UNIVERSITY OF KERALA

DRAFT

COURSE STRUCTURE AND SYLLABUS

FOR

Complementary Course in Biochemistry
For
First Degree Programme in Botany and Zoology

UNDER

CHOICE BASED CREDIT AND SEMESTER SYSTEM

Revised Syllabus-2020
[w.e.f. 2020 admissions]
SEMESTER -I

BC1131: Complementary Course-1
Course Title: Biophysical Chemistry

No. of Credits: 2
Hours/week: 2

No. of Contact Hours: 36
(L, T, P, C – 2, 1, 2, 2)

Objective of the course: To enable students to understand the basic concepts of acid, bases and colloidal systems and its importance in biological system and understanding the principle of different techniques used in the study of Biochemistry.

Course outcome: Student will be able to
• Gain knowledge about the preparation of different types of solutions and buffers
• Identify different types of bonds in biomolecules.
• Explain different biochemical separation techniques.

Course Outline

Module I
Water, Acids, Bases and Buffers

Core Text:

Module II
Colloids & Solutions

Methods of expressing concentration- normality, molality, molarity, percentage solution, mole fraction, parts per million and parts per billion. Fundamental principles of diffusion and osmosis: definition of osmotic pressure, relationship of osmotic pressure to gas laws-Vant Hoff’s law, general equations for dilute solutions with simple numerical problems. Biological significance of osmosis. Influence of ionization and molecular size on osmotic pressure. Definitions of isotonic, hypotonic and hypertonic solutions.

Core Text:
Module III (6 hrs)
Bio-organic Chemistry
Common functional groups and their significance in biomolecules –OH, -SH, -CHO, -C=O, -COOH, -NH₂.
Core Text:

Module IV (10 hrs)
Biochemical Separation Methods
Chromatography- Basics of Ion exchange, TLC, gel filtration, paper, affinity, GLC and HPLC. Electrophoresis- Native and SDS PAGE, Isoelectric focusing, two dimensional electrophoresis, flow cytometry. Centrifugation- Principle, Svedberg constant, principle and application of density gradient and ultracentrifugation.
Core Text:

Module V (6 hrs)
Colorimetry & Radioactivity
Core Text:

Suggested Reading
Objective of the course: To familiarize the students with the building blocks of living matter, the biomolecules, their structure, components, reactions, their derivatives, biological significance and the basic tests to identify them.

Course outcome: Student will be able to
- Classify and characterize different types of biomolecules like carbohydrates, lipids, amino acids, proteins, nucleic acids and hormones.

Course Outline

Module I (8 hrs)
Chemistry of Carbohydrates
Classification, isomerism, D and L configuration, epimers, anomers, mutarotation, reactions of carbohydrates (oxidation, reduction, oxidizing property, reducing property, dehydration and osazone formation). Structure and properties of monosaccharide (linear and cyclic structures of glucose, fructose, mannose and galactose), disaccharides (sucrose, lactose, maltose, isomaltose and cellobiose) and polysaccharides (cellulose, starch and glycogen). Glycosaminoglycans-types and functions (structure not required). Colour reactions of carbohydrates.

Core Text:

Module II (8 hrs)
Chemistry of Lipids
Classification of lipids, biological functions of lipids, classification of fatty acids, physical and chemical properties of fatty acids, saturated and unsaturated fatty acids, essential and non essential fatty acids, important reactions of fatty acids and Acrolein test for glycerol. Definition and significance of the following: saponification number, iodine number, acid value and Reichert-Meissl number. Triglycerides - simple and mixed triglycerides (basic structural representation of both). Steroids- structure of cholesterol & ergosterol and colour reactions of cholesterol. Phospholipids: structure and function of phosphatidic acid, phosphatidyl choline, phosphatidyl ethanolamine, phosphatidyl serine, plasmalogens, and phosphatidyl inositol. Sphingolipids- functions of sphingomyelin, cerebrosides and gangliosides.

Core Text:

Module III (8hrs)
Chemistry of Amino acids and Proteins
Classification, structure and important reactions of amino acids. Zwitter ion and isolectric point. Essential and non essential amino acids. Proteins- classification, levels of structural organization of proteins: primary, secondary, tertiary and quaternary structure. Forces stabilizing the structure of
proteins. Determination of N terminal amino acid (Edmans method) and C-terminal amino acid (using LIBH₄) -only basic principles of methods employed. Denaturation of proteins, precipitation reactions-salt effect and heavy metal precipitation. Colour reactions of amino acids and proteins. Structure and functions of hemoglobin and functions of plasma proteins.

**Core Text:**

**Module IV**

**Chemistry of Nucleic Acids**

Types of nucleic acids, nitrogenous bases, nucleosides, nucleotides, structure of adenine, guanine, cytosine, uracil and thymine. cAMP, cGMP, ATP and GTP. Types of RNA (basics only). Primary and secondary structure of DNA- Watson and Crick model, Chargaff’s rule, types of DNA. Comparison between RNA and DNA.

**Core Text:**

**Module V**

**Chemistry of Hormones**

General classification of hormones. Site of biosynthesis, chemical structure and function of the following hormones: Estrogens, Testosterone, Aldosterone, Cortisone, Cortisol, Corticosterone, Progesterone, T₃, T₄, Adrenalin, Noradrenalin, Insulin, Glucagon, TSH, ACTH, GTH, SH, MSH, Oxytocin, Vasopressin, PTH, Gastrin, Secretin (structures of peptide hormones not required). Second messengers, Mechanism of action of hormones (basics only).

**Core Text:**

**Suggested Readings:**
- Biochemistry (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc
**SEMESTER-III**

**BC 1331: Complementary Course-3**

**Course Title: Enzymes and Bioenergetics**

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<td>No. of Contact Hours:</td>
<td>54</td>
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**Objective of the course:** To introduce the students with the basics of enzymology, such as classification, types of inhibition, regulation, coenzymes and an introduction to bioenergetics.

**Course outcome:** Student will be able to
- Classify enzymes and describe the factors affecting an enzyme catalyzed reaction
- Describe different types of enzyme inhibition.
- Elaborate on the role of vitamins in human nutrition.
- Elicit different pathways and mechanism of energy production in carbohydrate metabolism.

### Course Outline

#### Module I (14hrs)

**Enzymes**


**Core Text:**

#### Module II (12hrs)

**Vitamins and Coenzymes**

Classification and types of vitamins. Basic physiological functions of vitamin A, D, E and K and water soluble vitamins C, B1, B2, Pyridoxine, Nicotinic acid, B12 and Folic acid. (Structure not required). Coenzyme forms of the above vitamins with example of reactions.

**Core Text:**

#### Module III (14 hrs)

**Bioenergetics**

Redox reactions, redox potential and free energy, structure of mitochondria, mitochondrial electron transport chain, coenzymes and prosthetic groups of respiratory chain enzymes- sites of ATP production, P/O ratio, inhibitors of electron transport chain, oxidative phosphorylation-chemiosmotic
hypothesis (outlines only), uncouplers of oxidative phosphorylation. Formation of ATP- oxidative and substrate level phosphorylation. Role of high energy compounds with structures (ATP, ADP, Creatine phosphate, 1, 3-bis Phosphoglycerate and PEP).

**Core Text:**

**Module IV**

**Photosynthesis**

Outlines of cyclic and non-cyclic photophosphorylation, photosystems I and II, Path of carbon in dark reaction-Calvin cycle, photorespiration and \( \text{C}_4 \) pathway, nitrogen cycle, nitrogen fixation-nitrogenase complex, nitrogen assimilation -role of glutamate dehydrogenase and synthetase (outline study only).

**Core Text:**

**Suggested Reading**
SEMESTER-IV  
BC 1431: Complementary Course-4  
Course Title: Intermediary Metabolism

No. of Credits: 3  
No. of Contact Hours: 54  
Hours/week: 3  
(L, T, P, C – 3, 1, 2, 3)

Objective of the course: The course aims at providing an overview of energy production by explaining the general principles of cellular energy metabolism and schematizing the different metabolic pathways.

Course outcome: Student will be able to
- Describe digestion and absorption of carbohydrates, lipids and proteins.
- Elaborate the reactions & regulations involved in carbohydrate, lipid & amino acid metabolism.
- Explain the genetic aspects of metabolism.

Course Outline

Module I  
Metabolism of Carbohydrates  
(15hrs)


Core Text:

Module II  
Metabolism of Lipids  
(15hrs)


Core Text:

Module III  
Metabolism of Amino acids and Proteins  
(9 hrs)

Module IV

Genetic aspects of Metabolism


Suggested Readings:

Semester-I

Complementary Practical-I

Hours/week: 2  No. of Contact Hours: 36

- Weighing in Chemical balance
- Preparation of solutions
  - percentage, molar & normal solutions, dilution from stock solution etc.
- Demonstration of dialysis
- Demonstration of PAGE
- Demonstration of Paper Chromatography
- Demonstration of Thin Layer Chromatography
- Colorimetry and Spectrophotometry techniques
- Verification of Beer Lambert’s law
- Verification of molar extinction coefficient of any known compound

References


Semester-II

Complementary Practical -II

Hours/week: 2  No. of Contact Hours: 36

1. Isolation of starch from potato
2. Estimation of glucose by titration method
3. Estimation of Saponification value of oil
4. Test for amylase in saliva
5. Test for mucin and calcium in saliva

References

Semester-III

Complementary Practical-III

Hours/week: 2  
No. of Contact Hours: 36

*Experiments are to be conducted individually*

Qualitative Analysis of Biomolecules
1. General Reactions of biomolecules
2. Qualitative analysis of reducing sugars
3. Qualitative analysis of starch
4. Qualitative analysis of amino acids
5. Qualitative analysis of proteins
6. Qualitative analysis of lipids

- **Reducing sugars:**
  Solubility, Molisch’s test, Fehling’s test, Barfoed’s test, Benedicts test, Picric acid test, Bial’s test, Seliwanoff’s test and Osazone test. (Glucose, Fructose, and Xylose).

- **Starch:**
  Molisch’s test, Iodine test, hydrolysis of starch and precipitation reactions with alcohol.

- **Aminoacids:**
  Solubility, Ninhydrin test, Xanthoproteic test, Millon’s test, Morners test, Glyoxalic acid test, Ehrlich’s test, Nitroprusside test, Lead acetate test, Test for Methionine, Aldehyde test, Sakaguchi reaction and Isatin test. (Any three amino acids- should include an aromatic amino acid and a sulphur containing amino acid).

- **Proteins:**
  Solubility, Xanthoproteic test, Folin’s test, Biuret test, Sulphosalicylic acid test, Heat denaturation, TCA precipitation, Hellar’s-nitric acid test, Metal precipitation and Alcohol precipitation.

- **Lipids:**
  *Fatty acids:* Stearic acid/Oleic acid: Solubility, Translucent spot tests, Test for Unsaturation
  *Glycerol:* Solubility, Acrolein Test, Borax fusion test.
  *Cholesterol:* Solubility, Salkowski reaction, Liebermann-Burchard reaction, Zaks test.

References

Semester-IV

BC-1432-Complementary Practical-IV

No. of Credits: 4  
No. of Contact Hours: 36  
Hours/week: 2

*Experiments are to be conducted individually*

**Quantitative Analysis of Biomolecules**  
(Minimum of **nine** experiments to be done)

1. Estimation of Glucose by Nelson-Somogyi method  
2. Estimation of Glucose by Anthrone method.  
3. Estimation of Fructose by Roe-Papadopoulos method  
4. Estimation of Xylose by Orcinol Method  
5. Estimation of Protein by Folin-Lowry method  
6. Estimation of Protein by Biuret method  
7. Estimation of Tyrosine by Folin-Denis method  
8. Estimation of Cholesterol by Zak’s method  
9. Estimation of DNA by Diphenylamine method  
10. Estimation of RNA by Orcinol method

References

Scheme of Evaluation

Theory & Practical
- Continuous Internal Assessment - 20 marks
- End Semester Assessment – 80 marks
Total - 100 marks

Scheme of Evaluation for Practical

BC1432- Complementary Practical - IV
Time: 3 hours Max. Marks: 80
Experiment: Qualitative and Quantitative Analysis of Biomolecules (Carbohydrates/ Lipids / Proteins / Amino acids)

Components

1. Major Experiment (Quantitative Analysis) - 40 marks
   - Principle and Procedure – 5 marks (2 + 3)
   - Tabular column- 2 ½ marks
   - Calculation- 2 ½ marks
   - Final Result – 30 marks
   - Error
     - 0-5 % – 30 marks
     - 6 – 10 % - deduct one mark each
     - 11- 13% - deduct 2 marks each
     - 13- 15% - deduct 3 marks each
     - >15%- grace mark

2. Minor Experiment (Qualitative Analysis of Biomolecules) – 25 marks
   Identification of specific biomolecule with general, positive, negative and confirmatory tests.

3. Record – 15 marks
   - Qualitative analysis - Minimum of 9 (nine) qualitative experiments to be done. Deduct 1 mark each for lesser number of experiments.
   - Quantitative analysis - Minimum of 9 (nine) quantitative experiments to be done. Deduct 1 mark each for lesser number of experiments.
   - Neatness – 3 marks.
Model Question Paper
BC1131: Complementary Course-1
Biophysical Chemistry

Time: 3 hours
Maximum marks: 80

Section-A
(Very Short Answer Type- maximum two sentences -Answer all questions)

1. Give any two differences between true solution and a colloid.
2. Mention the use of SDS in electrophoresis.
4. Give a biological application of $^{32}$P isotope
5. Define molar extinction coefficient.
6. Mention about the function of a monochromator.
7. List the two types of ion exchangers with an example.
8. How will you prepare a 1N solution of an acid?
9. State Vant Hoff’s law of osmotic pressure
10. Differentiate between osmosis and diffusion

(10x1=10 marks)

Section-B
(Short Answer Questions-not to exceed one paragraph-Answer any eight questions)

11. Illustrate the formation of a peptide bond.
12. Discuss about TLC and thin layer materials.
13. Define osmotic pressure and reverse osmosis.
15. Write note on pH scale.
16. A solution contains 8g NaOH/100ml. Calculate the molarity of the solution.
17. Illustrate Phosphodiester linkage and mention its significance.
18. Explain buffer capacity
19. Discuss about ion product of water.
20. List out the biological applications of osmosis.
22. Discuss about density gradient centrifugation

(8 x 2 = 16 marks)

Section-C
(Short Essay-not to exceed 120 words- Answer any six questions)

23. Describe the working of a pH meter.
24. Derive Henderson Hasselbalch equation. List out its applications.
25. Describe the principle and instrumentation of Spectrophotometer
26. Discuss about a technique for separating DNA fragments.
27. List the differences between lyophobic and lyophilic colloid.
28. Discuss about the types of isomerism exhibited by biomolecules.
29. Comment on the molecular interactions in protein.
30. Discuss about surface tension and its biological importance.
31. A buffer solution contains 0.015M of acetic acid and 0.025M of sodium acetate. Calculate the pH of the solution. Dissociation constant (Ka) of acetic acid is $1.80 \times 10^{-5}$.

(6 x 4 = 24 marks)

Section-D
(Long Essay-Answer any two questions)

32. Explain process of separation of proteins based on molecular weight.
33. Explain Donnan Membrane equilibrium and its biological significance.
34. Discuss the principal and applications of different types of centrifugation techniques.
35. Give a detailed account of the biological applications of radioactive isotopes.

(15 x 2 = 30 marks)

Model Question Paper
BC 1231: Complementary Course-2
Biomolecules

Time: 3 hours
Maximum marks: 80

Section-A
(Very Short Answer Type- maximum two sentences -Answer all questions)

1. Write the significance of iodine number and acid number.
2. Give a test to identify glycerol.
3. Write the structure of two aromatic amino acids.
4. Define a holoenzyme and write its components.
5. Mention the role of tRNA in protein synthesis.
6. How are anomers formed?
7. State Chargaff’s rule.
8. Define amphipathic nature of lipids.
9. Why are certain fatty acids considered as essential? Give two examples
10. Define Vmax

(10x1=10 marks)

Section-B
(Short Answer Questions-not to exceed one paragraph-Answer any eight questions)

11. Write a note on sphingolipids
12. Represent a glycosidic bond
13. Differentiate between reducing and non-reducing sugar
14. Give the structure of two second messengers
15. Write a note on collagen triple helix
16. Give function of two hormones involved in carbohydrate metabolism
17. Define zwitter ions. Give one example
18. Comment on glycosaminoglycans.
20. List out the essential amino acids. Why are they considered essential?
21. Define saponification number and its significance
22. Distinguish between fibrous proteins and globular proteins with examples.
Section-C
(Short Essay-not to exceed 120 words- Answer any six questions)
23. Discuss about precipitation reactions of proteins
24. Detail the types of DNA.
25. Give a brief account of phospholipids.
26. Illustrate the DNA double helical structure.
27. Give the structure and functions of the following: ATP and GTP
28. Discuss about the acid base properties of amino acids
29. Describe the classification of amino acids
30. Compare and contrast between cerebroside and ganglioside.
31. Explain the alpha helical and beta pleated sheet structure of proteins

(8 x 2 = 16 marks)

Section-D
(Long Essay- Answer any two questions)
32. Discuss the structural organization of proteins
33. Describe about the classification and functions of steroid hormones
34. Classify lipids. Explain each class with examples, structures and important functions
35. Illustrate the structure and function of different types of RNAs.

(6 x 4 = 24 marks)

Model Question Paper
BC 1331: Complementary Course-3
Enzymes and Bioenergetics
Time: 3 hours
Maximum marks: 80

Section-A
(Very Short Answer Type- maximum two sentences -Answer all questions)
1. Define photophosphorylation.
2. Which are the organelles involved in photorespiration.
3. Write about the deficiency disease of Vit C
4. Define turnover number of an enzyme.
5. Define optimum temperature and optimum pH for an enzyme reaction.
6. Give the name of coenzymes involved in dehydrogenation reactions.
7. Give the function of creatine phosphate.
8. Mention the cause of hypervitaminosis.
9. Mention the role of cyanide in relation to ETC.
10. Define redox potential and free energy.

(10x1=10 marks)

Section-B
(Short Answer Questions-not to exceed one paragraph-Answer any eight questions)
11. Write a short note on the features of Km value.
12. Explain L-B plot.
13. Write about the role of a vitamin involved in DNA synthesis.
14. Write about the major enzyme involved in fixation of carbon.

(15 x 2 = 30 marks)
15. Name two uncoupling agents of electron transport chain. How do they act?
16. Define P/O ratio. Mention its significance in respiration?
17. Give the functions and sources of vitamin E.
18. Give the structure of ATP.
19. Discuss about ATP synthase.
20. Give the coenzyme forms of Vitamin B1, B2 and B6.
22. Discuss about the various respiratory chain inhibitors.  

(8 x 2 = 16 marks)

Section-C
(Short Essay-not to exceed 120 words- Answer any six questions)

23. Write about enzyme specificity
24. Give a brief account of allosteric regulation of enzymes.
25. Write a note on the significance of $\Delta G^0$ value
26. List out the deficiency diseases of Vit A.
27. Differentiate substrate level phosphorylation and oxidative phosphorylation
28. Explain cyclic photophosphorylation.
29. Describe chemiosmotic hypothesis
30. Detail the factors affecting enzyme activity.
31. Explain clinical applications of isoenzymes of lactate dehydrogenase.  

(6 x 4 = 24 marks)

Section-D
(Long Essay- Answer any two questions)

32. Explain Calvin cycle
33. Give a detailed account on mitochondrial electron transport chain.
34. Illustrate enzyme inhibitions with suitable examples.
35. Discuss in detail the biochemical functions of Vitamin D and Vitamin C.  

(15 x 2 =30 marks)
10. Why are Okazaki fragments formed?  

Section-B  
(Short Answer Questions-not to exceed one paragraph-Answer any eight questions)  

11. List out the key enzymes of gluconeogenesis.  
12. Give two functions of phospholipids.  
13. Write about the role of lactate dehydrogenase in carbohydrate metabolism.  
15. Comment on Shine-Dalgarno sequence and anti-Shine Dalgarno sequence.  
16. Write note on ribosomes.  
17. Mention the action of endopeptidases with two examples.  
18. Give an account of codon-anticodon recognition.  
19. Define genetic code. Discuss its salient features.  
20. With regard to transcription, what are the roles of the promoter, terminator & regulatory sequences?  
21. How bile acids are formed?  
22. Write down the structural organization of a nucleosome.  

(8 x 2 = 16 marks)  

Section-C  
(Short Essay-not to exceed 120 words- Answer any six questions)  

23. Write down the significance of deamination reaction in the breakdown of amino acids.  
24. Describe Cori’s cycle and its significance.  
25. How is ammonia detoxified in the body?  
26. Discuss about the digestion and absorption of lipids.  
27. Explain the digestion and absorption of carbohydrates  
28. Compare and contrast α and ω oxidations  
29. Sketch the structure of tRNA and mention its role  
30. Detail the role of glutathione cycle in amino acid metabolism.  
31. List out the ketone bodies. How are they formed?  

(6 x 4 = 24 marks)  

Section-D  
(Long Essay- Answer any two questions)  

32. Why Glycolysis and gluconeogenesis are often described as“two sides of the same coin”. Illustrate this statement by describing the reactions of each pathway and discussing their regulation.  
33. Describe in detail the process of prokaryotic transcription.  
34. Illustrate scheme of β-oxidation and ATP yield of one mole of stearic acid.  
35. Give an account of the reactions of HMP shunt pathway.  

(15 x 2 =30 marks)