

Option B — Quantum Physics and Nuclear Physics

B1. This question is about the photoelectric effect.

(a) Outline **two** observations associated with the photoelectric effect that cannot be accounted for by the wave model of light. [2]

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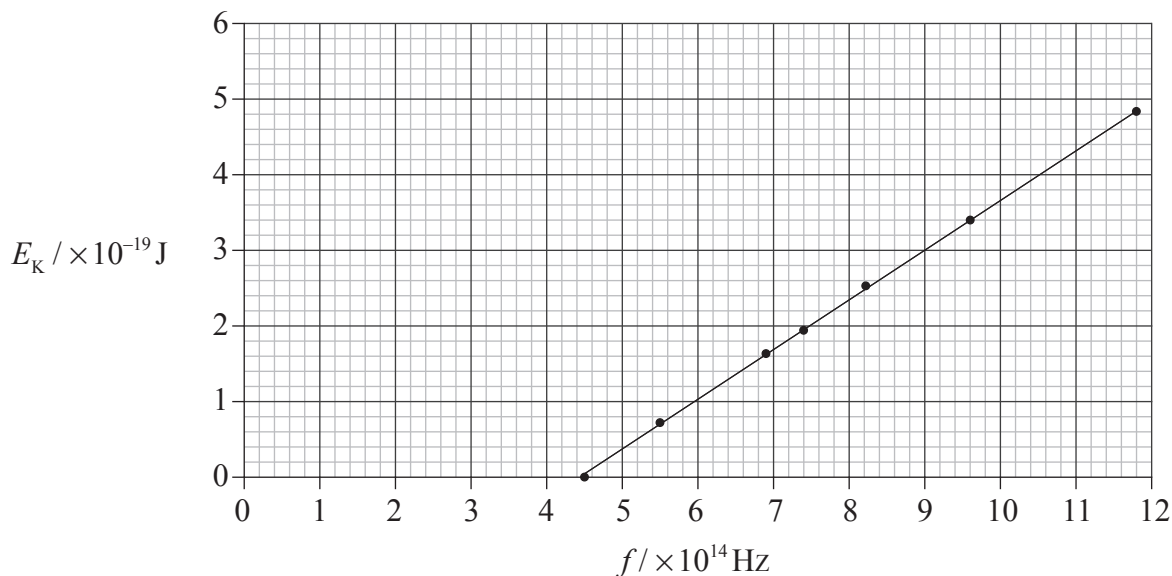
- 2.
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(Question B1 continued)

- (b) In 1916, Millikan carried out an experiment to verify Einstein's photoelectric theory. In the experiment, Millikan arranged for light of different frequencies f to be incident on the surface of a sodium cathode. By appropriate measurements, he determined the maximum kinetic energy E_K of electrons emitted from the surface for the different values of f . The results of his experiment are shown in the graph below.



Use the above graph to determine, explaining your working,

- (i) the threshold frequency of sodium. [2]

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- (ii) the Planck constant. [4]

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B2. (a) Describe the de Broglie hypothesis. [2]

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(b) The de Broglie wavelength of the electron in the ground state of the hydrogen atom is 3.3×10^{-10} m. Calculate the kinetic energy of the electron. [3]

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B3. This question is about radioactive decay.

(a) State the radioactive decay law. [1]

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(b) A nucleus of the isotope Zirconium-81 (Zr-81) decays into a nucleus of the isotope Yttrium (Y). The atomic number of Yttrium is 39. Complete the nuclear equation below for the decay of Zr-81. [3]



(c) A freshly prepared sample of Zr-81 contains 1.6×10^{16} atoms. The initial activity of the sample is 7.4×10^{14} Bq. Determine the half-life of Zr-81. [3]

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Option H — Optics

H1. This question is about refraction.

(a) Define *refractive index*. [1]

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(b) In a certain medium, the speed of light of a particular frequency is $2.1 \times 10^8 \text{ m s}^{-1}$. Calculate the refractive index of the medium for this frequency. [2]

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(c) With reference to your answer in (b), describe what is meant by optical dispersion. [3]

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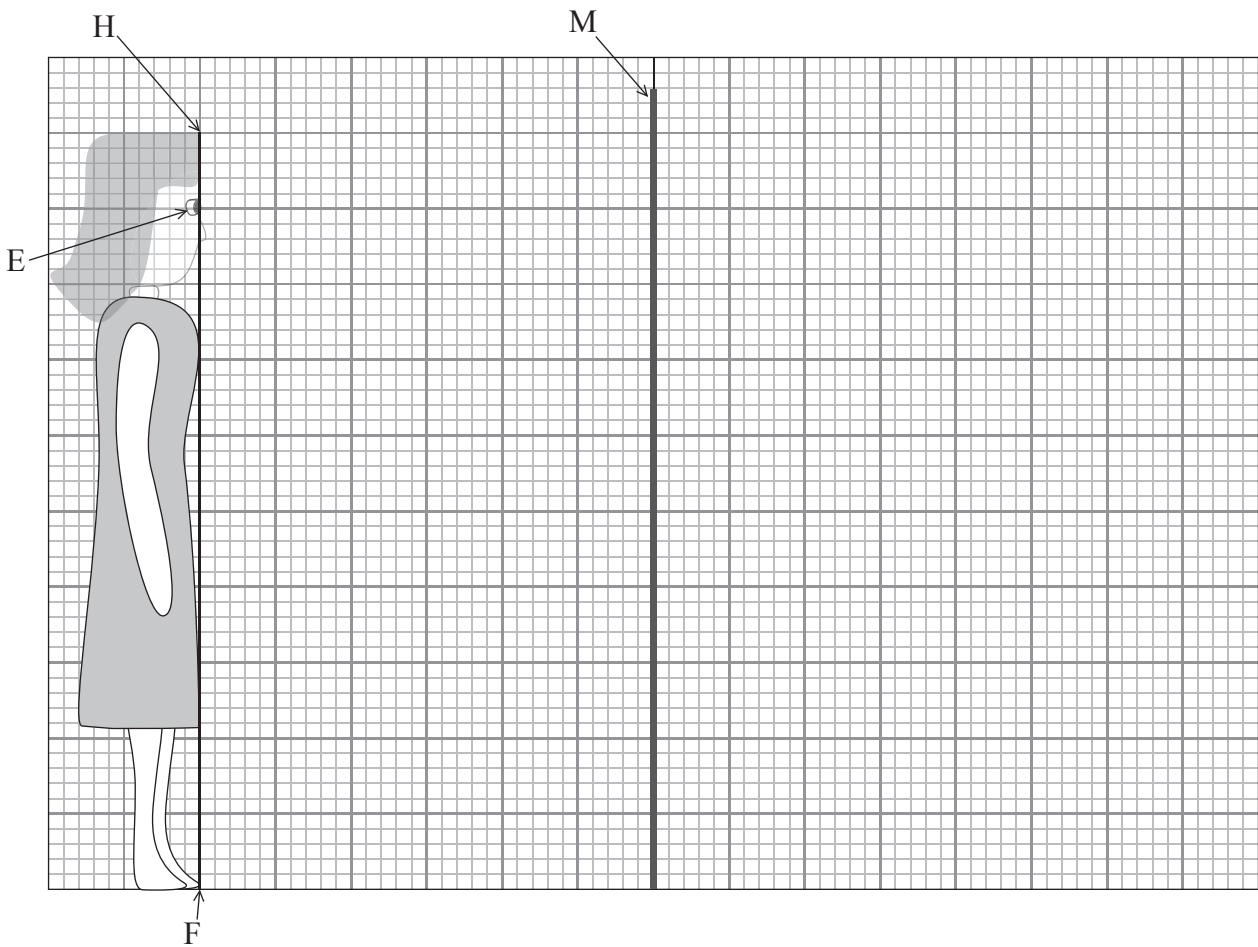


H2. This question is about image formation by a plane mirror.

(a) State the **two** laws of reflection of light. [2]

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(b) In the diagram below, the line labelled HF represents a person standing in front of a vertical mirror labelled M. The position of the person's eye is labelled E.



On the diagram above draw

(i) the position of the image of the person formed by the mirror. [2]

(ii) a ray from the foot F, and a ray from the top of the head H, to show the reflection of these rays into the eye E. [2]

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(Question H2 continued)

- (c) The height of the person is 1.50 m and her eye is 1.35 m above the floor. The length and height of the mirror above the floor are adjusted so that she can just see the whole of her image in the mirror.

By reference to your ray diagram in (b)(ii), deduce

- (i) the minimum length of the mirror. [1]

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- (ii) the height of the lower edge of the mirror above the floor. [1]

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- (d) The person now stands further away from the mirror. State the effect, if any, that this has to your answers in (c)(i) and (ii). [1]

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