

1)

(i)1	$d \sin \theta = \lambda$ $d \sin 11.4^\circ = 6.56 \times 10^{-7}$ $d = 6.56 \times 10^{-7} / 0.198$ $d = 3.3 \times 10^{-6}$ (m)	C1 C1 A1	choosing formula and substitution manipulation and $\sin 11.4^\circ = 0.198$
(i)2	$1/d = 3 \times 10^5 \text{ m}^{-1} = 300 \text{ mm}^{-1}$	A1	<b>ecf b(i)1</b> ; allow 301 or 302 as data given to 3 sig figs
(ii)	2 rays, one either side of normal to grating at about $8^\circ$ , say	B1	<b>accept</b> any sensible angle

2)

(i)	3 correct labels	B1	
(ii)	the (three) colours add up/superpose to give white light <b>or</b> no dispersion/diffraction of incident white light/AW	B1	<b>allow</b> use of formula $d \sin \theta = n\lambda$ so constructive interference at $\theta = 0$ for all $\lambda$
(iii)	select $\lambda = d \sin \theta$ $\lambda = 1.67 \times 10^{-6} \sin 19.1$ $\lambda = 546 \times 10^{-9}$ (m)	C1 C1 A1	<b>allow</b> $547 \times 10^{-9}$ as answer is $546.46 \times 10^{-9}$ <b>do not allow</b> $550 \times 10^{-9}$ unless SF mark already deducted

3)

(a)	(i)	line spacing $d = 1/(300 \times 1000)$ ( $= 3.3 \times 10^{-6}$ (m))	B1	look for clear reasoning to award mark
	(ii)	$\sin \theta = \lambda/d$ $= 6.3 \times 10^{-7} / 3.3 \times 10^{-6} = 0.19$ $\theta = 11$ degrees	C1 C1 A1	rounding error of 0.2 here gives $11.9^\circ$ $11.9^\circ$ gets 2 marks
	(iii)	spots can be seen where $n = d \sin \theta / \lambda$ maximum $n$ when $\sin \theta = 1$ (giving $n = 5.3$ ) so $n = 5$ can be seen thus 5 spots on either side of straight through + straight through = 11	B1 B1 B1	<b>accept</b> basic idea of orders for first mark N.B. calculation not necessary
(b)	(i)	$\epsilon = hc/\lambda = 6.6 \times 10^{-34} \times 3.0 \times 10^8 / 6.3 \times 10^{-7}$ $= 3.14 \times 10^{-19}$ (J)	C1 A1	<b>accept</b> $3.2 \times 10^{-19}$ (J) <b>ecf</b> from <b>b(i)1</b>
	(ii)	$5.0 \times 10^{-4} / 3.14 \times 10^{-19}$ $= 1.6 \times 10^{15}$	C1 A1	
(c)	(i)	Electrons behave as waves/have a wavelength  diffraction observable because gaps/atoms are similar to wavelength of electrons regular pattern of atoms acts as a grating allowing constructive interference to produce pattern on screen/AW rings occur because atomic 'crystals' at all possible orientations to beam/AW	B1 B1 B1 B1 B1	max 2 out of next 4 marking points <b>can</b> gain first 'waves' mark here as well as second mark if first line not written explicitly
	(ii) 1	$\lambda = h/mv = 6.63 \times 10^{-34} / 9.1 \times 10^{-31} v$ $v = 6.63 \times 10^{-34} / 9.1 \times 10^{-31} \times 5.0 \times 10^{-11}$ $v = 1.5 \times 10^7$ (m s <sup>-1</sup> )	C1 A1	using 6.6 instead of 6.63 gives $1.45 \times 10^7$
	2	$\frac{1}{2}mv^2 = eV$ $\frac{1}{2} \times 9.1 \times 10^{-31} \times 2.25 \times 10^{14} = 1.6 \times 10^{-19} V$ $V = 6.4 \times 10^2$ (V)	C1 C1 A1	using $v = 1.45 \times 10^7$ gives 600 V
<b>Total question 6</b>			<b>19</b>	

4)

<b>a</b>		All of the <i>rays/wavefronts/waves</i> are added together (at each point on the screen) when the path difference is an exact number of wavelengths the <i>rays/waves</i> interfere constructively giving maximum amplitude/intensity (at all other angles) when the path difference between rays is not an exact number of wavelengths the <i>rays/waves interfere destructively/cancel out</i> giving a <i>dark background/little to no intensity</i>	B1 B1 B1 B1 B1	<b>max</b> 4 marks to include the second marking point <b>NOT</b> <i>superpose</i> or <i>interfere</i> for <i>added</i> as in stem of Q <b>allow</b> $n\lambda$ <b>QWC mark</b> <b>allow</b> bright <i>line/light</i> <b>NOT</b> bright fringes <b>nor</b> maxima <b>NOT</b> when the path difference is $(2n + 1)\lambda/2$ there is destructive interference/AW <b>allow</b> suitable annotation of diagram to score marks
	<b>b i 1</b>	two lines between 5 and 15 degrees (judge by eye)	B1	<b>allow</b> with label C missing; actual value is $12.5^\circ$
	<b>i 2</b>	select $n\lambda = d \sin \theta$ $579 \times 10^{-9} = d \sin 20 = 0.342 d$ $d = 1.7 \times 10^{-6}$ (m)	C1 C1 A1	<b>allow</b> $n = 1$ in initial equation <b>allow</b> $1.69 \times 10^{-6}$
	<b>ii</b>	<b>E</b>	B1	
	<b>iii</b>	<b>D,E</b>	B1	