

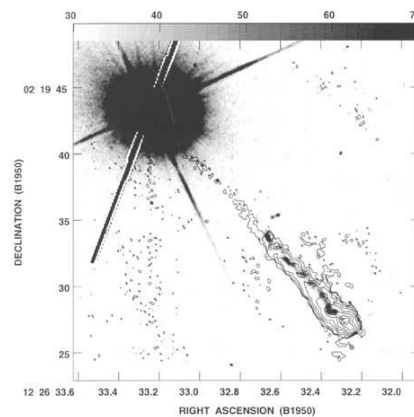
A.

i. first astronomer to suggest that the Earth is not the center of the Universe? [1] – 2

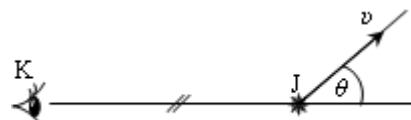
1. Galileo
2. Aristarchus
3. Copernicus
4. Cassini
5. Zhang Heng
6. al-Biruni
7. Kepler
8. Brahe
9. Aryabhata

ii. The obliquity of the ecliptic in degrees. (one decimal) [3] – 234

iii. The first known and brightest quasar is 3C\_.  
[3] – 273



iv. A relativistic jet moves at  $0.83c$ . If no Doppler shift is observed, how many degrees is the angle between the jet and the line of sight, assuming that the source has negligible velocity? (integer)  
[3] – 122

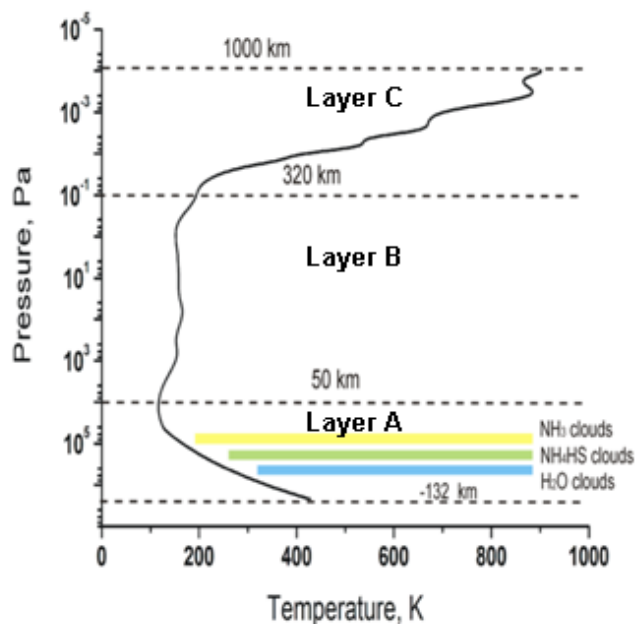


v. This nebula is NGC\_. [4] - 7000



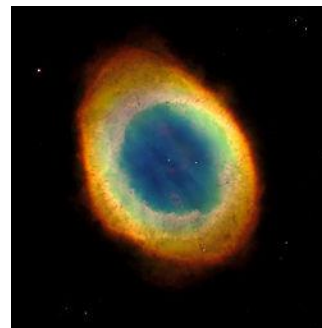
- vi. Choose the names of the layers A, B and C of the Jovian atmosphere, beginning from Layer A. [3] – 195

1. Troposphere
2. Magnetosphere
3. Ionosphere
4. Ozone layer
5. Thermosphere
6. Lithosphere
7. Chromosphere
8. Photosphere
9. Stratosphere



B.

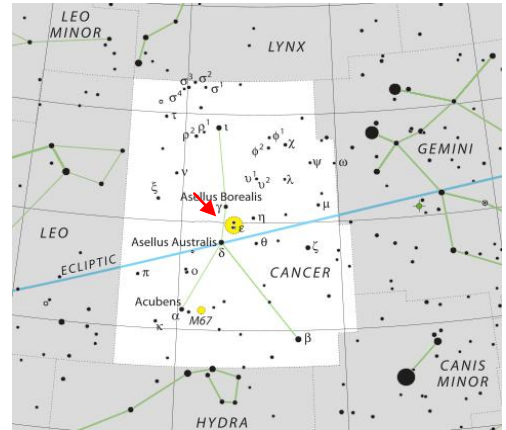
- i. How many AU is one parsec? (integer) [6] – 206265
- ii. Jupiter–Sun–Trojan Asteroids angle (degrees). (integer) [2] – 60
- iii. This nebula is M\_. [2] – 57



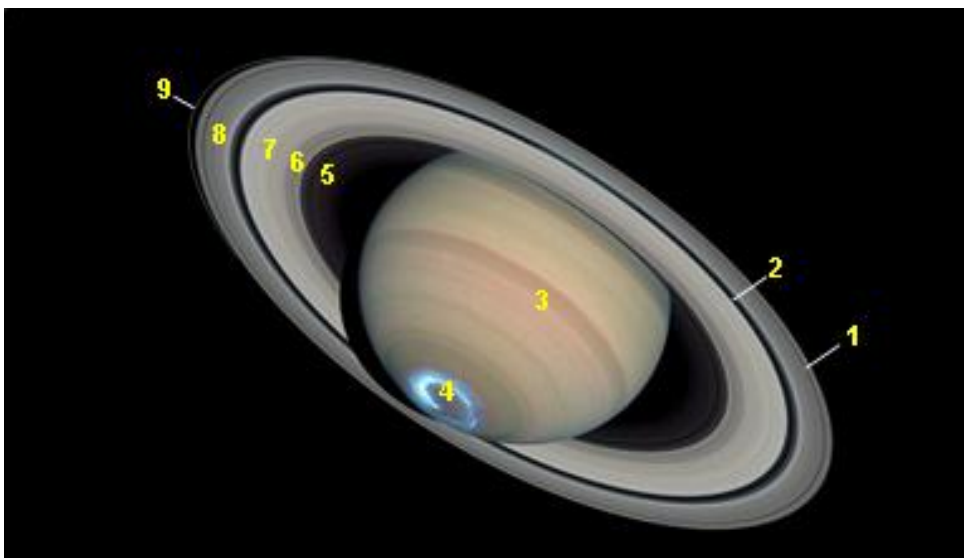
- iv. On the 25<sup>th</sup> of August, at a latitude of  $\phi > 0$  and longitude  $\lambda_L = 37^\circ W$  (time zone = GMT - 2hrs), we observe a star with Declination ( $\delta$ ) such that  $\phi + \delta = 90$ , and Right Ascension  $\alpha = 67.5^\circ$ . What is the local civil time at the hh:mm during the lower culmination of the star? It is given that at 00:00hrs on the 24<sup>th</sup> of August, hour angle of vernal equinox is  $21^h 58^m$ . [4] – 1857
- v. During a Meteor Shower, in a radius of 100km, an observer counted 600 meteors/min. If the rest frame velocity of the meteors was 10km/s with opposite direction to that of the Earth's orbital velocity, what is the mean distance between two meteors in km? Assume cylindrical geometry. (integer) [2] – 50
- vi. The photon's spin. [1] – 1

C.

- i. Difference between sidereal time of two places is  $2^h 47^m 24^s$ . The difference in their longitude is (in deg and min). [4] – 4151
- ii. A galaxy in the constellation Triangulum is M\_. [2] – 33
- iii. Pluto's moons. [1] – 5
- iv. The Beehive Cluster is M\_. [2] – 44

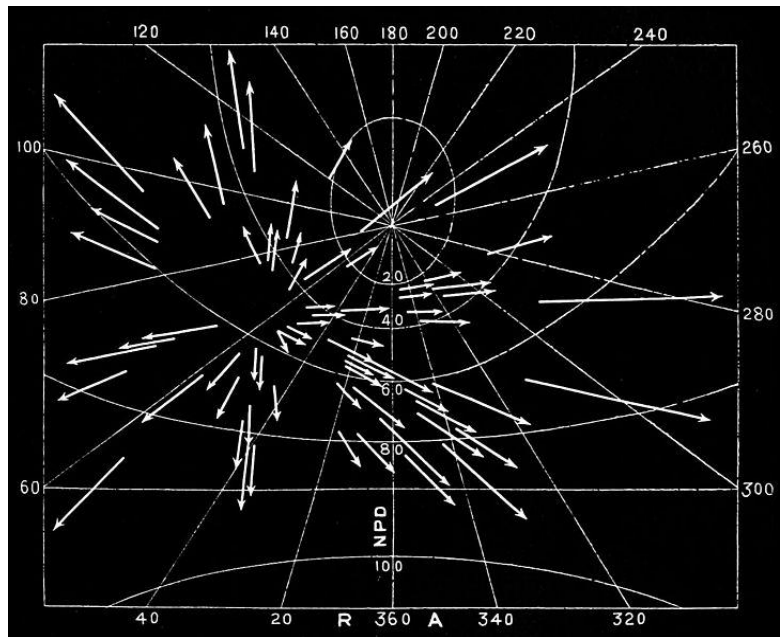


- v. Tidal forces are proportional to  $R^{-n}$ . Value of n is [1] – 3
- vi. Proxima Centauri is  $4.243ly$  distant. It has apparent magnitude of  $11.5mag$  and approaches Earth at  $21.7km/s$ . After how many thousands of years will it be visible to the naked eye? (integer) [2] – 54
- vii. Cassini Division, D Ring, Encke Gap, A Ring [4] – 2518



viii. The radiant of this meteor shower is in: [1] – 4

- 1.Cygnus
- 2.Gemini
- 3.Leo
- 4.Perseus
- 5.Cetus
- 6.Orion



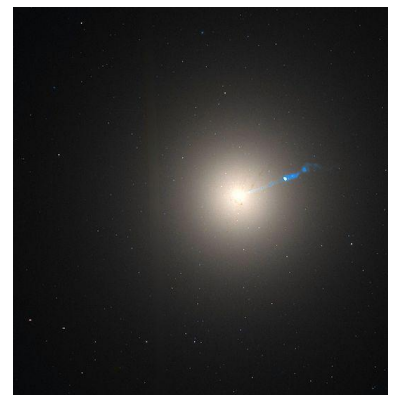
D.

i. At this Lagrange point on the orbit of Jupiter lies a Trojan camp! [1] – 5

ii. Kiloparsec to light-years. (integer) [2] – 3262

iii. The mean distance of Venus from Sun (AU). (two decimals) [3] – 072

iv. The supergiant elliptical galaxy near the centre of the Virgo Galaxy Cluster is M\_. [2] – 87



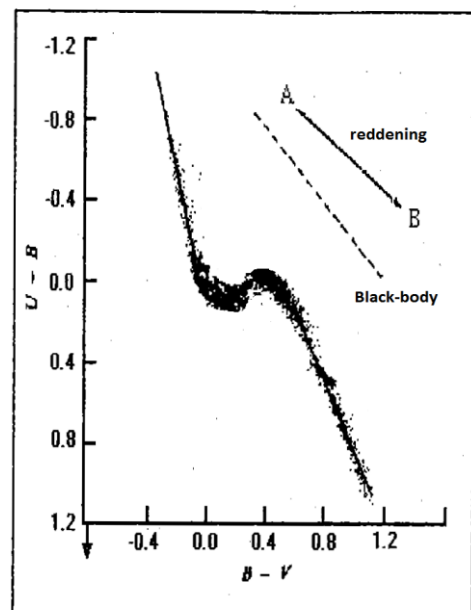
v. The molar mass of the substance that forms clouds in the upper atmosphere of Venus. [2] – 98

vi. spin of an electron (one decimal) [2] – 05

vii. Capella's parallax is 77.3 milliarcseconds. Find its distance in light years (2<sup>nd</sup> decimal) [3] – 422

E.

- i. A  $A_0V$  star has observed Colour Index  $B-V=0.70$ . How many times brighter would the star look if there was no interstellar extinction? Consider that  $A_V = 3 \times E_{B-V}$ , where  $E_{B-V}$  is the Colour Excess and  $A_V$  is the Visual Absorption. (integer) [1] – 7
- ii. The sidereal rotation period at the equator of the Sun (days). At the spectrum of the Sun, the line  $H_\alpha$  ( $\lambda=6,563\text{\AA}$ ) has a broadening of  $0.089\text{\AA}$ . (integer) [2] – 25
- iii. One star has a B-V colour index of  $0.2\text{mag}$  and a U-B colour index of  $-0.1\text{mag}$ . What is its Colour Excess  $E_{B-V}$ ? (one decimal) [2] – 03



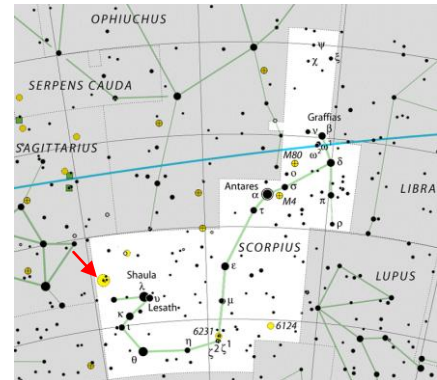
- iv. Chandrasekhar Mass limit in solar radii. (two decimals) [3] – 144
- v. The orbital period of Mercury (days). (integer) [2] – 88
- vi. The axial tilt of an exoplanet without atmosphere is  $0^\circ$ . Its orbital period is really long. How many times greater is the mean temperature of the illuminated (by the corresponding star) hemisphere when the planet spins really slowly compared to when it spins really quickly? (one decimal) [2] – 12
- vii. The atomic mass (in a.m.u.) of the heaviest element which can be produced in a star, before it meets its end. [2] – 56
- viii. Diameter of the biggest single aperture optical telescope in meters (integer) [2] – 10
- ix. The inventor of the telescope. [1] – 4
 

1.Demisianos	6.Harriot
2.Brache	7.Marius
3.Ibn Sahl	8.Newton
4.Lippershey	9.Galileo
5.Huygens	

F

- i. A binary system is consisted of two stars that revolve around the centre of mass with semi-major axes of 11.25 A.U. And 18.62 A.U. If the total mass of the system is 5 solar masses, calculate the period (in years) of the system. (integer) [2] – 73

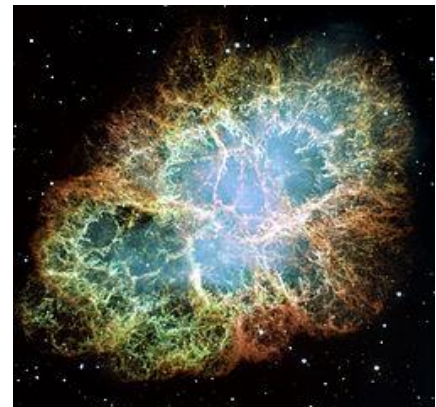
- ii. Ptolemy's Cluster is M\_. [1] – 7



- iii. What will be the diameter of the telescope (in meters) required to resolve a planet revolving around a star with orbital radius 1 A.U., if the distance to star is 226.26 light years? Ignore seeing. (one decimal) [2] – 96

- iv. Castor is a multiple star of how many components? [1] – 6

- v. The picture shows SNR \_. [4] – 1054



- vi. Luminosity class of sub-dwarfs [1] – 6

- vii. Alcyone, Taygeta, Maia, Electra, Atlas [5] – 51836



- viii. Luminosity class of the Sun [1] – 5

## G

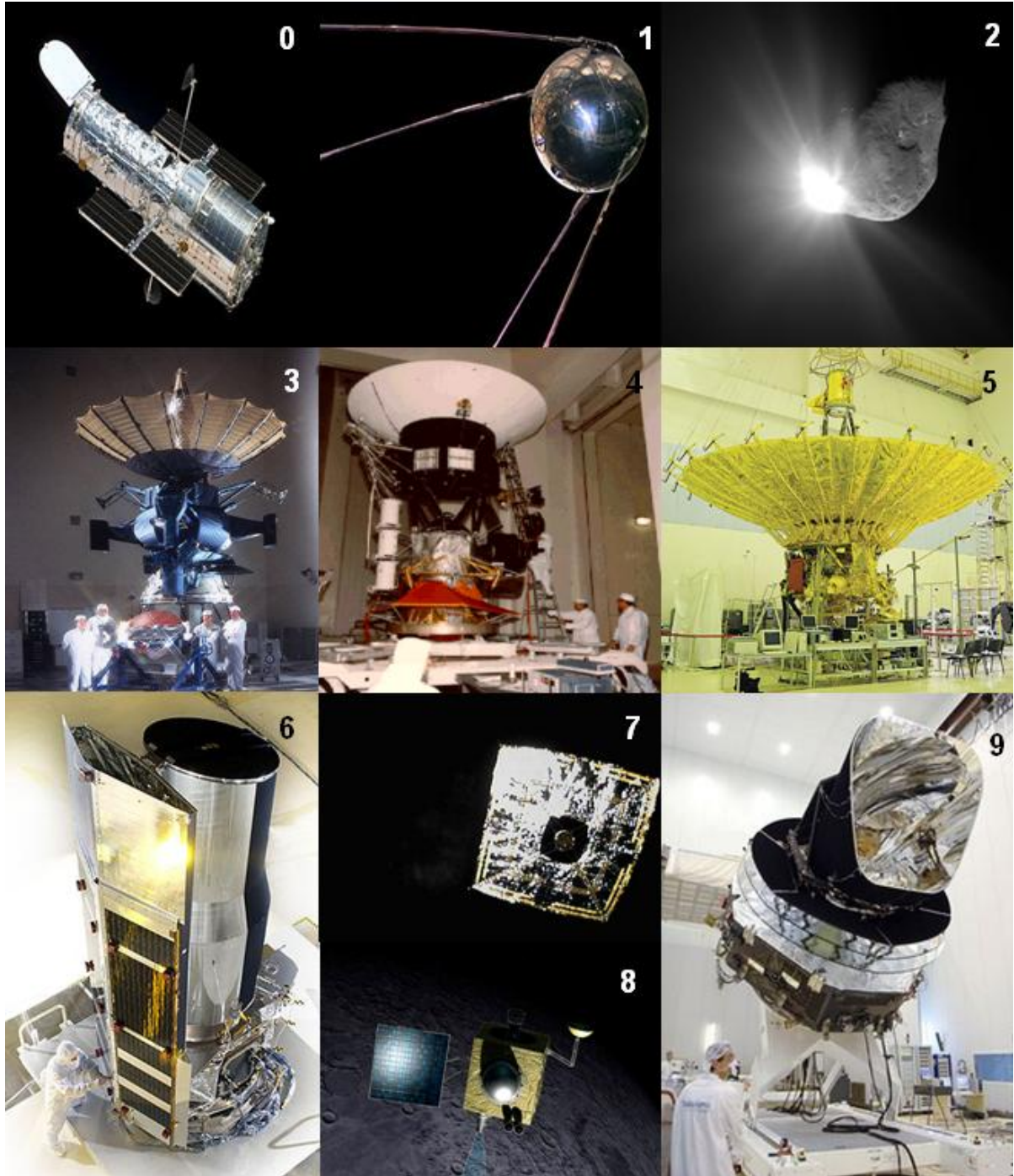
- i. Bode's Galaxy is M\_. [2] – 81
- ii. Cigar Galaxy is M\_. [2] – 82



- iii. How many times fainter will a star become if its magnitude is increased by 1mag? (three decimals) [4] – 2512
- iv. A Globular Cluster near the nostril of Pegasus is M\_. [2] – 15
- v. Hipparchus described a Solar Eclipse which was seen as Total in the Hellespont ( $40^{\circ} 25'N$ ,  $29^{\circ} 43'E$ ) but Partial in Alexandria ( $31^{\circ} 12'N$ ,  $29^{\circ} 55'E$ ), where at maximum  $4/5$  of the Sun was hidden. Hipparchus calculated the parallax of the limb of the Moon between the Hellespont and Alexandria, assuming that the parallax of the Sun is 0. He also knew that the Moon has the same apparent angular diameter as the Sun, with a value of  $1/650$  of the circle. Finally, by applying simple trigonometry, he calculated the approximate distance between the Earth and the Moon in Earth radii. How many Earth radii is the Earth–Moon distance? (integer) [2] – 64



vi. Chandrayan-1, Deep Impact, Planck Telescope, Hubble Space Telescope [4] – 8190



vii. If the mass of a star is  $5 \text{ solar masses}$ , and its initial radius and rotation period is  $21 \times 10^5 \text{ km}$  and  $4.083 \text{ days}$  respectively, how many microseconds will be its period when it turns into a Pulsar with a radius of  $10 \text{ km}$ ? Assume the star is a homogenous sphere and does not lose mass. [1] – 8

H.

- i. How many planets of the Solar System have rings? [1] – 4
- ii. Angle corresponding to  $16^h 16^m$  (integer) [3] – 244
- iii. The Saros in \_y \_d. [4] – 1811
- iv. If a more accurate indicator existed for the latitude scale of the telescopes you are going to use during the observational part, it would show \_° \_'. [4] – 3922
- v. R.A. of Duschbba i.e.  $\delta$  Scorpil (hh). [2] – 16
- vi. An asteroid is  $2.84U$  away from the Sun. At opposition, its visual brightness was  $1.46 \times 10^{-16} \text{ Watt/m}^2$ . What is its radius (in meters) if its albedo is 1.00? (integer) [3] – 496

# I

i. On 11<sup>th</sup> December 2117 a Venus Transit will take place. How many years later is the next one? [1] – 8

ii. An Open Cluster in Canis Major is M\_. [2] – 41

iii. Write the numbers of the three brightest stars in descending order of brightness: [3] – 324

1. Betelgeuse
2. Vega
3. Canopus
4.  $\alpha$  Centauri
5. Capella
6. Procyon
7. Altair
8. Rigel
9. Arcturus

iv. A circumpolar star's altitude at upper culmination is  $76.8^\circ$  and at lower culmination is  $10^\circ$ . What is the latitude of the place? [3] – 434

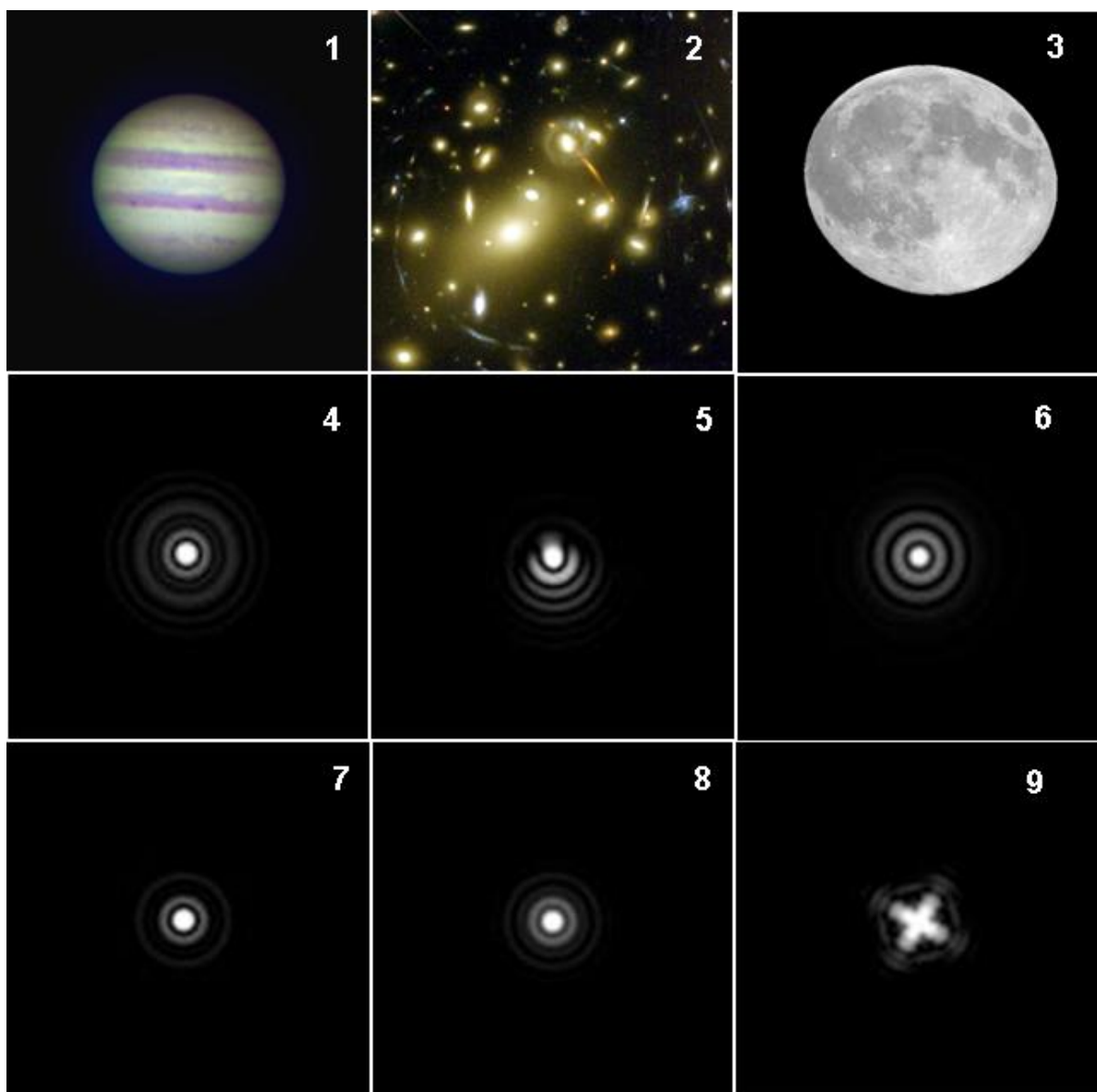
v. Leo is N<sup>th</sup> zodiacal sign. N is [1] – 5

vi. The Solar System lies within this arm of the Milky Way: [1] – 4

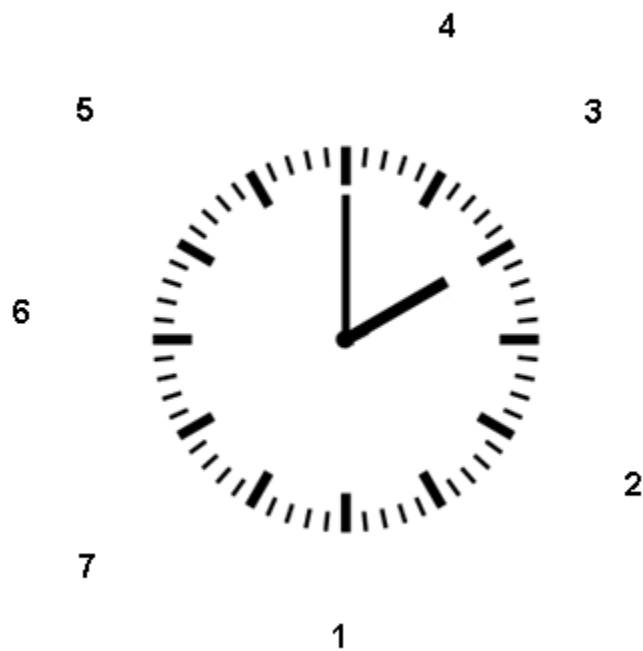
1. Sagittarius–Carina
2. Scutum–Crux
3. Norma
4. Orion
5. Perseus
6. Cygnus
7. Outer

vii. The resonance between Pluto and Neptune is \_:\_ . [2] – 23

viii. Distortion, Coma, Astigmatism [3] – 359

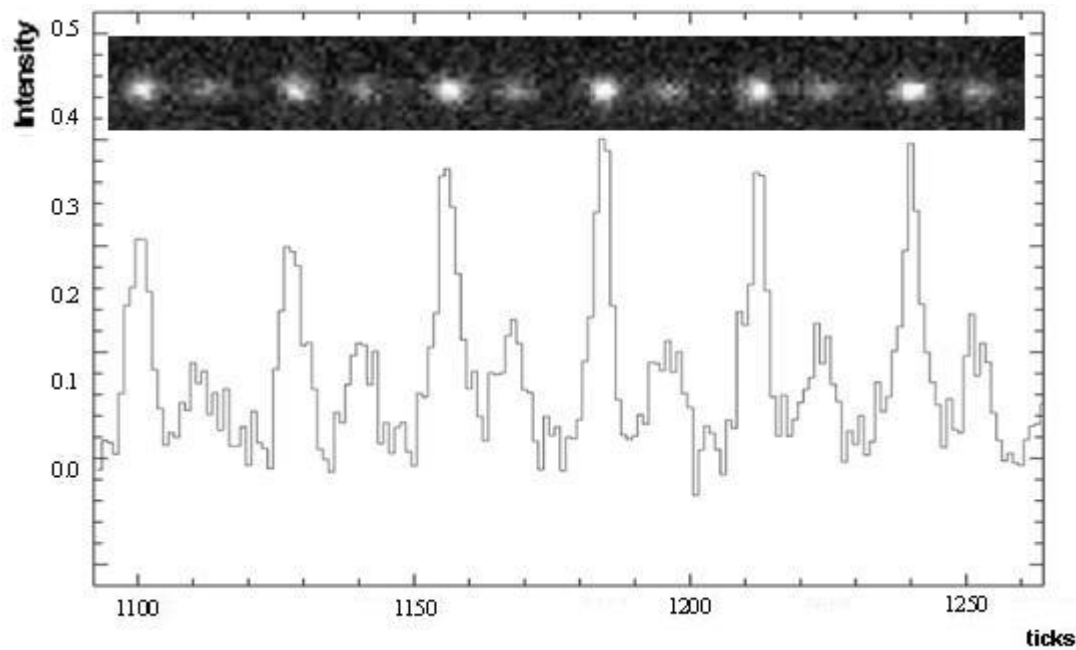


ix. On 16<sup>th</sup> December you visit a country of the Southern Hemisphere which uses Daylight Saving Time. When it is 2 o' clock, you place your watch so as the hour hand points to the projection of the Sun to the horizon. Which number indicates North (approximately)? [1] – 3



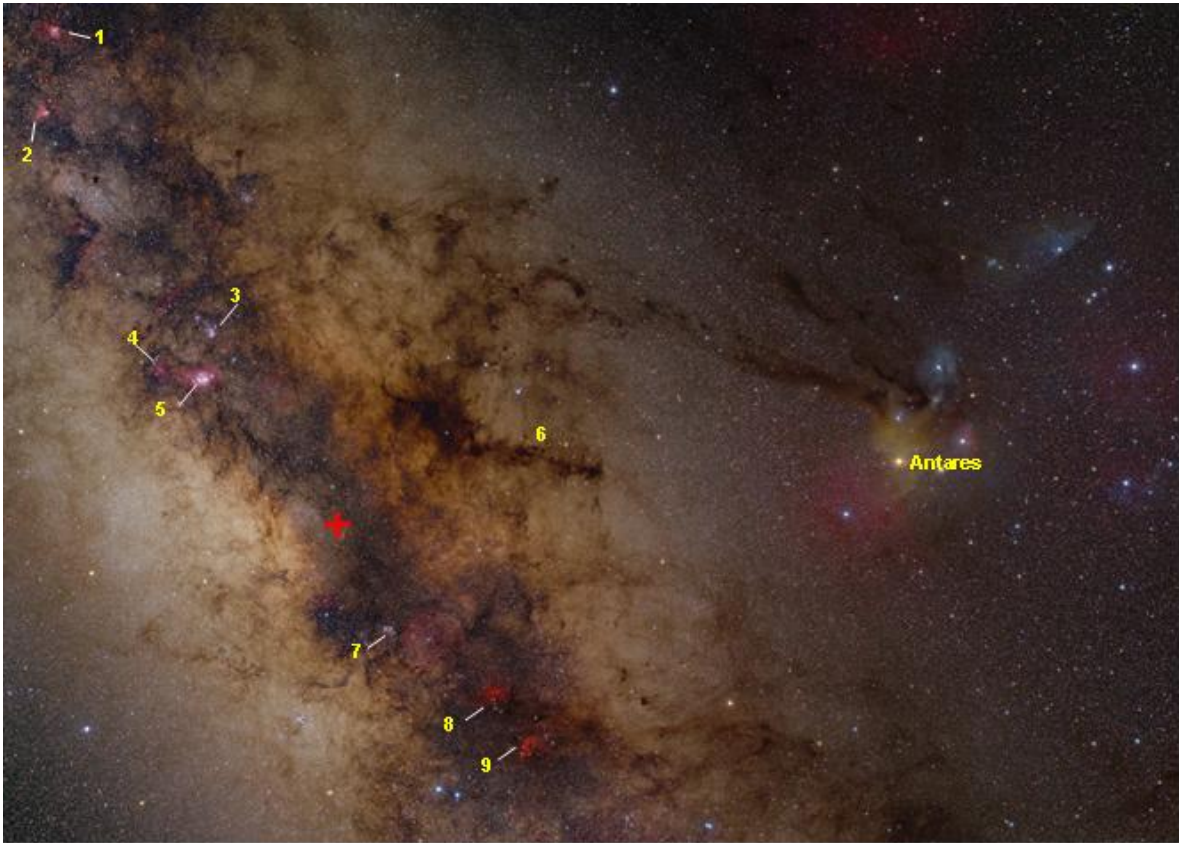
J.

- i. Each Zodiacal Sign extends for that many degrees along the ecliptic. [2] – 30
- ii. You are given the light curve of a pulsar. What is its rotation period (ms) if the time interval between two “ticks” is 1.1965ms? (one decimal) [3] – 335



iii.  
Pipe  
Nebu  
la,  
Trifi  
d  
Nebu  
la,  
Lago  
on  
Nebu  
la,  
Cat'  
s

Paw Nebula, Eagle Nebula [5] – 63591



- iv. Write the corresponding numbers of the three biggest asteroids in descending order: [3]  
– 248

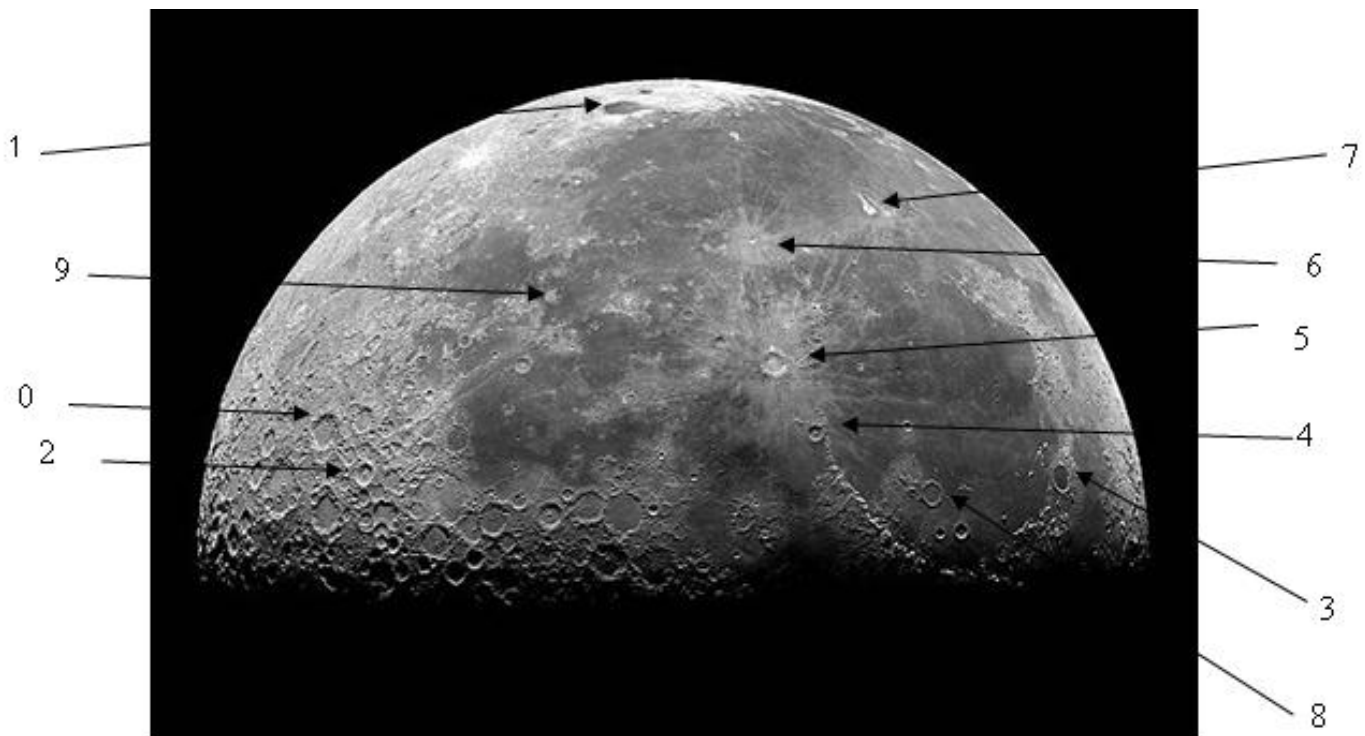
1. Hygiea
2. Ceres
3. Eugenia
4. Pallas
5. Fortuna
6. Aurora
7. Nemesis
8. Vesta
9. Psyche

- v. Baade and Hubble measured the distance to NGC 1049 to be 188 kpc. Thus the distance modulus ( $m - M$ ) they would get for this galaxy is (2 decimal points) [4] – 2137



K.

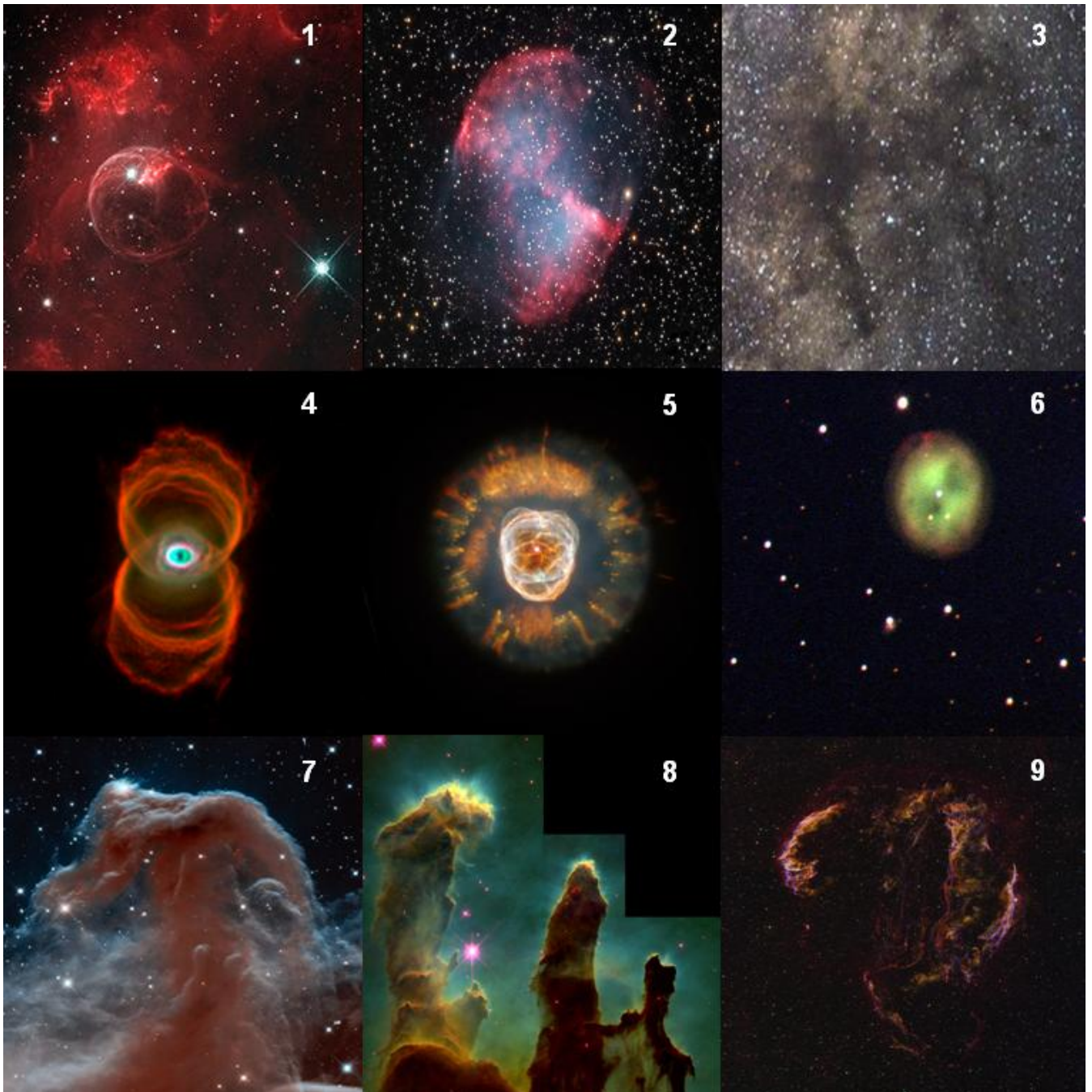
- i. Two stars have angular separation of  $13.84$  arcsec. We are photographing them with a  $f/10$  telescope with a diameter of  $20$  cm. What is their linear separation on the photograph in micrometers? (integer) [4] – 1342
- ii. Grimaldi, Plato, Tycho, Eratosthenes [4] – 1324



- iii. How many degrees under the horizon is the centre of the Sun when the Astronomical Twilight ends? [2] – 18
- iv. The mission of Apollo \_\_\_\_ was aborted after an oxygen tank exploded on the way to the Moon. [2] – 13
- v. If the Observatory Factor is  $0.95$ , what is the Wolf Number if the number of sunspot groups is  $13$  and the number of individual spots is  $14$ ? (integer) [3] – 137
- vi. A star is  $100pc$  away. Its Apparent Visual Magnitude is  $m_v=13.0mag$ , its Apparent Photographic Magnitude is  $m_{pg}=14.6mag$  and its Absolute Visual Magnitude is  $M_v=4.7mag$ . What is its Colour Excess? Consider that  $A_v = 3 \times E_{B-V}$ , where  $E_{B-V}$  is the Colour Excess and  $A_v$  is the Visual Absorption. (one decimal) [2] – 11

L.

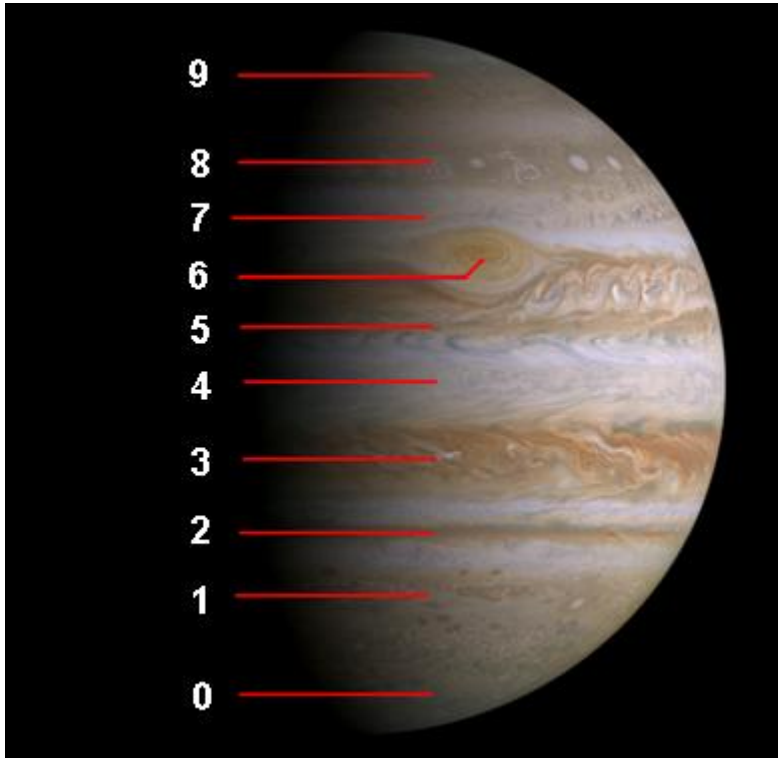
- i. Pillars of Creation, Dumbbell Nebula, Dark Horse Nebula (Great Dark Horse), Bubble Nebula, Engraved Hourglass Nebula [5] – 82314



- ii. What is the wavelength of the spectral line  $H\beta$ ? (integer) [4] – 4862
- iii. First planet to be discovered using Telescope (Mercury is 1, Neptune is 8) [1] – 7
- iv. Consider an eclipsing binary, with central eclipses. Time between the first and fourth contact of primary eclipse is 1.5 hours and time between the 2<sup>nd</sup> and 3<sup>rd</sup> contact is 1 hour. Find the ratio of their radii. (integer) [1] – 5
- v. The final Apollo lunar mission is Apollo \_\_. [2] – 17
- vi. How many times greater is the escape velocity of a satellite compared to the velocity that is required for an orbit with radius equal to the celestial body's radius? (one decimal) [2] – 14
- vii. A star is behind the Coalsack Nebula in a distance of  $200pc$ . If its apparent magnitude is  $m=18mag$  and the optical depth of the Nebula is  $\tau=1.38$ , what is its Absolute Magnitude? (integer) [2] – 10

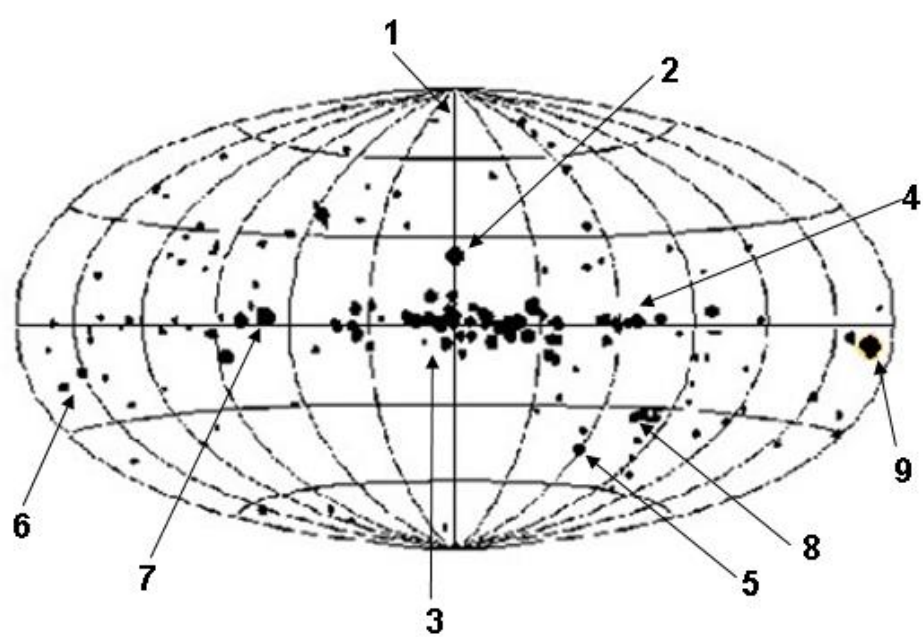
M.

- i. Great Red Spot, North Polar Region, South Equatorial Belt, Equatorial Zone [4] – 6054



- ii. This is a map of the sky in X-rays using galactic coordinates. [5] – 82971

- ÷ Large Magellanic Cloud
- ÷ Scorpio X-1
- ÷ Cancer Nebula
- ÷ Cygnus X-1
- ÷ Coma



- iii. The table shows the composition of the atmosphere of Mars, Earth, Jupiter, Neptune and Venus. Find Jupiter, Venus, Neptune. [3] – 532

	1	2	3	4	5
H <sub>2</sub>	0.000055%	80.0	-	-	86.4
He	0.000524%	19.0	12 ppm	-	13.6
CH <sub>4</sub>	0.000179%	2	-	10.5 ppb	0.0018
NH <sub>3</sub>	trace	<600 ppb	-	-	0.0006
H <sub>2</sub> O	locally 0.001%–5%	-	20 ppm	210 ppm	520 ppm
H <sub>2</sub> S	-	<3 ppm	-	-	70 ppm
CO <sub>2</sub>	0.0397%	0.3 ppb	96.5%	95.32%	30 ppb
HCN	-	60 ppb	-	-	60 ppb
N <sub>2</sub>	78.084%	-	3.5%	2.7%	-
O <sub>2</sub>	20.946%	-	-	1300 ppm	-
Ar	0.9340%	-	70 ppm	1.6%	-
H <sub>2</sub> SO <sub>4</sub> *	-	-	150 ppm	-	-

- iv. Lagoon nebula is M \_\_. [1] – 8



- v. Sequence in which following discoveries received Nobel prizes. [4] – 4253

1. Cepheid Period–Luminosity relation
2. Discovery of pulsars
3. Accelerated Expansion of the Universe
4. Discovery of cosmic rays
5. Chandrasekhar Mass Limit