Name of the Student:_____
Max. Marks : 20 Marks **Time : 20 Minutes**

Q1.

An electric wheelchair, powered by a battery, allows the user to move around independently.

One type of electric wheelchair has a mass of 55 kg. The maximum distance it can travel on level ground is 12 km when carrying a user of mass 65 kg and travelling at its maximum speed of 1.5 m s^{-1}.

The battery used has an emf of 12 V and can deliver 7.2×10^4 C as it discharges fully.

(a) Show that the average power output of the battery during the journey is about 100 W.

(3)

(b) During the journey, forces due to friction and air resistance act on the wheelchair and its user.

Assume that all the energy available in the battery is used to move the wheelchair and its user during the journey.

Calculate the total mean resistive force that acts on the wheelchair and its user.

total mean resistive force = _____ N

(2)

The diagram below shows the wheelchair and its user travelling up a hill. The hill makes an angle of 4.5° to the horizontal.

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(c) Calculate the force that gravity exerts on the wheelchair and its user parallel to the slope.

force parallel to the slope = _____ N

(1)

(d) Calculate the maximum speed of the wheelchair and its user when travelling up this hill when the power output of the battery is 100 W.

Assume that the resistive forces due to friction and air resistance are the same as in part (b).

maximum speed = _____ m s^{-1}

(2)

(e) Explain how and why the maximum range of the wheelchair on level ground is affected by

- the mass of the user
- the speed at which the wheelchair travels.

Effect of mass _____

_____

_____

_____

_____

_____

Effect of speed _____

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(4)
(Total 12 marks)

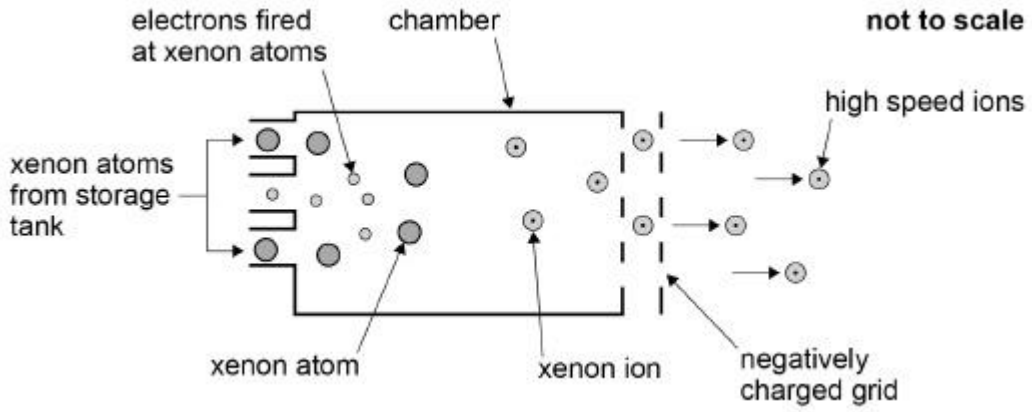
Q2.

Figure 1 represents an ion propulsion unit used on a spacecraft launched in 1998.

Atoms of xenon-131 ($^{131}_{54}Xe$) were injected from a storage tank into a chamber where they became ionised due to collisions with electrons.

A negatively charged grid attracted the xenon ions, accelerating them out of the back of the ion propulsion unit and causing the spacecraft to be propelled forward.

Figure 1



(a) The mass of a Xe^+ ion is 2.18×10^{-25} kg.

Calculate the specific charge of a Xe^+ ion.

Give an appropriate unit for your answer.

specific charge = _____ unit _____

(2)

(b) The storage tank contained 79 kg of xenon. When the ion propulsion unit was switched on it had an average power output of 2.1 kW.

Each xenon ion gained 1300 eV of energy as it was accelerated and ejected out of the propulsion unit.

Calculate the energy, in J, gained by each xenon ion.

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energy = _____ J

(1)

(c) Determine the length of time the ion propulsion unit operated before all of the 79 kg of xenon was used up.

mass of xenon atom = 2.18×10^{-25} kg

time = _____ s

(3)

(d) Ion propulsion units could use helium ions instead of xenon ions.

An ion of helium-4 (He^{+}) has a much higher specific charge than an ion of xenon-131 (Xe^{+}). Both ions would gain 1300 eV of kinetic energy in being accelerated and ejected from an ion propulsion unit.

Suggest whether helium ions or xenon ions are better to use as a propellant in future space programmes. In your answer you should compare the relative speeds and momentum changes of the ions.

_____

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_____

(3)

(Total 9 marks)

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