Light and refractive index answers

1)

Question	Expected answer	Mark
7(a)	normal drawn at X above and in the block	**B1**
7(b)	ray refracted toward normal drawn from X to side RS	**B1**
7(c)	angle of incidence correctly labelled angle of refraction correctly labelled	**B1** **B1**
7(d)	ray drawn refracted away from the normal	**B1**
		Total: 5

2)

6 **(a)** **(i)** (the) normal B1

(ii) *y* B1

(b) **(i)** (red), orange, yellow, green, blue, indigo, violet / purple B1

(ii) any three from: B3
(ON DIAGRAM) ray reflected
angle *i* = angle *r* (by eye)
explanation:
(incident angle) is greater than critical angle
(so there is) total internal reflection

[Total: 6]

3)

6 **(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 $1.62 = 3.0 \times 10^8 \div$ 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)

6 **(a)** **(i)** $n = v_a \div v_g$ in any form B1

(ii) 2.0×10^8 OR 2×10^8 m / s B1

(b) **(i)** $n = \sin(i) \div \sin(r)$ OR $\sin(r) = 1.5 \times \sin 41°$
OR $\sin^{-1}(r) = 0.98$ C1

(r =) 80° A1

(ii) total (internal) reflection OR no refraction OR all light reflected B1

(c) some indication of multiple reflections in optical fibre, accept from diagram B1

appropriate further information,
e.g. endoscope OR looking/illuminating inside body B1

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5)

7 **(a)** (α =) $\sin^{-1}(1/n)$ 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]

6)

6 **(a)** reflected ray in correct quadrant B1

34° ⩽ angle from surface ⩽ 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]

7)

11 **(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]

8) **5** **(a)** (n =) sin i / sin r **OR** sin 62 / sin 36 C1
1.5(02) C1
(v_g =) c / n **OR** $3.0 \times 10^8 / 1.5$ C1
$2.0 / 2.00 / 1.997 \times 10^8$ m / s A1

(b) (infra-red / light) encoded **OR** (sent as) pulses **OR** multiplexing **OR** many messages **OR** signal **OR** information **OR** data **OR** internet B1
(optical fibre transmits) light / infra-red (pulse) B1
total internal reflection / TIR (prevents escape) B1

[Total: 7]

9) **6** **(a)** correct reflection of left ray
AND 22° ≤ angle between right ray and surface ≤ 32°, by protractor B1
rays projected back to form image in correct position B1 [2]

(b) both rays refract down M1
rays projected back to form image somewhere in water to the left of where left ray strikes surface A1 [2]

(c) sin c = 1 / 1.33 OR sin c / sin r = 1 / 1.33 C1
OR $\sin^{-1}(1 / 1.33)$ OR $\sin^{-1} 0.75$
(c = 48.8° =) 49° A1 [2]

(d) appropriate use, accept diagram
accept 'endoscope', 'in medicine' is not sufficient M1
clear diagram of the above use or t.i.r. diagram for optical fibre A1
one from:
light goes down fibre/into body
illuminates internal organ
light/image returns from body/organ o.w.t.t.e. A1 [3]

[Total: 9]

10) **7** **(a)** n = sin i/sin r **or** n = sin r/sin i **or** (sin i =) 1.5 sin 40(°) i **or** (sin r =) 1.5 sin 40(°) **or** 25° C1
0.9641 C1
75/74.6 ° to 2 or more sig. figs. A1 [3]

(b) **(i)** (v =) $f\lambda$ **or** $3.8 \times 10^{14} \times 5.3 \times 10^{-7}$ C1
2.01×10^8 m / s to 2 or more sig. figs. A1 [2]

(ii) (c =) nv **or** $1.5 \times 2.0/2.01/2.014 \times 10^8$ (e.c.f. from **7(b)(i)**) C1
3.02×10^8 m / s (accept 3 or 3.0×10^8 m / s only with working)
(e.c.f. from **7(b)(i)**) A1 [2]

(c) wave(front) hits/enters the plastic at the same time **or** incident ray perpendicular along normal/at 90° **or** i = 0° (condone it doesn't hit at an angle) B1
wave(front) all slows down at the same time **or** refracted ray perpendicular normal/at 90° **or** r = 0° by calculation B1 [2]

[Total: 9]

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