Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
12	(a)		Metal filter to remove low energy X-rays (1) So they are not absorbed by tissue causing damage (1) Lead grid to absorb scattered X-rays (1) to increase contrast / reduce shadow areas (1)	4			4		
	(b)	(i)	$Q = It$ / current is charge per second (1) no of electrons per second = $\frac{0.015}{1.6 \times 10^{-19}} = 9.4 \times 10^{16}$ (1)	1	1		2	2	
		(ii)	Either: Application of $eV = \frac{1}{2} mv^2$ (1) $v = 1.03 \times 10^8$ m s^{-1} (1) $F = mv \times$ no of electrons per sec = 8.79×10^{-6} [N] (1) Or: Application of $p = \sqrt{2mE_k}$ (1) Electron momentum = 9.35×10^{-23} N s (1) $F = p \times$ no. of electrons per second = 8.79×10^{-6} [N] (1)		3		3	3	
	(c)		MRI works and non ionising/time consuming/expensive-ish (1) (£500) PET works but ionising/expensive/limited availability/low resolution (1) (£900) Ultrasound B won't work/too much air reflection (1) (£150) CT works but ionising/expensive-ish (1) (£500) Conclusion all work except ultrasound but MRI best (1)			5	5		
	(d)	(i)	Kidney to check flow / Thyroid to check uptake (of iodine)/blood flow through the brain check for blockages /any other example	1			1		
		(ii)	$\frac{0.12}{5} = 0.024$ [Bq cm^{-3}] (1) Activity = $160e^{(-0.0462 \times 7)}$ [or $160 \times 2^{-\frac{7}{15}}$] = 115.8 or 116 [Bq] (1) Volume ($\frac{115.8}{0.024}$) = 4825 cm^3 (1)		3		3	3	
		(iii)	Rearrangement $v = \frac{\Delta f_c}{2 f_0 \cos\theta}$ (1) $v = 0.14$[4] m s^{-1} (1)		2		2	2	
			Question 12 total	**6**	**9**	**5**	**20**	**10**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Curve identical to the original (including the line spectrum in the same place) but all the curve above the original with the minimum wavelength below original but not at (0,0)		1		1		
		(ii)	Use of $eV = \frac{hc}{\lambda}$ (1) $\lambda = 4.125 \times 10^{-11}$ [m] (1)	1	1		2	2	
		(iii)	Power = $120 \times 10^{-3} \times 30\,000$ (1) Heat production = $(0.9955 \times 3\,600) = 3\,583.8$ or 3 584 [W] (1)	1	1		2	2	
		(iv)	[No] for λ to be zero the voltage must be infinite (all other parts of the expression are constants) / It would require an infinite amount of energy		1		1		
	(b)	(i)	A high freq changing / alternating [electrical] voltage (1) causes the piezoelectric [crystal] to oscillate [producing ultrasound] (1)	2			2		
		(ii)	Time from scale 4.5 ± 0.5 [μs] (1) Distance = $4.5 \times 10^{-6} \times 1\,640 = 7.4 \times 10^{-3}$ [m] (1) Thickness = 3.7×10^{-3} [m] **ecf** (1)		3		3	3	
	(c)	(i)	CT scan (1) Gives a 3D image (1) In real time/only seconds of delay time (1) **Alternative for last 2 marks** A scan will only measure distance **and** tracers will not detect leaks (1) X-rays 2D **and** not in real time (1) (also poor quality for brain)			3	3		
		(ii)	Radioactive tracer (1) Taken up by the thyroid /detected using a gamma camera (1) **Alternative for the last mark** X-ray, CT and A scan will (only) detect the gland (1)			2	2		
	(d)		At centre B = $\frac{(0.80 + 1.40)}{2}$ **OR** 1.10 [T] (1) $f = 42.6 \times 10^6 \times 1.1 = 46.86 \times 10^6$ [Hz] (1) allow **ecf** $\lambda = \frac{3 \times 10^8}{46.86 \times 10^6} = 6.4$ m with units (1) allow **ecf** Radio waves (1)	1 1	 1 1 		 4	 3	
			Question total	**6**	**9**	**5**	**20**	**10**	**0**

#3

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(a)		Electrons accelerated through a pd (in a vacuum) (1) Collide with target (or anode) / decelerated by target (or nucleus) (1)	2			2		
	(b)	(i)	$\frac{I}{I_0} = \frac{1}{2}$ or $I = I_0 e^{-\mu x}$ (1) $2 = \frac{e^{\mu x}}{\frac{1}{2}} = e^{-\mu x}$ or $\frac{1}{2} = e^{-\mu x}$ (1) $\ln 2 = \mu x$ (1) If negative sign lost for no reason deduct 1 mark	1	1 1		3	3	
		(ii)	$\mu = \frac{\ln 2}{1.5}$ so μ = 0.46(2) or 46.2 (1) $\ln(\frac{100}{40}) = 0.46\,x$ **ecf** (1) x = 2 (.0) cm **with units** (1) **Alternative:** $0.5 = e^{-\mu x\,1.5}$ and $0.4 = e^{-\mu x}$ (1) $\mu = \frac{\ln 0.5}{1.5}$ and $\mu = \frac{\ln 0.4}{x}$ (1) $x = 1.5 \text{x} \frac{\ln 0.4}{\ln 0.5}$ x = 2(.0) cm **with units** (1) Answer of 1.1 award 2 marks If orders of magnitude incorrect award 1 mark maximum $\ln 0.4 = -\mu x$ (1)		3		3	3	
		(iii)	X-rays absorbed by skull / bone (1) MRI / PET (1) High quality images of *soft tissue* (1) or opposite statement i.e. X-rays poor soft tissue contrast	1		1 1	3		
	(c)		Alternating voltage or current applied (1) Crystal vibrates / resonates (1) don't accept just expands and contracts	2			2		
	(d)	(i)	1.71×10^6 1.34×10^6 7.78×10^6 Any 1 correct (1) All three correct (2)		2		2	2	
		(ii)	Must select bone as by far the largest (1) Bone and fat as difference biggest (1) Value calculated as 0.5 (1)		1	1 1	3	1	
	(e)		1.5 T **with units** (1) Patients with any metal in their bodies / pacemakers (1) (accept claustrophobic/young children need general anaesthetic)		1	1	2	1	
			Question total	**6**	**9**	**5**	**20**	**10**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
12	*(a)*	(i)	Two graphs with skewed normal distributions one always above the other labelled background or continuous [spectra] (1) Line spectra shown on both graphs in the same place and labelled (1) Minimum wavelengths labelled and not at (0,0) and not meeting at the x-axis (1) Higher curve labelled higher voltage (1)	4			4		
		(ii)	$v = \sqrt{\frac{2eV}{m}}$ (1) $v = 8.38$ [or 8.4] $\times 10^7$ [m s^{-1}] (1)		2		2	2	
		(iii)	$\lambda = \frac{hc}{eV}$ (1) $\lambda = 6.22 \times 10^{-11}$ [m] (1)		2		2	2	
	(b)	(i)	A-scans / amplitude scans (1) Only needed to measure depth / moving images not needed (1)			2	2		
		(ii)	Speed in fat / c = 1 450 [m s^{-1}] (1) Distance travelled = $1\,450 \times 0.04 \times 10^{-3} = 0.058$ [m] or 5.8 [cm] (1) Thickness of fat = $\frac{0.058}{2} = 0.029$ [m] or 2.9 [cm] or 0.03 [m] **ecf** (1)		3		3	2	
	(c)	(i)	Short half-life [hence small dose] (1) Gamma emitter & less ionising/more penetrating (1)	2			2		
		(ii)	Activity will not change [in a short time] / half-life too long for activity to change / uniform mixing in blood (1) [Dilution factor] = $\frac{160}{0.025}$ or 6 400 (1) [Volume = $6\,400 \times 0.8$] = 5 120 cm^3] (1)		1 1	1	3	2	
	(d)		They need to precess so $f = \frac{42.6 \times 10^6 \times 1.5}{6.39 \times 10^7}$ [=6.39×10^7 Hz] (1) Wavelength = $\frac{3 \times 10^8}{6.39 \times 10^7} = 4.7$ [m], so [Dr Francis] correct (1) Accept incorrect as 4.7 [m] is not equal to 5.0 [m] **Alternative:** Two frequencies compared with a correct conclusion			2	2	2	
			Question 12 total	**6**	**9**	**5**	**20**	**10**	**0**