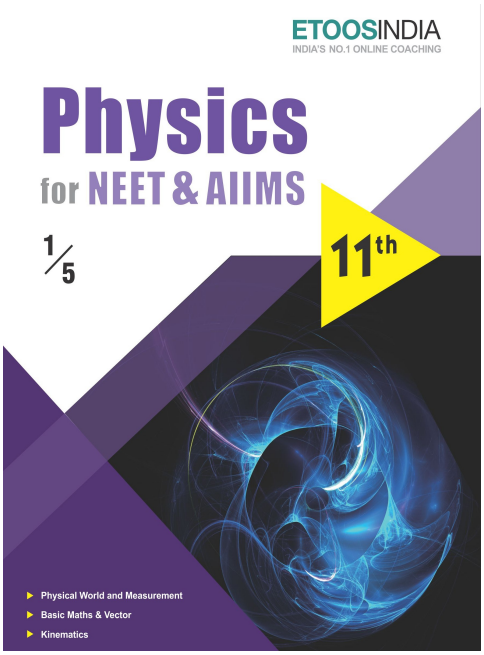
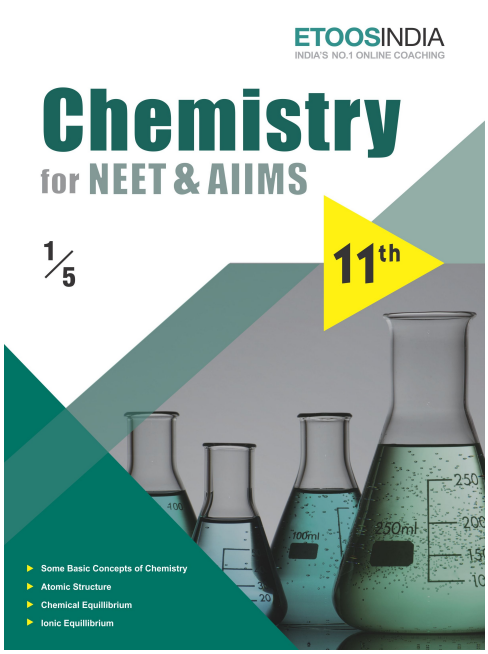
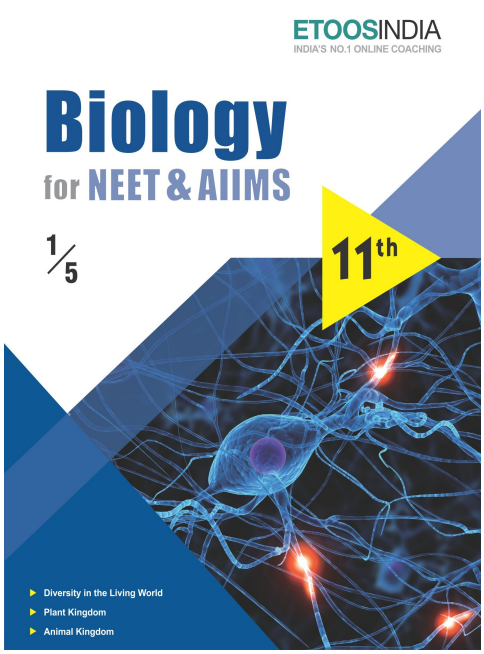
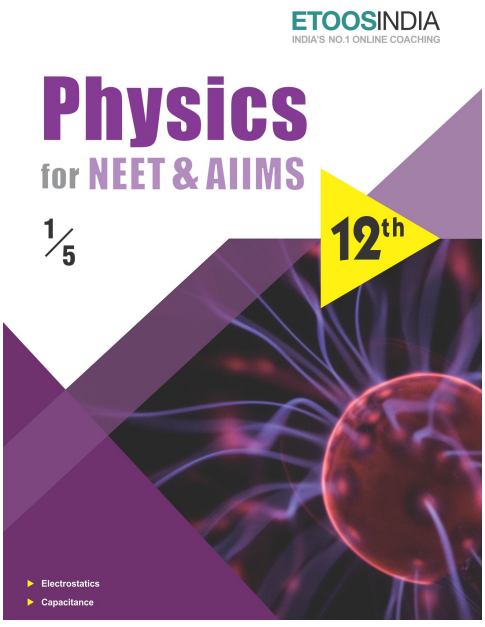
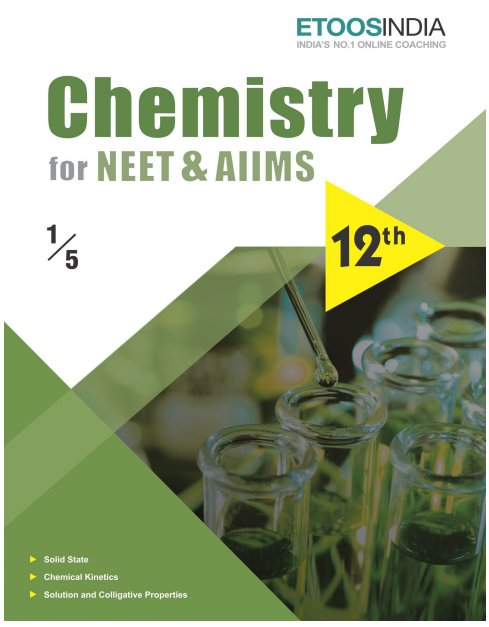
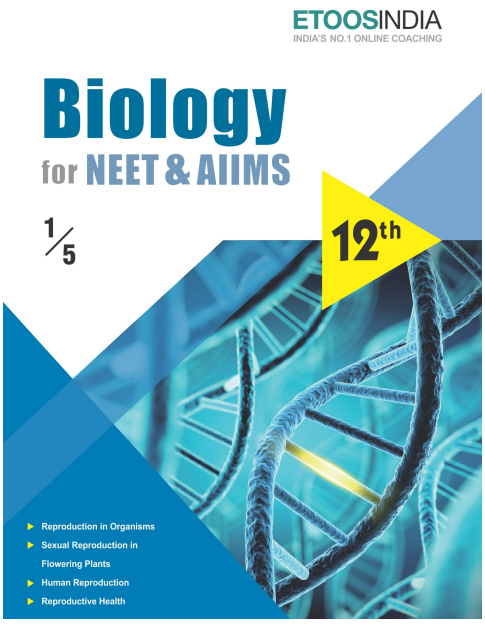












CHAPTER 18

EXCRETORY PRODUCTS AND THEIR ELIMINATION

" Owing to the difficulty of dealing with substances of high molecular weight we are still a long way from having determined the chemical characteristics and the constitution of proteins, which are regarded as the principal con-stituents of living organisms."

"WALTER BRADFORD CANNON(1871-1945)"

INTRODUCTION

Ammonia, urea, uric acid, carbon dioxide, water and ions like Na^+, K^+, Cl^-, Phosphate,sulphate, etc., either by metabolic activities or by other means like excess ingestion all gets accumulated in animals. These substances need to be removed partially or totally. Ammonia, Urea and Uric acid are the major forms of nitrogenous wastes excreted by the animals.

Ammmonia being most toxic form requires large amount of water for its elimination, whereas uric acid, being the least toxic, can be removed with a minimum loss of water. The process of removal of metabolic wastes from the body is called **Excretion.** The process of excreting ammonia is called **Ammonotelism.** Many aquatic insects or aquatic animals are ammonotelic in nature.Ammonia is readily soluble and is generally excreted by diffusion across body surfaces or through gill surfaces as ammonium ions. Mammals, many terrestial amphibians and marine fishes mainly excrete urea and are called **Ureotelic.** Reptiles, birds, land snails and insects excrete nitrogenous wastes as uric acid in the form of pellet or paste with a minimum loss of water and are called **ureotelic** animals.

EXCRETORY PRODUCTS & THEIR ELIMINATION

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

Carbohydrate metabolism, produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes–**ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (**Walter Cannon**).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur.

Osmoregulation:

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis) is called **osmoregulation**.

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

a. **Osmoconformers :** These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

- All marine invertebrates and some fresh water invertebrates.
- Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

b. **Osmoregulators :**

Osmoregulators are those who animals maintain an osmolarity internally different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium. Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

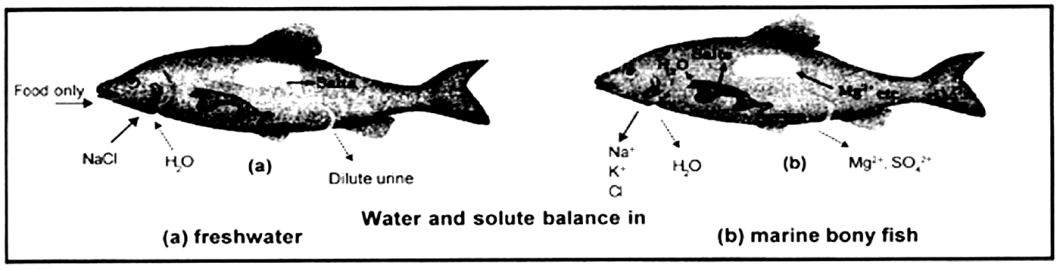
Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in (a) freshwater (b) marine bony fish

Etoos Tips & Formulas

→ Ammonia, Urea and Uric acid are the major forms of nitrogenous wastes excreted by the animals.
→ Toxicity sequence = Ammonia > Urea > Uric acid.
→ Ammonotelic animals = Many bony fishes, aquatic amphibians, aquatic insects.
→ Ureotelic animals = Mammals, Marine fishes, terrestrial amphibians.
→ Uricotelic animals = Reptiles, birds, insects, land snails.
→ A survey of animal kingdom presents a variety of excretory structures.

S.No.	Excretory structures	Examples
1.	Protonephridia (Flame cells)	Platyhelminthes, Rotiferes, Some-annelids and Cephalochordate (Amphioxus).
2.	Nephridia	Earthworms and other annelids
3.	Malpighian tubules	Most insects
4.	Antennal/Green glands	Crustaceans (Prawn)
5.	Vertebrates	Kidney

→ In humans, the excretory system consists of a pair of kidneys, one pair of ureters, a urinary bladder and a urethra.
→ The outer layer of kidney is a tough capsule. Inside the kidney, there are two zones, an outer cortex and an inner medulla.
→ The medulla is divided into a few conical masses (medullary pyramids) projecting into the calyces.
→ The cortex extends in between the medullary pyramids as renal columns called "Columns of Bertini".
→ Each kidney has nearly one million complex tubular structures called nephrons which are the functional units .
→ Glomerulus + Bowman's capsule = Malpighian body or Renal corpuscle.
→ The malpighian corpuscle, PCT and DCT of the nephron are situated in the cortical region of the kidney whereas the loop of Henle dip into the medulla.
→ Glomerular filtration takes place in Bowman's capsule and glomerular filtrate is formed which is protein less plasma.
→ On an average 1100-1200 ml of blood is filtered by the kidney per minute.
→ Glomerular filtration rate (GFR) in a healthy individual is 125 ml/minute or 180 litres per day.
→ Nearly 99 percent of the filtrate has to be reabsorbed by the renal tubules. This process is called reabsorption.
→ Substances like glucose, amino acids, Na^+ etc. in the filtrate are reabsorbed actively whereas the nitrogenous wastes and water are absorbed by passive transport.
→ During urine formation, the tubular cells secrete substances like H^+, K^+ and ammonia into the filtrate. This tubular secretion is an active process.

Functions of the tubules :

1. **PCT:**

   Maximum reabsorption occur

   All the essential nutrients, 70-80% of electrolytes and water, HCO_{3^-} are reabsorbed.

   Selective secretion of hydrogen ions, ammonia and potassium ions.

2. **Henle's loop:**

   Descending limb reabsorb water passively and ascending limb reabsorbed electrolytes actively or pas sively.

SOLVED EXAMPLE

Ex.1 Which one of the following blood vessels in mammals would normally carry the largest amount of urea.
(A) Hepatic portal vein
(B) Hepatic vein
(C) Renal artery
(D) Hepatic artery
Sol. (B) : Since urea formation takes place in liver.

Ex.2 The body cells in cockroach discharge their nitrogenous waste in the haemolymph mainly in the form of
(A) Potassium urate (B) Urea
(C) Calcium carbonate (D) Ammonia
Sol. (A)

Ex.3 Which one of the following characteristics is common both in humans and adult frogs
(A) Four-chambered heart
(B) Internal fertilisation
(C) Nucleated RBCs
(D) Ureotelic mode of excretion
Sol. (D) : Adult frog and human exhibit ureotelism because there excretory waste product is urea.

Ex.4 Almost all the aquatic animals excrete ammonia as the nitrogenous waste product. Which of the following statement is not in agreement with this situation.
(A) Ammonia is easily soluble in water
(B) Ammonia is released from the body in a gaseous state
(C) Ammonia is highly toxic and needs to be eliminated as and when formed
(D) Ammonia gets converted into a less toxic form called urea
Sol. (B)

Ex.5 Choose the wrong statement
(A) In ureotelic organisms, ammonia is not a product of metabolism
(B) In mammals some amount of urea may be retained in the kidney matrix of ureotelics to maintain osmolarity
(C) In fishes, kidneys do not play any significant role in the removal of ammonium ions
(D) Urea and uric acid are less toxic than ammonia
(E) Ammonia is readily soluble and can diffuse easily
Sol. (A)

Ex.6 Man is
(A) Ureotelic (B) Uricotelic
(C) Ammonotelic (D) Both (B) and (C)
Sol. (A)

Ex.7 Which of the following does not have an excretory system
(A) Myxine (B) Carcharodon
(C) Balanoglossus (D) Asterias
Sol. (D)

Ex.8 Proboscis gland in Balanoglossus is associated with
(A) Digestion (B) Respiration
(C) Circulation (D) Excretion
Sol. (D)

Ex.9 The region of the nephron found in the renal medulla is
(A) Malpighian corpuscle
(B) Proximal convoluted tubule
(C) Distal convoluted tubule
(D) Henle's loop
(E) Glomerulus
Sol. (D)

Ex.10 Urinary bladder is absent in
(A) Lizards (B) Snakes
(C) Crocodiles (D) All the above
Sol. (B)

Ex.11 Which one is the excretory organ in the following
(A) Archaeocyte (B) Choanocyte
(C) Pinacocyte (D) Solenocyte
Sol. (D) : Solenocytes (flame cells) help in excretion in flatworms (platyhelminthes)

Ex.12 Loop of Henle is concerned with
(A) Excretory system
(B) Reproductive system
(C) Nervous system
(D) Muscular system
Sol. (A)

Ex.13 Which is common to kidney and skeleton in mammals
(A) Cortex (B) Medulla
(C) Pelvis (D) Radius
Sol. (C)

Exercise # 1 SINGLE OBJECTIVE NEET LEVEL

1. Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(A) Urea (B) Uric acid
(C) Salt and water (D) Glucose

2. The afferent and efferent vessels are –
(A) Arterial in nature
(B) Venous in nature
(C) One is arterial and the other is venous
(D) None of the above

3. Blood vessel leading to glomerulus is called
(A) Afferent arteriole (B) Renal artery
(C) efferent arteriole (D) Renal vein

4. Ultrafilatration occurs in a glomerulus when-
(A) Osmotic pressure exceeds hydrostatic pressure
(B) Hydrostatic pressure exceeds osmotic pressure
(C) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(D) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

5. Workers in deep mines usually suffer from dehydration because –
(A) Water is lost due to defecation
(B) Water is lost due to evaporation
(C) Water is lost along with salts in the form of sweat
(D) Water is lost in the form of urine

6. The yellow colour of urine is due to –
(A) Urea (B) Melanin
(C) Uric acid (D) Urochrome

7. Excretion is a continuous process but urine is not passed out continuously because of –
(A) Ureter (B) Rectum
(C) Urinary bladder (D) Cloaca

8. ADH will be released from the posterior pituitary when there is a decrease in –
(A) Plasma potassium concentration
(B) Plasma pH
(C) Plasma sodium concentration
(D) Plasma volume

9. Mammalian kidney serve to excrete –
(A) Excess salts, urea and excess water
(B) Excess water, urea and amino acids
(C) Excess salts, urea and glucose
(D) Excess salts, excess water and excess amino acids

10. Aquatic animals are mostly ammonotelic because –
(A) Excretion of ammonia requires large amount of water which is available to these animals
(B) Ammonia helps in checking inflow of water into body
(C) These get less light
(D) Water contains less nitrogen

11. Aldosterone stimulates the reabsorption of–
(A) Keto acids (B) Glucose
(C) K^+ ions (D) Na^+ ions

12. Which blood vessel carries least percentage of urea –
(A) Renal artery (B) Pulmonary vein
(C) Hepatic portal vein (D) Renal vein

13. One of the following substance is not found in mammalian urine –
(A) Ammonium salt (B) Sucrose
(C) Sodium chloride (D) Water

14. In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(A) Urinary bladder (B) Collecting tubule
(C) Bowman's capsule (D) Loop of Henle

15. A person who is starving, that is not having food, water and beverages will have –
(A) Less urea in his urine
(B) Less fats in his urine
(C) More glucose in his blood
(D) More urea in his urine

16. When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(A) Excess of water in the tissues
(B) Loss of water from the tissue
(C) Loss of permeability of some membranes
(D) Loss of salts

Exercise # 2 SINGLE OBJECTIVE AIIMS LEVEL

1. Excretion involves process in which –
   (A) Harmful substance are stored in cells before being eliminated
   (B) Expulsion of urine from the urinary bladder and sweat from the skin
   (C) Harmful substance in the body are chemically changed
   (D) Substance of no further use or those present in excessive quantities are thrown out of the body

2. In aquatic organisms the waste end product of nitrogen metabolism is –
   (A) Urea (B) Ammonia
   (C) Nitrogen (D) Allantois

3. Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
   (A) Urea (B) Sodium chloride
   (C) Ammonia (D) Lysine

4. Which of the following sets of animals are uricotelic –
   (A) Fish, frog, lizard and fowl
   (B) Fish, snake, fowl and man
   (C) Camel, dog, monkey and man
   (D) Crow, snake, cockroach and lizard

5. Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
   (A) Ammonia (B) Amino acids
   (C) Urea (D) Uric acid

6. Which of the following sets of animals produce the same substance as their chief excretory product –
   (A) Camel, housefly and snake
   (B) Fish, pigeon and frog
   (C) Amoeba, ant and antelope
   (D) Frog, monkey and dog

7. Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
   (A) Mineral salts (B) Amino acids
   (C) Vitamins (D) Lipids

8. Most insects are –
   (A) Uricotelic (B) Ammonotelic
   (C) Aminotelic (D) Ureotelic

9. Uric acid is chief excretory product in –
   (A) Insects (B) Earthworms
   (C) Amphibians (D) Mammals

10. The least toxic nitrogenous waste is –
    (A) Ammonia + urea (B) Ammonia
    (C) Uric acid (D) Urea

11. If benzoic acid is present in the food of mammals, it is excreted out in the form of–
    (A) Hippuric acid (B) Ornithinic acid
    (C) Uric acid (D) Aspartic acid

12. Column of Bertini is found in –
    (A) Liver (B) Kidney
    (C) Ovaries (D) Testes

13. Man is –
    (A) Ammonotelic (B) Ureotelic
    (C) Uricotelic (D) None of these

14. The retroperitoneal kidney is –
    (A) Kidney covered by peritoneum on ventral side
    (B) Kidney of fish
    (C) Kidney uncovered by peritoneum on dorsal side
    (D) Kidney covered by peritoneum on dorsal side

15. The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
    (A) Constant composition of the blood irrespective of the nature of the food or fluid intake
    (B) Blood pressure constant
    (C) Temperature of the body
    (D) Equilibrium of the body

16. The functional part of the kidney of adult reptiles, birds and mammals is –
    (A) Holonephros (B) Pronephros
    (C) Mesonephros (D) Metanephros

Exercise # 3 PART - 1 MATRIX MATCH COLUMN

1. Match Column-I with Column - II and select the correct option from the codes given below.

Column - I	Column - II
A. Nephridia	i. Crustaceans
B. Malpighian tubules	ii. Annelids
C. Antennal gland	iii. Insects or Green glands

(A) A-i, B-ii, C-iii (B) A-iii, B-ii, C-i
(C) A-ii, B-iii, C-i (D) A-ii, B-i, C-iii

2. Match Column - I with Column - II and select the correct option from the codes given below.

Column - I	Column - II
A. Delivers blood	i. Ascending glomerulus descending limbs
B. Carries urine to pelvis	ii. Renal artery
C. Collects filtrate from	iii. Collecting duct Bowman's capsule
D. Loop of Henle	iv. PCT

(A) A-ii, B-iii, C-iv, D-i (B) A-i, B-iii, C-ii, D-iv
(C) A-ii, B-iv, C-i, D-iii (D) A-iv, B-iii, C-ii, D-i

3. Match Column-I with Column-II and select the correct option from the codes given below.

Column - I	Column - II
A. PCT	i. Concentrated urine formation
B. DCT	ii. Filtration of blood
C. Loop of Henle	iii. Reabsorption of 70-80% electrolytes
D. Counter-current	iv. Ionic balance mechanism
E. Renal corpuscle	v. Maintenance of concentration gradient in medulla

(A) A-iii, B-iv, C-i, D-v, E-ii (B) A-iii, B-v, C-iv, D-ii, E-i
(C) A-i, B-iii, C-ii, D-v, E-iv (D) A-iii, B-i, C-iv, D-v, E-ii

4. Match Column - I with Column - II and select the correct option from the codes given below.

Column - I	Column - II
A. Lungs	i. Lactic acid
B. Liver	ii. Hypertonic urine
C. Micturition	iii. Counter-current system
D. Sweat	iv. CO_2
E. Vasa recta	v. Urinary bladder
F. Sebum	vi. Glucose
G. ADH	vii. Bilirubin
H. Tubular reabsorption	viii. Sterols

(A) A-iv, B-vii, C-v, D-i, E-iii, F-viii, G-ii, H-vi
(B) A-iii, B-i, C-iv, D-viii, E-ii, F-v, G-vii, H-vi
(C) A-iv, B-viii, C-i, D-vi, E-v, F-iii, G-ii, H-vii
(D) A-vii, B-i, C-iv, D-iii, E-viii, F-vi, G-v, H-ii

Exercise # 4

PART - 1 PREVIOUS YEAR (NEET/AIPMT)

1. The ability of the vertebrates to produce concentrated (hyperosmotic) urine usually depends upon the [CBSE AIPMT 2000]
(A) Area of Bowmann's capsule epithelium
(B) Length of Henle's loop
(C) Length of proximal convoluted tubule
(D) Capillary network forming glomerulus

2. The enteronephric nephridia of earthworms are mainly concerned with [CBSE AIPMT 2000]
(A) digestion
(B) respiration
(C) osmoregulation
(D) Excretion of nitrogenous wastes

3. In living beings, ammonia is converted into urea through [CBSE AIPMT 2000]
(A) Ornithine cycle (B) Citrulline cycle
(C) Fumarine cycle (D) Arginine cycle

4. Which one of the following is correctly matched pair of the given secretion and its primary role in human physiology ? [CBSE AIPMT 2000]
(A) Sebum – Sexual attraction
(B) Sweat –Thermoregulation
(C) Saliva – Tasting food
(D) Tears – Excretion of salts

5. In Hydra, waste material of food digestion and nitrogenous waste material removed from : - [CBSE AIPMT 2001]
(A) Mouth and mouth
(B) Body wall and body wall
(C) Mouth and body wall
(D) Mouth and tentacles

6. In protozoa like Amoeba and Paramecium, a organ is found for osmoregulation which is : - [CBSE AIPMT 2002]
(A) Contractile vacuole (2) Mitochondria
(C) Nucleus (D) Food vacuole

7. If Henle's loop were absent from mammalian nephron, which of the following is to be expected : - [CBSE AIPMT 2003]
(A) The urine will be more concentrated
(B) The urine will be more dilute
(C) There will be no urine formation
(D) There will be hardly any change in the quality and quantity of urine formed

8. When a fresh water protozoan possessing a contractile vacuole, is placed in a glass containing marine water, the vacuole will- [CBSE AIPMT 2004]
(A) Increase in number (B) Disappear
(C) Increase in size (D) Decrease in size

9. Uricotelism is found in - [CBSE AIPMT 2004]
(A) Mammals and birds
(C) Fishes and Fresh water protozoans
(D) Birds, reptiles and insects
(D) Frogs and toads

10. In ornithine cycle which of the following wastes are removed form the blood - [CBSE AIPMT 2005]
(A) CO_2 and urea (B) Urea and urine
(C) CO_2 and ammonia (D) Ammonia and urea

11. A person is undergoing prolonged fasting. His urine will be found to contain abnormal quantities of - [CBSE AIPMT 2005]
(A) Fats (B) Ketones
(C) Amino acids (D) Glucose

12. The net pressure gradient that causes the fluid to filter out of the glomeruli into the capsule is - [CBSE AIPMT 2005]
(A) 20 mm Hg (B) 75 mm Hg
(C) 30 mm Hg (D) 50 mm Hg

13. Angiotensinogen is a protein produced and secreted by- [CBSE AIPMT 2006]
(A) Macula densa cells
(B) Endothelial cells (cells lining the blood vessels)
(C) Liver cells
(D) Juxtaglomerular (JG) cells

14. Bowman's glands are found in- [CBSE AIPMT 2006]
(A) Olfactory epithelium
(B) External auditory canal
(C) Cortical nephrons only
(D) Juxtamedullary nephrons

15. A person who is on a long hunger strike and is surviving only on water, will have: [CBSE AIPMT 2007]
(A) more sodium in his urine
(B) less amino acids in his urine
(C) more glucose in his blood.
(D) less urea in his urine

MOCK TEST

1. In mammals, ammonia produced by metabolism is converted into urea in the
(A) Kidney (B) LIver (C) Spleen (D) Blood
(E) Lymph.

2. Excretory structures in Rotifers are
(A) green glands (B) malpighian tubules (C) flame cells (D) gills
(E) kidneys.

3. Uricotelism is found in
(A) mammals and birds
(B) birds, reptiles and insects
(C) fishes and freshwater protozoans
(D) frogs and toads

4. Which one of the following options gives the correct categorisation of six animals according to the type of nitrogenous waste they give out?

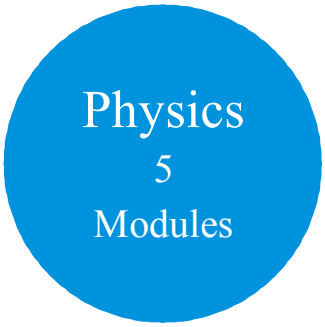
	Ammonotelic	Ureotelic	Uricotelic
(A)	Pigeon, humans	Aquatic amphibia, lizards	Cockroach, frog
(B)	Frog, lizards	Aquatic, amphibia, humans	Cockroach, pigeon
(C)	Aquatic amphibia	Frog, humans	Pigeon, lizards, cockroach
(D)	Aquatic amphibia	Cockroach, humans	Frog, pigeon, lizards

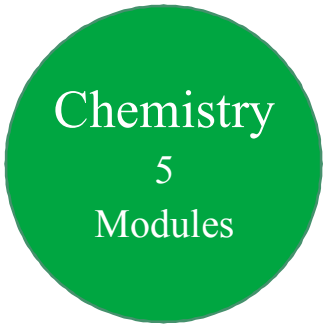
5. Fresh water bony fishes maintain water balance by
(A) excreting a hypotonic urine
(B) drinking small amount of water
(C) excreting salt across their gills
(D) excreting wastes in form of uric acid

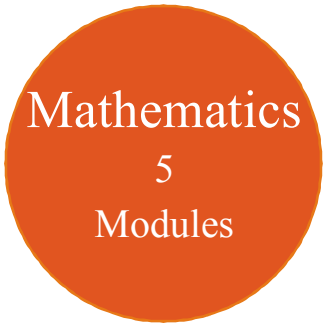
6. In which one of the following organisms its excretory organs are correctly stated?
(A) Humans – kidneys, sebaceous glands and tear glands
(B) Earthworm – pharyngeal, integumentary and septal nephridia
(C) Cockroach – Malpighian tubules and enteric caeca
(D) Frog – kidneys, skin and buccal epithelium

7. The nitrogenous excretory products are formed from the catabolism of amino acids by
(A) Calvin cycle (B) nitrogen cycle (C) ornithine cycle (D) Kreb's cycle

11th Class Modules Chapter Details







PHYSICS

Module-1

1. Physical World & Measurements
2. Basic Maths & Vector
3. Kinematics

Module-2

1. Law of Motion & Friction
2. Work, Energy & Power

Module-3

1. Motion of system of particles & Rigid Body
2. Gravitation

Module-4

1. Mechanical Properties of Matter
2. Thermal Properties of Matter

Module-5

1. Oscillations
2. Waves

CHEMISTRY

Module-1(PC)

1. Some Basic Conceps of Chemistry
2. Atomic Structure
3. Chemical Equilibrium
4. Ionic Equilibrium

Module-2(PC)

1. Thermodynamics & Thermochemistry
2. Redox Reaction
3. States Of Matter (Gaseous & Liquid)

Module-3(IC)

1. Periodic Table
2. Chemical Bonding
3. Hydrogen & Its Compounds
4. S-Block

Module-4(OC)

1. Nomenclature of Organic Compounds
2. Isomerism
3. General Organic Chemistry

Module-5(OC)

1. Reaction Mechanism
2. Hydrocarbon
3. Aromatic Hydrocarbon
4. Environmental Chemistry & Analysis Of Organic Compounds

BIOLOGY

Module-1

1. Diversity in the Living World
2. Plant Kingdom
3. Animal Kingdom

Module-2

1. Morphology in Flowering Plants
2. Anatomy of Flowering Plants
3. Structural Organization in Animals

Module-3

1. Cell: The Unit of Life
2. Biomolecules
3. Cell Cycle & Cell Division
4. Transport in Plants
5. Mineral Nutrition

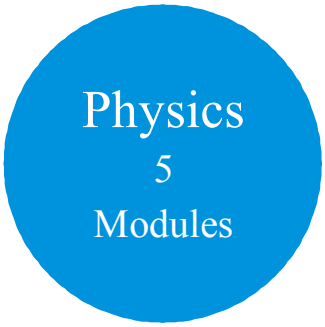
Module-4

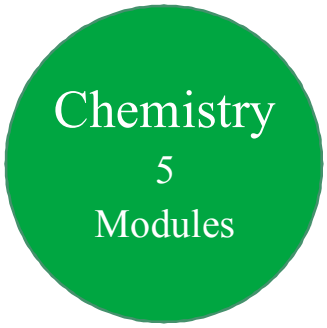
1. Photosynthesis in Higher Plants
2. Respiration in Plants
3. Plant Growth and Development
4. Digestion & Absorption
5. Breathing & Exchange of Gases

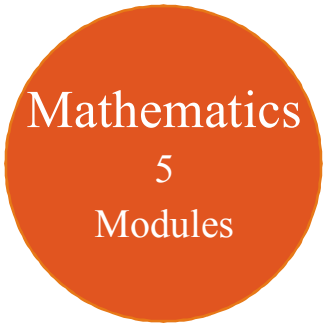
Module-5

1. Body Fluids & Its Circulation
2. Excretory Products & Their Elimination
3. Locomotion & Its Movement
4. Neural Control & Coordination
5. Chemical Coordination and Integration

12th Class Modules Chapter Details







PHYSICS

Module-1

1. Electrostatics
2. Capacitance

Module-2

1. Current Electricity
2. Magnetic Effect of Current and Magnetism

Module-3

1. Electromagnetic Induction
2. Alternating Current

Module-4

1. Geometrical Optics
2. Wave Optics

Module-5

1. Modern Physics
2. Nuclear Physics
3. Solids & Semiconductor Devices
4. Electromagnetic Waves

CHEMISTRY

Module-1(PC)

1. Solid State
2. Chemical Kinetics
3. Solutions and Colligative Properties

Module-2(PC)

1. Electrochemistry
2. Surface Chemistry

Module-3(IC)

1. P-Block Elements
2. Transition Elements (d & f block)
3. Co-ordination Compound
4. Metallurgy

Module-4(OC)

1. HaloAlkanes & HaloArenes
2. Alcohol, Phenol & Ether
3. Aldehyde, Ketone & Carboxylic Acid

Module-5(OC)

1. Nitrogen & Its Derivatives
2. Biomolecules & Polymers
3. Chemistry in Everyday Life

BIOLOGY

Module-1

1. Reproduction in Organisms
2. Sexual Reproduction in Flowering Plants
3. Human Reproduction
4. Reproductive Health

Module-2

1. Principles of Inheritance and Variation
2. Molecular Basis of Inheritance
3. Evolution

Module-3

1. Human Health and Disease
2. Strategies for Enhancement in Food Production
3. Microbes in Human Welfare

Module-4

1. Biotechnology: Principles and Processes
2. Biotechnology and Its Applications
3. Organisms and Populations

Module-5

1. Ecosystem
2. Biodiversity and Conservation
3. Environmental Issues