| Question | | | Expected Answers | M | Additional Guidance |
|---|---|---|---|---|---|
| **1** | | | | | |
| | **a** | **i** | method of producing coherent sources at $S_1$ and $S_2$<br>light (waves) from the two slits/sources must be coherent;<br>that is, they must have a constant phase relationship/difference<br>slits must be narrow/close together (so that diffraction patterns overlap)<br>light (waves) from two slits must have similar amplitudes/intensities | B1<br>B1<br>B1<br><br>B1<br>B1 | e.g. initial single slit<br><br><br><br><br>**max 3 marks** from 5 marking points |
| | | **ii** | *bright*: constructive interference occurs/waves add to give a maximum amplitude at the screen<br>path difference between slits and screen is a whole/integer number of wavelengths/waves arrive in phase at screen<br>*dark*: destructive interference occurs/waves add to give a minimum amplitude/zero at the screen<br>path difference between slits and screen is an odd half number of wavelengths/waves arrive out of/in antiphase at screen | <br>B1<br><br>B1<br><br>B1<br><br>B1 | <br><br>**accept** explanation in terms of distance or phase<br><br><br><br>**accept** explanation in terms of distance or phase |
| | **b** | **i** | 7.4/5 = 1.48 x $10^{-3}$ (m) | B1 | **accept** 1.5 mm |
| | | **ii** | λ = xd/L<br>= 1.48 x $10^{-3}$ x 0.6 x $10^{-3}$/1.5<br>= 5.9(2) x $10^{-7}$ (m) | C1<br>C1<br>A1 | using 1.5 mm gives 600 nm<br>**ecf(b)(i)** e.g. 4 92 x $10^{-7}$ for 1.23 mm<br>**accept** 590 nm |
| | **c** | | pattern/fringes vanish<br>because there is now no interference from light from the two slits/AW<br>light spreads out over whole/similar region<br>light intensity (at screen) is less<br>diffraction spreads light<br>simple description of single slit pattern<br><br>further features of single slit pattern | B1<br>B1<br>B1<br>B1<br>B1<br>B1<br><br>B2 | <br><br><br><br><br>e.g. bright in middle and dim at edges/sketch of bell shape<br>**max 3 marks** from 8 marking points |
| | | | **Total question 6** | **14** | |

| Question | | | Expected Answers | M | Additional Guidance |
|---|---|---|---|---|---|
| **2** | | | | | |
| | **a** | | reference to a transverse wave or to vibrations in plane normal to the direction of (energy) propagation | B1 | can be answered with suitable diagram(s) |
| | | | oscillations/vibrations in one direction only/confined to single plane (containing the direction of propagation) | B1 | NOT the wave oscillating in one plane |
| | **b** | | set up apparatus, e.g. tray of water on table with lamp/light from window | B1 | |
| | | | rotate the filter | B1 | QWC mark essential for full marks |
| | | | rotation of filter changes the image intensity/brightness/AW | B1 | **allow** from bright to zero or vice versa |
| | | | correct orientation for maximum and minimum intensities of image | B1 | transmission axis parallel to water surface for maximum and perpendicular for minimum |
| | | | move head up or down to change angle of reflected light observed | B1 | can hold head still and move lamp |
| | | | use of protractor to measure angles | B1 | |
| | | | image/reflection becomes partially plane polarised/ image changes from bright to dim but does not disappear | B1 | **max 3** from 6 marking points **+ QWC mark** |
| | **c** | | $I = I_0 \cos^2\theta$ | B1 | |
| | | | where $I_0$ is the maximum intensity (of the polarised beam) | B1 | **allow** incident/original/initial for maximum |
| | | | when $\theta$ is zero maximum intensity transmitted/ image bright | B1 | |
| | | | when $\theta$ is $90^o$ minimum/zero intensity transmitted/image dim/vanished | B1 | |
| | | | **Total question 7** | **10** | |

| Question | | | Expected Answers | M | Additional Guidance |
|---|---|---|---|---|---|
| **3** | | | | | |
| | **a** | **i** | travel through a vacuum | B1 | **allow** travel at c (in a vacuum) |
| | **b** | **ii** | A gamma; C uv;<br>F microwave | B3 | **allow** 1 mark for A radio; C ir;<br>F X-ray |
| | **c** | **i** | $3.0 \times 10^8 = 1.0 \times 10^9 \lambda$<br>$\lambda = 0.30$ m | C1<br>A1 | <br>**allow** 0.3 no SF error |
| | | **ii** | aerial length = $\lambda/2 = 0.15$ m | A1 | **ecf (c)(i)** |
| | | **iii** | emitted wave is (plane) polarised<br>detecting aerial will receive weaker signal/cos θ component<br>when it is rotated (through angle θ)/AW<br>signal falls to zero at $90^o$<br>and then rises to max again at $180^o$ | B1<br><br>B1<br>B1<br> | **allow** max signal initially/at $0^o$<br><br><br><br>**max 3 marks** from 4 marking points |
| | **d** | **i** | UV-A causes tanning or skin ageing ; most of (99%) uv light; 400-31<br>UV-B causes damage or sunburn or skin cancer; 315-260 nm<br>UV-C is filtered out by atmosphere/ozone layer; 260-100 nm | B1<br><br>B1<br>B1 | accept values within ranges with tolerance of 20 nm **allow** $\lambda_A > \lambda_B > \lambda_C$ for 1 mark<br><br>**max 3 marks** from 7 marking points |
| | | **ii** | filters out/blocks/reflects/absorbs UV(-B) | B1 | **allow** chemicals prevent sunburn/skin cancer<br>**not** stops UV penetrating skin |
| | **e** | | energy of the infra-red photon is less than<br>the work function of the metal surface | B1<br>B1 | **accept** frequency and threshold frequency **or** wavelength and threshold wavelength used correctly in place of energy and work function<br>**1 mark** only: energy of the uv photon greater than work function with no mention of ir |
| | | | **Total question 5** | **16** | |