3.8 Space Physics: 1-hour Pack

AQA 8463 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 State what a light-year measures.

(a) State what a light-year is a measure of. **(1)**

(Total for Question 1 is 1 mark)

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2 A small satellite travels 40 000 km along its orbit in 90 minutes. Calculate the average speed of the satellite in km/s. Show your working.

(a) Calculate average speed = distance / time. Distance = 40000 km, time = 90 minutes. **(2)**

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(Total for Question 2 is 2 marks)

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3 A star that is much more massive than the Sun follows a different life cycle after leaving the main sequence.

(a) Name the stage a very massive star enters after leaving the main sequence. **(1)**

(b) Name the explosive event that ends the life of a red super giant. **(1)**

(c) State the two possible objects that can be left behind after a supernova, and state what determines which one forms. **(2)**

(Total for Question 3 is 4 marks)

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4 Elements are created within stars during their life cycles.

(a) State the process by which elements up to the mass of iron are formed within a star. **(1)**

(b) Explain how elements heavier than iron are formed, and how they are then spread throughout the universe. **(2)**

(Total for Question 4 is 3 marks)

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5 Explain how two pieces of observational evidence support the Big Bang theory. You should include relevant observations and say how each observation supports the idea of an expanding universe that began in a hot, dense state.

(Total for Question 5 is 6 marks)

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6 A satellite orbits the Earth at an orbital radius of 6.6×10^6 m, completing one orbit every 5400 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. **(2)**

(b) A second satellite orbits at a much larger radius than the first, with a longer time period. State and explain how the orbital speed of the second satellite would compare with the first. **(2)**

(Total for Question 6 is 4 marks)

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7 Satellite A orbits the Earth at a low altitude, with an orbital period of 90 minutes. Satellite B orbits much further from the Earth, at geostationary altitude, with an orbital period of 24 hours.

(a) State which satellite, A or B, has the smaller orbital radius. **(1)**

(b) Explain how you can tell this from the information given, without using a formula. **(2)**

(Total for Question 7 is 3 marks)

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8 Cosmic microwave background radiation (CMBR) is further evidence supporting the Big Bang theory.

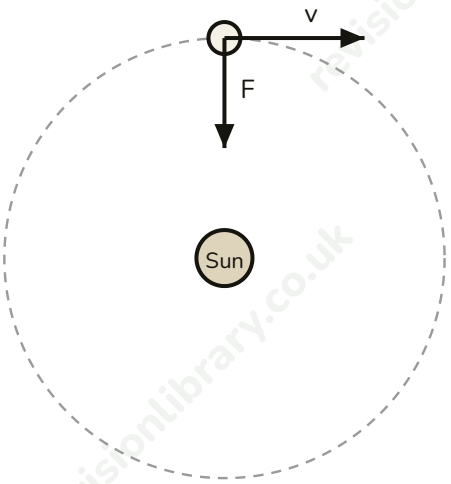
(a) State what CMBR is. **(1)**

(b) Explain how the existence of CMBR supports the Big Bang theory. **(2)**

(Total for Question 8 is 3 marks)

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9 A planet orbits the Sun in a stable, roughly circular orbit at a constant orbital radius.



(a) Name the force that provides the centripetal force needed to keep the planet in its circular orbit. **(1)**

(b) Explain why a planet moving at constant speed in a circular orbit is still accelerating. **(2)**

(Total for Question 9 is 3 marks)

10 A weather satellite moves at a constant speed around the Earth in a circular orbit.

(a) State whether the satellite's velocity is constant, and explain your answer. **(2)**

(b) Explain why the satellite is accelerating, even though its speed does not change. **(1)**

(Total for Question 10 is 3 marks)

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11 Compare the life cycle of a star with a similar mass to the Sun with the life cycle of a star with a much greater mass than the Sun, from the main sequence stage onwards. In your answer, refer to: the stages each type of star passes through after the main sequence; the final object left at the end of each life cycle.

(Total for Question 11 is 6 marks)

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12 Two satellites, X and Y, orbit the Earth. Satellite X has a small orbital radius, close to the Earth's surface. Satellite Y has a much larger orbital radius, far from the Earth's surface.

(a) State and explain which satellite, X or Y, has the greater orbital speed. **(2)**

(b) State and explain which satellite, X or Y, has the longer orbital time period. **(2)**

(Total for Question 12 is 4 marks)

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13 Higher Tier only. A satellite is designed to orbit the Earth at an orbital speed of 3900 m/s, at an orbital radius of 2.0×10^7 m. Use the Physics Equations Sheet. Use the equation: orbital speed = (2 x π x orbital radius) / time period.

(a) Rearrange the equation to make time period the subject. **(1)**

(b) Calculate the time period of the satellite's orbit, in seconds. **(3)**

(Total for Question 13 is 4 marks)

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Mark scheme · 3.8 Space Physics: 1-hour Pack

Question 1

(a) a unit of distance equal to the distance light travels in one year, cao **B1**

(a) Answer: A light-year is the distance that light travels in one year.

Question 2

(a) substitutes with time converted to seconds: 40000 km / (90 x 60 s) or equivalent **M1**

(a) 7.41 km/s (3 s.f.) cao **A1**

(a) Answer: 7.41 km/s

Question 3

(a) red super giant (red supergiant) **B1**

(a) Answer: Red super giant.

(b) supernova **B1**

(b) Answer: Supernova.

(c) neutron star or black hole named **B1**

(c) a black hole only forms if the remaining core/original star is massive enough, oe **B1**

(c) Answer: A neutron star or a black hole; a black hole only forms if the original star was massive enough.

Question 4

(a) nuclear fusion **B1**

(a) Answer: Nuclear fusion.

(b) elements heavier than iron are formed during a supernova explosion **B1**

(b) the explosion distributes/spreads these elements throughout the universe, oe **B1**

(b) Answer: Elements heavier than iron form during a supernova explosion, which then distributes them throughout the universe.

Question 5

Level 3 A clear, detailed explanation linking two observations to the Big Bang theory. Each observation is described accurately and the answer explains how it supports expansion from a hot, dense state. **5-6**

Level 2 A partially developed answer. At least one observation is described and linked to expansion or a hot dense early state, but explanations lack detail or one observation is not fully linked. **3-4**

Level 1 A simple answer with brief statements of observations or claims with little explanation of how they support the Big Bang theory. **1-2**

Indicative content:

- Observation 1: Redshift of galaxies - light from distant galaxies shifted to longer wavelengths; this shows galaxies are moving away, implying the universe is expanding.
- How it supports Big Bang: expansion means in the past galaxies were closer together, consistent with origin from a dense state.
- Observation 2: Cosmic microwave background radiation (CMB) - a background of microwave radiation detected in all directions with a temperature of about 2.7 K.
- How it supports Big Bang: CMB is interpreted as cooled radiation left over from an early hot dense phase, so it is direct evidence of an earlier hotter state.
- Additional points: observation of element abundances (e.g. hydrogen and helium ratios) is consistent with predictions from early hot conditions and supports the theory.
- A balanced answer may note limitations or that alternative explanations must also match these observations.

Question 6

(a) substitution: $v = (2 \times \pi \times 6.6 \times 10^6) / 5400$, oe **M1**

(a) v = 7680 m/s (3 s.f.), cao (accept awrt 7680 m/s) **A1**

(a) Answer: v = 7680 m/s

(b) the second satellite's orbital speed would be lower/slower **B1**

(b) because gravitational force is weaker at a larger orbital radius, so a lower orbital speed is needed to maintain a stable orbit, oe **B1**

(b) Answer: The second satellite's orbital speed would be lower, because gravity is weaker at the larger radius.

Question 7

(a) satellite A **B1**

(a) Answer: Satellite A.

(b) satellites orbiting at a smaller radius experience a stronger gravitational force, travel faster and complete an orbit in less time **B1**

(b) satellite A has a much shorter orbital period than satellite B, so it must be orbiting at a smaller radius, oe **B1**

(b) Answer: Satellite A has a much shorter period, and a smaller orbital radius gives a shorter period, so satellite A must have the smaller radius.

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Question 8

(a) electromagnetic radiation (in the microwave part of the spectrum) that fills all of space/the universe **B1**

(a) Answer: Electromagnetic (microwave) radiation filling all of space.

(b) CMBR is believed to be radiation created shortly after the very early, hot, dense universe **B1**

(b) as the universe has expanded and cooled, this radiation has been stretched to the microwave wavelengths observed today, and its presence throughout the universe is explained by the theory, oe **B1**

(b) Answer: CMBR is radiation from the very early universe, stretched to microwave wavelengths as the universe has expanded, matching what the Big Bang theory predicts.

Question 9

(a) the gravitational force (of attraction) between the Sun and the planet **B1**

(a) Answer: Gravitational force between the Sun and the planet.

(b) velocity is a vector, so although the planet's speed is constant, its direction of motion is constantly changing **B1**

(b) a change in velocity means the planet is accelerating (the acceleration is directed towards the centre of the orbit), oe **B1**

(b) Answer: Speed is constant but direction keeps changing, so velocity changes, meaning the planet is accelerating towards the centre of its orbit.

Question 10

(a) the satellite's velocity is not constant (it is changing), oe **B1**

(a) because velocity is a vector, and although the satellite's speed stays constant, its direction of travel is continuously changing as it moves around the circular orbit, oe **B1**

(a) Answer: The satellite's velocity is not constant. Although its speed stays the same, velocity is a vector, and its direction of travel is continuously changing as it moves around the circular orbit.

(b) acceleration is defined as a change in velocity; because the satellite's direction (and therefore its velocity) is continuously changing, it is continuously accelerating, even though its speed is constant, oe **B1**

(b) Answer: Acceleration is a change in velocity. Because the satellite's direction, and therefore its velocity, is continuously changing, it is continuously accelerating, even though its speed stays the same.

Question 11

Level 0 No relevant content. **0**

Level 1 Isolated statement(s) are made about one or both life cycles, with little or no comparison. **1-2**

Level 2 Relevant points are made about both life cycles, showing some comparison, but the description may be incomplete or the two life cycles not clearly linked. **3-4**

Level 3 A clear, detailed and accurately sequenced comparison of both life cycles is given, correctly identifying the final objects formed, with correct scientific terminology throughout. **5-6**

Indicative content:

- Both types of star begin on the main sequence, a long stable period fuelled by nuclear fusion of hydrogen into helium.
- A Sun-sized star leaves the main sequence and expands into a red giant.
- The red giant loses its outer layers, leaving behind a white dwarf, which cools over a very long time to eventually become a black dwarf.
- A much more massive star leaves the main sequence and expands into a red super giant.
- The red super giant explodes as a supernova.
- After a supernova, the remaining core collapses to leave either a neutron star, or, if the original star was massive enough, a black hole.
- Massive stars have much shorter overall lifetimes than Sun-sized stars, because they use up their fuel more quickly.
- Elements heavier than iron are only formed during a supernova explosion, not during the life cycle of a Sun-sized star.

Question 12

(a) satellite X (the one with the smaller orbital radius) **B1**

(a) a satellite closer to the Earth experiences a stronger gravitational force, which requires (and provides) a greater orbital speed to maintain a stable circular orbit at that radius, oe **B1**

(a) Answer: Satellite X, the one with the smaller orbital radius, has the greater orbital speed, because it experiences a stronger gravitational force, which requires a greater speed to maintain a stable orbit at that radius.

(b) satellite Y (the one with the larger orbital radius) **B1**

(b) satellite Y has both a much longer distance to travel to complete one orbit, and a lower orbital speed, so it takes much longer to complete one full orbit, oe **B1**

(b) Answer: Satellite Y, the one with the larger orbital radius, has the longer orbital time period, because it has a much greater distance to travel and a lower orbital speed.

Question 13

(a) time period = (2 x π x orbital radius) / orbital speed **B1**

(a) Answer: T = (2 x π x r) / v

(b) substitution: $T = (2 \times \pi \times 2.0 \times 10^7) / 3900$, oe **M1**

(b) correct evaluation of the numerator: $2 \times \pi \times 2.0 \times 10^7 = 1.257 \times 10^8$ **M1**

(b) T = 32200 s (3 s.f.), cao (accept awrt 32200 s) **A1**

(b) Answer: T = 32200 s (about 8.9 hours)

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