2 **(a)** With a suitable definition of the unit of force, Newton's second law can be written as the following relationship

force = mass x acceleration

for a body of constant mass.

Using this definition together with Newton's third law, deduce the principle of conservation of momentum.

....

....

....

....

....

.... [2]

(b) In an experiment, an α-particle of mass m and initial velocity v_0 is directed head-on towards a stationary heavy nucleus of mass M from afar. The variations with time of the velocities of the α-particle and the nucleus are shown in Fig. 2.1.

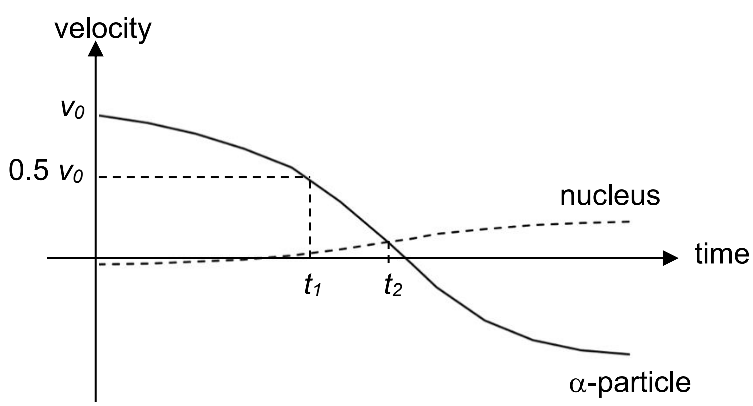

Fig. 2.1

(i) Write down, in terms of m and v_0, an expression for the momentum of the nucleus at time t_1.

[1]

(ii) Explain how you obtained the expression in **(b)(i)**.

....

....

....

.... [2]

(iii) The α-particle is closest to the nucleus at time t_2. The velocity of the α-particle at this time is v.

Determine the velocity v of the α-particle in terms of m, M and v_0.

velocity = ... [2]

(c) In a separate experiment, an alpha particle collides head-on with a stationary nitrogen-14 atom. The nitrogen atom moves off in the same direction as the approaching alpha particle with a speed of 0.005 c, where c is the speed of light.

Discuss quantitatively whether the interaction is elastic in nature if the initial speed of the alpha particle is 0.02 c.