U.G. 6th Semester Examination 2022

PHYSICS (Honours)

Paper Code : DSE 4 - A & B

Full Marks : 32 Time : Two Hours

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

DSE 4 - A

(Astronomy and Astrophysics)

1. Answer any *six* questions : 2×6=12

   (a) Why are red giants called 'red' and 'giants' ? 2

   (b) The apparent magnitude of the full Moon is –12.73 and that of Sirius *A* is –1.47. Calculate their brightness ratio. 2

   (c) Why do we need a big telescope for better angular resolution ? 2

   (d) Estimate the age of the universe given that the Hubble's constant is 70 km/Mpc. 2

   (e) Write two characteristics of the terrestrial and two characteristics of the Jovian planets. 2

   (f) What is stellar nucleo-synthesis ? 2

   (g) How is the hydrostatic equilibrium maintained in a white dwarf star ? 2

   (h) What do you mean by 'Chandrashekhar's limit' ? 2

   (i) The luminosity of a star is 20 times that of sun and its temperature is twice as much. Determine the radius of the star. 2

2. Answer any *four* questions : 5×4=20

   (a) What is tidal force ? Show that its expression is given by

   $$\Delta\vec{F} = \frac{GMmR}{r^3}\left(2\cos\phi\,\hat{i} - \sin\phi\,\hat{j}\right)$$ 1+4

[P.T.O.]

(b) (i) Suppose two stars have the same size and they emit blackbody radiation. If the surface temperature of one star is eight times that of the other, find the ratio of their luminosities. Assume the stars to be spherical.

(ii) Explain the concepts of apparent and absolute magnitudes. 3+2

(c) If there are billions of stars in the galaxy, why is the night sky so dark ?

Explain why we require space telescopes to perform multi-wavelength observation. 3+2

(d) Consider a star having its mass equal to the solar mass but size equal to that of the earth. Find the approximate value of its acceleration due to gravity (g). How is this value compared with that of the earth ? 4+1

(e) (i) What observation related to galaxy rotation curves gave rise to the idea of dark matter in the universe ?

(ii) What are main sequence stars ? 3+2

(f) (i) What are black holes ?

Explain briefly any one recent experiment in which we have observed the event horizon of a black hole. 2+1

(ii) What would be the radius of sun if it suddenly becomes a black hole ? Mass of the sun is 2×10^{30} kg. 2

(g) What is circumpolar star ? Explain when the sun would be a circumpolar star for observers located at the North Pole. Give an appropriate diagram. 1+2+2

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DSE 4 - B

(Nano Materials and Applications)

1. Answer any *six* questions : 2×6=12

   (a) Write down two important applications of carbon nanotubes.

   (b) What do you mean by MEMS and NEMS ?

   (c) What is the non-stoichiometric defect in crystal ?

   (d) The band gap of a direct band gap semiconductor is 1.42 eV. Calculate the wavelength of the band-to-band luminescence radiation coming out of it.

   (e) What is a phonon ? Is it a real particle ?

   (f) Why TEM instrument is operated in vacuum ?

   (g) What do you mean by quantum wire ? Give two examples.

   (h) For one cube volume, the surface area is 6 m^2. When it is divided into 27 cubes, then calculate the surface area of its.

   (i) What does the density of states for a material represent ?

2. Answer any *four* questions : 5×4=20

   (a) What do you mean by quantum confinement ? Show that the dimension of quantum confinement must be the order of deBroglie wavelength of charge carrier. 1+4

   (b) Discuss briefly the major applications of quantum dots in solar cells. What are the advantages and disadvantages of quantum dot solar cell ? 2+3

   (c) What do you mean by density of states (DOS) ? For a metal of volume 10^{-9} m^3 having the DOS 10^{25} m^{-3} eV^{-1} at an energy of 5 eV, calculate the number of states in the energy range 0.003 eV centered at 5 eV. 2+3

   (d) Distinguish between top-down and bottom-up approach for nanomaterial synthesis. Give examples in each case. What are the main disadvantages of top-down and bottom-up approaches ? 2+1+2

   (e) What do you mean by Mott-Wannier excitons ? Calculate the exciton Rydberge and Bohr radius for *GaAs*, which has $\varepsilon_r = 12.8$, $m_e^* = 0.067\, m_0$, and $m_h^* = 0.2\, m_0$. [Given Rydberg constant of hydrogen atom is 13.6eV]. 2+3

   (f) What is quantum dot ? Explain briefly Coulomb blockade effect in connection with quantum dot. 1+4

[P.T.O.]

(g) Consider a particle of mass m moving in a one-dimension (ID) potential given by

$$V(x) = 0, \quad \text{if } 0 < x < L \text{ (inside) and}$$

$$= \infty, \quad \text{if otherwise } [x > L] \text{ outside}$$

where L is the width of the infinite potential well. Find out the energy levels of the particle. 5