GCE PHYSICS

S21-A420QS

Assessment Resource number 22

Light and Nuclei Resource D

1

(a) State the difference between transverse and longitudinal waves. [2]

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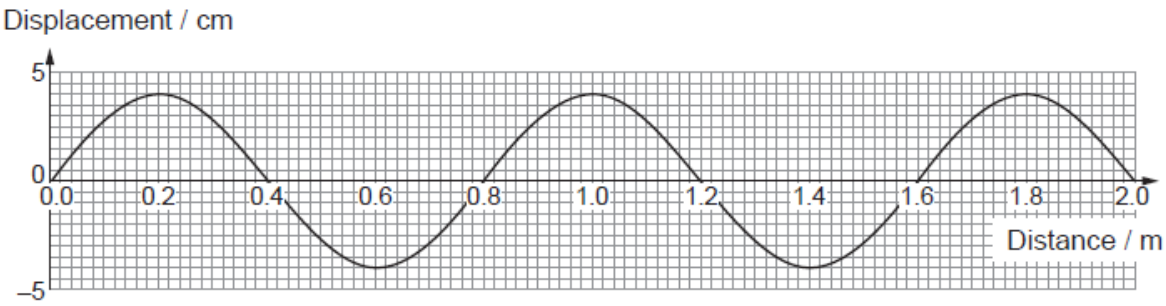
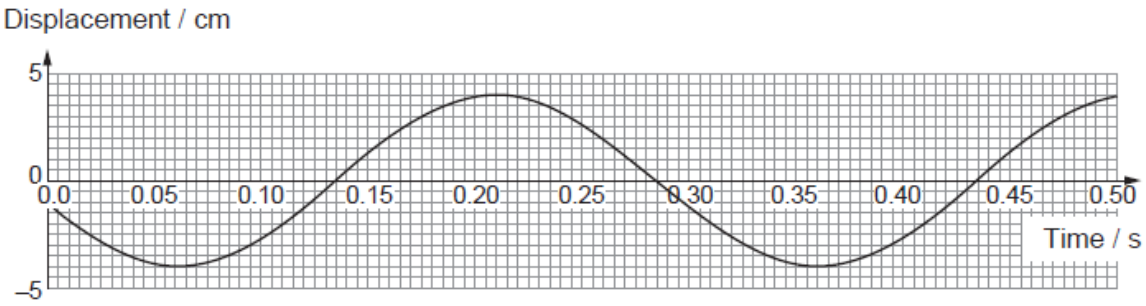
(b) The variation of displacement with respect to position and time is shown in the following two graphs for the same surface wave on water.

Graph of displacement against distance (at a given time)





(i) State the amplitude of the wave. ..... [1]

(ii) State the wavelength of the wave. ..... [1]

(iii) Calculate the speed of the wave. [3]

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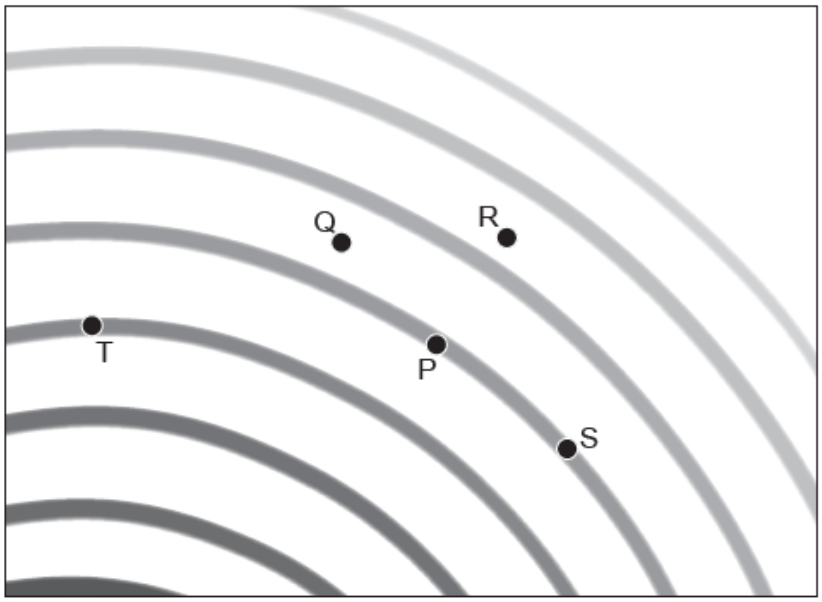
(c) A wavefront diagram for waves on the surface of water is shown.



(i) **Draw an arrow** to indicate the direction of motion of the wavefront at point **S**. [1]

(ii) State the point(s) oscillating in phase with point **P**. ..... [1]

2

(a) Single slit diffraction of light is demonstrated by using a red laser and the results are shown below. The two different diffraction patterns are obtained by varying the slit width only.

Figure 2a

Figure 2b

(i) Explain whether Figure 2a or Figure 2b has the wider slit. [2]

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(ii) State what can be done to the single slit to obtain the greatest amount of diffraction. [1]

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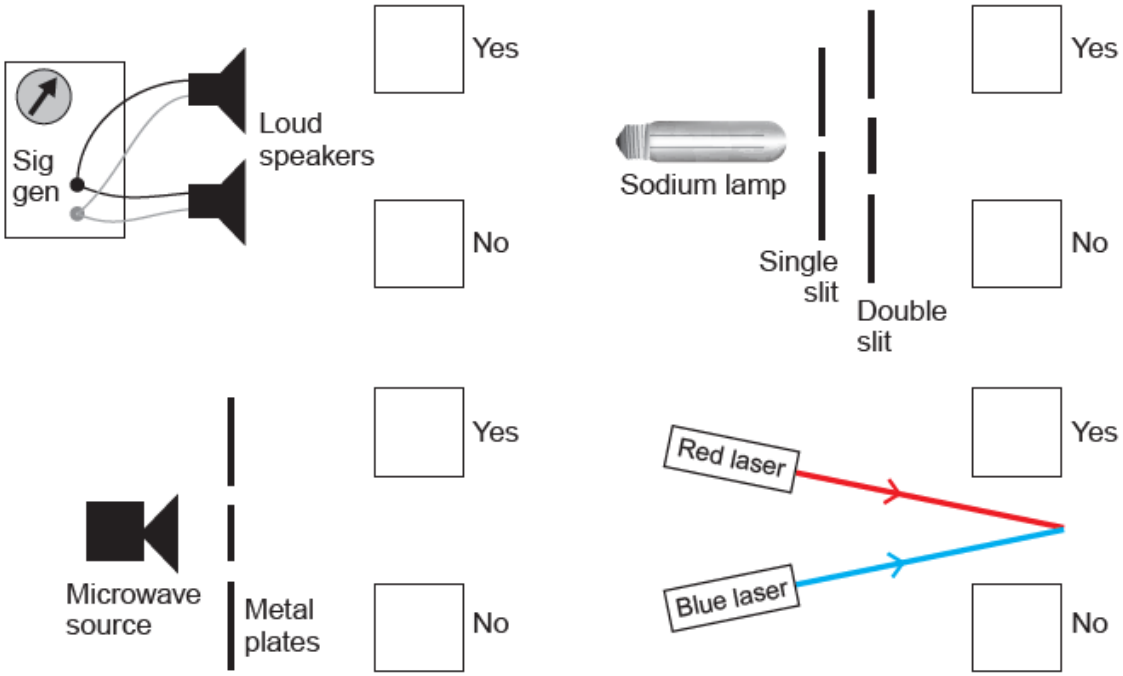
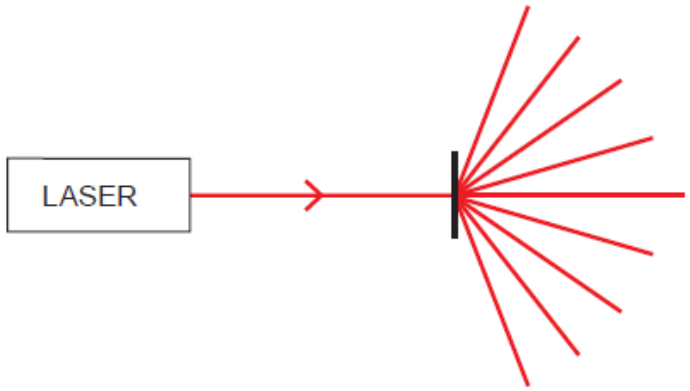
(b) Tick (✓) the appropriate boxes to show which of the following arrangements allow an interference pattern to be observed/heard. [2]



(c) Laser light is shone at a diffraction grating with slit separation 2.4 μm and a total of nine bright beams are produced (see below). Determine the maximum and minimum possible wavelengths for the laser light. [4]

Diagram not to scale



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3

(a) (i) Explain why a population inversion is not usually possible with a 2-level energy system pumped using light. [2]

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(ii) State an advantage of semiconductor lasers and an example of their use. [2]

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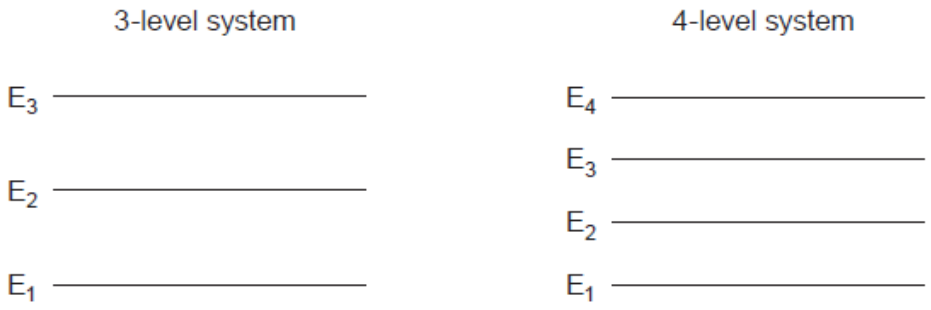
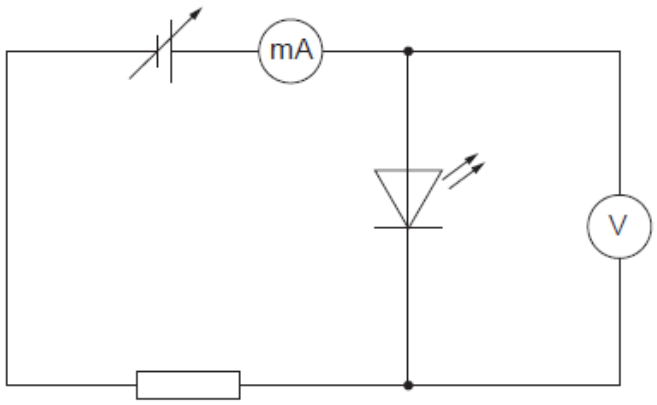
(b) Explain how 3-level and 4-level laser systems work and the advantages of a 4-level system. Refer to the diagrams in your answer. [6 QER]



4

(a) The following circuit is used to find the pd across an LED when it is switched on.



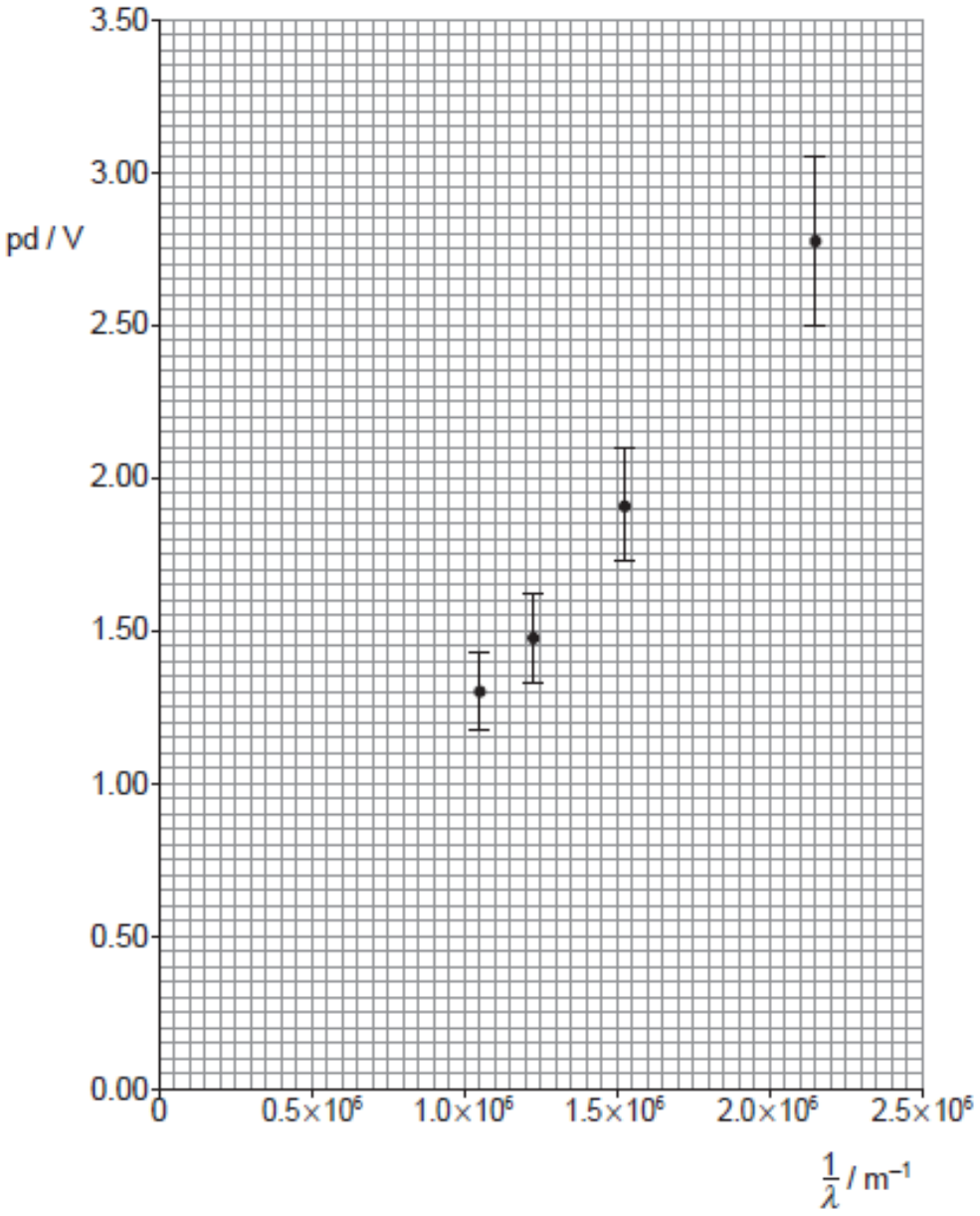
Aled decides that the LED is switched on when a current of 10.0 mA passes through it. He adjusts the variable power supply and records the switching-on pd. He repeats this procedure for different LEDs which emit light of different wavelengths. His results are tabulated below.

(i) **Complete** the table. [2]

Wavelength λ of LED / nm	$\frac{1}{\lambda}$ / m^{-1}	Switching-on pd / V (± 10%)
465	2.15×10^6	2.78 ± 0.28
569	..... $\times 10^6$	2.26 ± .....
660	1.52×10^6	1.91 ± 0.19
820	1.22×10^6	1.47 ± 0.15
890	..... $\times 10^6$	1.44 ± .....
950	1.05×10^6	1.29 ± 0.13

(ii) **Complete** the graph by plotting the **two** missing points whose values you have calculated together with their error bars. [2]

(iii) **Draw** the line of maximum gradient and the line of minimum gradient through the error bars. [2]


3.50
3.00
pd / V
2.50
2.00
1.50
1.00
0.50
0.00
0
0.5×10⁶
1.0×10⁶
1.5×10⁶
2.0×10⁶
2.5×10⁶
1/λ / m⁻¹

(b) Conservation of energy applied to an electron and photon involved in the light emitting process of the LED gives:

$$eV = \frac{hc}{\lambda}$$

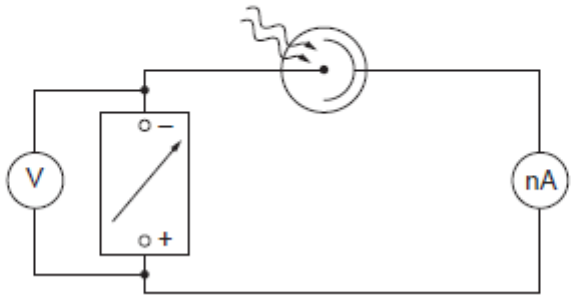
(i) Use your two lines from *(a)*(iii) to obtain a value for the Planck constant along with its absolute uncertainty to an appropriate number of significant figures. [5]

(ii) Explain to what extent Aled's data displayed in the graph confirm the relationship. [4]

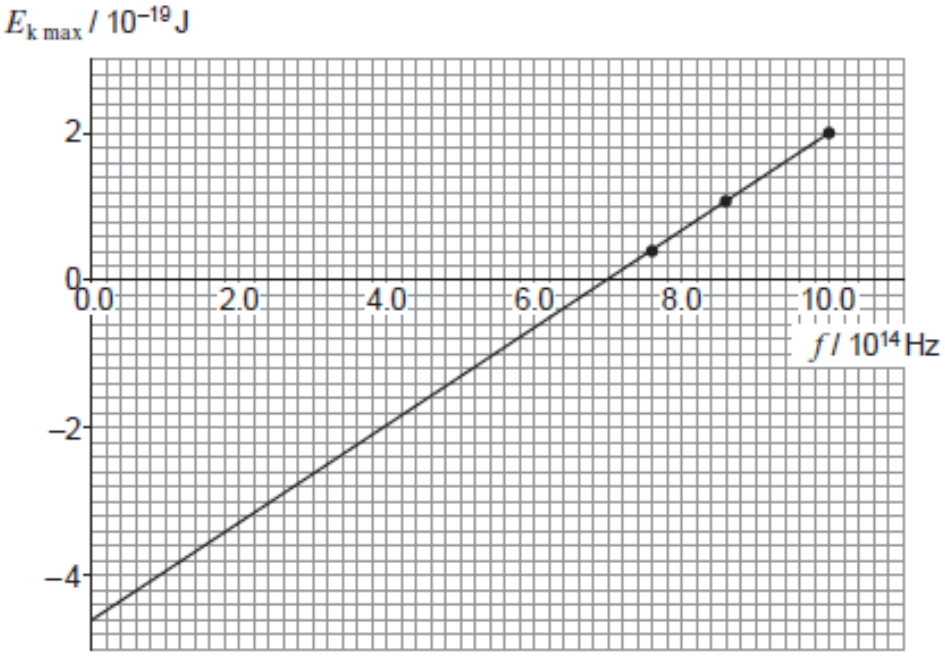
$$eV = \frac{hc}{\lambda}$$

(c) Suggest **one** reason why choosing a constant current of 10.0 mA is better than using your eye to detect the emitted radiation for these LEDs. [1]

(d) The Planck constant can also be determined using the photoelectric effect. Light of various frequencies is incident on a calcium photoelectric cell as shown and the maximum kinetic energy, $E_{k\,max}$, of the emitted electrons is determined for each frequency, f.



The following graph is obtained.



(i) Determine a value for the Planck constant. [2]

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(ii) Determine a value of the work function of calcium and explain why no data points are possible below a frequency of 6.9×10^{14} Hz. [3]

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