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(May)

PHYSICS

(Major)

Course : 604

(Optional Course)

Full Marks : 60

Pass Marks : 24/18

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

OPTION—A

Paper : 60410

(ASTROPHYSICS AND PARTICLE PHYSICS)

1. Choose the correct answer from the following : 1×6=6

(a) Which of the following quantities are related in Hertzsprung-Russell diagram?

(i) Surface gravity and effective temperature

(ii) Effective temperature and turbulent velocity

(iii) Stellar temperature and luminosity

(iv) Chemical composition and luminosity

(Turn Over)

- (b) 1 parsec is a distance measured, if a star makes a parallax angle of 1 arc second, which is equal to

- (i) 2.99×10^8 km
- (ii) 3.08×10^{13} km
- (iii) 3×10^5 km
- (iv) 2.06×10^5 km

- (c) A binary system whose two stars periodically eclipse one another leading to a periodic changes in the apparent brightness of the system is known as

- (i) visual binary
- (ii) eclipsing binary
- (iii) optical binary
- (iv) spectroscopic binary

- (d) The luminosity of the sun is obtained as

- (i) 3.09×10^{33} erg sec⁻¹
- (ii) 3.90×10^{30} erg sec⁻¹
- (iii) 3.827×10^{33} erg sec⁻¹
- (iv) 2.90×10^{33} erg sec⁻¹

- (e) The end point of evolution of a star of 1 solar mass is known as

- (i) red giant
- (ii) pulsar
- (iii) white dwarf
- (iv) neutron star

(Continued)

- (f) Particles, which do not respond to strong interaction but only to weak and electromagnetic interactions, are referred to as

- (i) protons
- (ii) leptons
- (iii) hyperons
- (iv) neutrons

2. (a) What are the various branches of astronomy on the basis of observational point of view? What do you understand by astronomy and astrophysics? Give a brief idea of the difference of optical and radio telescopes. 2+2+2=6

- (b) Explain why an X-ray telescope is superior to other telescopes. 2

3. (a) Define the absolute magnitude of a star. Obtain the relation connecting the absolute magnitude with apparent magnitude and the distance of the star in parsec 2+3=5

- (b) Star A has colour index 0.0, star B has colour index 1.0. Which one of them has a higher surface temperature? 2

- (c) What is spectral classification of stars? What are the various spectral classes? What is H-R diagram? 2+1+2=5

(Turn Over)

4. (a) What are the various processes of energy transport in stellar interior? Show that the variations of the luminous flux within the stellar interior is

$$\frac{dL(r)}{dr} = 4\pi r^2 \rho \epsilon$$

where ϵ is the energy generated due to thermonuclear reactions. 3+3=6

- (b) Give an account of the PP chain and CNO cycle as a source of nuclear energy in a star. 4

5. (a) What do you understand by cosmology? Give a brief idea of Newtonian cosmology. 2+2=4

- (b) State Hubble's law. Discuss the phenomenon of expanding universe on the basis of this law. 1+3=4

6. (a) What are elementary particles? Explain clearly the meaning of isotopic spin and strangeness. In what respect are they important in classifying elementary particles? 1+2+2=5

- (b) Compare the properties of leptons and baryons. Which is the mediator in strong interactions? 3

7. (a) State and explain with examples the conservation laws, which govern the elementary particle reactions and decay. 1+2=3

- (b) What are quarks? Depict the quark models of (i) mesons and (ii) protons and antiprotons. 1+2+2=5

Or

Write short notes on any two of the following : 2½×2=5

- (i) Red giant
- (ii) Fermions
- (iii) Gluons

OPTION—B

Paper : 60420

(SPACE AND ATMOSPHERIC PHYSICS)

1. (a) Choose the correct answer : 1

The layer from the stratopause to about 85–90 km, in which the temperature falls with altitude is called

- (i) stratosphere
- (ii) troposphere
- (iii) mesosphere
- (iv) ionosphere

- (b) Choose the correct answer : 1

Which of the following absorbs ultraviolet solar radiation, thereby protecting the biosphere from potentially damaging effects?

- (i) Water vapour
- (ii) Ozone layer
- (iii) Mesosphere
- (iv) None of the above

- (c) Fill in the blank : 1

Virtual height in summer ranges from 300 km to 400 km whereas in winter it goes down to 225 km, this ionospheric layer is called ____.

- (d) Choose the correct answer : 1

In the ionosphere, recombination coefficient (cm^3/sec) for F_1 region is

- (i) 4×10^{-9}
- (ii) 4×10^{-10}
- (iii) 4×10^{-11}
- (iv) None of the above

- (e) Choose the correct answer : 1

Solar wind flowing out from the sun consist of

- (i) electrons
- (ii) protons
- (iii) both electrons and protons
- (iv) None of the above

- (f) Choose the correct answer : 1

The solar photosphere is

- (i) cooler than the solar corona
- (ii) less dense than the solar corona
- (iii) hotter than the solar corona
- (iv) None of the above

2. Answer the following questions : $2 \times 6 = 12$

- (a) What is the difference between heat and internal energy?
- (b) Define geopotential.

- (c) When air is pumped into the tube of a bicycle, the temperature of air in the tube increases. Why?
- (d) Explain briefly the characteristics of various regions in the ionosphere.
- (e) How does electron number density vary with zenith angle of the sun?
- (f) What is solar wind? How is it produced?

3. Answer the following questions :

- (a) Define thermodynamical parameters. 4

Or

What do you mean by dry air and moist air? Explain briefly thermal stress. $2+2=4$

- (b) Why are sun spots important to the sun? 3
- (c) What is potential temperature? How is it related to entropy? $2+3=5$
- (d) What type of star is the sun? Explain the physical significance of stars of this type. $2+3=5$

4. Answer the following questions :

- (a) Describe the structure of ionosphere. Discuss the theory which explains the formation of ionosphere. $2+5=7$

- (b) Discuss briefly the limitations of first law of thermodynamics. 3
- (c) What is the basic theory of photo-ionization? 3

5. Write short notes on any three of the following : $4 \times 3 = 12$

- (a) Temperature structure
- (b) Coronal heating
- (c) Balance of ionization
- (d) Solar activity

OPTION—C

Paper : 60430

(LASER AND ITS APPLICATIONS)

1. Choose the correct answer from the following : 1×6=6

(a) The quality factor (Q) of a cavity resonator is high, if

- (i) the amount of energy stored in the cavity is small
- (ii) the amount of energy dissipated in the cavity is large
- (iii) the line width is small
- (iv) the line width is large

(b) In which of the following mechanisms the adiabatic expansion of the gas is utilized for creating population inversion between two energy levels?

- (i) Electrical pumping
- (ii) Optical pumping
- (iii) Chemical pumping
- (iv) Gas dynamic pumping

(Continued)

(c) In ammonia beam maser, separation between upper level and lower level ammonia molecules (NH_3) is done by using the properties/property of

- (i) repulsion between the electric field and upper state NH_3 molecules, and attraction between electric field and lower state NH_3 molecules
- (ii) repulsion between the electric field and lower state NH_3 molecules, and attraction between the electric field and upper state NH_3 molecules
- (iii) repulsion between electric field and lower state NH_3 molecules
- (iv) attraction between the electric field and upper state NH_3 molecules

(d) The degree of coherence is higher, if

- (i) the degree of monochromaticity is lower
- (ii) the degree of monochromaticity is higher
- (iii) the degree of divergence of the beam is higher
- (iv) the degree of polarization is lower

(e) If μ_1 and μ_2 be the refractive indices of core and cladding respectively of an optical fibre, then

- (i) $\mu_1 < \mu_2$
- (ii) $\mu_2 < \mu_1$
- (iii) $\mu_1 \leq \mu_2$
- (iv) $\mu_2 \leq \mu_1$

(Turn Over)

(f) The phenomenon of splitting of spectral lines emitted by a source into a set of lines due to the application of a strong magnetic field is called

- (i) Stark effect
- (ii) Zeeman effect
- (iii) Faraday effect
- (iv) Kerr effect

2. (a) State the different types of processes through which transition between two energy levels of atoms can take place. Discuss how the Einstein's coefficients are related to these processes. $3+4=7$

Or

Show that Planck's black-body radiation formula can be derived by using Einstein's coefficients. Under what condition the probability of absorption is equal to that of stimulated emission? $6+1=7$

- (b) What is meant by population inversion? Discuss the different types of mechanism used to create population inversion. $1+4=5$
- (c) Derive the threshold condition for laser oscillation. 6

3. (a) Describe the construction and working of a He-Ne laser. Whether CW or pulse is produced in this laser? $4+1=5$

(b) Explain the principle of generation of laser in semiconductor. 4

4. (a) Describe briefly about five basic requirements for the generation of laser. 5

(b) Discuss the different types of coherence in laser. 4

5. (a) Describe with diagram how a signal is transmitted through an optical fibre. Also define acceptance cone and acceptance angle of an optical fibre. $4+2=6$

(b) A typical relative refractive index difference of an optical fibre tube design for long distance transmission is 20%. Estimate the numerical aperture and critical angle at core-cladding interface with the fibre, where core refractive index is 1.46. 3

6. What is Faraday effect? Describe with necessary arrangement how this effect can be experimentally demonstrated. What is meant by Verdet's constant? $2+6+1=9$

OPTION—D

Paper : 60440

(MATERIAL SCIENCE AND NANOMATERIALS)

1. What are engineering materials? How are they classified? Explain. 2+4
2. What are semiconductors? Why are they so important as engineering material? Discuss with example an important area of application of semiconducting materials. 1+1+4
3. (a) What are biomaterials? What are their advantages and disadvantages as engineering material? Mention one important application of biomaterial. 1+4+1

Or

- (b) Compare biomaterial with inorganic and organic engineering materials with reference to their abilities and limitations as engineering material. 6
4. What are the advantages that a composite material can possess? Give an example of a potential composite material discussing its applications. 3+3
5. What is a quantum dot? What is band gap engineering associated to a quantum dot? 1+1

6. What are nanostructured materials (NSMs)? Why do they show significantly different behaviour in comparison to their bulk counterpart? 2+3
7. (a) What is the major consequence of confining an electron in a quantum dot? How is the behaviour of an electron under this confinement is different from a free electron? 3+2

Or

- (b) What are carbon nanotubes (CNTs)? Why are they so important now-a-days as engineering material? Explain with examples. 2+3
8. What is sol-gel technique? Why is it so called? Discuss the advantages and disadvantages associated with the preparation of nanostructured materials (NSMs) by this method. 1+2+3
9. (a) Discuss the plasma arcing method for the fabrication of nanostructured materials (NSMs) 4

Or

- (b) What is chemical bath deposition technique? Explain in brief the production of nanostructured materials (NSMs) by this method. 4

10. What do you understand by top-down and bottom-up approach of production of nanostructured materials? 2
11. What is Bragg's law of X-ray diffraction? Why is it not possible to use visible light for crystal structure determination? 2+2
12. (a) What is the basic principle of Scanning Electron Microscope (SEM)? What are the interactions that the incident electron encounters in an SEM image recording? Mention one important advantage of this characterization technique. 3+2+1

Or

- (b) How Transmission Electron Microscope (TEM) is different from SEM? Why is the typical energy for incident electrons in usual TEM analysis? Explain its basic principle. 2+1+3
13. Explain why nanostructured materials (NSMs) are better catalysts in comparison to their bulk counterparts. 2

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