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QUESTION WORKBOOK

Black-body radiation and spectral classes

Astrophysics · Year 13

AQA 3.9.2.3, 3.9.2.4 · CIE 25.2.1, 25.2.2, 25.2.3 · OCR A 5.5.2(e), 5.5.2(i), 5.5.2(j), 5.5.2(k)

19 questions · 57 marks

PRINT EDITION

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SECTION A · Warm-up

A1 State Stefan's law and Wien's displacement law, defining each symbol and giving the unit of Wien's constant. [2]

A2 Write the spectral classes in order from hottest to coolest, and state the class of the Sun. [2]

A3 State the two assumptions made when a star's temperature, power and radius are deduced from its measured spectrum. [2]

A4 State what is meant by a black body. [2]

A5 State the colour of a class O star and of a class M star, and name the molecule prominent in class M absorption spectra. [2]

A6 A star's surface temperature rises. Describe two changes to its black-body radiation curve. [2]

SECTION B · Standard

B1 Calculate the peak wavelength of the radiation from a star with a surface temperature of 10 000 K, and state the region of the spectrum in which it lies. [3]

B2 A star's spectrum peaks at 9.7×10^{-7} m. Calculate its surface temperature and suggest its spectral class. [3]

B3 A star has twice the Sun's radius (take the Sun's radius as 6.96×10^{8} m) and a surface temperature of 9000 K. Calculate its power output. [4]

B4 Explain why the hydrogen Balmer absorption lines are strongest in class A stars, weaker in cooler stars, and weak again in the hottest stars. [3]

B5 A star's surface temperature triples while its radius stays the same. State the factor by which its power output increases. [2]

B6 Two stars have equal radii. One has its spectral peak at 400 nm, the other at 800 nm. Calculate the ratio of their power outputs. [3]

B7 A white dwarf of radius 7.0×10^{6} m radiates a total power of 1.1×10^{24} W. Calculate its surface temperature. $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}. [4]

B8 Calculate the power radiated by each square metre of the Sun's surface, taking the surface temperature as 5800 K and $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}. [2]

SECTION C · Stretch

C1 A red giant radiates 3.9×10^{28} W, one hundred times the Sun's output, from a surface at 3480 K. Calculate its radius, and express it in solar radii (Sun's radius 6.96×10^{8} m). [5]

C2 Two stars have the same radius. Star X is class M and star Y is class A. Compare, with reasons, their colours and their power outputs. [3]

C3 A student says a star's colour tells you its temperature. State what measurement makes this precise, and the law that converts it. [2]

C4 An astronomer must decide which of two stars is the larger. Star J radiates 4.6×10^{26} W with its spectral peak at 690 nm; star K radiates 1.5×10^{27} W with its peak at 230 nm. Deduce which star has the larger radius. $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}; Wien constant 2.9×10^{-3} m K. [5]

C5 Describe fully how astronomers determine the radius of a distant star from its spectrum and its measured brightness, naming each law used and stating the assumptions involved. [6]