3.25 Red-shift and the Expanding Universe: 30-minute Pack

Total Marks

AQA 8463 · Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Almost every galaxy observed shows red-shift, in every direction we look.

(a) Explain what this observation suggests about the universe as a whole. **(2)**

(b) State the name of the widely accepted theory, based on this evidence, that describes the origin and expansion of the universe. **(1)**

(Total for Question 1 is 3 marks)

2 Cosmic microwave background radiation (CMBR) is observed coming from all directions in space.

(a) State what CMBR is. **(1)**

(b) State when, according to the Big Bang theory, this radiation was created. **(1)**

(c) Explain why the discovery of CMBR provided strong evidence to support the Big Bang theory. **(2)**

(Total for Question 2 is 4 marks)

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3 As the universe has expanded, the wavelength of the CMBR has also changed since it was first created. Explain how the wavelength of the CMBR has changed over time, and why.

(Total for Question 3 is 3 marks)

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4 Higher Tier only. Scientists' current best explanation for the origin of the universe is the Big Bang theory.

(a) State the two main pieces of observational evidence that support the Big Bang theory. **(2)**

(b) Explain why scientists continue to look for new evidence and refine this model, rather than treating it as a fixed, final theory. **(2)**

(Total for Question 4 is 4 marks)

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5 Evaluate how the observations of red-shift and cosmic microwave background radiation (CMBR) support the Big Bang theory of the origin of the universe. In your answer, you should refer to: what each piece of evidence shows; how each piece of evidence links to the predictions of the Big Bang theory.

(Total for Question 5 is 6 marks)

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6 Before the discovery of CMBR, some scientists supported a different theory (the steady state theory), which proposed that the universe has always looked the same, without a definite beginning.

(a) State what effect the discovery of CMBR had on scientific support for the steady state theory. **(1)**

(b) Explain what this shows about how scientific theories can change over time. **(2)**

(Total for Question 6 is 3 marks)

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Mark scheme · 3.25 Red-shift and the Expanding Universe: 30-minute Pack

Question 1

(a) galaxies are moving apart from each other/from Earth in every direction **B1**

(a) this suggests that the whole universe is expanding, oe **B1**

(a) Answer: It suggests the whole universe is expanding.

(b) the Big Bang theory (model) **B1**

(b) Answer: The Big Bang theory.

Question 2

(a) electromagnetic radiation, in the microwave region of the spectrum, spread throughout (filling) the universe **B1**

(a) Answer: Microwave electromagnetic radiation filling the universe.

(b) shortly after the beginning of the universe (the Big Bang itself), oe **B1**

(b) Answer: Shortly after the beginning of the universe.

(c) the Big Bang theory predicted that leftover radiation from the very early, hot, dense universe should still be detectable today, spread throughout all of space **B1**

(c) CMBR was found to closely match this prediction, coming from every direction at the predicted wavelength/temperature, providing strong observational support, oe **B1**

(c) Answer: CMBR matches a specific prediction of the Big Bang theory, so its discovery strongly supported the theory.

Question 3

the wavelength has increased (stretched) over time **B1**

because the space through which the radiation travels has been expanding along with the universe **B1**

as the universe expanded, the original very short wavelength/high-energy radiation was stretched to the much longer microwave wavelengths observed today, oe **B1**

Answer: The wavelength has increased (stretched) as the expanding universe has stretched the space the radiation travels through.

Question 4

(a) red-shift (evidence that galaxies are moving apart / the universe is expanding) **B1**

(a) cosmic microwave background radiation (CMBR) **B1**

(a) Answer: Red-shift and cosmic microwave background radiation.

(b) scientific models/theories are provisional and are always open to being tested, refined or replaced as new evidence becomes available **B1**

(b) testing the model against new observations (e.g. of more distant galaxies, more precise measurements) increases confidence in it, or could reveal limitations needing a better model, oe **B1**

(b) Answer: Scientific theories are provisional, and continued testing either strengthens confidence in the model or reveals where it needs improvement.

Question 5

Level 0 No relevant content. **0**

Level 1 Isolated statement(s) are made about red-shift and/or CMBR, with little or no link to the Big Bang theory. **1-2**

Level 2 Relevant points are made about both red-shift and CMBR, with some explanation of how they relate to the Big Bang theory, but the evaluation may be incomplete or not fully linked. **3-4**

Level 3 A detailed, well-linked evaluation of both pieces of evidence is given, clearly explaining how each supports the Big Bang theory, with correct scientific vocabulary throughout. **5-6**

Indicative content:

- Red-shift is the observed increase in wavelength of light from distant galaxies, shifted towards the red end of the spectrum.
- By comparison with the Doppler effect, red-shift shows that distant galaxies are moving away from the Earth.
- More distant galaxies show greater red-shift, meaning they are moving away faster, and this pattern is seen in every direction.
- This is consistent with the whole universe expanding uniformly, a key prediction of the Big Bang theory.
- The Big Bang theory predicts that the universe began as a very small, hot, dense region and has been expanding and cooling ever since.
- CMBR is electromagnetic radiation, in the microwave region, detected coming from every direction in space.
- The Big Bang theory predicts that radiation released shortly after the beginning of the universe would have been stretched to much longer (microwave) wavelengths by the universe's expansion, and would now be detectable throughout all of space.
- The discovery of CMBR, matching this prediction closely, provides strong, independent evidence supporting the Big Bang theory, in addition to red-shift.
- Together, the two pieces of evidence support each other and are not currently explained equally well by any competing model, giving scientists confidence in the Big Bang theory.

Question 6

(a) it provided strong evidence against the steady state theory, since it could not explain the existence of CMBR, and support shifted towards the Big Bang theory, oe **B1**

(a) Answer: It provided strong evidence against the steady state theory.

(b) scientific theories/models are accepted based on the evidence available at the time, and are not necessarily permanent or certain **B1**

(b) new evidence, such as the discovery of CMBR, can lead the scientific community to reject or revise a previously accepted theory in favour of a better-supported one, oe **B1**

(b) Answer: Theories are accepted based on current evidence, and can be revised or replaced when new evidence emerges.

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