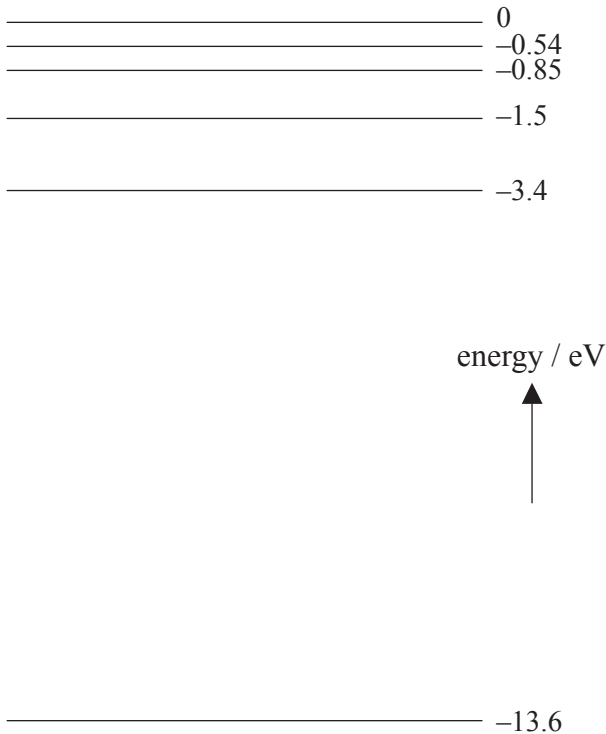


**Option B — Quantum Physics and Nuclear Physics**

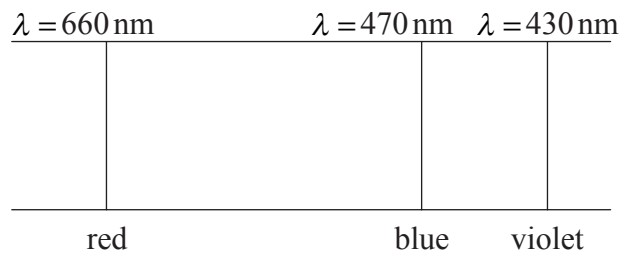
**B1.** This question is about energy levels and atomic models.

- (a) Diagram 1 below shows some of the energy levels (measured in electron-volts) of the hydrogen atom. Diagram 2 is a representation of part of the visible spectrum of atomic hydrogen (not to scale).

**Diagram 1**



**Diagram 2**



- (i) State the value of the ionization energy of hydrogen. [1]

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- (ii) The wavelength corresponding to the red line in the visible spectrum of atomic hydrogen is 660 nm. Deduce that the energy of a photon of wavelength 660 nm is 1.9 eV. [3]

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*(This question continues on the following page)*



(Question B1 continued)

(iii) On **diagram 1**, draw an arrow to show the electron transition between energy levels that gives rise to a photon of energy 1.9 eV. Label this arrow with the letter R. [1]

(iv) On **diagram 1** and using your answer to (iii), draw arrows to show the electron transitions that give rise to the blue line and to the violet line in the visible spectrum of atomic hydrogen. Label these arrows B and V respectively. [1]

(b) The kinetic energy of an electron in the ground state of a hydrogen atom is 13.6 eV. Deduce that an electron in the ground state of the hydrogen atom has a de Broglie wavelength of approximately  $3.3 \times 10^{-10}$  m (mass of electron =  $9.1 \times 10^{-31}$  kg). [4]

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(c) The “radius” of the hydrogen atom is of the order of  $10^{-10}$  m. Outline how the value of the de Broglie wavelength in (b) is consistent with the Schrödinger model of the hydrogen atom. [3]

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**B2.** This question is about radioactive decay.

(a) Define the term *decay constant*. [1]

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(b) The isotope potassium-40 undergoes beta decay to form the isotope calcium-40.

State the name of the

(i) interaction responsible for this decay process. [1]

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(ii) exchange particle associated with the interaction in (i). [1]

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(c) The mass of potassium-40 and the mass of calcium-40 in a sample of some rocks is measured. The following data are available:

mass of potassium-40                      = 5.0 mg  
mass of calcium-40                         = 24 mg  
decay constant of potassium-40 =  $5.3 \times 10^{-10} \text{ year}^{-1}$

When the rocks were created they contained no calcium-40 but did contain potassium-40. By determining the time that has elapsed since there was only potassium-40 in the sample, calculate the age of the rocks. [4]

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