7 **(a)** Describe the structure of an **atom** of uranium-238, $^{238}_{92}U$.

....

....

.... [2]

(b) The decay of uranium-238 is shown by the equation

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + X.$$

For nucleus X, calculate the ratio, in $C\,kg^{-1}$, of

$$\frac{\text{charge}}{\text{mass}}.$$

ratio = ... $C\,kg^{-1}$ [3]

(c) Two particles P and Q each consist of three quarks. These quarks are up (u) or down (d) quarks.

Particle P has no overall charge.

Particle Q has an overall charge of $+2e$, where e is the elementary charge.

State the quark composition of:

(i) particle P

.... [1]

(ii) particle Q.

.... [1]

[Total: 7]

4 A child moves down a long slide, as shown in Fig. 4.1.

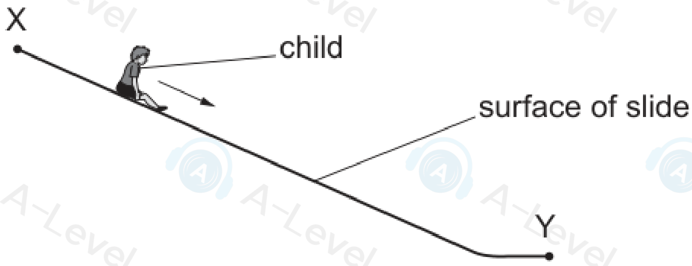

Fig. 4.1 (not to scale)

The child moves from rest at the top end X of the slide. An average resistive force of 76 N opposes the motion of the child as they move to the lower end Y of the slide. The kinetic energy of the child at Y is 300 J. The decrease in gravitational potential energy of the child as it moves from X to Y is 3200 J.

(a) Determine the ratio

$$\frac{\text{kinetic energy of the child at Y when the resistive force is 76 N}}{\text{kinetic energy of the child at Y if there is no resistive force}}.$$

ratio = ... [1]

(b) Use the answer in **(a)** to calculate the ratio

$$\frac{\text{speed of the child at Y when the resistive force is 76 N}}{\text{speed of the child at Y if there is no resistive force}}.$$

ratio = ... [2]

(c) Calculate the length of the slide from X to Y.

length = ... m [2]

(d) At end Y of the slide, the child is brought to rest by a board, as shown in Fig. 4.2.

4 A horizontal spring is fixed at one end. A block is pushed against the other end of the spring so that the spring is compressed, as shown in Fig. 4.1.

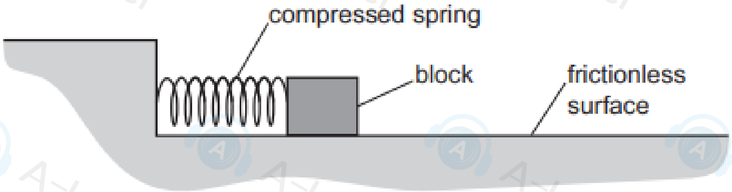

Fig. 4.1

The block is released and accelerates along a horizontal frictionless surface as the spring returns to its original length. The block leaves the end of the spring with a speed of $2.3\,\mathrm{m\,s^{-1}}$, as shown in Fig. 4.2.

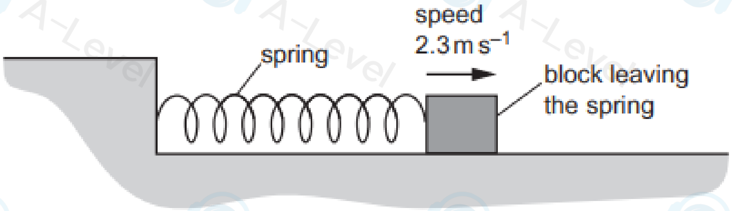

Fig. 4.2

The block has a mass of $250\,\mathrm{g}$ and the spring has a spring constant of $420\,\mathrm{N\,m^{-1}}$.

Assume that the spring always obeys Hooke's law and that all the elastic potential energy of the spring is transferred to the kinetic energy of the block.

(a) Calculate the kinetic energy of the block as it leaves the spring.

kinetic energy = ... J [2]

(b) Calculate the compression of the spring immediately before the block is released.

compression = ... m [2]

(c) After leaving the spring, the block moves along the surface until it hits a barrier at a speed of $2.3\,m\,s^{-1}$. The block then rebounds at a speed of $1.5\,m\,s^{-1}$ and moves back along its original path. The block is in contact with the barrier for a time of 0.086 s.

Calculate:

(i) the change in momentum of the block during the collision

change in momentum = ... Ns [2]

(ii) the average resultant force exerted on the block during the collision.

average resultant force = ... N [1]

(d) The maximum compression x of the spring is now varied in order to vary the kinetic energy E_K of the block as it leaves the spring. Assume that all the elastic potential energy in the spring is always transferred to the kinetic energy of the block.

On Fig. 4.3, sketch a graph to show the variation with x of E_K.

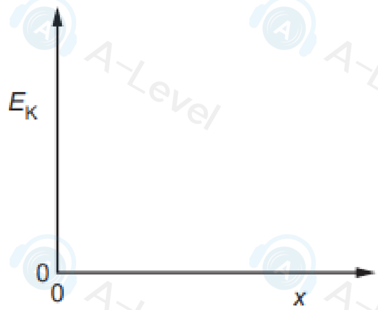

Fig. 4.3

[1]

[Total: 8]