ASTROCHALLENGE 2015 MCQ ROUND (SENIOR)

INSTRUCTIONS

- This paper consists of 14 printed pages, excluding this cover page.
- Do **NOT** turn over this page until instructed to do so.
- You have 2 hours to finish all questions in this paper. If you think there is more than one correct answer, choose the most correct answer.
- At the end of the paper, submit this booklet together with your answer script.
- Your answer script should clearly indicate your name, school, and team.
- It is your responsibility to ensure that your answer script has been submitted.

1) What is the last phase of a low-mass star like our Sun?
   A. Black hole
   B. Neutron star
   C. White dwarf
   D. Nothing
   E. None of the above

2) Several members of an astronomy club are considering the state of their logistics. Which member has made a factually incorrect claim?
   A. If your scope suffers from chromatic aberration, a quick fix is to simply add a narrow-band filter. The resultant visual image should come into sharp focus
   B. But you are dimming the image unnecessarily. Just get an apochromatic triplet lens: it perfectly corrects for chromatic aberration!
   C. I hate our 8" Schmidt-Cassegrain (C8): its large focal ratio means it takes an extremely long time just to image the Orion Nebula.
   D. You have to admit however that the C8 isn't totally useless. For one, the C8's large focal length means it can provide extremely high magnification. I've had excellent images of Jupiter through it.
   E. Everyone above has made factually accurate claims.

3) If the semi-major axis and eccentricity of Venus' orbit are 0.72 AU and 0.007 respectively, what is the angular diameter of Venus at its nearest possible distance from Earth? Earth's eccentricity is 0.017, and the diameter of Venus is 1.2×10^7 m. Assume coplanar orbits with perihelia that precess over time (but with unchanging eccentricity).
   A. 125"
   B. 95"
   C. 64"
   D. 59"
   E. 54"

4) There is a binary star system with a mass ratio $m_1 : m_2$ of 3:4. What is the ratio of radiation fluxes received from these stars ($B_1 : B_2$) at the center of mass of the system? For simplicity, suppose the mass-luminosity relationship is $L \propto M^4$
   A. 16 : 9
   B. 9 : 16
   C. 3 : 4
   D. 4 : 3
   E. √3 :√4

5) Which one of the following statements is correct?
   A. If we view the spectrum of an incandescent low-pressure gas, it will show only absorption spectrum lines.
   B. If the hydrogen lines of a stellar spectrum look weak, the temperature of the star must be either extremely high or low.
   C. Spectrum lines of TiO can be seen at B-star spectrum.
   D. A star classified as a B5III star is a hypergiant with a temperature of 20000 K.
   E. Molecular spectral lines (like CH) are prominent in a M-star spectrum.

6) One of the weaknesses of a refractor telescope compared to a reflector telescope is…
   A. Difficult to use
   B. Has size limitation
   C. Weaker resolving power
   D. More expensive
   E. Requires more optical instruments

7) Which city cannot see the Sun passing through its zenith?
   A. Hong Kong (22°16′ N, 114°11′ E)
   B. Singapore (1°17′ N 103°50′ E)
   C. Bangkok (13°45′ N 100°28′ E)
   D. Jakarta (6°12′ S 106°48′ E)
   E. Taipei (25°02′ N 121°38′ E)

8) The Angular momentum vector of Earth's orbit points to which direction?
   A. North Celestial Pole
   B. North Ecliptic Pole
   C. South Celestial Pole
   D. South Ecliptic Pole
   E. Not constantly pointing at the same direction

9) Suppose the Earth's orbit has an eccentricity of 0.0167 and semi-major axis of 1 AU. Further, suppose the Sun has a mass of 2×10^{30} kg. What is the ratio of angular momentum at perihelion and aphelion?
   A. 0
   B. 0.0167
   C. 0.0967
   D. 1
   E. Cannot be determined

10) Which one of the statements below is correct?
    A. Bolometric magnitude is measured at Gamma-ray wavelength
    B. Hot stars always have low absolute bolometric magnitude and high luminosity
    C. An F0 star has nearly the same bolometric and visual magnitude
    D. A0 stars have huge positive color index (B-V)
    E. Very hot stars have huge positive color index (B-V)

11) Suppose that several asteroids of high rigidity are to enter an orbit around Neptune at a certain distance away from the surface (given below), and their density is exactly 5000 kg/m^3. Which asteroid(s) is/are likely to be reduced to fragments before it/they can establish an orbit?
    (Assume all celestial bodies in this question to be perfect spheres of volume $4/3\ \pi\ R^3$, where R refers to its radius)

    Asteroid W is to orbit 5,000 km above the surface
    Asteroid X is to orbit 10,000 km above the surface
    Asteroid Y is to orbit 50,000 km above the surface
    Asteroid Z is to orbit 100,000 km above the surface

    A. Asteroid W only
    B. Asteroid W and X
    C. Asteroid W, X and Y
    D. Asteroid Z only
    E. All of the asteroids will not fragment.

12) A static black hole with neither charge nor angular momentum is observed to have a mass of about 11.85 solar masses. Which of the following statements about this black hole is correct?

    I. It has a Schwarzchild radius of approximately 35000 m.
    II. It is classified as a Schwarzchild black-hole.
    III. If it was rotating (i.e. possessed angular momentum), it would be reclassified as a Reissner–Nordström black hole instead.
    IV. Given its size, it likely collapsed at a mass below the Chandrasekhar limit.
    V. It possibly formed from the supernova of a O or A class main-sequence star.

    A. I and IV only.
    B. III and V only.
    C. I, III and IV
    D. I, II and V
    E. All of the above statements are correct.

13) Which of the following statements is true?

A. The Sun is a population III star at the latest stage of its development, while population I stars are pioneers since the Big Bang and are metal-free.
B. The Pleiades is a small open cluster that consists of exactly 7 stars.
C. The Messier, New General Catalogue and Index Catalogue all consists of astronomical objects/systems composed of at least hundreds of stars or more.
D. An analemma of the sun in Singapore, when plotted on paper or taken in a time lapse photograph, still retains its characteristic figure-of-8 shape.
E. All of the above statements are false

14) A Cepheid variable varying in apparent magnitude from a maximum of 6.5 to a minimum of 7.5 has a period of exactly 42 days. Which of the following statements about this Cepheid variable is true?

I. The Cepheid variable, on average, has an absolute magnitude of -5.88.
II. The Cepheid variable is approximately 3770 parsecs away.
III. The Cepheid variable becomes 10 times as bright when it is the most luminous compared to when it is the least luminous.
IV. The Cepheid variable is dimmer than our sun in terms of absolute magnitude.
V. The Cepheid variable serves as a good yardstick to estimate distances in space.

A. I and V only
B. II and III only
C. III and IV only
D. I, II and V
E. All of the above.

15) Helium (^{4}He) and/or α-particles are involved as an end product for the following processes in stellar nucleosynthesis:

I. proton-proton chain (p-p chain)
II. CNO cycle
III. Triple-α process
IV. Lithium burning in stars
V. r-process

A. I and II only
B. III and V only
C. IV and V only
D. I, II, and IV
E. I, II, III and V

16) Which of the following statements are false?

A. Reflecting telescopes themselves do not suffer from chromatic aberration
B. All refractors are unaffected by spherical aberration
C. Optical systems with slower optics (aka larger F-ratios) are less affected by spherical aberration than fast optical systems.
D. If objects at the edge of the field of view appear elongated (even if the image is in focus), the telescope probably suffers from coma, astigmatism or both
E. As a rule of thumb, most aberrations are minimized if the object is positioned at the center of the field of view.

17) Kemble's Cascade in Camelopardalis consists of more than 20 stars of varying magnitudes and colors arranged in a straight line. With an apparent diameter of more than 5 Moon widths, the southern end of Kemble's Cascade seems to terminate at the open cluster NGC 1502 (RA: 04h 07m 48s, DE: +62° 20' 00"), which has a known distance of 2700 light years (830 pc).

Several teams of astronomers attempt to test whether the members of Kemble's Cascade are related to each other and/or NGC 1502. Which method is fatally flawed and is unlikely to achieve its aim?

A. Measure the redshift of the members of Kemble's Cascade and NGC 1502 with spectroscopy. If the members of Kemble's Cascade have significantly different redshifts compared to each other (and NGC 1502), they are unlikely to be part of the same association of stars.
B. Calculate the absolute magnitude/luminosity of stars in Kemble's Cascade, assuming that they are 2700 light years away. Then plot all stars in an H-R diagram and compare it to NGC 1502. If the stars of Kemble's Cascade fit into the population of NGC 1502, they are possibly part of the same population of stars.
C. Measure the parallax of the stars in Kemble's Cascade through a ground-based observatory. Compare the parallaxes to NGC 1502. If the resultant distances agree with each other, the members of Kemble's Cascade are likely related to NGC 1502.
D. Plot all the members of Kemble's Cascade and NGC 1502 on a color-magnitude diagram. If the members in Kemble's Cascade have a wildly different color-luminosity relation (if one exists) from those of NGC 1502, they are unlikely to be part of the same population of stars.
E. All of the listed methods are appropriate

18) Suppose we scaled down the mass of the Earth to that of a watermelon (5 kg). At this scale, we can estimate the mass of the Andromeda Galaxy to be roughly on the order of
    A. 500 trillion watermelons, aka $\approx 10^{15}$ kg
    B. 500 quadrillion watermelons, aka $\approx 10^{18}$ kg
    C. 500 quintillion watermelons, aka $\approx 10^{21}$ kg
    D. 500 sextillion watermelons, aka $\approx 10^{24}$ kg
    E. 500 septillion watermelons, aka $\approx 10^{27}$ kg

19) An astronomer dreams that the Astronomical Unit (AU) turns out to be mismeasured all these years. Due to a software fault in radar ranging experiments, the observations involved in estimating the AU turn out to be below the true value, causing the AU to be drastically underestimated. In this horrific nightmare, what measured value is most likely to remain unchanged? [Assume that the length of the light year remains the same]

    A. The distance to Polaris in light years, as measured through parallax
    B. The semi-major axis of Jupiter's orbit in AU, as estimated through Kepler's Third Law
    C. The distance to the Orion Trapezium Cluster in light years, as measured through main-sequence fitting
    D. The distance to the Sloan Great Wall in AU, as estimated through Hubble's Law
    E. The distance to the Pinwheel Galaxy in light years, as estimated from Type Ia supernovae.

20) One night, an astronomy club was attempting a Messier marathon under dark skies. Unfortunately, in the midst of their session, one of the participants ended up misidentifying their target. Which participant committed this mistake?

    A. I can see the the central star of the Ring Nebula (M57) in Vulpecula!
    B. The globular cluster M15 looks amazing in Pegasus!
    C. I can actually fit Bode's Galaxy AND the Cigar Galaxy (M81 & M82) in this eyepiece! Both are easily found in Ursa Major!
    D. I can actually see the nebulosity within the Trifid Nebula, M20 in Sagittarius!
    E. I've found the Wild Duck Cluster (M11) in Scutum!

21) Deep sky photos of M42 (the Orion Nebula) often show it as having a reddish hue. This is due to:

    A. Red giants in the nebula
    B. Preferential reflection of red light by dust
    C. Rayleigh scattering of blue light by Earth's atmosphere
    D. Emission by ionized hydrogen
    E. Overzealous photoshopping by astrophotographers

22) Exoplanets are more easily detected around small low-mass stars rather than large massive stars. This is known as the small star advantage. Which of the following are NOT factors behind the small star advantage?

A. Exoplanets would create larger Doppler shifts around a small host star than a large host star
B. Exoplanets would create greater dips in brightness around a small host star than a large host star
C. For any given semi-major axis, an exoplanet has a higher probability of transiting a small host star (from our viewpoint) than a large host star
D. Young hot exoplanets can be more easily imaged next to a small host star than a large host star
E. All of the above are components of the small star advantage

23) If I told you that the absolute visual magnitude of the Milky Way was -5.5, then you know that...

A. I added up the individual absolute magnitudes of all members of the Milky Way.
B. I hypothetically combined the visible emission of all members of the Milky Way, placed them at a distance of 1 parsec away from me, and removed all the dust between them and me. I then recorded the resultant apparent magnitude.
C. I hypothetically combined the visible emission of all members in the Milky Way core, and placed them at a distance of 10 parsecs away from me. I then recorded the resultant apparent magnitude.
D. I hypothetically combined the luminosity of all members of the entire Milky Way across the entire EM spectrum. By comparing that to the luminosity of the Sun, I can use the appropriate formulae to obtain this result.
E. I'm a liar liar, pants on fire: the Milky Way obviously does not have an absolute magnitude of -5.5

24) A spaceship was initially planning to travel to Venus using a Hohmann transfer orbit. Unfortunately, due to bad weather, the spaceship missed its target launch window. If the spaceship still wishes to use the same trajectory & the same Hohmann transfer, approximately how many days much it wait for the next launch window?

A. 225 days
B. 365 days
C. 499 days
D. 584 days
E. 650 days

25) A gamma ray burst (GRB) with a redshift of z was observed in a distant galaxy. Which of the following statements is most accurate?
   A. The galaxy is approaching us with speed $|v| = cz$(for small v)
   B. For large z, the relationship between the observed frequency of light (f_{observed}) and the emitted frequency of light (f_{emit}) is $f_{\text{observed}} = \text{z}f_{emit}$
   C. Under certain conventional cosmological assumptions (FLRW metric), the radius of the universe then (when the GRB was emitted) is $\frac{1}{1+z}$ of what it is today.
   D. We have just witnessed the formation of a new star.
   E. We have just witnessed light from the Big Bang

26) City A and City B have a time zone difference of 8 hours. While both cities have the same latitude, City A is east of City B by 105 degrees of longitude. What can we say about the cities?

   A. City B will always experience a sunrise exactly 8 hours after City A.
   B. If City A and City B can both see the same star above the horizon at the same time, they will record **exactly** the same altitude and azimuth of the star
   C. If City A and City B can both see a satellite above the horizon at the exact same time, they will record **exactly** the same right ascension and declination of the satellite
   D. If a star crosses the zenith at 12 midnight in City A, the same star will do so at 1 AM in City B.
   E. The local sidereal time of City A and City B will be the same

27) What does the term “lucky imaging” mean?
   A. A compliment/expression of awe in astrophotography
   B. The process of taking numerous short exposures (<0.1s), and combining the best into a single image.
   C. A quick test in astronomy to determine seeing. This involves taking a quick test shot and then measuring the apparent diameter of stars.
   D. A way of finding previously unknown galaxies by taking long exposures of a random patch of sky.
   E. No such term exists

28) If Mars crosses an observer’s meridian at local midnight, then it is at
   A. Aphelion
   B. Eastern quadrature
   C. Western quadrature
   D. Opposition
   E. Conjunction

29) What is the maximum possible elongation of Venus? Assume circular orbits.
   A. 49.3°
   B. 46.3°
   C. 43.7°
   D. 39.8°
   E. 35.9°

30) The radiation of Sun peaks at the wavelengths of visible light. The Sun has a total luminosity of L=3.86 × 10^{26} W. Assume half of this energy is emitted as visible light whose photons have a wavelength of λ=550 nm. What is the number of visible photons emitted from the Sun each second?
   A. 5.34 × 10^{45}
   B. 1.07 × 10^{45}
   C. 5.34 × 10^{44}
   D. 1.07 × 10^{44}
   E. 5.34 × 10^{43}

31) It is known that the synodic period of Minor Planet Z is 398.9 days. What is its sidereal period?
   A. 5.4 years
   B. 5.8 years
   C. 6 years
   D. 11.8 years
   E. 15.4 years

32) The effective temperature of a star is 10,000 K and its absolute bolometric magnitude is 0. Given that the effective temperature of the Sun is 5000 K and its absolute bolometric magnitude 5.0 , the diameter of the star is
   A. $4R_{sun}$
   B. $4.2R_{sun}$
   C. $5R_{sun}$
   D. $5.4R_{sun}$
   E. $5.8R_{sun}$

33) A star rises in the horizon at azimuth 50°. It will set at azimuth
   A. 130°
   B. 180°
   C. 230°
   D. 270°
   E. 310°

34) Approximately, on which day of the year will you see Betelgeuse (RA = 05^h 55^m) highest at midnight?
   A. 13th January
   B. 22th September
   C. 18th October
   D. 11th November
   E. 20th December

35) What are one of the reasons why total solar eclipses are observed less frequently as total lunar eclipses? (given a fixed location)
   A. The orbit of the Moon is highly inclined and eccentric, creating an unfavorable geometry for total solar eclipses
   B. The moon is much smaller than the Earth, hence the region that can observe a total solar eclipse is extremely small.
   C. The orbital period of the moon is shorter than the orbital period of the Earth about the Sun.
   D. Overall seasonal changes results in longer nights than days in a year.
   E. This is because the distance between the Earth and the moon is shorter than the distance between the Earth and the Sun.

36) What is the Chandrasekhar limit?
   A. It is the limit of how massive a white dwarf can be.
   B. It is the best possible resolution that can be achieved by a Newtonian reflector
   C. It is the maximum mass a star that can be supported by electron degeneracy.
   D. The highest possible temperature in the core of a star
   E. The highest proton number of an element that can be produced by nuclear fusion in the core of a star.

37) Which of the following phrases is the best definition of a protoplanet?

   A. A solid object formed through accretion in a protoplanetary disk bound together by gravitation but not large enough to melt and chemically differentiate
   B. A solid (but non-spherical) object that has cleared its neighbourhood of other objects, thus carving a gap in the protoplanetary disk
   C. A spherical object formed through the merger of large planetesimals that possesses a chemically differentiated interior
   D. A spherical object orbiting a star that has not cleared its orbit of other objects.
   E. A solid object formed in a protoplanetary disk by the chemical adhesion of solid particles

38) Which of the following are thought to be examples of the effects of orbital resonance?

I. The rapid rearrangement of outer Solar system orbits in the Nice model
II. The gaps in planetary ring systems
III. The relation between the Moon's period of rotation about its axis and the period of its orbital motion about Earth
IV. KBOs tend to cluster around certain semi-major axes (e.g. 39.2 AU)
V. The 3:2 relation between Mercury's period of rotation about its axis and the period of its orbital motion about the Sun
VI. The Kirkwood gaps in the asteroid belt

A. II, III, V
B. II, IV, V
C. I, IV, V
D. I, II, VI
E. I, III, VI

39) Mean motion orbital resonances occur when the period of a body's orbit is an integer ratio of another body. Which of the following statements are true?

A. These resonances are always stable
B. These resonances are stable if the resonance keeps both bodies close to each other
C. These resonances are the reason why most objects are confined to the Ecliptic plane
D. All Kuiper Belt Objects are in a mean motion orbital resonance with Neptune.
E. All plutinos are in a 2:3 mean motion resonance with Neptune

40) The central region of a planetary nebula has an apparent magnitude of 8.5 and a surface area of 2.25 square arcseconds. Therefore, its average surface brightness (in terms of magnitude per square arcsecond) is:

A. 3.8 mag/arcsecond^2
B. 7.6 mag/ arcsecond^2
C. 9.4 mag/arcsecond^2
D. 19.1 mag/ arcsecond^2
E. Insufficient information to answer the question

41) Suppose the Sun, Moon, and the star Aldebaran all rose at the same time today. Which will rise first tomorrow?

A. The Sun
B. The Moon
C. Aldebaran
D. The Sun and Aldebaran
E. All three will rise at the same time

The following table is for questions 42-46. Your observation plan has the following targets listed for an overnight observation session near the Equator.

Object	R.A.	Dec	Apparent Magnitude
η **Cassiopeia**	0h 49m	+57 49’	3.5
M 45	3h 47m	+24 07’	1.5
M 79	5h 24m	-24 31’	8
M 1	5h 35m	+22 01’	8.5
M 13	16h 42m	+36 27’	5.8
M8	18h 03m	-24 22'	6.0
M 57 (Ring Nebula)	18h 54m	+33 02’	9.7
β **Cygni (Albireo)**	19h 31m	+27 58’	3.2
M 27 (Dumbell Nebula)	20h 00m	+22 43’	7.6

42) At around 10pm during an observation session, you observe M45 near the meridian. Around what time would you expect β Cygni to rise at the same location following the observation session?

A. 3 am
B. 5 am
C. 6 am
D. 8 am
E. 12 noon

43) At some time of the year, you observe M45 to rise at around 7pm. At around what time would you expect M27 to set?

A. 9 pm
B. 12 midnight
C. 3 am
D. 5 am
E. 2 pm

44) Given that at the beginning of the observing session, β Cygni (Albireo) is close to the meridian, in what order should you make your observations (by basis of practicality)?

A. η Cassiopeia, M13, M8
B. β Cygni, M27, M13
C. M13, M8, M57
D. M27, M13, M57
E. M8, M57, β Cygni

45) Which other column should you add to the table to make it more useful as an observing plan?

A. Object size
B. Altitude
C. Azimuth
D. Zenith Angle
E. Absolute magnitude

46) If you are at a location with latitude 65° S, which objects in this observation plan would you be able to observe? (Assuming you are in a clear field with little or no visual obstructions at the horizon.)

A. M57, β Cygni, M8, η Cassiopeia
B. M1, M79, M8, M27
C. M13, M1, M79, M8
D. M27, η Cassiopeia, M45, M57
E. All objects except M79 and M8 can be observed

47) In the knowledge that the Sun is about to explode, you travel on a spaceship to the nearest solar system β suspected to be habitable. However, at the midpoint during your journey, you see that both the Sun and the Star of β explodes. Regard the distance between the two stars as 16 light-years apart and answer question 47 and 48 below.
In the frame of reference in which the Sun and the Star are at rest (Sun-Star frame) did the Sun and Star of β explode simultaneously? And why?

A. Yes, this is because speed of light is a constant in all frames of reference as postulated by Einstein in the Theory of Special Relativity.
B. Yes, this is because the Sun and Star are equidistance from the midpoint, hence if the light reaches the midpoint at the same time in the Sun-Star frame, the two events would have to had occurred simultaneously.
C. No, this is because the spaceship should see the light coming from the Star's explosion to reach him first and hence the Star should explode first even in the Sun-Star frame
D. No, this is because the light from the frame of reference of the spaceship, light from the Sun's explosion will take a longer time to reach the spaceship.
E. None of the above.

48) In the frame of reference in which the spaceship is at rest (Spaceship's frame), did the Sun and Star of β explode simultaneously? And why?

A. Yes, this is because speed of light is a constant in all frames of reference as postulated by Einstein in the Theory of Special Relativity.
B. Yes, this is because the Sun and Star are equidistance from the midpoint, hence if the light reaches the midpoint at the same time in the Sun-Star frame, the two events would have to had occurred simultaneously.
C. No, this is because the Star is moving towards the spaceship in the Spaceship's frame and took a longer time to reach midpoint than that the time for the light from Sun to reach midpoint.
D. No, this is because from the frame of reference of the spaceship, light from the Sun's explosion will have to travel faster than the speed of light to reach the midpoint at the same time as light from the Star.
E. None of the above.

A spaceship of length 50m travels at 0.6c past a star. Further, suppose that clocks in the frame of reference of the spaceship and star are synchronized and set to zero such that t' = t = 0 at the instant the **front** of a spaceship (point F) passes a point A on the star located at x' = x = 0. At this instance, a light flashes at F.

49) What is the length of the spaceship, as measured from the star?

A. 50m
B. 40m
C. 35m
D. 62.5m
E. None of the above

50) When the light from point F reaches the rear of the spaceship, what is the reading t1' of a clock in the spaceship?

A. 50/c s
B. 40/c s
C. 35/c s
D. 62.5/c s
E. None of the above