Physics

Question	Maximum Mark	Mark Awarded
#1	6	
#2	8	
#3	10	
#4	8	
#5	8	
#6	19	
#7	10	
#8	11	
#9	12	
#10	13	
#11	16	
#12	21	
Total	142	

#1

(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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Question taken from Eduqas examination paper 842103, November 2020

#2

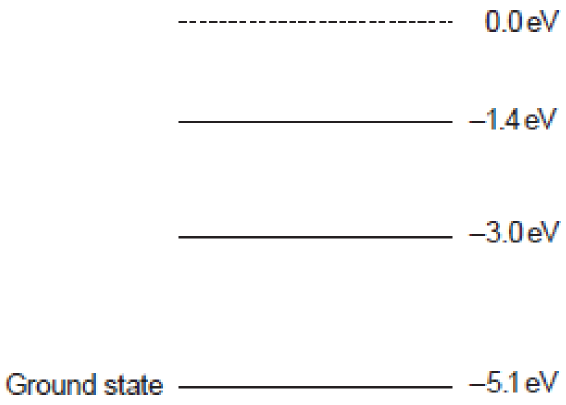
(a) A sphere made of caesium is placed in space and illuminated by ultraviolet radiation of photon energy 10.3 eV. The work function of caesium is 2.1 eV. Explain in clear steps, using Einstein's photoelectric equation (and other physics), why the maximum potential attainable by the caesium sphere is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

Question taken from Eduqas examination paper 842103, November 2020

#3

6. The diagram shows three energy levels of a sodium atom.



(a) State the ionisation energy of a sodium atom. [1]

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(b) White light passes through a cloud of sodium atoms. The light which emerges is found to have the continuous spectrum of white light but with dark lines crossing the spectrum. State briefly how the dark lines are caused and what happens to the atoms in the process. [3]

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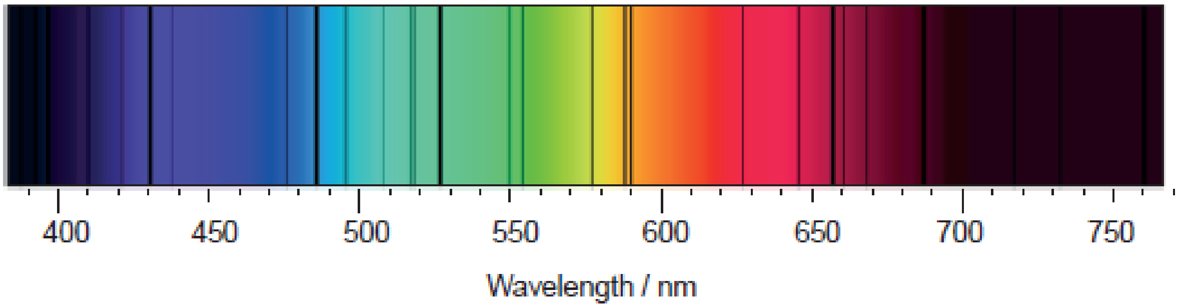
(c) (i) The spectrum of a star is shown below. The wavelength of one of the dark lines is 590 nm. Evaluate whether this is evidence for the presence of sodium in the star. [3]



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(ii) The wavelength of peak emission of the star is 100 nm. Determine its surface temperature. [3]

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Question taken from Eduqas examination paper 842002, June 2019

#4

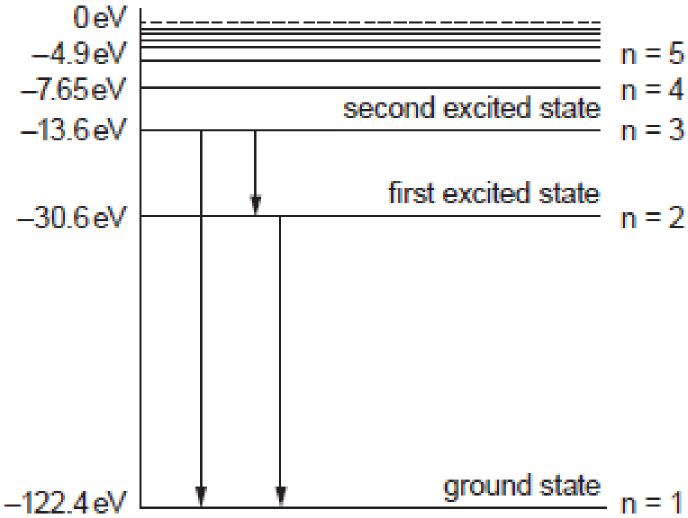
(a) Describe an experiment using a range of LEDs to determine the Planck constant. [6 QER]

(b) A university research group uses a new experimental method to determine a value for the Planck constant that is higher than the accepted value of 6.63×10^{-34} J s. Explain how other scientists would attempt to confirm this result. [2]

Question taken from Eduqas examination paper 842002, June 2017

#5

8. The energy levels of a lithium ion are shown.



(a) Calculate the ionisation energy of the lithium ion in joules. [2]

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(b) Calculate the wavelength of the electromagnetic radiation emitted when an electron drops from the second excited state (n = 3) to the first excited state (n = 2) and state the region of the electromagnetic spectrum to which it belongs. [3]

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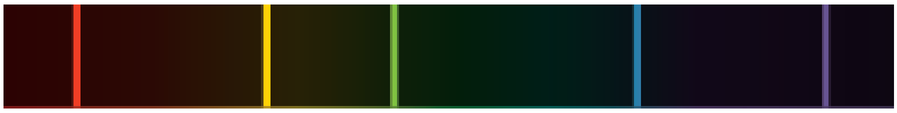
(c) The emission and absorption spectra of another element are shown below.



Emission spectrum

Absorption spectrum

Explain briefly the processes that give rise to these spectra and why the lines appear at the same wavelengths in the two spectra. [3]

Question taken from Eduqas examination paper 842103, June 2019

#6

3. *(a)* (i) State what is meant by the photoelectric effect. [1]

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(ii) Einstein's photoelectric equation may be written as:

$$E_{k\,max} = hf - \phi$$

Explain this equation in terms of energy. [3]

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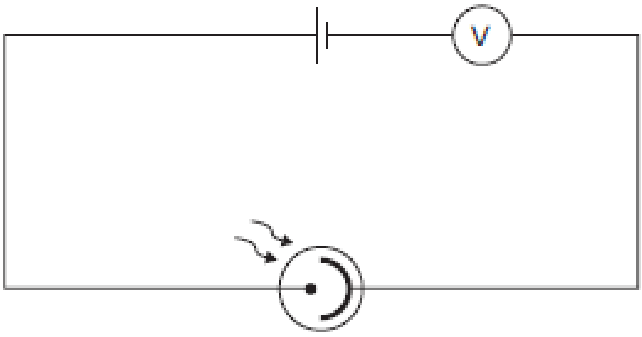
(b) Evaluate why the following circuit is incorrect and cannot be used to measure the maximum kinetic energy of the emitted electrons. [4]



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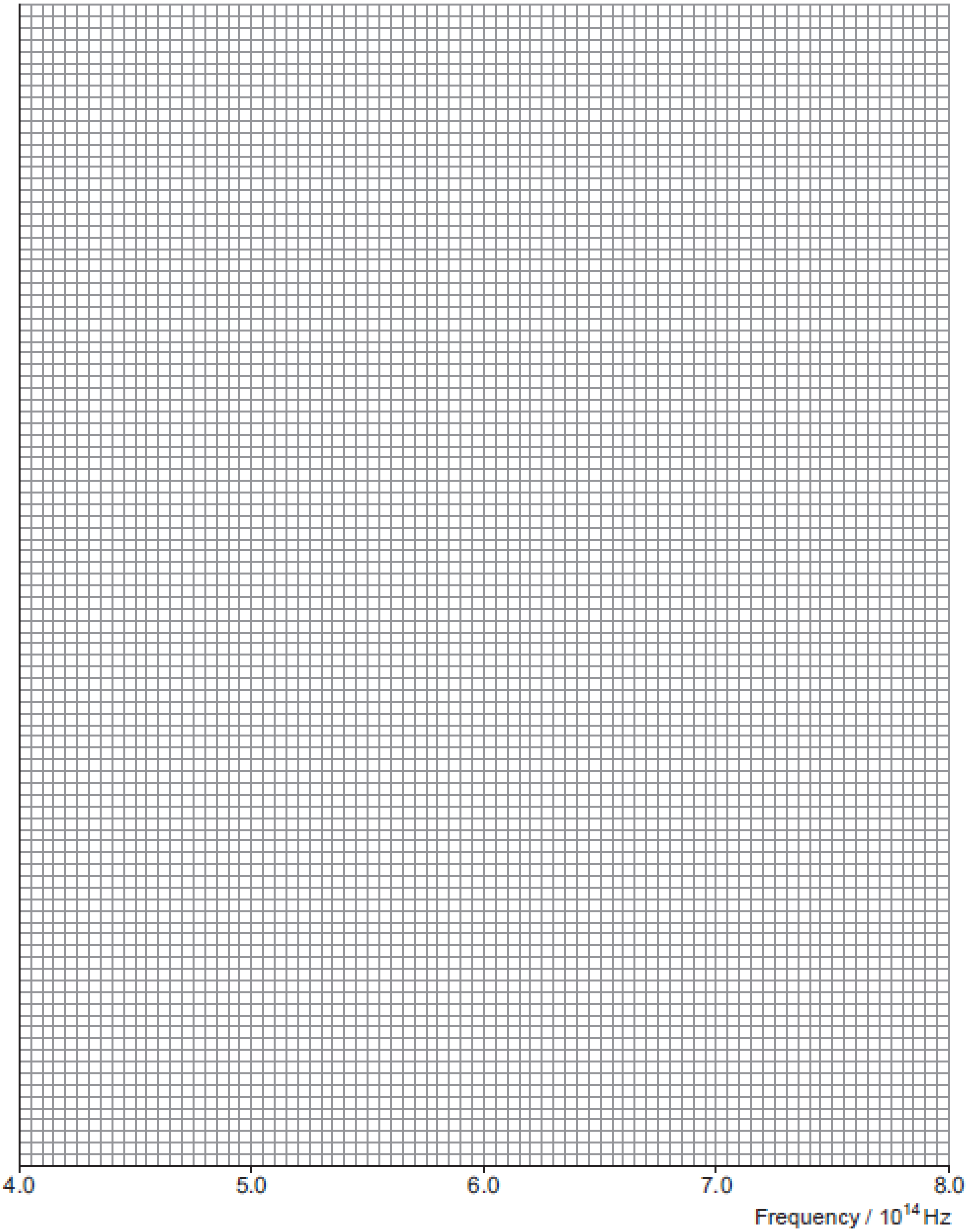
(c) Different frequencies of light are used with a correct circuit and the following results are obtained.

Frequency / 10^{14} Hz	5.1	6.0	6.9	7.5
$E_{k\,max}$ / 10^{-19} J	0.36	0.93	1.50	1.95

(i) Plot E_{kmax} (y-axis) against frequency (x-axis) on the grid below and draw a line of best fit through your data. [3]



(ii) Explain whether or not your graph is in agreement with Einstein's photoelectric equation. [3]

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(iii) Calculate a value for the Planck constant using the gradient of your graph. [3]

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(iv) An answer can be considered to be accurate if it is within 5% of the accepted value for the Planck constant. Evaluate whether your answer for the Planck constant can be considered to be accurate. [2]

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Question taken from Eduqas examination paper 842002, June 2018

#7

7. Einstein's photoelectric equation can be written as

$$E_{k\,max} = hf - \phi$$

(a) Explain what is meant by the term work function, ϕ . [2]

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(b) (i) Light of frequency 7.3×10^{14} Hz is incident on a sodium surface at a rate of 2.5×10^{-10} J s^{-1}. Determine the number of photons per second incident on the sodium surface. [2]

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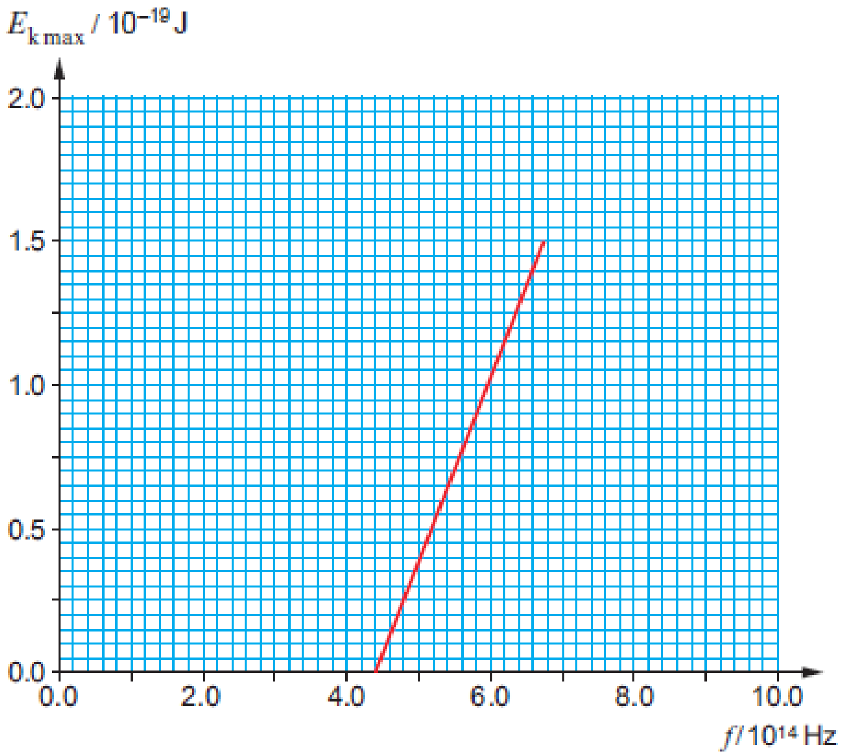
(ii) A graph of $E_{k\,max}$ against f for the sodium surface is given below.



I. Calculate the work function of sodium. [2]

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II. Draw a line on the graph to show how $E_{k\,max}$ varies with f for a metal which has a greater work function than sodium. [2]

III. The rate at which light falls on to the sodium surface is increased from $2.5 \times 10^{-10}\,J\,s^{-1}$ to $3.0 \times 10^{-10}\,J\,s^{-1}$. Explain clearly why the graph would not change. [2]

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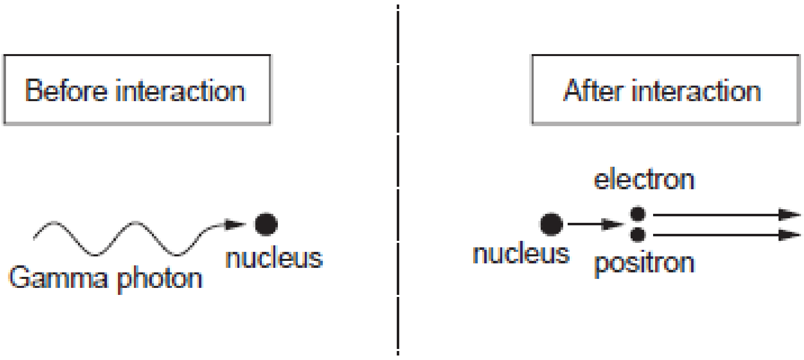
Question taken from Eduqas examination paper 842002, June 2019

#8

5. The following interaction can take place when a gamma photon encounters a stationary nucleus.



The energy of the gamma photon "creates" a positron-electron pair and the nucleus gains some momentum in the direction of the original gamma photon.

(a) Show that this interaction can only take place if the energy of the gamma photon is greater than 1.02 MeV. [3]

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(b) The actual energy of the incident gamma photon is 1.03 MeV. **Assuming that the kinetic energy of the nucleus after the interaction is negligible**, explain briefly why the kinetic energies of the positron and electron are approximately 0.005 MeV **each**. [2]

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(c) Use the kinetic energies of 0.005 MeV and conservation of momentum to show that the speeds of the positron and electron are $4.2 \times 10^7\,\text{m s}^{-1}$ and that the momentum of the nucleus after the collision is $4.7 \times 10^{-22}\,\text{kg m s}^{-1}$. [4]

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(d) The momentum of the nucleus ($4.7 \times 10^{-22}\,\text{kg m s}^{-1}$) is essential otherwise conservation of momentum would be impossible. Deduce whether or not the assumption in part *(b)* is valid (the mass of the nucleus is 3.3×10^{-25} kg). [2]

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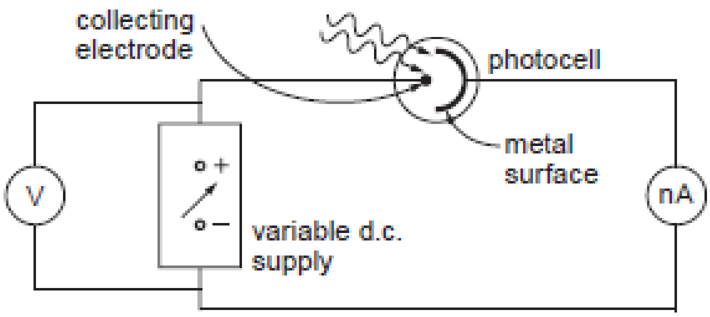
Question taken from Eduqas examination paper 842103, June 2019

#9

3. Light is incident on a photoelectric cell as shown.



(a) Explain why a current is detected by the ammeter. [3]

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(b) The work function of the metal surface is 2.7 eV and electrons are emitted with a maximum kinetic energy of 1.2 eV.

Calculate the frequency of the incident photons. [3]

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(c) (i) Explain how you would modify and use the circuit opposite to measure the stopping potential. [3]

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(ii) The metal surface of the photocell is radioactive and emits alpha particles some of which arrive at the collecting electrode. Explain briefly what effect this would have on measuring the stopping potential and what could be done to reduce this effect. [3]

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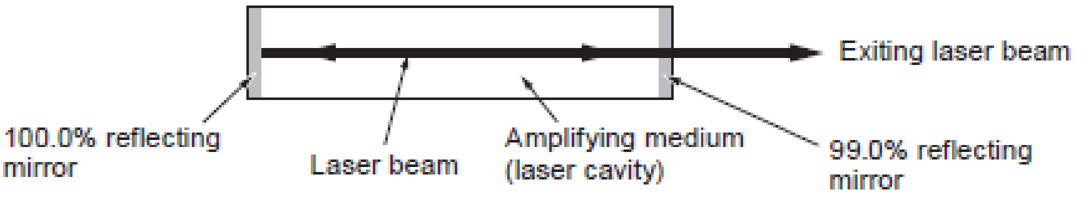
Question taken from Eduqas examination paper 842103, June 2018

#10

4. A laser has two mirrors either side of the amplifying medium as shown.



(a) Explain the purpose of the 99.0% reflecting mirror and the 100.0% reflecting mirror. [2]

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(b) Explain the purpose of a population inversion in the laser cavity. [3]

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(c) (i) The light intensity inside a powerful laser is 2.0×10^{15} W and its wavelength is 1.05 μm. Show that this corresponds to approximately 1×10^{34} photons per second. [2]

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(ii) Show that the momentum of a 1.05 μm photon is approximately 6×10^{-28} kg m s^{-1}. [1]

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(iii) Show that the force exerted on a 100.0% reflecting mirror by a beam of power 2.0×10^{15} W is approximately 1×10^{7} N. [2]

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(iv) Calculate the strain produced in a laser structure if the power of the beam between the mirrors is 2.0×10^{15} W. You may assume that the structure of the laser cavity has a cross-sectional area of 43 cm^2 and is made of a material with Young modulus 2.8×10^{11} Pa. [3]

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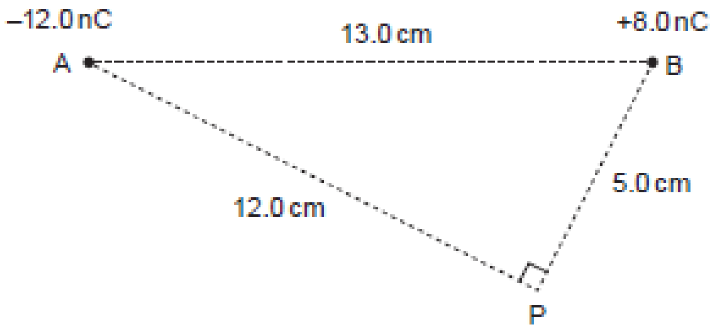
Question taken from Eduqas examination paper 842103, June 2018

#11

7. (a) Complete the following table: [3]

Quantity	Definition	Vector or Scalar
Electric field strength, E	....	....
Electric potential, V	....	....

(b) Point charges of –12.0 nC and +8.0 nC are placed at A and B, 13.0 cm apart as shown. P is a point in space which is 12.0 cm from A and 5.0 cm from B.



(i) Draw on the diagram two arrows to show the directions of the field strength at P due to each charge. [1]

(ii) Hence draw on the diagram one arrow to represent the direction of the resultant field strength at P. Label this arrow R. [1]

(iii) Calculate the **magnitude and direction** of the electric field strength at P. [4]

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(c) (i) Show that the potential at P is + 540 V. [2]

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(ii) Calculate the gain in kinetic energy in joules of an electron as it moves from infinity to P. [2]

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(d) Without calculation, explain how the de Broglie wavelength of the electron changes as it moves towards P. [3]

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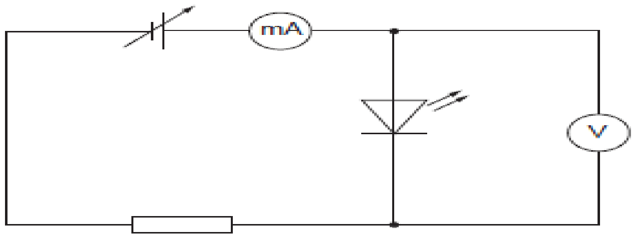
Question taken from Eduqas examination paper 842102, June 2018

#12

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



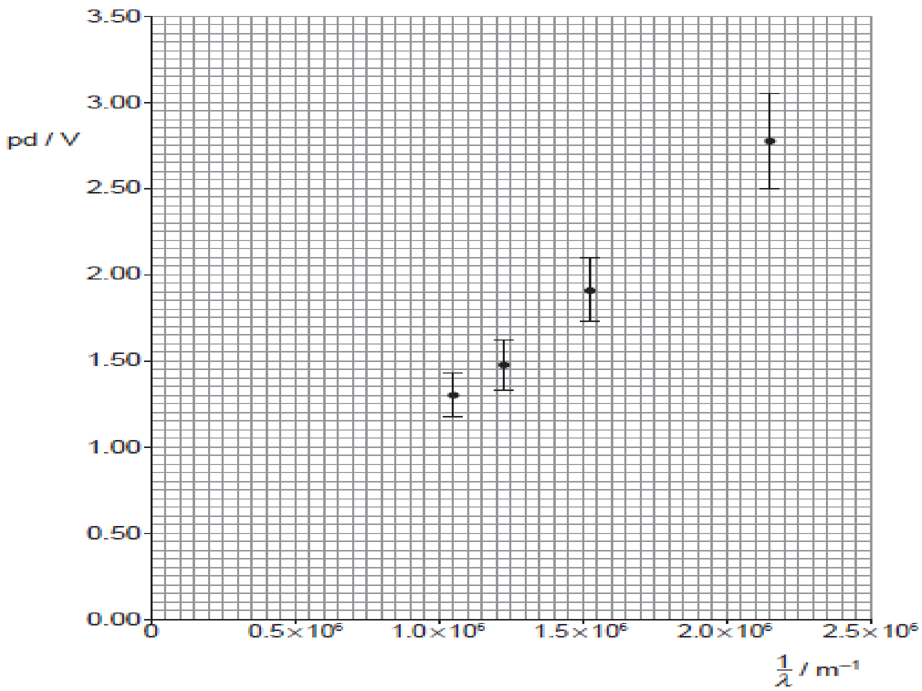
Aled decides that the LED is switched on when a current of 10.0 mA passes through it. He adjusts the variable power supply and records the switching-on pd. He repeats this procedure for different LEDs which emit light of different wavelengths. His results are tabulated below.

(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	.... $\times 10^6$	$2.26 \pm$ ....
660	1.52×10^6	1.91 ± 0.19
820	1.22×10^6	1.47 ± 0.15
890	.... $\times 10^6$	$1.44 \pm$ ....
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]



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

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

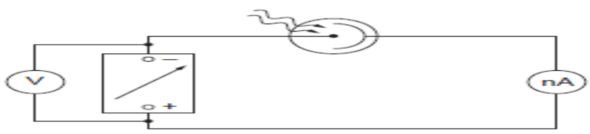
(i) Use your two lines from *(a)*(iii) to obtain a value for the Planck constant along with its absolute uncertainty to an appropriate number of significant figures. [5]

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

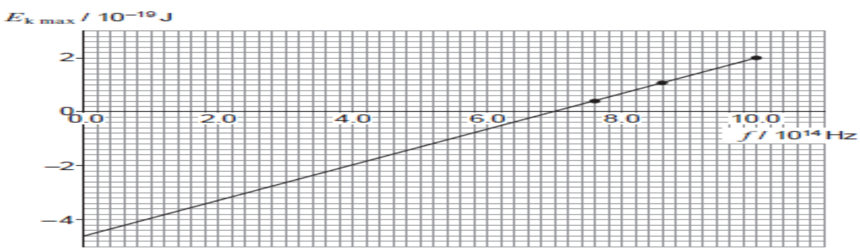
$$eV = \frac{hc}{\lambda}$$

(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]

(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]

Question taken from Eduqas examination paper 842103, June 2019