6 **(a)** A child starts to skate from rest in a straight line along a horizontal asphalt surface. The force of rolling (static) friction between her skates and the road is constant at 160 N.

Fig. 6.1 shows the relationship between the driving force F_D that she exerts and her distance x from her starting position. She has a mass of 30.5 kg.

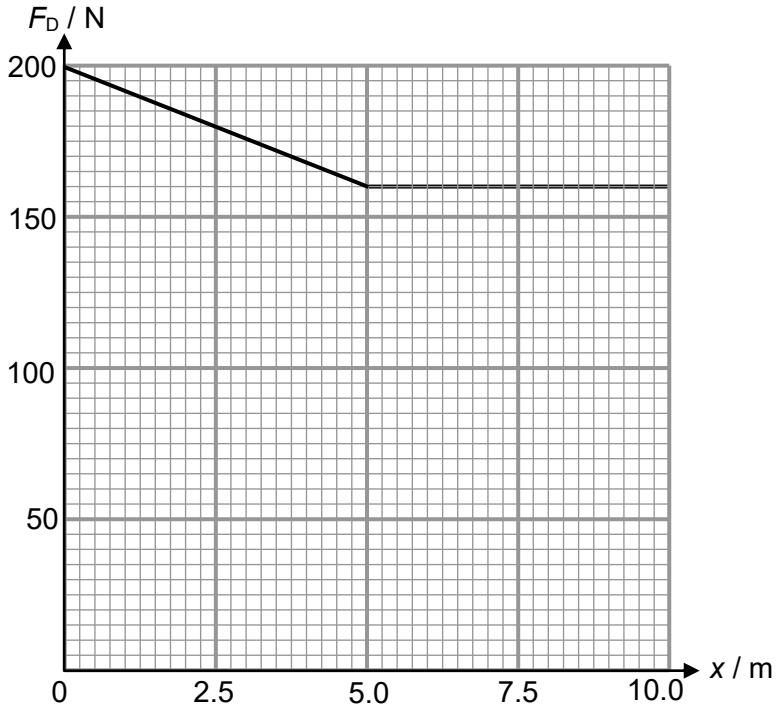

Fig. 6.1

(i) Calculate the work done by the child in the first 5.0 m of travel.

work done = …….. J [1]

(ii) Determine her speed after travelling 10.0 m.

speed = …….. m s^{-1} [2]

(b) Muons and anti-muons have the same mass. When a muon meets an anti-muon, both are destroyed and two gamma photons are formed. If the muon and anti-muon have negligible kinetic energy and the two photons have a total energy of 3.38×10^{-11} J, determine the mass of a muon.

mass = ……. kg [2]

(c) A method of producing a range of artificial isotopes is 'neutron activation'. This is where a stable isotope is bombarded by a neutron to produce an unstable isotope, which in turn decays by beta emission to produce a new element.

By writing two nuclear equations, deduce the final isotope produced by neutron activation of deuterium, $^{2}_{1}\mathrm{H}$.

Equation 1: ……..

Equation 2: ……..

final isotope = …… [2]

(d) We now know that during beta decay, the neutrino is emitted. But before its discovery, physicists analysing emitted beta particles were perplexed by the continuous spread of its energy.

Explain why this continuous energy spectrum was a problem to physicists.

……..……..……...

……..……..……...

……[2]

(e) One isotope of potassium, $^{40}_{19}K$ has a half-life of 1.37×10^9 years and decays to form argon, $^{40}_{18}Ar$, which is stable. A lunar sample of rock was discovered to contain both elements in the ratio

$$\frac{\text{number of K-40 atoms}}{\text{number of Ar-40 atoms}} = \frac{1}{6} .$$

(i) Estimate the age of this sample.

age = …… years [2]

(ii) State and explain whether the answer in **(e)(i)** is an underestimate or overestimate if some argon had escaped from the rock.

……

……

……[2]

[Total: 13]