# Black Body Radiation

## Question Paper

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|---|---|
| **Level** | International A Level |
| **Subject** | Physics |
| **Exam Board** | Edexcel |
| **Topic** | Physics from Creation to Collaps |
| **Sub Topic** | Black Body Radiation |
| **Booklet** | Question Paper |

**Time Allowed:** **46 minutes**

**Score:** **/38**

**Percentage:** **/100**

**Grade Boundaries:**

| A* | A | B | C | D | E | U |
|---|---|---|---|---|---|---|
| >85% | '77.5% | 70% | 62.5% | 57.5% | 45% | <45% |

**1** A pan contains water at a temperature of 300 K. The water temperature is increased to 330 K. Assuming that the pan behaves like a black body, the rate at which energy is emitted as radiation from the pan changes by a factor of

☒ **A** 0.9

☒ **B** 1.1

☒ **C** 1.2

☒ **D** 1.5

**(Total for Question 1 = 1 mark)**

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**2** All objects at a temperature above absolute zero radiate energy. Both the wavelength $\lambda_{max}$ at which peak energy emission occurs and the rate of energy emitted per unit surface area $P$ depend upon the temperature of the object.

If the temperature of the object is increased

☒ **A** $\lambda_{max}$ and $P$ both decrease.

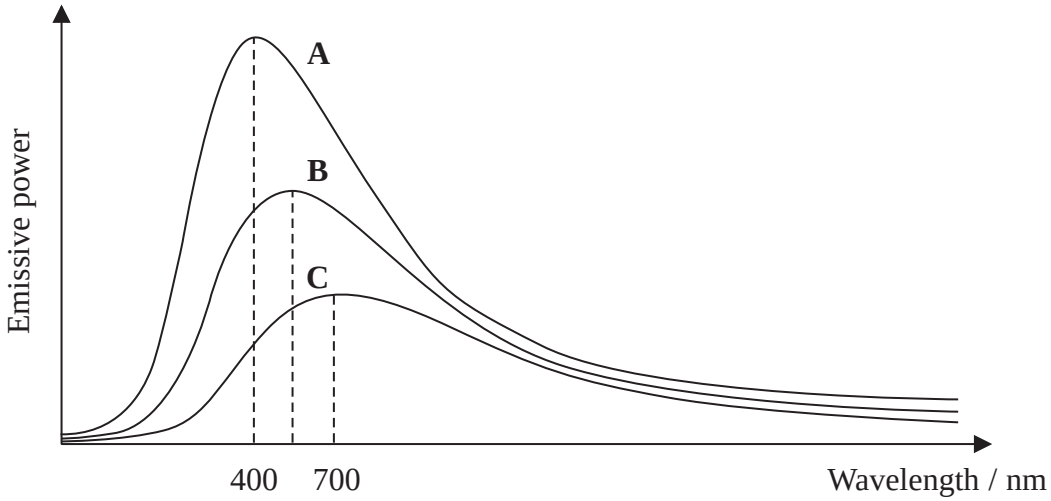
☒ **B** $\lambda_{max}$ and $P$ both increase.

☒ **C** $\lambda_{max}$ decreases and $P$ increases.

☒ **D** $\lambda_{max}$ increases and $P$ decreases.

**(Total for Question 2 = 1 mark)**

**3** Curves A, B and C show the radiation spectra of stars with three different surface temperatures.




(a) (i) Curve B represents radiation from the Sun. State what evidence from the graphs suggests that this might be so.

**(1)**

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(ii) State with a reason which curve represents a star with a greater surface temperature than the Sun.

**(1)**

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(iii) Use the graphs to explain how the radiation from the star identified in (ii) differs from the radiation from the Sun.

**(2)**

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(b) Stars other than the Sun are too far away from the Earth for us to make a direct measurement of their diameter.
Explain how we can deduce that some are giant stars and some are dwarf stars.

**(3)**

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(c) For stars which are relatively close to the Earth, describe how parallax measurements can be used to determine their distances from the Earth.

**(4)**

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**(Total for Question 3 = 11 marks)**

**4** "Hot-Spot" is an infrared imaging system introduced in cricket in 2005 to check if the ball has struck a batsman on his pads or the bat. The Hot-Spot system shows a bright spot where the ball has made contact.

(a) Suggest why a bright spot is produced on the image where the ball makes contact with the bat.

**(1)**

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(b) The bat is initially at a temperature of 20.0 °C. The smallest temperature change that can be detected by the system is 0.015 °C.

The wavelength at which peak energy emission occurs is $\lambda_{max}$. Assuming that the bat behaves as a black body radiator, calculate the change in $\lambda_{max}$ for a temperature change of 0.015 °C.

**(3)**

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Change in $\lambda_{max}$ = .....

(c) There is an increase in temperature of 0.50 K in the region of the bat where the ball has made contact. The wood from which the bat is made is a poor thermal conductor, so the heating caused by the ball is localised in a small region.

Calculate the energy transferred to the bat.

mass of contact region = 15 g

specific heat capacity of wood = 1700 J $kg^{-1}$ $K^{-1}$

**(2)**

Energy transferred to the bat = .....

(d) In the test series between England and Australia in the summer of 2013, it was claimed that some players had used silicone tape on their bats.

Suggest and explain a reason why using silicone tape may reduce the chances of a bright spot being produced.

**(2)**

**(Total for Question 4 = 8 marks)**

**5** (a) Explain how the light emitted from a star enables us to determine the temperature of the star and hence its luminosity.

**(3)**

*(b) An object whose luminosity is known may be referred to as a standard candle.

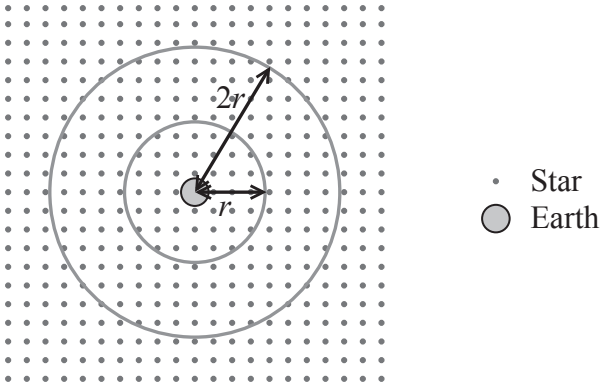
Explain why standard candles are important to astronomers and outline how standard candles are used to find distances to stars.

**(3)**

**(Total for Question 5 = 6 marks)**

**6** In the early 19th century, Heinrich Olbers asked the question, "Why is the night sky dark?" He reasoned that in an infinite universe light from very distant stars should make the whole of the visible sky bright.

To see how much distant stars contribute to light reaching the Earth, the universe can be modelled as a uniform distribution of identical stars. If this universe is divided into a series of thin concentric 'shells' centred on Earth, there will be a certain number of stars on each shell.




The diagram shows two shells of equal thickness at distances $r$ and $2r$ from the centre of the Earth.
There are four times as many stars on the shell at $2r$ than on the shell at $r$.

(a) Explain why the total radiation flux received at the Earth from the stars on each shell is the same.

**(2)**

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(b) One explanation proposed for why the night sky is not bright was that there is too much dust in space for distant stars to be seen. However, such dust would absorb radiation and heat up.

(i) Space is estimated to be at a temperature of 2.7 K. Use this value to calculate the radiant power emitted per $m^2$ of a body at this temperature.

**(2)**

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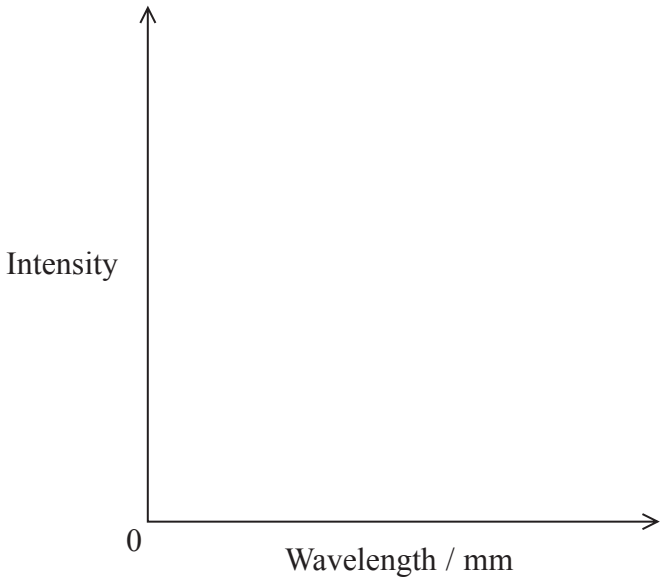
Radiant power emitted per $m^2$ = ..... W $m^{-2}$

(ii) Calculate the value of $\lambda_{max}$ for the radiation emitted by a black body at a temperature of 2.7 K, and sketch a graph of the radiation spectrum.

**(4)**

$\lambda_{max}$ = .....




(iii) State how your graph would change if the black body were at a higher temperature.

**(2)**

(c) The commonly accepted solution to Olbers' question is that the universe is expanding and has a finite age.

Suggest why some stars may be unobservable in a universe of finite age.

**(1)**

**(Total for Question 6 = 11 marks)**