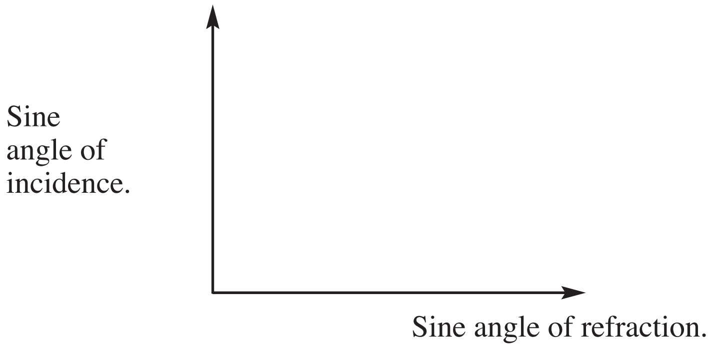
3. *(a)* A student investigates the refraction of light in glass. She measures the angle of refraction for various angles of incidence for light passing from air into glass. She then plots a graph of 'Sine (angle of incidence)' against 'Sine (angle of refraction)'.

(i) Sketch, on the axes below, the graph that she might expect. [1]

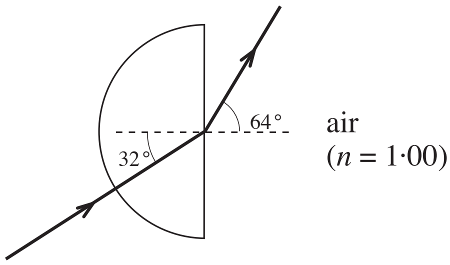


(ii) State whose law this confirms.

....

[1]

(b) The diagram shows a ray of light passing through a semicircular block of dense glass.



(i) Determine the angle of incidence which would give an angle of refraction of 90°.

....

....

....

....

[4]

(ii) What name is given to the angle calculated in *(b)* (i)?

....

[1]

(iii) Calculate the radius of the glass block given that the time taken for the light to pass through it is 0·34 ns. [Refer to the data on page 2]

....

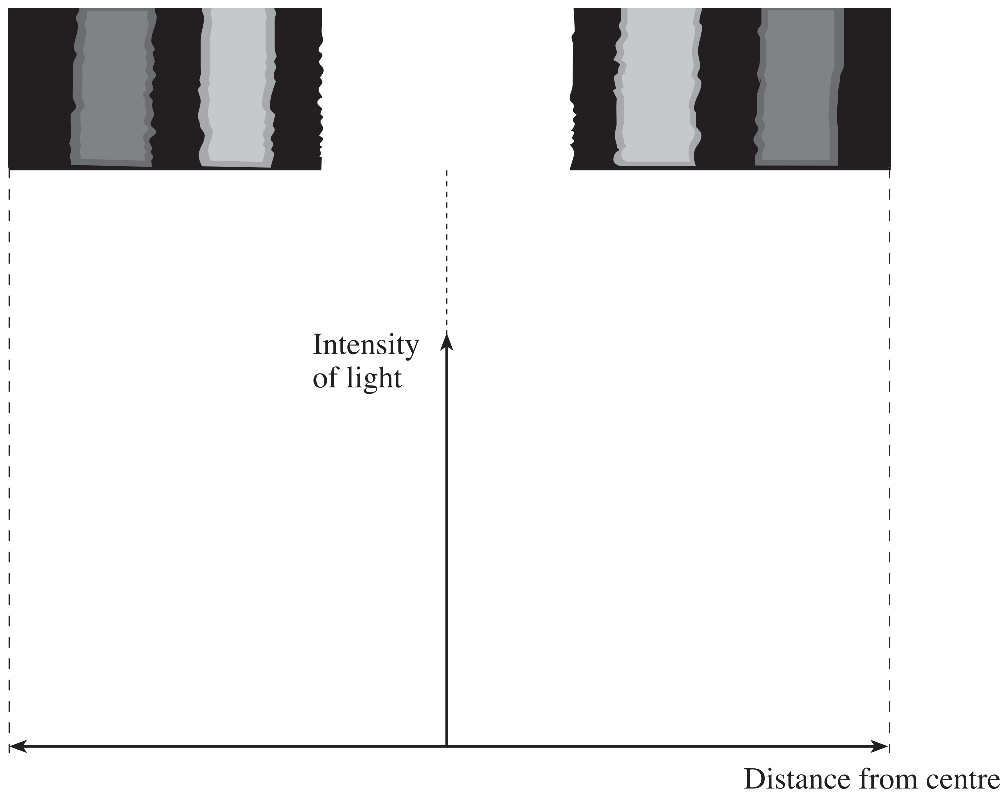
....

....

....

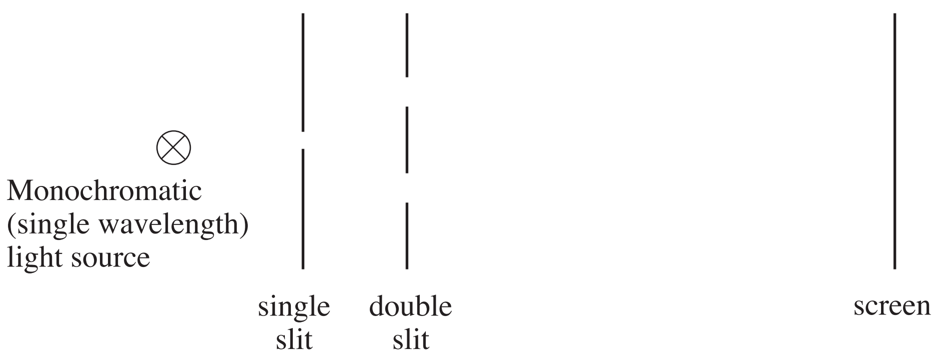
[3]

4. Monochromatic (single wavelength) light is diffracted through a narrow single slit onto a distant screen. The diffraction pattern observed on the screen is shown below.



(a) On the graph axes sketch a graph of intensity of light against distance from centre for the above diffraction pattern. [4]

(b) The single slit is now placed directly in front of a double slit arrangement as shown. (*The diagram is not to scale*).



(i) Explain the purpose of the single slit in this arrangement.

....

....

[1]

(ii) A student wishes to produce a pattern of light and dark fringes of spacing 2·0 mm on the screen. He uses light of wavelength $5{\cdot}9 \times 10^{-7}$ m and the spacing between the double slits is 0·50 mm. Calculate the distance from the double slits to the screen.

....

....

....

....

....

[3]

(iii) Explain briefly why the dark bands appear on the screen.

....

....

....

[2]

6. *(a)* (i) A stretched string can carry both progressive and stationary waves. State how the **amplitude** varies with position along the string for each of these waves.

Progressive wave:

....

....

Stationary wave:

....

.... [2]

(ii) Explain how the energy flow for a progressive wave differs from that for a stationary wave.

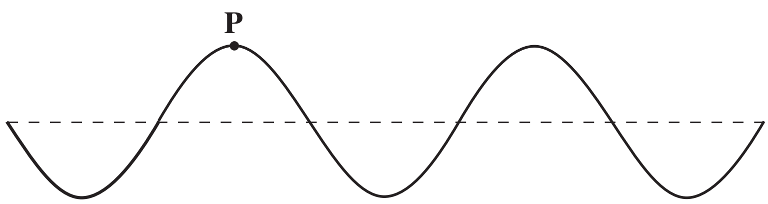
....

....

....

.... [2]

(b) Two points (**P** and **Q**) on a progressive wave differ in phase by 90°. The distance between them is 0·30 m and their period of oscillation is 0·050 s. **P** is shown on the following sketch.



(i) Label a possible position for **Q** on the above sketch. [1]

(ii) Define *wavelength*, and calculate its value for this wave.

....

....

....

....

.... [3]

Examiner only

(iii) Calculate the speed of the wave.

....

....

.... [3]

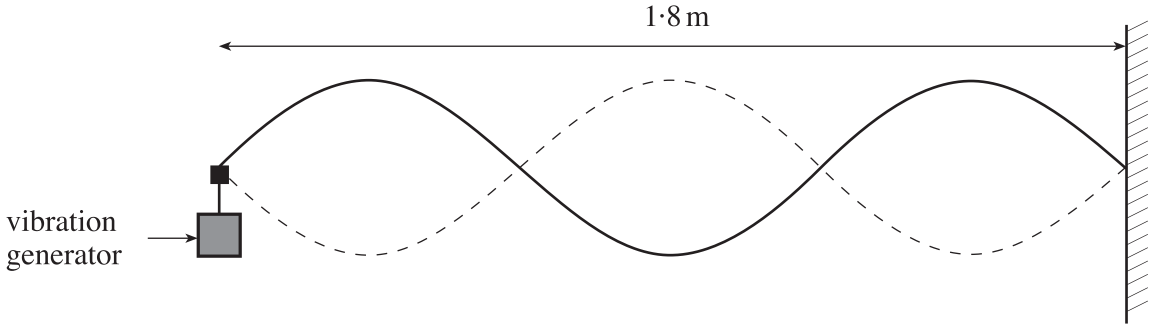
(iv) The amplitude of the wave is 0·020 m. Calculate the mean speed of particle **P** over one complete cycle.

....

....

.... [2]

(c) The following apparatus is set up to study stationary waves in a string of length 1·8 m. The vibration generator is set to 10·4 Hz initially in order to produce a stationary wave with three 'loops' as shown.



(i) Label **a node** on the above sketch. [1]

(ii) Show on the diagram three points **R**, **S** and **T** that oscillate in phase. [1]

(iii) Calculate the speed of the wave.

....

.... [2]

(iv) When the frequency of the vibration generator is **doubled**, the number of loops observed increases to **six**. Explain carefully how this change would affect, if at all, the speed of the wave.

....

....

....

....

.... [3]

Examiner only

6. *(a)* The *resistivity,* ρ, of a material is defined by the equation $\rho = \frac{RA}{l}$

(i) Show that the S.I. unit of resistivity is Ωm. [1]

....

....

(ii) The resistivity of the alloy *constantan* is $4{\cdot}9 \times 10^{-7}\,\Omega$m. Calculate the resistance between opposite faces of a constantan cube of 0·010m × 0·010 m × 0·010m. [2]

....

....

....

....

(iii) Give **two** reasons why it would not be possible to measure this resistance using ordinary laboratory meters and connecting wires. [2]

....

....

....

....

(iv) A 3·0 Ω resistor is to be made by winding a length of constantan wire on to a glass rod. The **diameter** of the wire is $4{\cdot}0 \times 10^{-4}$ m. Calculate the length of wire needed. [3]

....

....

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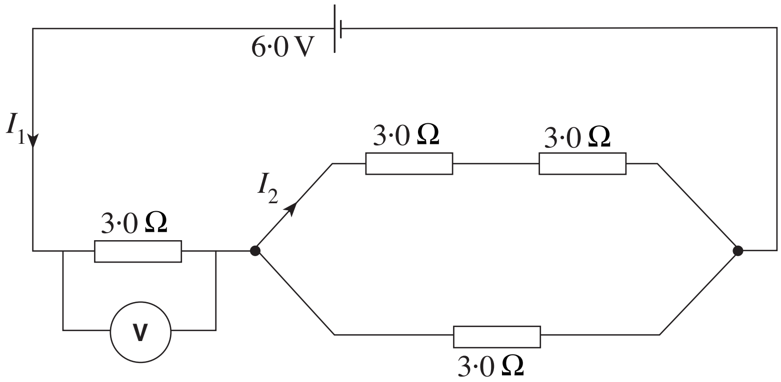
....

Examiner only

(b) In the circuit shown the internal resistance of the battery is negligible.



(i) Show in clear steps that the combined resistance of the resistors is 5·0 Ω. [3]

....

....

....

....

....

(ii) Calculate

(I) the current I_1, [1]

....

(II) the p.d. measured by the voltmeter, [1]

....

(III) the current I_2. [2]

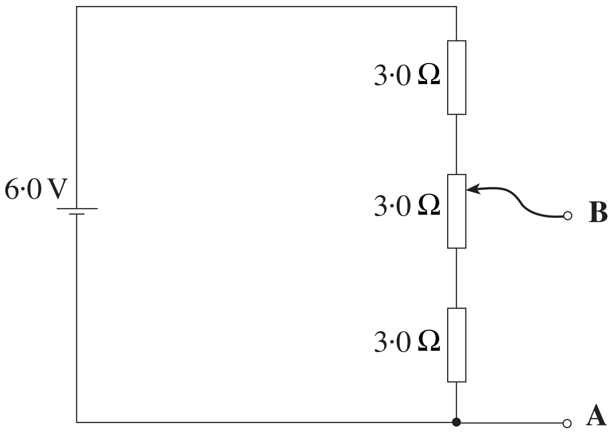
....

....

....

Examiner only

(c)



(i) Three 3·0 Ω resistors are connected as shown across a battery of negligible internal resistance. The middle resistor is fitted with a sliding contact as shown in the top diagram. Calculate

(I) the lowest possible p.d. between **A** and **B**. [1]

....

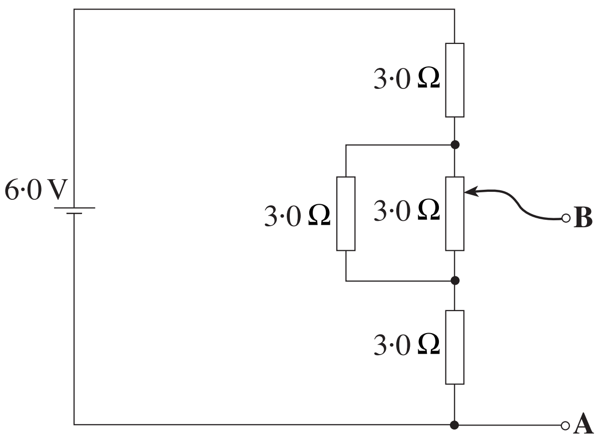
....

(II) the highest possible p.d. between **A** and **B**. [1]

....

....

(ii) Another 3·0 Ω resistor is added as shown in the lower diagram. State and explain whether it will increase or decrease



(I) the lowest possible p.d. between **A** and **B**, [2]

....

....

....

....

....

(II) the highest possible p.d. between **A** and **B**. [1]

....

....

....

....

Examiner only

7. *(a)* *Einstein's photoelectric equation* may be written as

$$K.E._{max} = hf - \phi$$

Give the meanings of the following in terms of *energy*.

(i) $K.E._{max}$ [2]

....

....

(ii) hf [1]

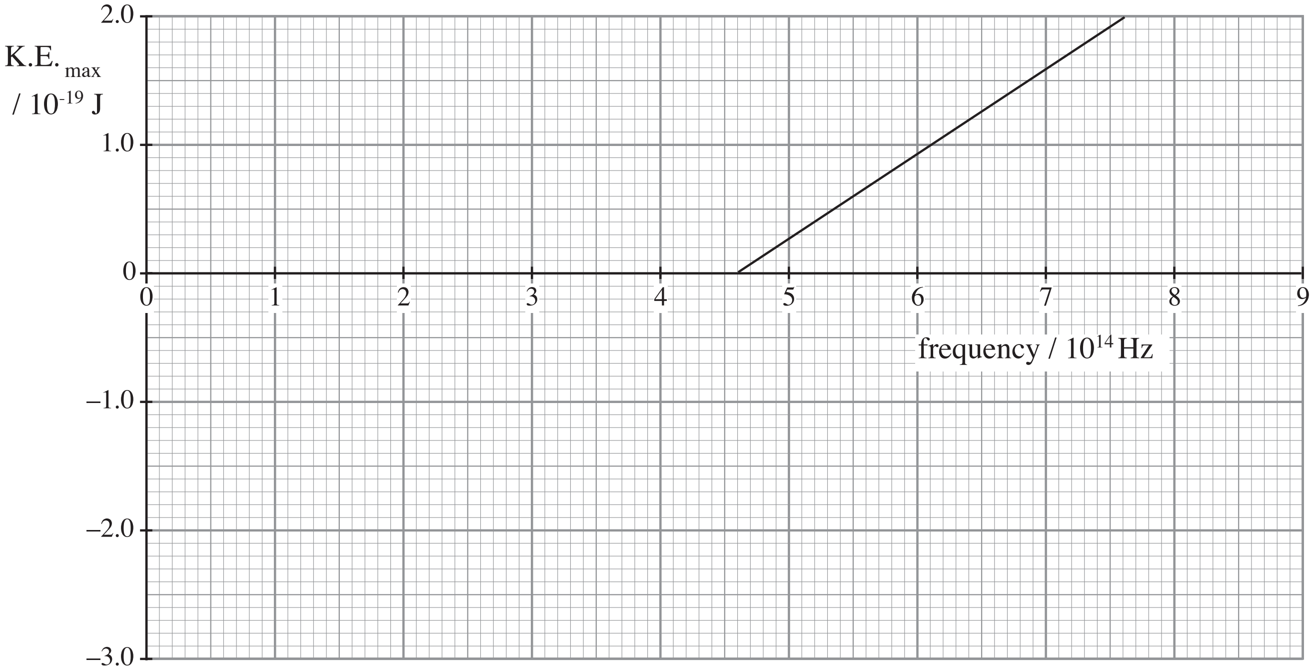
....

(iii) ϕ [1]

....

....

(b) A graph of $K.E_{max}$ against frequency of light is drawn for a caesium surface, from experimental data.



Examiner only

(i) Explain why no data can be obtained for frequencies of less than $4{\cdot}6 \times 10^{14}$Hz. [1]

(ii) Calculate the gradient of the line, showing your working clearly. [3]

(iii) (I) What physical quantity does this gradient represent? [1]

(II) Use Einstein's equation to justify this. [1]

(iv) Determine from the graph the work function of caesium. [2]

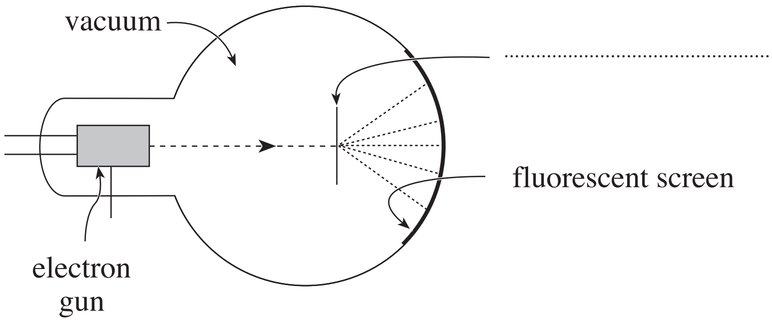
(v) Using data from the graph, and referring to the data on page 2, calculate the *stopping potential* for electrons ejected from caesium by light of frequency $6{\cdot}0 \times 10^{14}$ Hz. [2]

(vi) Draw on the grid a line which might be obtained for a metal with a larger work function than caesium. [2]

QUESTION 7 CONTINUES ON PAGE 18

Examiner only

(c) The photoelectric effect shows light behaving as particles. The diagram below shows apparatus in which particles can be seen behaving as waves.



(i) Insert the missing label. [1]

(ii) Describe what can be seen on the screen. [2]

....

....

(iii) Which wave property does this demonstrate? [1]

....