	Question	Answer
1	Which one of the following statements best explains why there is not a solar eclipse during every new moon? A. The Moon's orbital plane is tilted by about 5° relative to the ecliptic plane B. The Moon takes about 27 ⅓ days to complete an orbit relative to the position of distant stars C. The Moon takes about 29 1/2 days to complete a cycle of lunar phases D. The Moon's diameter is about 4 times smaller than the Earth's E. The Moon undergoes axial precession	A Only A would prevent solar eclipses from occurring every new moon – the others would have no effect
2	Relative to the Sun, which of the following planets has the highest orbital speed? A. Mars B. Jupiter C. Saturn D. Uranus E. It depends on the location of the planets along their respective orbits	A Orbital speed is inversely proportional to the distance to the Sun. Thus, from the list, pick the planet that is the closest to the Sun. Further, as all planets have roughly circular orbits, their orbital speed remains roughly the same across time.
3	What are the lunar 'seas' made of? A. Saltwater over oceanic crust. B. Freshwater over oceanic crust. C. Ejecta from impactors D. Cooled lava. E. High albedo intrusive metamorphic rock.	D Trick/troll question. The lunar maria is made of basalt, a type of extrusive igneous rock that formed by volcanic eruptions on the Moon billions of years ago. These basaltic plains i.e. mare have low albedo due to a low reflectivity.
4	In the Northern Hemisphere, where must one point the polar axis of the equatorial mount towards, such that moving the telescope in Right Ascension will most precisely mimic the motion of the sky over the course of a night? A. Sirius (Alpha Canis Majoris) B. Polaris (Alpha Ursae Minoris) C. Capella (Alpha Aurigae) D. Alpheratz (Alpha Andromedae) E. Rigil Kentarus (Alpha Centauri)	B Polaris is the Pole Star, thus aligning the polar axis to it approximately means the mount is aligned with celestial north.

5	What will be the fate of our Sun immediately after it runs out of fuel and ceases all nuclear fusion? A. Brown dwarf B. Red dwarf C. White dwarf D. Neutron star E. Black hole	C Brown dwarves are failed stars, red dwarves are still fusing hydrogen in their cores and the Sun is not massive enough to create a neutron star or black hole.
6	Based on our current understanding of the history of the solar system, arrange the following statements in chronological order i. Planetary migration of the outer planets generates the Late Heavy Bombardment ii. A protoplanetary disk forms, with a protostar (the future sun) in the center. iii. Planetesimals collide to form the cores of future planets iv. A gas cloud becomes unstable and begins gravitational collapse v. Orbiting dust grains collide with each other to form larger bodies (planetesimals) vi. The gas within the protoplanetary disk is fully dispersed by the Sun's strong stellar wind A. ii, iv, v, iii, i, vi B. iv, i, ii, iii, v, vi C. iv, ii, v, iii, vi, i D. ii, iv, iii, v, vi, i E. ii, v, iv, vi, i, iii	C The process starts with the collapse of a gas cloud (iv), and ends with the Late Heavy Bombardment (i). This leaves only one sensible option – option C.
7	Which of the following planets is not expected to be visible from Singapore at local midnight? A. Venus B. Mars C. Jupiter D. Saturn E. All the above planets can be visible.	A As Venus is an inferior planet, it cannot be seen at midnight from Singapore.
8	The apparent magnitude of the Sun is known to be approximately –26 while the Full Moon is known to have an apparent magnitude of approximately –12, both rounding down to the nearest integer. According to the information given above, how many times is the Sun brighter than the Full Moon? Choose the closest answer. A. 1 million times B. 400 thousand times	B The magnitude scale is logarithmic, each step of one magnitude is equivalent to the difference in brightness of a factor of 2.512 approximately. Since the difference in magnitude of

	C. 140 thousand times D. 14 times E. 35 times	the Sun and the Full Moon is –12+26=14 steps of one magnitude, the Sun is approximately 2.51214 = ~400 000 times brighter than the Full Moon.
9	For a given comet, when is its gas tail the longest? A. When the comet is heading towards the Sun. B. When the comet is heading away from the Sun. C. When the comet is nearest to the Sun. D. When the comet is in the Oort Cloud. E. The colder it is, the longer the comet gas tail.	C A comet's gas tail is produced when solar heating sublimates ice on the comet's surface. For this reason, gas tails are the longest when solar heating is at a maximum (i.e. nearest to the Sun)
10	Which of the following is TRUE about Vega and Altair? A. Vega and Altair are only visible in Autumn B. The distance between Vega and Altair is the closest on the 7th day of the 7th lunar month in the Chinese calendar, hence resulting in the ancient myth of Vega and Altair being star crossed lovers C. Vega and Altair together form a gravitationally bound binary star system D. Vega and Altair are part of the "Summer Triangle" asterism, together with Deneb E. None of the above	D The distance between Vega and Altair is approximately 16 light years – they are too far to be bound to each other. Further, their distance means that their relative position to each other does not change appreciably over the course of a year, contrary to the ancient Chinese folklore. Both stars, together with Deneb, form the "Summer Triangle" asterism which is part of the summer sky in the northern celestial hemisphere. Vega and Altair do not form a binary star system.
11	Although radio waves are commonly used to measure distance to objects within the solar system, the distance to the sun was first measured using parallax during a Venus transit. Given that two observatories at each of the poles on Earth are measuring the parallax of Venus while it is transiting the Sun, what will be the parallax? Assume Venus to be a point. Hint: calculate the distance from Venus to Earth during the transit. a. 1.11 arc minutes b. 1.62 arc minutes c. 1.06 arc minutes d. 0.554 arc minutes	Ans: c. Distance from Venus to Earth is (1.496-1.082)x10^11=4.14x10^10m. Radius of Earth is 6.370x10^6m Using small angle approximation, θ=radius of earth/distance from Earth to Venus = 1.5386x10^-4 rad = 31.74 arc seconds

	e. 0.843 arc minutes	Taking the anglex2: 31.74x2=63.5 arc seconds = 1.06 arc minutes
12	An observer notices that star A culminates (in other words, crosses the meridian) at local midnight on January 1st. Two days later, he notices that star B (rather than star A) now culminates at local midnight. Which of the following statements are definitely true? A. Both stars share the same declination B. Both stars share the same right ascension C. Both stars are separated by around 8 minutes of declination D. Both stars are separated by around 8 minutes of right ascension E. Culmination time depends on location, and thus there is insufficient information to answer the question	D When a star crosses the local meridian is only determined by the right ascension of the star & the time of year (thus A/C/E is wrong). The last part of the puzzle requires one to know that stars rise approximately 4 minutes later every night, yielding D
13	Post processing images is an essential part of astrophotography. Which of the following isn't a purpose of post processing? a. To remove certain wavelengths of light to reduce light pollution b. Adding colour and/or adjusting the colour balance of the image c. Crop and framing the image d. Adjusting exposure and contrast to bring out details e. Combining colour data from separate exposures to build an image	A There's no way to remove certain wavelengths of light after the image is taken.
14	Three friends are arguing over the positions of sunrise and sunset at different latitudes and seasons. Alni Tak: The sun rises due east and sets due west. Differences in latitude only changes the angle of the sun's path in the sky. Alni Lam: No, the point of sunrise and sunset can be anywhere between 0 degree and 180 degree from North on the East and West sides respectively depending on latitude and season. Min Taka: Both of you are wrong. While it is true the point of sunrise and sunset varies according to latitude and season, it can only vary between 30	B Option A is wrong because the sun only rises and sets due East and West at equinox. For option C, 30 degrees and 120 degrees azimuth are random values with no physical basis whatsoever. Options D and E are non-answers to begin with.B: Consider the scenario of the sun at summer solstice, i.e. at its most northerly declination of 23.4 deg. The above

	degrees and 120 degrees from due north. Who is right? A. Alni Tak B. Alni Lam C. Min Taka D. None of them. E. All of them are correct according to their own unique subjective view of the universe.	diagram shows the path of the sun (in red) at the north pole (90 deg N latitude), with the red arrow pointing towards the north celestial pole.N Moving towards more southern latitudes, at about 66.6 deg N, the path of the sun tilts such that it touches the horizon at a single point, which is in the direction ofdue North.Moving further south, the path of the sun crosses the horizon at two points on the northeast and northwest.At the equator, the sun rises 23.4 deg north of east and sets 23.4 deg north of west. Moving south of the equator, the scenario repeats, and the point of sunrise and sunset slowly converges towards the north, and you can see that the length of the day gets shorter and shorter until it reaches eternal night beyond 66.6 deg South. Thus at summer solstice the azimuth of sunrise ranges between due North and 23.4 deg north of east across latitudes.The inverse is true at winter solstice, where the azimuth of sunrise ranges between due south and 23.4 deg south of east.The sun rises between 23.4 deg north and 23.4 deg south of east in the period between solstices at latitudes nearer to the equator (diagrams can be found in the original document, but I have omitted them here for the sake of brevity)

15	On June 21st, an observer in the Northern hemisphere notices that the maximum and minimum length of shadow of a 1.0 m pole is 16.3 m and 1.05 m respectively. What is the latitude of the observer? A. 10 degrees N B. 25 degrees N C. 40 degrees N D. 55 degrees N E. 70 degrees N	E While the declination of the sun (already given as + 23.5) and latitude of observer can be solved for, it is faster to note that the maximum length of shadow is given (i.e. the sun does not set). A circumpolar sun is only possible for Northern observers above the arctic circle. (66.5 degrees N)
16	The vast majority of globular clusters no longer appear to produce any new stars today. This is mainly because A. Gravitational interactions over billions of years have ejected gas out of the cluster. B. The strong solar winds of the stars have pushed out gas. C. Most globular clusters formed very early in the history of the universe and have long since exhausted their gas reserves. D. The production of new stars is outshadowed by the light of the cluster. E. This is a trick question: Many new stars are still being born in most globular clusters.	C Most globular clusters were some of the first objects to have formed in the galaxies, and most are over 12 billion years old. Their gas has long since depleted over this time and thus no star formation occurs within them today.
17	Copernicus was known for introducing the Heliocentric System which placed the Sun, rather than the Earth, at the center of the universe. What were some advantages of the Copernican model over the then prevailing Ptolemaic geocentric model? i. The Copernican model had removed the need for epicycles. ii. The Copernican model provided a simpler account of retrograde motion. iii. The Copernican model could predict eclipses. iv. The Copernican model explains the orbit of comets. A. i, ii B. ii only C. i,ii,iii D. i,ii,iv E. i only	B The only one real advantage of Copernicus' heliocentric model over the prevailing geocentric system was that it eliminated some of the major epicycles used to explain retrograde motion, which was explained as a result of parallax between the planets and the background stars. Other smaller epicycles were required to make up for discrepancies between predicted and observed planetary positions because the Copernican system utilized perfect circles. It is only after

		Kepler's introduction of elliptical orbits were all epicycles then removed.In a similar vein, the Copernican system was no better at eclipse prediction due to its use of circular orbits, which did not allow for accurate calculations of planetary positions. More accurate predictions only came after Kepler's elliptical orbits and his three laws of planetary motion. The case is similar for comets, which travel on highly elliptical orbits
18	Refer to the following passage for Q18-19 **This Week's Planet Roundup** **Mercury, Venus, and Mars** remain deep in the glare of the Sun. **Jupiter** (magnitude –2.0, in the feet of Ophiuchus) is the white dot low in the southwest as twilight fades. Can you still spot Antares, one sixteenth as bright at magnitude +1.0, 10° to Jupiter's lower right? **Saturn** (magnitude +0.5, in Sagittarius) is the steady yellow "star" in the south-southwest during and after dusk. It's 25° upper left of Jupiter. Below Saturn is the handle of the Sagittarius Teapot. Barely above it is the dimmer, smaller bowl of the Sagittarius Teaspoon. **Uranus** (magnitude 5.7, in Aries) is well up in the east by 10 p.m. daylight saving time. It's highest in the south around 1 or 2 a.m. **Neptune** (magnitude 7.8, in Aquarius) is in the southeast after dark and highest in the south by 10 or 11. Extracted from Sky and Telescope's This Week's Sky at A Glance, Oct 4-12 https://www.skyandtelescope.com/observing/this-weeks-sky-at-a-glance-october-4-12/ (do not include the reference in the question paper)	E All references to up/down/left/right are relative to the observer's orientation –thus they can flip depending on where the observer is facing. While the cardinal directions are defined relative to the celestial sphere (and thus one person's north does not differ from another person's north), objects themselves can shift in position as we move from one observer to another. In other words, observers in the far south would notice all the planets to lie in the NORTHERN half of the sky – and thus E is correct.

	This passage is written from the perspective of North American observers at a certain point in time. Suppose we keep the time fixed, but allow the observer's location to change. Which of the following statements are still valid from an observer stationed ANYWHERE ELSE on Earth? Exclude the geographic North and South Poles from consideration A. Jupiter is the white dot low in the southwest as twilight fades B. Antares is 10° to Jupiter's lower right C. Saturn is in the south-southwest during and after dusk D. Uranus is highest in the south around 1-2 a.m E. None of the above	
19	This passage is written for the first week of a certain month. This month is most probably: A. January B. March C. July D. October E. Insufficient information to determine the answer	D Notice that Antares (with Jupiter) is low in the southwest during sunset. As Antares is located within Scorpius, an early summer constellation, this tells us that summer has just ended. Another way to see this is to observe that Uranus is near opposition, and is currently located within Aries. Recalling the significance of the first point of Aries (which is not within the boundaries of Aries but lies close to it in the present day), this tells us that the Earth is approximately half a year away from the March equinox
20	Benjamin is attempting to view M31, the Andromeda Galaxy through a pair of binoculars in Singapore. At the position where M31 should be, he sees a dim fuzzy elliptical blob. Unfortunately, he could not see the spiral arms of M31. What is the most likely explanation? A. The surface brightness of M31 is too low to be seen in Singapore. Benjamin is most	D The core of M31 is a lot brighter than its spiral arms (as is the case with most spiral galaxies), such that astrophotographers have to take special care not to

	likely looking at M110, a dwarf elliptical galaxy near M31 which has a much higher surface brightness. B. Binoculars do not have sufficient magnification and resolution to resolve the spiral arm structure, thus the whole galaxy appears as a fuzzy elliptical blob. C. No galaxies can be seen in Singapore. Benjamin is most likely hallucinating. D. Benjamin is only seeing the bright center core of M31, while its spiral arms are too dim to be visible. E. M31 does not have spiral arms as it is actually a globular cluster.	overexpose the core when imaging the galaxy.M110 has actually very low surface brightness and can only be seen from sufficiently dark sites.
21	The crescent moon was photographed to have the "dark part" of the moon bright enough such that the lunar features are visible to the naked eye. Which of the following best explains this? A. The "dark side" of the moon is a misnomer -all areas of the moon receive about equal sunlight when averaged out throughout a year B. The dark area is not in total shadow and hence some light still reaches it from the Sun. C. This phenomenon can be observed a few days before a lunar eclipse. The "dark part" is Earth's shadow on the moon D. The '"dark part" of the moon receives reflected light off Earth to be illuminated. E. This phenomenon occurs when 2 conditions are met -the moon is in syzygy with Earth and the Sun, and the moon is at its perihelion  Credit: Instagram -rami_astro	D This phenomenon is known as Earthshine. From the perspective of an observer on the Moon, the Earth would appear nearly full. This casts sufficient illumination to visibly light up the surface. E cannot be true – when the Moon is in syzygy with Earth and the Sun, this means that all 3 bodies are in a straight line. In other words, the Moon is either new or full, which is clearly not the case as per the image.
22	Consider the following three pairs of binoculars. (I) Pentax 8.5×21 U-series Papilio II	C

	(II) Vixen 10×50 Ascot (III) Orion 20×80 Astronomy Which of the above would NOT be recommended for astronomy via handheld binocular viewing? A. I only. B. I and II only. C. I and III only. D. II and III only. E. All of the above would not be recommended	The Aperture of I is too small, leading to insufficient light collecting power. Coupled with its relatively high magnification, any resultant images will be dim. II is typical for astronomy binoculars III is not recommended as the rather high magnification makes the image very unstable with handheld viewing
23	While a superior planet is experiencing apparent retrograde motion, the planet _____. A. Rises in the west and sets in the east B. Rises and sets earlier than expected C. Moves backwards in its orbit around the Sun D. Appears to stop its westward motion, and then drifts eastwards relative to the stars E. Appears to stop its eastward motion, and then drifts westwards relative to the stars	E Superior planets generally drift eastward relative to the stars. The exception occurs during apparent retrograde motion, when the planet actually appears to drift west for a time.
24	Hindu cosmology (c 1700 to 1100 BCE) states that one cycle of existence is approximately 311 trillion years, and the life of one universe is approximately 8 billion years. The universal cycle is preceded by an infinite number of universes and is to be followed by an infinite number of universes. This concept is most similar to the concept of… A. the Big Bang B. steady state C. the Big Crunch D. accelerating expansion E. negative pressure	C The Big Crunch is a proposed model in which the universe's acceleration eventually slows and reverses, leading the universe to collapse back into a single point, bringing about another Big Bang and another universe. Sound familiar?
25	I want to take a color image of the Great Dark Spot (6600 km across), using individual 10s exposures in 3 different wavelengths. My setup enjoys clear skies in the Australian outback and uses a Schmidt-Cassegrain telescope and tracking equatorial mount only. Suppose I only can vary the aperture of my telescope. What is the minimum diameter my telescope needs to have, such that all exposures satisfy my technical requirements?	Answer: E. Using trigonometry, the Great Dark Spot spans $\arcsin\left(\frac{6600}{4.4\ billion}\right) = 3.18 \times 10^{-7}\ rad = 0.065\ arcsec.$ Since the Rayleigh Criterion is given by: $$\sin\theta_{min} = 1.22\frac{\lambda}{D}$$

	You are given that Neptune will be 4.4 billion kilometres away at the time of the shot and the exposures will be taken in red (650nm), green (550nm) and blue (450 nm) A. 0.05 cm B. 37 cm C. 45 cm D. 53 cm E. Not possible given the current setup.	This reduces to $D = 1.22\lambda \div \frac{6600}{4.4\ billion}$ Yielding approximately 53 cm, 45 cm and 37 cm for each wavelength of light respectively. But wait a minute: we have had telescopes way larger than this when Neptune was discovered. Why didn't we know of the Great Dark Spot then? The answer is that due to atmospheric turbulence, large telescopes are limited by **<u>seeing</u>**. In other words, without adaptive optics, increasing the aperture beyond 4-8" does not increase the resolution of a ground-based telescope.
26	For Questions 26-28, refer to the image below <image moved to end of table for readability> Which of the following is the star Canopus A. A B. B C. C D. D E. None of the above	D Refer to the annotated image. A (Rigel), B(Sirius) and D (Aldebaran) are part of the Winter Hexagon
27	Which of the below Asterisms is not in the field of view below A. The W of Cassiopeia B. Winter Triangle C. Winter Hexagon D. False Cross E. All of the above Asterisms are in	A Cassiopeia is not in the image. Refer to the annotated image.
28	Can you see the plane of the Milky Way in the above field of view? If so, state which section of the Milky Way is visible A. Yes, the section between Crux and Auriga B. Yes, the section between Cancer and Taurus	A Crux and Auriga lie within the plane of the Milky Way and are located at the edges of the image. Cancer and

	C. Yes, the section between Scutum and Crux D. Yes, the section between Orion and Perseus E. No I cannot see the Milky Way in this field of view even if viewed from a dark sky site.	Taurus are zodiac constellations – they do not lie on the plane of the Milky Way and thus B is false. Scutum and Perseus are not visible (thus C and D are false)
29	hich of the following is TRUE about an emission nebula? A. It emits hundreds to millions of stars and gravitationally binds them together tightly B. It appears to have spiral arms that are emitted from its center C. It does not appear to interact with observable electromagnetic radiation D. It is made up of ionized gases that emit light of various wavelengths E. It only emits light of a single wavelength.	D A/B are nonsense options that are attempts to describe a galaxy. C is a description of dark matter. E is wrong – while emission nebulae tend to emit strongly in certain wavelengths, they do not ONLY emit light of one wavelength.
30	Suppose there is a planet beyond Neptune, moving in a orbit about 20 times larger than Neptune's orbit on average. What would be its approximate orbital period? A. 740 years B. 3,300 years C. 14,700 years D. 4.5 million years E. 10.9 million years	C Apply Kepler's Third Law $T^2 \propto r^3$ Hence, the result of your calculation should be $T = \sqrt{164.79^2 * 20^3} = 14739$ years.
31	What is light trespass in astronomy? a. It is when unwanted and uncontrolled light enters people's property and affects them. b. It is when light pollution lights up and trespasses into the night sky. c. It is when light from a reflection nebula affects the emission nebula that you are trying to photograph. d. It is when light from a star shines through a dark nebula, causing the dark nebula to glow. e. It is when you trespass a private observatory, but just slightly.	Ans: A. B is skyglow, while C, D and E have nothing to do with light trespass.
32	The Winter Hexagon is an asterism that contains 7 extremely bright stars from The Bull, The Hunter, The Great Dog, The Lesser Dog, The Charioteer and The Twins. Which of these stars is not part of the Winter Hexagon?	E Arcturus is of the constellation Bootes and thus not part of the Winter

	A. Capella B. Procyon C. Sirius D. Castor E. Arcturus	Hexagon which contains stars of Orion, Canis Major, Canis Minor, Gemini, Taurus and Auriga.
33	The classification of stars is primarily based on their temperatures. The Harvard spectral classification scheme assigns each star a spectral type. If there are 3 stars which are blue, yellow and red in colour respectively, what can be a possible combination of their spectral types in that specific sequence (ie. Blue, yellow, red)? A. O,G,M B. B,M,A C. A,M,K D. M,K,G E. A,B,O	A In order of decreasing surface temperature, the spectral classes are OBAFGKM. Hotter stars are bluer, thus connecting these two concepts together yields the desired answer.
34	At 4am on 3rd August, you notice that Alpheratz, the Alpha star in Pegasus, is right on the meridian. On which date would Alpheratz rise at approximately 6pm? A. 2nd September B. 2nd October C. 2nd November D. 2nd December E. 2nd January	B Stars rise 4 minutes earlier every day. This translates to approximately 2 hours earlier every month. If Alpheratz is on the meridian at 4 am, that means it rose at 10 pm in August. Thus we need to advance two months, yielding B.
35	The luminosity of the Sun, $L\odot$, is 3.828∗1026W. Polaris has a mass of 7.5$M\odot$and a diameter 30 times that of the Sun. The difference between their absolute magnitudes is 8.47. What is the surface temperature on Polaris? A. 7600K B. 7400K C. 7200K D. 7000K E. 6800K	Answer: B With the mass of Polaris and the difference between absolute magnitudes, you can easily find the luminosity of Polaris. $\frac{L_1}{L_2} = 10^{\frac{M_2 - M_1}{2.5}}$ where $M_2 - M_1$ is the difference in absolute magnitudes, L_1 is the luminosity of Polaris and $L_2 = L_\odot$. Your calculation should yield $L_1 = 9.35 * 10^{29}$ W

		Use the Stefan-Boltzmann Law, $Luminosity\ L = 4\pi R^2 \sigma T^4$ Your answer should be $T = 7410$ K.
36	Consider the following two scenarios: Scenario A: The Earth is orbiting around the Sun in the anti-clockwise direction as viewed vertically above from its North Pole. Scenario B: The Earth is orbiting around the Sun in the clockwise direction as viewed vertically above from its North Pole. Which of following corresponds to the approximately best local time in each scenario to observe as many sporadic meteors as possible? Note that in both scenarios, Earth is rotating in the anti-clockwise direction. <table at end of document>	C The following diagram might shed some light on how to visualise this problem. Note that the higher the relative speed of the incoming meteor, the higher the frequency of sporadic meteors observed. <image at end of document>
37	Tides are the rise and fall of sea levels caused by the combined effects of gravitational forces exerted by the moon and the sun, and the rotation of the earth. A spring tide is when the tide is at its maximum. Generally, when does a spring tide occur? A. The moon and the sun is on the same side of the earth B. The moon and the sun is on the opposite side of the earth C. Neither, it occurs during spring when the moon is closest to the earth D. Both a) and b) E. Whenever the angular distance between the Moon and Sun reaches 90 degrees, as measured from earth.	D More formally, a spring tide occurs when the Moon, Earth and Sun are in syzygy (aka all 3 bodies are in a straight line)
38	Suppose we are currently at Tokyo (35°41’22’’ N). Which of the stars will always be seen? I. Alderamin (RA/DEC: 21h 19min/+62°40’18”) II. Antares (RA/DEC: 16h 21min/-26°28’29”) III. Betelgeuse (RA/DEC: 5h 26min/+7°24’31”) IV. Capella (RA/DEC: 5h 18min/+46°00’57’’) V. Shedar(RA/DEC: 0h 41min/+56°38’54’’) A. II only	B For a star to never set, its declination must be more than 90°-latitude. In this case, stars with declination north of 54°18’38’’ N never set.

	B. I and V only C. II and III only D. I, IV and V only E. I, III, IV and V only	
39	Enceladus, a moon of Saturn, is known to possess cryovolcanoes near its south pole. These cryovolcanoes are observed to constantly eject jets of water vapour and other volatiles into space. Which of these CANNOT possibly be reasons why Enceladus exhibits cryovolcanic activity? A. Enceladus contains a subsurface water ocean under the south pole, providing a source of water for these jets. B. Tidal friction exerted upon Enceladus heats up the interior of Enceladus, helping to sustain these jets. C. Dark albedo features preferentially absorb sunlight, generating warm spots on Enceladus that create jet activity. D. The decay of radioactive elements within Enceladus heats the ocean and helps to power these jets. E. All of the options above are possible reasons for cryovolcanism on Enceladus	C Due to its great distance from the Sun, Enceladus receives very little solar insolation. Furthermore, these jets are located near the pole, which generally experiences a low sun angle and thus little direct sunlight. Thus, this mechanism cannot possibly be a cause of cryovolcanic activity.
40	Sharadh's Q3	E
41	Sharadh's Q4	D
42	Sharadh's Q5	B
43	Two days before a full moon, you wish to observe a meteor shower. At approximately what time would the moon rise? You are given that sunset occurred around 1900 and that you are in Singapore. A. 0517 B. 0913 C. 1654 D. 1734 E. 2041	D On full moon, the moon rises at approximately 1900 (when the sun sets). It sets later by about 50 minutes each day. Thus subtract 100 minutes from 7 pm to obtain the answer. Note: actual moonrise time on 13 August 2019.
44	You are currently on holiday in Svalbard, Norway (78° 13'N, 15° 39'E). You observe that the sun rises northeast, and sets northwest. Which direction will the sun be at local noon? A. North	B From the diagram it can be seen that the sun will

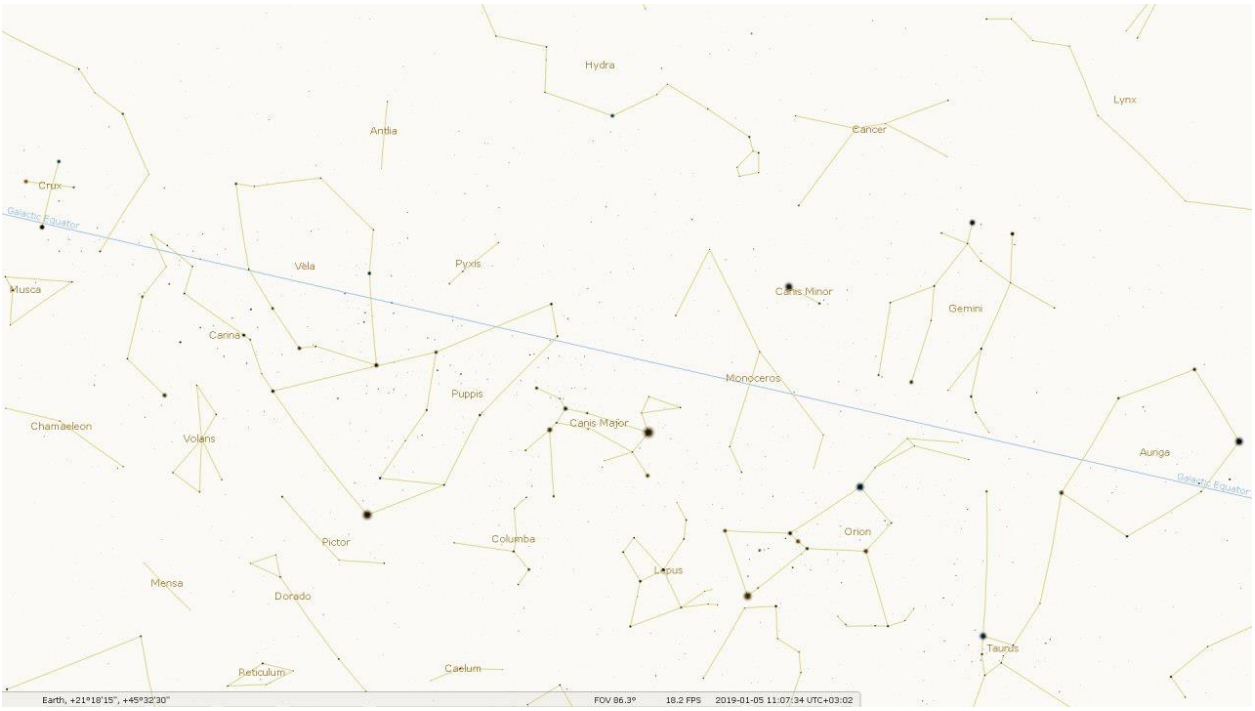
	B. South C. East D. West E. Zenith	culminate in the south at northern latitudes <diagram at end of document>
45	Which of these statements about the night sky is factually accurate? You are given that these statements are written for an observer in Singapore. A. One can easily see the Orion Nebula at midnight in May B. As it is circumpolar, Polaris is easily visible above the horizon for all Singaporeans. C. A line drawn from Sirius to Canopus points approximately due South towards the South Celestial Pole D. During the June holidays, Andromeda is above the horizon immediately after sunset. E. One can use the Big Dipper to find Polaris by following the arc of its handle.	C A is false – Orion sets almost immediately after sunset in May. While Polaris is technically circumpolar from Singapore, its exceedingly low altitude means that it is often obstructed from view, and suffers from large amounts of atmospheric extinction. D is false – Andromeda is an autumn constellation, and thus would not have risen at the stated time. E is false – these are finding instructions for finding Arcturus instead.
46	Why is the sky blue? A. The ocean reflects light to the atmosphere, causing it to appear blue B. Blue light scatters more than red light in sunlight due to its shorter wavelength, causing the sky to appear blue as the atmosphere scatters blue light more effectively than red light C. The atmosphere absorbs other colours of light more than blue due to its shorter wavelength, causing the sky to appear blue D. Both a) and b) E. The upper atmosphere of the earth emits blue light due to ionisation when solar radiation interacts with the particles in the sky.	B A is false for the sky is clearly still blue inland. C is false because the atmosphere is largely transparent at visible wavelengths. For similar reasons, D is false. E is false/nonsense – the ionosphere is too rarefied to produce enough blue light to colour the entire sky with such intensity.
47	The fastest-spinning neutron star is known as PSR J1748-2446ad. Given that its radius is 16km and it spins at a rate of 43000 revolutions per minute,	B

	find the greatest speed at which its surface is moving in terms of the speed of light. A. 0.12c B. 0.24c C. 0.36c D. 0.48c E. 0.80c	This speed will be at the equator. 43000/min = 716.667/s ω = 716.667 * 2π = 4503 rad/sV = Rω = (16x103)*(4503) = 7.2047x107m/s = 0.24c
48	Which option correctly depicts the sequence of events detailing how a solar mass star evolves over time? 1) A nebula collapses, forming a protostar 2) Hydrogen runs out in the core, leading to expansion into a red giant star 3) Hydrogen fusion begins, leading to a main sequence star 4) Outer layers are expelled into space, leaving behind a white dwarf. 5) Core helium fusion begins, producing carbon. Helium eventually runs out. 6) The core of the star commences fusion of carbon and heavier elements. 7) Core collapse leads to a supernova A. 1>2>4 B. 1>3>2>5>4 C. 1>3>6>7 D. 1>5>3>2>6>7 E. 1>5>3>4	B Solar mass stars do not become supernovae. They are massive enough to fuse helium into carbon, but no more.
49	You've recently bought a new 254mm aperture F/5 Dobsonian reflector from Astroshop Science Centre Singapore and it came with a standard 25mm 52°eyepiece. Calculate the magnification and true field of view of the set up a. 50.8 times, 1.63° b. 10.2 times, 5.12° c. 102 times, 0.512° d. 50.8 times, 1.02° e. 312 times, 0.182°	D The focal length is $5 \times 254mm = 1270mm$ The associated magnification is thus $\frac{1270}{25} = 50.8$ times The true field of view is then $\frac{52}{50.8} = 1.02°$
50	Why do star trails appear in long exposure astrophotos? <insert Julian's picture – at the end of table. Original is in box> Pic credit: Julian Cheung	D The stars appear to rotate about the NCP and SCP.

	a. Stars have ‘tails’ like comets b. Internal camera defects/errors/miscalibration. c. The camera’s tripod is loose and the camera is slowly tilting. d. Due to the rotation of the Earth, causing the stars to move across the sky. e. The stars in the sky are orbiting around the Earth.	

Q26-28

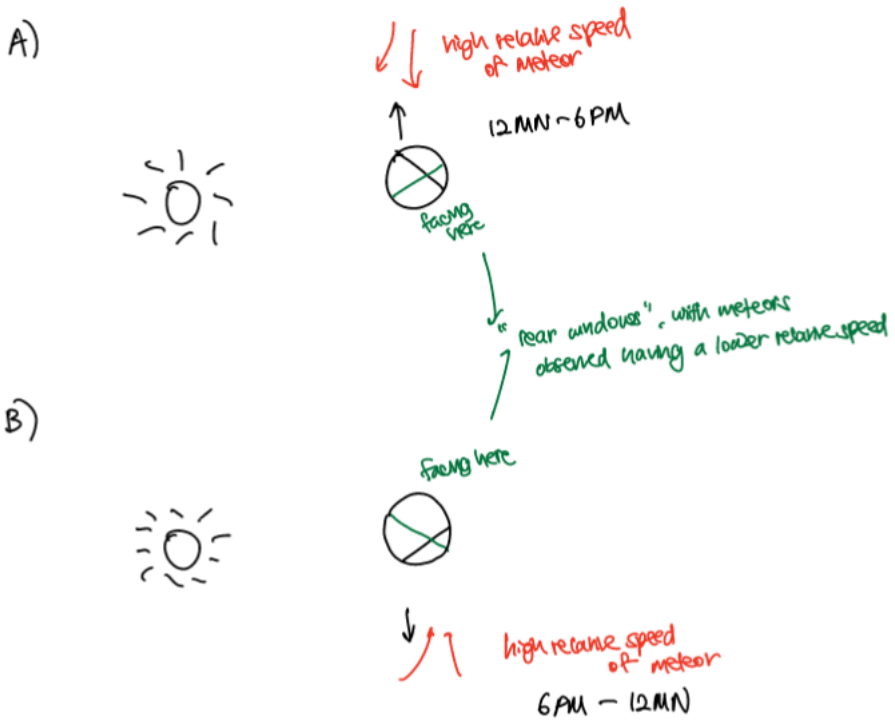
Annotated version (answer only)



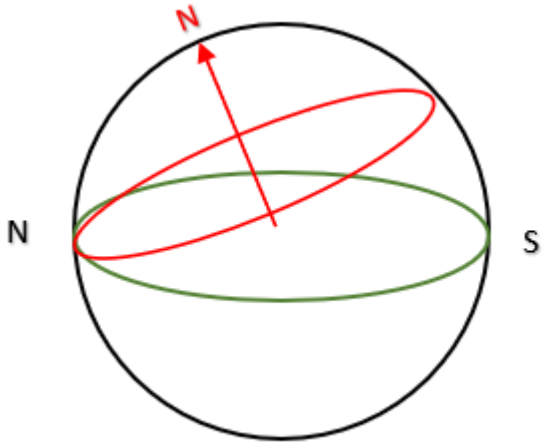
Q36 Table

	Scenario A	**Scenario B**
A	6 PM – 12 MN	6 PM – 12 MN
B	6 PM – 12 MN	12 MN – 6 AM
C	12 MN – 6 AM	6 PM – 12 MN
D	12 MN – 6 AM	12 MN – 6 AM
E	The best time is season dependent	

Q36 Answer



Q44 Answer



Q50