6 A light bulb manufacturer makes 240 V, 60 W bulbs, like the one shown in Fig. 6.1.

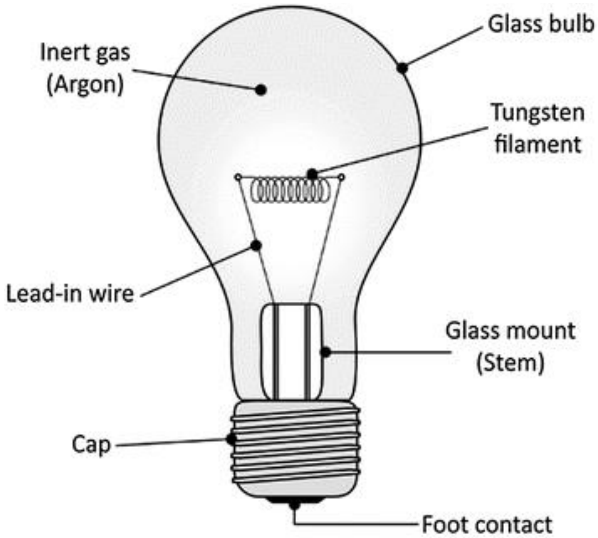

Fig. 6.1

The filament of the bulb is at a temperature of 2600 °C and the bulb lasts for 1000 hours before the filament breaks.

There are two schools of thought concerning these bulbs. One group of people want the manufacturer to raise the temperature at which the filament operates, so that for the same power, more light is emitted. The other group of people thinks that the manufacturer makes too much profit on the bulbs by making them so that they break after 1000 hours. They want the manufacturer to make bulbs that last 2000 hours. The manufacturer can happily satisfy both of these requirements – but only by manufacturing two other bulbs alongside the original bulb.

The material used for making the filament of the bulb is made of tungsten which has a resistivity of $7.9 \times 10^{-7}\ \Omega$ m at 2600 °C.

The manufacturer is going to make 3 bulbs using different length and diameters of tungsten filament as shown in Fig. 6.2. The filament B is used to manufacture the standard bulb operating at 2600 °C.

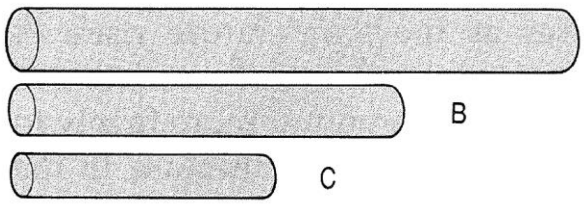

Fig. 6.2

The manufactured bulbs will have the same resistance.

(a) **(i)** What is meant by the *resistance* of the bulb?

……………........…………………………………………………………………………
...

………..……………………………………………………………………………………...
[1]

(ii) Calculate the resistance of the 240 V, 60 W bulb.

resistance = ………………………..Ω [2]

(b) If the length of the filament wire in bulb B is 0.14 m, calculate the diameter of tungsten wire needed to manufacture this bulb.

diameter = ………………………mm [2]

(c) Explain how it is possible for the filaments in Fig 6.2, to have the same resistance.

……..…………........…………………………………………………………………………
…...

……..………..………………………………………………………………………..……
[1]

(d) State which filament will be used to manufacture

(i) the bulb with higher temperature than 2600 °C

………………..………………………………………………………………………
[1]

(ii) the bulb that can last 2000 hours

………………..………………………………………………………………………
[1]

(e) Fig 6.3 compares the characteristics of the different filaments.

	A	B	C
resistance/ Ω			

diameter/ mm	0.0129		0.0113
length/ m		0.14	
surface area/ m^2			
power lost per unit area/ W m^{-2}			

Fig. 6.3

Complete the missing values in Fig. 6.3.

[3]

(f) The variation with temperature of the power lost per unit area of the filament is shown in Fig. 6.4.

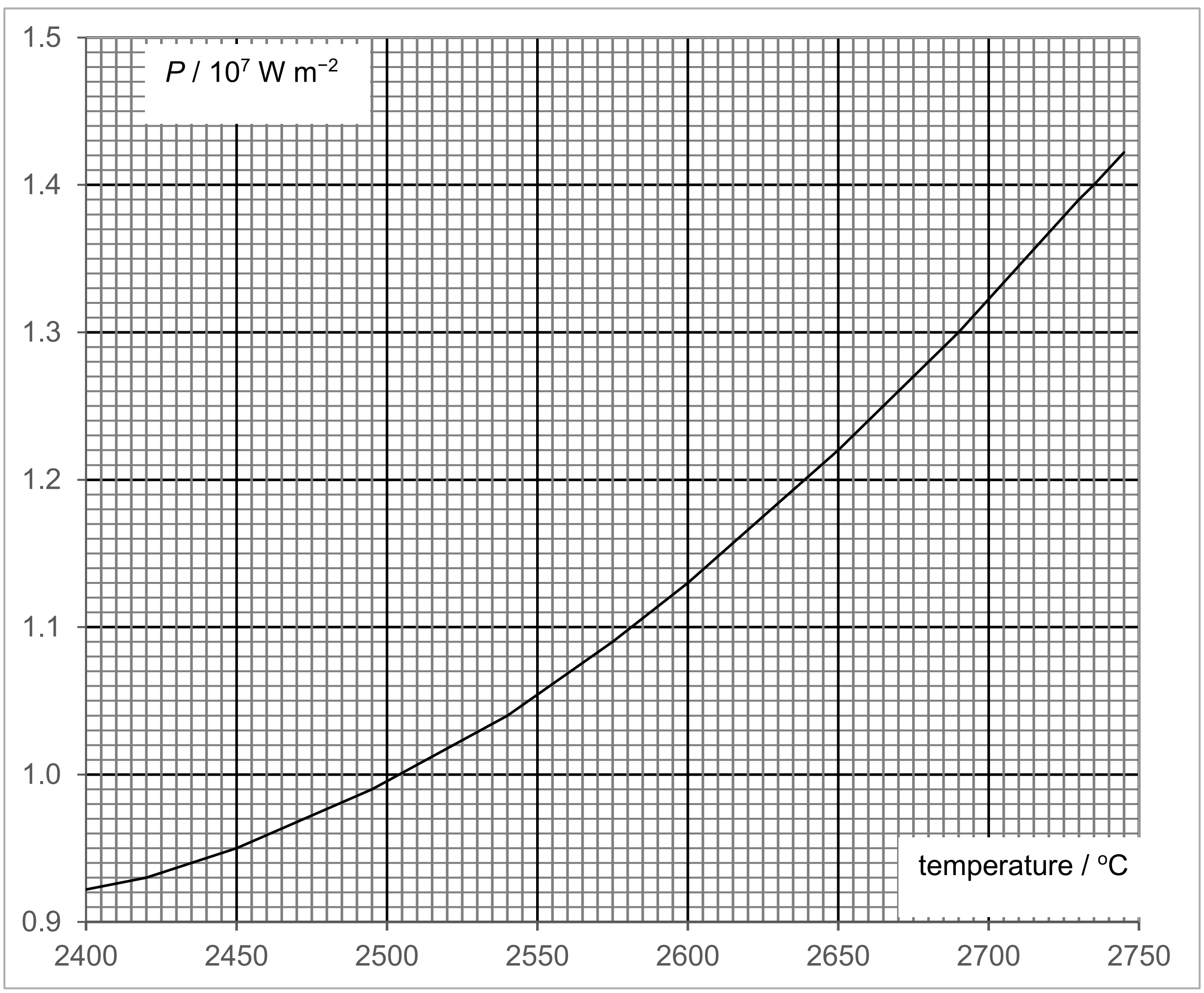

Fig. 6.4

Using your values from Fig. 6.3, determine the temperature at which each filament operates.

filament A temperature = ……...………………. °C [1]

filament B temperature
= ……………………….. °C [1]

filament C temperature
= …….……………………. °C [1]

(g) The bulb at the highest temperature gives out 12% of power as light but it only lasts 500 hours. The bulb at the lowest temperature gives out 9.0% of its power as light. The cost of manufacturing each bulb is \$0.50 and each kilowatt-hour electricity costs \$0.172.

When used for a duration of 2000 hours,

(i) determine which bulb has a higher running cost,

bulb with ………..……………..………………… has a higher running cost [3]

(ii) calculate the ratio $\dfrac{\text{cost of a unit of light energy from the lowest temperature bulb}}{\text{cost of a unit of light energy from the highest temperature bulb}}$.

ratio
= …………..…..……….. [4]

(iii) Suggest two other types of lightbulbs that are commonly available in the market other than the filament incandescent lightbulbs.

………………………………………………………………………………………………
…...

………………………………………………………………………………………………
.. [1]

(iv) State the key advantage of the type of lightbulbs suggested in **(iii)**.

………………………………………………………………………………………………
…...

………………………………………………………………………………………………
.. [1]

End of Paper