1 **(a) (i)** diffraction B1

(ii) waves travel slow(er) / water is shallow(er) B1

(iii) angular spread of wavefronts increases o.w.t.t.e.
OR amplitude of waves is smaller B1

(b) (i) oscillation / up and down motion (of rope) is at right angles to the direction of the wave
OR motion of rope / particles is at right angles to the direction of the wave B1

(ii) $\lambda = 2.4 / 2 = 1.2$ m C1
$v = f\lambda$ in any form OR ($f =$) v/λ OR 3.2 / 1.2 C1
2.7 Hz A1
OR
$t = 2.4 / 3.2$ (
$f = 2 \times 3.2 / 2.4$ (
2.7 Hz (A

[Total: 7]

2 **(a)**

light in air	BOX 5	3×10^8 m / s	B
sound in air	BOX 2	300 m / s	B
sound in water	BOX 3	1500 m / s	B [3]

(b) distance = speed × time in any form NOT speed = $2d/t$ C1

t_{air} = 120 ÷ value for speed of sound in air C1

t_{rail} (= 120 / 5000) = 0.024 s C

(time difference =) candidate's t_{air} – candidate's t_{rail} correctly evaluated
(expect 0.400 – 0.024 = 0.376 s) [4]

[Total: 7]

3 **(a** (Molecule) moves up and down / rises and falls
OR oscillates perpendicular to direction of wave
OR describes a circle B1

(b) (i) At least 3 circular arcs, angular spread greater than 90° (symmetrically above and below slit B1
Centre of arcs at centre of slit <u>and</u> with same spacing (by eye) as incident waves B1

(ii) Diffraction B1

(c) $v = f \times \lambda$ OR $12 = f \times 1.4$ OR $f = v / \lambda$ OR $f = 12 / 1.4$ C1
f = 8.57 Hz / per s / waves or vibrations per s A1
at least 2 s.f.

[Total: 6]

4 **(a)** CD B1

(ii) any 3 points from
- wavefront changes direction/refracted OR <u>wavefront</u> bends B1
- in Q distances travelled (by waves) shorter/wavelength less B1
- wave spreads in region Q from B B1
- all points on wavefront AB move to (corresponding) points on CD
- <u>in same time that</u>/<u>while</u> end A of wavefront AB move to C and end B moves to D [4]

(b) regions P and Q same depth/regions P and Q (now) one medium B1
same wavelength/wavefronts travel same speed/distance in each region
OR no refraction/change of direction OR no bending of waves B1 [2]

[Total: 6]

5 **(a)** idea of fine ray/beam shone into (glass) block / pins appropriately placed shown in diagram or described B1
angles *i* & *r* or *C* measured OR correct *i* & *r* or *C* marked on diagram B1
sin*i*/sin*r* OR sin*r*/sin*i* OR 1/sin*C* OR sin*C* B1
n = speed in air/speed in glass OR *c*/*v* = sin*i*/sin*r* OR *n* = 1/sin*C* OR *c*/*v* = 1/sin*C* B1

(b) **(i)** $v = f\lambda$ OR $240/1.9 \times 10^5$ OR $T=d/s$ AND $f=1/T$ B1
0.00126 Hz OR 0.0013 Hz NOT 0.0012 Hz
ignore more than 3 s.f. accept s^{-1} A1

(ii) distance = speed × time in any form accept $s = 2d/t$ C1
(time for tremor =) 240 (s) or 4 mins also gives first C1 C1
(time for tsunami =) 2500 (s) or 41 mins 40 s also gives first C1 C1
(warning time =) 2260 (s) or 37 mins 40 s A1 [10]

6 **(a** **(i)** shake end of rope (e.g. from side to side / up and down) B1

(ii) distance from crest to crest / trough to trough / any 2 adjacent points in phase, labelled λ B1

distance from central horizontal line to peak or trough, labelled A B1

(iii) increase rate of shaking end of rope (to increase frequency) / shake faster / move more quickly B1

(b) in shallow water wavelength is smaller OR waves / lines are closer together B1
frequency is constant B1
(slower because) speed = frequency × wavelength B1
OR
lines / waves closer together in shallow water / waves in shallow water lag behind B1
smaller distance travelled in same time by waves in shallow water o.w.t.t.e. B1
(slower because) speed = distance / time B1 [7]