18 The photograph shows a typical lightning strike which occurs as a result of an electrical discharge through the atmosphere in a narrow channel between a cloud and the ground.

(Source: © Joshua Lewis/EyeEm/Getty Images)

The high current in a lightning strike heats the air sufficiently to cause rapid expansion; the resulting shock wave is heard as thunder.

(a) A teacher says that a lightning strike taking place 1 km away from the observer will result in a time of 3 s between seeing the lightning and hearing the thunder.

Determine whether the teacher is correct.

speed of sound in air = 340 m s^{-1}

(3)

(b) The following data was collected for one particular lightning strike:

distance between cloud and ground = 400 m
current = 25 000 A
duration of lightning strike = 30 μs
potential difference between cloud and ground = 1.2×10^9 V
diameter of lightning channel = 5.0 cm

(i) Calculate the total charge transferred during the lightning strike.

(2)

Total charge transferred = ...

(ii) Calculate the power dissipated by the lightning strike.

(2)

Power dissipated = ...

(iii) Show that the resistivity of the air in the lightning channel is about 0.2 Ω m.

(3)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(iv) The accepted value for the resistivity of air is $10^{16}\,\Omega$m.

Suggest why the value calculated from the data is so much less than the accepted value.

(1)

(c) Air consists mainly of nitrogen and oxygen molecules. Analysis of the light produced during a lightning strike shows a weak line spectrum.

(i) Explain the process by which nitrogen atoms produce a line spectrum.

(4)

(ii) State why the line spectrum produced by oxygen atoms in the air would be different from the line spectrum produced by nitrogen atoms.

(1)

(Total for Question 18 = 16 marks)