Answers to examination-style questions

Answers	Marks	Examiner's tips
1 (a) (i) 4.6 cm × 2.0 ms cm^{-1} = 9.2 ms	1 1	The question is about an ultrasonic distance finder. In part **a**, you are expected to apply your knowledge of the use of an oscilloscope and of speed to calculate a distance.
(ii) distance = speed × half the transit time of the pulse = 340 × 0.5 × 9.2 ms = 1.56 m	1 1 1	
(b) The position of each pulse on the screen can be measured to an accuracy of ±0.1 cm. So the distance on the screen between the two pulses is measured to ±0.2 cm. The measured time for each pulse is therefore accurate to ± 0.4 ms (= 0.2 cm × 2.0 ms cm^{-1}). The distance from the transmitter to the receiver is therefore accurate to ±0.14 m (= 340 m × 0.4 ms).	1 1 1 1	This is about 'How Science Works' as you have to use your experimental skills to estimate the accuracy of an oscilloscope measurement and then use that estimate to find the accuracy of the distance measurement.
2 (a) (i) square all the values of current find the average of the squares and take the square root $\text{rms current} = \frac{\text{peak current}}{\sqrt{2}}$	1 1 1	It is the square root of the mean (i.e. average) of all the instantaneous values of the squared current. You can get the √2 in the right place in this equation by remembering that the rms value must be **smaller** than the peak value.
(ii) the rms current value is the equivalent of the direct current value power calculations make use of the rms value (or $P = I_{rms}{}^2 R$)	1 1	The average value of a sinusoidal a.c. quantity is zero, but an a.c. current still dissipates power. Heat is produced whatever the direction of the current.
(b) (i) $V_{max} = V_{peak} = 110\sqrt{2} = 156$ V	1	The maximum instantaneous voltage is the peak value (whether positive or negative). Peak values are always √2 times greater than rms values.
(ii) the USA supply has a higher frequency (or it is 60 Hz instead of 50 Hz in Britain)	1	You ought to be aware that the standard mains supply in Britain is quoted as 230 V, 50 Hz.
(iii) *Advantage*: safer, less hazardous, or less likely to cause electrocution	1	Many countries use supply voltages similar to that in Britain, but the USA standard voltage is slightly safer.

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(iv) *Disadvantage*: higher currents (or thicker wires) are needed to provide the same power	1	Because $P = I\,V$, halving the voltage means you have to double the current in order to produce the same power. A 3 kW electric fire takes a current of over 27 A in the USA. Thicker wires are needed to carry high currents safely.
3 **(i)** peak voltage = 8.0 V	1	Peak value on screen is 2.0 divisions. $2 \times 4.0\ \text{V div}^{-1} = 8.0\ \text{V}$
(ii) $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{8.0}{\sqrt{2}} = 5.7\ \text{V}$	1	You simply have to divide the peak voltage by $\sqrt{2}$.
(iii) time period $T = 3.0$ ms	1	The time period is the time for one complete cycle. This corresponds to 3.0 divisions in the screen, at 1.0 ms per division.
(iv) frequency $f = \frac{1}{3.0 \times 10^{-3}}$ = 330 Hz (333)	1	The frequency of a wave is given by $(1/T)$. The answer is quoted as 330 Hz (rather than 333 Hz) because the data in the question is provided to only 2 significant figures.
4 **(a)** **(i)** period $= \frac{1}{f} = \frac{1}{50} = 2.0 \times 10^{-2}\ \text{s}$ (or 20 ms)	1	You are about to make use of this result when sketching the ac waveform in **(ii)**.
(ii) sinusoidal shape with peak value of 0.20A period of 20 ms shown correctly by intersections with time axis	1 1	'Sinusoidal' means 'like the shape of a sine wave'. A correct drawing will show just more than one complete wave, with time intersections at 0, 10, 20 and 40 ms and peaks at ± 0.20 A.
(b) **(i)** $V_0 = I_0\,R = 0.20 \times 47 = 9.4\ \text{V}$ **(ii)** $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{9.4}{\sqrt{2}} = 6.6\ \text{V}$ **(iii)** maximum rate of energy supply = maximum power $P_0 = I_0\,V_0$ $= 0.20 \times 9.4 = 1.9$ W	1 1 1	The equation $V = I\,R$ still applies for ac, whether you use it with peak or rms values. Power is the rate of doing work (or supplying energy), so **(iii)** is asking for the value of the instantaneous power when the current and voltage are both at their peaks.

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(c) *Relevant points include*: • conduction electrons are free to move • the voltage causes an alternating force on each conduction electron • they move alternately towards one end then towards the other end of the resistor • this movement is superimposed on their random motion • conduction electrons collide with ions (or atoms) in the resistor	**3**	The alternating voltage causes the free electrons to oscillate back and forth at the frequency of the supply. Their **mean** displacement due to this effect is, of course, **zero**. If a larger voltage were applied, the oscillations would be of greater amplitude.
5 (a) (i) $V_0 = 7.1\sqrt{2} = 10$ V	**1**	7.1 V is given in the data of this question, but you have to read the 10 ms from the oscilloscope trace (1 cycle is 2 divisions at 5.0 ms per division). Don't forget that 10 ms is 10×10^{-3} in seconds.
(ii) period $T = 10$ ms frequency $= \frac{1}{T} = \frac{1}{10 \times 10^{-3}} = 100$ Hz	**1** **1**	
(b) *One control*: time base setting new period $= \frac{1}{f} = \frac{1}{200} = 5.0$ ms setting should be changed to 2.5 ms per division	**1** **1** **1**	The supply frequency has been doubled, meaning that the voltage waveform will appear squashed, with 8 cycles on the screen. The time base needs to be speeded up by a factor of 2 to restore the original four cycles.
Other control: voltage sensitivity (or Y-gain) setting should be changed to 20 V per division	**1** **1**	To occupy the full screen, the peak value must correspond to 4.0 divisions. A peak voltage should therefore be represented by 20 volts per division.