1 (a) Figure 2 shows some lines in the absorption spectra from four different galaxies (A, B, C, and D) and from a laboratory source.

All the spectra are aligned and to the same scale.

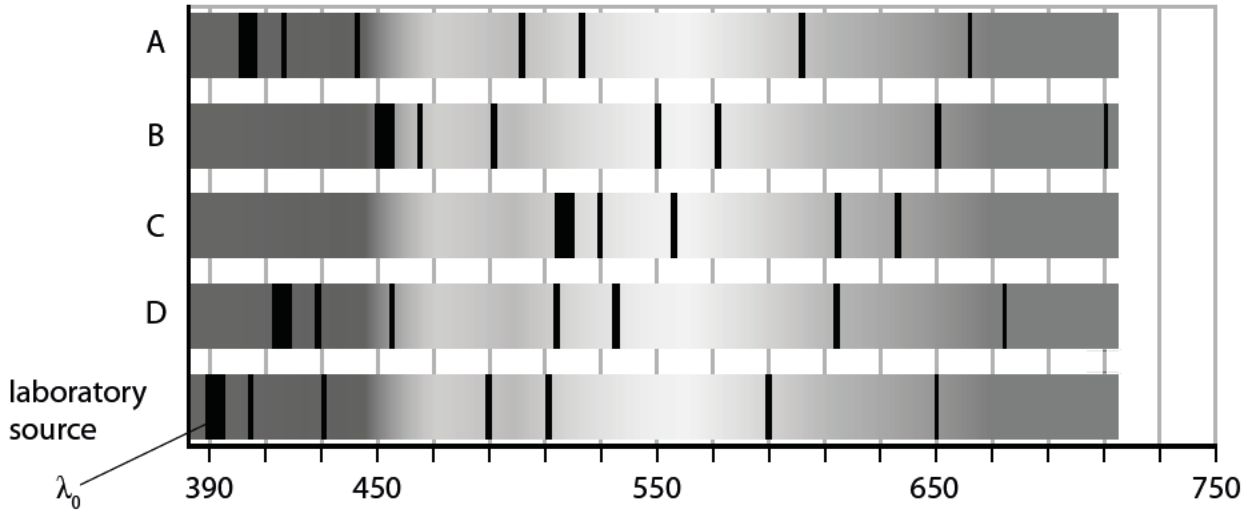

Figure 2

(i) Explain, using Figure 2, which galaxy is furthest away from us.

(3)

.....

.....

.....

.....

.....

.....

(ii) In Figure 2, the reference wavelength, λ_0, is shown at 390 nm.

Estimate the change in the reference wavelength, $\Delta\lambda$, for the light from galaxy D.

(1)

$\Delta\lambda$ = ... nm

(iii) Calculate the speed, *v*, of galaxy D.

Use the equation

$$v = c\frac{\Delta\lambda}{\lambda_0}$$

[c = speed of light = 3×10^8 m/s]

(2)

v = ... m/s

(b) Figure 3 shows a photograph of galaxy D.

This photograph was taken by a student at his home.

(Source: Paul Curtis)

Figure 3

State **two** ways that the student can improve the observational techniques so that the quality of the image is improved.

(2)

1 .....

.....

2 .....

.....

(Total for Question 3 = 8 marks)

2 (a) Explain what ha nto glass. **(2)**

*(b) Figure 13 shows a beam of red light approaching one side of a rectangular glass block.

The beam of light will pass through the block and leave through the opposite side.

AB is a wavefront.

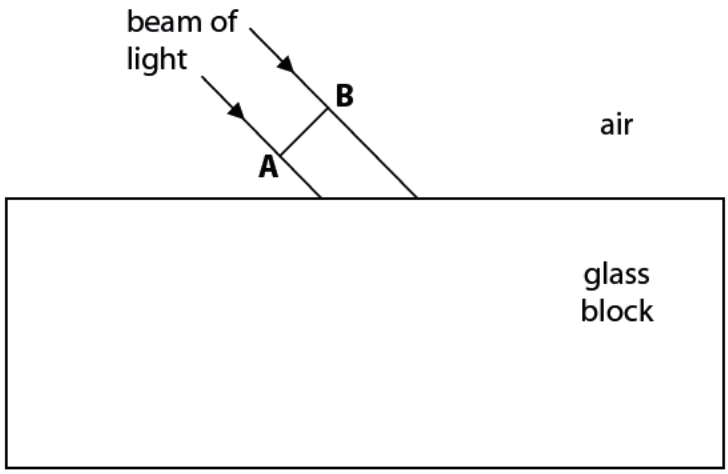

Figure 13

Discuss the path of the wavefront **AB** as it enters and leaves the glass block.

(6)

(c) The distance between the Earth and the Sun is 1.50×10^{11} m.

Light takes 500 s to travel from the Sun to the Earth.

The wavelength of red light is 670 nm.

Calculate the frequency of red light, using only the data provided.

(4)

frequency = ... Hz

(Total for Question 9 = 12 marks)