GCE PHYSICS

S21-A420QS

Assessment Resource number 25

Light and Nuclei Resource G

1. *(a)* Bruce throws a lump of coal towards Dani which she catches. Bruce claims that, because chemical energy is being transferred from himself to Dani, the lump of coal is a **wave**. Explain whether or not Bruce is correct. [2]

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(b) The door of a microwave oven has a metal grille and this grille has holes in it of diameter 2 mm so that the food can be seen within the oven.

(i) Explain why the food can be seen through the door while the user is safe from dangerous microwaves of wavelength 12 cm. [3]

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(ii) State or calculate a typical photon energy of visible light. [1]

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(iii) Explain whether or not a microwave photon has a greater or smaller energy than a visible photon. [1]

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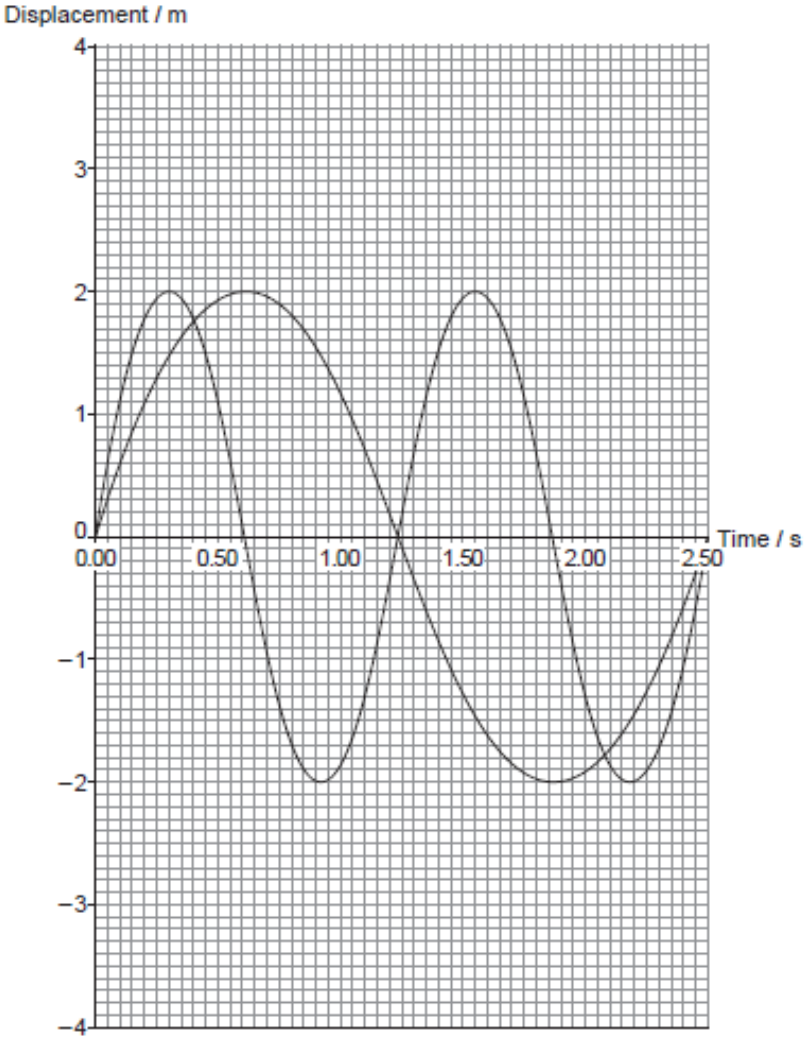
(c) Two water waves of equal amplitude but different frequencies meet. The variation of the displacements of each wave is shown in the graph at the meeting point of the two waves.



Use the principle of superposition to plot the resultant displacement of the two waves at times 0.00 s, 0.40 s, 1.00 s, 1.25 s, 1.50 s, 2.10 s, 2.50 s **on the same grid** and draw a suitable curve. [4]

2. *(a)* Calculate the de Broglie wavelength of an electron accelerated by a pd of 2200 V. [3]

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(b) Explain how electrons can be used in a laboratory to produce a diffraction pattern and the effect of increasing the pd on the diffraction pattern. [3]

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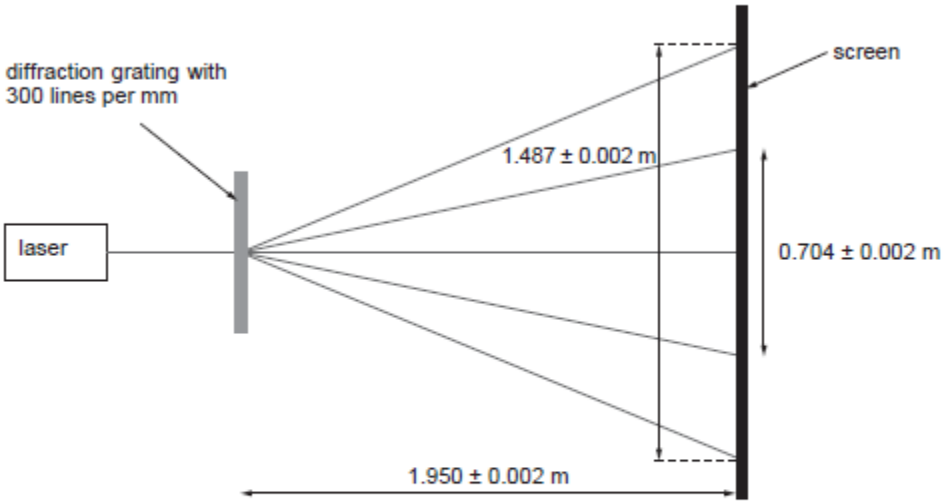
3. Rachel carries out an experiment to measure the wavelength of light emitted by a laser. Her measurements and set-up are shown in the diagram below.



(a) (i) **Show clearly** that the measured wavelength of the laser light is 592 nm using the $n = 1$ data in the diagram. [3]

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(ii) **Show clearly** that the $n = 1$ data in the diagram leads to an uncertainty in the wavelength of ±2 nm. You may assume that the manufacturer's labelling of 300 lines per mm for the diffraction grating is exact and that $\tan\theta \approx \sin\theta \approx \theta$. [4]

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(b) The manufacturer of the laser states that its wavelength is exactly 593.5 nm. The $n = 2$ data in the diagram lead to a measured laser wavelength of 594 ± 1 nm. Explain whether or not these values and the value from part *(a)* are all consistent. [2]

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(c) Explain why the $n = 1$ data (592 ± 2 nm) lead to a larger uncertainty than the $n = 2$ data (594 ± 1 nm). [2]

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4. *(a)* Explain what is meant by stimulated emission of radiation. [2]

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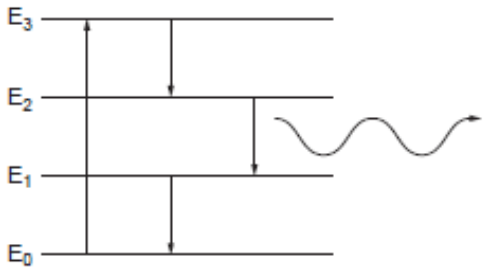
(b) The energy levels of a 4-level laser system are shown.

4-level system



Give **two** reasons why energy level E_1 is always nearly empty. [2]

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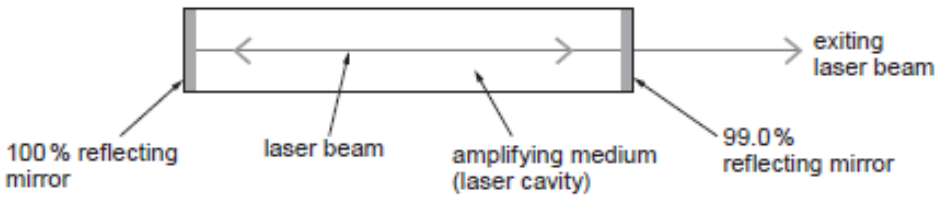
(c) Victoria claims that when the laser system shown below **is in equilibrium**, the amplifying medium provides only a 0.5 % increase in intensity of the beam each time it travels across the cavity. Her research partner, David, insists that the exponential increase in light intensity provided by the amplifying medium means that the beam intensity is increased by a factor of thousands for each pass even when the laser is in equilibrium. Discuss whether Victoria or David is correct. [3]



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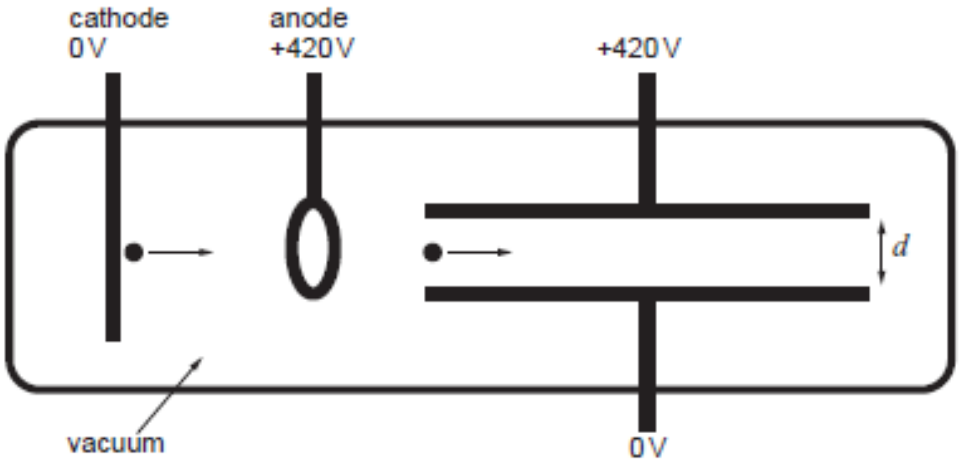
An electron is accelerated from rest by a pd of 420 V and then enters the uniform electric field between two parallel plates separated by a distance, d. These parallel plates also have a pd of 420 V across them and the electron enters halfway between the two plates.



(a) Show that, when the electron has travelled a distance, d, horizontally, it will have travelled a distance of $\frac{1}{4}d$ vertically (from the point where it enters the parallel plates). [5]

(b) Explain whether or not an oxygen ion with charge $-2e$ accelerated from rest in the above set-up instead of an electron would pass through the same point. [2]

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(a) A sphere made of caesium is placed in space and illuminated by ultraviolet radiation of photon energy 10.3 eV. The work function of caesium is 2.1 eV. Explain in clear steps, using Einstein's photoelectric equation (and other physics), why the maximum potential attainable by the caesium sphere is +8.2 V. [5]

(b) Hence, calculate the maximum electric field strength around the caesium sphere given that its radius is 6.5 cm. [3]