1 **(a** mirror: 2 reflected rays approx correct   M1
                   projected back to approx correct labelled image   A1
                   note: images may be dots or lines
          lens: ray through F, correct by eye   M1
                   ray <u>through</u> centre OR ray through other F, correct by eye   M1
                   projected back to approx correct (labelled) image   A1

   (b)   not produced by real rays crossing
                   OR cannot be caught on a screen
                   OR rays appear to come from image   B1

      (ii) upright/right way up/erect c.a.o.   B1

     (iii) lens image enlarged AND mirror image same size c.a.o.
                OR (different) size OR (different) distance OR different side   B1

                                                                                       [Total: 8]

2 **(a**   red ray refracted away from normal   B1
           violet ray refracted more than red ray in prism   B1
           violet ray further refracted from red ray to screen   B1   **3**

   (b) 1.52 = sin 40°/sin r   M1
            sin r = sin 40°/ 1.52 (= 0.423)   C1
            r = 25°   A1   **3**

   (c) **(i)** 3×10^8 m/s   A1

            (ii) same as **(i)**   A1   **2**
                                                                                                        [8]

3 **(a** completed path   B1   [1]

     (b) any two correct, -1 each incorrect
        virtual, inverted, same size as object   B2   [2

     (c) angle of incidence zero/at right angles/along normal   B1   [1]

     (d) $1.5 = V_a/V_g = 3 \times 10^8/V_g$

          C1
        $V_g = 2 \times 10^8$ m/s   A1   [2]

     (e) angle of incidence = 45°, so angle of reflection = 45°, so ray turns through 90°
        OR angle i> angle c   B1
        so totally internally reflects   B1   [2]

[Total: 8]

4	**(a)**	along normal or angle i = 0 so angle r = 0	B1	**1**
	(b)	speed reduced, wavelength reduced, frequency unchanged		
		any two correct scores one mark	B1	
		third correct scores second mark	B1	**2**
	(c)	reflected at 30°	B1	
		refracted at > 30°	B1	**2**
	(d)	sin 30°/sin r = 0.67	C1	
		sin r = sin 30°/0.67	C1	
		r = 48°	A1	**3** [8]

5	(a) (i)	two approximately correct reflections evidence of projecting back to image or use of equal distance from the mirror, object and image	B1 B1	
	(ii)	virtual any one of upright, same size, same distance from mirror	B1 B1	[4]
	(b) (i)	ray 1 correct ray 2 correct image correctly located	B1 B1 B1	
	(ii)	eye symbol to right of lens	B1	[4] Total [8]

6   **(a**   **(i)**   Refraction at Q approx. correct, ray emerge from AB
                        parallel PQ   **B1**
               (ii)   Angle of incidence correctly marked   **B1**
                        Angle of refraction correctly marked   **B1**

                        (can score even if incorrect / no refraction shown)   **3**

      (b)   **(i)**   Refractive index = speed in air / speed in glass   **B1**
               (ii)   Refractive index = $(3 \times 10^8 / 2 \times 10^8) = 1.5$ **B1**   **2**

      (c)   **(i)**   Wavelength = v/f or $3 \times 10^8 / 6 \times 10^{14}$ **C1**
                        Wavelength = 5×10^7 m   **A1**   **2**
                                                                         [7]