1. One way of measuring the temperature of a star is by analysing its spectrum. A hotter star, when compared to a cooler star, will have more radiation with a;

A shorter wavelength
B longer wavelength
C the same wavelength
D a different type of wave

Using Wien's Law

$$\lambda = \frac{2.9 \times 10^{-3}}{T}$$

The higher the temperature the smaller (shorter) the peak wavelength.
Shorter wavelength

$\therefore$ *A*

2. By knowing the colour of a star, we can predict the temperature at its surface.

a. Consider a violet star, with a wavelength of 4×10^{-7} m. Use Wien's Law to determine the temperature at the surface of this star. Compare this temperature to the temperature at the surface of the sun.

$$T = \frac{2.9 \times 10^{-3}}{\lambda max}$$

$$= \frac{2.9 \times 10^{-3}}{4 \times 10^{-7}}$$

$$= 7.25 \times 10^{3} \text{ K}$$

The sun is 5.8 x 10^3 K, so this star is
1.45 x 10^3 K hotter.

b. Consider a red star, with a wavelength of 7×10^{-7} m. Use Wien's Law to determine the temperature at the surface of this star. Compare this temperature to the temperature at the surface of the sun (5800 K).

$$T = \frac{2.9 \times 10^{-3}}{4 \times 10^{-7}}$$

$$= 4.1 \times 10^{3}$$

$$= 4100 \text{ K}$$

The red star is 1700 K cooler than the sun.

3. When an iron reaches about 480 °C it begins to glow with a red colour.

   a. How much more energy per second is emitted by the iron at this temperature compared to when it is at a room temperature of 20 °C?

$$P = \sigma T^4$$

$$= \frac{5.67 \times 10^{-8} \times 753^4}{5.67 \times 10^{-8} \times 293^4}$$

$$= 44 \text{ times as much energy}$$

   b. How much hotter than 20 °C would the iron need to be to emit 10 times as much energy per second?

$$\frac{P_{hot}}{P_{cold}} = \left(\frac{T_{hot}}{T_{cold}}\right)^4$$

$$10 = \left(\frac{T_{hot}}{293}\right)^4$$

$$\frac{T_{hot}}{293} = \sqrt[4]{10}$$

$$T_{hot} = 293 \times \sqrt[4]{10}$$

$$= 521\text{K}$$

$$= 248\ °\text{C}$$

Therefore it is 248 – 20 = 228 °C hotter.

4. A star has a λ_{max} of 650 nm and a radius of 700 000 km.

   a. Use Wein's Law to calculate its surface temperature.

$$T = \frac{2.9 \times 10^{-3}}{650 \times 10^{-9}}$$

$$= 4.5 \times 10^3 \text{K}$$

   b. Calculate its surface area

$$A = 4\pi r^2$$

$$= 4\pi \times (700\,000)^2$$

$$= 6.2 \times 10^{12} \text{ m}^2$$

c. Use Stefan-Boltzmann's law to calculate its power output.

$P = \sigma T^4$

$= 5.67 \times 10^{-8} \times (2.9 \times 10^3 / 650 \times 10^{-9})^4$

$= 2.2 \times 10^7$ W m^{-2}

5. The electromagnetic spectrum includes the visible light we can see.

a. Which has the longest wavelength, red light or violet light?

Red

b. Which has the most energy, red light or violet light?

Violet

6. How much energy is emitted by a surface whose temperature is 230 K?

$P = 5.67 \times 10^{-8} \times 230^4 = 158.67\ W\ m^{-2}$

7. If an object has a temperature of -180 degrees C, how much energy per square meter does it emit?

$P = 5.67 \times 10^{-8} \times 93^4 = 4.24\ W\ m^{-2}$

8. What is the temperature of a surface that emits 0.00043 W per square meter?

$$T = \sqrt[4]{\frac{4.3 \times 10^{-4}}{5.67 \times 10^{-8}}} = 9.3\ K$$

9. If Oven A has a λ_{max} of 6 µm and Oven B has a λ_{max} of 7 µm , which oven is cooler? Show work.

$$T = \frac{2.9 \times 10^{-3}}{\lambda_{max}}\ greater\ \lambda_{max}\ means\ smaller\ temperature, so\ 7\ \mu m\ cooler.$$

10. 5.0 x 10 $^{-9}$ W per square meter strikes a field of grass with an average albedo of 0.6. How much energy is reflected? How much is absorbed?

$Reflected\ 5.0 \times 10^{-9} \times 0.6 = 3 \times 10^{-9}\ W\ m^{-2}, absorbed\ 2 \times 10^{-9}\ W\ m^{-2}$

11. Using a radiation sensor, you detect 401 Wm^{-2} radiating from a surface. Solve for temperature.

$$T = \sqrt[4]{\frac{401}{5.67 \times 10^{-8}}}` = 291.6\ K$$

12. Star has intensity peaks at a wavelength of 0.4 μm. Find its surface temperature.

$$T = \frac{2.9\times10^{-3}}{4\times10^{-7}} = 7250\ K$$

13. Surface temperature of the star is 7200 k. What is the wavelength at which it has peak of emission? What is its colour?

$$\lambda_{max} = \frac{2.9\times10^{-3}}{7200} = 4.03 \times 10^{-7}\ m \quad violet$$

14. 3. The star from the question 1 has a radius of $9 \times 10^7\ m$. What is its surface area?

$$A = 4\pi r^2 = 1.02 \times 10^{17}\ m^2$$

15. 4. If its emissivity is 0.95, what is power output?

$$P = e\sigma A T^4 = 0.95 \times 5.67 \times 10^{-8} \times 1.02 \times 10^{17} \times 7250^4 = 1.52 \times 10^{25}\ W$$

16. 5. An unclothed person has a body surface area of 1.4 m^2 with an emissivity of 0.85 and skin temperature of 37°C and stands in 20°C room. How much energy does the person lose through radiation per minute?

$$P = e\sigma A(T^4 - T_{room}^4) \quad E = Pt$$
$$= 0.85 \times\ 5.67 \times 10^{-8} \times 1.4 \times (310^4 - 293^4) \times 60$$
$$= 7.6\ kJ$$

17. What is the frequency of electromagnetic radiation that has a wavelength of 1380 nm?

$$f = \frac{3 \times 10^8}{1.38 \times 10^{-6}} = 2.17 \times 10^{15}\ Hz$$

18. What is the wavelength (in nanometers) of electromagnetic radiation that has a frequency of 5.4×10^{11} kHz?

$$\lambda = \frac{3 \times 10^8}{5.4 \times 10^{14}} = 5.56 \times 10^{-7}\ m = 556\ nm$$