K15D Space Physics: Exam Drill

AQA AQA KS3 Science - Physics · Calculator allowed · about 75 minutes

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Name the main star at the centre of our Solar System.

(1)

2 Complete the sentences about the Moon.

(a) The Moon orbits the Earth once in about ____ days. **(1)**

(b) One complete cycle of moon phases (new to new) is called a ____. **(1)**

(c) During a new moon the side of the Moon facing Earth receives ____ sunlight. **(1)**

3 Which planet is known as the Red Planet? Choose one.

- ☐ A) Venus
- ☐ B) Mars
- ☐ C) Jupiter
- ☐ D) Mercury

4 A probe orbits a small moon at height 50 km above the surface. The moon's radius is 1000 km and its mass produces a gravitational field strength at the surface of 0.5 N/kg. Assume g decreases with distance from the centre according to the inverse square law.

(a) Calculate the gravitational field strength at the probe (at distance from centre = radius + height). **(3)**

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(b) Explain briefly why the probe weighs less at that height than on the surface. **(1)**

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5 A student times how long it takes a beam of light to travel from Earth to a nearby star 4 light years away. Explain why this is not practical for an experiment and give the actual time in seconds a light beam takes to travel 4 light years. Use speed of light = 3.00×10^8 m/s and 1 light year = 9.46×10^{15} m.

(a) Why is timing this in a classroom not practical? **(1)**

(b) Calculate the time in seconds for light to travel 4 light years. Give your answer to 2 significant figures. **(2)**

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6 An experiment measures how temperature on a model 'planet' changes with distance from a lamp representing the Sun. The student records average temperature at four distances: 20 cm, 30 cm, 40 cm and 50 cm from the lamp. Data: distance (cm): 20, 30, 40, 50. temperature (degrees C): 60, 44, 33, 26. The student plots temperature (y axis) against distance (x axis).

(a) Plot the points on graph paper and draw a best-fit curve (description acceptable here). Describe the shape of the graph between 20 cm and 50 cm. **(2)**

(b) Calculate the temperature change between 20 cm and 30 cm and between 40 cm and 50 cm. Which interval shows the greater change? **(2)**

(c) Suggest one improvement to make this experiment a fair test and explain why it helps. **(1)**

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7 State two reasons why astronauts in orbit appear weightless even though Earth's gravity is still acting on them.

(4)

8 A space telescope slews to observe a distant galaxy. The control system must rotate the telescope with a constant angular speed of 0.2 degrees per second for a calibration test lasting 2 minutes. Calculate the total angle turned in that time and state whether the telescope has rotated more or less than one full circle.

(a) Calculate the total angle rotated in degrees. **(3)**

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(b) Has the telescope rotated more or less than one full circle (360 degrees)? **(1)**

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9 A comet moves rapidly past the Sun and its icy surface turns directly into gas, forming a tail. Name this change of state and explain in one sentence what happens to the particles.

(3)

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10 Explain what is meant by a light year and calculate how many kilometres are in 0.5 light years. Use 1 light year = 9.46×10^{12} km.

(a) Explain what a light year is. **(1)**

(b) Calculate how many kilometres are in 0.5 light years. **(2)**

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11 State one hazard to spacecraft from micrometeorites and suggest one engineering method to reduce the hazard.

(2)

12 A small satellite is in low Earth orbit at 300 km altitude. The period of the orbit is about 90 minutes. Calculate the number of orbits the satellite completes in one 24-hour Earth day. Give your answer to the nearest whole number.

(3)

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13 Describe how telescopes that operate outside Earth's atmosphere (space telescopes) give better images than similar telescopes on the ground. Give two effects of the atmosphere and their consequences.

(4)

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14 A simplified model shows Earth and Moon as point masses. A small satellite is placed halfway between Earth and Moon and is stationary relative to them. Explain whether this position is stable and name the general region where gravitational forces cancel approximately.

(2)

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15 A planet orbits its star in a circular orbit of radius 2.0×10^8 km. Write down the relationship between orbital period, orbital circumference and orbital speed, then calculate the orbital speed if the period is 200 Earth days. Give your answer in km/s (1 day = 86400 s).

(3)

16 A student tests models of communication delay between Earth and Mars. At one point Mars is 80 million km from Earth. Radio signals travel at the speed of light 300 000 km/s. Calculate the one-way time delay in minutes and explain why missions must allow for this delay when sending commands.

(a) Calculate the one-way time delay in minutes. **(2)**

(b) Explain why missions must allow for this delay when sending commands. **(1)**

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17 An experiment measures the brightness of a light source at different distances to test the inverse square law. The student places a light sensor at distances 0.5 m, 1.0 m and 2.0 m and obtains readings proportional to brightness: 400, 100, 25 (arbitrary units).

(3)

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18 Extended response (6 marks). Satellites in different orbits are used for weather imaging, GPS and deep-space astronomy. Discuss how the orbit height and orbital speed are chosen for these different uses, and evaluate the trade-offs engineers face when selecting an orbit. Use examples and refer to factors such as resolution, coverage, signal delay and launch cost.

(6)

Mark scheme · K15D Space Physics: Exam Drill

Question 1

- **B1** Sun cao
- Answer: **Sun**

Question 2

- (a) **B1** 27 or 27.3 or 28 days, accept 27-28 days, oe
- (a) Answer: **27 days**
- (b) **B1** month or lunar month or synodic month, oe
- (b) Answer: **lunar month**
- (c) **B1** no visible or little oe
- (c) Answer: **no visible**

Question 3

- **B1** B cao
- **B1** Mars is called the Red Planet because of its reddish surface, oe
- Answer: **B) Mars**

Question 4

- (a) **M1** use g2 = g1 x $(r1/r2)^2$ with r1 = 1000 km and r2 = 1050 km
- (a) **A1** 0.454 N/kg cao
- (a) **B1** units N/kg or N per kg
- (a) Answer: **0.454 N/kg**
- (b) **B1** weight depends on gravitational field strength which is smaller further from the centre, so weight decreases, oe
- (b) Answer: **Because gravitational field strength is smaller at greater distance from the centre, so the probe's weight is less.**

Question 5

- (a) **B1** because light travel time is many years so it cannot be measured in a classroom or human timescale
- (a) Answer: **Because light takes years to travel that distance so it is far longer than a classroom experiment can run.**
- (b) **M1** time = distance / speed = 4 x 9.46 x 10^{15} / 3.00 x 10^{8}
- (b) **A1** 1.3e8 s cao
- (b) Answer: **1.3e8 s**

Question 6

- (a) **M1** description that the temperature falls as distance increases and curve is steep at small distances then shallows (inverse-square like) or similar
- (a) **A1** statement that curve is decreasing and becomes less steep as distance increases, oe
- (a) Answer: **Temperature decreases as distance increases; the curve is steep between 20 and 30 cm and becomes shallower between 30 and 50 cm.**
- (b) **M1** calculate 60 - 44 = 16 and 33 - 26 = 7
- (b) **A1** 16 degrees and 7 degrees, first interval greater cao
- (b) Answer: **20-30 cm: 16 degrees C; 40-50 cm: 7 degrees C; the 20-30 cm interval shows the greater change.**
- (c) **B1** one clear improvement and reason, eg keep lamp brightness constant and use same lamp position so only distance changes, oe
- (c) Answer: **Keep the lamp brightness and orientation the same for every reading so only the distance changes, making the test fair.**

Question 7

- **B1** they are in free fall/orbiting Earth so both astronaut and spacecraft fall together, oe
- **B1** there is no contact normal force from a surface on the astronauts, so they feel weightless, oe
- **B1** they have the same acceleration as their spacecraft so no relative force is felt, oe
- **B1** gravity is weaker but still present; weightlessness is due to free fall rather than absence of gravity, oe
- Answer: **Because they and the spacecraft are in free fall around Earth so they fall together; there is no contact force from a surface acting on them, so they feel weightless.**

Question 8

- (a) **M1** angle = angular speed x time = 0.2 degrees/s x (2 x 60) s
- (a) **M1** substitute time 120 s and calculate angle = 0.2 x 120 = 24
- (a) **A1** 24 degrees cao
- (a) Answer: **24 degrees**
- (b) **B1** less than one full circle, since 24 < 360
- (b) Answer: **Less than one full circle.**

Question 9

- **B1** sublimation or sublimating cao
- **M1** particles gain energy, break free from solid structure and move apart as gas
- **A1** clear sentence linking particle behaviour to change of state, oe
- Answer: **Sublimation. The particles gain energy, escape the solid structure and move apart as a gas forming the tail.**

Question 10

- (a) **B1** distance that light travels in one year cao
- (a) Answer: **A light year is the distance that light travels in one year.**
- (b) **M1** 0.5 x 9.46 x 10^{12} km
- (b) **A1** 4.73 x 10^{12} km cao
- (b) Answer: **4.73e12 km**

Question 11

- **B1** hazard e.g. puncture, damage to instruments, short circuit, oe
- **B1** method e.g. shielding like Whipple shield, redundant systems, protective layers, oe
- Answer: **Hazard: puncture or damage to instruments. Method: use protective shielding such as a Whipple shield to absorb impacts.**

Question 12

- **M1** calculate number = 24 hours x 60 minutes / 90 minutes
- **A1** 16 orbits cao
- **B1** units or statement 'orbits per day' (implicit) or rounding shown
- Answer: **16 orbits per day**

Question 13

- **B1** atmospheric turbulence causes twinkling/blur, reducing sharpness
- **B1** atmospheric absorption blocks some wavelengths (UV, X-ray, infrared), so space telescopes can detect these wavelengths
- **B1** scattering by air and dust reduces contrast, space avoids this
- **B1** overall: space telescopes give sharper, clearer images and access to more wavelengths, oe
- Answer: **Earth's atmosphere causes turbulence that blurs images and scatters light, and it absorbs some wavelengths; space telescopes avoid turbulence and absorption so they give sharper images and can see wavelengths blocked by the atmosphere.**

Question 14

- **B1** position halfway is not stable because small perturbations move it away, oe
- **B1** name region as a Lagrange point region or specifically between Earth and Moon the neutral point; accept L1 region or equilibrium point, oe
- Answer: **The halfway point is not stable; small disturbances will move the satellite away. The region is near a Lagrange point (L1) or gravitational equilibrium point.**

Question 15

- **M1** state speed = distance / time and distance = circumference = 2 π r
- **M1** substitute r = 2.0 x 10^8 km and t = 200 x 86400 s and calculate
- **A1** answer 72.7 km/s (to 3 s.f.) cao
- Answer: **72.7 km/s**

Question 16

- (a) **M1** time = distance / speed = 80 000 000 km / 300 000 km/s
- (a) **A1** 266.67 s -> 4.44 minutes cao
- (a) Answer: **4.44 minutes**
- (b) **B1** because the delay means commands and telemetry take minutes, so real-time control is impossible and autonomy or pre-programmed sequences are needed, oe
- (b) Answer: **Because commands and responses take several minutes to travel, ground control cannot operate in real time, so missions need autonomous systems or pre-planned commands.**

Question 17

- **M1** recognise that brightness is proportional to 1/distance^2 and check ratios: 0.5 to 1 to 2 gives factors (1/0.5^2):(1/1^2):(1/2^2) = 4:1:0.25 so expected relative brightness 4:1:0.25
- **M1** compare measured values 400:100:25 which simplify to 4:1:0.25 showing good agreement
- **A1** conclude that results support inverse square law with brief reason, oe
- Answer: **Measured values 400:100:25 simplify to 4:1:0.25 which matches the expected 4:1:0.25 from an inverse square relationship, so the results support the inverse square law for brightness.**

Question 18

- **Level 3** (5-6): Detailed explanation and evaluation. The answer explains how orbit height and speed affect resolution, coverage, and delay; gives specific examples (e.g. low Earth orbit for high-resolution imaging, geostationary for continuous weather cover, high orbits for astronomy), considers trade-offs including launch cost, signal delay and revisit time, and reaches a justified conclusion about selecting an orbit.
- **Level 2** (3-4): Clear explanation with some evaluation. Covers two or three relevant factors and gives example(s) but with limited detail or justification.
- **Level 1** (1-2): Basic statements about orbit height or speed with little linking to uses and few or no examples; evaluation missing or minimal.
- **Indicative content:**
  - Low Earth Orbit (LEO, a few hundred to 2000 km) gives high resolution and low signal delay; suitable for detailed imaging and some communications; disadvantage limited coverage and short revisit times.
  - Geostationary orbit (~36 000 km) matches Earth's rotation so satellite stays over one point; good for continuous weather monitoring and some communications; disadvantage lower resolution for imaging and large signal delay.
  - Medium Earth Orbit and specific orbits used for GPS trade coverage and revisit against cost; constellation design increases coverage.
  - Deep-space or high orbits reduce atmosphere interference for astronomy but are expensive to reach and have long signal delays; stability and thermal environment also matter.
  - Engineers trade higher launch cost and longer delays against coverage and resolution; mission goals determine the best compromise.