3.8 Space Physics: Test Pack

AQA 8463 · Calculator allowed · about 40 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Name two different types of object found in our Solar System (for example, 'planet' is one).

(a) Give two different types of object found in our Solar System. **(2)**

(Total for Question 1 is 2 marks)

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2 State why gravity is important for keeping a planet in orbit around a star.

(a) State why gravity keeps a planet in orbit. **(1)**

(Total for Question 2 is 1 mark)

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3 Explain in simple terms what astronomers mean by 'redshift'.

(a) Explain what redshift means. **(1)**

(Total for Question 3 is 1 mark)

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4 A star has brightness 100 arbitrary units at a distance of 2 parsecs. Using the inverse-square law, calculate its brightness at 4 parsecs. Show your working.

(a) Brightness is proportional to $1/d^2$. If brightness = 100 at d = 2 pc, find brightness at d = 4 pc. **(2)**

(Total for Question 4 is 2 marks)

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5 A geostationary satellite stays above the same point on the Earth's surface at all times.

(a) State the orbital period of a geostationary satellite. **(1)**

(b) Explain why this orbital period allows the satellite to stay above the same point on the Earth's surface. **(1)**

(Total for Question 5 is 2 marks)

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6 The table shows the recession speed (the speed at which a galaxy is moving away from Earth, found from its red-shift) for four galaxies at different distances from Earth.
Distance (millions of light years): 100, 200, 300, 400
Recession speed (km/s): 2200, 4300, 6600, 8700

(a) Describe the relationship shown by the data between a galaxy's distance from Earth and its recession speed. **(2)**

(b) State what this relationship provides evidence for. **(1)**

(Total for Question 6 is 3 marks)

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7 Satellites are placed in orbits of very different radii, depending on their purpose. A weather-monitoring satellite is often placed in a low orbit, close to the Earth's surface. A communications satellite is often placed in a much higher, geostationary orbit, where its orbital period matches the Earth's rotation period of 24 hours, so it stays above the same point on the Earth's surface.

(a) Suggest one advantage of using a low orbit for a weather-monitoring satellite. **(1)**

(b) Suggest one advantage of using a geostationary orbit for a communications satellite. **(1)**

(Total for Question 7 is 2 marks)

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8 Stars form from clouds of dust and gas, and their eventual fate depends on their mass. Consider a star with roughly the same mass as the Sun, and a much more massive star.

(a) Describe the life cycle of a star with roughly the same mass as the Sun, from the main sequence stage onwards. **(3)**

(b) Describe how the life cycle of a much more massive star differs after the main sequence stage. **(3)**

(Total for Question 8 is 6 marks)

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9 In the 1960s, scientists Arno Penzias and Robert Wilson detected faint microwave radiation coming from every direction in space, with a very similar intensity wherever they pointed their detector.

(a) Name this radiation. **(1)**

(b) Explain how the existence of this radiation, detected uniformly from every direction, provides evidence for the Big Bang theory of the origin of the universe. **(2)**

(Total for Question 9 is 3 marks)

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10 The table shows the observed red-shift of light from four galaxies, and their approximate distance from Earth.

Galaxy	Distance from Earth (million light years)	Observed red-shift
P	100	small
Q	400	moderate
R	900	large
S	1600	very large

(a) Describe the relationship between a galaxy's distance from Earth and the size of its observed red-shift, as shown by the data. **(1)**

(b) Explain what this relationship shows about how the speed at which galaxies are moving away from Earth depends on their distance. **(1)**

(c) Explain how this relationship between distance and speed supports the theory that the universe is expanding. **(2)**

(Total for Question 10 is 4 marks)

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11 Higher Tier only. A geostationary communications satellite orbits the Earth at an orbital radius of 4.2×10^7 m, with a time period of 86000 s. Use the Physics Equations Sheet. Use the equation: orbital speed = (2 x π x orbital radius) / time period.

(a) Calculate the orbital speed of the satellite. **(3)**

(b) Compare this orbital speed with the orbital speed calculated in Q10 for a satellite at a smaller orbital radius, and state whether this comparison is consistent with the relationship described in Q7. **(1)**

(Total for Question 11 is 4 marks)

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Mark scheme · 3.8 Space Physics: Test Pack

Question 1

(a) one correct type named, e.g. planet, moon, comet, asteroid, dwarf planet, meteoroid, B1 — **B1**

(a) a different correct type named, oe — **B1**

(a) Answer: Any two of: planet; moon; comet; asteroid; dwarf planet; meteoroid.

Question 2

(a) gravity provides a force pulling the planet towards the star, causing the planet to follow a curved path or orbit, oe — **B1**

(a) Answer: Because gravity pulls the planet towards the star, causing it to move in a curved path around the star.

Question 3

(a) light from an object is shifted to longer wavelengths (towards red) usually because the object is moving away, oe — **B1**

(a) Answer: Redshift is when light from an object is shifted to longer wavelengths (towards red), usually because the object is moving away.

Question 4

(a) uses inverse square: brightness new = 100 x $(2/4)^2$ or shows 100 x $(1/2)^2$ — **M1**

(a) 25 units cao — **A1**

(a) Answer: 25 units

Question 5

(a) 24 hours (1 day) — **B1**

(a) Answer: 24 hours.

(b) its orbital period matches the time the Earth takes to rotate once, so the satellite stays above the same point as the Earth turns beneath it, oe — **B1**

(b) Answer: Its orbital period matches the Earth's rotation, so it stays above the same point.

Question 6

(a) as distance increases, recession speed increases — **B1**

(a) the relationship is approximately directly proportional, e.g. doubling the distance from 100 to 200 approximately doubles the speed from 2200 to 4300, oe — **B1**

(a) Answer: Recession speed increases with distance, and the relationship is approximately directly proportional.

(b) that the universe is expanding (uniformly in all directions), oe — **B1**

(b) Answer: That the universe is expanding.

Question 7

(a) e.g. it is much closer to the Earth's surface, so it can capture more detailed (higher-resolution) images of weather systems, oe — **B1**

(a) Answer: A low orbit is much closer to the Earth's surface, allowing the satellite to capture more detailed, higher-resolution images.

(b) e.g. because it stays above the same point on the Earth, a receiving dish on the ground can be fixed in one direction and does not need to track/move to follow the satellite, oe — **B1**

(b) Answer: Because the satellite stays above the same point on the Earth, a ground-based receiving dish can be fixed in one direction and does not need to track the satellite.

Question 8

(a) the star spends most of its life on the main sequence, fusing hydrogen into helium in its core, oe — **B1**

(a) once the hydrogen in the core is used up, the star expands to become a red giant, oe — **B1**

(a) the red giant then sheds its outer layers, forming a planetary nebula, leaving behind a white dwarf, which gradually cools, oe — **B1**

(a) Answer: The star spends most of its life on the main sequence, fusing hydrogen into helium. When the hydrogen in its core runs out, it expands into a red giant, which then sheds its outer layers as a planetary nebula, leaving behind a white dwarf that gradually cools.

(b) the massive star expands to become a red supergiant (rather than a red giant), oe — **B1**

(b) the red supergiant explodes in a supernova, oe — **B1**

(b) the supernova leaves behind either a neutron star or, if the original star was massive enough, a black hole, oe — **B1**

(b) Answer: The much more massive star expands to become a red supergiant, which then explodes as a supernova. This leaves behind either a neutron star or, for the most massive stars, a black hole.

Question 9

(a) cosmic microwave background radiation (CMBR / CMB) — **B1**

(a) Answer: Cosmic microwave background radiation (CMBR).

(b) the Big Bang theory predicts that the universe began in an extremely hot, dense state, oe — **B1**

(b) as the universe has since expanded and cooled, the radiation released in this early hot state would have stretched to much longer (microwave) wavelengths, and would now be detected uniformly from all directions, which matches what is observed, oe — **B1**

(b) Answer: The Big Bang theory predicts that the universe began in an extremely hot, dense state. As the universe expanded and cooled, radiation from this early state would stretch to much longer, microwave wavelengths and be detected uniformly from every direction, which matches the observed cosmic microwave background radiation.

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Question 10

(a) the further away a galaxy is from Earth, the greater (larger) its observed red-shift, oe **B1**

(a) Answer: The further away a galaxy is, the greater its observed red-shift.

(b) the further away a galaxy is, the faster it is moving away from the Earth (its red-shift, and therefore its speed of recession, increases with distance), oe **B1**

(b) Answer: The further away a galaxy is, the faster it is moving away from the Earth; red-shift, and therefore recession speed, increases with distance.

(c) if every galaxy is moving away from every other galaxy, with more distant galaxies moving away faster, this is consistent with the space between all galaxies stretching (expanding) uniformly, oe **B1**

(c) rather than, for example, all the galaxies simply moving away from one single fixed point in space, oe **B1**

(c) Answer: If every galaxy is moving away from every other galaxy, with more distant ones moving away faster, this is consistent with the space between all galaxies stretching uniformly, that is, the universe expanding, rather than the galaxies simply moving away from one fixed point.

Question 11

(a) substitution: $v = (2 \times \pi \times 4.2 \times 10^7) / 86000$, oe **M1**

(a) correct evaluation of the numerator: $2 \times \pi \times 4.2 \times 10^7 = 2.639 \times 10^8$ **M1**

(a) v = 3070 m/s (3 s.f.), cao (accept awrt 3070 m/s) **A1**

(a) Answer: v = 3070 m/s

(b) yes, it is consistent - this satellite, at the larger orbital radius, has a lower orbital speed (about 3070 m/s) than the satellite in Q10 (about 7680 m/s) at the smaller radius, which agrees with Q7 **B1**

(b) Answer: Yes, consistent: the larger-radius satellite here has a lower orbital speed than the smaller-radius satellite in Q10.

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