# Option D - Astrophysics

| # | Physical Quantity | Definition |
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| 1 | **A Planet** | " Is a body that (i) orbits the Sun (or another star), (ii) is massive enough so that its self-gravity makes it more or less spherical, and (iii) has cleared its orbit of other bodies." |
| 2 | **Asteroids** | " Are non-spherical celestial bodies that move around the sun mainly between the orbits of Mars and Jupiter." |
| 3 | **Comets** | " Are icy bodies, formed from the Oort Cloud, that fall towards the sun in highly elliptical orbits, giving off streams of gas as they warm up, forming the characteristic tail of the comet." |
| 4 | **A Nebula (plural Nebulae)** | " Is a vast cloud of dust and gas. The dust consists of compounds of carbon, oxygen, silicon, as well as molecular hydrogen, in the space in between stars." |
| 5 | **Stellar Cluster** | " Is a group of stars of similar age that are physically close together in the Milky Way galaxy, having condensed from the same nebula, and are gravitationally bound to each other." |
| 6 | **Constellation** | " Is a pattern of stars that are not bound by gravity and they appear to be close to each other as seen from Earth." |
| 7 | **Galaxy** | " Is a collection of a very large number of stars and stellar clusters." |
| 8 | **Cluster** | " Is a collection of galaxies that are gravitationally bound." |
| 9 | **Super Cluster** | " Is a collection of clusters of galaxies." |
| 10 | **Main-Sequence Star** | " Is a normal star that is undergoing nuclear fusion of hydrogen into helium. Our Sun is a typical main-sequence star." |
| 11 | **The p-p Chain (proton-proton Cycle)** | " Is one of the fusion reactions which occur in stellar cores of stars on the main sequence. Its net effect is to convert four hydrogen nuclei into one helium-4 nucleus. It is the fusion reaction which occurs in the core of the Sun. |
| 12 | **Binary Stars** | " Are two stars which rotate around a common centre of mass." |
| 13 | **Radiation Pressure** | " Is the pressure exerted by the photons, which result from the hydrogen to helium-4 fusion reaction in stars." |
| 14 | **Gas Pressure** | " Is present by virtue of the kinetic energy of the gas particles that make up the stars." |
| 15 | **The Parallax Angle** | " Is the angle, at the position of a star, that is subtended by a distance equal to the radius of the Earth's orbit around the sun." |
| 16 | **The Parsec** | " Is the distance to a star whose parallax is 1 arc second." |
| 17 | **A Light Year, ly** | " Is the distance travelled by light in one year. Thus 1 ly = $9.46 \times 10^{15}$ m." |
| 18 | **Luminosity, L** | " The luminosity of a star is the rate at which it radiates energy. It is thus the power of the star, usually given in units of watts (W) and depends only on the characteristic intrinsic of the star." |
| 19 | **Apparent Brightness, b** | " It is the power of the star's radiation received by an observer per unit area, usually measured in watts per square metre ($Wm^{-2}$). |
| 20 | **The Peak Wavelength** | " of a Star is the wavelength at which most of its radiation is emitted." |
| 21 | **A Black Body** | " Is a body that absorbs all the radiation incident on it and re-radiates that in the form of the famous black body spectrum of intensity vs. wavelength, also known as the Planck curve, that is a function of its temperature only." |
| 22 | **The Hertzsprung-Russell Diagram** | " An HR diagram is a plot of the luminosity of star versus its surface temperature. Temperature is plotted increasing to the left on the horizontal axis." |
| 23 | **Cepheid Variable (Standard Candle)** | " Is a star of variable luminosity: The luminosity increases sharply and falls off gently with a well-defined period. The period is related to the absolute luminosity of the star and so can be used to estimate the distance to the star." |
| 24 | **Red Giant** | " A main-sequence star evolves into a red giant - a very large reddish star. There are nuclear reactions involving the fusion of helium into heavier elements." |
| 25 | **White Dwarf** | " The end result of the explosion of a red giant. A small, dense star in which no nuclear reactions take place. It is very hot but its small size gives it a very low luminosity." |
| 26 | **Black Dwarf** | " Is the remnant of a white dwarf after it has cooled down. It has very low luminosity." |
| 27 | **Supernova (Type Ia)** | " The explosion of a white dwarf that has accreted mass from a companion star exceeding its stability limit." |
| 28 | **Supernova (Type II)** | " The explosion of a red supergiant star: The amount of energy emitted in a supernova explosion can be staggering - comparable to the total energy radiated by our sun in its entire lifetime." |
| 29 | **Pauli Exclusion Principle** | " States that fermions (electrons and quarks) in the same state cannot occupy the same place in space." |

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| 30 | **The Chandrasekhar Limit** | " If the mass of the remnant of the star (non-rotating white dwarf) is greater than 1.4 solar masses, electron degeneracy pressure fails and the star must collapse further and will become either a neutron star or a black hole rather than a white dwarf." |
| 31 | **The Oppenheimer-Volkoff Limit** | " If the mass of the remnant of the star is greater than 3 to 4 solar masses, neutron degeneracy pressure fails and the star must collapse further and will become a black hole rather than a neutron star." |
| 32 | **Helium Flash** | " Is the explosion of the inner helium core of a red giant as a result of the helium nuclear fusion after reaching a certain high temperature." |
| 33 | **Cosmology** | " Is the study of the universe: how big it is, how old it is, where it came from, and how it will end." |
| 34 | **Isotropic** | " Something is isotropic if it has the property of being the same in all directions." |
| 35 | **The Cosmic Scale Factor** | " Is a measure of the relative expansion of the universe. It is a time-dependent function that describes how the scale of space changes in time. As such it sets a scale, or size, to the universe. |
| 36 | **The Hubble Parameter, H** | " Is a measure of the rate at which space in the universe expands. The value of the Hubble parameter changes over time, by convention $H_0$ is used to indicate its value today, as opposed to in an earlier epoch in the universe's evolution. |
| 37 | **Peculiar Velocity** | " Is the galaxy's velocity component due to the local gravitational interaction with other masses in a gravitationally bound system." |
| | HL Only | |
| 38 | **The CNO Cycle** | " Is the second fusion reaction which occurs in stellar cores of stars on the main sequence. Its net effect is also to convert four hydrogen nuclei into one helium-4 nucleus, but it uses carbon, nitrogen and oxygen nuclei as catalysts. As a consequence of the stronger repulsive Coulomb forces between the higher ionised carbon, nitrogen and oxygen nuclei, as compared to the p-p chain nuclei, the CNO cycle is only dominant in the more massive stars, greater than 1.5$M_{\odot}$, whose core temperatures are greater than 17 million K." |
| 39 | **The Triple-Alpha Process** | " Is a fusion reaction that occurs in the core of stars which have left the main sequence of the H-R diagram and its net effect is to convert three helium-4 nuclei into one carbon-12 nucleus. It is the final fusion reaction for those main sequence stars with a mass smaller than eight solar masses, which end up as white dwarfs surrounded by a planetary nebula." |
| 40 | **The s-Process** | " or slow neutron capture is a nucleosynthesis process that occurs in relatively low neutron flux and intermediate temperatures conditions in stars. Heavier nuclei are created through neutron capture to form an isotope which may then undergo β-decay to form a new element heavier than iron. The rate of neutron capture is slow in comparison to the rate of ß-decay." |
| 41 | **The r-Process** | " or rapid neutron capture is a nucleosynthesis process that occurs in the high neutron flux and high temperatures conditions of core-collapse supernovae, such as Type II supernovae. Neutrons are captured rapidly leading to super-neutron-rich isotopes which may eventually undergo β-decay to form new elements heavier than iron." |
| 42 | **Neutron Flux** | " Is roughly the number of neutrons incident per unit area per unit time." |
| 43 | **The Cosmological Principle** | " Asserts that the universe is both homogeneous and isotropic. A homogeneous universe is one that looks the same from any location; an isotropic universe is one that looks the same in any direction. Hence, the cosmological principle implies that the universe looks the same in any direction from any location." |
| 44 | **Olber's Paradox** | " is the contradiction that in an infinite, homogenous and static universe populated with stars, the night sky should be glowing bright with star light from all directions. The fact that the night sky is overwhelmingly dark with only a scattering of stars leads one to question any of the assumptions of this universe, i.e. whether it is infinite, homogenous or static." |
| 45 | **Dark Matter** | " Is a type of matter that is postulated to exist but has not yet been detected directly. Evidence from rotation curves of galaxies, as well as clusters of galaxies, indicates that there is considerably more dark matter than found in the luminous mass of stars. Dark matter takes it name from its property that it does not emit or interact strongly with electromagnetic radiation, i.e. 'light'." |
| 46 | **MACHOs** | " or Massive (Astrophysical) Compact Halo Objects, which are generally taken to be made up of ordinary baryonic matter (atoms) and are those astrophysical objects which simply do not shine but contain mass, such as brown dwarfs, Jupiter mass objects and black hole remnants. While these MACHOs can account for the flatness of the rotational curves of galaxies, there is not sufficient to account for all the dark matter known to exist." |
| 47 | **WIMPs** | " or Weakly Interactive Massive Particles are generally taken to be particles that are not part of the standard model in particle physics, with leading candidates from the proposed supersymmetry theory. WIMPs do not interact with ordinary matter except through gravity and the weak nuclear force. To date, no WIMP candidates have been found." |
| 48 | **The Critical Density, $\rho_c$** | " Is the density which would give the universe a flat, Euclidean geometry." |
| 49 | **The Density Parameter, Ω** | " Is the ratio of the actual density of the universe, ρ, to the critical density. Thus, $\Omega=\rho/\rho_c$." |
| 50 | **The Cosmological Constant, Λ** | " Is a term introduced by Einstein into his General Relativity theory in order for his cosmological solutions to be static. Its nature is to provide a cosmic, or gravitational, repulsion to counterbalance the gravitational attractive forces between matter. It is often used synonymously with dark energy, which is the energy density that accounts for an accelerating universe that has a flat spatial geometry." |