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 $N = N_0 e^{-\lambda t}$ $\lambda = \frac{0.693}{t_{1/2}}$ $\lambda = \frac{0.693}{0.52}$	**C1**
	λ = **1.3 s^{-1}**	**A1**
9(b)(ii)	A=λN $= 1.3 \times 24 \times 10^{12}$ $= 3.1 \times 10^{13}$ 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	Answer	Marks
10(a)	energy = mcΔT	**C1**
	energy = ItV $(\Delta T =) \dfrac{0.40 \times 0.020 \times 75\,000 \times 0.95}{0.015 \times 130}$	**C1**
	=290 K	**A1**
10(b)	$I = I_o e^{-\mu t}$ $0.20 = e^{-0.22t}$	**C1**
	t = 7.3 cm	**A1**

Question	Answer	Marks
10(c)	*either* (linear) attenuation coefficients / μ <u>very</u> different for bone and muscle	**M1**
	(very) different amounts (of X-rays) absorbed so good contrast or (very) different intensities transmitted so good contrast	**A1**
	or (linear) attenuation coefficients / μ similar for blood and muscle	**(M1)**
	similar amounts (of X-rays) absorbed so poor contrast or similar intensities transmitted so poor contrast	**(A1)**

Question	Answer	Marks
11(a)	substance containing radioactive nuclei that is introduced into the body *or* substance containing radioactive nuclei that is absorbed by the tissue being studied	**B1**
11(b)(i)	a particle interacting with its antiparticle so that mass is converted into energy	**B1**
11(b)(ii)	electron(s) and positron(s)	**B1**
11(c)(i)	$E = 2mc^2$ $= 2 \times 9.11 \times 10^{-31} \times 3.00 \times 10^{-82}$ $= 1.64 \times 10^{-13}$ J	**A1**

Question	Answer	Marks
11(c)(ii)	$\lambda = \dfrac{2hc}{E}$ $= \dfrac{2 \times 6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{1.64 \times 10^{-13}}$	C1
	$= 2.43 \times 10^{-12}$ m	A1
11(d)	Any 3 from: • the two gamma photons travel in opposite directions • gamma photons detected (outside body / by detectors) • gamma photons arrive (at detector) at different times • determine location of production (of gamma) • image of tracer concentration in tissue produced	B3

Question	Answer	Marks
12(a)	total power of radiation emitted (by the star)	B1
12(b)	$F = \dfrac{L}{4\pi d^2}$ $= \dfrac{3.83 \times 10^{26}}{4 \times \pi \times 1.51 \times 10^{112}}$	C1
	$= 1340$ W m^{-2}	A1

Question	Answer	Marks
12(c)	$m = \dfrac{E}{c^2}$ $= \dfrac{3.83 \times 10^{26}}{3.00 \times 10^{82}}$ $= 4.26 \times 10^{9}$ kg	A1
12(d)	$L = 4\pi\sigma r^2 T^4$ $3.83 \times 10^{26} = 4 \times \pi \times 5.67 \times 10^{-8} \times 6.96 \times 10^{82} \times T^4$ leading to T = 5770 K	B1
12(e)	$\lambda_{(max)} \propto \dfrac{1}{T}$ $\dfrac{5.00 \times 10^{-7}}{\lambda} = \dfrac{9940}{5770}$	C1
	$\lambda = 2.90 \times 10^{-7}$m	A1