Exercise 3.4 Energy transfers

1 A firework rocket of mass 50 g is set off from the ground. It travels vertically upwards until it explodes in a shower of brightly coloured sparkles. (Use $g = 10\ \text{ms}^{-2}$.)

a Outline the energy transformations taking place as the rocket sets off and moves vertically upwards.

b When the rocket explodes at the top of its trajectory, what energy transformation(s) occur?

c If the rocket reaches 150 m above the ground when it explodes,

i what is the minimum amount of chemical energy the rocket stored before it was set off?

ii why is your answer to **part i** a minimum?

2 A worker pushes a large block of stone horizontally along some rough ground at a constant speed.

a Outline the energy transformations taking place.

b How does the horizontal component of the force being applied by the worker compare to the kinetic frictional force between the block and the ground?

c Suggest why the actual force applied by the worker is larger than the kinetic frictional force between the block and the ground.

3 A pendulum consisting of an inelastic string attached to a mass is made to oscillate to-and-fro with a large amplitude.

a Outline the energy transformations that occur during one compete oscillation.

b How might your answer to **part a** differ if the string were replaced by an elastic string?

4 Comets move in highly elliptical orbits around the Sun. Outline any energy transformations that take place during a comet's orbit.

5 A car is driving at a constant speed up an incline that is covered with loose gravel.

List as many energy transformations that are occurring as you can.

TIP

You may find this question easier to answer *after* you have worked through Unit D.

6 Lord Rutherford and his research team of Hans Geiger and Ernest Marsden fired alpha particles (the nuclei of helium atoms) at nuclei of gold atoms to investigate the structure of atoms.

Outline any energy transformations that occurred during the paths that the alpha particles followed as they approached and were deflected by the helium nuclei.

7 **a** Consider a mass tethered between two horizontal springs that is oscillating from side to side. Outline the energy transformations that take place during one complete oscillation. You may assume no friction.

b Now consider a mass oscillating in a vertical plane on the end of a spring. Outline the energy transformations taking place during one complete oscillation.

8 Outline the main energy transformations that take place in a hydroelectric power station.

TIP

This question may form the basis of a nice TOK-type lesson and should produce a good variety of responses from students.

9 **a** As far as we know, is the principle of conservation of energy universal? That is, can it be shown not to apply to all events and circumstances?

b Does the principle of conservation of energy suggest that the total energy of the universe is constant? Is it possible for us test this scientifically?

c The existence of friction forces (which we might understand to be really just electrostatic forces between electrons in atoms) means that bodies that move have some of their kinetic energy transformed into internal energy.

i The whole universe is moving—and in some places (like here on the Earth) frictional forces can be quite large. Does this suggest that our universe must be getting warmer?

ii Doesn't our current understanding of the evolution of the universe tell us that the universe is getting cooler, not warmer?

iii How might you reconcile your answers to **parts i** and **ii**?

iv Will there be a limit as to how warm—or cold—the universe can become?

v What might the principle of conservation of energy imply if the universe actually reaches a constant temperature at some stage in the future?