Astrophysics Questions – OCR A Level Physics

Praneel Physics

1. State what is meant by a light-year. **(P)**

Working and Answer:

The distance light travels in one year in a vacuum.

2. What is the approximate age of the Universe? **(P)**

Working and Answer:

Approximately 13.8 billion years.

3. Define the parsec. **(P)**

Working and Answer:

The distance at which 1 AU subtends an angle of 1 arcsecond.

4. What is meant by red shift? **(P)**

Working and Answer:

An increase in wavelength (or decrease in frequency) of light from a receding object.

5. What is a standard candle? **(P)**

Working and Answer:

An astronomical object of known luminosity, used to measure distance.

6. Explain how redshift provides evidence for the expansion of the universe. **(PP)**

Working and Answer:

More distant galaxies show greater redshifts, indicating they are moving away faster—consistent with space itself expanding.

7. Describe how parallax is used to determine the distance to nearby stars. **(PP)**

Working and Answer:

By measuring the angular shift of a star's position from Earth at two points in its orbit 6 months apart, and using trigonometry.

8. Explain why Cepheid variables are important in determining distances. **(PP)**

Working and Answer:

Their period of brightness variation correlates with luminosity, allowing distance calculation using the inverse square law.

9. State one piece of evidence for dark matter. **(PP)**

Working and Answer:

Galaxies rotate faster than expected based on visible mass, implying additional unseen mass (dark matter).

10. A galaxy is observed with a redshift $z = 0.05$. Estimate its recessional velocity. **(PPP)**

Working and Answer:

$$v = zc = 0.05 \times 3.0 \times 10^8 = 1.5 \times 10^7 \,\text{ms}^{-1}$$

11. A star has an apparent magnitude of 7.2 and an absolute magnitude of 2.2. Estimate its distance in parsecs. **(PPP)**

Working and Answer:

$$m - M = 5\log_{10}(d) - 5 \Rightarrow d = 10^{(m-M+5)/5}$$
$$d = 10^{(7.2-2.2+5)/5} = 10^2 = 100\,\text{pc}$$

12. Calculate the energy output per second of a star with luminosity 3.8×10^{26} W. **(PPP)**

Working and Answer:

That is the energy output: 3.8×10^{26} J/s.

13. The Sun has a surface temperature of 5778 K and radius 6.96×10^8 m. Calculate its luminosity. **(PPP)**

Working and Answer:

$$L = 4\pi R^2 \sigma T^4$$
$$= 4\pi(6.96 \times 10^8)^2 \times 5.67 \times 10^{-8} \times 5778^4 \approx 3.83 \times 10^{26}\,\text{W}$$

14. Outline the life cycle of a star with mass similar to the Sun. **(PPPP)**

Working and Answer:

Nebula → Protostar → Main sequence → Red giant → Planetary nebula → White dwarf.

15. Describe how Hubble's law is used to estimate the age of the Universe. **(PPPP)**

Working and Answer:

Using $v = H_0 d$, invert Hubble constant H_0 to get $t = 1/H_0$, the time since expansion began.

16. Explain how absorption spectra can be used to identify elements in stars. **(PPPP)**

Working and Answer:

Dark lines in the spectrum correspond to specific wavelengths absorbed by elements in the star's atmosphere.

17. Describe the evolution of a star much more massive than the Sun. **(PPPP)**

Working and Answer:

Nebula → Protostar → Main sequence → Red supergiant → Supernova → Neutron star or black hole.

18. A star has temperature 6000 K and radius 1.5×10^8 m. Calculate its luminosity. **(PPPPP)**

Working and Answer:

$$L = 4\pi R^2 \sigma T^4$$

$$= 4\pi(1.5 \times 10^8)^2 \times 5.67 \times 10^{-8} \times 6000^4 \approx 6.13 \times 10^{26}\,\text{W}$$

19. A galaxy is 2×10^{24} m away and has recessional velocity $6 \times 10^{7}\,\mathrm{ms}^{-1}$. Estimate the Hubble constant. **(PPPPP)**

Working and Answer:

$$H_0 = \frac{v}{d} = \frac{6 \times 10^{7}}{2 \times 10^{24}} = 3.0 \times 10^{-17}\,\mathrm{s}^{-1}$$

20. Describe how the cosmic microwave background radiation supports the Big Bang theory. **(PPPPP)**

Working and Answer:

It is uniform blackbody radiation at 2.7 K, interpreted as cooled radiation from an initially hot, dense universe—consistent with predictions.

21. Calculate the intensity received from a star of luminosity $1.2 \times 10^{28}\,\text{W}$ at a distance of $3 \times 10^{16}\,\text{m}$. **(PPPPP)**

Working and Answer:

$$I = \frac{L}{4\pi r^2} = \frac{1.2 \times 10^{28}}{4\pi(3 \times 10^{16})^2} \approx 1.06 \times 10^{-6}\,\text{W/m}^2$$