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)	<u>number</u> of nuclear disintegrations per unit time	**B1**
8(c)(ii)	decay constant $= \ln 2 / (2.04 \times 60)$	**C1**
	$= 5.66 \times 10^{-3}\ \text{s}^{-1}$	**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**
	$= 6.48 \times 10^{17}\ \text{s}^{-1}$	**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**

Question 8

(a) Candidates found it difficult to give a complete and correct meaning of a tracer. The radioactive substance was often referred to, but was stated without mention of the need to introduce it into the body. Some candidates implied the substance or the positrons were already inside the body. Absorption into the tissue 'being studied' or equivalent wording was rarely stated.

(b) (i) The majority of the candidates gained full credit.

(ii) The most common incorrect answer was 'neutron'.

(c) (i) Candidates found it difficult to give a correct definition of activity. Common incomplete answers were versions of 'rate of decay of nuclei'.

(ii) Some candidates gave answers with less than three significant figures, especially those giving answers in min^{-1}. Some candidates gave the unit as Bq instead of s^{-1}.

(iii) The candidates who used the method in the mark scheme often gained full credit, but some gave insufficient significant figures in their final answers or made premature rounding errors. Candidates who calculated the number of moles of oxygen-15 and multiplied by the Avogadro constant to find the number of nuclei frequently made the power-of-ten error of not converting kg to g before dividing by 15 u.

(d) (i) Many candidates gave incomplete answers such as 'photons', 'gamma rays', 'gamma particles', 'gamma radiation' etc. Others gave incorrect answers, most commonly 'electrons'.

(ii) The description of gamma photon production often missed out that it is the total mass of the positron and electron that is converted. Candidates often either did not mention mass at all, or wrote that 'mass' was converted without making it clear that it is the mass of the particles. It was not always clear that the mass is converted into the energy of photons (and not just energy in general).

10(a)	difference in degrees of blackening	**B1**

10(b)(i)	$I = I_0 \exp(-\mu x)$ $= I_0 \exp(-5.8 \times 0.35) = 0.13\ I_0$	**A1**

10(b)(ii)	use of exp $\{-(0.35 \times 3.7)\}$ factor	**C1**
	$0.053 I_0 = I_0 \exp\{-[(0.35 \times 3.7) + 2.1\mu]\}$	**C1**
	$\mu = 0.78\ \text{cm}^{-1}$	**A1**

10(b)(iii)	factor of only 2.5 between the (detected) intensities (so not good contrast)	**B1**

10(c)	(structure) scanned in (thin) sections	**B1**
	(many) scans (of each section) taken from different angles	**B1**
	scanning repeated for all sections and (data) compiled (to form 3D image)	**B1**

Question 10

(a) Many candidates gave responses dealing with how contrast is achieved rather than the meaning of the term.

(b) (i) This question was generally well answered.

(ii) Many candidates found this a challenging question and found it difficult to set up the starting equation. Of those who did start correctly, most then went on to calculate the correct answer. Some made the correct start but then had difficulty with the arithmetic.

(iii) A common mistake was for candidates to compare the linear attenuation coefficients rather than the detected intensities. Other candidates compared the detected intensities with the incident intensity, or thought that it was the absolute values of the detected intensities rather than their relative values that determined the contrast.

(c) Many candidates found it difficult to articulate the notion that the structure is scanned in sections, and that the images of the sections are compiled together to form the 3D image. The word ‘slice’ was used frequently, but often inappropriately as ‘slices of the image’. Many candidates knew that the scanning was from multiple angles.

10(a)	product of density and speed	**M1**
	speed of sound in medium (and density of the medium)	**A1**

10(b)	ultrasound waves cause crystal to vibrate	**B1**
	vibrations (of crystal) cause induced e.m.f. (across crystal)	**B1**

10(c)(i)	intensity reflection coefficient= $(40.4 - 1.48)^2 / (40.4 + 1.48)^2$	**C1**
	= 0.86	**A1**

10(c)(ii)	*Z* values are very similar	**B1**
	(almost) all the ultrasound will be transmitted **or** (almost) none of the ultrasound will be reflected	**B1**

Question 10

(a) Specific acoustic impedance was generally defined correctly by candidates. Some candidates were not specific enough about the speed, and did not identify it as being that of (ultra)sound or that the speed was specifically that within the medium.

(b) Many candidates wasted time by describing the production process of ultrasound, and this did not gain credit as it was not what the question asked for. Where the detection was described, most candidates described ultrasound waves as the cause of crystal vibration. Fewer candidates identified those vibrations as the cause of an induced e.m.f. across the crystal.

(c) (i) The equation to calculate the intensity reflection coefficient was applied correctly by the majority of the candidates.

(ii) Candidates often used vague or general terms such as ‘most’, ‘less’ or ‘quite’ throughout. Successful responses used precise wording to describe the very similar *Z* values, which meant almost all the ultrasound was transmitted.

10(a)	alternating p.d. (applied to crystal) makes crystal vibrate	**B1**
	when frequency of applied p.d. equals natural frequency of crystal, crystal resonates	**B1**
	natural frequency of crystal is in ultrasound range	**B1**

10(b)(i)	product of density and speed	**M1**
	speed is speed of ultrasound in medium (and density of medium)	**A1**

10(b)(ii)	(α is close to) 0 when Z_1 and Z_2 are equal	**B1**
	(α is close to) 1 when Z_1 and Z_2 are very different	**B1**

10(c)	$I = I_0 \exp(-\mu x)$	**C1**
	$\ln(I / I_0) = -\mu x$ $\ln 0.62 = -\mu \times 2.1$ $\mu = 0.23\,\text{cm}^{-1}$	**A1**

Question 10

(a) Many candidates were well prepared for this question, and it was common to see a full answer covering all the marking points. Reading the question carefully would have shown that this question was only asking for a description of the method of generation of ultrasound at the natural frequency of the crystal. Additional descriptions of the pathway of the ultrasound in the body, and the reception of the returning waves were not assessed. Some candidates wrongly described a current passing through the crystal.

(b) (i) The product of density and speed was mostly well known by candidates, but fewer were specific about what had the speed and where that speed occurred.

(ii) Answering this question required a careful choice of words. It was clear that the general picture of the physics involved when ultrasound meets a boundary between two media was understood by many candidates. Any errors were usually because of imprecision in the use of words, such as describing the two specific acoustic impedances as being just 'different' rather than 'very different' (for example). Likewise, the reflected fraction α was often described as 'big' or 'small' rather than relating it to the extreme values of 1 or 0.

(c) This question was generally well answered, and most candidates were able to give a correct unit consistent with their value.

6(a)	plate X marked as negative and plate Y marked as positive	**B1**

6(b)(i)	$E = V / x$	**C1**
	$= (58 \times 10^3) / 0.041$ $= 1.4 \times 10^6 \text{ N C}^{-1}$	**A1**

6(b)(ii)	$ma = eE$	**C1**
	$a = (1.60 \times 10^{-19} \times 1.41 \times 10^6) / (9.11 \times 10^{-31})$ $= 2.5 \times 10^{17} \text{ m s}^{-2}$	**A1**

6(c)(i)	$eV = hc / \lambda$ **or** $eV = hf$ **and** $f = c / \lambda$	**C1**
	$(1.60 \times 10^{-19} \times 58 \times 10^3) = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / \lambda$	**M1**
	clear conversion from m to pm leading to $\lambda = 21$ pm	**A1**

6(c)(ii)	X-rays	**B1**

6(c)(iii)	*Any two points from:* • waves are passed into structure and transmitted waves detected • different parts of the structure absorb different fractions of energy • difference in detected / transmitted <u>intensities</u> used (to form image)	**B2**

Question 6

(a) This question was generally well answered, with most candidates recognising that negatively charged electrons accelerate from the negative plate to the positive plate.

(b) (i) This question was also generally well answered, with most candidates able to calculate the correct value and give it with a correct unit.

(ii) The more able candidates were generally able to calculate the acceleration correctly. Many of the weaker candidates equated the product of mass and acceleration with an energy or the electric field strength instead of the electric force, and others attempted to use an equation of uniform acceleration.

(c) (i) Most candidates knew the relationship between photon energy and wavelength. Many were unsure of how to determine the photon energy from the energy of the electron. Some candidates calculated the energy by working backwards from the wavelength value. Of candidates that did correctly show the working for the wavelength, some had difficulty in showing the final conversion from m to pm.

(ii) Most candidates were able to identify the electromagnetic waves as X-rays, from a combination of the order of magnitude of the wavelength and the method of production of the radiation.

(iii) Many candidates found it difficult to answer the question that was asked here, with many accounts given of how X-rays are produced. The idea that the image is formed by the differences in transmitted intensities of X-rays that are detected after passing through different parts of the body structure was not well articulated.

4(a)	$\omega = 2\pi / T$	**C1**
	$= 2\pi / (0.15 \times 10^{-6}) = 4.2 \times 10^{7}\,\text{rad s}^{-1}$	**A1**

4(b)	$a_0 = \omega^2 x_0$	**C1**
	$= (4.2 \times 10^{7})^2 \times 40 \times 10^{-6}$ $= 7.1 \times 10^{10}\,\text{m s}^{-2}$	**A1**

4(c)	$E = ½ m\omega^2 x_0^2$	**C1**
	$= ½ \times 2.4 \times 10^{-4} \times (4.2 \times 10^{7})^2 \times (40 \times 10^{-6})^2$	**C1**
	$= 340\,\text{J}$	**A1**

4(d)(i)	apply alternating p.d. (to / across crystal)	**B1**
	applying p.d. to / across crystal causes it to distort	**B1**

4(d)(ii)	$Z = \rho c$ $Z_m = 1100 \times 1600$ $(= 1.76 \times 10^{6})$ $Z_b = 1900 \times 4100$ $(= 7.79 \times 10^{6})$	**C1**
	intensity reflection co-efficient= $[(7.79 - 1.76) / (7.79 + 1.76)]^2$ $= 0.40$ or 40%	**C1**
	percentage transmitted = 60%	**A1**

Question 4

(a) Generally well-answered.

(b) This question was well-answered by the candidates who knew the starting equation.

(c) Many candidates knew the correct equation for total energy, though various errors were seen in its use. These ranged from power-of-ten errors to forgetting which quantities needed to be squared. A common error from some of the weaker candidates was to use the maximum acceleration value from the previous part as the amplitude.

(d) (i) Examiners expected to see reference to an alternating voltage applied across the crystal, making it alternately expand and contract. Many candidates confused the concepts of a voltage being applied (to cause distortion of the crystal) with a voltage being induced in the crystal by mechanical vibrations. Some candidates confused voltage with current.

(ii) Well-answered by many candidates, with full credit being common. Many other candidates calculated the percentage reflected and stopped short of using that value to determine the percentage transmitted.

10(a)	time gives information about depth (of boundary)	**B1**
	intensity gives information about <u>nature</u> of <u>boundary</u>	**B1**

10(b)(i)	product of density and speed	**M1**
	speed of ultrasound in medium (and density of medium)	**A1**

10(b)(ii)	$Z_{water} = 1000 \times 1420$ (= 1.42×10^{6} kg m^{-2} s^{-1}) **and** $Z_{glass} = 2500 \times 4560$ (= 11.4×10^{6} kg m^{-2} s^{-1})	**C1**
	intensity reflection coefficient = $(11.4 - 1.42)^2 / (11.4 + 1.42)^2$	**C1**
	= 0.61	**A1**

Question 10

(a) Many responses focussed on how ultrasound pulses are generated or detected, rather than addressing the question about how the pulses are used to obtain diagnostic information.

(b) (i) The definition of specific acoustic impedance was generally well known, although some candidates struggled to convey that it is the <u>product</u> of a density and a speed. Many responses were ambiguous as to whether it was a product or a ratio that was being described.

(ii) This was a multi-step calculation which nevertheless was answered well by many candidates. The majority of the candidates realised that the first step was to calculate the specific acoustic impedances of the materials from the density and speed data, then to put these values into the intensity reflection coefficient equation. Some candidates forgot to square at the end, or made an arithmetic error in the final calculation, but the correct final answer was common and many candidates were able to achieve full credit.

9(a)(i)	$eV = hc / \lambda$	**C1**
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (84 \times 10^{3} \times 1.60 \times 10^{-19})$ $= 1.5 \times 10^{-11}$ m	**A1**

9(a)(ii)	**either** (some) kinetic energy (of electrons) is converted to thermal energy at target **or** some X-rays are absorbed by the target so its temperature increases	**B1**
	(tungsten) has higher melting point so does not melt quickly / easily	**B1**

9(b)	$I = I_0 \exp(-\mu t)$	**C1**
	$0.13 = [\exp(-3.0x)] \times [\exp(-0.22x)]$ $= \exp(-3.22x)$	**C1**
	$x = 0.63$ cm	**A1**

9(c)(i)	product of density and speed	**M1**
	speed of ultrasound in medium	**A1**

9(c)(ii)	$I_R / I_0 = (7.8 - 1.7)^2 / (7.8 + 1.7)^2$ $= 0.41$ fraction transmitted = 1.00 – 0.41 = 0.59	**C1**
	percentage transmitted = **59%**	**A1**

9(c)(iii)	more than one <u>boundary</u> so more reflections	**B1**
	some ultrasound is attenuated in matter	**B1**

NOT FOUND:

9702_m24_qp_42 EXAMINER REPORT (Qu 9)

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 9

(a) (i) Many candidates gave part of the answer but not a full answer as to what is meant by a tracer. A significant minority of weaker candidates attempted to describe how a tracer is used rather than answering the question that was asked.

(ii) This question was a straightforward exercise in balancing a nuclear equation. Some candidates did not know the symbol for a positron, and many others did not know the effect on proton number and nucleon number of beta-plus decay.

(b) (i) Most candidates were able to state that positrons encounter electrons and undergo annihilation. The idea that this involves all of the mass of the particles becoming the energy of the gamma photons was less well articulated by many candidates.

(ii) There was much confusion with other types of medical imaging in responses seen to this question, with image formation in ultrasound scanning and CT scanning being commonly discussed.

(c) (i) Many candidates were able to access either or both of the marks available for use of the correct starting equations. Full credit for a fully correct final expression was only awarded to a small number of candidates who realised that there are two photons produced from each decay.

(ii) Many candidates correctly drew a smooth exponential decay curve or a line passing through the correct points at $t = T$ and $t = 2T$. The number of candidates who demonstrated both of these features was comparatively small.

10(a)	ultrasound production:	vibrating quartz crystal	**B1**
	X-ray production:	electrons hitting metal target	**B1**
	ultrasound detected wave:	reflected	**B1**
	X-ray detected wave:	transmitted	**B1**

10(b)(i)	$I = I_0 \exp(-\mu x)$	**C1**
	$\ln(0.72) = -6.2\mu$ $\mu = 0.053\,\text{cm}^{-1}$	**A1**

10(b)(ii)	$I / I_0 = \exp(-9.3 \times 0.053)$ $(= 0.61)$	**C1**
	percentage attenuated $= 100 \times (1.00 - 0.61)$ $= 39\%$	**A1**

NOT FOUND:

9702_w23_qp_41 EXAMINER REPORT (Qu 10)

10(a)(i)	electrons	**B1**

10(a)(ii)	electrons are decelerated / stopped on impact with the target	**B1**
	(kinetic) energy lost by electrons emitted as (X-ray) photons	**B1**

10(a)(iii)	$eV = hc / \lambda$	**C1**
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (1.60 \times 10^{-19} \times 5800)$	**C1**
	$= 2.14 \times 10^{-10}$ m	**A1**

10(b)	$I = I_0 \exp(-\mu x)$	**C1**
	$I_T / I_0 = \exp(-(1.4 \times 2.8))$ $= 0.020$	**C1**
	% absorbed $= (1.000 - 0.0198) \times 100$ $= 98\%$	**A1**

Question 10

(a) (i) Most candidates correctly identified the charged particle as an electron, although a significant minority of weaker candidates confused the whole process of X-ray production with positron emission tomography, and gave the positron as the answer here.

(ii) The process of X-ray production by electron bombardment of a metal target was generally well known, although many candidates found it difficult to articulate that the energy of the emitted X-ray photons comes from the kinetic energy of the electrons. Many answers were seen to this question in which candidates attempted to answer a different question from the one asked, and offered responses that attempted to replicate previous mark schemes for a question asking why the emitted X-rays have a range of energies. Such responses were irrelevant to the question asked and could not be awarded credit.

(iii) Many of the weaker candidates found it difficult to start with this question because they did not know how to calculate the energy of the electron from the accelerating p.d. The p.d. was often treated as the energy and directly equated to hc/λ, which is wrong physics and could be awarded no credit. Stronger candidates generally used the correct starting equation and were able to calculate an answer, though many did not appreciate that the nature of the data in this question demands a three significant figure answer.

(b) Weaker candidates were often able to obtain partial credit for a correct starting equation, and many went on to calculate the 2.0% value for the percentage transmitted. Stronger candidates were usually able to carry out the final subtraction from 100 to arrive at the correct answer for the percentage absorbed.

8(a)(i)	specific acoustic impedance = 1200 × 1400 = 1.68×10^6 kg m^{-2} s^{-1}	**A1**

8(a)(ii)	density of air shown in table as 1.29	**A1**
	speed of sound in tissue shown in table as 1540	**A1**

8(b)(i)	intensity reflection coefficient $= (Z_1 - Z_2)^2 / (Z_1 + Z_2)^2$ $= (1680000 - 440)^2 / (1680000 + 440)^2$	**C1**
	$= 0.999$	**A1**

8(b)(ii)	intensity reflection coefficient $= (Z_1 - Z_2)^2 / (Z_1 + Z_2)^2$ $= (1680000 - 1680000)^2 / (1680000 + 1680000)^2$ $= 0$	**A1**

8(c)	without gel, (almost) all of the (incident) ultrasound is reflected (from skin)	**B1**
	with gel, (almost) all of the (incident) ultrasound is transmitted (into the body)	**B1**

Question 8

(a) (i) Most candidates correctly showed how to reach the required value of the specific acoustic impedance.

(ii) The majority of candidates were able to complete the table, but not all candidates gave values to three significant figures as required by the question.

(b) (i) Most candidates applied the correct equation here and calculated the correct answer. However, there were some issues with rounding and quoting the final answer to the correct number of significant figures.

(ii) The majority of candidates reached the correct value.

(c) Candidates demonstrated good knowledge of the purpose of the gel used in ultrasound scanning. They knew this would increase the transmission, but some candidates were imprecise in their descriptions, stating that ‘most’ of the ultrasound was transmitted rather than ‘almost all’ of the ultrasound. ‘Most’ can be very much less that almost all of it.

9(a)	piezo-electric crystal	**B1**
	(ultrasound) wave causes shape change / vibrations (of crystal)	**B1**
	shape change / vibrations causes e.m.f. (which is detected)	**B1**

9(b)(i)	93 V	**A1**

9(b)(ii)	2.7×10^{7} rad s^{-1}	**A1**

9(c)(i)	kg m^{-2} s^{-1}	**B1**

9(c)(ii)	$\rho = Z / c = 1.7 \times 10^{6} / 1600$ $= 1100$ kg m^{-3}	**A1**

9(c)(iii)	intensity reflection coefficient ≈ 1 **or** Z_1 and Z_2 are very different	**B1**
	almost no / no ultrasound transmitted (into air filled cavity)	**B1**

Question 9

(a) Whilst most candidates did refer to a piezo-electric crystal, the context in which this was mentioned was often in relation to the production of the ultrasound rather than its detection. Of those who did address the aspect that the question was asking about (detection), there was confusion between the concepts of stress and strain. Many candidates appeared to incorrectly think that the concept of stress refers to the deformation of the crystal.

(b) (i) The majority of candidates answered this correctly. A small number divided by $\sqrt{2}$.

(ii) The majority of candidates answered this correctly. There were some power of ten errors due to the lack of knowledge of the meaning of 'mega'.

(c) (i) Most candidates were able to determine the unit for specific acoustic impedance.

(ii) The majority of candidates answered this correctly.

(iii) Many candidates struggled with this question, giving responses that were too vague. For example, many candidates stated that 'most' of the ultrasound is reflected (which could be taken as just more than half). Candidates needed to state the idea that 'almost all' the ultrasound is reflected. The strongest candidates evaluated the intensity reflection coefficient, almost 1, in supporting their answers.

10(a)(i)	introduction of tracer (into the body)	**M1**
	containing a β^+ emitter	**A1**

10(a)(ii)	positron interacts with electron	**B1**
	(pair) annihilation occurs	**B1**
	mass of particles converted into gamma photons	**B1**

10(b)	(annihilation of electron and positron) produces two photons	**B1**
	$E = (\Delta)mc^2$	**B1**
	$E = hf$ **and** $f = c / \lambda$ **or** $E = hc / \lambda$	**B1**
	$\lambda = \{[2\times]\ 6.63 \times 10^{-34} \times 3.00 \times 10^8\} / \{[2\times]\ 9.11 \times 10^{-31} \times (3.00 \times 10^8)^2\}$ $= 2.4(3) \times 10^{-12}$ m or 2.4(3) pm (*full substitution and answer with unit needed*)	**B1**

Question 10

(a) (i) The use of a β^+-emitting tracer was generally well known by candidates, and most candidates were able to articulate it well enough to be awarded at least partial credit.

(ii) This was another well-answered question, with the pair annihilation of the positron with an electron being familiar to most candidates. Candidates did not always make clear that pair annihilation involves the conversion of the whole mass of the positron and electron into the energy of the gamma photons.

(b) The more able candidates were usually able to correctly use $E = mc^2$ and $E = hc / \lambda$ to demonstrate the calculation of the 2.4 pm wavelength value. Often missing from responses was an explanation that the masses of the two particles involved become the energy of two gamma photons. Another common error was to use the de Broglie wavelength equation as a starting point, and to calculate momentums of electrons apparently travelling at the speed of light.

7(a)(i)	peak voltage = $4.2 \times \sqrt{2}$ (= 5.9 V)	**B1**
	power = V^2 / R $= 5.9^2 / 760 = 0.046$ W or 46 mW	**A1**

7(a)(ii)	sketch shows peak(s) in power at 46 mW	**B1**
	correct shape (sinusoidal wave sitting on *t*-axis)	**B1**
	four cycles of repeating pattern shown, with $P = 0$ at 0, 10, 20, 30, 40 μs	**B1**

7(a)(iii)	line is symmetrical about 23 mW	**B1**

7(b)(i)	(alternating p.d. makes) the crystal vibrate	**B1**
	vibrations (of crystal) causes air to vibrate	**B1**
	frequency is in ultrasound range	**B1**

7(b)(ii)	(air makes) crystal vibrate, which causes an e.m.f. to be generated across the (second) crystal	**B1**

Question 7

(a) (i) A small number of candidates used the r.m.s. potential difference rather than the peak voltage here. However, there were many answers that correctly and clearly showed the maximum power dissipated.

(ii) The most common misconception here was with the shape of the line drawn. The modulus of a sine wave was drawn rather than a $\sin^2$ shape. There were only a few problems with the value of the peak power values and the period of the shape.

(iii) The majority of answers here did not refer to the line but just said that the mean power was half of the peak power. The fact the line was symmetrical about this value was not often known, and candidates who had drawn an incorrect shape of line without the relevant symmetry found it difficult to use their line to answer this question.

(b) (i) Candidates need to make it clear in their answers when one phenomenon causes something else. Here, the vibration of the crystal causing the air to vibrate was often missed.

(ii) Many candidates did not realise that the second crystal would be acting as a receiver. Some stated that the second crystal would vibrate but few went on the add that this would cause an e.m.f. to be generated.