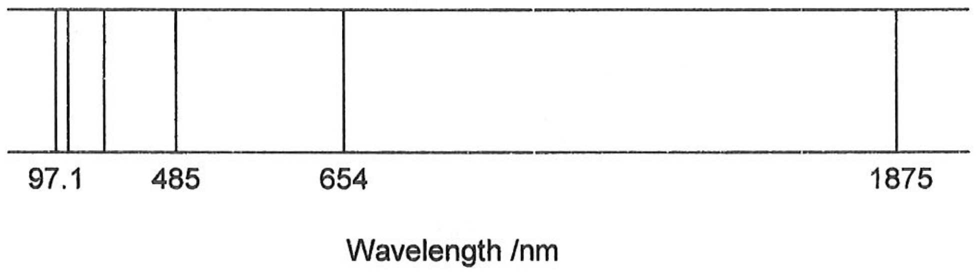
Section C Answer only ONE question on writing paper.
(You are advised to spend not more than 30 minutes on a question.)

33(a) (i) Emission spectra are often produced in the laboratory using a discharge lamp containing gas to be investigated. Explain briefly the physical processes occurring within such a lamp which lead to the production of an emission spectrum. [2]

(ii) The figure below shows the line emission spectrum of hydrogen due to transitions between exactly 4 lowest energy levels. The wavelengths of lines are indicated on the figure. There are no lines in this series with wavelengths less than 97.1 nm.



1. Calculate the energy of the photon that gives rise to each of the indicated wavelengths.

2. Hence draw a partial energy level diagram for hydrogen indicating the energy of each level clearly. (Assign 0 J to the lowest energy level)

3. On the partial energy level diagram, show clearly with labelled arrow the transitions A which gives rise to the 97.1 nm line.

[7]

(b)

(i) With a simple diagram of the experimental set-up, explain how Rutherford's α-particle scattering experiment provided evidence for the existence and small size of the nucleus within an atom. [4]

(ii) A tube containing an isotope of radon ($^{222}_{86}Rn$), is to be implanted in a patient for cancer treatment. Radon spontaneously decays by alpha emission to polonium (Po). The α-particle is emitted with an energy of 8.61×10^{-13} J.

1. Write down a nuclear equation to represent α-decay of the radon nucleus.

2. Find the speed with which the α-particle is ejected from the radon nucleus.

3. Calculate the energy released in this decay and hence determine the speed of the Polonium nucleus.

4. Suggest a reason why an alpha emitter is preferred to a beta or gamma emitter for such medical purposes.

[7]

Some useful constants:

Mass of radon nucleus	=	222.01757 u
Mass of polonium nucleus	=	218.00908 u
Mass of alpha particle	=	4.00260 u

34(a) Write down the defining equation of magnetic flux and explain the symbols used. [2]

(b) A metal rod WX of mass 6.0 g is placed on parallel conducting rails on a slope at 23° as shown in Fig 34.1. The rails are separated by a distance 0.15 m. Y and Z are at the upper ends of the rails. A vertical magnetic field B of flux density 0.40 T acts vertically downwards on the setup.

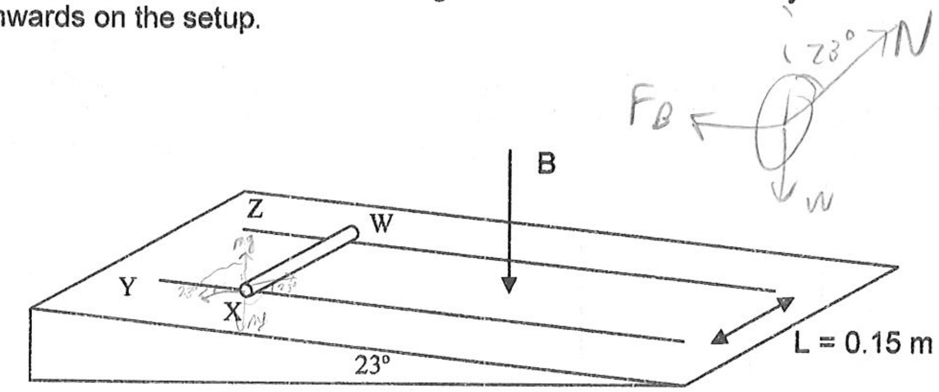


Figure 34.1

(i) A direct current supply is connected between YZ such that the rod is stationary.

1. Draw a free body diagram of the cross-section of the rod when it is stationary. Indicate clearly any significant angle(s).

2. State the direction of current in the rod for it to remain stationary. X to W

3. Show that the required value of current for it to remain stationary is 0.37 A. $mg \tan 23° = BIL$ $N \cos 23 = W$

$I = 0.42A$ $N \sin 23 = BIL$

[5]

(ii) When the direct current supply is removed and a connecting wire is attached between YZ, the rod is found to slide downslope.

$E = \frac{d}{dt}\phi = \frac{d}{dt}(BA\cos\theta)$
$= (B\cos\theta)(\frac{d}{dt}A)$
$= (B\cos 23)(LV)$
$I = \frac{E}{R} = \cancel{0.24}\ 0.242A$

$P = I^2R$

1. If the resistance of the rod is 0.20 Ω and the resistance of the rest of the loop is negligible, find the magnitude and direction of the induced current in the rod when it is sliding at 0.90 m s^{-1}.

2. Use Lenz's Law to explain whether the magnetic force due to this current flow in the presence of the magnetic field tends to accelerate or stop the rod. Hence, explain how energy is conserved in this situation.

3. Find the terminal speed of the rod as it slides without friction down the slope. N

4. State and explain the effect on the terminal velocity if the rod (mg) is replaced with another of the same mass but of material that has half the density. The length of the rod remains the same.

$mg =$ [13]