

- 1 (a) the **spreading out** of waves (as they pass through a gap) (WTTE) B1 [1]  
 (b) (i) gap about same size wavelength (i.e between  $0.5\lambda$  and  $1.5\lambda$ ) B1  
 semicircular arcs (ie nothing straight) B1  
 no change in wavelength shown or stated or labelled B1 [3]  
 {n.b mark this rigidly because Question suggests they label the diagram}  
 (ii) **LESS** diffraction (less spreading out) (WTTE) B1 [1]

[Total: 5]

- 2 (a) refractive index =  $c_i / c_r$  OR  $\sin i / \sin r$  B1  
 $c_i$  = speed of incident light / speed in air OR  $i$  = angle of incidence  
 AND  $c_r$  = speed of refracted light / speed in material OR  $r$  = angle of refraction B1 [2]  
 {Allow RI = speed of light in air / speed of light in material or 2 marks}  
 {Allow RI = sine angle of incidence / sine angle of refraction for 2 marks}  
 (b) Use of  $n = c_i / c_r$  (WTE) seen anywhere {allow BACK CREDIT for (a)} C1

Material	Refractive Index	Speed of light in the material $m\ s^{-1}$	
Water	1.33	<b>2.26 (or 2.3) <math>\times 10^8</math></b>	- A1
diamond	<b>2.42 (or 2.4)</b>	$1.24 \times 10^8$	- A1

[3]

- (c) (i) ray is refracted / changes direction / changes speed B1 [1]  
 (ii) ray refracted towards normal AND away from normal on exit B1  
 amount of refraction the same at entry and exit (WTTE) B1 [2]  
 (iii) statement that path of refracted ray is drawn (on sheet) B1  
 evidence of correct angles of incidence (i) AND refraction (r)  
measure (or find) i and r B1 [3]

[Total: 11]

- 3 (a) (i) **LESS** (WTTE) B1 [1]  
(ii) angle of incidence must be greater than critical angle (WTTE) B1 [1]
- (b) different rays follow different paths OR reflected at different angles (WTTE) B1  
some arrive before others (WTTE) B1  
signal is distorted/smeared/spread out (WTTE) (reject weakened) B1 [3]
- (c) (i) correct substitution into  $RI = 1/\sin C$  : e.g  $1.02 = 1/\sin C$   
 $C = 78.5^\circ$  (or  $78$  or  $79$ ) {NO MARKS if  $n = 0.98$  is used} C1  
A1 [2]
- (ii) High C makes TIR less likely (WTTE) M1  
(hence) fewer alternative paths (WTTE) M1  
and less multipath dispersion (WTTE) A1 [3]  
{The A mark can be scored provided either M mark is obtained}
- [Total: 10]**
- 4 (a) (i) amplitude = 3.75 cm {allow 3.7 to 3.8} B1 [1]  
(ii) when  $t = 1.8$  ms displacement = ANY negative value B1  
(-) 3.35 cm (ALLOW 3.3 TO 3.4) B1 [2]  
(iii) period = 2.64 ms (allow 2.64 to 2.68) B1 [1]  
(iv) frequency = 1/period C1  
=  $1/(2.64 \times 10^{-3}) = 379$  Hz (379 to 373 or 380) {ecf for T} A1 [2]
- (b) recall of  $v = f\lambda$  C1  
 $\lambda = v/f = 300/379 = 0.79$  m (or 0.8 m) {allow ecf from (iv)} A1 [2]
- [Total: 8]**
- 5 (a) (i) ANY 3 correct phenomena from REFLECTION, REFRACTION,  
INTERFERENCE, SUPERPOSITION, DIFFRACTION, ( allow transfer energy) B2 [2]  
3 correct scores 2 marks, 2 correct scores 1 mark otherwise zero
- (ii) POLARISATION B1 [1]
- (b) (i) it consists of nodes and antinodes / it does not transfer energy (WTTE) B1  
formed by two identical waves travelling in opposite directions (WTTE) B1  
(microwaves leaving transmitter) interfere (with reflected waves) (WTTE) B1 [3]  
{allow superimpose/interact/cancel out/reinforce for interfere}
- (ii) 1. wavelength of the microwaves =  $2 \times 1.4 = 2.8$  cm B1 [1]  
2. speed of microwaves in air =  $3 \times 10^8$  m/s OR c M1  
frequency =  $3 \times 10^8 / 2.8 \times 10^{-2}$  (allow ecf) =  $1.07 \times 10^{10}$  Hz A1 [2]
- (iii) Place a metal grid {allow "Polaroid"} (between T and D) and rotate B1  
(or place at  $90^\circ$ ) OR rotate grid/transmitter/detector B1 [2]  
this causes minm/zero signal (WTTE)

**[Total: 11]**

**Paper total = 5 + 11 + 10 + 8 + 11 = 45**