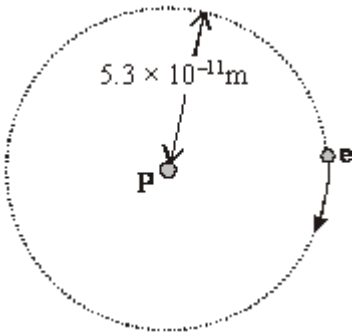
Name of the Student:_____
Max. Marks : 26 Marks **Time : 26 Minutes**

Q1.

The Bohr model of a hydrogen atom assumes that an electron **e** is in a circular orbit around a proton **P**. The model is shown schematically in **Figure 1**.

Figure 1



In the ground state the orbit has a radius of 5.3×10^{-11} m. At this separation the electron is attracted to the proton by a force of 8.1×10^{-8} N.

(a) State what is meant by the ground state.

_____

_____

(1)

(b) (i) Show that the speed of the electron in this orbit is about 2.2×10^{6} m s^{-1}.
mass of an electron = 9.1×10^{-31} k g

(3)

(ii) Calculate the de Broglie wavelength of an electron travelling at this speed.
Planck constant = 6.6×10^{-34} J s

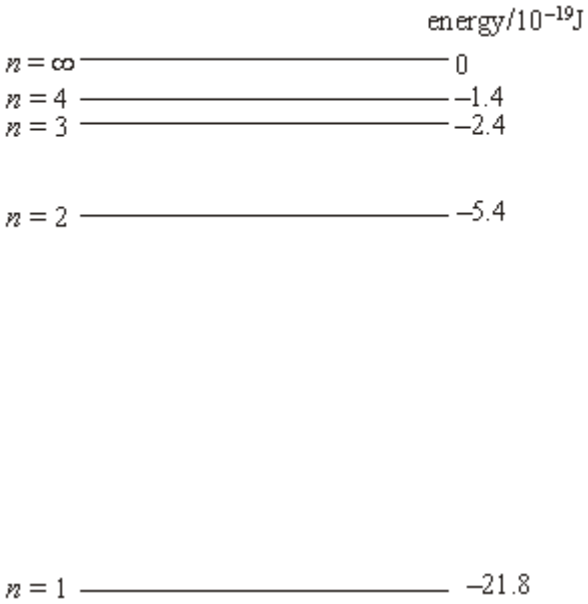
(2)

(iii) How many waves of this wavelength fit the circumference of the electron orbit? Show your reasoning.

(2)

(c) The quantum theory suggests that the electron in a hydrogen atom can only exist in certain well-defined energy states. Some of these are shown in **Figure 2**.

Figure 2



An electron **E** of energy 2.5×10^{-18} J collides with a hydrogen atom that is in its ground state and excites the electron in the hydrogen atom to the $n = 3$ level.

Calculate

(i) the energy that is needed to excite an electron in the hydrogen atom from the ground state to the $n = 3$ level,

(1)

(ii) the kinetic energy of the incident electron **E** after the collision,

(1)

(iii) the wavelength of the lowest energy photon that could be emitted as the excited electron returns to the ground state.

speed of electromagnetic radiation = 3.0×10^8 m s^{-1}

(3)

(Total 13 marks)

Q2.

A girl sits at rest on a garden swing. The swing consists of a wooden seat of mass 1.2 kg supported by two ropes. The mass of the girl is 16.8 kg. The mass of the ropes should be ignored throughout this question.

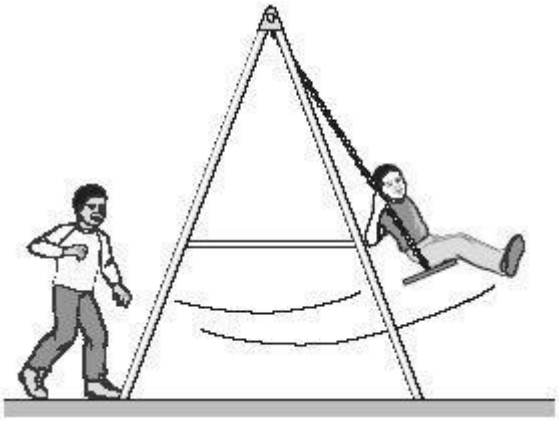


Figure 1

(a) A boy grips the seat and gives a firm push with both hands so that the girl swings upwards as shown in **Figure 1**. The swing just reaches a vertical height of 0.50 m above its rest position.

(i) Show that the maximum gain in gravitational potential energy of the girl and the swing is about 88 J.

acceleration due to gravity = 9.8 m s^{-2}

(3)

(ii) The work done against resistive forces as the swing moves upwards is 20 J. Calculate the work done on the swing by the boy during the push.

(1)

(iii) As he pushed, the boy's hands were in contact with the seat of the swing for a distance of 0.40 m. Calculate the average force applied to the swing.

(2)

(b) Calculate the speed of the girl as she passes back through the lowest point of her ride for the first time. Assume that the work done against resistive forces is the same in both directions.

(4)

(c) The girl is not pushed again. On the axes in **Figure 2**, sketch a graph to show how the kinetic energy of the girl varies with time over two complete cycles of the motion. Start your graph from the time when she is 0.50 m above the rest position. You are not required to mark a scale on either axis.

Figure 2

(3)

(Total 13 marks)