For Examiner's Use

7 **(a)** Explain what is meant by a *photon*.

……

……

…… [2]

(b) **(i)** Describe the appearance of a visible line emission spectrum.

……

…… [1]

(ii) Explain how the emission line spectra provides evidence for discrete energy levels in isolated atoms.

……

……

……

…… [2]

(c) The energy levels in eV of the electron in the hydrogen atom are given by

$$E = -\frac{13.6}{n^2},$$

where n = 1, 2, 3, …

(i) Explain what is meant by the ground state of an atom.

……

…… [1]

(ii) The electron in the hydrogen atom is in its ground state.

Calculate the energy in joules required to remove this electron from the atom.

energy = …… J [2]

For Examiner's Use

(d) The wavelengths λ of electromagnetic radiation emitted by hydrogen atoms when electrons move to level $n = 2$ from a higher level m is given by the formula

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{m^2}\right) \quad , \quad m = 3, 4, 5, ...$$

where R is a constant called Rydberg constant.

(i) Show that R is 1.09×10^7 m^{-1}.

[3]

(ii) Calculate the longest wavelength of the photons emitted for electron transitions to level $n = 2$.

longest wavelength = …… m [2]

(iii) State the region of the electromagnetic spectrum this wavelength belongs to.

…… [1]

[Turn over

For Examiner's Use

(e) De Broglie proposed that particles such as electrons exhibit wave behaviour and have an associated wavelength called the de Broglie wavelength. To explain the existence of discrete energy levels in an atom, de Broglie further proposed that electrons in an atom can only occupy orbits in which the circumference of the orbit is equal to whole number multiples of the electron wavelength. Hence, electrons can only possess specific energies associated with these allowed orbits.

(i) State an evidence that shows that electrons behave like waves.

…… [1]

(ii) A particular allowed orbit in the hydrogen atom has a radius 4.78×10^{-10} m. The circumference of this orbit is equal to three times the electron wavelength.

Determine the velocity v of an electron in this orbit.

v = …… m s^{-1} [3]

(iii) If the uncertainty in the position of an electron in this orbit is 0.0100 nm, determine the uncertainty in the electron's velocity.

uncertainty = …… m s^{-1} [2]

[Total: 20]

End of Paper