Name of the Student:_____
Max. Marks : 24 Marks **Time : 24 Minutes**

Q1.

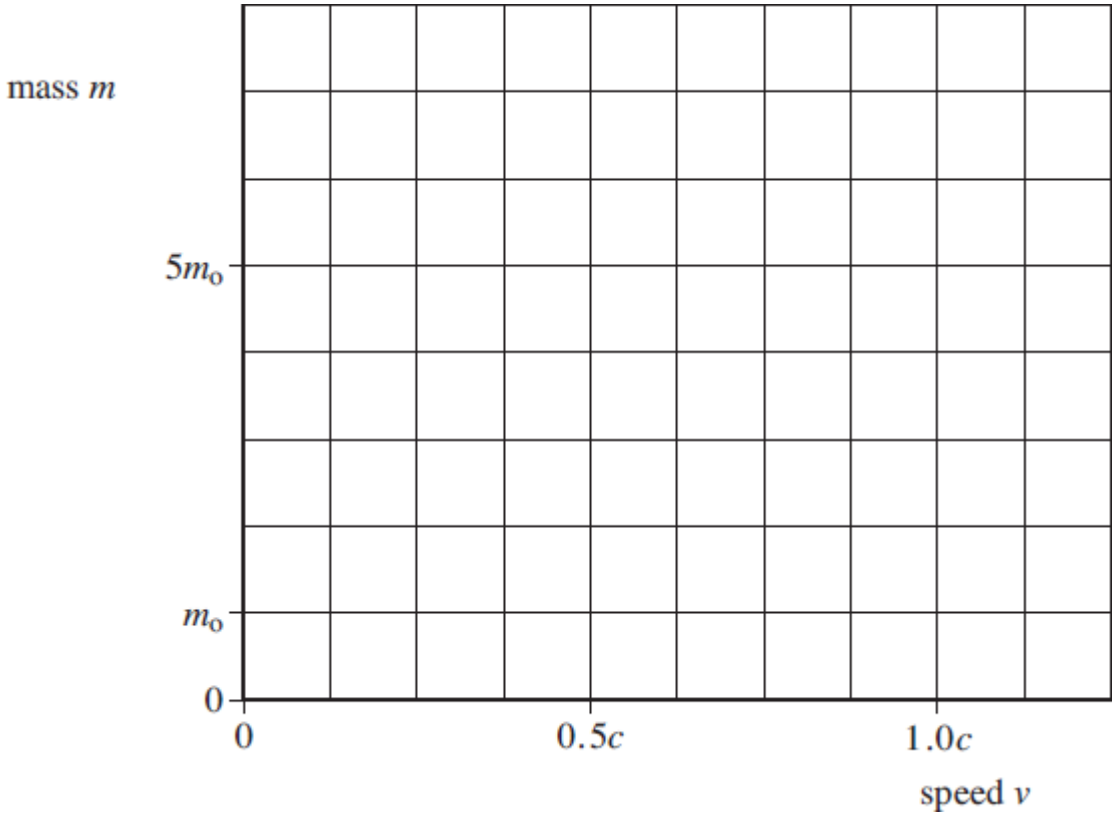
(a) Calculate the speed of a particle at which its mass is twice its rest mass.

speed _____ m s^{-1}

(2)

(b) Use the axes below to show how the mass *m* of a particle changes from its rest mass m_o as its speed *v* increases from zero.

Mark and label on the graph the point **P** where the mass of the particle is twice its rest mass.



(3)

(c) By considering the relationship between the energy of a particle and its mass, explain why the

theory of special relativity does not allow a matter particle to travel as fast as light.

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_____

_____

_____

(2)

(Total 7 marks)

Q2.

(a) State de Broglie's hypothesis.

_____

_____

_____

(2)

(b) Neutrons in a narrow beam can be diffracted by crystals thereby exhibiting wave behaviour. Calculate the de Broglie wavelength of a neutron of kinetic energy 0.021 eV. Give your answer to an appropriate number of significant figures.

de Broglie wavelength _____ m

(4)

(c) Explain why an electron of the same de Broglie wavelength as the neutron in part (b) has much more kinetic energy than 0.021 eV. Assume relativistic effects are negligible.

_____

_____

_____

_____

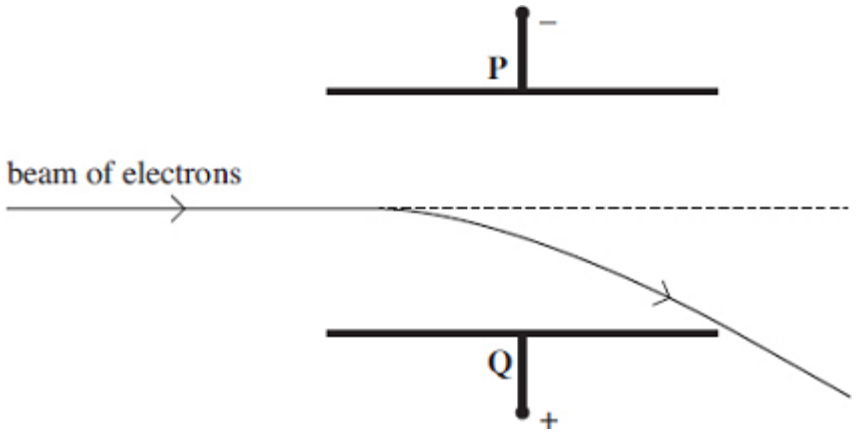
_____

(2)

(Total 8 marks)

Q3.

A narrow beam of electrons is directed into the region between two parallel plates, **P** and **Q**. When a constant potential difference is applied between the two plates, the beam curves downwards towards plate **Q** as shown in the figure below.



(a) Explain why the beam curves downwards at an increasing angle to its initial direction.

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_____

(3)

(b) A uniform magnetic field is then applied at right angles to both the beam and the electric field between the plates **P** and **Q**. As a result, the downward deflection of the beam is increased.

(i) The arrangement is to be used to determine the speed of the electrons in the beam. Describe what adjustments to the flux density *B* of the magnetic field should be made to reduce the deflection of the beam to zero.

_____

_____

_____

(1)

(ii) Explain why the electrons pass undeflected through the fields when their speed *v* is given by

$$v = \frac{V}{Bd}$$

where *V* is the potential difference between plates **P** and **Q** and *d* is the perpendicular distance between the plates.

_____

(2)

(c) The beam of electrons was produced by thermionic emission from a heated filament. When the potential difference between the anode and the filament was 4200 V, the speed of the electrons in the beam was 3.9×10^7 ms^{-1}.

Use this information to determine the specific charge of the electron.

answer = _____ $C\ kg^{-1}$

(3)

(Total 9 marks)