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6 SEM TDC PHY M 4 (Op)

2019

(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) The resolving power of a mirror or a lens of diameter D is given by

(i) $\theta = 1{\cdot}22\frac{\lambda}{D}$ *(ii)* $\theta = 1{\cdot}22\frac{D}{\lambda}$

(iii) $\theta = 1{\cdot}41\frac{D}{\lambda}$ *(iv)* $\theta = 1{\cdot}41\frac{\lambda}{D}$

(Turn Over)

(b) The V magnitude of the sun is

(i) −2·674

(ii) −26·74

(iii) 26·74

(iv) 2·674

(c) The luminosity of a star is related to its effective surface temperature as

(i) $L \propto T_{eff}$

(ii) $L \propto T_{eff}^2$

(iii) $L \propto T_{eff}^4$

(iv) $L \propto T_{eff}^6$

(d) The galactic centre is situated at a distance of about

(i) 1 Au

(ii) 1 kpc

(iii) 8 kpc

(iv) 1 Mpc

from the solar system.

(e) Which of the following is not a boson?

(i) Photon

(ii) Z

(iii) $W\pm$

(iv) Electron

(Continued)

(f) Which combination of quarks represents the internal structure of neutron?

(i) udd

(ii) uud

(iii) ddd

(iv) uuu

2. Answer any *six* from the following : 2×6=12

(a) What is one parsec? Convert 1 parsec into meters.

(b) How is the apparent brightness of two stars related to their magnitude classes? What is absolute magnitude of a celestial object?

(c) Show that inside temperatures of different stars should be proportional to M/R.

(d) State Hubble's law and its physical significance.

(e) Write down the spin, baryon number, lepton number and charge of electrons.

(f) Compare the relative strengths of the four fundamental forces.

(g) Write down the charge and strangeness number of strange and charm quarks.

(Turn Over)

3. *(a)* Give a brief introduction to the celestial coordinates. What is equatorial mounting of a telescope? 3+2=

(b) Using the idea of hydrostatic equilibrium in stars, obtain the first and second stellar structure equations. 3+4=

Or

Obtain the Eddington luminosity limit for main sequence stars. Why is it significant? 5+2=7

(c) Give a brief description of distance measurement with the help of Cepheid variables. 5

(d) How can one determine the effective surface temperature of a star? 5

Or

Obtain the mass-luminosity relation of main-sequence stars. 5

4. *(a)* Describe how did Hubble classify the galaxies. 4

(b) What is luminosity distance? Obtain an expression of luminosity distance in terms of redshift. 3

Or

Write a note on the accelerated expansion of the universe. 3

(Continued)

5. *(a)* What is strangeness number? How is it related to baryon number and hypercharge? 2+1=3

(b) Write down the composition of proton p in terms of quarks and show that the same is in agreement with charge, baryon number, strangeness number and spin of the particle. 4

(c) If in the following reaction, the incident kaon has a kinetic energy of 1·63 GeV, calculate the total energy to be divided between the four recoiling particles :

$$\bar{k}^- + p^+ \rightarrow \Sigma^- + \pi^+ + \pi^- + \pi^+$$

The mass energy of π-mesons are 139·6 MeV, Σ^- = 1197·3 MeV, proton = 938·3 MeV and $\bar{k}^-$ = 493·8 MeV. 4

Or

What is isospin? Write the conservation laws for isospin in different interactions. 1+3=4

(d) Write whether the following reactions are allowed or forbidden with justification (any *two*) : 1+1=2

(i) $p \rightarrow \pi^+ + \pi^- + e^{-1}$

(ii) $\pi^+ + n \rightarrow \wedge^\circ + k^+$

(iii) $\bar{\nu}_\mu + p \rightarrow n + \mu^+$

(Turn Over)

OPTION—B

Paper : 60420

(SPACE AND ATMOSPHERIC PHYSICS)

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

(a) The environmental lapse rate is ____ in the stratosphere.

(i) positive *(ii)* negative

(iii) negligible *(iv)* zero

(b) The mass of dry air is ____ than that of moist air.

(i) lesser

(ii) greater

(iii) equal

(iv) comparable

(c) The solar flares are more prominent when the sun is

(i) quiet *(ii)* active

(iii) overhead *(iv)* at horizon

(d) The greatest electron concentration is found in

(i) D region *(ii)* E region

(iii) F_1 region *(iv)* F_2 region

(Continued)

(e) The temperature of the photosphere is

(i) 6000 K

(ii) 10^5 K

(iii) 10^6 K

(iv) 10^{12} K

(f) Solar wind is composed of

(i) electrons and photon

(ii) protons and photon

(iii) electrons and protons

(iv) electrons and ions

2. *(a)* What are fixed and variable gases in the earth's atmosphere? 2

(b) How does pressure vary with altitude in the earth's atmosphere? Derive an expression for it using hydrostatic equation. 1+4=5

(c) Obtain the expression for potential temperature of dry air. 3

3. *(a)* Derive the equations of state for dry and moist air. Calculate the density of dry air at the earth's surface where dry air partial pressure is 1013 mb and temperature is 288 K. Given gas constant for dry air is 2·8704 $m^3 mb\ kg^{-1}K^{-1}$. 4+2=6

(Turn Over)

(b) Explain the role of water in the atmosphere. 4

Or

State the difference between dry and wet adiabatic lapse rates. How is the stability of the atmosphere explained in terms of dry adiabatic lapse rate? 2+2=4

4. (a) Describe the process of formation of the D, E, F_1, F_2 layers. 6

(b) Discuss how radio communication is affected by the ionosphere. 4

5. (a) Derive Chapman's theory of photo-ionization. 6

(b) Mention the factors on which the production function depends. 2

6. (a) Describe the structure of the sun. 5

(b) Define solar constant and mention its value. 2

7. (a) Explain what solar wind is and describe its general features. 5

(b) Discuss coronal heating and coronal mass ejection. 4

(Continued)

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OPTION—C

Paper : 60430

(LASER AND ITS APPLICATIONS)

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

(a) A two-level laser is not possible because

(i) population inversion is not possible

(ii) population inversion will be very less

(iii) cavity for a two-level system is not possible

(iv) None of the above

(b) It is easier to obtain a maser than a laser because

(i) microwaves have less frequency than optical frequency

(ii) population inversion is not needed in maser

(iii) to create population inversion in maser is easier

(iv) None of the above

(Turn Over)

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

(i) Chemical pumping

(ii) Electrical pumping

(iii) Gas dynamic pumping

(iv) Optical pumping

(d) If n_1 and n_2 be the refractive indices of core and cladding respectively of an optical fibre, then

(i) $n_1 < n_2$ (ii) $n_1 > n_2$

(iii) $n_1 \leq n_2$ (iv) $n_1 \geq n_2$

(e) Ratio of probabilities of spontaneous emission and stimulated emission is

(i) proportional to frequency (ν)

(ii) independent of frequency

(iii) proportional to ν^2

(iv) proportional to ν^3

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

(i) the line width is large

(ii) the line width is small

(iii) the amount of energy dissipated in the cavity is small

(iv) the amount of energy dissipated in the cavity is large

(Continued)

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2. Answer the following : 2×6=12

(a) Draw the energy level diagram of ruby laser.

(b) State the condition for steady state oscillations in optical resonator.

(c) What are the main components of a laser system?

(d) Why does a three-level laser normally provide pulsed output?

(e) Explain spatial and temporal coherences.

(f) Determine the SI units of Einstein's coefficients A and B.

3. (a) What is meant by population inversion? Discuss the different types of mechanism used to create population inversion. 1+4=5

(b) Specify three types of possible energy transition between two atomic energy levels and derive the relation between Einstein's coefficients. 2+3=5

(c) Show that degree of visibility of fringes is a measure of degree of coherence between waves of equal intensities. 5

(Turn Over)

(d) Show that temporal coherence depends upon the value of coherence lengths and coherent time. 5

(e) Explaining the role of helium atoms, discuss He-Ne laser. 5

Or

Describe the principle of operation of semiconductor laser.

(f) What is an optical fibre? Derive an expression for numerical aperture of an optical fibre. Why do we prefer small numerical aperture for long distance communication? 1+3+1=5

4. (a) Describe with necessary experimental arrangement for demonstration of Faraday effect. 4

(b) Give the classical theory of Faraday effect and hence derive the value of Verdet's constant. 5

(c) Write a short note on any *one* the following : 3

(i) Second harmonic generation

(ii) Kerr effect

(Continued)

OPTION—D

Paper : 60440

(MATERIAL SCIENCE AND NANOMATERIALS)

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

(a) A piezoelectric material, shape-memory alloys and shape-memory polymers are

(i) engineering materials

(ii) advanced materials

(iii) smart materials

(iv) biological materials

(b) Nanomaterials show different properties from its bulk counterpart because of

(i) high surface to volume ratio

(ii) low surface to volume ratio

(iii) its lower size

(iv) None of the above

(c) Mohs scale is for

(i) mineral hardness

(ii) ceramic hardness

(iii) polymer hardness

(iv) plastic hardness

(Turn Over)

(d) 'Glass transition temperature' of polymer means

(i) polymer transitions from hard, glossy materials to soft, rubbery materials

(ii) polymer transitions from soft, rubbery to hard, glossy materials

(iii) polymers change into plastics

(iv) polymers change into ceramics

(e) What is 'nanite'?

(i) Nanomaterial

(ii) Nano-machine

(iii) Nanotechnology

(iv) Nanoparticle

(f) Quantum confinement is in

(i) quantum well

(ii) quantum wire

(iii) quantum dot

(iv) All of the above

2. Answer the following : $2\times7=14$

(a) How are biomaterials different from organic and inorganic materials?

(b) What are engineering materials?

(Continued)

(c) Describe nano-composite materials with suitable example.

(d) What is chemical bath deposition?

(e) Mention the importance of carbon nanotubes.

(f) Explain why nanomaterials are better catalysis than their bulk counterpart.

(g) Explain quantum confinement phenomena in nanomaterials.

3. Discuss the factors that affect the selection of materials for engineering purpose. 6

4. What is spintronics? Discuss its impact on technology. Is spintronics has any relation to Moore's law? 1+4+1=6

5. Explain three important and unique properties of nano-structured materials. 2+2+2=6

6. What are top-down and bottom-up approaches of preparation of nanomaterials? Discuss one physical method for preparation of nano-structured materials. 3+3=6

(Turn Over)

7. Discuss sol-gel technique. Mention its advantages and disadvantages. 5+

Or

Discuss about plasma arcing method and electrodeposition method. 4+4

8. What are differences of transmission electron microscope and scanning tunneling microscope? What are the interactions that the incident electron encounter in a scanning tunneling microscope image recording? Explain its basic principle. 3+2+3

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