2019

PHYSICS

Paper : CBCC-A

(Physics at Different Scales)

Full Marks : 50

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Answer ***any five*** questions.

(a) Write the names of the forces observed in nature and the ranges of those forces.

(b) State why the following reactions are not allowed

(i) $n \rightarrow p + e^-$

(ii) $\pi^- + p \rightarrow \pi^- + \pi^+$

(c) State how the concept of colour quantum number was introduced in particle physics.

(d) Name all the flavours of quarks. 4+2+1+3

(a) Draw the necessary strangesness-charge graph(s) to explain the eightfold way of mesons.

(b) Consider a triplet of quarks (u, d, s) and a triplet of anti-quarks ($\bar{u}, \bar{d}, \bar{s}$). Perform the multiplication $3 \times \bar{3}$ and plot the result in a strangeness-charge graph. 5+5

(a) A red-shift (z) of 2 has been observed while measuring the spectrum of Hydrogen from a distant galaxy. Calculate the speed of the galaxy relative to the observer in $Km\ s^{-1}$. If value of Hubble parameter is 50 km $s^{-1}Mpc^{-1}$, calculate the distance of the galaxy from the observer.

(b) Supposing that a typical value of peculiar velocity of a galaxy is 600 km s^{-1}. How far away would a galaxy have to be before it could be used to determine the Hubble parameter at 10% accuracy? Assume that the distance of the galaxy from the observer can be measured accurately.

(c) Argue without solving the fluid equation, why does the energy density of pure radiation fall with the fourth power of scale factor a, as the Universe expands? (2+2)+4+2

(a) Using Friedmann's equation $\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{k}{a^2}$ and fluid equation $\dot{\rho} + 3\frac{\dot{a}}{a}\left(\rho + \frac{p}{c^2}\right) = 0$, show that $\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + \frac{3p}{c^2}\right)$. Here $a(t)$ is the scale factor, ρ is energy density, p is pressure, G is the Gravitational constant and k is curvature of the Universe.

(b) Argue from the above that neither with non-relativistic matter nor with pure radiation, Universe can have accelerated expansion.

(c) Assuming a more general form of equation of state $p = \omega\rho c^2$, show that accelerated expansion of Universe is possible for $\omega < -\frac{1}{3}$.

(d) Assuming that observed Universe is nearly flat, calculate the density of present Universe if measured value of Hubble parameter is 50 km s^{-1}Mpc^{-1}. 3+3+2+2

5. (a) What are the main disadvantages of a reflecting telescope? Why do we need big dishes for radio telescopes? Name one astronomical object that emits radio waves in our solar system.

(b) Explain with a diagram how the distances of nearby stars are measured through geometrical parallax method.

(c) Our sun has a surface temperature of 5800 K and solar radiation peaks at the wavelength 500 nm. The radiation of the white dwarf Sirius B peaks at 125 nm, find out the surface temperature of Sirius B. (2+2+1)+3+2

6. (a) Draw the Hertzsprung-Russel diagram indicating the main sequence, the positions of our Sun and the white dwarfs.

(b) Using Kepler's law, show how the masses of the members of a visual binary can be measured.

(c) For an interstellar cloud to collapse to form a star, obtain an expression for the minimum value of the mass of the cloud as a function of its density and temperature. 3+3+4

7. (a) Name the spectral class to which the hottest stars belong. What is the spectral class of our Sun?

(b) Write down the nuclear reactions that occurred in the Big Bang nucleosynthesis. What are the nuclear reactions that takes place at the time of helium burning in stars?

(c) Assuming a constant mean free path of 1 mm for the photons and the solar radius to be 7,00,000 km, deduce the average time taken by a photon to come from the centre of the Sun to its surface. Assume that the Sun is fully ionised. 2+(3+2)+3
