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)	λ = 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 × 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 at least 2 s.f.	A1

[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 × 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* = 2*d*/*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]