (110 \times 60) = 1.05 \times 10^{-4}\ s^{-1}$	**A1**
9(a)(iii)	$N = M / (18\ u)$ **or** (M in grams $\times N_A / 18$) $N = (2.1 \times 10^{-12}) / (18 \times 1.66 \times 10^{-27})$ **or** $(2.1 \times 10^{-9} \times 6.02 \times 10^{23}) / 18$ $(= 7.0 \times 10^{13})$	**C1**
	$A = \lambda N$	**C1**
	$= 1.05 \times 10^{-4} \times 7.0 \times 10^{13}$ $= 7.4 \times 10^{9}$ Bq	**A1**
9(b)(i)	• (pair) annihilation occurs • the mass of the two particles is converted into energy • two gamma photons are formed and travel in opposite directions **or** two gamma photons are formed and leave the body • difference in arrival times of photons (at detector) is processed *Any three points, 1 mark each*	**B3**
9(b)(ii)	with a shorter half-life: sample would (almost) fully decay before the test is complete	**B1**
	a longer half-life: exposes patient to harmful/ionising radiation unnecessarily **or** with a longer half-life: a larger dose (of tracer) needed to produce detectable activity	**B1**

Question 18 — Mark Scheme

Question	Answer	Marks
10(a)(i)	cannot predict when a particular nucleus will decay **or** cannot predict which nucleus will decay next	**B1**
10(a)(ii)	(decay is) not affected by external (environmental) factors	**B1**
10(a)(iii)	fluctuations in (measured) count rate	**B1**
10(b)(i)	• large nuclei undergo fission whereas small nuclei undergo fusion • fission involves one nucleus splitting into two (or more) (smaller) nuclei • fusion involves two nuclei joining together to form one (larger) nucleus • fission is (usually) initiated by neutron bombardment • fusion is (usually) initiated by (very) high temperatures *Any three points, 1 mark each*	**B3**
10(b)(ii)	binding energy per nucleon is greatest for intermediate nucleon numbers (may be shown on sketch graph with axes labelled 'binding energy per nucleon' and 'nucleon number')	**B1**
	both fusion and fission involve an increase in binding energy (per nucleon)	**B1**

Question 19 — Mark Scheme

Question	Answer	Marks
9(a)(i)	*either*: cannot predict when a (particular) nucleus will decay *or*: cannot predict which nucleus will decay next	**B1**
9(a)(ii)	not affected by external / environmental factors	**B1**
9(b)	time for activity to halve	**B1**
9(c)	energy = (189 × 7.826) + (4 × 7.074) – (193 × 7.774)	**C1**
	= 7.03 eV	**A1**
9(d)(i)	decay constant	**A1**
9(d)(ii)	decay constant / magnitude of gradient = 1.4 / 0.84	**C1**
	half-life = ln2 / (1.4 / 0.84) = 0.42 ms	**A1**
9(e)(i)	positrons collide with electrons and annihilate	**B1**
9(e)(ii)	long enough to have time to conduct investigation, not so long as to cause patient unnecessary exposure to radiation	**B1**

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Question 20 — Mark Scheme

Question	Answer	Marks
9(a)	number of nuclear disintegrations per unit time	**B1**
9(b)	activity is proportional to the number of undecayed nuclei	**B1**
	activity = (–) rate of change of number of undecayed nuclei	**B1**
	N is proportional to the rate of change of N (so exponential variation)	**B1**
9(c)(i)	$120 = 180 \exp(-\lambda \times 8.4)$	**C1**
	$\lambda = 0.048\ \text{min}^{-1}$	**A1**
9(c)(ii)	half-life = ln 2 / 0.048 = 14 min	**A1**
9(c)(iii)	line with negative gradient throughout, starting at (0, 180)	**B1**
	curve with negative gradient passing through (8.4, 120)	**B1**
	curve with decreasing negative gradient, from $t = 0$ to $t = 24$ min, passing through (14, 90)	**B1**

Question 21 — Mark Scheme

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>10(a)</td><td>(decay is) not affected by external / environmental factors</td><td>B1</td></tr>
<tr><td rowspan="3">10(b)(i)</td><td>half-life of X = 2T <u>and</u> half-life of Y = 3T</td><td>B1</td></tr>
<tr><td>both samples show decay constant, in terms of 1 / T, equal to ln 2 / half-life
(decay constant of X = ln 2 / 2T and decay constant of Y = ln 2 / 3T if both half-lives correct)</td><td>B1</td></tr>
<tr><td>both samples show N_0, in terms of AT, equal to initial activity / decay constant
(N_0 for X = $8AT$ / ln 2 and N_0 for Y = $3AT$ / ln 2 if both decay constants correct)

(Fully correct table:
<table>
<tr><th></th><th>half-life</th><th>decay constant</th><th>A_0</th><th>N_0</th></tr>
<tr><td>X</td><td>2T</td><td>ln 2 / 2T</td><td>4A</td><td>$8AT$ / ln 2</td></tr>
<tr><td>Y</td><td>3T</td><td>ln 2 / 3T</td><td>A</td><td>$3AT$ / ln 2</td></tr>
</table>
)</td><td>B1</td></tr>
<tr><td rowspan="3">10(b)(ii)</td><td>correct substitution of A_0 and λ into $A_0 \exp(-\lambda t)$ for sample X or sample Y</td><td>C1</td></tr>
<tr><td>$4A \exp(-t \ln 2 / 2T) = A \exp(-t \ln 2 / 3T)$</td><td>C1</td></tr>
<tr><td>$t = 12T$</td><td>A1</td></tr>
<tr><td>10(c)</td><td>Any two points from:
• (radiation) emitted in all directions, not just in direction of detector
• some radiation absorbed by air / sample / window of detector
• some radiation may not register even though it reaches detector</td><td>B2</td></tr>
</table>

Question 22 — Mark Scheme

9702/44 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** May/June 2025

Question	Answer	Marks
11(a)(i)	(nuclear) fusion	**B1**
11(a)(ii)	Δm = [0.030377 – (3 × 0.002388)] u (= 0.023213 u)	**B1**
	$E = \Delta m\, c^2$	**C1**
	= 0.023213 × 1.66 × 10^{-27} × (3.00 × 10^8)^2 = 3.47 × 10^{-12} J	**A1**
11(b)(i)	mass of 1 mol of helium-4 = 4 g **or** mass of 1 helium atom = 4 u	**C1**
	N rate = (6.02 × 10^{23} × 7.34 × 10^{11}) / (4 × 10^{-3}) **or** N rate = (7.34 × 10^{11}) / (4 × 1.66 × 10^{-27})	**C1**
	luminosity = 1.10 × 10^{38} × 3.47 × 10^{-12} = 3.83 × 10^{26} W	**A1**
11(b)(ii)	$L = 4\pi\sigma r^2 T^4$ 3.83 × 10^{26} = 4π × 5.67 × 10^{-8} × (6.96 × 10^8)^2 × T^4	**C1**
	T = 5770 K	**A1**

Question 23 — Mark Scheme

9702/41 Cambridge International AS & A Level – Mark Scheme October/November 2025
PUBLISHED

Question	Answer	Marks
8(a)	packet / quantum of energy	M1
	of electromagnetic radiation	A1
8(b)(i)	$E = c^2\Delta m$	C1
	$\Delta m = (4.274 \times 10^6 \times 1.60 \times 10^{-19}) / (1.66 \times 10^{-27} \times (3.00 \times 10^8)^2)$ (= 0.00458 u)	C1
	m = 233.915174 + 4.000407 + 0.00458 = 237.92016 u	A1
8(b)(ii)	$E = hc / \lambda$ **or** $E = hf$ **and** $c = f\lambda$	C1
	$(4.274 - 4.200) \times 1.60 \times 10^{-13} = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / \lambda$	C1
	$\lambda = 1.7 \times 10^{-11}$ m	A1
8(b)(iii)	(true) energy of gamma photon is smaller so (true) wavelength is larger	B1
8(c)	(anti)neutrinos are emitted during beta decay	B1
	particles emitted during beta decay carry varying amounts of energy, so energy of gamma photon is also variable (between decays)	B1

Question 24 — Mark Scheme

9702/42 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** October/November 2025

Question	Answer	Marks
9(a)	difference between mass of nucleus and mass of (constituent) nucleons	M1
	when nucleons are separated to infinity	A1
9(b)	$\Delta m = (2 \times 2.013553) - (4.001505)$ (u) $(= 0.025601$ u)	C1
	$E = c^2\Delta m$	C1
	energy from one He-4 nucleus= $0.025601 \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$ $(= 3.82 \times 10^{-12}$ J)	C1
	energy to form 1.00 mol= $3.82 \times 10^{-12} \times 6.02 \times 10^{23}$ $= 2.30 \times 10^{12}$ J	A1
9(c)(i)	$L = 1.09 \times 10^{11} \times (3.00 \times 10^8)^2$	C1
	$= 9.81 \times 10^{27}$ W	A1
9(c)(ii)	$L = 4\pi\sigma r^2 T^4$ $9.81 \times 10^{27} = 4\pi \times 5.67 \times 10^{-8} \times (1.19 \times 10^9)^2 \times T^4$	C1
	$T = 9930$ K	A1
9(d)	standard candles have known luminosity	B1
	radiant flux intensity (from star) measured (on the Earth)	B1
	distance found from $F = L / (4\pi d^2)$	B1

Question 25 — Mark Scheme

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Question	Answer	Marks
8(a)	(radioactive) substance introduced into the body	B1
	substance absorbed by the tissues being studied	B1
8(b)(i)	$P = 15$ **and** $R = 0$	A1
	$Q = 7$ **and** $S = (+)1$	A1
8(b)(ii)	(electron) neutrino	B1
8(c)(i)	number of nuclear disintegrations per unit time	B1
8(c)(ii)	decay constant $= \ln 2 / (2.04 \times 60)$	C1
	$= 5.66 \times 10^{-3}\ s^{-1}$	A1
8(c)(iii)	$N = (2.85 \times 10^{-6}) / (15 \times 1.66 \times 10^{-27})$	C1
	$A = \lambda N$	C1
	rate $= (5.66 \times 10^{-3}) \times (2.85 \times 10^{-6}) / (15 \times 1.66 \times 10^{-27})$	C1
	$= 6.48 \times 10^{17}\ s^{-1}$	A1
8(d)(i)	gamma photons	B1
8(d)(ii)	positron collides with electron (in body)	B1
	annihilation results in their masses becoming photon energy	B1

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