



# ASTROCHALLENGE 2021 SENIOR MCQ ROUND

Monday 7<sup>th</sup> June 2021

**PLEASE READ THESE INSTRUCTIONS CAREFULLY.**

1. This paper consists of **20** printed pages, including this cover page.
2. You are required to keep your microphone and camera on at all times throughout the round.
3. You are not allowed to use your keyboard at all times, but you may use your mouse to scroll through the question paper as well as switch to the formula booklet.
4. Any materials other than the Question Paper and Formula Booklet are strictly prohibited.
5. You have **2 hours** to attempt **ALL** questions in this paper. If you think there is more than one correct answer, choose the *most* correct answer.
6. Write your answers on a piece of A4 paper. Write your **Name, School, and Team Number** at the **bottom right corner** before taking a photo to submit. Failure to conform to this may result in us being unable to find the owner of the script.
7. It is *your* responsibility to ensure that your answer script has been submitted.

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1. Venus completes 13 full orbits around the Sun every 8 years. Venus last made a conjunction with the Pleiades star cluster in April 2020. When will Venus next undergo a conjunction with the Pleiades?
  - (A) Nov 2022
  - (B) Nov 2020
  - (C) Apr 2028
  - (D) Apr 2023
  - (E) Aug 2022
  
2. Which of the statements below is generally true?
  - (A) Epicycles cannot explain the retrograde motion of superior planets.
  - (B) The cube of a body's orbital period is directly proportional to the square of the semi-major axis of its orbit.
  - (C) The gravitational force between two objects is proportional to both the product of the masses of the two objects as well as the square of the distance between them.
  - (D) The geocentric model cannot explain seasons on Earth.
  - (E) None of the above statements are generally true.
  
3. During the quarter moon, what kind of tides are generally expected on Earth? Where is the Moon approximately located?
  - (A) Spring tides. The Moon is between the Earth and the Sun.
  - (B) Spring tides. The Moon is on the opposite side of the Sun.
  - (C) Neap tides. The Moon is on the opposite side of the Sun.
  - (D) Trick question. Tides occur every day and are of the same magnitude regardless of the Moon's position, hence there is no differentiation.
  - (E) None of the above.
  
4. Which of the following stars make up the Summer Triangle?
  - (A) Vega, Shaula, and Mizar
  - (B) Albeiro, Altair, and Vega
  - (C) Vega, Albeiro, and Deneb
  - (D) Altair, Denebola, and Vega
  - (E) None of the above

5. Billy was visiting his alien friend Timmy who had set up base at Mercury to observe our Sun. While there, Billy saw the Sun rising from the east, only to backtrack in the opposite direction and then set below the horizon again two Earth days later! Billy was bewildered. How can Timmy best explain what was observed?
- (A) Mercury is at perihelion and its angular rotational velocity has exceeded its angular orbital speed.
  - (B) Mercury is at aphelion and its angular orbital speed has exceeded its angular rotational velocity.
  - (C) Mercury is tidally locked to the Sun but wobbles just enough for the solar terminator to shift.
  - (D) Atmospheric distortion creates this optical illusion.
  - (E) None of the above explains the phenomenon.
6. A distant planet has been discovered to have an orbital period of 800 days with a rotational period of 40 Earth hours per day. Assuming that the planet's rotational axis is aligned with its orbital plane, how many minutes do the stars rise earlier between successive days?
- (A) 5 hours
  - (B) 3 minutes
  - (C) 0.5 days
  - (D) 3.2 hours
  - (E) 6.4 hours
7. Every second, the sun converts roughly 600 million tons of hydrogen into 596 million tons of helium. Which statement correctly describes what happens to the remaining 4 million tons?
- (A) Ejected into space
  - (B) Reabsorbed by molecular hydrogen
  - (C) Converted into other elements
  - (D) Converted into light
  - (E) Trick question. This is not possible.

8. Suppose that a civilisation that has developed in the northern hemisphere of Mars is currently at a developmental stage roughly similar to that of the Ming Dynasty (14<sup>th</sup> century to 17<sup>th</sup> century) on Earth. Which of the following myths is most unlikely to have appeared and prevailed in the civilisation?
- (A) Sun God Ram and his twin sister the Moon God Kham.
  - (B) A Hunter killed by a Giant Scorpion.
  - (C) The Sun God Ram struck a deal with The God of the Underworld Bam to create the four seasons.
  - (D) The Sky Dogs Puppis and Doggis cannot devour the Sun God Ram as a whole.
  - (E) None of the above is possible.
9. What is one possible reason why Galileo Galilei come to realise that the Earth was not, as was commonly believed at that time in the West, the centre of the Solar System?
- (A) He observed the solar analemma.
  - (B) He observed the Milky Way.
  - (C) He read astronomy books written by the Chinese brought back by Marco Polo.
  - (D) He observed the phases of Venus.
  - (E) Trick question. Galileo had in fact thought that the Earth was in fact at the centre of the Solar System all along.
10. Which of the following statements is generally true?
- (A) Omega Centauri was not listed in the Messier catalogue because it had not formed yet at the time of the catalogue's publication.
  - (B) Uranus was first discovered and recognised by Galileo Galilei using a telescope in 1640.
  - (C) The ancient Chinese came up with 25 solar terms in a year to track the progress of the Sun every 15 degrees as it moves across the celestial sphere.
  - (D) The Newtonian telescope using mirrors was invented before refractors due to the complexity of glass-making at that time.
  - (E) None of the above statements are generally true.

11. Jerry has bought a new Dobsonian telescope with the specifications below. Which of the following eyepiece and Barlow combinations should he use if he wants to observe the Ring Nebula (M57) in Lyra, knowing that the angular diameter of M57 is 1.5 arcminutes? Assume that all the eyepieces have an apparent field of view of 52 degrees.

<b>Aperture</b>	305 mm
<b>Focal Length</b>	1500 mm
<b>Focal Ratio</b>	$f/4.9$
<b>Tube Length</b>	1400 mm

- (A) 32mm with 2x Barlow
- (B) 25mm with no Barlow
- (C) 25mm with 3x Barlow
- (D) 20mm with 2x Barlow
- (E) 16mm with 3x Barlow
12. If you stand on the Moon and Earth gaze, what would you observe?
- (A) The Earth rises and sets every 12 hours.
- (B) The Earth looks as big from the Moon as the Moon looks from the Earth.
- (C) Total solar eclipses on the moon make the Earth appear red, just like the Moon does during total lunar eclipses on Earth.
- (D) The Earth's geographical features will change over the course of a lunar day.
- (E) None of the above are correct.
13. Which of the following statements about the (solar) analemma is false?
- (A) The complete analemma cannot be seen inside both the Arctic and Antarctic Circles.
- (B) The smaller loop of the analemma always points towards the north.
- (C) The analemma is created by taking a photo of the position of the Sun at the same mean solar time between regular days.
- (D) The image of the Sun at the intersection in the middle of the figure-eight shape is taken on the day of vernal equinox.
- (E) Both Earth's eccentricity and obliquity result in the figure-8 shape. with a big lobe and a small lobe.

14. Which of the following statements regarding Hubble's law is correct?
- (A) It is a set of laws to regulate the operation and use of the Hubble Space Telescope.
  - (B) It is a set of laws to regulate the Hubble tuning fork.
  - (C) It is used to show that galaxies move away from us at a rate proportional to their distance from us.
  - (D) It is used to show that the Universe is flat.
  - (E) None of the above statements are correct.
15. Consider a binary star system where the semi-major axis between the stars is 0.97AU and the period is 0.38 years. What is the total mass of the combined system?
- (A)  $2.40 \times 10^{11}\text{kg}$
  - (B)  $5.57 \times 10^{16}\text{kg}$
  - (C)  $1.26 \times 10^{31}\text{kg}$
  - (D)  $2.91 \times 10^{31}\text{kg}$
  - (E)  $1.67 \times 10^{34}\text{kg}$
16. Omega Centauri is a globular cluster that is commonly seen in the night sky with an apparent magnitude of 5.33 at a distance of 4.84kpc from Earth. What is the luminosity of Omega Centauri as a ratio of the Sun's luminosity? Take the absolute magnitude of the Sun to be 4.83.
- (A)  $1.12 \times 10^{-1}$
  - (B)  $1.48 \times 10^5$
  - (C)  $1.35 \times 10^9$
  - (D)  $1.94 \times 10^{13}$
  - (E)  $1.24 \times 10^{17}$

17. Which of the following statements about relativity is generally true?
- (A) Generally, with respect to the observer, objects moving forward at speed  $v$  affected by length contraction can counteract the effect of the contraction by moving backwards at the same speed  $v$ .
  - (B) Generally, with respect to the observer and with all other factors kept constant, a clock located in a weaker magnetic field will tick slower. However, a clock located in a stronger magnetic field will tick faster.
  - (C) Generally, with respect to the observer, a clock located on an object moving forwards will tick slower. However, a clock located on an object moving backwards will tick faster.
  - (D) Generally, with respect to the observer, a clock located in a weaker gravitational field will tick faster. However, a clock located in a stronger gravitational field will tick slower.
  - (E) None of the above statements are generally true.
18. Imagine that you are in a post-COVID world without travel restrictions and are currently on a stargazing trip in a remote location at a latitude of  $35^\circ\text{N}$ . Capella (RA/DE: 5h 18m /  $+46^\circ\text{01}'$ ) is currently 3 degrees above the western horizon. The following table shows a list of DSOs you have decided to try to observe for tonight.

Object Name	RA	DEC
Heart Nebula	2h 34m	$+61^\circ\text{32}'$
Omega Centauri	13h 28m	$-47^\circ\text{35}'$
Black-Eye Galaxy	12h 57m	$+21^\circ\text{34}'$
Dumbbell Nebula	20h 00m	$+22^\circ\text{46}'$

In what order, from highest to lowest priority, should you arrange your observations so as to maximise your chances of seeing every one of the DSOs on your list?

- (A) Omega Centauri, Black Eye Galaxy, Dumbbell Nebula, Heart Nebula
- (B) Heart Nebula, Black Eye Galaxy, Omega Centauri, Dumbbell Nebula
- (C) Black Eye Galaxy, Omega Centauri, Heart Nebula, Dumbbell Nebula
- (D) Dumbbell Nebula, Omega Centauri, Black Eye Galaxy, Heart Nebula
- (E) Dumbbell Nebula, Heart Nebula, Omega Centauri, Black Eye Galaxy

19. Which of the following statements about stellar evolution is true?
- (A) Pair-instability supernovae are hypothesised to be one of the causes of gamma-ray bursts.
  - (B) Electron-degeneracy pressure is the main support against gravity when Sun-like stars turn into white dwarfs.
  - (C) It is not possible for a star with 1 solar mass to eventually undergo a supernova.
  - (D) The Sun will turn into a red supergiant as it begins fusing hydrogen to helium in shells around the helium core.
  - (E) None of the above.
20. Justin is using an apochromatic refractor, a polar-aligned motorised equatorial mount, and a standard DSLR with T-Ring adapter for astrophotography. The refractor has a focal length of 600mm and an aperture of 102mm. After reviewing a 60s exposure shot, he found that the image contained unwanted star trails.
- Which of the following mistakes would be least significant in contributing to the star trails?
- (A) Not using a guide scope and autoguiding camera.
  - (B) Setting up the equatorial mount in an open field that is prone to wind.
  - (C) Centring a wrong star in the telescope during the polar alignment of the equatorial mount.
  - (D) Not balancing the set-up with enough counterweights.
  - (E) Setting up the equatorial mount on soft ground that is prone to vibrations.
21. The study of how life originated on Earth plays a significant role in determining if extra-terrestrial life exists beyond the Solar System. By studying how life originates from non-living, simple organic compounds, we develop an appreciation of how life can form elsewhere in the universe. Which of the following astrobiological statements is true?
- (A) Water is the only solvent in which biochemical reactions can take place.
  - (B) The abiogenesis hypothesis suggests that life exists as simple micro-organisms lying dormant in bodies such as asteroids and comets, and are distributed when these bodies collide.
  - (C) Panspermia is the hypothesis that life came about from the reaction of non-living matter, such as simple organic compounds.
  - (D) The Rare Earth hypothesis suggests that the probability of finding extra-terrestrial life is high.
  - (E) The Drake equation is a way to compute the probability of existing civilisations capable of communicating with us.

22. Under what circumstances in Beijing ( $39.9042^{\circ}\text{N}$ ,  $116.4074^{\circ}\text{E}$ ) will the tip of a shadow of a stick over the period of a day draw a straight line on the ground?
- (A) At the winter solstice.
  - (B) At the vernal equinox.
  - (C) When the Sun is directly above Beijing.
  - (D) Trick question. It is impossible.
  - (E) It is possible, but none of the above circumstances are correct.

*For Questions 23 to 25, please refer to the following passage.*

The sky is dark and the night is chilly. A constant wind blows as you consider if you want to stargaze. You know that the W of Cassiopeia can be seen all night and so can Draco. But barely so. You observe that the Sun will set around 1700 and you have to plan for a long night ahead.

With this in mind, you obtain the following information from the local observatory.

If you are willing to get up early this morning, you will enjoy one of the finest sights in the northern hemisphere sky, the great globular cluster in Hercules, cataloged as M13. Hercules rises in the east about three hours before sunrise; give it another hour and M13 will sit a respectable  $15^{\circ}$  (and climbing) above the horizon. You can find it about one-third of the way between Eta ( $\eta$ ) and Zeta ( $\zeta$ ) Herculis.

Shining at magnitude 5.3, this ancient star cluster spans  $16.6'$  and is easily visible in binoculars. A telescope will bring out even more of its over 100,000 members. Embedded within the cluster's core are three dark lanes, often called the propeller. Spanning  $3'$ , this feature sits just southeast of the central region of the core. It is best viewed under higher magnification ( $200\times$  to  $300\times$ ) in larger (8-inch or so) scopes, but good observing conditions will afford those with smaller instruments a better chance. Some observers find that using averted vision, or looking slightly away from the region you want to focus on, makes the propeller appear more easily.

Even if you can't find this feature, the Hercules Cluster is still a sparkling wonderland you can enjoy through the eyepiece until dawn. It's arguably the best northern hemisphere globular and will rise earlier each morning as the month goes on, affording even better views with time. There are a few hours between sunset and moonrise to enjoy dark skies tonight. Once darkness falls, consider trying for the Andromeda Galaxy (M31), located high in the east in its namesake constellation. From a particularly dark location, you may be able to see a dim, gray smudge without any optical aid at all. It is the farthest object visible to the naked eye. Look for it about  $1.3^{\circ}$  west of Nu ( $\nu$ ) Andromedae. Pull out binoculars or a telescope for an even better view of the galaxy's bright centre and dimmer outskirts.

23. Based on the passage above, which northern hemisphere astronomical season is most likely referenced above?
- (A) Between Autumn and Winter
  - (B) Between Winter and Spring
  - (C) Between Spring and Summer
  - (D) Between Summer and Autumn
  - (E) Not enough information to determine

24. Based on the passage above, which phase is the moon most likely to be in?
- (A) Full
  - (B) New
  - (C) Waxing crescent
  - (D) Waning gibbous
  - (E) Not enough information to determine
25. Based on the passage above, which of the following constellations is likely to be at the zenith at local midnight?
- (A) Auriga
  - (B) Andromeda
  - (C) Hercules
  - (D) Crux
  - (E) Ursa Minor
26. Some random person thought that it would be a good idea to adapt a sundial to keep time at night using the Moon instead of the Sun. Which of the following issues is/are unlikely to arise?
- (A) The time measured may vary significantly one night to another night.
  - (B) It would not work for at least one entire night a month and at least part of the night on most of the month.
  - (C) The shadow may be affected by artificial light sources and as such may not be readily visible.
  - (D) All of the above are possible issues.
  - (E) None of the above are possible issues.
27. How much time elapses in the frame of a photon that has travelled for 0.03s in the perspective of a non-relativistic observer?
- (A) 0.015s
  - (B) 0.02s
  - (C) 0.03s
  - (D) 0.04s
  - (E) No time passes for the photon

28. Order the following time periods of the universe from the earliest to the latest.

- I The Big Bang
- II Age of reionisation
- III Inflationary epoch
- IV Quark epoch
- V Planck epoch
- VI Photon epoch

- (A) I, II, III, IV, V, VI
- (B) I, IV, V, VI, III, II
- (C) I, V, III, IV, VI, II
- (D) I, V, IV, VI, III, II
- (E) None of the above orders are correct

29. Celestial navigation has a rich and interesting history. The navigator would use ‘sights’, or angular measurements taken between a celestial body (e.g., the Sun, the Moon, Polaris, or one of 57 other navigational stars and planets) and the visible horizon to locate one’s position in the world, on land as well as at sea.

Let us explore a simple application of Celestial Navigation using our wrist watch.

To use our watch as a compass in the northern hemisphere, hold the watch horizontal and point the hour hand at the Sun. The halfway mark between the hour hand and the twelve o’clock mark is south.

For example, if it is 8 o’clock, point the 8 on the watch face at the Sun. South would then be at the 10 o’clock position. If it is 4 o’clock, point the 4 on the watch face at the Sun. South would be in the 2 o’clock position.

What assumptions were used in the passage above?

- I Your wristwatch is correctly synced to local time.
- II Your wristwatch is correctly synced to local solar time.
- III You are located not in the tropics at a latitude below the Tropic of Cancer.
- IV The season is not winter.
- V The time is not noon.

- (A) I and III only
- (B) II and III only
- (C) III and IV only
- (D) II, III, and V only
- (E) I, III, and V only

For Questions 30 and 31, please refer to the following table.

Object Name	Apparent Magnitude	Apparent Size (arcminutes)
Triangulum Galaxy	5.72	$70.8 \times 41.7$
Andromeda Galaxy	3.44	$190.2 \times 60.0$
Orion Nebula	4.0	$65.0 \times 60.0$
Dumbbell Nebula	7.5	$8.0 \times 6.0$
Eskimo Nebula	10.1	$0.8 \times 0.8$

30. Calculate the surface brightness of each DSO in  $\text{mag}/\text{arcsec}^2$ , and hence arrange them in order of increasing surface brightness.

- (A) Eskimo Nebula, Dumbbell Nebula, Orion Nebula, Andromeda Galaxy, Triangulum Galaxy
- (B) Andromeda Galaxy, Orion Nebula, Triangulum Galaxy, Dumbbell Nebula, Eskimo Nebula
- (C) Triangulum Galaxy, Andromeda Galaxy, Orion Nebula, Dumbbell nebula, Eskimo Nebula
- (D) Triangulum galaxy, Dumbbell Nebula, Eskimo Nebula, Andromeda Galaxy, Orion Nebula
- (E) Eskimo Nebula, Dumbbell Nebula, Triangulum Galaxy, Orion Nebula, Andromeda Galaxy

31. In a mildly light-polluted night sky with a surface brightness of  $19.4\text{mag}/\text{arcsec}^2$ , which of the above objects are visible with the naked eye.

- (A) Eskimo Nebula only
- (B) Dumbbell Nebula and Eskimo Nebula
- (C) Orion Nebula and Andromeda Galaxy
- (D) Orion Nebula, Andromeda Galaxy, Dumbbell Nebula, and Eskimo Nebula
- (E) Triangulum Galaxy, Orion Nebula, and Andromeda Galaxy

32. The James Webb Space Telescope (JWST) will be deployed at the second Lagrange point (L2) of the Earth-Sun system, unlike the upcoming Chinese Space Telescope Xuntian, which orbits the Earth at low Earth orbit. The JWST observes in the visible light through mid-infrared region of the electromagnetic spectrum, whereas the Xuntian observes in the ultraviolet, visible light, and near-infrared regions.

With reference to the above information, which of the following statements is/are true?

- I It is necessary for the JWST to employ a sunshield to shield its observing instruments from significant heat sources such as the Sun.
- II The JWST is positioned at L2 such that the Earth, Sun, and Moon are in the same general direction, reducing instrumental interference due to radio waves emitted by these bodies.
- III The JWST is positioned at L2 because it is a point of stable equilibrium and no fuel will be required to keep it on its intended orbital path.
- IV The JWST is not positioned at L4 or L5 because they are relatively far away from the Earth. At 0.5AUs from Earth, light takes a longer time to travel to L4 or L5, limiting the ability to perform real-time commands.

- (A) I only
- (B) I and III only
- (C) I and IV only
- (D) I, II, and III only
- (E) I, III, and IV only

33. The Hubble Space Telescope (HST) has a Cassegrain reflector design and employs a hyperbolic primary and secondary mirror. When the HST was first deployed, it was found that the outer perimeter of the primary mirror was polished to be too flat, a serious problem that caused its images to be flawed. What was the type and cause of the main optical aberration that was introduced?

- (A) Chromatic aberration due to different wavelengths of light being reflected at different angles.
- (B) Coma aberration where light reflected from the edges of the primary mirror is focused at the image plane closer to the optical axis compared to light reflected nearer to the centre.
- (C) Coma aberration where light reflected from the edges of the primary mirror is focused at the image plane further from the optical axis compared to light reflected nearer to the centre.
- (D) Spherical aberration where light reflected from the edges of the primary mirror are focused to a plane closer to the mirror compared to light reflected nearer to the centre.
- (E) Spherical aberration where light reflected from the edges of the primary mirror are focused at a plane further from the mirror compared to light reflected nearer to the centre.

34. Olbers' paradox describes how every point in the night sky should be bright on the assumption that the Universe is endless and uniformly populated with stars, contrary to observation. Which of the following is not a possible solution to Olbers' paradox?
- (A) The Universe is finitely old and ends at some point.
  - (B) The speed of light is finite.
  - (C) The age of stars is finite.
  - (D) Light from distant stars get scattered too much and is hence too dim to detect.
  - (E) The number of stars in the Universe is finite.
35. A deep-sky object located directly at the celestial equator with an angular diameter of  $10'$  is viewed from the eyepiece of a telescope with a true field of view of  $0.8^\circ$ . Object tracking on the telescope is disabled and the object is aligned at the edge of the field of view. Assuming the object moves along the diameter of the eyepiece before disappearing, calculate the time it takes for the object to drift out of view of the eyepiece.
- (A) 13 seconds
  - (B) 19 seconds
  - (C) 3.2 minutes
  - (D) 4.8 minutes
  - (E) There is not enough information to determine the time.
36. Gravity assists are commonly used to slingshot spacecraft by utilising the gravitational pull of astronomical bodies. Which of the following statements is/are true?
- I A gravity assist can be used to increase or decrease the speed of a spacecraft, as well as redirect its path.
  - II A practical limitation of gravitational assists using planets is atmospheric drag, where the energy lost due to drag is greater than the energy gained from the planet's gravity.
  - III Assuming no atmospheric drag, the total sum of kinetic energy of the spacecraft and astronomical body remains constant.
  - IV Gravitational assists using the Sun are feasible but depend solely on the spacecraft's ability to resist the Sun's heat.
- (A) I only
  - (B) I and III only
  - (C) I, II, and III only
  - (D) I, III, and IV only
  - (E) I, II, III, and IV

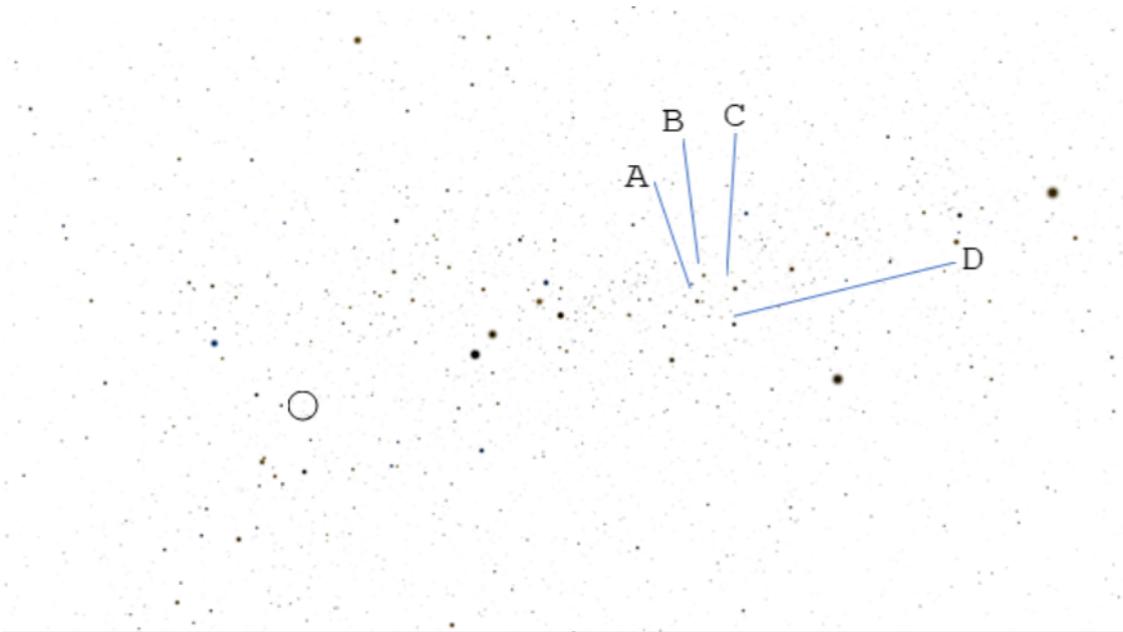
37. Which of the following lines of evidence could possibly support the existence of dark matter?
- (A) The Universe is dark.
  - (B) Dark nebulae have been detected.
  - (C) Black holes have been recently photographed.
  - (D) The galactic rotation curve of most galaxies does not make sense.
  - (E) The rate of expansion of the universe is speeding up, not slowing down.
38. Your classmate Donovan has been an avid amateur astronomer for three years and owns a 6" Newtonian reflector ( $f/5$ ) with a manual equatorial mount. He wishes to do astrophotography and has sought your advice on what equipment to buy. Based on his current equipment, which of the following statements can you offer him as advice?
- I He should get a light pollution filter to sieve out unwanted stray light entering his telescope.
  - II He should purchase an auto-guider to help him automatically track objects that his telescope is pointed at.
  - III A high-speed video camera and Barlow lens can be purchased for capturing detailed images of planets by utilising the large aperture of his telescope.
  - IV Since he possesses an equatorial mount and a fast Newtonian reflector, he can use a DSLR or purchase a dedicated astronomy imaging camera to take pictures of deep-sky objects like the Orion Nebula and the Andromeda Galaxy.
- (A) I only
  - (B) III only
  - (C) II and III only
  - (D) I, II, and III only
  - (E) II, III, and IV only

39. Collimation is the process of aligning all components in a telescope to bring light to its best focus. Generally, which of the following telescopes require frequent collimation?

- I Newtonian reflector
- II Schmidt-Newtonian
- III Schmidt-Cassegrain
- IV Keplerian refractor
- V Galilean refractor
- VI Ritchey-Chrétien

- (A) I only
- (B) I and II only
- (C) I, II, III and V only
- (D) I, III, and VI only
- (E) None of the above combinations are correct

For Questions 40 and 41, please refer to the following image.



40. Which DSO would one expect to see in the circled region?

- (A) False Comet
- (B) False Cross
- (C) False Eskimo
- (D) Jewel Box
- (E) Southern Pleiades

41. The stars A, B, C, and D form part of a constellation. What is that constellation?

- (A) Crux
- (B) Argo Navis
- (C) Carina
- (D) Scorpius
- (E) Trick question. This is an asterism formed from at least two different constellations.

For Questions 42 to 44, please refer to the following table.

Star	A	B	C
<b>Spectral Type</b>	B0IV	B3III	A5IV
<b>Right Ascension</b>	0h 58m 00s	1h 55m 56s	1h 27m 12s
<b>Declination</b>	60°49'50"	63°46'23"	60°20'39"
<b>Apparent Magnitude</b>	1.6–3.0	3.3	2.7
<b>Distance from Earth</b>	615ly	448ly	99.5ly
<b>Color Index (B–V)</b>	–0.05	–0.15	0.16

42. Which of the following statements is/are correct?

- I Star C is a white dwarf.
- II Star B is definitely more massive than the Sun.
- III Stars A and C are located on the main sequence.
- IV Star A is the hottest among them all.
- V All three stars are very much likely gravitationally bound.

- (A) I and II only
- (B) II and III only
- (C) II and IV only
- (D) II, IV and V only
- (E) None of the above options are correct

43. Rank the following in increasing order of luminosity. You are given that the Sun is located 8 light minutes away and that its apparent magnitude is  $-26.7$ .
- I The Sun
  - II Type 1a supernova
  - III Star A
  - IV Star B
  - V Star C
- (A) I, II, III, IV, V
- (B) I, IV, V, II, III
- (C) II, III, IV, V, I
- (D) IV, V, III, II, I
- (E) None of the above orders are correct
44. It is further given that the radial velocities of Star B and Star C is  $-8.1\text{kms}^{-1}$  and  $-6.7\text{kms}^{-1}$  respectively. Assuming a fixed and constant rate of motion, roughly how long will it take for the apparent magnitude of Star B to be dimmer than that of Star C?
- (A) 2000 years
- (B) 20000 years
- (C) 200000 years
- (D) 2 million years
- (E) 20 million years
45. Which of the following statements about the midnight sun is false?
- (A) The midnight sun lasts for 6 months for locations near the celestial poles.
- (B) The midnight sun can be seen outside the Arctic Circle and the Antarctic Circle, due to atmospheric refraction of the sun below the horizon.
- (C) At the north and south celestial poles, the Sun only rises and sets once a year on the equinoxes.
- (D) On the winter solstice at the north celestial pole, the Sun will stop moving north, change direction, and start to move south.
- (E) At the south celestial pole, the midnight sun can be seen longer than September 23 to March 21 due to atmospheric refraction of the Sun below the horizon.

46. Which of the below practical astronomy tips for use in Singapore is correct?
- (A) You should proceed to stargaze when the Moon is full.
  - (B) You should align your mount to the north by using a polar scope and finding Polaris.
  - (C) You should balance the mount before you mount the telescope.
  - (D) You should load the counterweight before loading anything else onto the mount.
  - (E) None of the above tips make sense.
47. Which of the following factors are not considered when calculating the orbital speed of a satellite?
- (A) Gravitational constant
  - (B) Mass of the parent body
  - (C) Mass of the satellite
  - (D) Orbital radius/semi-major axis of the satellite around the parent body
  - (E) All of the above are considered
48. Europa is the second inner-most Galilean moon of Jupiter. It is seen as a possible candidate for extra-terrestrial life due to the conditions it experiences. Which of the following observations of Europa is/are significant in determining if it can possibly host life?
- I A subsurface ocean is hypothesised to exist below Europa's surface.
  - II Europa is located outside the circumstellar habitable zone of the solar system.
  - III Tidal heating exists due to the gravitational interaction between Jupiter and Europa.
- (A) I only
  - (B) I and II only
  - (C) I and III only
  - (D) I, II, and III
  - (E) None of the above

49. In 1964, a weak radio signal was detected using a supersensitive horn antenna after attempting to eliminate all sources of interference. The radio waves detected were evenly spread across all parts of the sky and were subsequently attributed to the Cosmic Microwave Background Radiation (CMBR). Which of the following statements is/are true?
- I The expansion of the universe causes the temperature of the CMBR to decrease over time.
  - II The discovery of the CMBR supports the steady-state model, where the density of matter in the expanding universe is constant due to the continuous creation of matter.
  - III As the universe expands, the CMBR is redshifted, decreasing the wavelength of the radiation over time.
- (A) I only
  - (B) I and II only
  - (C) I and III only
  - (D) I, II, and III
  - (E) None of the above
50. When studying the stellar spectrum of the binary Delta Orionis, Johannes Hartman realised the calcium absorption lines did not share the same periodic displacements as absorption lines of other similar stars. What did this observation lend evidence to?
- (A) Presence of a third component in the Delta Orionis star system.
  - (B) The presence of atmospheric calcium in Earth's upper atmosphere.
  - (C) The presence of interstellar gas.
  - (D) The use of calcium fluoride in coating mirrors was not suitable for spectroscopy.
  - (E) Hartman made a mistake somewhere somehow.