**6 SEM TDC DSE BOT (CBCS) 1 (H)**

# 2 0 2 3

( May/June )

## BOTANY

( Discipline Specific Elective )

( For Honours )

Paper : DSE–1

### ( Plant Breeding )

*Full Marks* : 53

*Pass Marks* : 21

*Time* : 3 hours

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

1. (a) Choose the correct answer of the following : 1×3=3

   (i) The oldest method of plant breeding is

   (1) introduction

   (2) selection

(3) hybridization

(4) mutation breeding

(ii) The method of selection in plants showing vegetative propagation is

(1) pedigree method

(2) pure-line selection

(3) mass selection

(4) clonal selection

(iii) Emasculation is achieved by

(1) removal of stigma

(2) removal of anther

(3) removal of calyx

(4) removal of corolla

(b) Fill in the blanks :      1×2=2

(i) N. I. Vavilov conceived the idea of _____ _____.

(ii) Superiority of $F_1$ hybrids over its parents is called _____.

     *( Continued )*

2. Write short notes on the following (any *three*) :      4×3=12

(a) Objectives of plant breeding

(b) Plant introduction

(c) Plant genetic resources

(d) Clonal selection

(e) Mutation breeding

3. Write explanatory notes on any *two* of the following :      6×2=12

(a) Pedigree method of breeding

(b) Mode of reproduction in crop plants

(c) Kernal colour in wheat

(d) Merits and demerits of mass selection

4. What is backcross method? Write its procedure, merits and demerits.    2+6+2+2=12

*Or*

Define pure-line selection. Write briefly the selection procedure of pure line. Mention its merits and demerits.      1+7+2+2=12

     *( Turn Over )*

**5.** Define heterosis. Write its characteristics. Explain the genetic basis of hybrid vigour.

2+4+6=12

*Or*

Write notes on the following :.    4×3=12

*(a)* Polyploidy in plant breeding

*(b)* Inbreeding depression

*(c)* Biotechnology in crop improvement

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6 SEM TDC DSE
BOT (CBCS) 1 (H)

**6 SEM TDC DSE BOT (CBCS) 2 (H)**

# 2 0 2 3

( May/June )

## BOTANY

( Discipline Specific Elective )

( For Honours )

Paper : DSE–2

**( Natural Resource Management )**

*Full Marks : 53*

*Pass Marks : 21*

*Time : 3 hours*

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

1. *(a)* Choose the correct answer of the following :     1×3=3

    *(i)* The Earth Summit was held in the year

       (1) 1992

       (2) 1989

       (3) 1972

       (4) 1987

( 2 )

(ii) National Remote Sensing Agency (NRSA) is located at

(1) Kanpur

(2) Hyderabad

(3) Kolkata

(4) Lucknow

(iii) Which State of India has the largest forest area?

(1) Uttar Pradesh

(2) Assam

(3) Madhya Pradesh

(4) Andhra Pradesh

(b) Fill in the blanks :      1×2=2

(i) India is the _____ largest installed wind power capacity in the world.

(ii) The Environmental Protection and Biodiversity Act was passed in the year _____.

2. Write short notes on any *three* of the following :      4×3=12

(a) Advantages of solar energy

(b) Solid-waste management

(c) Biosphere reserve programme

(d) Non-renewable natural resources

(e) NTFP and rural economy

( 3 )

3. Write explanatory notes on any *two* of the following :      6×2=12

(a) Environmental Impact Assessment (EIA) in India.

(b) Management of Soil Degradation

(c) Bioenergy

(d) Features of Geographic Information System (GIS)

4. What do you mean by sustainability? Give an account of various approaches to sustainable development of natural resources.      3+9=12

*Or*

What do you mean by aquifers? Give an account of threats and management strategies of water resources.      3+9=12

5. What is biodiversity? Describe briefly various threats to biodiversity. Give a brief account of management strategies for biodiversity conservation.      2+5+5=12

*Or*

Write an essay on forest management policies in India.      12

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**6 SEM TDC BOTH (CBCS) C 13**

**2 0 2 3**

( May/June )

BOTANY

( Core )

Paper : C–13

**( Plant Metabolism )**

*Full Marks : 53*
*Pass Marks : 21*

*Time :* 3 hours

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

1. Choose the correct answer of the following :

   1×5=5

   (a) In CAM plants, $CO_2$ uptake takes place mainly during daytime/night in dark/ evening/noon.

   (b) Receptors are primary effectors/signal transducers/secondary messengers/ ligands.

*( Turn Over )*

( 2 )

(c) The end product of gluconeogenesis is glucose/acetyl CoA/pyruvate/glycerol.

(d) For producing nodules, the *nif* genes are present in which part of the bacteria?
Ribosome/Bacterial genome/Plasmid/Mesosome

(e) The conformational coupling theory was proposed by Peter Mitchell/Slater/Boyer *et al.*/Mahler and Cordes.

2. Write short notes on any *three* of the following : 4×3=12

(a) Isozymes

(b) Accessory pigments

(c) Cyanide-resistant respiration

(d) Photolysis of water

(e) IAA

3. Write explanatory notes on any *two* of the following : 6×2=12

(a) β-oxidation of fatty acids

(b) Biological nitrogen fixation

(c) Allosteric inhibition

(d) Nitric oxide signalling in plants

( 3 )

4. What is photophosphorylation? Give an account of cyclic and non-cyclic electron transports in photosynthesis. 2+(5+5)=12

*Or*

What is $C_2$ cycle? Summarize the various steps involved in the process and mention its significance. 2+(8+2)=12

5. Describe the citric acid cycle in plants. Explain how ATP molecules are generated in plants. 9+3=12

*Or*

What is glyoxylate cycle? Where does this cycle occur and how is the accumulation of sugars in fatty seeds accomplished through this cycle? 2+10=12

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**6 SEM TDC BOTH (CBCS) C 14**

**2 0 2 3**

( May/June )

BOTANY

( Core )

Paper : C–14

**( Plant Biotechnology )**

_Full Marks : 53_
_Pass Marks : 21_

_Time_ : 3 hours

_The figures in the margin indicate full marks_
_for the questions_

1. Answer the following questions :  1×5=5

   (a) Define callus.

   (b) What is synthetic seed?

   (c) Define androgenesis.

   (d) What is edible vaccine?

   (e) Who coined the term 'biotechnology'?

_( Turn Over )_

## ( 2 )

**2.** Write briefly on any *five* of the following :

                                  2×5=10

    (a) Cryopreservation

    (b) Recombinant DNA

    (c) Phagemid

    (d) Shuttle vector

    (e) Golden rice

    (f) Humulin

**3.** Write short notes on any *four* of the following :         5×4=20

    (a) Composition of MS medium

    (b) Role of growth regulators in tissue culture

    (c) Biological role of restriction enzyme

    (d) Properties of a good cloning vector

    (e) Lambda phage

    (f) Tissue culture media

**4.** Define transgenic crop. Discuss about the approaches to improve quality traits in transgenic crops.         1+7=8

*Or*

Describe about the electroporation and microprojectile bombardment method of gene transfer.         4+4=8

## ( 3 )

**5.** Describe the method of protoplast isolation. Also discuss two strategies used for the selection of hybrid protoplast.     5+5=10

*Or*

What do you mean by gene cloning? Discuss in detail any two methods of construction of genomic library.     2+8=10

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# 6 SEM TDC DSE ZOO (CBCS) 3 (H)

# 2 0 2 3

( May/June )

## ZOOLOGY

( Discipline Specific Elective )

( For Honours )

Paper : DSE–3

## ( Immunology )

*Full Marks : 53*

*Pass Marks : 21*

*Time : 3 hours*

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

1. Fill in the blanks :               1×5=5

   (a) The ability of an organism to resist pathogenic infections is called _____.

   (b) _____ cytokines are released in response to virus infections.

   (c) _____ is involved in primary immune reaction.

*(d)* The specificity of an antibody is due to
_____.

*(e)* B-cells are activated by _____.

2. Write short notes on (any *three*) : 4×3=12

*(a)* Organs of the immune system

*(b)* MHC molecules

*(c)* AIDS

*(d)* Hybridoma technology

3. Write on briefly the following (any *three*) :
4×3=12

*(a)* Components and pathways of complement activation

*(b)* Factors that influence immunogenicity

*(c)* Vaccines and their types

*(d)* Adaptive immunity

4. What are immunoassays? Describe ELISA with suitable illustrations. 2+10=12

*Or*

What are immunoglobulins and their types? Discuss briefly the process of antigen-antibody interactions. 2+4+6=12

5. Explain the process of cell-mediated and humoral immunity. Write about auto-immunity with suitable example. 6+3+3=12

*Or*

What are cytokines? List the different types of cytokines and mention their functions.
2+10=12

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# 6 SEM TDC DSE ZOO (CBCS) 4 (H)

## 2 0 2 3

( May/June )

## ZOOLOGY

( Discipline Specific Elective )

( For Honours )

Paper : DSE–4

### ( Parasitology )

*Full Marks : 53*
*Pass Marks : 21*

*Time* : 3 hours

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

1. Fill in the blanks :                     1×5=5

    (a) _____ disease is caused by *Fasciolopsis buski.*

    (b) Filariasis is caused by _____.

    (c) Scientific name of Hookworm is _____.

(d) Chloroquine drug is used for _____.

(e) The scientific name of Cookicutter shark is _____.

2. Write short notes on (any *two*) : 4×2=8

(a) Importance of Meloidogyne (root-knot nematode)

(b) Candiru

(c) Vampire bat

(d) Host-parasite relationship

3. Write explanatory notes on any *two* of the following : 4×2=8

(a) Brief account of Parasite and Parasitoid

(b) Life cycle of *Entamoeba histolytica*

(c) Importance and control of *Cimex lectularius*

(d) Life cycle of *Plasmodium vivax*

4. Describe the life cycle, pathogenicity and treatment of *Leishmania donovani*. 4+2+2=8

*Or*

Describe the life cycle, pathogenicity and treatment of *Trypanosoma gambiense*. 4+2+2=8

5. Write a brief note on life cycle, epidemiology and prophylaxis of *Hymenolepsis nana*. 3+3+2=8

*Or*

Write a brief note on life cycle, epidemiology and prophylaxis of *Ancylostoma duodenale*. 8

6. Describe briefly the morphology, pathogenicity and treatment of *Trichinella spiralis*. 3+3+2=8

*Or*

Describe briefly the biology, importance and control of ticks. 3+3+2=8

7. Write a brief note on structure, life cycle and importance of *Pratylenchus* sp. 3+3+2=8

*Or*

Write a note on biology, importance and control of *Xenopsylla cheopis*. 3+3+2=8

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## 6 SEM TDC ZOOH (CBCS) C 13

# 2 0 2 3

( May/June )

## ZOOLOGY

( Core )

Paper : C–13

**( Developmental Biology )**

*Full Marks* : 53
*Pass Marks* : 21

*Time* : 3 hours

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

1. Fill in the blanks :  1×5=5

   (a) The _____ membrane is a structure surrounding the outer surface of plasma membrane of an ovum.

   (b) _____ pattern arises from the spatial and temporal regulation and coordination of the events.

   (c) In vertebrate, protein yolk is synthesized in _____.

*( Turn Over )*

*(d)* The placental barrier between the maternal and foetal blood is minimum in _____.

*(e)* _____ is the temporary connection between the maternal and foetal tissues.

**2.** Distinguish between the following (any *two*) : $2×2=4$

*(a)* Capacitation and Acrosome reaction

*(b)* Intra- and Inter-cellular differentiation

*(c)* Genetic teratogenesis and Environmental teratogenesis

**3.** Write short notes on the following (any *two*) : $5×2=10$

*(a)* IVF

*(b)* Cytoplasmic determinants

*(c)* Amniocentesis

**4.** What is gametogenesis? Discuss the various events that take place during spermatogenesis. $2+8=10$

*Or*

Discuss about fertilizin-antifertilizin reaction. How can polyspermy be prevented? $7+3=10$

**5.** Discuss the fate of germ layers. Write a note on implantation of an embryo in human. $6+6=12$

*Or*

What are organisers? Mention its role in the process of development. Add a note on fate map. $2+6+4=12$

**6.** What is regeneration? Discuss its different modes. $2+10=12$

*Or*

What is metamorphosis? Discuss in detail about the insect metamorphosis. $2+10=12$

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**6 SEM TDC ZOOH (CBCS) C 14**

**2 0 2 3**

( May/June )

ZOOLOGY

( Core )

Paper : C–14

**( Evolutionary Biology )**

*Full Marks : 53*
*Pass Marks : 21*

*Time : 3 hours*

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

1. Select the correct answer :  1×5=5

 (a) What was the source of energy at the time of origin of life?

  (i) Heat

  (ii) Cosmic rays

  (iii) Lightning

  (iv) All of the above

( Turn Over )

(b) In which era did unicellular organisms originate?

(i) Paleozoic era

(ii) Proterozoic era

(iii) Archeozoic era

(iv) Mesozoic era

(c) Which of the following ideas. was proposed by Lamarck?

(i) Use and disuse of structures

(ii) Natural selection

(iii) Struggle for existence

(iv) None of the above

(d) A drastic reduction in the size of a population that can change allele frequency is called

(i) the bottleneck effect

(ii) the founder effect

(iii) the gene flow effect

(iv) mutation

(e) Which of the following organisms are least closely related?

(i) Organisms that share a domain

(ii) Organisms that share a family

(iii) Organisms that share a genus

(iv) Organisms that share a species

2. Write short notes on any *two* of the following :                4×2=8

(a) RNA world

(b) Bottleneck phenomenon

(c) Allopatric speciation

(d) Origin of variations

3. Describe the process of chemical origin of life on earth. Which experiment supported this theory?                6+2=8

*Or*

Explain the process of origin of species as described by Darwin.                8

4. What are transitional forms? Describe one transitional form of fossil. Add a note on evolution of horse.                1+3+4=8

*Or*

What is a molecular clock? Explain the neutral theory of molecular evolution.                2+6=8

5. Discuss the role of mutation in changing allele frequencies. What are the factors that disrupt Hardy-Weinberg equilibrium?                4+4=8

*Or*

What is kin selection? Discuss the effect of different types of selection on a population.

2+6=8

**6.** Describe with the help of an example, the K-T extinction event and its role in evolution. 8

*Or*

What are different modes of speciation? Explain the role of isolating mechanism in speciation. 3+5=8

**7.** What is a phylogenetic tree? Explain the process of construction and interpretation of phylogenetic trees. 2+3+3=8

*Or*

Discuss how modern man evolved from primitive primates. 8

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## 6 SEM TDC DSE MTH (CBCS) 2 (H)

# 2 0 2 3

( May/June )

## MATHEMATICS

( Discipline Specific Elective )

( For Honours )

Paper : DSE–2

### ( Linear Programming )

*Full Marks : 80*

*Pass Marks : 32*

*Time : 3 hours*

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

1. Answer the following questions :  1×8=8

   *(a)* Define degenerate basic feasible solution.

   *(b)* Write about decision variable.

   *(c)* Define slack variable.

   *(d)* Write the standard form of primal in duality.

( *Turn Over* )

*(e)* Define symmetric primal dual problem.

*(f)* State the rim condition of transportation problem.

*(g)* Define saddle point in a game theory.

*(h)* What is fair game in a game theory?

**2.** Answer any *two* from the following : 2×2=4

*(a)* Write the mathematical formulation of transportation problem.

*(b)* Explain briefly the basic solution of linear programming problem.

*(c)* Describe general rule of dominance property of game theory.

**3.** Answer the following questions : 4×5=20

*(a)* Write the rule of construction of dual from primal.

*(b)* Write the characteristic of standard form of general linear programming problem.

*( Continued )*

*(c)* Find the dual :

$$\text{Max } Z = 4x_1 - 3x_2 + 2x_3$$

subject to

$$x_1 - 7x_2 + 3x_3 \leq 6$$
$$-5x_2 + 3x_3 \geq 8$$
$$2x_1 - 4x_2 + 5x_3 = 7$$

$x_1, x_3 \geq 0$, $x_2$ is unrestricted in sign

*(d)* In an assignment problem, if we add (or subtract) a constant to every element of a row (or column) of the cost matrix $[c_{ij}]$, then show that an assignment plan that minimizes the total cost for new cost matrix also minimizes the total cost for the original cost matrix.

*(e)* Find the range of the values of $p$ and $q$ which will render the entry (2, 2), a saddle point for the game :

|  |  | Player B |  |  |
|---|---|---|---|---|
|  |  | $B_1$ | $B_2$ | $B_3$ |
|  | $A_1$ | 2 | 4 | 5 |
| Player A | $A_2$ | 10 | 7 | q |
|  | $A_3$ | 4 | p | 6 |

**4.** *(a)* Prove that dual of the dual is primal itself. 5

*( Turn Over )*

*Or*

If $x^*$ and $w^*$ be any two feasible solutions of the primal, Max $Z_x = cx$, subject to $Ax \leq b$, $x \geq 0$ and corresponding dual, Min $Z_w = b'w$, subject to $A'w \geq c'$, $w \geq 0$ respectively and $cx^* = b'w^*$, then $x^*$ and $w^*$ are optimal feasible solutions of the primal and dual respectively. Prove it.

(b) Solve the pay-off matrix with respect to player *A* by using dominance property : 5

Player B

| | | *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|---|---|
| | *1* | 4 | 6 | 5 | 10 | 6 |
| | *2* | 7 | 8 | 5 | 9 | 10 |
| Player A | *3* | 8 | 9 | 11 | 10 | 9 |
| | *4* | 6 | 4 | 10 | 6 | 4 |

**5.** Answer any *one* of the following : 6

(a) Find the optimal assignment of the corresponding assignment cost from the following cost matrix :

| | A | B | C | D | E |
|---|---|---|---|---|---|
| I | 9 | 8 | 7 | 6 | 4 |
| II | 5 | 7 | 5 | 6 | 8 |
| III | 8 | 7 | 6 | 3 | 5 |
| IV | 8 | 5 | 4 | 9 | 3 |
| V | 6 | 7 | 6 | 8 | 5 |

(b) Find the optimal assignment profit from the following profit matrix :

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ |
|---|---|---|---|---|---|
| $O_1$ | 2 | 4 | 3 | 5 | 4 |
| $O_2$ | 7 | 4 | 6 | 8 | 4 |
| $O_3$ | 2 | 9 | 8 | 10 | 4 |
| $O_4$ | 8 | 6 | 12 | 7 | 4 |
| $O_5$ | 2 | 8 | 5 | 8 | 8 |

**6.** Answer any *two* of the following : 8×2=16

(a) Solve by Big-M method :

$$\text{Max } Z = -2x_1 - x_2$$

subject to

$$3x_1 + x_2 = 3$$
$$4x_1 + 3x_2 \geq 6$$
$$x_1 + 2x_2 \leq 4$$
$$x_1, \ x_2 \geq 0$$

(b) Solve :

$$\text{Min } Z = x_1 - 3x_2 + 2x_3$$

subject to

$$3x_1 - x_2 + 2x_3 \leq 7$$
$$-2x_1 + 4x_2 \leq 12$$
$$-4x_1 + 3x_2 + 8x_3 \leq 10$$
$$x_1, x_2, x_3 \geq 0$$

(c) Solve by two-phase method :

$$\text{Min} \quad Z = \frac{15}{2}x_1 - 3x_2$$

subject to

$$3x_1 - x_2 - x_3 \geq 3$$
$$x_1 - x_2 + x_3 \geq 2$$
$$x_1, \ x_2, \ x_3 \geq 0$$

7. Answer any *one* of the following :      9

(a) Determine the initial basic feasible solution to the following transportation problem by least cost method and then find the optimal solution :

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $a_i$ |
|---|---|---|---|---|---|
| $O_1$ | 5 | 3 | 6 | 2 | 19 |
| $O_2$ | 4 | 7 | 9 | 1 | 37 |
| $O_3$ | 3 | 4 | 7 | 5 | 34 |
| $b_j$ | 16 | 18 | 31 | 25 | |

where $O_i$ and $D_j$ denote the $i$th origin and $j$th destination respectively.

(b) Find the initial basic feasible solution using VAM and find the optimal solution :

| | $A$ | $B$ | $C$ | $D$ | $a_i$ |
|---|---|---|---|---|---|
| $S_1$ | 8 | 9 | 6 | 3 | 18 |
| $S_2$ | 6 | 11 | 5 | 10 | 20 |
| $S_3$ | 3 | 8 | 7 | 9 | 18 |
| $b_j$ | 15 | 16 | 12 | 13 | |

     *( Continued )*

8. Answer any *one* of the following :      7

(a) Obtain the optimal strategies of each player from the pay-off matrix :

|  | | Player B | | | |
|---|---|---|---|---|---|
| | | I | II | III | IV |
| Player A | I | 3 | 2 | 4 | 0 |
| | II | 3 | 4 | 2 | 4 |
| | III | 4 | 2 | 4 | 6 |
| | IV | 0 | 4 | 0 | 8 |

(b) Player A can choose his strategies from $A_1$, $A_2$ and $A_3$ only while player B can choose from $B_1$, $B_2$ only. The rule of game states that the payment should be made in accordance with the selection of strategies :

| Strategy pair selected | Payment to be made |
|---|---|
| $A_1 \ B_1$ | A to B ₹ 1 |
| $A_1 \ B_2$ | B to A ₹ 6 |
| $A_2 \ B_1$ | B to A ₹ 3 |
| $A_2 \ B_2$ | B to A ₹ 4 |
| $A_3 \ B_1$ | A to B ₹ 2 |
| $A_3 \ B_2$ | A to B ₹ 6 |

Find the pay-off matrix and optimal strategies of each player.

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# 6 SEM TDC DSE MTH (CBCS) 3 (H)

## 2 0 2 3

( May/June )

## MATHEMATICS

( Discipline Specific Elective )

( For Honours )

Paper : DSE-3

### ( Discrete Mathematics )

*Full Marks : 80*

*Pass Marks : 32*

*Time : 3 hours*

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

1. *(a)* Define an order-isomorphism. Is an order-isomorphism a bijective function?

    1+1=2

    *(b)* Draw the Hasse diagram of the ordered set $(P(X), \subseteq)$ where $X = \{a, b, c\}$ and $P(X)$ is the power set of $X$.    3

*( Turn Over )*

(c) Let $P$ and $Q$ be two finite order sets. Then show that $P$ and $Q$ are order-isomorphic if and only if they can be drawn with identical Hasse diagram.    5

*Or*

Define the dual of an ordered set and state the duality principle. The ordered set $P$ is given by the following Hasse diagram :
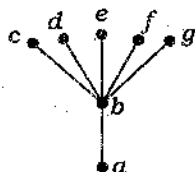


Find the dual of $P$.    2+1+2=5

2. (a) Define a lattice as an ordered set. Give an example.    1+1=2

(b) Let $(L, \leq)$ be a lattice and $a, b, c \in L$. Show that—

(i) $a \wedge (a \vee b) = a$;

(ii) $a \leq b$ and $a \leq c \Rightarrow a \leq b \wedge c$.    3+2=5

(c) Find three subsets of the lattice $(P(X), \subseteq)$ where $X = \{1, 2, 3\}$ and $P(X)$ is the power set of $X$, which are not sub-lattices of $(P(X), \subseteq)$.    3

(d) Define a complete lattice with an example. Let $(L, \vee, \wedge)$ be a complete lattice and 0 and 1 be the least and greatest elements of $L$ respectively. Then show that $a \vee 0 = a$ and $a \vee 1 = 1$.    1+1+3=5

*Or*

Let $(L, \leq)$ be a lattice. Prove that $L$ is a chain if and only if every non-empty subset of $L$ is a sublattice.    5

3. (a) Show that the lattice pentagon depicted in the following Hasse diagram
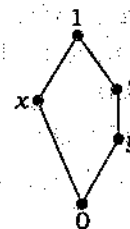


is not modular.    2

(b) Let $(L, \vee, \wedge)$ be a distributive lattice and $a, b, c \in L$. If $a \wedge b = a \wedge c$ and $a \vee b = a \vee c$, then show that $b = c$. Hence show that complement of an element of $L$, if it exists, is unique.    3+1=4

## ( 4 )

(c) Let $B$ be a Boolean algebra and $a, b \in B$. Then show that—

    (i) $(a + b)' = a' \cdot b'$;

    (ii) $(a')' = a$.            3+2=5

(d) Let $(A, \vee, \wedge)$ and $(B, +, \cdot)$ be two Boolean algebra and $f : A \to B$ be a function such that $f(a \vee b) = f(a) + f(b)$ and $f(a') = \overline{f(a)}$. Then show that $f$ is a Boolean algebra homomorphism.     4

(e) Answer any *two* of the following :    5×2=10

    (i) Obtain the sum-of-products canonical form of the Boolean expression

$$[\overline{x}_2 + \{\overline{x}_2 + x_1 + \overline{(x_2 x_3)}\}]\,(x_2 + \overline{x}_1 x_2)$$

    in the variables $x_1$, $x_2$ and $x_3$.

    (ii) Obtain a minimal sum-of-products representation for the Boolean expression

$$ab\overline{c} + abc + \overline{a}\,\overline{b}c + \overline{a}b\overline{c} + \overline{a}bc$$

    using Karnaugh map.

    (iii) Design a twin-switch that is used to switch on the light from the first step and the topmost step of a staircase, so that the light can be switched on/off using any of these switches. Give the logic network for this twin switches.

P23/820                             *( Continued )*

## ( 5 )

4. (a) Define a complete graph. Find the number of edges of the complete graph with 5 vertices.     1+1=2

(b) Graphs $G$ and $H$ are depicted in the following figure :
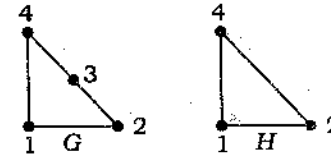


    Is $H$ a subgraph of $G$?     1

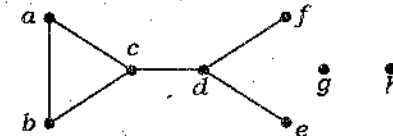(c) Answer any *three* of the following :    3×3=9

    (i) Show that a bipartite graph cannot contain an odd cycle.

    (ii) Draw the graph of $K_7$, $K_{3,4}$ and $K_{2,6}$.

    (iii) Show that if a graph has exactly two odd vertices, then there exists a path between the two odd vertices.

    (iv) Represent the Königsberg bridge problem by a graph. Does the Königsberg bridge problem have solution? Justify.

(d) Find the adjacency matrix of the graph.     2



P23/820                             *( Turn Over )*

(e) A connected graph has 14 vertices and 88 edges. Show that $G$ is Hamiltonian but not Eulerian.     2

5. Answer any *two* of the following :     7×2=14

(a) If a graph $G$ has $n \geq 3$ vertices and every vertex has degree at least $\frac{n}{2}$, then show that $G$ is Hamiltonian.     7

(b) Define Eulerian graph and Hamiltonian graph. Give an example of an Eulerian graph with 6 vertices which is not Hamiltonian. Show that if a graph $G$ is Eulerian, then every vertex of $G$ is of even degree.     1+1+1+4=7

(c) Find the distance between every pair of vertices of the following weighted graph using Floyd-Warshall algorithm :     7
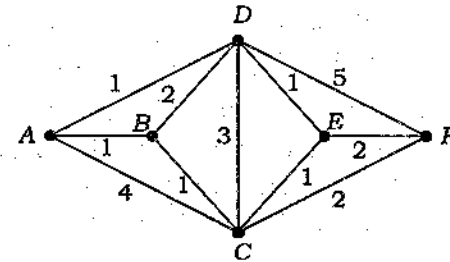


(d) Discuss Dijkstra's algorithm with an example.     7

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**6 SEM TDC DSE MTH (CBCS) 6 (H)**

**2 0 2 3**

( May/June )

## MATHEMATICS

( Discipline Specific Elective )

( For Honours )

Paper : DSE–6

**( Mathematical Methods )**

*Full Marks : 80*

*Pass Marks : 32*

*Time : 3 hours*

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

1. *(a)* If $T$ is the period of the function $f(x)$, then write the period of $f(ax)$, where $a \neq 0$. 1

   *(b)* Write two Dirichlet conditions for Fourier expansion of a function. 2

   *(c)* Find a Fourier series for the function $f(x) = x^2$ in the interval $(0, 2\pi)$. 7

*( Turn Over )*

*Or*

Find the Fourier series for the function $f(x) = x \sin x$ in $(-\pi, \pi)$.

2. (a) Write the value of (i) $L\{t\}$ and (ii) $L\{\cos 3t\}$.     1+1=2

   (b) Find $L\{\cos^2 t\}$.     2

   (c) If $f(s) = L\{F(t)\}$, then prove that $L\{e^{at} F(t)\} = f(s-a)$.     4

*Or*

Find $L\{t e^{at} \sin at\}$.

   (d) Find any *three* of the following :     4×3=12

     (i) $L\{\sinh^2 t\}$

     (ii) $L\{(t+2)^3\}$

     (iii) $L\{e^{3t} \sin 2t\}$

     (iv) $L\{t \cos^2 t\}$

     (v) $L\{t^2 \cos at\}$

3. (a) Write the value of (i) $L^{-1}\{\dfrac{S}{S^2+4}\}$ and

     (ii) $L^{-1}\left\{\dfrac{1}{S^4}\right\}$.     1+1=2

   (b) Find $L^{-1}\left\{\dfrac{S+2}{(S+2)^2+6^2}\right\}$.     2

   (c) Find any *two* of the following :     3×2=6

     (i) $L^{-1}\left\{\dfrac{S}{(S+3)^{7/2}}\right\}$

     (ii) $L^{-1}\left\{\dfrac{e^{-\pi S}}{S^2+4}\right\}$

     (iii) $L^{-1}\left\{\dfrac{e^{-3S}}{(S-4)^2}\right\}$

     (iv) $L^{-1}\left\{\log\dfrac{S+4}{S+2}\right\}$

4. (a) Write the Fourier cosine integral formula.     1

   (b) Define Fourier transform of a function.     1

   (c) State and prove the linear property of Fourier transform.     5

*Or*

Find the Fourier sine transform of

$$2e^{-5x} + 5e^{-2x}$$

   (d) Find the Fourier cosine transform of $e^{-x^2}$.     8

*Or*

Find the Fourier transform of

$$f(x) = xe^{-x}, \ 0 \le x < \infty$$

(e) Find the Fourier transform of

$$f(x) = \begin{cases} \dfrac{1}{2x}, & \text{for} \ |x| \le a \\ 0, & \text{for} \ |x| > a \end{cases}$$

8

*Or*

Find the Fourier transform of

$$f(x) = \begin{cases} \sin x, & 0 < x < \pi \\ 0, & \text{otherwise} \end{cases}$$

(f) Write the formula for inverse Fourier transform of a function $f(x)$.    2

5. (a) Write the value of $L\left\{\dfrac{\partial^2 y}{\partial t^2}\right\}$.    1

(b) Find the value of $L\left\{\dfrac{\partial^2 y}{\partial x^2}\right\}$.    2

(c) Solve any *two* of the following :    6×2=12

(i) $\dfrac{d^2 y}{dt^2} + \dfrac{dy}{dt} = t^2 + 2t, \ y(0) = 4, \ y'(0) = 2$

(ii) $\dfrac{d^2 y}{dt^2} + 25y = 10\cos 5t,$

$$y(0) = 2, \ y'(0) = 0$$

(iii) $t\dfrac{d^2 y}{dt^2} + \dfrac{dy}{dt} + 4ty = 0, \ y(0) = 3, \ y'(0) = 0$

(iv) $\dfrac{\partial y}{\partial x} - \dfrac{\partial y}{\partial t} = 1 - e^{-t}, \ 0 < x < 1, \ t > 0$

$$\text{and} \ y(x, 0) = x$$

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## 6 SEM TDC MTMH (CBCS) C 13

# 2 0 2 3

( May/June )

## MATHEMATICS

( Core )

Paper : C–13

**( Metric Spaces and Complex Analysis )**

_Full Marks : 80_
_Pass Marks : 32_

_Time_ : 3 hours

_The figures in the margin indicate full marks
for the questions_

1. (a) Real line is a metric space. State true or false. 1

   (b) Write when a metric space is called complete. 1

   (c) Define usual metric on R. 2

   (d) Define Cauchy sequence in a metric space. 2

　　　　　　　　　　_( Turn Over )_

*(e)* Let $X$ be a metric space. Show that any union of open sets in $X$ is open.     4

*Or*

Show that every convergent sequence in a metric space $(X, d)$ is a Cauchy sequence.

*(f)* Let $X$ be a metric space. Show that a subset $F$ of $X$ is closed if and only if complement $F'$ is open.     5

*Or*

In a metric space $(X, d)$, show that each closed sphere is a closed set.

*(g)* Let $(X, d)$ be a metric space and $A \subset X$. Then show that interior of $A$ is an open set.     5

*Or*

Let $(X, d)$ be a metric space and $Y \subset X$. Then show that $Y$ is separable if $X$ is separable.

**2.** *(a)* Define an identity function in a metric space.     1

*(b)* Write one example of homeomorphic spaces.     1

*(c)* Define uniform continuity in metric spaces.     1

*(d)* Define connected sets in a metric space.     2

*(e)* Answer any *two* questions from the following :     5×2=10

    *(i)* Let $(X, d)$ and $(Y, r)$ be metric spaces and $f : X \to Y$ be a function. Then prove that $f$ is continuous if and only if $f^{-1}(G)$ is open in $X$ whenever $G$ is open in $Y$.

    *(ii)* Let $(X, d)$ and $(Y, r)$ be metric spaces and $f : X \to Y$ be a uniformly continuous function. If $\{x_n\}$ is a Cauchy sequence in $X$, then show that $\{f(x_n)\}$ is a Cauchy sequence in $Y$.

    *(iii)* Let $(X, d)$ be a compact metric space. Then show that a closed subset of $X$ is compact.

**3.** *(a)* Write the condition when the complex numbers $(a, b)$ and $(c, d)$ are equal.     1

*(b)* The $n$th roots of unity represents the $n$ vertices of a regular polygon. Write where the polygon is inscribed.     1

*(c)* Write the necessary and sufficient condition that the complex numbers represented by $z_1$ and $z_2$ become parallel.     1

*(d)* Find the limit of the function $f(z)$ as $z \to i$ defined by

$$f(z) = \begin{cases} z^2, & z \neq i \\ 0, & z = i \end{cases}$$     3

*Or*

Write the equation $(x-3)^2 + y^2 = 9$ in terms of conjugate coordinates.

*(e)* Show that $\dfrac{d\bar{z}}{dz}$ does not exist anywhere.     4

*Or*

Prove that $f(z) = \begin{cases} z^2, & z \neq z_0 \\ 0, & z = z_0 \end{cases}$, where $z_0 \neq 0$ is discontinuous at $z = z_0$.

*(f)* Find the Cauchy-Riemann equations for an analytic function $f(z) = u + iv$, where $z = x + iy$.     5

*Or*

Find the equation of the circle having the line joining $z_1$ and $z_2$ as diameter.

    *( Continued )*

**4.** *(a)* Write the point at which the function $f(z) = \dfrac{1+z}{1-z}$ is not analytic.     1

*(b)* Define singularity of a function.     2

*(c)* Write the statement of Cauchy's integral formula.     2

*(d)* Prove the equivalence of

$$\frac{\partial}{\partial x} = \frac{\partial}{\partial z} + \frac{\partial}{\partial \bar{z}}$$     3

*(e)* Find the analytic function $f(z) = u + iv$, where $u = e^x(x\cos y - y\sin y)$.     4

*Or*

Find the value of the integral $\displaystyle\int \frac{dz}{z-a}$ round a circle whose equation is $|z-a| = r$.

**5.** *(a)* Define radius of convergence.     1

*(b)* Write the necessary and sufficient condition that $\displaystyle\sum_{n=1}^{\infty}(a_n + ib_n)$ converges, where $a_n$ and $b_n$ are real.     1

    *( Turn Over )*

(c) Define a power series. 2

(d) State and prove the fundamental theorem of algebra. 6

*Or*

Expand $f(z) = \log(1 + z)$ in a Taylor's series about $z = 0$.

6. (a) Let $R$ be the radius of convergence of the series

$$\sum_{n=0}^{\infty} a_n z^n$$

Then write the radius of convergence of the series

$$\sum_{n=0}^{\infty} na_n z^{n-1}$$ 1

(b) Choose the correct answer from the following : 1

An absolutely convergent series is

(i) divergent

(ii) convergent

(iii) oscillatory

(iv) conditionally convergent

*( Continued )*

(c) State and prove Laurent's theorem. 6

*Or*

Expand $f(z) = \dfrac{1}{(z+1)(z+3)}$ in a Laurent series valid for $1 < |z| < 3$.

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**6 SEM TDC MTMH (CBCS) C 14**

# 2 0 2 3

( May/June )

## MATHEMATICS

( Core )

Paper : C–14

**( Ring Theory and Linear Algebra—II )**

*Full Marks : 80*

*Pass Marks : 32*

*Time :* 3 hours

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

1. Answer any *three* from the following :  5×3=15

   (a) Prove that a ring $R$ is a commutative ring with unity if and only if the corresponding polynomial ring $R[x]$ is commutative with unity.

   (b) If $F$ is a field, then prove that the polynomial ring $F[x]$ is not a field.

*( Turn Over )*

(c) Write about irreducibility of a polynomial. Test the irreducibility of the following polynomials :     1+2+2=5

    (i) $f(x) = 3x^5 + 15x^4 - 20x^3 + 10x + 20,$

                   over $Q$

    (ii) $f(x) = 21x^3 - 3x^2 + 2x + 9,$ over $Z_2$

(d) Define principal ideal domain and prove that in a principal ideal domain, an element is an irreducible iff it is prime.

                          1+4=5

**2.** Answer any *three* of the following :     5×3=15

(a) Define unique factorization domain (UFD) and prove that every field is unique factorization domain.     1+4=5

(b) Prove that the ring of Gaussian integer $Z[i] = \{a + ib \mid a, b \in Z\}$ is Euclidian domain.

(c) Let $f(x) = a_n x^n + a_{n-1} x^{n-1} + \cdots + a_0 \in Z[x]$. If there is a prime such that $p \mid a_n$, $p \mid a_{n-1}, \cdots, p \mid a_0$ and $p^2 \nmid a_0$, then prove that $f(x)$ is irreducible over $Q$.

(d) Prove that every Euclidian domain is a principal ideal domain.

**3.** Answer any *three* of the following :     6×3=18

(a) Let $V$ be a finite dimensional vector space over the field $F$. If $\alpha$ is any vector in $V$, the function $L_\alpha$ of $V^*$ defined by $L_\alpha(f) = f(\alpha)$, $\forall f \in V^*$, then prove that $L_\alpha$ is a linear functional and the mapping $\alpha \to L_\alpha$ is an isomorphism of $V$ onto $V^{**}$.

(b) Determine the eigenvalues and the corresponding eigenspaces for the matrix

$$A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 1 & 1 \end{bmatrix}$$

(c) Show that similar matrices have the same minimal polynomial. Also, find the minimal polynomial for the real matrix

$$\begin{bmatrix} 5 & -6 & -6 \\ -1 & 4 & 2 \\ 3 & -6 & -4 \end{bmatrix}$$

(d) Let $V$ be a finite dimensional vector space over the field $F$ and $W$ be a subspace of $V$. Then prove that

$$\dim W + \dim W^o = \dim V$$

4. (a) Let $T : R^2 \to R^2$ be a linear operator defined by

$$T\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 2 & -5 \\ 1 & -2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

Then find all the $T$-invariant subspace of $R^2(R)$. 2

(b) Let $T$ be a linear operator on $R^3$ which is represented in the standard basis by the matrix

$$\begin{bmatrix} -9 & 4 & 4 \\ -8 & 3 & 4 \\ -16 & 8 & 7 \end{bmatrix}$$

Prove that $T$ is diagonalizable. 5

( Continued )

*Or*

If $T$ is a linear operator on a vector space $V$ and $W$ is any subspace of $V$, then prove that $T(W)$ is a subspace of $V$. Also show that $W$ is invariant under $T$ iff $T(W) \subseteq W$.

5. (a) If $V$ is inner product space, then for any vectors $\alpha, \beta \in V$ and any scalar $c$, prove that—

(i) $\|\alpha\| > 0$ for $\alpha \neq 0$

(ii) $\|c\alpha\| = |c| \|\alpha\|$

(iii) $|(\alpha|\beta)| \leq \|\alpha\| \|\beta\|$ 5

(b) Apply Gram-Schmidt process to the vectors $\beta_1 = (1, 0, 1)$, $\beta_2 = (1, 0, -1)$, $\beta_3 = (0, 3, 4)$ to obtain an orthonormal basis for $V_3(R)$ with the standard inner product. 5

(c) Let $W$ be any subspace of a finite dimensional inner product space $V$ and let $E$ be the orthogonal projection of $V$ on $W$. Prove that $V = W + W^\perp$, where $W^\perp$ is the null space of $E$. 5

( Turn Over )

*Or*

If $B = \{\alpha_1, \alpha_2, \cdots, \alpha_m\}$ is any finite orthonormal set in an inner product space $V$ and if $\beta$ is any vector in $V$, then prove that

$$\sum_{i=1}^{m} |(\beta, \alpha_i)|^2 \leq \| \beta \|^2$$

6. (a) Define orthogonal set. If $\alpha$ and $\beta$ are orthogonal unit vectors, then write the distance between them. 1+1=2

(b) Answer any *two* of the following : 4×2=8

(i) Let $T$ be a linear operator on $R^2$, defined by $T(x, y) = (x + 2y, x - y)$. Find the adjoint $T^*$, if the inner product is standard one.

(ii) Let $V$ be a finite dimensional inner product space and let $B = \{\alpha_1, \alpha_2, \cdots, \alpha_n\}$ be an ordered orthonormal basis for $V$. Let $T$ be a linear operator on $V$. Let $A = [a_{ij}]_{n \times n}$ be the matrix of $T$ with respect to ordered basis $B$, then prove that $a_{ij} = (T\alpha_j, \alpha_i)$.

(iii) Let $S = \{\alpha_1, \alpha_2, \cdots, \alpha_m\}$ be an orthogonal set of non-zero vectors in an inner product space $V$. If a vector $\beta$ in $V$ is in the linear span of $S$, then show that

$$\beta = \sum_{k=1}^{m} \frac{(\beta, \alpha_k)}{\| \alpha_k \|^2} \alpha_k$$

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# 6 SEM TDC DSE CHM (CBCS) 2 (H)

## 2 0 2 3

( May/June )

## CHEMISTRY

( Discipline Specific Elective )

( For Honours )

Paper : DSE–6.2

**( Industrial Chemicals and Environment )**

*Full Marks : 53*
*Pass Marks : 21*

*Time : 3 hours*

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

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

   (a) The most powerful eye irritant present
       in the smog is

       (i) NO

       (ii) $O_3$

       (iii) PAN

       (iv) $SO_2$

(b) Global warming is the effect of

(i) water pollution

(ii) soil pollution

(iii) air pollution

(iv) radiation pollution

(c) Water samples with BOD values of 4 ppm and 18 ppm, respectively, are

(i) clean and highly polluted

(ii) highly polluted and highly polluted

(iii) highly polluted and clear

(iv) clear and clear

(d) The major contributor of carbon monoxide is

(i) stationary fuel combustion

(ii) industrial process

(iii) motor vehicle

(iv) plastic wastage

(e) What does OTEC stand for?

(i) Ocean Thermal Energy Cultivation

(ii) Ocean Thermal Energy Conservation

(iii) Ocean Techno Energy Conservation

(iv) Ocean Thermal Energy Consumption

(f) The layer of atmosphere which is characterised by extreme low moisture and presence of ozone layer is

(i) troposphere

(ii) thermosphere

(iii) mesosphere

(iv) stratosphere

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

(a) Write two uses and two hazards caused by potassium permanganate.

(b) Briefly discuss about the sterilization of water by UV rays.

(c) What is ozone layer depletion? Write any two effects. of it.

**( 4 )**

(d) Explain how helium is produced from natural gas.

(e) What is dechlorination? Explain briefly.

(f) Discuss briefly particulate matter pollution.

(g) Write a short note on 'syngas'.

UNIT—I

3. Answer any *two* questions from the following : 3½×2=7

(a) Describe any one method of production of sulphur dioxide. How is sulphur dioxide purified? Write one use of it. 2+1+½=3½

(b) Describe how hydrogen peroxide is prepared by electrolytic method. Write two uses of it. Mention one health hazard of hydrogen peroxide. 2+1+½=3½

(c) Describe the method of preparation of bleaching powder in industry. Mention some uses of bleaching powder. 2½+1=3½

**( 5 )**

UNIT—II

4. Answer any *one* question from the following : 4

(a) What are ultrapure metals? Describe the extraction process of ultrapure silicon.

(b) What is electrolytic reduction? Describe briefly aluminothermite reduction.

UNIT—III

5. Answer any *four* questions from the following : 4×4=16

(a) What is an ecosystem? Describe nitrogen cycle. 1+3=4

(b) What are primary and secondary air pollutants? Give one example of each of the pollutants. (1+1)+(1+1)=4

(c) What is ecological pyramid? Describe briefly about the three components of an ecological pyramid. 1+3=4

(d) Write short notes on any *two* of the following : 2×2=4

(i) Global warming

(ii) Characteristics of potable water

(iii) Ecological efficiency

(e) What is sewage disposal? Describe any two sewage disposal methods briefly. 1+3=4

(f) Describe briefly ion-exchange method and chlorination method for purification of water. 2+2=4

UNIT—IV

6. Answer any *one* question from the following : 4

(a) Explain why coal is called conventional non-renewable sources of energy. What are the advantages and disadvantages of solid coal? 2+2=4

(b) What is nuclear pollution? Discuss the effects of radiation on human health. 2+2=4

UNIT—V

7. Answer any *one* question from the following : 4

(a) What is a biocatalyst? Write the examples of two biocatalysts used in industry. Discuss the advantages of biocatalysts over conventional catalysts. 1+1+2=4

(b) Explain how biocatalysis is a green process. 4

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**6 SEM TDC CHMH (CBCS) C 13**

# 2 0 2 3

( May/June )

## CHEMISTRY

( Core )

Paper : C–13

**[ Inorganic Chemistry
( Organometallic Chemistry ) ]**

*Full Marks : 53*

*Pass Marks : 21*

*Time : 3 hours*

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

1. Choose the correct answer from the
   following :                                    1×7=7

   (a)  The total electron count for the complex
        $[Fe_4N(CO)_{12}]^-$ is

        (i)  60

        (ii) 62

        (iii) 72

        (iv) 59

(b) The EAN for $[CoNO(CN)_5]^{3-}$ is

   (i) 35

   (ii) 36

   (iii) 37

   (iv) 38

(c) Which of the following has minimum *trans*-effect?

   (i) $H_2O$

   (ii) $NH_3$

   (iii) Py

   (iv) $Cl^-$

(d) Which of the following complexes obeys $18\ e^-$ rule?

   (i) $(\eta^5-C_5H_5)Mn(CO)_3$

   (ii) $Cr(\eta^5-C_5H_5)_2$

   (iii) $Co_2(CO)_8$

   (iv) $Fe(CO)_3(\eta^5-C_5H_5)$

(e) Which of the following group cations is precipitated in alkaline medium?

   (i) Group I

   (ii) Group II

   (iii) Group IV

   (iv) None of the above

(f) Which of the following combinations of basic radicals belong to group III?

   (i) Fe, Al, Cr

   (ii) Fe, Mg, Ba

   (iii) Mg, Ba, Ca

   (iv) Mg, Ba, Fe

(g) Find the hapticity of $C_5H_5$ ligand in $Fe(C_5H_5)_2$ complex.

   (i) Monohapto ligand

   (ii) Trihapto ligand

   (iii) Pentahapto ligand

   (iv) Dihapto ligand

2. Answer any *five* questions from the following : 2×5=10

(a) Why is $H_2S$ passed in alkaline medium for the precipitation of group IV basic radicals?

(b) Define solubility product and ionic product of a solution.

(c) What is the importance of Zeise's salt in organometallic chemistry? How was it prepared? 1+1=2

(d) Give an example of reaction in which $HCO(CO)_4$ is used as a catalyst.

(e) What is Wilkinson's catalyst? Mention one use of this catalyst.

(f) How is $18\ e^-$ rule helpful in determining the number of metal-metal bonds in metal carbonyl compounds?

UNIT—I

3. Answer any *two* questions from the following :        3×2=6

(a) How will you detect the presence of phosphate as interfering radical in a salt mixture? How does phosphate interfere in the detection of basic radicals?       1+2=3

(b) What is common-ion effect? Explain why during the precipitation of group III radicals $NH_4OH$ is added in presence of $NH_4Cl$.       1+2=3

(c) What is the group reagent for group V? Write the chemical form of the precipitate of group V. How will you confirm the presence of $Ba^{2+}$ ion in a salt mixture?       1+1+1=3

UNIT—II

4. Answer any *four* questions from the following :       3×4=12

(a) The CO molecule has IR stretching frequency of $2143\ cm^{-1}$, but it shifts to different regions in metal carbonyls. Explain.

(b) What is Ziegler-Natta catalyst? Discuss its use in the polymerization of ethane.       1+2=3

(c) What is synergic effect in metal carbonyls? Draw the molecular orbital energy-level diagram of CO molecule.       1+2=3

(d) Compare the aromaticity of ferrocene with that of benzene. Does ferrocene obey $18\ e^-$ rule?       2+1=3

(e) Give one method of preparation for each of the following :

    (i) Metal carbonyl

    (ii) Zeise's salt

    (iii) Ferrocene

## UNIT—III

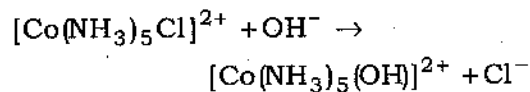5. Answer any *four* questions from the following :                    $3 \times 4 = 12$

   (a) Write a note on acid hydrolysis of cobalt (III) compounds with suitable example.

   (b) Draw the structures of the intermediates that are formed in $S_N 1$ and $S_N 2$ mechanisms of the reaction between $[MA_5X]^{n+}$ and $[Y]$. Compare their stability.                    $2+1=3$

   (c) What is *trans*-effect? Outline the synthesis of *cis*- and *trans*-dichloro-diammineplatinum (o). How will you distinguish between them?

   (d) Explain the mechanism of the following :

   $$[L_5MX] \xrightarrow{\text{slow}} X + [L_5M] \xrightarrow[\text{fast}]{+Y} [L_5MY]$$
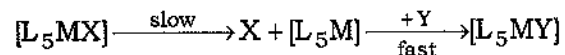
   (e) Explain the $S_N 1$ CB mechanism for the following reaction :

   $$[Co(NH_3)_5Cl]^{2+} + OH^- \rightarrow$$
   $$[Co(NH_3)_5(OH)]^{2+} + Cl^-$$

( *Continued* )

## UNIT—IV

6. Answer any *two* questions from the following :                    $3 \times 2 = 6$

   (a) Discuss briefly about Wacker process highlighting its mechanism.

   (b) Discuss the method of synthesis gas by metal carbonyl complexes.

   (c) Write a note on synthetic gasoline.

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**6 SEM TDC CHMH (CBCS) C 14**

# 2 0 2 3

( May/June )

## CHEMISTRY

( Core )

Paper : C–14

**( Organic Chemistry )**

*Full Marks* : 53

*Pass Marks* : 21

*Time* : 3 hours

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

1. Choose the correct answer from the following :                    1×5=5

   *(a)* The absence of absorption bands near $1600 \, cm^{-1}$, $1580 \, cm^{-1}$ and $1500 \, cm^{-1}$ is a proof for the absence of

   *(i)* carbonyl group

   *(ii)* aromatic ring

   *(iii)* —OH group

   *(iv)* secondary amino group

*( Turn Over )*

*(b)* Which of the following is an auxochrome?

*(i)* $-N=O$

*(ii)* $-NO_2$

*(iii)* $-N=N-$

*(iv)* $-OH$
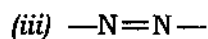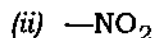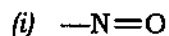
*(c)* The NMR spectrum of an unknown compound exhibits signals $\delta$ 7·5–8·0, *(m, 5H)* and 10·0 *(s, 1H)*. Which of the following structures represents these data?

*(i)* CH$_3$—⟨O⟩—CHO

*(ii)* ⟨O⟩—CH$_2$—CHO

*(iii)* ⟨O⟩—CHO

*(iv)* ⟨O⟩—C(=O)—CH$_3$
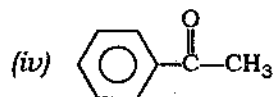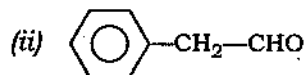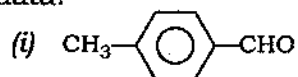
*(d)* Invert sugar is

*(i)* sucrose

*(ii)* mannose

*(iii)* a mixture of glucose and fructose

*(iv)* None of the above

*( Continued )*

*(e)* Which one of the following is a natural polymer?

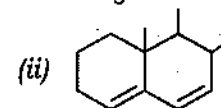*(i)* Celluloid

*(ii)* Viscose rayon

*(iii)* Terylene

*(iv)* Cellulose

## UNIT—I

**2.** Answer the following questions :

*(a)* Using Woodward-Fieser rule, calculate $\lambda_{max}$ for the following : $1 \times 2 = 2$

*(i)*

(CH$_3$)(CH$_3$)C=CH—C(=O)—CH$_3$

*(ii)*
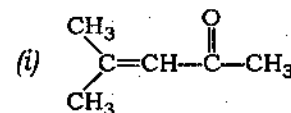


*(b)* Explain how *cis*-cinnamic acid and *trans*-cinnamic acid can be distinguished with the help of UV spectroscopy.

2

*(c)* Aniline absorbs at 280 nm, $\varepsilon_{max}$ 8600, however in acidic solution the main absorption band is seen at 203 nm. Explain. 2

*( Turn Over )*

(d) Distinguish the following pair of isomers with the help of IR spectra : 2

(i) $CH_3CH_2-CHO$ 　　　(ii) $CH_3-\overset{\overset{O}{\|}}{C}-CH_3$

Or

(i) $CH_3CH_2-OH$ 　　　(ii) $CH_3-O-CH_3$

(e) A compound with molecular formula $C_8H_8O$ gives the following signals in NMR spectrum :

(i) Multiplet $J$ 2·72 (5$H$)

(ii) Doublet $J$ 7·2 (2$H$)

(iii) Triplet $J$ 0·22 (1$H$)

Identify the structure of the compound. 3

Or

Predict the structure of an organic compound with molecular mass 88, whose NMR data are given below :

(i) A triplet, $\delta$ 1·2, 2$H$

(ii) A singlet, $\delta$ 1·97, 3$H$

(iii) A quartet, $\delta$ 4·06, 2$H$

(f) Define $M^+$ and $M^{+\cdot}$ ions. What do you mean by base peak in the mass spectrum of a compound? 1+1=2

Or

Write a short note on McLafferty rearrangement. 2

(g) An organic compound with molecular mass 72 absorbs at 274 nm, $\varepsilon_{max}$17. In IR region, a strong absorption band is found at 1715 cm$^{-1}$ and medium absorption bands are found at 2941–2857 cm$^{-1}$($m$) and at 1460 cm$^{-1}$($m$). The signals in the NMR spectrum are—

(i) 7·52 $J$, quartet;

(ii) 7·88 $J$, singlet;

(iii) 8·93 $J$, triplet.

Establish the structure of the compound. 4

(h) Explain shielding of acetylene protons and deshielding of ethylenic protons. 2+2=4

Or

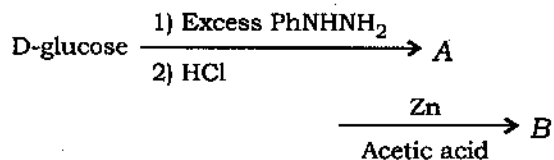Write in short about chemical shift. 4

UNIT—II

3. Answer the following questions :
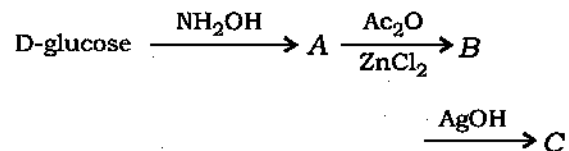
(a) Define epimerization. 1

(b) Sketch the stable conformational structure of the $\alpha$-D-glucopyranose. 1

(c) Identify A and B from the following : 2

$$D\text{-glucose} \xrightarrow[\text{2) HCl}]{\text{1) Excess PhNHNH}_2} A$$

$$\xrightarrow[\text{Acetic acid}]{\text{Zn}} B$$

(d) Complete the following reactions and identify A, B and C : 2

$$D\text{-glucose} \xrightarrow{\text{NH}_2\text{OH}} A \xrightarrow[\text{ZnCl}_2]{\text{Ac}_2\text{O}} B$$

$$\xrightarrow{\text{AgOH}} C$$

(e) Convert D-arabinose into D-glucose with the help of Kiliani-Fischer synthesis. 2

(f) Write a short note about mutarotation. 2

*Or*

When D-glucose is treated with dilute aqueous alkali, a mixture of D-mannose, D-fructose and D-glucose is obtained. Explain the mechanism of the reaction. What is the name of the reaction?

( *Continued* )

UNIT—III

4. Answer the following questions :

(a) Write the structural formulas of the following dyes and mark the chromophore and auxochrome in each case : 2

(i) Congo red

(ii) Rosaniline

(b) How can alizarin be synthesized from anthracene? 2

*Or*

Write down the preparation of Congo red.

(c) Synthesize crystal violet from dimethyl aniline. 2

(d) How will you synthesize malachite green? 2

*Or*

Account the colour changes occurring when phenolphthalein is used as indicator in acid-base titration.

( *Turn Over* )

UNIT—IV

5. Answer the following questions :

(a) What are polyurethanes? How are they formed? 1+1=2

(b) How can phenol-formaldehyde resin be prepared? Explain. 2

(c) What is biodegradable polymer? Give one example of it. 1+1=2

(d) Explain vulcanization of natural rubber. 2

(e) How can Terylene be synthesized? 1

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**6 SEM TDC DSE PHY (CBCS) 1 (H)**

**2 0 2 3**

( May/June )

PHYSICS

( Discipline Specific Elective )

( For Honours )

Paper : DSE–1

**( Nuclear and Particle Physics )**

_Full Marks : 80_
_Pass Marks : 32_

_Time : 3 hours_

_The figures in the margin indicate full marks_
_for the questions_

1. Choose the correct option from the following :

    $1 \times 5 = 5$

    (a) With increase in mass number, the neutron to proton ratio

    (i) increases

    (ii) decreases

    (iii) increases first and then decreases

    (iv) None of the above

( _Turn Over_ )

*(b)* Neutrons have a _____ value of dipole magnetic moment.

    *(i)* positive

    *(ii)* negative

    *(iii)* zero

    *(iv)* None of the above

*(c)* In alpha decay

    *(i)* mass number $A$ decreases by 4 and atomic number $Z$ increases by 2

    *(ii)* mass number $A$ decreases by 4 and atomic number $Z$ decreases by 2

    *(iii)* mass number $A$ increases by 4 and atomic number $Z$ decreases by 2

    *(iv)* mass number $A$ increases by 4 and atomic number $Z$ increases by 2

*(d)* Electron is a _____ generation particle.

    *(i)* first

    *(ii)* second

    *(iii)* third

    *(iv)* None of the above

*(e)* Isospin is to be conserved in

    *(i)* all elementary interactions

    *(ii)* strong interactions only

    *(iii)* weak interactions only

    *(iv)* None of the above

**2.** *(a)* What is nuclear quadrupole moment?   1

*(b)* Write down the relation between mass number and radius of a nucleus. Describe a method for determining nuclear radius.   1+3=4

*Or*

Explain the terms 'nuclear angular momentum' and 'nuclear quadrupole moment'.   2+2=4

**3.** *(a)* What are magic numbers? What is their significance in the shell model of the nucleus?   1+2=3

*(b)* What are the applications of the semi-empirical mass formula? Draw a graph indicating the contribution of the various terms of the semi-empirical mass formula to the total binding energy.   2+2=4

*(c)* Describe the liquid-drop model of the nucleus describing the similarities of the nucleus with a drop of liquid. How can nuclear fission be explained on the basis of this model?   4+2=6

4. (a) Describe how the range of alpha particles can be determined. What is straggling? Write down the relation connecting range and disintegration constant. 3+1+1=5

(b) Write down the equation showing the three modes of beta radioactivity. Describe the role of neutrino in explaining continuous energy spectrum of beta particles. 1+3=4

5. (a) Discuss Rutherford scattering in a nucleus. 3

(b) Derive an expression for $Q$-value of a nuclear reaction. 3

(c) A 7·7 MeV alpha particle interacts with a target nucleus $^{14}_{7}N$ to produce a residual nucleus $^{17}_{8}N$ and a product particle $^{1}_{1}H$. The protons emitted at 90° to the incident beam direction are found to have kinetic energy of 4·44 MeV. Calculate the $Q$-value of the reaction. 3

*Or*

Differentiate between direct reaction and compound nucleus reaction.

( Continued )

6. Write short notes on any *two* of the following : 4×2=8

(a) Cerenkov radiation

(b) Photoelectric effect

(c) Interaction of neutron with matter

7. What are the gas filled detectors? Describe briefly how gas filled detectors work in the following different regions on varying the plate voltage : 1+2+3+3=9

(a) Ionization chamber region

(b) Proportional region

(c) Geiger region

*Or*

Describe the principle and working of a scintillation detector. Name any two scintillators. Describe the working of a photomultiplier tube. 4+2+3=9

8. Describe the working of a cyclotron. How are the difficulties faced in a cyclotron removed in a synchrotron? 3+1+1=5

*Or*

What are tandem accelerators? Describe the construction and working of a van de Graaff generator. 2+3=5

( Turn Over )

**9.** *(a)* What is strong interaction? What are the conservation laws to be satisfied in strong interaction? What is the associated exchange particle? 1+2+1=4

*(b)* What does generation mean in particle physics? Which particles are the first-, second- and third-generation leptons? 1+3=4

*(c)* What are hadrons? Which fundamental interaction is specific to them? 2+1=3

*(d)* Check whether isospin and strangeness are conserved in the following reactions : 2×3=6

    *(i)* $\pi^+ + n \rightarrow \pi^- + p$

    *(ii)* $\pi^- + p \rightarrow \Lambda^\circ + K^\circ$

    *(iii)* $\pi^+ + \Lambda^\circ \rightarrow \Sigma^+ + K^\circ$

*Or*

What are quarks? Give the quark structure of pions. 3+3=6

★ ★ ★

## 6 SEM TDC DSE PHY (CBCS) 2 (H)

## 2 0 2 3

( May/June )

PHYSICS

( Discipline Specific Elective )

( For Honours )

Paper : DSE–2

**( Nanomaterials and Applications )**

_Full Marks : 53_
_Pass Marks : 21_

_Time_ : 3 hours

_The figures in the margin indicate full marks
for the questions_

1. Choose the correct option from the following :
   1×5=5

   (a) The density of states for a zero-dimensional system shows the variation like that of a

   (i) δ-function

   (ii) exponential function

   (iii) step-like behaviour

   (iv) None of the above

( Turn Over )

( 2 )

(b) Which of the following is an example of a top-down approach?

    (i) Molecular beam epitaxy

    (ii) Mechanical grinding

    (iii) Gas phase condensation

    (iv) Molecular self-assembly

(c) Mott-Wannier exciton cannot be formed in which of the following materials?

    (i) CdTe

    (ii) CdSe

    (iii) Si

    (iv) NaCl

(d) Coulomb interaction happens in

    (i) insulators

    (ii) metals

    (iii) semiconductors

    (iv) All of the above

(e) The charging effect which blocks the injection of single charge into or from the quantum dot is

    (i) tunneling effect

    (ii) hopping effect

    (iii) Coulomb blockage

    (iv) None of the above

        ( Continued )

( 3 )

2. (a) Write down the basic difference between PVD and CVD techniques.   2

  (b) Discuss the steps involved for synthesis of nanostructure materials by Sol-Gel method or spray pyrolysis method.   4

  (c) Write the various factors that affect the resolving power of an optical instrument.   2

  (d) Explain the different modes of operation of STM.   3

Or

Explain direct and indirect semiconductors with schematic diagram.   3

3. (a) Give the schematic diagram and discuss the working principle of a transmission electron microscope.   4

  (b) What is meant by optical storage? Describe briefly about various optical storage devices.   1+3=4

  (c) Define density of states of materials at nanoregime. Derive the expression for density of states (DoS) of a three-dimensional bulk system.   1+3=4

4. (a) For an electron in a 1-D box of length 2 nm, calculate the energy separation between the levels for $n = 7$ and $n = 3$.   2

        ( Turn Over )

(b) How can the lowering of size affect band gap?     2

5. (a) What are excitons? Explain the different types of excitons.     1+2=3

  (b) Calculate the exciton Bohr radius for CdSe. Given $m_e^* = 0\cdot13\,m_e$, $m_h^* = 0\cdot4\,mm_e$, where $m_e$ is free electron mass and dielectric constant $\varepsilon = 9\cdot4$.     3

6. (a) How can thin films be used for making LEDs and solar cells?     3

  (b) Write briefly about the charging effect in quantum dot.     3

  (c) What is hopping conductivity? Mention different types of hopping conduction.     1+2=3

*Or*

What do you mean by surface defects and deep-level defects?     1½+1½=3

7. Write short notes on any *two* of the following :     3×2=6

  (a) Single-electron transistor

  (b) Quantum dots in LED

  (c) MEMS

★ ★ ★

## 6 SEM TDC DSE PHY (CBCS) 3 (H)

## 2 0 2 3

( May/June )

PHYSICS

( Discipline Specific Elective )

( For Honours )

Paper : DSE–3

**( Experimental Techniques )**

*Full Marks : 53*
*Pass Marks : 21*

*Time : 3 hours*

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

1. Choose the correct option from the following :

1×5=5

(a) The number of significant figures in 12300 is

(i) 5

(ii) 3

(iii) 1

(iv) 4

( *Turn Over* )

(b) The noise figure (F) is defined as

(i) $\dfrac{S/N \text{ (input)}}{S/N \text{ (output)}}$

(ii) $\dfrac{S/N \text{ (output)}}{S/N \text{ (input)}}$

(iii) $\dfrac{S/N \text{ (input)}}{S/N \text{ (output)}} + 1$

(iv) $\dfrac{S/N \text{ (output)}}{S/N \text{ (input)}} + 1$

(c) Which of the following is not a static characteristic of instruments?

(i) Accuracy

(ii) Sensitivity

(iii) Speed of response

(iv) Reproducibility

(d) Thermocouples operate on the principle of

(i) Seebeck effect

(ii) Peltier effect

(iii) Thomson effect

(iv) None of the above

(e) The Penning gauge is designed for vacuum measurement in the pressure range of

(i) $10^{-5}$ to $10^{-13}$ mbar

(ii) $10^{-3}$ to $10^{-9}$ mbar

(iii) $10^{-1}$ to $10^{-5}$ mbar

(iv) $10^{-5}$ to $10^{-9}$ mbar

2. What are systematic and random errors? Calculate mean value, mean deviation, sample variance and standard deviation from the following data :  2+4=6

| Serial No. of Measurements | Light intensity $(W/m^2)$ |
|---|---|
| 1 | 10·3 |
| 2 | 12·6 |
| 3 | 11·5 |
| 4 | 14·3 |
| 5 | 15·2 |
| 6 | 13·6 |
| 7 | 12·3 |
| 8 | 14·5 |
| 9 | 12·9 |
| 10 | 10·8 |

**3.** What are the different sources of noise in instruments? Obtain an expression for r.m.s. value of shot noise current. 3+3=6

*Or*

Define transfer function of systems. Obtain an expression for transfer function of first-order instruments. Discuss its frequency response. 1+3+2=6

**4.** What is meant by electrical earthing or grounding? Why is it so important? Describe briefly the different methods of electrical grounding. 1+1+2=4

**5.** Answer any *three* from the following questions : 6×3=18

(a) Obtain an expression for transfer function of second-order instruments. Hence find natural frequency and damping ratio of a mass-loaded spring.

(b) What are the three different types of temperature transducers? Describe their working principles.

(c) Describe the working principle of a strain gauge (Resistance Strain Gauge). Derive an expression for gauge factor.

*( Continued )*

(d) Write a short note on semiconductor-type temperature sensors AD590 and LM35.

(e) What are radiation sensors? Describe the working of a gas-filled detector with proper diagram.

(f) Explain the working principles of piezoelectric and capacitance transducers.

**6.** What is the difference between an analog and a digital meter? Draw the block diagram of a digital multimeter. How is it used to measure voltage? 2+2+1=5

**7.** What is a Q-meter? Write its working principle. 1+1=2

**8.** (a) What are the characteristics of vacuum? Describe the elements of a vacuum system. 1+3=4

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

(i) Diffusion pump

(ii) Penning gauge

★★★

**6 SEM TDC PHYH (CBCS) C 13**

**2 0 2 3**

( May/June )

PHYSICS

( Core )

Paper : C–13

**( Electromagnetic Theory )**

_Full Marks_ : 53

_Pass Marks_ : 21

_Time_ : 3 hours

_The figures in the margin indicate full marks_
_for the questions_

1. Choose the correct answer (any _five_) :  1×5=5

   (a) If $E$ is the electric field intensity, then the electrostatic energy density is proportional to

      (i) $E$                     (ii) $E^{1/2}$

      (iii) $E^2$             (iv) $\dfrac{1}{E^2}$

   (b) The direction of propagation of electro-magnetic wave is given by

      (i) $\vec{E} \cdot \vec{B}$             (ii) $\vec{E}$

      (iii) $\vec{B}$               (iv) $\vec{E} \times \vec{B}$

                          ( _Turn Over_ )

**( 2 )**

(c) In Lorentz gauge, Lorentz condition is given by

   (i) $\operatorname{div}\vec{A} - \mu\epsilon\dfrac{\partial\phi}{\partial t} = 0$

   (ii) $\operatorname{div}\vec{A} + \mu\epsilon\dfrac{\partial\phi}{\partial t} = 0$

   (iii) $-\operatorname{div}\vec{A} + \mu\epsilon\dfrac{\partial\phi}{\partial t} = 0$

   (iv) $-\operatorname{div}\vec{A} - \mu\epsilon\dfrac{\partial\phi}{\partial t} = 0$

(d) When angle of incidence is greater than Brewster's angle, the reflected ray suffers a phase change of

   (i) $\dfrac{\pi}{2}$       (ii) $\pi$

   (iii) $0$       (iv) $2\pi$

(e) The degree of polarization for ordinary light reflected from glass (index 1·5) at an angle-incidence at 45° is

   (i) 83·3%       (ii) 6·7%

   (iii) 28·1%       (iv) 61·9%

(f) The set of cutoff frequencies for TM and TE modes of a rectangular wave guide is

   (i) same

   (ii) different

   (iii) independent

   (iv) None of the above

**( 3 )**

2. Answer any *five* of the following questions :

                       2×5=10

   (a) What is displacement current?

   (b) What are momentum density and angular momentum density?

   (c) Define relaxation time.

   (d) State Brewster's law.

   (e) Distinguish between uniaxial and biaxial crystals.

   (f) What are step and guided indices?

3. (a) Write down Maxwell's equations in differential and integral forms and explain their physical meaning.   2+2=4

*Or*

Use Maxwell's equations in free space to show that $\vec{E}$ and $\vec{B}$ are in phase and in constant ratio.   4

   (b) What are gauge transformations? What are Coulomb and Lorentz gauges? What are their importances?   1+2+1=4

4. (a) Discuss the propagation of plane electromagnetic waves in an isotropic dielectric medium and show that electric field vector $(\vec{E})$ and magnetic field vector $(\vec{H})$ are perpendicular to each other.   5

   (b) What is plasma frequency?   2

**5.** Discuss the reflection and refraction of electromagnetic waves at a plane interface between dielectrics. Under what condition will the incident wave be totally internally reflected? 5+2=7

*Or*

Derive Fresnel's equation for reflection of light from a dielectric surface. How are the relations verified experimentally? 5+2=7

**6.** *(a)* Discuss the propagation of electro-magnetic wave in anisotropic medium. 5

*Or*

Discuss the Fresnel's theory of optical rotation.

*(b)* Explain phase and group velocities of guided wave. 3

**7.** Write short notes on any *two* of the following : 4×2=8

*(a)* Skin depth

*(b)* Quarter-wave plate

*(c)* Optical fibre

★★★

**6 SEM TDC PHYH (CBCS) C 14**

**2 0 2 3**

( May/June )

PHYSICS

( Core )

Paper : C–14

**( Statistical Mechanics )**

_Full Marks : 53_
_Pass Marks : 21_

_Time : 3 hours_

_The figures in the margin indicate full marks_
_for the questions_

1. Choose the correct answer from the following : 1×5=5

   (a) The absolute temperature of a perfectly blackbody is increased to twice its value. The rate of emission of energy per unit area will be

      (i) 2 times

      (ii) 4 times

      (iii) 8 times

      (iv) 16 times

( Turn Over )

(b) According to Boltzmann canonical law

    (i) low energy cells contain more particles

    (ii) high energy cells contain more particles

    (iii) number of molecules having zero energy is greater than any other energy

    (iv) zero energy molecules are zero

(c) In a microcanonical ensemble, a system A of fixed volume is in contact with a large reservoir B. Which one is correct?

    (i) A can exchange neither energy nor particles with B

    (ii) A can exchange both energy and particles with B

    (iii) A can exchange only energy with B

    (iv) A can exchange only particles with B

     *( Continued )*

(d) Pauli's exclusion principle applies to

    (i) M-B statistics

    (ii) B-E statistics

    (iii) F-D statistics

    (iv) None of the above

(e) Bosons have spin value

    (i) 0

    (ii) 1

    (iii) ½

    (iv) 0 or 1

2. (a) Define phase space and ensemble. Calculate the number of states per unit volume of the phase space.     2+2=4

(b) State the law of equipartition of energy and prove it by using the concept of partition function.     1+3=4

     *( Turn Over )*

*(c)* Discuss Gibbs paradox by deriving necessary equations. Obtain Sackur-Tetrode equation from it.  3+3=6

*Or*

Derive the expressions

$$S = k\,N\log Z + \frac{3}{2}\,Nk \text{ and}$$

$$F = -NkT\log Z$$

where $S$ is entropy, $F$ is Helmholtz free energy and $Z$ is partition function of ideal monatomic gas.  3+3=6

3. *(a)* Write short notes on (any *two*) :  3×2=6

   *(i)* Saha's ionization equation

   *(ii)* Ultraviolet catastrophe

   *(iii)* Properties of thermal radiation

   *(iv)* Planck's law of black-body radiation

*(b)* State Rayleigh-Jeans law. Derive it from Planck's radiation law.  2+3=5

*(c)* Draw the black-body spectrum at different temperatures.  2

*Or*

A body at 1500 K emits maximum energy of wavelength 2000 nm. If the sun emits maximum energy of wavelength 550 nm, what would be the temperature of the sun?

4. *(a)* Derive Planck's law of black-body radiation from Bose-Einstein energy distribution law.  4

*Or*

Show that the average energy of Planck's oscillator of frequency $\nu$ in thermal equilibrium at temperature $T$ is

$$\bar{E} = \frac{h\nu}{e^{\frac{h\nu}{KT}} - 1}$$

*(b)* Describe the peculiar behaviour of liquid helium.  3

*(c)* Derive the expression for specific heat of a strongly degenerate Bose gas.  4

*Or*

How many photons are present in 1 cm$^3$ of radiation at 727 °C? What is the average energy of photons present in 1 cm$^3$ of radiation at 727 °C? Given

$$\int_0^\infty \frac{x^2 dx}{e^x - 1} = 2 \cdot 405$$

5. (a) How is Fermi-Dirac statistics used to discuss white dwarf stars? What is Chandrasekhar mass limit?  4+1=5

*Or*

Derive Fermi-Dirac distribution law for fermions. Write down Fermi-Dirac distribution function. What is its physical significance? Justify your answer considering the situation at absolute zero temperature.  3+2=5

(b) State Fermi-Dirac law of energy distribution in terms of Fermi energy. Using this expression for Fermi-Dirac law of distribution of energy among electrons within a metal, prove that at 0 K, the average kinetic energy is $\overline{E} = \frac{3}{5} E_f$, where $E_f$ is the Fermi energy.

2+3=5

*Or*

Fermi energy of conduction electrons in silver is 5·8 eV. Calculate the number of such electrons per cm$^3$, given that $h = 6 \cdot 62 \times 10^{-27}$ erg sec and 1 eV = $1 \cdot 62 \times 10^{-12}$ erg.

The Fermi energy of silver at 0 K is 5·5 eV. Find the average kinetic energy per electron in silver.  2+3=5

★★★