



QUESTION WORKBOOK

# The Doppler effect and Hubble's law

Astrophysics · Year 13

AQA 3.9.3.1, 3.9.3.2

10 questions · 31 marks

PRINT EDITION

**SECTION A** · Warm-up

**A1** State what is meant by the red shift of a galaxy's spectrum, and what it tells you about the galaxy's motion. [2]

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**A2** State Hubble's law, and the meaning of the Hubble constant. [2]

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**A3** Name the two key pieces of observational evidence for the Big Bang, other than the expansion itself. [2]

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**SECTION B** · Standard

**B1** Hydrogen's 486.1 nm line arrives from a galaxy at 490.0 nm. Calculate the galaxy's red shift and its recession speed. [3]

- B2** A spectral line from one star of a binary system swings periodically by up to 0.080 nm either side of 550 nm. Calculate the star's orbital speed, and state what the period of the swing represents. [3]

- B3** A galaxy recedes at  $8800 \text{ km s}^{-1}$ . Taking  $H = 65 \text{ km s}^{-1} \text{ Mpc}^{-1}$ , calculate its distance. [4]

- B4** Explain why the clean textbook treatment of a spectroscopic binary specifies that the orbit is observed in its own plane. [3]

## SECTION C · Stretch

- C1** Assuming every galaxy has always receded at its present speed, estimate the age of the universe for  $H = 65 \text{ km s}^{-1} \text{ Mpc}^{-1}$ , with  $1 \text{ Mpc} = 3.08 \times 10^{22} \text{ m}$ . Give the answer in years. [5]

- C2** A student describes the Big Bang as an explosion flinging galaxies outward through space from a central point. Give the better description, and one observation the student's picture fails to explain. [3]

- C3** A quasar shows  $z = 0.30$ . Estimate its recession speed and distance ( $H = 65 \text{ km s}^{-1} \text{ Mpc}^{-1}$ ), and state why the speed is only approximate. [4]