MOMENTUM

IB Physics HL

Atomic physics - Set 1

E.1-E.3 | First assessment 2025 | Higher Level

Independent examination-style practice material

10 original problems

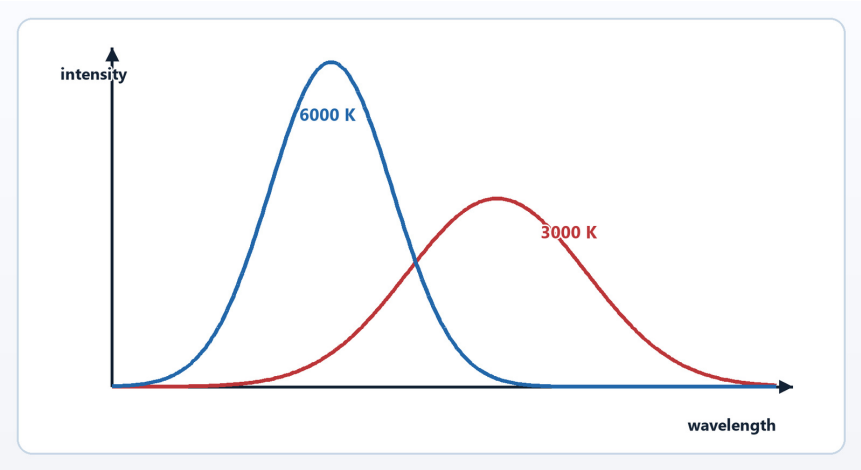
TASK 01

[6]

Black-body radiation at two temperatures

Paper 2 style | IB code E.1

Two identical black surfaces have temperatures 3000 K and 6000 K. Use Wien constant 2.90e-3 m K.



(a) Determine the peak wavelength for each surface. [2]

(b) Determine the ratio of their emitted powers per unit area. [2]

(c) Explain why the hotter curve has both a shorter peak wavelength and a larger area. [2]

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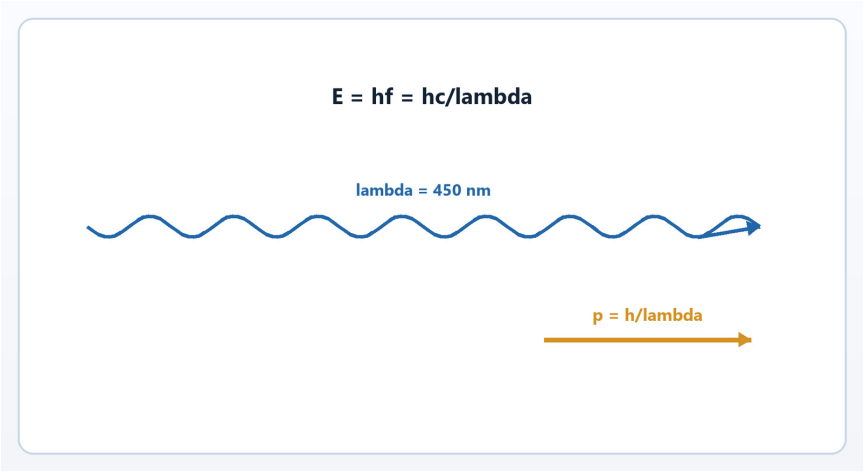
TASK 02

[6]

Photon energy and momentum

Paper 2 style | IB code E.1

A photon has wavelength 450 nm. Use h = 6.626e-34 J s and c = 3.00e8 m s^{-1}.



(a) Determine its frequency and energy in joules. [3]

(b) Determine its energy in eV and momentum. [3]

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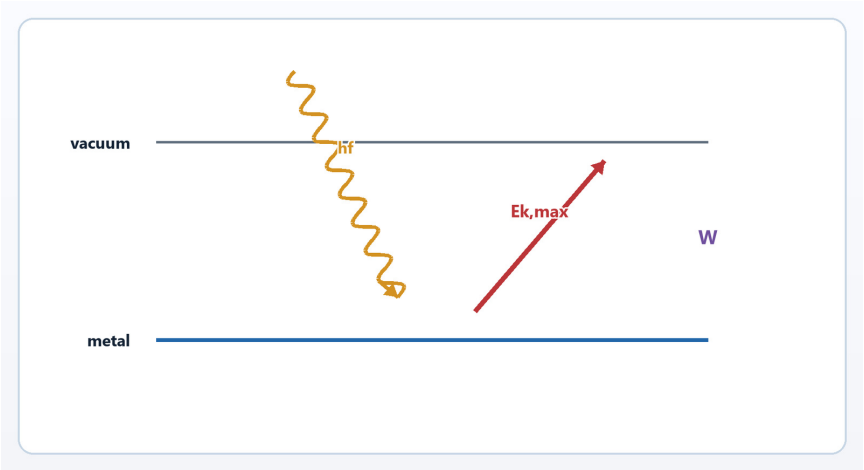
TASK 03
[7]

Photoelectric threshold and stopping potential

Paper 2 style | IB code E.2

A metal has photoelectric threshold wavelength 620 nm. It is illuminated with 400 nm light.



(a) Determine the work function in eV. [2]

(b) Determine the maximum electron kinetic energy and stopping potential. [3]

(c) State the effect of doubling light intensity at unchanged wavelength. [2]

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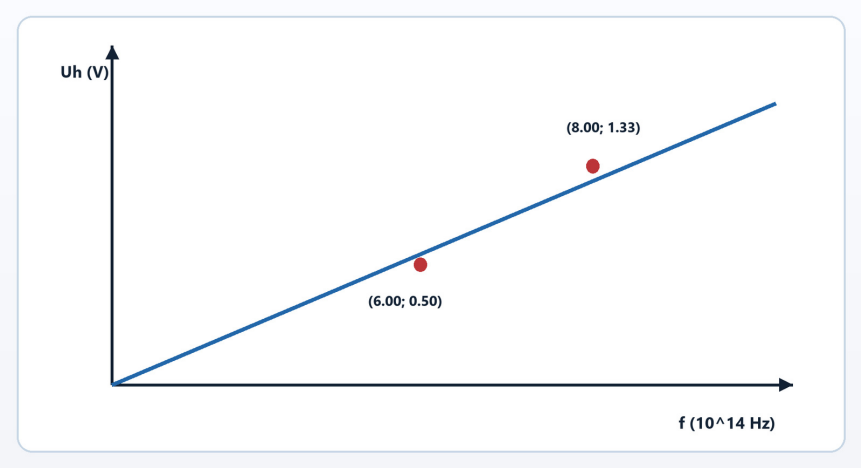
TASK 04

[6]

Planck's constant from a graph

Paper 2 style | IB code E.2

Stopping potentials are 0.50 V at 6.00e14 Hz and 1.33 V at 8.00e14 Hz for the same metal.



(a) Determine Planck's constant from the gradient. [3]

(b) Determine the work function and threshold frequency. [3]

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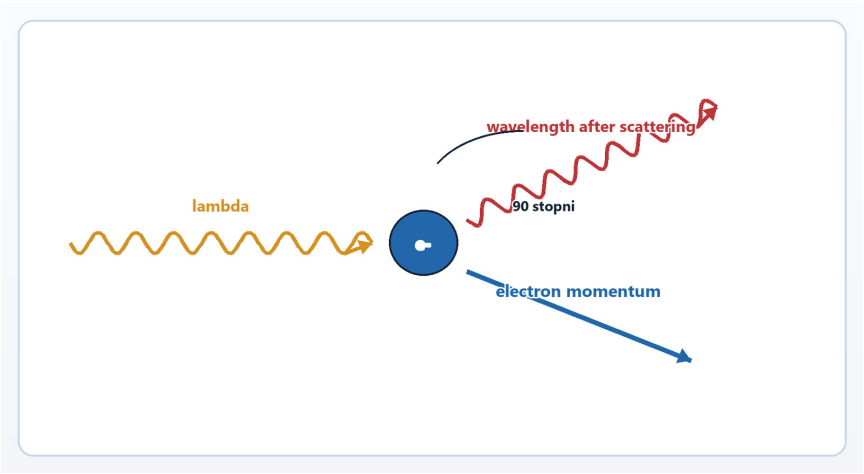
TASK 05
[6]

Compton scattering

Paper 2 style | IB code E.2

A 0.0710 nm X-ray photon scatters from a free electron through 90.0 degrees. The electron Compton wavelength is 2.426 pm.



(a) Determine the scattered wavelength. [2]

(b) Determine the kinetic energy gained by the electron. [3]

(c) State why the scattered wavelength is longer. [1]

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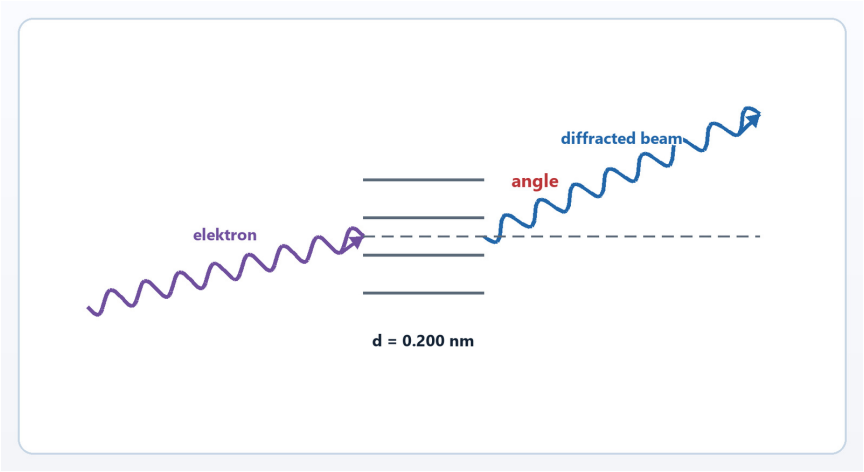
TASK 06

[6]

Electron diffraction from a crystal

Paper 2 style | IB code E.2

Electrons of wavelength 0.100 nm strike crystal planes separated by 0.200 nm.



(a) Determine the first-order Bragg angle. [2]

(b) The accelerating voltage is quadrupled. Determine the new wavelength and Bragg angle. [3]

(c) State what the diffraction demonstrates. [1]

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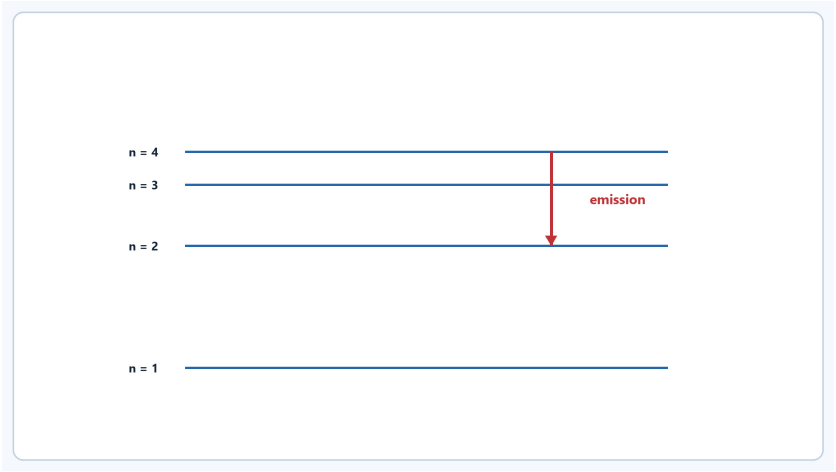
TASK 07

[6]

A hydrogen transition

Paper 2 style | IB code E.3

An electron in hydrogen changes from n = 4 to n = 2. Hydrogen energy levels are E_n = -13.6/n^2 eV.



(a) Determine the photon energy. [2]

(b) Determine its frequency and wavelength. [3]

(c) State the spectral series. [1]

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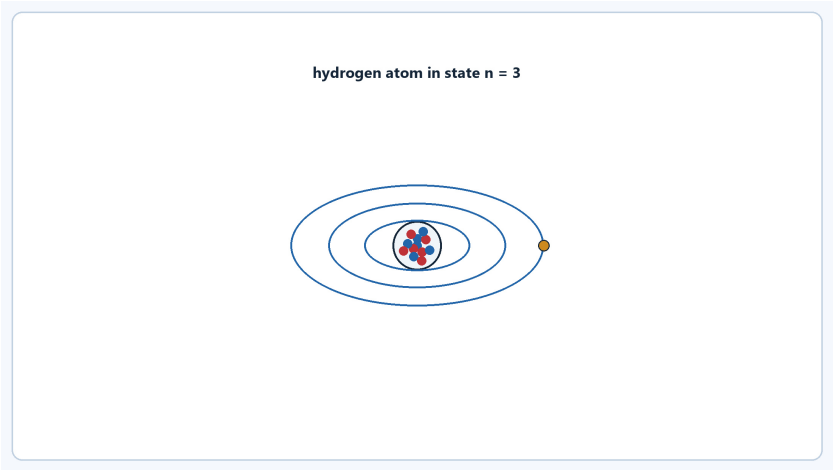
TASK 08
[6]

Ionizing hydrogen from an excited state

Paper 2 style | IB code E.3

A hydrogen atom is in state n = 3. Use a0 = 0.0529 nm.



(a) Determine the electron energy and the ionization energy from this state. [2]

(b) Determine the orbit radius in the Bohr model. [2]

(c) Determine the longest wavelength photon capable of ionization. [2]

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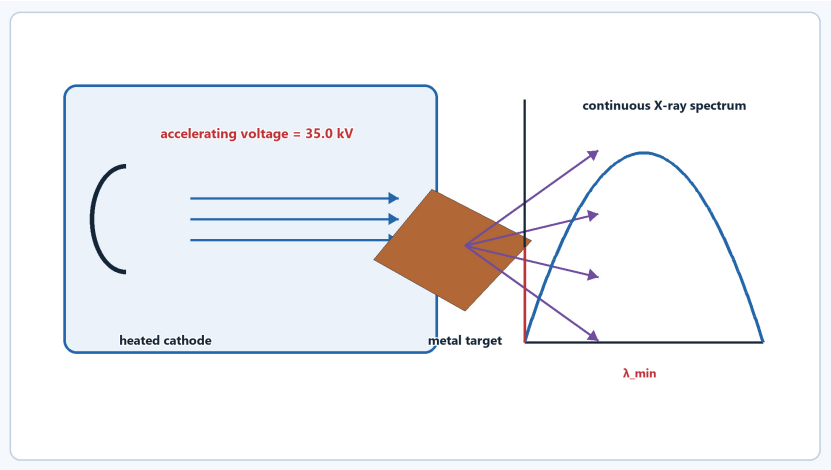
TASK 09

[6]

The short-wavelength limit of an X-ray tube

Paper 2 style | IB code E.3

An X-ray tube operates at 35.0 kV.



(a) Determine the maximum photon energy. [1]

(b) Determine the minimum wavelength. [2]

(c) Explain the origin of the continuous spectrum and the characteristic peaks. [3]

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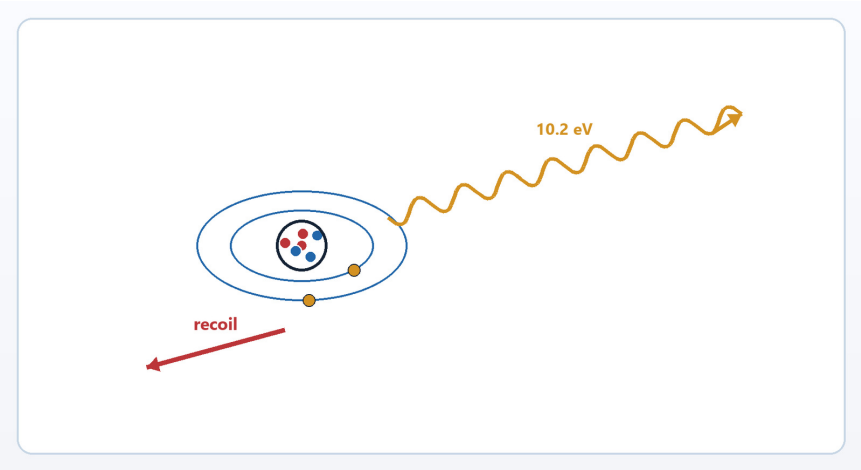
TASK 10

[7]

Atomic recoil after photon emission

Paper 2 style | IB code E.1, E.3

A stationary hydrogen atom emits a 10.2 eV photon. Take atom mass 1.67e-27 kg.



(a) Determine the photon momentum. [2]

(b) Determine the recoil speed of the atom. [2]

(c) Determine the recoil kinetic energy and comment on its size compared with 10.2 eV. [3]

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