# Mark scheme for Extension Worksheet – Topic 8, Worksheet 1

**1** Extracting the information from a CD means having the ability to distinguish between flat areas on the CD (i.e. lands and pits) and edges between flats and pits; laser rays reflecting near an edge will destructively interfere if the path difference is half a wavelength; and so if destructive interference takes place a '1' is assigned otherwise a '0'. [3]

**2** Destructive interference takes place when $2d = \frac{\lambda}{2} \Rightarrow d = \frac{\lambda}{4}$; so $d = \frac{640}{4} = 160$ nm [2]

**3** In 1 second the number of bits stored is $32N$; so in $T$ seconds it will be $32NT$. [2]

**4** The number of incident photons in the given time interval is $6.8 \times 10^5 \times 120 \times 10^{-3} = 81600$; hence the number of electrons emitted is $0.80 \times 81600 = 65280$ [2]

**5** Use $Q = CV$ to find $V = \frac{Q}{C} = \frac{3.6 \times 10^{-14}}{15 \times 10^{-12}} = 2.4$ mV [1]

**6** **a** The ratio of the number of electrons emitted to the number of photons incident. [1]

**b** The area of one pixel is $\frac{62}{8.0 \times 10^6} = 7.75 \times 10^{-6}$ mm$^2$ $= 7.75 \times 10^{-6} \times (10^{-3})^2$ m$^2$ $= 7.75 \times 10^{-12}$ m$^2$; and so the energy incident on one pixel in 35 ms is $240 \times 10^{-3} \times 35 \times 10^{-3} \times 7.75 \times 10^{-12} = 6.15 \times 10^{-14}$ J; the energy of one of the photons is $\frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{540 \times 10^{-9}} = 3.68 \times 10^{-19}$ J; and hence the number of incident photons is $\frac{6.15 \times 10^{-14}}{3.68 \times 10^{-19}} = 1.75 \times 10^5$; and so the charge deposited is $0.85 \times 1.75 \times 10^5 \times 1.6 \times 10^{-19} = 2.38 \times 10^{-14}$ C; finally the potential difference at the ends of the pixel is $V = \frac{Q}{C} = \frac{2.38 \times 10^{-14}}{22 \times 10^{-12}} = 1.1$ mV [6]

**c** The side of a pixel has length $\sqrt{7.75 \times 10^{-12}\ \text{m}^2} = 2.78 \times 10^{-6}$ m; if $d$ is the required distance then on the CCD this length would be equal to $2.5 \times 10^{-3} d$ and for resolution this would have to be larger than 2 pixel lengths i.e. $2.5 \times 10^{-3} d > 2 \times 2.78 \times 10^{-6}$ m $\Rightarrow d > 2.2$ mm [3]