

- 1 (a) (i)  $50^\circ$  B1
- (ii) total internal (reflection) B1 [2]
- (b) use of  $\frac{\sin i}{\sin r} = n$  OR  $1/n$  in any form C1  
OR  $1/\sin c = n$  OR  $1/n$  C1  
 $i = 40^\circ$  and  $r = 90^\circ$  OR vice versa ecf if measured from interface not normal C1  
 $n = (1/\sin i = 1/0.643 = ) 1.556$  ecf from previous line A1 [3]
- (c) reflected ray drawn in same position as original reflected ray B1  
 $0^\circ < \text{angle of refracted ray from surface} < 13^\circ$  B1 [2]
- (d) prism drawn in correct orientation to give t.i.r. B1  
correct reflection of rays B1 [2]
- [Total: 9]**
- 2 (a) (i) Diagram to show – boundary, normal and ray bending towards normal B1  
Angle of incidence labelled  $i$  or  $51^\circ$  B1  
Angle of refraction labelled  $r$  or  $29^\circ$  B1
- (ii)  $n = \sin i / \sin r$  OR  $n = \sin 51 / \sin 29$  C1  
 $n = 1.603$  at least 2 s.f. \*Unit penalty applies A1
- (b) Ray is totally internally reflected / undergoes TIR B1  
Angle of incidence is more than / equal to the critical angle (of the glass) B1  
OR  
Ray travels along the boundary (B1)  
Angle of incidence = critical angle (of the glass) (B1)  
OR  
Critical angle calculated as  $38.6^\circ$  ecf from (a)(ii) (B1)  
Angle of incidence greater than critical angle (of the glass) (B1) [7]

- 3 (a) ignore arrows on rays  
 if no scale quoted, mark as if drawn full size; accept scale diagram if clearly stated  
 one correct ray B1  
 second correct ray B1  
 basically correct rays extended back meet 5–7 cm from lens  
 AND some indication that this is image e.g. arrow/label I or image B1 [3]
- (b) cannot be formed on a screen/rays diverge away from the image/  
 do not meet to form image B1 [1]
- (ii) magnifying glass/lens/magnifier B1 [1]
- 4 (a) (i) any two of these rays from top of object:  
 paraxial to lens and on through focal point  
 undeviated to centre of lens  
 as if from focal point to lens and then paraxial B2
- traced back to locate image B1
- (ii) any two of: virtual/upright/magnified/further from lens/dimmer B2
- (b) (i) 3.4 – 3.6 cm \*Unit penalty applies B1
- (ii) magnifying glass/magnifier (c.a.o.) B [7]

\*Apply unit penalty once onl

- 5 (a) total (internal) reflection OR reflection but no refraction/doesn't emerge  
angle (of incidence) > critical angle B1  
B1
- (ii) initial reflection + 0 or 1 further reflection only, not at lower surface  
must be straight and reach within 1cm of end B1
- (b) bends easily/less likely to break (ignore stronger) OR smaller pixels/  
more detail/greater resolution/see smaller objects/wider field of view B1
- (ii) light travels down/along/through fibres B1
- (iii) light/image returns up/along/through fibres ignore cameras B1 [6]
- 6 (a) distance from (principal) focus/focal point to (the centre of) the lens B1
- (b) image can be formed on a screen  
OR is formed by rays of light meeting  
OR is formed on the opposite side of the lens from the object B1
- (ii) straight line ray from point A to point B  
AND lens at intersection of ray and axis. B1
2. ray from A parallel to axis, bent at lens to pass through B. F at intersection of ray and axis.  
OR Ray from point A through nearer focus, labelled F, to lens, bent at lens, then parallel to axis, to point B B1
3. any third ray from A to B, bent at lens B1
- (iii) (distance from image to lens is) reduced B1  
(image is) smaller B1 [7]