7 Fig 7.1 shows an experimental set-up to produce the emission line spectrum of a hydrogen gas.

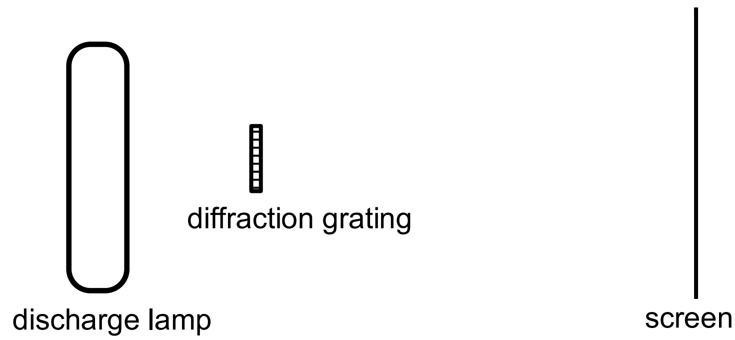

Fig. 7.1

(a) Explain how the line spectrum of hydrogen provides evidence for the existence of discrete electron energy levels in atoms.

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……………………………………………………………………………………………………..........[2]

(b) Some of the lines of the emission spectrum of atomic hydrogen for the 1st order maxima are shown in Fig 7.2, which is drawn to scale.

Fig. 7.2 (drawn to scale)

Estimate the wavelength of the photon emitted for emission line labelled X. You can use the equation of d sin $\theta = \lambda$ and assume θ is small such that sin $\theta \approx$ tan $\theta \approx \theta$ in your answer.

wavelength = ……………………………….m [2]

(c) Fig. 7.3 shows a partially completed diagram depicting the energy levels of a hydrogen atom. The energy changes corresponding to photon emissions of wavelength 486 nm and 434 nm are also shown.

Draw on Fig. 7.3 the energy level that shows the corresponding energy change that gives rise to photons of wavelength 410 nm. Label with appropriate values.

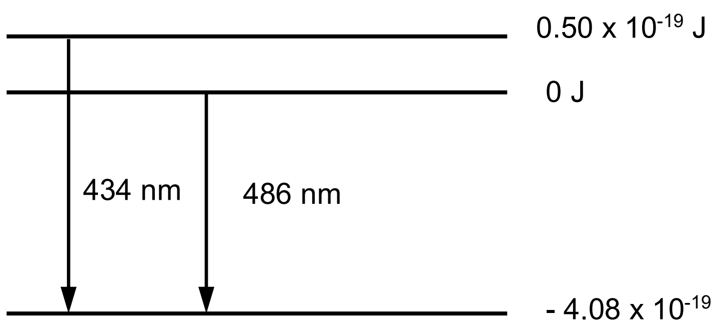

Fig. 7.3

[3]

(d) When each accelerated electron in the discharge tube has a kinetic energy of 4.08×10^{-19} J, they do not cause the excitation of the cool hydrogen gas atoms.

By reference to Fig. 7.3, explain this observation.

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…………………………………………………………………………………………………..........[1]

(e) Describe a situation in which the electrons mentioned in **(d)** can be shown to have a wave nature.

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…………………………………………………………………………………………..………….

…………………………………………………………………………………………………..........[2]

(f) Determine the de Broglie wavelength of the electrons in the discharge tube that has a kinetic energy of 4.08×10^{-19} J.

wavelength = …………………………….m [2]

[Total: 12]