1 (a (i) correct O label   B1

      (ii) correct I label   B1

     (iii) correct F label, allow correctly labelled dot to left of lens   B1

     (iv) correct arrows on both rays, anywhere on each ray   B1

   (b) $1/n = \sin i / \sin r$ OR $n = \sin i / \sin r$ in any form OR $\sin i / n$ OR $n \sin i$ C1
        $(r = \sin^{-1}((\sin 35)/1.5) =)\ 22°$
        accept if in diagram   A1
        emergent ray drawn with $27° \geq r \geq 18°$ B1

                                                                                                    [Total: 7]

2 (a $(\alpha =) \sin^{-1}(1/n)$ OR $\sin \alpha = 1/n$ OR $\sin 90(°)/\sin \alpha = n$ C1
       $(C =) \sin^{-1}(1/1.6)$ C1
       $39°$ OR $38.7(38.682)°$ A1

   (b) any **four** from:
        (initially/θ C) refracted ray/ray in air/ray emerges
        (initially/$\theta \leq C$) refracted ray/ray in air/ray emerges AND reflected ray
        (initially/θ C) angle of refraction increasing
        (initially/θ C) refracted ray gets weaker OR reflected rays gets stronger
        ($\theta = C$) refracted ray along surface
        (eventually/$\theta > C/r > 90°$) refracted ray disappears OR no more refraction OR does not
        emerge OR total internal reflection
        (description of) angle of reflection increasing OR always equals angle of incidence   B4

                                                                                                    [Total: 7]

3 **(a (i)** Normal at Q drawn AND refracted ray drawn with *r* less than *i*   B1
   (ii) Emerging ray drawn parallel to PQ AND normal drawn   B1
   (iii) Two equal angles, marked X, between rays and normal   B1

   (b) (i) $n = \sin i \div \sin r$ in any form OR $1.62 = \sin 65 \div \sin r$ in any form   C1
        OR $\sin r = \sin 65 \div 1.62$

        $r = 34°$ A1

   (ii) n = speed (of light) in air ÷ speed (of light) in glass in any form   C1
        OR $1.62 = 3.0 \times 10^8$ ÷ speed in glass in any form
        (speed in glass = $3.0 \times 10^8 \div 1.62$) = 1.8 OR 1.9×10^8 m/s   A1

   (c) Dispersion   B1

                                                                                                                          [Total: 8]

4 **(a** reflected ray in correct quadrant   B1

      $34° \leqslant$ angle from surface $\leqslant 42°$ B1
      ignore refracted ray for both marks

   (b) angle of incidence: any mark in v box only   B1

      angle of refraction: any mark in y box only   B1

   (c) $\sin i / \sin r = n$ or $\sin i / \sin r = 1/n$ in any form   C1

      $\sin r = 1.33 \sin 30$ or $(\sin 30)/1.33$ or 0.665 or 0.376   C1

      $(r =)42°$ A1

   (d) refracted down compared to incident ray   ignore emerging ray   M1

      between dashed line and 25° above it   ignore emerging ray   A1

                                                                                                                          [Total: 9]

5 (a (i) two rays from lamp to mirror **AND** one good (i ≈ r) reflected ray   B1

two good reflected rays **AND** rays traced back above mirror   B1

labelled / clear image located at intersection **AND** in correct position   B1

(ii) any two from:
virtual
(longitudinally) inverted
same size (as lamp) **OR** same distance (from mirror)   B2

(b) light reflected back / down **OR** not wasted **OR** room brighter **OR** more light etc.

[Total: 6]

6 (a (i) **1.** one normal to mirror drawn   B1
2. angle of incidence, labelled   B1

(ii)   both reflected rays drawn   B1
2. construction lines to locate image, marked I   B1

(b) (i) dot marked C in correct position   B1

(ii) two circular arcs each joining correct points on barrier   B1
spacing of arcs same as spacing of incident waves   B1

[Total: 7]

7 **(a)** internal reflection **AND** $i = r$ for 1st reflection
     NOT any ray emerges from sides   M1

     ray reaches end of tube after 1 or 2 reflections only   A1

  (b) $\sin^{-1} 1/n$ **OR** Snell's Law in any form   C1
     ($c = \sin^{-1} 1/1.52 =$) 41°   B1

  (c) **(i)** <u>total internal</u> reflection   B1

     (ii) angle of incidence > c
        OR light must reach end of fibre with small losses o.w.t.t.e.   B1

[Total: 6]