7 A serious hazard for fire-fighters is the explosion of containers of 'liquefied gas' (butane) that have been heated in a fire. When the butane suddenly burns in an explosion, the fire spreads very rapidly in the form of a spherical fireball of increasing radius that is at very high temperature.

In order to study such fireballs, a series of experiments is carried out. Some butane of volume 12.5×10^{-3} m^3 is put in a sealed container and is then heated until it explodes. The variation with time t of the radius R of the fireball is determined. The results are shown in Fig. 7.1.

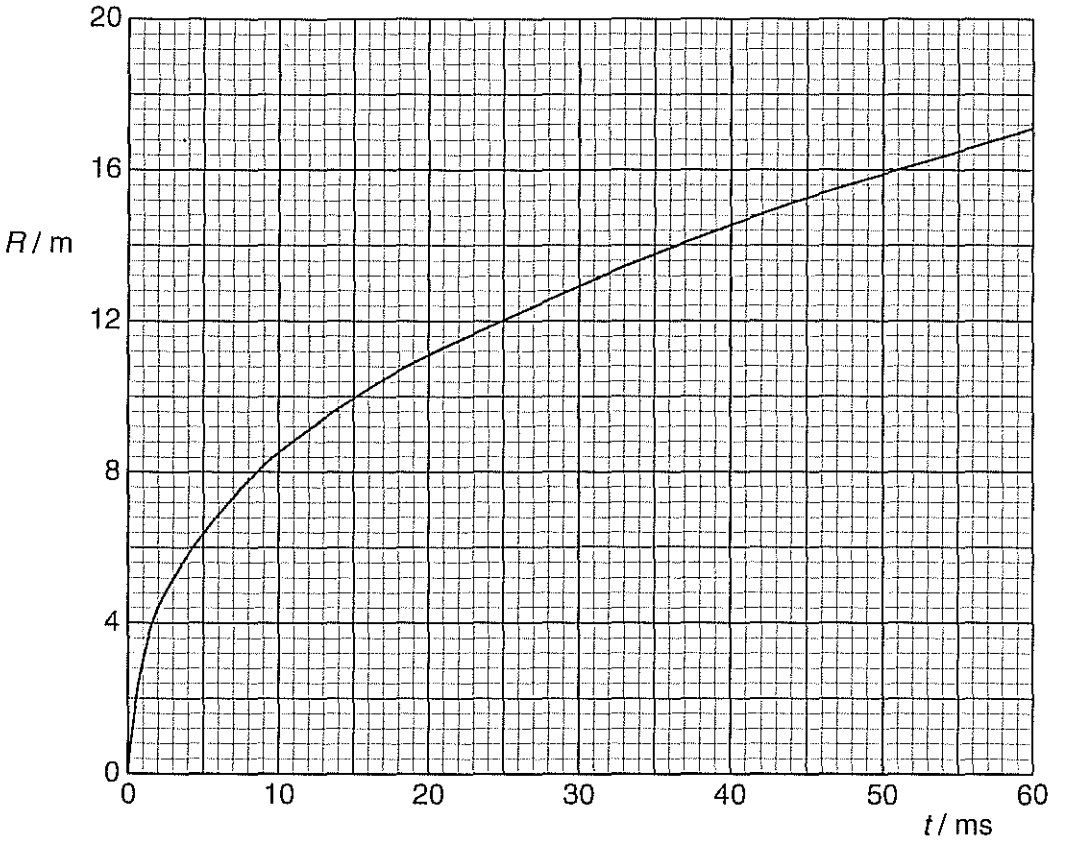

Fig. 7.1

(a) Use Fig. 7.1 to

(i) describe, without any calculation, the variation with time of the **rate** at which the radius of the fireball increases,

.....

.....

..... [2]

(ii) suggest why, in a room of length 12 m, width 5 m and height 3 m, such an explosion would be very hazardous.

.....

.....

.....

.....[3]

(b) It is thought that, for a fixed volume of butane, the radius R of the fireball varies with time t according to the expression

$$R^n = k\,t^m,$$

where n and m are integers and k is a constant.

Some corresponding values of lg t and lg R for the data in Fig.7.1 are plotted on the graph of Fig.7.2.

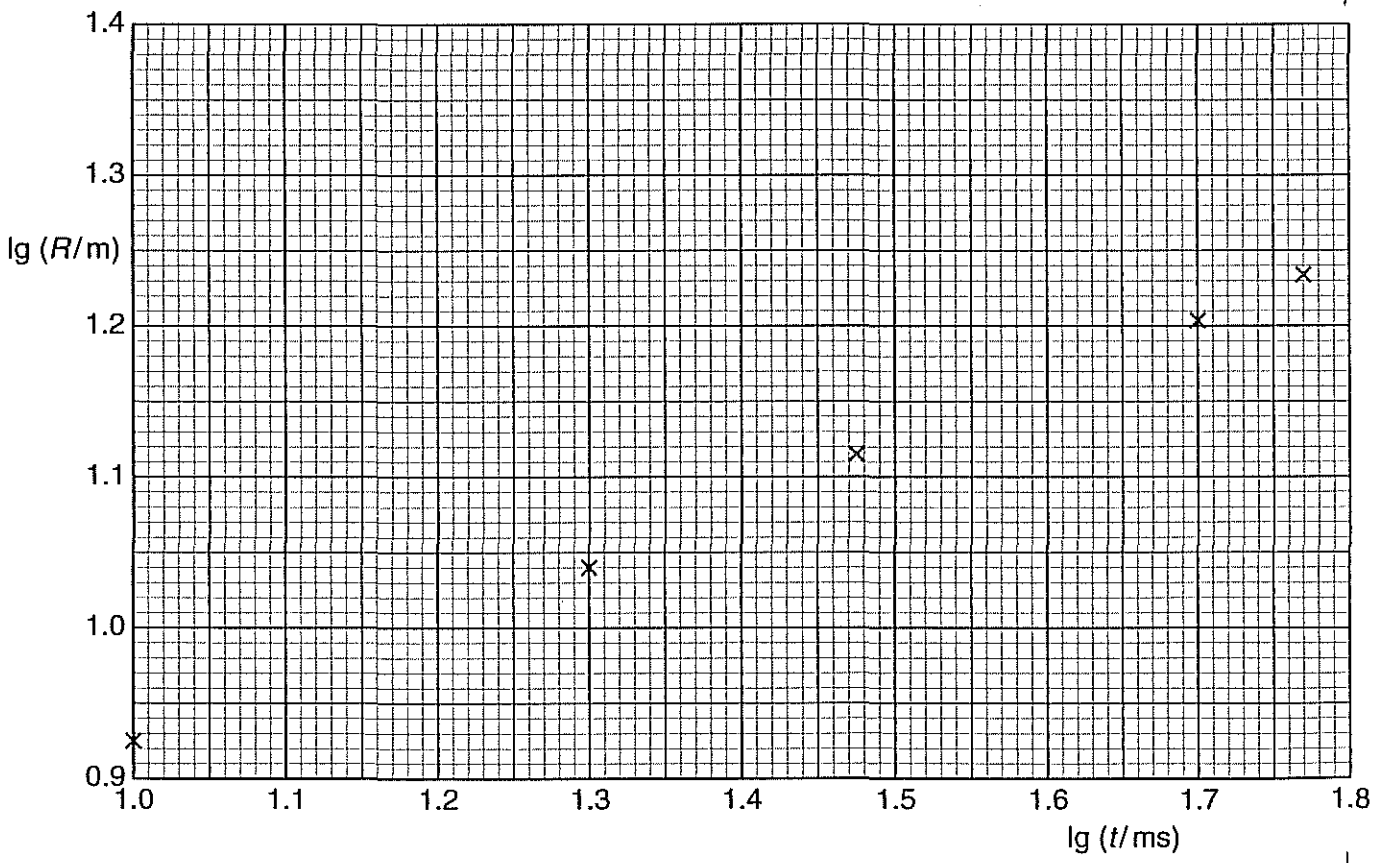

Fig. 7.2

(i) On Fig. 7.2,

1. plot the point corresponding to time $t = 40$ ms,

2. draw the best-fit line for all the plotted points.

[2]

(ii) Determine the gradient of the line drawn in **(i) part 2.**

gradient = ...[2]

(iii) Hence suggest values for the integers n and m. Explain your working.

n = ...

m = ...[3]

(c) The experiment is repeated using similar containers but with different volumes of butane. The results are shown in Fig. 7.3.

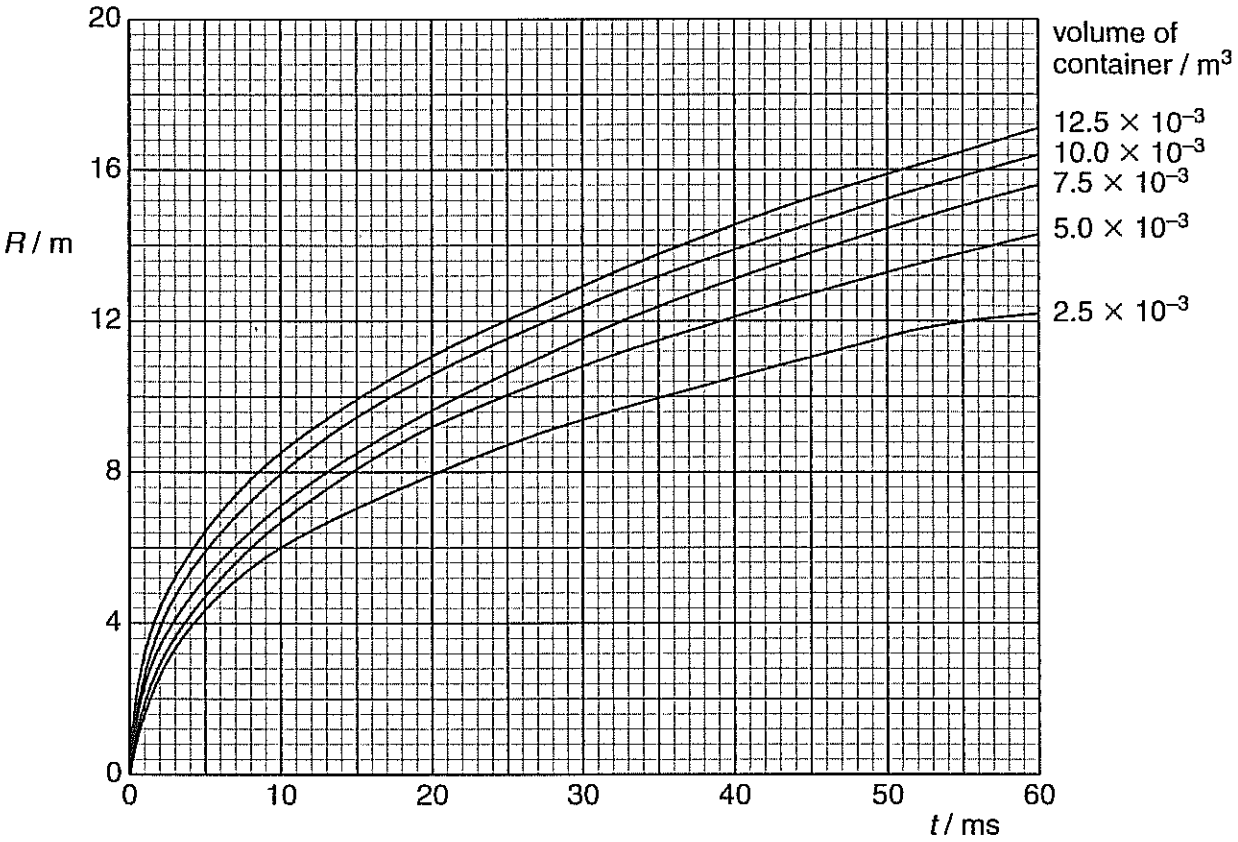

Fig. 7.3

Without drawing a further graph, show that, at time $t = 40\,\text{ms}$, the radius R of the fireball is related to the volume V of butane by the expression

$$R^5 = cV,$$

where c is a constant.

[3]

(d) **(i)** The equation in **(c)** may also be applied to other exploding gases.
Suggest **one** physical quantity on which the constant c will depend.

.....[1]

(ii) The data were collected for butane in a container in a room.
Suggest **one** other situation where the theory developed predicts a high level of hazard for fire-fighters.

.....[1]