

SECTION B

Answer ALL questions.

15 (a) Solar sails are a form of propulsion for spacecraft. The sail is made of a thin sheet of reflective material. When photons of light from the Sun reflect from the material a force is exerted on the sail. The photons reflect with a momentum equal to their initial momentum but in the opposite direction.

(i) Show that a single photon of frequency 1.5×10^{15} Hz has a momentum of about 3×10^{-27} N s.

(2)

(ii) Hence determine the momentum transferred to the solar sail by this photon.

(1)

Momentum transferred =

(b) An alternative method of producing a momentum change is being investigated. Researchers have suggested that 'larger changes in momentum could be produced by directing laser light at graphene oxide'. Electrons are emitted from the graphene oxide surface, resulting in a force being exerted on the graphene oxide in the opposite direction.

A researcher has suggested that one possible mechanism for the emission of the electrons is the photoelectric effect.

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- (i) Show that the maximum velocity for a photoelectron emitted after absorption of a photon of light of frequency 1.5×10^{15} Hz is about 8×10^5 m s⁻¹.

work function of graphene oxide = 6.7×10^{-19} J

(3)

- (ii) Hence calculate the momentum of the photoelectron.

(2)

Momentum of photoelectron =

- (c) Explain whether the suggestion in (b) that ‘larger changes in momentum could be produced by directing laser light at graphene oxide’ is true.

(2)

(Total for Question 15 = 10 marks)

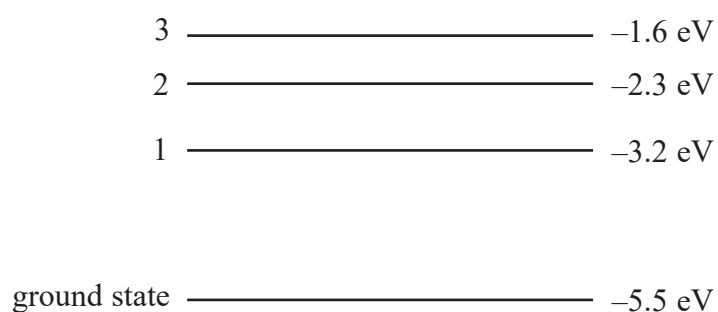
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5 The diagram shows the lowest energy levels for a certain atom.



A photon with energy 3.2 eV is absorbed.

An electron could move from

- A ground state to level 1.
- B ground state to level 2.
- C level 1 to ground state.
- D level 2 to ground state.

(Total for Question 5 = 1 mark)

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- 4 Einstein's photoelectric equation states

$$hf = \phi + \frac{1}{2}mv_{\max}^2$$

The quantity denoted by ϕ is the minimum

- A amount of energy of a photon needed to release an electron.
- B amount of energy of an electron needed to release a photon.
- C frequency of a photon needed to release an electron.
- D frequency of an electron needed to release a photon.

(Total for Question 4 = 1 mark)

