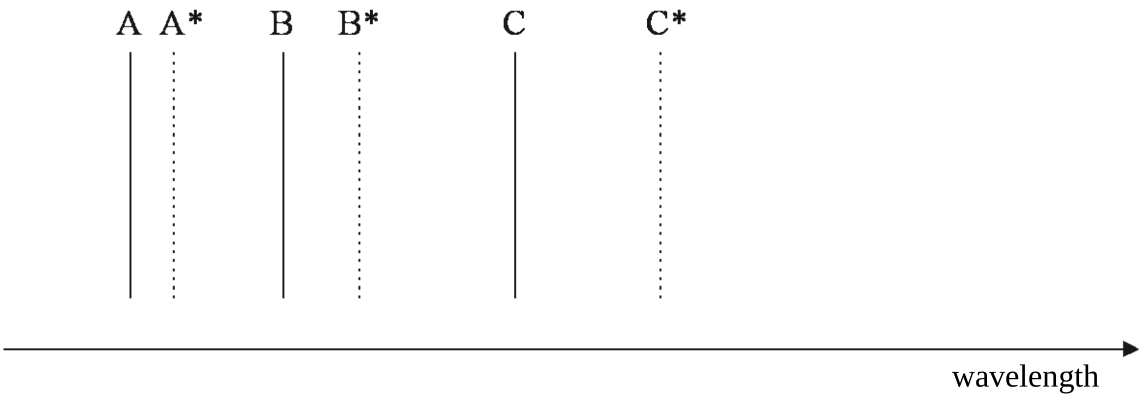
Option A — Sight and wave phenomena

A1. (a) (i) *Correct positioning of*:
lens, retina and optic nerve; ***[1]***

(ii) convert a light signal into an electrical signal;
rods are used for black and white vision/contrast/scotopic;
cones are used for colour vision/photopic; ***[3]***

(b) for objects at different distances from the eye;
for the image to be focused;
the (ciliary) muscle changes the shape of the lens; ***[3]***

A2. *The diagram should be as follows*:



lines shifted all in the same direction;
shift in B or the shift in C being noticeably larger than the shift in A;
lines shifted right; ***[3]***
*Award **[2 max]** if lines are not labelled.*

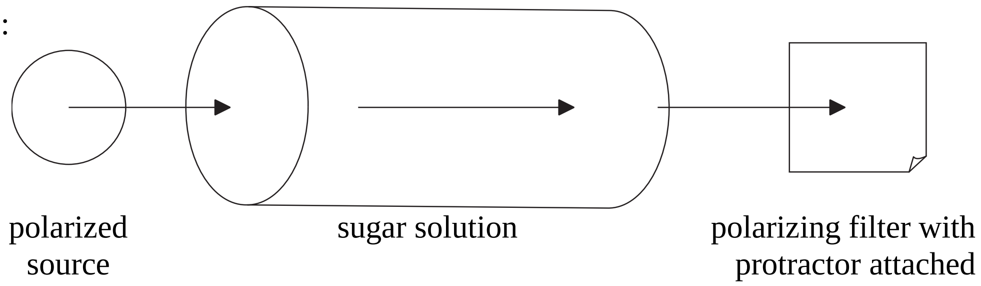
A3. (a) $\theta = \frac{1.22\lambda}{b} = 6.1 \times 10^{-6}$ radians;
distance $= \theta \times$ altitude;
$= 6.1 \times 10^{-6} \times 400 \times 10^{3} = 2.4\,\text{m}$; ***[3]***

(b) increase the lens diameter; ***[1]***

A4. (a) hold the sheets one at a time up to each source and rotate them / *OWTTE*;
the sheet and source which give a variation in intensity upon rotation are the polarizing/polarized ones / *OWTTE*; ***[2]***

(b) the solution rotates the plane of polarization;
light from polarized source is rotated by the solution;
the degree of rotation is measured by rotating the polarizing filter;
the angle of rotation gives an indication of the solution concentration / *OWTTE*;
measure angle of rotation for a standard solution; ***[4 max]***

apparatus is:



Option A — Sight and wave phenomena

A1. (a) Scotopic vision / uses rod cells/is used in low intensity light/does not distinguish between colours/does not see detail;
Photopic vision / uses cone cells/is used in high intensity light/distinguishes colours/sees detail; ***[2]***

(b) Scotopic vision using rods is to be used;
sensitivity for blue wavelengths is high for rod cells;
and so blue will be seen most clearly;
*Award **[0]** for bald answer, blue only, or incorrect argument.* ***[3]***

(c) (i) $\theta = \left(\frac{1.22\lambda}{d} = \frac{1.22 \times 680 \times 10^{-9}}{1.5 \times 10^{-3}} = \right) 5.5 \times 10^{-4}$ rad; ***[1]***

Accept answer missing the factor of 1.22 i.e. 4.5×10^{-4} *rad.*
Do not penalize absence of rad.

(ii) $d = \left(\frac{s}{\theta} = \right) \frac{4.0 \times 10^{13}}{5.5 \times 10^{-4}}$;
$d = 7.2 \times 10^{16}$ m; ***[2]***

Accept answer that uses rounded answer from (i) i.e. $d = 7.3 \times 10^{15}$ *m or has missed the factor of 1.22 i.e.* $d = 8.9 \times 10^{15}$ *m.*

A2. (a) light in which the electric field is oscillating on only one plane; ***[1]***

(b) (i) refracted ray shown <u>at right angles</u> to reflected ray; ***[1]***
Judge by eye.

(ii) $\sin\varphi = n\sin(90^o - \varphi)$;
$\sin\varphi = n\cos\varphi$;
$n = \tan\varphi$; *(this marking point must be justified)* ***[3]***

(iii) $\varphi = 52^\circ$ ***or*** 0.92 rad; ***[1]***

A3. (a) the change in the observed frequency;
when there is relative motion between the source and the observer / when either source or osbserver is moving; ***[2]***

(b) (i) Doppler effect occurs twice / moving detector (blood cells) and moving source (blood cells in reflection) / "image" source moves at twice velocity of red blood cells / *OWTTE*; ***[1]***

(ii) $\Rightarrow\left(\frac{3.5}{5.2\times10^{3}}=\frac{2v}{1.5\times10^{3}}\Rightarrow\right)v=0.50\text{ m s}^{-1}$;

Accept 1.0×10^{5} ms^{-1} if 3.0×10^{8} ms^{-1} has been used for c. ***[1]***

or

use of Doppler formulas to give

$$\left(f''=f\frac{1-\frac{v}{c}}{1+\frac{v}{c}}\right)\Rightarrow 5.2\times10^{3}-3.5=5.2\times10^{3}\frac{1-\frac{v}{1.5\times10^{3}}}{1+\frac{v}{1.5\times10^{3}}}$$

$\therefore v=0.50\text{ m s}^{-1}$;

(iii) the blood cells have a range of speeds;
the direction at which the ultrasound is incident on the cells varies / cells are rotating/tumbling / ultrasound reflects from objects other than blood cells; ***[2]***

Option A — Sight and wave phenomena

A1. (a) yellow; ***[1]***

(b) the eye responds to the frequency (or energy per photon) of the light;
the frequency is unchanged by changes in refractive index; ***[2]***

A2. (a) (i)  ; ***[1]***

(ii)  ; ***[1]***

(b) $f = \frac{v}{\lambda}$;
to give $f = 120\,\text{Hz}$; ***[2]***

(c) $\lambda = 4L = \left(\frac{330}{120}\right)$;
$L = 0.69\,\text{m}$; ***[2]***

A3. (a) when source is moving towards the observer the wavefronts are compressed/ frequency is increased;
(when source is moving away) the wavefronts are expanded / frequency is decreased;
(this repeats so) a continuous rise and fall in pitch/frequency is heard; ***[3]***

(b) the maximum frequency occurs when the speaker is approaching the observer;
$f = \frac{1000 \times 330}{330 - 30}$;
$= 1100\,\text{Hz}$; ***[3]***

A4. (a) all possible polarization directions are equally represented / where the direction of polarization is random; ***[1]***

(b) $0.50\,\text{W m}^{-2}$;
$\left(I \propto \cos^2 \theta\right)$ average value is $\frac{1}{2}$; ***[2]***

(c) polarizer and analyser separated by sugar solution; { *Accept a diagram for this marking point.*
measure angle / rotation of plane of polarization;
concentration proportional to angle; ***[2 max]***