AIIMS BSc Nursing 2025 Question Paper

Question Paper (Memory-Based) with Solutions

Conducted by All India Institute of Medical Sciences (AIIMS)

General Instructions

(i) The test is of 2 hours duration.

(ii) This test paper consists of 100 questions. The exam is worth 100 marks.

(iii) Physics, Chemistry, Biology, General Knowledge.

(iv) Each question carries +1 marks for correct answer and there's a penalty of -1/3 for each incorrect answer.

1. Which gas was absent in Miller experiment?

(A) O_2

(B) H_2

(C) NH_3

(D) CH_4

Correct Answer: (A) O_2

Solution:

Concept:

The Miller-Urey experiment, conducted in 1953 by Stanley Miller and Harold Urey, was designed to test the hypothesis proposed by Oparin and Haldane regarding the origin of life on Earth. According to this hypothesis, the primitive atmosphere of Earth was reducing in nature and contained simple inorganic gases. When these gases were subjected to energy sources such as lightning, they could form complex organic molecules that are essential for life.

The experiment successfully demonstrated the abiotic synthesis of amino acids from simple gases under simulated primitive Earth conditions.

Step 1: Identify the gases used in the experiment.

The apparatus contained a mixture of gases believed to represent the primitive atmosphere.

These gases were:

$$CH_4, \quad NH_3, \quad H_2, \quad H_2O$$

where:

- CH_4 = Methane
- NH_3 = Ammonia
- H_2 = Hydrogen
- H_2O = Water vapour

Step 2: Understand the nature of primitive atmosphere.

The primitive atmosphere was considered reducing in nature. Free molecular oxygen was absent because oxygen is highly reactive and would have oxidized newly formed organic compounds.

Therefore, oxygen was deliberately excluded from the experimental setup.

Step 3: Draw the conclusion.

Among the given options, oxygen was not present in the Miller-Urey experiment.

$$\boxed{O_2}$$

Hence, the correct answer is

$$\boxed{(A)\ O_2}$$

Quick Tip: Remember the gas combination used in the Miller-Urey experiment as CHNH: Methane (CH_4), Ammonia (NH_3), Hydrogen (H_2), and Water Vapour (H_2O). Free oxygen was absent.

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2. Which disease is caused by a virus?

(1) Common cold

(2) Typhoid

(3) Malaria

(4) Pneumonia

Correct Answer: (1) Common cold

Solution:

Concept:

Diseases can be caused by different pathogens such as viruses, bacteria, protozoa, fungi, and helminths. Identifying the causative organism is important in biology as well as medicine. Viruses are acellular infectious particles that can reproduce only inside living host cells.

Step 1: Examine each option.

Common Cold

The common cold is generally caused by Rhinoviruses and sometimes by Coronaviruses. Therefore, it is a viral disease.

Typhoid

Typhoid is caused by the bacterium

$$Salmonella\ typhi$$

Hence it is a bacterial disease.

Malaria

Malaria is caused by

$$Plasmodium$$

which is a protozoan parasite.

Pneumonia

Pneumonia is commonly caused by bacteria such as

$$Streptococcus\ pneumoniae$$

although some viral forms also exist. In standard NCERT-based MCQs, pneumonia is classified as a bacterial disease.

Step 2: Select the viral disease.

Among all the options, only common cold is primarily viral.

$$\boxed{\text{Common Cold}}$$

Hence, the correct answer is

(1) Common Cold

Quick Tip: Common Cold → Virus, Typhoid → Bacteria, Malaria → Protozoa. This comparison is frequently asked in examinations.

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3. Which of the following is an autoimmune disease?

(1) Alzheimer's disease

(2) Cystic fibrosis

(3) Sickle cell anemia

(4) Rheumatoid arthritis

Correct Answer: (4) Rheumatoid arthritis

Solution:

Concept:

Autoimmune diseases occur when the body's immune system mistakenly attacks its own cells, tissues, or organs. Normally, the immune system distinguishes self from non-self, but in autoimmune disorders this recognition mechanism fails.

Step 1: Analyze each option.

Alzheimer's disease

Alzheimer's disease is a neurodegenerative disorder affecting the brain and memory.

It is not classified as an autoimmune disease.

Cystic Fibrosis

Cystic fibrosis is an inherited genetic disorder caused by mutations in the CFTR gene.

Therefore, it is not autoimmune.

Sickle Cell Anemia

Sickle cell anemia is a hereditary genetic disorder caused by mutation in the gene coding for the β-globin chain of hemoglobin.

It is not autoimmune.

Rheumatoid Arthritis

In rheumatoid arthritis, the immune system attacks the synovial membranes of joints, causing inflammation, pain, and joint deformity.

This is a classic autoimmune disease.

Step 2: Identify the correct option.

Only rheumatoid arthritis is autoimmune in nature.

Rheumatoid Arthritis

Hence, the correct answer is

(4) Rheumatoid Arthritis

Quick Tip: Important autoimmune diseases: Rheumatoid arthritis, Myasthenia gravis, Multiple sclerosis, Type-1 diabetes, and Systemic lupus erythematosus (SLE).

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4. First antibiotic is -

(A) Fungus

(B) Bacteria

(C) Virus

(D) Protozoa

Correct Answer: (A) Fungus

Solution:

Concept:

The first antibiotic discovered was Penicillin. It was discovered accidentally by Alexander Fleming in 1928 while studying bacterial cultures.

Penicillin was obtained from a fungus belonging to the genus *Penicillium*.

Step 1: Recall the discovery.

Alexander Fleming observed that bacterial growth was inhibited around colonies of the fungus *Penicillium notatum*.

The substance responsible for this inhibition was named Penicillin.

Step 2: Identify the source organism.

Penicillin is produced by a fungus.

Therefore, the first antibiotic was obtained from a fungal source.

Step 3: Select the correct option.

Among the given choices, fungus is correct.

Fungus

Hence, the correct answer is

(*A*) Fungus

Quick Tip: Penicillin was discovered by Alexander Fleming in 1928 from the fungus *Penicillium*. This is one of the most frequently asked facts in Biology.

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5. Which hormone is secreted by ovary?

(A) HCG

(B) HPL

(C) Relaxin

(D) Oxytocin

Correct Answer: (C) Relaxin

Solution:

Concept:

The ovary functions both as a reproductive organ and as an endocrine gland. It secretes several hormones that regulate the female reproductive cycle and pregnancy.

The major ovarian hormones include:

Estrogen, Progesterone, Relaxin

Step 1: Examine each hormone.

HCG

Human Chorionic Gonadotropin (HCG) is secreted by the placenta during pregnancy.

HPL

Human Placental Lactogen (HPL) is also secreted by the placenta.

Relaxin

Relaxin is secreted by the ovary, particularly by the corpus luteum during pregnancy.

It helps relax pelvic ligaments and facilitates childbirth.

Oxytocin

Oxytocin is secreted from the posterior pituitary gland.

Step 2: Identify the ovarian hormone.

Among the given options, only Relaxin is secreted by the ovary.

Relaxin

Hence, the correct answer is

(*C*) Relaxin

Quick Tip: Remember: Ovary secretes Estrogen, Progesterone and Relaxin, whereas HCG and HPL are placental hormones and Oxytocin is released from the posterior pituitary.

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6. CO_2 Acceptor in C_4 Plants -

(A) PGA

(B) RuBP

(C) PEP

(D) PGAL

Correct Answer: (C) PEP

Solution:

Concept:

Photosynthesis in C_4 plants differs from that in C_3 plants because the initial fixation of carbon dioxide occurs in mesophyll cells through a specialized pathway known as the Hatch-Slack pathway. This adaptation helps minimize photorespiration and increases photosynthetic efficiency under conditions of high temperature and intense sunlight.

In C_4 plants, the first stable carbon dioxide acceptor is not RuBP as in the Calvin cycle. Instead, a three-carbon compound called phosphoenol pyruvate (PEP) accepts carbon dioxide to form a four-carbon compound.

Step 1: Understand the first carbon fixation reaction.

In the mesophyll cells of C_4 plants, carbon dioxide combines with phosphoenol pyruvate (PEP) in the presence of the enzyme PEP carboxylase.

$$PEP + CO_2 \rightarrow OAA$$

Thus, PEP acts as the primary acceptor of carbon dioxide.

Step 2: Analyze the given options.

PGA is the first stable product of the Calvin cycle in C_3 plants and is not the primary CO_2 acceptor.

RuBP acts as the carbon dioxide acceptor in the Calvin cycle but not during the initial fixation step of the C_4 pathway.

PEP is the actual initial carbon dioxide acceptor in C_4 plants.

PGAL is a three-carbon sugar produced during later stages of photosynthesis and does not function as a carbon dioxide acceptor.

Step 3: Draw the conclusion.

Therefore, the primary carbon dioxide acceptor in C_4 plants is phosphoenol pyruvate.

PEP

Hence, the correct answer is

(C) PEP

Quick Tip: Remember: C_3 plants use RuBP as the carbon dioxide acceptor, whereas C_4 plants use PEP as the primary carbon dioxide acceptor.

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7. First product of C_4 cycle

(A) OAA

(B) PGA

(C) PEP

(D) RuBP

Correct Answer: (A) OAA

Solution:

Concept:

The C_4 pathway is also called the Hatch-Slack pathway. It is characterized by the formation of a four-carbon compound immediately after carbon dioxide fixation.

The initial fixation of carbon dioxide occurs in mesophyll cells and results in the formation of oxaloacetic acid (OAA), which is the first stable product of the pathway.

Step 1: Study the sequence of reactions.

The first reaction in C_4 photosynthesis is

$$PEP + CO_2 \xrightarrow{\text{PEP Carboxylase}} OAA$$

where OAA stands for oxaloacetic acid.

Step 2: Identify the first stable product.

Since OAA is produced immediately after carbon dioxide fixation and contains four carbon atoms, it is considered the first stable product of the C_4 pathway.

Step 3: Examine other options.

PGA is the first stable product of the Calvin cycle in C_3 plants.

PEP is the carbon dioxide acceptor and not the first product.

RuBP participates in the Calvin cycle and is not the first product of the C_4 pathway.

Step 4: Conclude.

The first stable product of the C_4 cycle is oxaloacetic acid.

$$\boxed{\text{OAA}}$$

Hence, the correct answer is

$$\boxed{(A)\ \text{OAA}}$$

Quick Tip: In C_4 plants, PEP is the first carbon dioxide acceptor and OAA is the first stable product formed after fixation.

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8. Which ion is known to suppress sperm motility?

(A) Copper

(B) Magnesium

(C) Mercury

(D) Calcium

Correct Answer: (A) Copper

Solution:

Concept:

Certain contraceptive devices utilize the action of metallic ions to prevent fertilization. Copper-releasing intrauterine devices (IUDs) are widely used because copper ions affect sperm physiology and reduce the probability of fertilization.

Copper ions interfere with sperm movement and viability within the female reproductive tract.

Step 1: Understand the action of copper ions.

Copper-releasing IUDs such as Copper-T release copper ions continuously into the uterine cavity.

These copper ions suppress sperm motility and decrease the fertilizing capacity of sperms.

Step 2: Analyze the options.

Copper ions are specifically known for reducing sperm motility.

Magnesium does not have this contraceptive role.

Mercury is toxic but is not used for suppression of sperm motility in contraception.

Calcium is important for several cellular functions and does not suppress sperm movement.

Step 3: Draw the conclusion.

Therefore, the ion responsible for suppressing sperm motility is copper.

Copper

Hence, the correct answer is

(*A*) Copper

Quick Tip: Copper-T and other copper-releasing IUDs work by increasing phagocytosis of sperms and suppressing sperm motility and fertilizing capacity.

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9. Antagonist of Gibberellin Hormone -

(A) Auxin

(B) Cytokinin

(C) Abscisic Acid (ABA)

(D) Ethylene

Correct Answer: (C) Abscisic Acid (ABA)

Solution:

Concept:

Plant growth regulators coordinate growth, development, dormancy, flowering, and fruit formation. Some hormones promote growth while others inhibit growth. Abscisic acid is generally regarded as a growth-inhibiting hormone and often acts antagonistically to gibberellins.

Step 1: Understand the role of gibberellins.

Gibberellins promote:

- Stem elongation
- Seed germination
- Breaking of dormancy
- Flowering in some plants

Thus, gibberellins are growth-promoting hormones.

Step 2: Understand the role of ABA.

Abscisic acid promotes:

- Seed dormancy
- Bud dormancy
- Stomatal closure
- Growth inhibition

These effects are generally opposite to those of gibberellins.

Step 3: Identify the antagonist.

Since ABA opposes many actions of gibberellins, it is regarded as their physiological antagonist.

ABA

Hence, the correct answer is

$\boxed{(C)\text{ Abscisic Acid}}$

Quick Tip: Gibberellins promote seed germination, whereas ABA promotes seed dormancy. This opposite action makes ABA the antagonist of gibberellins.

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10. Protonema is a characteristic of -

(A) Ulothrix

(B) Polytrichum

(C) Polysiphonia

(D) Marchantia

Correct Answer: (B) Polytrichum

Solution:

Concept:

Bryophytes exhibit a distinct life cycle involving a gametophytic stage and a sporophytic stage. In mosses, spores germinate to form a green, filamentous structure known as protonema. This protonema subsequently develops into the mature leafy gametophyte.

Therefore, protonema is a characteristic stage in the life cycle of mosses.

Step 1: Understand what protonema is.

Protonema is a branched, filamentous, green structure that develops from the germination of a moss spore.

It represents the juvenile stage of the gametophyte.

Step 2: Examine the options.

Ulothrix is a green alga and does not possess a protonema stage.

Polytrichum is a moss and exhibits a well-developed protonema stage.

Polysiphonia is a red alga and lacks protonema.

Marchantia is a liverwort; the characteristic protonema stage is associated with mosses rather than liverworts.

Step 3: Draw the conclusion.

Among the given options, Polytrichum shows a protonema stage.

Polytrichum

Hence, the correct answer is

(*B*) Polytrichum

Quick Tip: Protonema is characteristic of mosses such as Funaria and Polytrichum. It develops from spores and later forms the leafy gametophyte.

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11. What family does house fly belong to?

(A) Insecta

(B) Muscidae

(C) Diptera

(D) Formicidae

Correct Answer: (B) Muscidae

Solution:

Concept:

Biological classification places organisms into different taxonomic categories such as Kingdom, Phylum, Class, Order, Family, Genus, and Species. Every organism occupies a definite position in this hierarchy.

The common house fly is scientifically known as

Musca domestica

and belongs to a specific family within the order Diptera.

Step 1: Recall the classification of house fly.

The classification of house fly is:

Kingdom → *Animalia*

Phylum → *Arthropoda*

Class → *Insecta*

Order → *Diptera*

Family → *Muscidae*

Genus → *Musca*

Species → *domestica*

Step 2: Examine the options.

Insecta is the class and not the family.

Muscidae is the correct family.

Diptera is the order.

Formicidae is the family of ants.

Step 3: Conclude.

The house fly belongs to the family Muscidae.

Muscidae

Hence, the correct answer is

(*B*) Muscidae

Quick Tip: Remember: House fly (*Musca domestica*) belongs to Order Diptera and Family Muscidae.

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12. RNA without protein capsid -

(A) Viroid

(B) Lichen

(C) Prion

(D) Virus

Correct Answer: (A) Viroid

Solution:

Concept:

Various infectious agents differ in their structural organization. Some contain nucleic acids and proteins, while others may contain only nucleic acid or only protein.

Viroids are the smallest known infectious agents and are composed solely of RNA molecules.

Step 1: Understand what a viroid is.

Viroids were discovered by T.O. Diener.

A viroid consists of:

Only circular single-stranded RNA

and lacks any protective protein coat.

Step 2: Compare with other options.

Viruses possess both nucleic acid and a protein coat called a capsid.

Prions are infectious protein particles and do not contain nucleic acids.

Lichens are symbiotic associations between algae and fungi.

Step 3: Identify the correct answer.

The infectious agent containing RNA but lacking a protein capsid is the viroid.

Viroid

Hence, the correct answer is

(*A*) Viroid

Quick Tip: Viroid = RNA only. Prion = Protein only. Virus = Nucleic acid + Protein coat.

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13. Sex Determination in Human -

(A) XY

(B) XO

(C) ZW

(D) Haplodiploid

Correct Answer: (A) XY

Solution:

Concept:

Sex determination is the mechanism through which the sex of an individual is established.

Different organisms exhibit different systems of sex determination.

Humans possess an XX-XY type mechanism of sex determination.

Step 1: Understand the chromosomal constitution.

In humans:

$$\text{Female} = XX$$

$$\text{Male} = XY$$

The female produces only X-bearing ova.

The male produces two kinds of sperms:

$$X\text{-bearing sperm}$$

and

$$Y\text{-bearing sperm}$$

Step 2: Determine how sex is decided.

If an X-bearing sperm fertilizes the ovum:

$$XX$$

a female child is produced.

If a Y-bearing sperm fertilizes the ovum:

$$XY$$

a male child is produced.

Thus, sex determination in humans follows the XY mechanism.

Step 3: Examine other options.

XO occurs in certain insects.

ZW occurs in birds.

Haplodiploidy occurs in honey bees and some other insects.

Step 4: Conclude.

Humans exhibit XY type sex determination.

$$\boxed{XY}$$

Hence, the correct answer is

$$\boxed{(A)\ XY}$$

Quick Tip: Humans: Female = XX, Male = XY. The father determines the sex of the offspring because sperms carry either X or Y chromosome.

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14. Which is not part of stomatal apparatus?

(A) Guard cells

(B) Subsidiary cells

(C) Stomatal pore

(D) Cuticle

Correct Answer: (D) Cuticle

Solution:

Concept:

The stomatal apparatus is a specialized structure present in the epidermis of leaves. It regulates gaseous exchange and transpiration.

A typical stomatal apparatus consists of a pore and associated cells that help control opening and closing.

Step 1: Identify the components of stomatal apparatus.

A stomatal apparatus consists of:

- Stomatal pore
- Two guard cells

- Subsidiary cells (in many plants)

These components collectively regulate gas exchange.

Step 2: Analyze each option.

Guard cells are essential components.

Subsidiary cells are associated cells surrounding guard cells.

Stomatal pore is the opening through which gaseous exchange occurs.

Cuticle is a waxy protective covering present on the epidermis and is not considered a component of the stomatal apparatus.

Step 3: Conclude.

Therefore, cuticle is not a part of the stomatal apparatus.

$$\boxed{\text{Cuticle}}$$

Hence, the correct answer is

$$\boxed{(D)\ \text{Cuticle}}$$

Quick Tip: Stomatal apparatus = Stomatal pore + Guard cells + Subsidiary cells. Cuticle is a protective epidermal layer and not a component of the apparatus.

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15. Which of the following statements about binomial nomenclature is incorrect?

(A) The genus name is written with a capital first letter.

(B) The species epithet is written in small letters.

(C) Both words are separately underlined when handwritten.

(D) When typed, both names are italicized.

Correct Answer: No incorrect statement among the given options

Solution:

Concept:

Binomial nomenclature is the universally accepted system of naming organisms developed by the Swedish scientist Carolus Linnaeus. Under this system, every organism is assigned a

scientific name consisting of two words.

The first word represents the genus and the second word represents the species epithet.

Step 1: Examine statement (A).

The genus name always begins with a capital letter.

Example:

Homo sapiens

Here, Homo begins with a capital letter.

Thus statement (A) is correct.

Step 2: Examine statement (B).

The species epithet always begins with a small letter.

In

Homo sapiens

“sapiens” starts with a small letter.

Thus statement (B) is correct.

Step 3: Examine statement (C).

When scientific names are handwritten, the genus and species names are underlined separately.

Thus statement (C) is also correct.

Step 4: Examine statement (D).

When scientific names are printed or typed, they are written in italics.

Thus statement (D) is correct.

Step 5: Draw the conclusion.

All four statements follow the internationally accepted rules of binomial nomenclature.

Therefore, none of the given statements is incorrect.

All statements are correct

Hence, the question appears to contain an error because no incorrect statement is present among the options.

Quick Tip: Rules of binomial nomenclature: Genus starts with a capital letter, species starts with a small letter, names are italicized when printed and separately underlined when handwritten.

16. Which of the following statements about *Drosophila melanogaster* (fruit fly) is incorrect in the context of its use in genetic experiments?

(A) It has a short 2-week life cycle

(B) Grows in complex rare medium

(C) Shows clear sex differentiation

(D) A single mating produces a large population

Correct Answer: (B) Grows in complex rare medium

Solution:

Concept:

Drosophila melanogaster, commonly known as the fruit fly, is one of the most extensively used model organisms in genetics. Scientists prefer this organism because it is easy to culture in laboratories, has a short life cycle, produces a large number of offspring, and exhibits clear hereditary traits. The pioneering genetic experiments conducted by Thomas Hunt Morgan on *Drosophila* helped establish the chromosomal theory of inheritance.

To identify the incorrect statement, we must examine each option carefully.

Step 1: Analysis of Option (A)

Fruit flies complete their life cycle in approximately 10–14 days under suitable laboratory conditions. This short generation time allows researchers to study multiple generations within a relatively short period.

Therefore, this statement is correct.

Step 2: Analysis of Option (B)

One of the major advantages of using *Drosophila* is that it can be easily grown on a simple and inexpensive culture medium consisting of materials such as banana, yeast, cornmeal, and agar. The statement that it grows in a “complex rare medium” is incorrect because no specialized or rare growth medium is required.

Therefore, Option (B) is the incorrect statement.

Step 3: Analysis of Option (C)

Male and female fruit flies exhibit clear sexual dimorphism. Males are generally smaller and possess darker posterior abdominal segments, whereas females are larger with pointed abdomens.

Thus, this statement is correct.

Step 4: Analysis of Option (D)

A single mating can produce hundreds of offspring. This large progeny size helps geneticists study inheritance patterns with statistical reliability.

Therefore, this statement is also correct.

Conclusion:

Among all the given options, only Option (B) is incorrect.

(B) Grows in complex rare medium

Quick Tip: Remember the major advantages of *Drosophila*: short life cycle, high fertility, easy maintenance, and distinct hereditary traits.

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17. Alternate phyllotaxy is found in which of the following plants?

(A) Calotropis

(B) Guava

(C) Alstonia

(D) China Rose

Correct Answer: (D) China Rose

Solution:

Concept:

Phyllotaxy refers to the arrangement of leaves on the stem or branch of a plant. The three common types are:

- Alternate phyllotaxy

- Opposite phyllotaxy
- Whorled phyllotaxy

Understanding examples of each type is important in plant morphology.

Step 1: Understanding Alternate Phyllotaxy

In alternate phyllotaxy, a single leaf arises at each node and the leaves are arranged alternately along the stem.

Examples include:

- China Rose
- Mustard
- Sunflower

Step 2: Examine Option (A)

Calotropis exhibits opposite phyllotaxy where two leaves arise at the same node in opposite directions.

Therefore, Option (A) is incorrect.

Step 3: Examine Option (B)

Guava also exhibits opposite phyllotaxy.

Hence, Option (B) is incorrect.

Step 4: Examine Option (C)

Alstonia exhibits whorled phyllotaxy in which more than two leaves arise from a single node.

Hence, Option (C) is incorrect.

Step 5: Examine Option (D)

China Rose is the classic example of alternate phyllotaxy.

Hence, Option (D) is correct.

(D) China Rose

Quick Tip: Remember: China Rose = Alternate, Guava and Calotropis = Opposite, Alstonia = Whorled.

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18. Absent in female frogs are:

(A) Trunk

(B) Copulatory pad

(C) Webbed feet

(D) Tympanum

Correct Answer: (B) Copulatory pad

Solution:

Concept:

Male and female frogs exhibit certain sexual differences. During the breeding season, males develop specialized structures that assist in mating.

One such structure is the copulatory pad or nuptial pad.

Step 1: Examine Option (A)

Both male and female frogs possess a trunk region.

Hence, this cannot be absent in females.

Step 2: Examine Option (B)

Copulatory pads are specialized rough pads present on the forelimbs of male frogs.

These structures help males firmly grasp females during amplexus.

Female frogs do not possess copulatory pads.

Therefore, Option (B) is correct.

Step 3: Examine Option (C)

Webbed feet are present in both sexes and assist in swimming.

Hence, this option is incorrect.

Step 4: Examine Option (D)

The tympanum is present in both male and female frogs although its size may differ.

Hence, this option is incorrect.

(B) Copulatory pad

Quick Tip: A quick way to identify male frogs is the presence of vocal sacs and copulatory (nuptial) pads during the breeding season.

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19. Which of the following statements about Kingdom Monera is not true?

(A) All bacteria are heterotrophs

(B) Cyanobacteria are photosynthetic

(C) Anabaena is a cyanobacterium

(D) Methanogens live in harsh habitats

Correct Answer: (A) All bacteria are heterotrophs

Solution:

Concept:

Kingdom Monera includes all prokaryotic organisms. Bacteria exhibit remarkable diversity in nutrition and habitat.

They may be:

- Autotrophic
- Heterotrophic
- Photosynthetic
- Chemosynthetic

Therefore, not all bacteria have the same nutritional mode.

Step 1: Examine Option (A)

Many bacteria are heterotrophic, but several bacteria are autotrophic.

Examples:

- Cyanobacteria are photosynthetic autotrophs.
- Nitrifying bacteria are chemosynthetic autotrophs.

Hence, the statement that all bacteria are heterotrophs is false.

Step 2: Examine Option (B)

Cyanobacteria contain chlorophyll and perform photosynthesis.

Thus, this statement is true.

Step 3: Examine Option (C)

Anabaena is a filamentous cyanobacterium capable of nitrogen fixation.

Thus, this statement is true.

Step 4: Examine Option (D)

Methanogens are archaebacteria that inhabit anaerobic and extreme environments such as marshes and the rumen of cattle.

Hence, this statement is true.

(A) All bacteria are heterotrophs

Quick Tip: Remember that bacteria show every major nutritional mode. Therefore, statements beginning with "all bacteria are heterotrophs" are usually incorrect.

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20. Identify the missing region in the root tip sequence:

(A) Root cap

(B) Cortex

(C) Endodermis

(D) Pericycle

Correct Answer: (A) Root cap

Solution:

Concept:

The root apex consists of different regions arranged in a definite sequence. Each region performs a specific role in root growth and development.

The sequence from the upper portion toward the tip is:

Maturation Region → Elongation Region → Meristematic Region → Root Cap

Step 1: Region of Maturation

Cells become fully differentiated and root hairs develop in this region.

Step 2: Region of Elongation

Cells rapidly increase in size, causing root growth in length.

Step 3: Region of Meristematic Activity

Cells actively divide through mitosis.

Step 4: Root Cap

The root cap lies at the extreme tip and protects the delicate meristematic tissue from mechanical injury as the root penetrates the soil.

Thus, the missing structure after the meristematic region is the root cap.

(A) Root cap

Quick Tip: Root tip sequence from top to bottom: Maturation Region → Elongation Region → Meristematic Region → Root Cap.

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21. Which of the following statements about pollen grains is incorrect?

(A) Vegetative cell is bigger and generative cell is smaller

(B) The outer layer of pollen grain, called exine, is made up of sporopollenin

(C) Pollen grains lose their viability immediately after being released from the anther

(D) Pollen grains are produced in the ovule of a flower

Correct Answer: (D) Pollen grains are produced in the ovule of a flower

Solution:

Concept:

Pollen grains are the male gametophytes of flowering plants. They are produced inside the microsporangia of the anther and play an essential role in plant reproduction. A mature pollen grain generally consists of a larger vegetative cell and a smaller generative cell enclosed within protective walls known as exine and intine.

To identify the incorrect statement, each option must be analyzed carefully using the structure and development of pollen grains.

Step 1: Examine Option (A)

A mature pollen grain generally contains two unequal cells. The larger cell is called the

vegetative cell, while the smaller cell is known as the generative cell.
The vegetative cell contains abundant cytoplasm and food reserves, whereas the generative cell ultimately gives rise to two male gametes.
Therefore, Option (A) is a correct statement.

Step 2: Examine Option (B)

The outer wall of the pollen grain is called the exine.
Exine is composed of sporopollenin, one of the most resistant organic substances known in nature. It is highly resistant to high temperatures, strong acids, strong alkalis, and enzymatic degradation.
Therefore, Option (B) is also correct.

Step 3: Examine Option (C)

Although pollen viability decreases after release from the anther, pollen grains do not always lose viability immediately.
In cereals such as rice and wheat, viability may last for only a few minutes, whereas in many other flowering plants, pollen grains can remain viable for several days, weeks, or even months under suitable conditions.
Thus, the statement is scientifically inaccurate.

Step 4: Examine Option (D)

Pollen grains are produced inside the anther, specifically within the microsporangia or pollen sacs.
The ovule is a female reproductive structure that produces the embryo sac, not pollen grains.
Hence, Option (D) is clearly incorrect.

Conclusion:

Pollen grains are produced in the anther and not in the ovule.

(D) Pollen grains are produced in the ovule of a flower

Quick Tip: Remember: Anther produces pollen grains (male gametophyte), whereas ovule produces the embryo sac (female gametophyte).

22. Which type of DNA is primarily used in DNA fingerprinting?

(A) Coding DNA

(B) Mitochondrial DNA

(C) Satellite DNA / Non-coding repetitive DNA

(D) Ribosomal DNA

Correct Answer: (C) Satellite DNA / Non-coding repetitive DNA

Solution:

Concept:

DNA fingerprinting is a molecular technique used to identify individuals based on unique DNA patterns. The technique relies on highly variable repetitive DNA sequences that differ significantly among individuals.

These repetitive DNA regions are collectively known as satellite DNA.

Step 1: Understanding DNA Fingerprinting

Every human being possesses a unique pattern of repetitive DNA sequences except identical twins.

These sequence variations allow scientists to identify individuals accurately.

Step 2: Role of Satellite DNA

Satellite DNA consists of highly repetitive non-coding sequences.

Because the number of repeats varies among individuals, these regions exhibit a high degree of polymorphism.

This polymorphism forms the basis of DNA fingerprinting.

Step 3: Examine Other Options

Coding DNA generally remains highly conserved because it determines protein synthesis.

Mitochondrial DNA is useful in evolutionary and maternal lineage studies but is not the primary DNA used in classical DNA fingerprinting.

Ribosomal DNA is also relatively conserved and therefore unsuitable for individual identification.

Step 4: Final Identification

Since satellite DNA exhibits maximum variation among individuals, it serves as the primary material for DNA fingerprinting.

(C) Satellite DNA / Non-coding repetitive DNA

Quick Tip: DNA fingerprinting is based on polymorphism in repetitive non-coding DNA sequences known as satellite DNA or VNTRs.

---

23. What is the function of the tapetum?

(A) Provide protection

(B) Produce pollen grains

(C) Provide nourishment to the developing pollen grains

(D) Store and protect pollen grains

Correct Answer: (C) Provide nourishment to the developing pollen grains

Solution:

Concept:

The tapetum is the innermost layer of the anther wall. It surrounds the developing microspores and serves as a nutritive tissue.

The proper functioning of the tapetum is essential for successful pollen development.

Step 1: Structure of Anther Wall

The anther wall consists of four layers:

- Epidermis
- Endothecium
- Middle layers

- Tapetum

Among these, the tapetum is the innermost layer.

Step 2: Function of Tapetum

Tapetal cells are rich in cytoplasm and nutrients.

They provide nourishment and metabolic support to developing microspores and pollen grains.

Step 3: Additional Functions

Tapetum also contributes materials required for pollen wall formation and supplies enzymes involved in pollen maturation.

Step 4: Evaluation of Options

Protection is mainly provided by outer wall layers.

Pollen grains are formed from microspore mother cells, not by tapetum.

Storage is not the primary role of tapetal tissue.

Therefore, nourishment of developing pollen grains is its most important function.

(C) Provide nourishment to the developing pollen grains

Quick Tip: Tapetum = Nutritive layer of the anther. Always associate tapetum with nourishment and pollen development.

---

24. Which of the following fishes has four pairs of gills covered by an operculum?

(A) Petromyzon

(B) Pristis

(C) Trygon

(D) Labeo (Rohu), Catla, Clarias (Magur)

Correct Answer: (D) Labeo (Rohu), Catla, Clarias (Magur)

Solution:

Concept:

Bony fishes (Osteichthyes) possess four pairs of gills covered by a bony flap called the operculum.

This operculum protects the gills and helps in respiration.

Step 1: Understanding Operculum

An operculum is a movable bony covering present over the gill chamber in bony fishes.

It protects delicate gill filaments and facilitates water flow during respiration.

Step 2: Examine Petromyzon

Petromyzon is a jawless fish belonging to Cyclostomata.

It lacks an operculum.

Step 3: Examine Pristis and Trygon

Pristis (sawfish) and Trygon (stingray) belong to Chondrichthyes.

Cartilaginous fishes possess multiple gill slits but lack an operculum.

Step 4: Examine Labeo, Catla and Clarias

These are bony fishes belonging to Osteichthyes.

They possess four pairs of gills covered by an operculum.

Therefore, Option (D) is correct.

(D) Labeo (Rohu), Catla, Clarias (Magur)

Quick Tip: Operculum is characteristic of bony fishes (Osteichthyes), whereas cartilaginous fishes possess exposed gill slits.

---

25. Which of the following statements is true regarding open vascular bundles?

(A) They are present in dicot stem

(B) Secondary growth is absent

(C) They are found in monocot root

(D) Xylem and phloem are not separated by cambium

Correct Answer: (A) They are present in dicot stem

Solution:

Concept:

A vascular bundle consists of xylem and phloem tissues. Depending on the presence or absence of cambium between these tissues, vascular bundles are classified as open or closed.

Step 1: Definition of Open Vascular Bundle

When cambium is present between xylem and phloem, the vascular bundle is called an open vascular bundle.

Such bundles possess the ability to undergo secondary growth.

Step 2: Occurrence in Plants

Open vascular bundles are characteristic of dicot stems.

The cambium remains active and produces secondary xylem and secondary phloem.

Step 3: Examine Option (B)

Secondary growth is not absent; rather, it is possible because cambium is present.

Therefore, Option (B) is incorrect.

Step 4: Examine Option (C)

Monocot roots do not possess typical open vascular bundles responsible for extensive secondary growth.

Hence, this statement is incorrect.

Step 5: Examine Option (D)

In open vascular bundles, xylem and phloem are separated by cambium.

Therefore, this statement is incorrect.

Conclusion:

Open vascular bundles are characteristic of dicot stems.

(A) They are present in dicot stem

Quick Tip: Open vascular bundle = Cambium present = Secondary growth possible = Typical feature of dicot stems.

---

26. Open vascular bundle and secondary growth are present in:

(A) Monocot stem

(B) Monocot root

(C) Dicot stem

(D) Dicot leaf

Correct Answer: (C) Dicot stem

Solution:

Concept:

Vascular bundles are the conducting tissues of plants and consist of xylem and phloem. Depending upon the presence or absence of cambium between xylem and phloem, vascular bundles are classified as open or closed.

An open vascular bundle contains cambium, whereas a closed vascular bundle lacks cambium. Since cambium is a meristematic tissue capable of producing new vascular elements, open vascular bundles can undergo secondary growth.

Secondary growth is the increase in the girth or thickness of plant organs due to the activity of lateral meristems such as vascular cambium and cork cambium.

Step 1: Understanding Open Vascular Bundles

In an open vascular bundle, a strip of cambium is present between xylem and phloem.

The cambium continuously divides and forms secondary xylem towards the inner side and secondary phloem towards the outer side.

Therefore, open vascular bundles are directly associated with secondary growth.

Step 2: Analysis of Monocot Stem

Monocot stems possess scattered vascular bundles.

These bundles are closed because cambium is absent.

Since cambium is absent, secondary growth generally does not occur.

Hence, Option (A) is incorrect.

Step 3: Analysis of Monocot Root

Monocot roots generally do not show significant secondary growth because vascular cambium is either absent or poorly developed.

Therefore, Option (B) is incorrect.

Step 4: Analysis of Dicot Stem

Dicot stems possess open vascular bundles arranged in a ring.

The cambium remains active and produces secondary vascular tissues.

Consequently, secondary growth occurs and increases stem thickness.

Thus, Option (C) is correct.

Step 5: Analysis of Dicot Leaf

Leaves generally do not undergo secondary growth like stems.

Hence, Option (D) is incorrect.

Conclusion:

Open vascular bundles and secondary growth are characteristic features of dicot stems.

(C) Dicot stem

Quick Tip: Remember the sequence: Open vascular bundle ⇒ Cambium present ⇒ Secondary growth possible ⇒ Typical feature of dicot stems.

---

27. Match the following:

Column A	-	Column B
1. Delivery of baby	-	a. Parturition
2. Embryo development in female body	-	b. Gestation
3. Introducing sperm into female tract	-	c. Insemination

(A) 1-a, 2-b, 3-c

(B) 1-b, 2-a, 3-c

(C) 1-c, 2-b, 3-a

(D) 1-a, 2-c, 3-b

Correct Answer: (A) 1-a, 2-b, 3-c

Solution:

Concept:

Human reproduction involves several important biological processes. Each process has a specific scientific term associated with it. Understanding these terms is essential for studying reproductive biology.

Step 1: Identify Delivery of Baby

The process of childbirth or delivery of the fully developed fetus is called parturition.

Therefore,

$$1 \rightarrow a$$

Step 2: Identify Embryo Development in Female Body

The period during which the embryo develops inside the uterus from fertilization until birth is called gestation.

Therefore,

$$2 \rightarrow b$$

Step 3: Identify Introduction of Sperm into Female Reproductive Tract

The deposition or introduction of sperm into the female reproductive tract is known as insemination.

Therefore,

$$3 \to c$$

Step 4: Form the Correct Matching

Combining all matches:

$$1-a, \quad 2-b, \quad 3-c$$

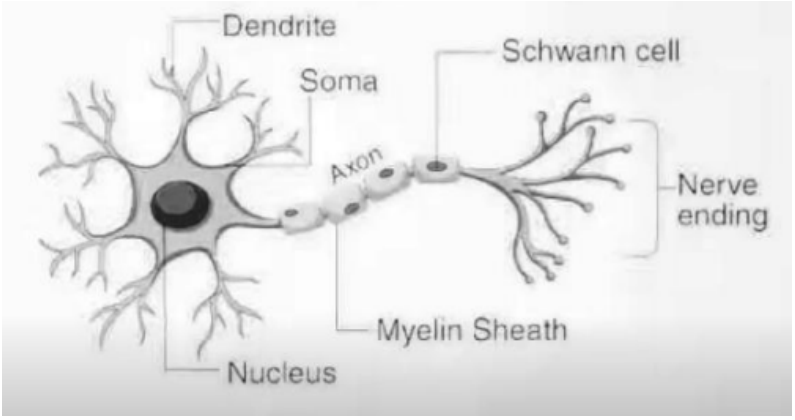
This corresponds to Option (A).

$$\boxed{\text{(A) } 1-a,\ 2-b,\ 3-c}$$

Quick Tip: Parturition = Childbirth, Gestation = Pregnancy period, Insemination = Introduction of sperm into female reproductive tract.

---

28. Identify the labels a, b and c in the neuron diagram.



(A) Dendrite

(B) Schwann Cell

(C) Synaptic Knob

(D) Diagram Based Question

Correct Answer: Diagram Required

Solution:

Concept:

This question depends on a labelled neuron diagram. Since the figure is not provided in the text, the exact identification of labels a, b, and c cannot be determined with certainty.

Generally, in a neuron:

- Dendrites receive nerve impulses.
- Schwann cells form the myelin sheath around axons in the peripheral nervous system.
- Synaptic knobs are terminal swellings at the end of axons that release neurotransmitters.

Step 1: Dendrite

Dendrites are short, branched projections that receive signals from receptors or other neurons.

Step 2: Schwann Cell

Schwann cells wrap around the axon and form the myelin sheath.

Step 3: Synaptic Knob

The terminal end of the axon expands into a synaptic knob containing neurotransmitter vesicles.

Conclusion:

The exact answer requires the original diagram. Please provide the figure for accurate labeling.

Quick Tip: In most neuron diagrams: Dendrites are near the cell body, Schwann cells surround the axon, and synaptic knobs are located at the terminal ends of the axon.

---

29. Why is the activity of juxtaglomerular (JG) cells required?

(A) To increase blood glucose levels

(B) To regulate blood pressure and blood volume

(C) To reabsorb urea from urine

(D) To digest proteins in the stomach

Correct Answer: (B) To regulate blood pressure and blood volume

Solution:

Concept:

Juxtaglomerular (JG) cells are specialized smooth muscle cells located in the walls of the afferent arteriole near the glomerulus of the nephron.

These cells play a crucial role in maintaining blood pressure and blood volume through the renin-angiotensin-aldosterone system (RAAS).

Step 1: Location of JG Cells

JG cells are found in close association with the glomerulus and form part of the juxtaglomerular apparatus (JGA).

Step 2: Function of JG Cells

Whenever blood pressure falls, JG cells secrete renin.

Renin initiates a hormonal cascade that eventually increases blood pressure and blood volume.

Step 3: Evaluate Other Options

Blood glucose regulation is mainly controlled by insulin and glucagon.

Urea reabsorption occurs in kidney tubules and is not the primary function of JG cells.

Protein digestion occurs in the stomach through enzymes such as pepsin.

Thus, Options (A), (C), and (D) are incorrect.

Conclusion:

JG cells are required for maintaining normal blood pressure and blood volume.

(B) To regulate blood pressure and blood volume

Quick Tip: JG Cells → Renin Secretion → RAAS Activation → Increased Blood Pressure and Blood Volume.

---

30. What is the function of renin secreted by juxtaglomerular (JG) cells?

(A) Increase blood pressure

(B) Increase blood volume

(C) Decrease blood volume

(D) A and B

Correct Answer: (D) A and B

Solution:

Concept:

Renin is an enzyme released by juxtaglomerular cells when blood pressure or blood volume decreases.

It initiates the renin-angiotensin-aldosterone system (RAAS), which helps restore circulatory homeostasis.

Step 1: Release of Renin

When blood pressure falls, JG cells detect the change and secrete renin into the bloodstream.

Step 2: Formation of Angiotensin II

Renin converts angiotensinogen into angiotensin I.

Angiotensin I is subsequently converted into angiotensin II.

Angiotensin II is a powerful vasoconstrictor.

Step 3: Increase in Blood Pressure

Vasoconstriction narrows blood vessels, thereby increasing blood pressure.

Thus, renin indirectly causes an increase in blood pressure.

Step 4: Increase in Blood Volume

Angiotensin II stimulates secretion of aldosterone from the adrenal cortex.

Aldosterone enhances sodium and water reabsorption in the kidneys.

As a result, blood volume increases.

Step 5: Evaluate the Options

Option (A) is correct because blood pressure increases.

Option (B) is correct because blood volume increases.

Option (C) is incorrect because blood volume does not decrease.

Therefore, the best answer is Option (D).

(D) A and B

Quick Tip: Renin activates RAAS. The ultimate effects are increased blood pressure, increased sodium retention, increased water retention, and increased blood volume.

---

31. What will be the oxidation number of the elements in O_3, P_4 and S_8?

(a) $-1, 0, +1$

(b) $1, +1, -2$

(c) $0, 0, 0$

(d) $-2, 1, 0$

Correct Answer: (c) $0, 0, 0$

Solution:

Concept:

The oxidation number of an element represents the apparent charge that an atom would possess if all bonds were considered completely ionic. For elements present in their free or elemental state, the oxidation number is always zero irrespective of the molecular complexity of the species.

Examples of elemental forms include:

$$H_2, \quad O_2, \quad O_3, \quad P_4, \quad S_8, \quad N_2$$

Even though these molecules contain multiple atoms bonded together, all atoms belong to the same element and share electrons equally. Therefore, no atom acquires a positive or negative oxidation state.

Step 1: Determine the oxidation number of oxygen in ozone (O_3).

Ozone is an allotrope of oxygen consisting only of oxygen atoms.

$$O_3$$

Since it is the elemental form of oxygen, every oxygen atom has oxidation number:

$$0$$

Step 2: Determine the oxidation number of phosphorus in P_4.

White phosphorus exists as:

$$P_4$$

Since phosphorus is present in its elemental form, the oxidation number of each phosphorus atom is:

$$0$$

Step 3: Determine the oxidation number of sulfur in S_8.

Sulfur commonly exists as:

$$S_8$$

This is also an elemental form of sulfur.

Therefore,

$$\text{Oxidation number of sulfur} = 0$$

Hence,

$$O_3 : 0, \qquad P_4 : 0, \qquad S_8 : 0$$

Therefore, the correct option is

$$\boxed{(c)}$$

Quick Tip: The oxidation number of any element in its free or elemental state is always zero, regardless of whether it exists as monoatomic, diatomic, or polyatomic molecules.

---

32. Which of the following is true for an adiabatic process?

(1) $\Delta H = 0$

(2) $\Delta W = 0$

(3) $\Delta Q = 0$

(4) $\Delta V = 0$

Correct Answer: (3) $\Delta Q = 0$

Solution:

Concept:

An adiabatic process is a thermodynamic process in which no heat is exchanged between the system and the surroundings.

The defining condition for an adiabatic process is:

$$q = 0$$

According to the first law of thermodynamics,

$$\Delta U = q + w$$

For an adiabatic process,

$$q = 0$$

therefore,

$$\Delta U = w$$

Thus, the change in internal energy is entirely due to work done.

Step 1: Recall the definition of an adiabatic process.

In an adiabatic process, the system is perfectly insulated.

Hence,

$$\boxed{\Delta Q = 0}$$

Step 2: Examine other options.

$$\Delta H = 0$$

is not generally true.

$$\Delta W = 0$$

is also not true because work may be done during expansion or compression.

Similarly,

$$\Delta V = 0$$

is not a necessary condition.

Step 3: Select the correct statement.

The only universally true condition for an adiabatic process is:

$$\boxed{\Delta Q = 0}$$

Hence, the correct option is

$$\boxed{(3)}$$

Quick Tip: Remember: Adiabatic means "No Heat Exchange". Therefore $q = 0$ is always the defining condition.

---

33. What products are obtained from the hydrolysis of lactose?

(a) Lactose + Glucose

(b) Glucose + Glucose

(c) Glucose + Fructose

(d) Galactose + Glucose

Correct Answer: (d) Galactose + Glucose

Solution:

Concept:

Lactose is a disaccharide commonly known as milk sugar. It consists of two monosaccharide units joined through a glycosidic linkage.

The constituent monosaccharides are:

$$\text{Glucose} + \text{Galactose}$$

Upon hydrolysis, the glycosidic bond breaks and the constituent monosaccharides are obtained.

Step 1: Identify the composition of lactose.

Lactose contains:

$$\text{Galactose} + \text{Glucose}$$

joined by a β-glycosidic bond.

Step 2: Write the hydrolysis reaction.

$$\text{Lactose} + H_2O \longrightarrow \text{Glucose} + \text{Galactose}$$

The water molecule breaks the glycosidic linkage.

Step 3: Match with the given options.

The products formed are:

$$\boxed{\text{Galactose} + \text{Glucose}}$$

Therefore, the correct option is

$$\boxed{(d)}$$

Quick Tip: Important disaccharides: Sucrose = Glucose + Fructose, Lactose = Glucose + Galactose, Maltose = Glucose + Glucose.

34. What is the electronic configuration of palladium?

(A) $[Kr]5s^2\,4d^8$

(B) $[Kr]5s^1\,4d^9$

(C) $[Kr]4d^{10}$

(D) $[Kr]5s^2\,4d^{10}$

Correct Answer: (C) $[Kr]4d^{10}$

Solution:

Concept:

Palladium is one of the exceptional transition elements that does not follow the expected Aufbau filling pattern.

Its atomic number is:

$$Z = 46$$

The expected configuration would be:

$$[Kr]5s^2\,4d^8$$

However, greater stability is achieved when the $4d$ subshell becomes completely filled.

Step 1: Determine the atomic number.

Palladium contains:

$$46 \text{ electrons}$$

The first 36 electrons constitute the krypton core.

$$[Kr]$$

Step 2: Apply the exceptional configuration rule.

Instead of

$$[Kr]5s^2\,4d^8$$

electrons rearrange to produce a completely filled $4d$ subshell.

$$[Kr]4d^{10}$$

Step 3: Identify the correct option.

The accepted electronic configuration of palladium is:

$$\boxed{[Kr]4d^{10}}$$

Therefore, the correct option is

$$\boxed{(C)}$$

Quick Tip: Palladium is a famous exception. Its ground-state configuration is $[Kr]4d^{10}$ with an empty $5s$ orbital.

---

35. If 200 mL aqueous solution of 10 g NaOH is prepared, find the molarity of the resulting solution.

(a) 1.25 M

(b) 1.5 M

(c) 1.66 M

(d) 12.5 M

Correct Answer: (a) 1.25 M

Solution:

Concept:

Molarity is defined as the number of moles of solute dissolved in one litre of solution.

$$M = \frac{\text{Number of moles}}{\text{Volume in litre}}$$

To calculate molarity, we first determine the number of moles from the given mass and molar mass.

Step 1: Calculate the molar mass of sodium hydroxide.

$$NaOH = 23 + 16 + 1$$

$$= 40\, g\, mol^{-1}$$

Step 2: Calculate the number of moles present in 10 g NaOH.

$$n = \frac{\text{Mass}}{\text{Molar Mass}}$$

$$n = \frac{10}{40}$$

$$n = 0.25 \text{ mol}$$

Step 3: Convert volume into litres.

$$200\, mL = \frac{200}{1000}$$

$$= 0.2\, L$$

Step 4: Calculate molarity.

$$M = \frac{0.25}{0.2}$$

$$M = 1.25$$

Therefore,

$$\boxed{M = 1.25\, M}$$

Hence, the correct option is

$$\boxed{(a)}$$

Quick Tip: For molarity problems, always convert volume into litres before substituting into the formula $M = \frac{n}{V}$.

---

36. Atomic radii and ionic radius of lanthanoid series increases from La to Lu due to?

(1) Lanthanoid contraction

(2) Actinoid contraction

(3) Intermolecular bonding

(4) None

Correct Answer: (1) Lanthanoid contraction

Solution:

Concept:

The lanthanoids comprise fourteen elements from cerium ($Z = 58$) to lutetium ($Z = 71$). As we move across the lanthanoid series, electrons are progressively added to the $4f$-subshell. The $4f$-electrons are poor at shielding the nuclear charge. Consequently, the effective nuclear charge experienced by the outer electrons increases steadily from left to right in the series. As a result, the electrons are pulled closer towards the nucleus, causing a gradual decrease in both atomic and ionic radii.

This gradual decrease in size across the lanthanoid series is known as **lanthanoid contraction**.

Step 1: Understand the filling of the $4f$-orbitals.

As we move from La to Lu, electrons enter the $4f$-orbitals.

$$La \rightarrow Ce \rightarrow \cdots \rightarrow Lu$$

The $4f$-electrons do not effectively shield the increasing nuclear charge.

Step 2: Examine the effect on atomic size.

Due to the increase in effective nuclear charge, the outer electrons experience stronger attraction toward the nucleus.

Hence,

Atomic radius decreases

and

Ionic radius decreases

throughout the series.

Step 3: Identify the phenomenon responsible.

The observed decrease in atomic and ionic radii from La to Lu is called:

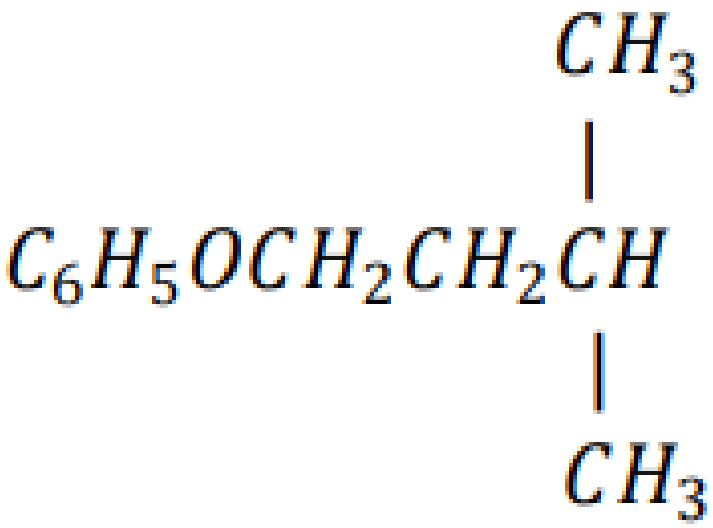
Lanthanoid Contraction

Therefore, the correct option is

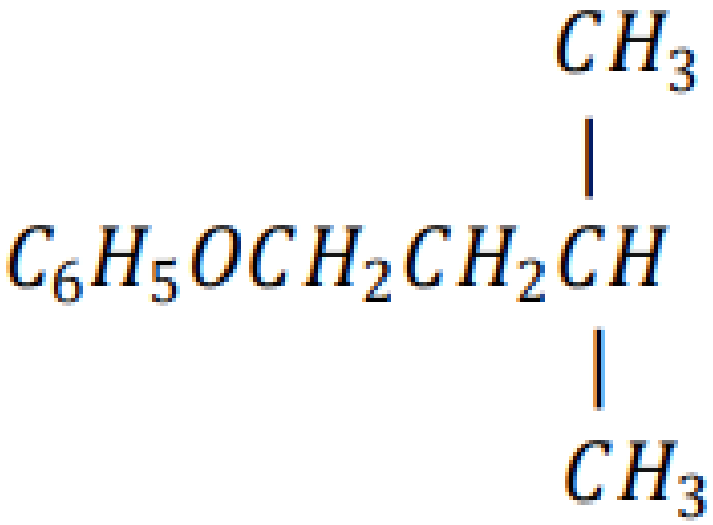
(1)

Quick Tip: Lanthanoid contraction arises because $4f$-electrons shield the nuclear charge very poorly. This causes a steady decrease in atomic and ionic sizes across the lanthanoid series.

37.



Find the IUPAC name of the compound



(A) 1-Methylethyl 2-phenoxyethyl ether

(B) 3-Methylbutyl phenyl ether

(C) 1-Phenoxy-3-methylbutane

(D) 4-Phenoxy-2-methylbutane

Correct Answer: (C) 1-Phenoxy-3-methylbutane

Solution:

Concept:

According to IUPAC nomenclature, ethers are named as alkoxy derivatives of hydrocarbons. The larger carbon chain is selected as the parent chain, while the smaller group attached through oxygen is considered an alkoxy substituent.

The given compound contains a phenoxy group attached to a four-carbon chain.

$$C_6H_5OCH_2CH_2CH(CH_3)_2$$

The group

$$C_6H_5O-$$

is called the phenoxy group.

Step 1: Identify the longest carbon chain.

The carbon chain attached to oxygen is:

$$CH_2 - CH_2 - CH(CH_3) - CH_3$$

which corresponds to butane.

Step 2: Locate the substituents.

The phenoxy group is attached to carbon-1.

The methyl group is attached to carbon-3.

Hence, the substituents are:

1-phenoxy

and

3-methyl

Step 3: Construct the IUPAC name.

Combining the substituents and parent chain:

1-Phenoxy-3-methylbutane

Therefore, the correct option is

(C)

Quick Tip: For ethers, choose the longer carbon chain as the parent hydrocarbon and treat the smaller part attached through oxygen as an alkoxy substituent.

---

38. Which of the following compounds does not give Friedel-Crafts reaction?

(A) Benzene

(B) Chloro Benzene

(C) Benzoic Acid

(D) Phenol

Correct Answer: (C) Benzoic Acid

Solution:

Concept:

Friedel-Crafts alkylation and acylation are electrophilic aromatic substitution reactions carried out in the presence of Lewis acid catalysts such as $AlCl_3$.

For these reactions to occur efficiently, the aromatic ring should not be strongly deactivated.

Electron-withdrawing groups decrease electron density on the ring and hinder Friedel-Crafts reactions.

Step 1: Analyze benzene.

Benzene readily undergoes Friedel-Crafts alkylation and acylation.

Step 2: Analyze chlorobenzene and phenol.

Although chlorobenzene is less reactive than benzene, it can participate under suitable conditions.

Phenol contains an electron-donating oxygen atom and activates the ring.

Step 3: Analyze benzoic acid.

Benzoic acid contains the strongly electron-withdrawing group:

$$-COOH$$

This group significantly deactivates the benzene ring.

Moreover, it can interact with the Lewis acid catalyst and suppress the Friedel-Crafts reaction.

Therefore,

Benzoic Acid does not undergo Friedel-Crafts reaction

Hence, the correct option is

(C)

Quick Tip: Aromatic rings containing strongly deactivating groups such as $-NO_2$, $-SO_3H$, $-CN$, and $-COOH$ generally do not undergo Friedel-Crafts reactions.

---

39. The number of unpaired electrons in the paramagnetic complex ion $[FeF_6]^{3-}$ is

(1) 2

(2) 3

(3) 5

(4) 4

Correct Answer: **(3) 5**

Solution:

Concept:

To determine the number of unpaired electrons in a coordination complex, we first determine the oxidation state of the metal ion, then its electronic configuration, and finally whether the ligand is strong-field or weak-field.

Fluoride ion (F^-) is a weak-field ligand and generally forms high-spin complexes.

Step 1: Determine the oxidation state of iron.

For the complex:

$$[FeF_6]^{3-}$$

Let oxidation state of Fe be x.

$$x + 6(-1) = -3$$

$$x - 6 = -3$$

$$x = +3$$

Thus,

$$Fe^{3+}$$

Step 2: Write the electronic configuration of Fe^{3+}.

Atomic number of iron:

$$Z = 26$$

Electronic configuration of Fe:

$$[Ar]\,3d^6\,4s^2$$

For Fe^{3+}:

$$[Ar]\,3d^5$$

Step 3: Consider the effect of fluoride ligand.

Since F^- is a weak-field ligand, pairing does not occur.

Therefore, all five d-electrons remain unpaired.

5 unpaired electrons

Hence, the correct option is

(3)

Quick Tip: **Weak-field ligands such as F^-, Cl^-, and Br^- usually produce high-spin complexes with maximum possible unpaired electrons.**

---

40. Which of the following is not a nucleophile?

(A) BF_3

(B) NH_3

(C) $C_2H_5O^-$

(D) All of these

Correct Answer: **(A)** BF_3

Solution:

Concept:

A nucleophile is an electron-rich species capable of donating an electron pair to an electron-deficient center.

Characteristics of nucleophiles:

- **Possess lone pairs of electrons.**
- **Carry negative charge or high electron density.**
- **Act as Lewis bases.**

Species that accept electron pairs are called electrophiles or Lewis acids.

Step 1: Analyze NH_3.

Ammonia contains a lone pair on nitrogen.

$$NH_3$$

Therefore, it acts as a nucleophile.

Step 2: Analyze $C_2H_5O^-$.

Ethoxide ion carries a negative charge and possesses lone pairs on oxygen.

Hence, it is a strong nucleophile.

Step 3: Analyze BF_3.

Boron in BF_3 has only six electrons in its valence shell.

Therefore, it is electron deficient and readily accepts electron pairs.

Hence,

$$BF_3$$

acts as a Lewis acid (electrophile), not a nucleophile.

Thus,

$$\boxed{BF_3}$$

is not a nucleophile.

Therefore, the correct option is

$\boxed{(A)}$

Quick Tip: Electron-deficient compounds such as BF_3, $AlCl_3$, and $FeCl_3$ are Lewis acids and behave as electrophiles rather than nucleophiles.

---

41. Which of the following statements is/are correct?

I. Atomic radius increases as we go from left to right in a period

II. Atomic size increases as we go down a group.

1. Both I and II

2. Neither I nor II

3. Only II

4. Only I

Correct Answer: (3) Only II

Solution:

Concept:

Atomic radius is one of the most important periodic properties. It refers to the distance between the nucleus and the outermost shell of an atom. The variation of atomic size across periods and down groups is governed mainly by two factors:

- **Effective nuclear charge**
- **Number of electron shells**

As we move across a period, electrons are added to the same shell while the nuclear charge increases. This causes a stronger attraction between the nucleus and the electrons, resulting in a decrease in atomic size.

As we move down a group, new electron shells are added. The increase in the number of shells outweighs the increase in nuclear charge, causing the atomic size to increase.

Step 1: Examine Statement I.

Statement I says:

Atomic radius increases from left to right in a period

This statement is incorrect.

Across a period, the effective nuclear charge increases continuously and pulls the electrons closer to the nucleus.

Therefore:

Atomic radius decreases from left to right

Hence Statement I is false.

Step 2: Examine Statement II.

Statement II says:

Atomic size increases down a group

As we move downward in a group, a new electron shell is added at each step.

For example:

$$Li < Na < K < Rb < Cs$$

Thus atomic size increases down the group.

Hence Statement II is true.

Step 3: Choose the correct option.

Statement I is false.

Statement II is true.

Therefore only Statement II is correct.

$$\boxed{\text{Correct Option} = (3)}$$

Quick Tip: **Remember: Across a period atomic size decreases, whereas down a group atomic size increases due to the addition of new shells.**

42. Write the highest oxidation state of Cr and Mn.

1. $+2, +3$

2. $+6, +7$

3. $+4, -4$

4. $+3, -5$

Correct Answer: **(2)** $+6, +7$

Solution:

Concept:

Transition elements exhibit variable oxidation states because both the ns and $(n-1)d$ electrons can participate in bonding.

Chromium and manganese belong to the first transition series and possess several oxidation states.

The highest oxidation state generally corresponds to the total number of valence electrons available for bonding.

Step 1: Determine the highest oxidation state of chromium.

Electronic configuration of chromium:

$$Cr = [Ar]\,3d^5\,4s^1$$

Total valence electrons:

$$5 + 1 = 6$$

Therefore chromium can exhibit a maximum oxidation state of:

$$\boxed{+6}$$

Example:

$$CrO_4^{2-}, \quad Cr_2O_7^{2-}$$

Step 2: Determine the highest oxidation state of manganese.

Electronic configuration of manganese:

$$Mn = [Ar]\,3d^5\,4s^2$$

Total valence electrons:

$$5 + 2 = 7$$

Thus manganese exhibits a maximum oxidation state of:

$$\boxed{+7}$$

Example:

$$MnO_4^-$$

Step 3: Select the correct option.

$$Cr = +6$$

$$Mn = +7$$

Hence,

$$\boxed{(2)}$$

is the correct answer.

Quick Tip: **Maximum oxidation state in the first transition series generally corresponds to the group number. Chromium shows +6 and manganese shows +7.**

---

43. By which bond are amino acids joined together?

1. Dipole-Dipole

2. Ionic

3. Hydrogen

4. Amide

Correct Answer: (4) Amide

Solution:

Concept:

Proteins are polymers formed by the linkage of amino acids. Each amino acid contains:

$$-NH_2$$

and

$$-COOH$$

functional groups.

When two amino acids react, the carboxyl group of one amino acid combines with the amino group of another amino acid with the elimination of a water molecule.

The resulting linkage is called a peptide bond, which is chemically an amide bond.

Step 1: Consider two amino acids.

Let two amino acids be:

$$H_2N-CHR-COOH$$

and

$$H_2N-CHR'-COOH$$

Step 2: Formation of peptide linkage.

The reaction occurs as:

$$-COOH+-NH_2 \rightarrow -CONH-+H_2O$$

Water is eliminated during the reaction.

Step 3: Identify the bond formed.

The bond

$$-CONH-$$

is an amide linkage.

Therefore amino acids are connected through:

Amide Bond

Hence option (4) is correct.

Quick Tip: Peptide bond = Amide bond. Proteins are long chains of amino acids linked through peptide (amide) bonds.

---

44. Match the following.

(I) Homohaptic / होमोहैप्टिक	-	A) EDTA
(ii) Heterohaptic / हेटरोहैप्टिक	-	B) $[Fe(CNH_3)]^{3+}$
(iii) Polydentate / पॉलीडेंटेट	-	C) $[Re(H_2O)_2(NH_3)_2]$
(iv) Bidentate / बाइडेंटेट	-	D) $C_2O_4^{2-}$

(A) I-B, II-C, III-A, IV-D

(B) I-C, II-B, III-D, IV-A

(C) I-D, II-A, III-C, IV-B

(D) I-A, II-D, III-B, IV-C

Correct Answer: (i)–B, (ii)–C, (iii)–A, (iv)–D

Solution:

Concept:

Ligands are ions or molecules that donate electron pairs to a central metal atom. Depending upon the number and nature of donor atoms, ligands are classified into various categories.

Step 1: Identify the polydentate ligand.

EDTA contains six donor atoms and can bind through six coordination sites.

Therefore:

Polydentate → EDTA

Step 2: Identify the bidentate ligand.

Oxalate ion:

$$C_2O_4^{2-}$$

coordinates through two oxygen atoms.

Hence:

Bidentate → $C_2O_4^{2-}$

Step 3: Identify the remaining pairs.

Homohaptic ligands coordinate through identical donor atoms.

Heterohaptic ligands coordinate through different donor atoms.

Thus:

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

Final Matching

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

Quick Tip: **EDTA is the most important hexadentate ligand, while oxalate ($C_2O_4^{2-}$) is a common bidentate ligand.**

---

45. Match the following.

Column I	-	Column II
(a) Vit E	-	(i) Night blindness
(b) Vit C	-	(ii) Beri-Beri
(c) Vit A	-	(iii) Muscular weakness
(d) Vit B	-	(iv) Scurvy

(A) a-iii, b-iv, c-i, d-ii

(B) a-iv, b-iii, c-ii, d-i

(C) a-i, b-ii, c-iii, d-iv

(D) a-ii, b-i, c-iv, d-iii

Correct Answer:

$$(a) \rightarrow (iii), \quad (b) \rightarrow (iv), \quad (c) \rightarrow (i), \quad (d) \rightarrow (ii)$$

Solution:

Concept:

Vitamins are essential organic compounds required in small quantities for normal growth and metabolism. Deficiency of different vitamins leads to characteristic diseases. Knowledge of vitamin deficiency diseases is important in biomolecules and human health studies.

Step 1: Match Vitamin A.

Deficiency of Vitamin A causes:

Night Blindness

Therefore:

$$(c) \rightarrow (i)$$

Step 2: Match Vitamin C.

Deficiency of Vitamin C causes:

Scurvy

Hence:

$$(b) \rightarrow (iv)$$

Step 3: Match Vitamin B.

Deficiency of Vitamin B_1 causes:

Beri-Beri

Therefore:

$$(d) \rightarrow (ii)$$

Step 4: Match Vitamin E.

Vitamin E deficiency is associated with muscular weakness and reproductive disorders.

Hence:

$$(a) \rightarrow (iii)$$

Therefore the correct matching is:

$$\boxed{(a) \rightarrow (iii),\ (b) \rightarrow (iv),\ (c) \rightarrow (i),\ (d) \rightarrow (ii)}$$

Quick Tip: Vitamin A → Night Blindness, Vitamin B_1 → Beri-Beri, Vitamin C → Scurvy, Vitamin E → Muscular Weakness.

---

46. Statement-I: All aldehydes and ketones give positive Tollens' test.

Statement-II: Only aldehydes give positive Fehling's test.

(A) Both I and II

(B) Neither I nor II

(C) Only II

(D) Only I

Correct Answer: (C) Only II

Solution:

Concept:

Tollens' reagent and Fehling's solution are important qualitative reagents used for distinguishing aldehydes and ketones.

Tollens' reagent contains diamminesilver(I) ion:

$$[Ag(NH_3)_2]^+$$

which acts as a mild oxidizing agent.

Fehling's solution contains alkaline copper(II) ions which are reduced to brick-red cuprous oxide in the presence of suitable reducing agents.

Aldehydes are generally more easily oxidized than ketones because they contain a hydrogen atom attached directly to the carbonyl carbon.

Step 1: Examine Statement-I.

Statement-I says:

All aldehydes and ketones give positive Tollens' test

This statement is incorrect.

Aldehydes readily reduce Tollens' reagent and produce a silver mirror.

However, ordinary ketones do not reduce Tollens' reagent.

Only a few special ketones such as α-hydroxy ketones may give positive Tollens' test.

Therefore:

Statement-I is false

Step 2: Examine Statement-II.

Statement-II says:

Only aldehydes give positive Fehling's test

Fehling's solution is reduced by aliphatic aldehydes giving a brick-red precipitate of cuprous oxide.

Most ketones do not respond to Fehling's test.

Therefore:

$$\boxed{\text{Statement-II is true}}$$

Step 3: Choose the correct option.

Statement-I is false.

Statement-II is true.

Hence,

$$\boxed{\text{Only II}}$$

Therefore, the correct option is

$$\boxed{(C)}$$

Quick Tip: Tollens' reagent gives a silver mirror with aldehydes, while Fehling's solution gives a brick-red precipitate mainly with aliphatic aldehydes.

---

47. Solutions having the same osmotic pressure are called:

(A) Hypertonic

(B) Hypotonic

(C) Isotonic

(D) Normal

Correct Answer: (C) Isotonic

Solution:

Concept:

Osmotic pressure is the pressure that must be applied to a solution to prevent the flow

of solvent through a semipermeable membrane.

According to van't Hoff equation,

$$\pi = CRT$$

where

$$\pi = \text{osmotic pressure}$$

$$C = \text{molar concentration}$$

$$R = \text{gas constant}$$

$$T = \text{absolute temperature}$$

Solutions are classified based on comparison of osmotic pressures.

Step 1: Define isotonic solutions.

When two solutions possess identical osmotic pressure at the same temperature, they are called isotonic solutions.

Mathematically,

$$\pi_1 = \pi_2$$

Step 2: Understand other terms.

Hypertonic solution:

$$\pi_{\text{solution}} > \pi_{\text{reference}}$$

Hypotonic solution:

$$\pi_{\text{solution}} < \pi_{\text{reference}}$$

Therefore these terms do not represent equal osmotic pressure.

Step 3: Select the correct answer.

Solutions having the same osmotic pressure are called:

$$\boxed{\text{Isotonic Solutions}}$$

Hence the correct option is

$$\boxed{(C)}$$

Quick Tip: Equal osmotic pressure $\Rightarrow$ Isotonic. This concept is widely used in biological systems and intravenous fluid preparations.

---

48. For a spontaneous process at constant pressure and temperature, ΔG° and ΔS are:

1. $\Delta G^\circ = 0,\ \Delta S = 0$

2. $\Delta G^\circ < 0,\ \Delta S > 0$

3. $\Delta G^\circ > 0,\ \Delta S > 0$

4. $\Delta G^\circ = 1,\ \Delta S = 1$

Correct Answer: **(2)** $\Delta G^\circ < 0,\ \Delta S > 0$

Solution:

Concept:

The spontaneity of a process at constant temperature and pressure is determined by Gibbs free energy.

The Gibbs free energy equation is:

$$\Delta G = \Delta H - T\Delta S$$

A process is spontaneous if:

$$\Delta G < 0$$

The entropy change indicates the degree of disorder in a system.

A positive entropy change generally favors spontaneity.

Step 1: Recall the criterion for spontaneity.

For a spontaneous process:

$$\boxed{\Delta G < 0}$$

This is the fundamental condition.

Step 2: Consider the entropy change.

Spontaneous processes generally proceed toward greater randomness.

Hence entropy tends to increase.

$$\boxed{\Delta S > 0}$$

Step 3: Choose the correct option.

Combining both conditions:

$$\Delta G^\circ < 0$$

and

$$\Delta S > 0$$

Therefore,

$$\boxed{(2)}$$

is the correct answer.

Quick Tip: **Always remember: Spontaneous process $\Rightarrow \Delta G < 0$. At equilibrium, $\Delta G = 0$.**

---

49. The decreasing order of C–X bond length in $CH_3 - X$ is

(a) $CH_3I > CH_3Br > CH_3Cl > CH_3F$

(b) $CH_3F > CH_3Cl > CH_3Br > CH_3I$

(c) $CH_3F > CH_3Cl > CH_3I > CH_3Br$

(d) $CH_3I > CH_3Cl > CH_3F > CH_3Br$

Correct Answer: (a) $CH_3I > CH_3Br > CH_3Cl > CH_3F$

Solution:

Concept:

Bond length depends mainly upon the size of the bonded atoms.

As atomic radius increases, bond length also increases.

The halogen atomic radii follow the order:

$$F < Cl < Br < I$$

Therefore, the carbon-halogen bond length increases as the size of halogen increases.

Step 1: Compare the sizes of halogens.

The atomic sizes are:

$$F < Cl < Br < I$$

Iodine is the largest halogen while fluorine is the smallest.

Step 2: Relate size to bond length.

Larger halogen atoms form longer bonds with carbon.

Hence:

$$C-I > C-Br > C-Cl > C-F$$

Step 3: Write the decreasing order.

Thus,

$$CH_3I > CH_3Br > CH_3Cl > CH_3F$$

Therefore the correct option is

$$\boxed{(a)}$$

Quick Tip: Bond length increases with increasing atomic size. Since iodine is the largest halogen, C–I bond is the longest among methyl halides.

---

50. Zirconium is a transition element, but Zinc is not. Why?

(1) Both Zr^{3+} and Zn^{2+} ions are colourless and form white compounds

(2) In case of transition elements, d-orbitals are partially filled, but in Zn they are completely filled

(3) Last electron is added to 4s level in case of Zn

(4) Both Zr and Zn do not exhibit variable oxidation states

Correct Answer: **(2)**

Solution:

Concept:

According to IUPAC, a transition element is an element that has a partially filled d-subshell in its atom or in one of its common oxidation states.

The presence of partially filled d-orbitals gives rise to many characteristic properties such as variable oxidation states, colored compounds, and magnetic behavior.

Step 1: Examine Zinc.

Electronic configuration of zinc:

$$Zn = [Ar]\,3d^{10}4s^2$$

The $3d$-subshell is completely filled.

For the common ion:

$$Zn^{2+} = [Ar]\,3d^{10}$$

The d-orbitals remain completely filled.

Hence zinc does not satisfy the transition element definition.

Step 2: Examine Zirconium.

Electronic configuration:

$$Zr = [Kr]4d^2 5s^2$$

The d-subshell is partially filled.

Therefore zirconium fulfills the criterion of a transition element.

Step 3: Select the correct reason.

Transition elements contain partially filled d-orbitals.

Zinc possesses completely filled d-orbitals.

Therefore,

Option (2)

is correct.

Quick Tip: **Zn, Cd, and Hg are generally not considered transition elements because their atoms and common ions contain completely filled d^{10} configurations.**

---

51. For the reaction

$$N_2 + O_2 \rightleftharpoons 2NO$$

the equilibrium concentrations are given as

$$[N_2] = 0.5\,M, \qquad [O_2] = 0.7\,M, \qquad [NO] = 0.4\,M$$

Calculate the value of K_c.

(1) 0.58

(2) 0.48

(3) 1.15

(4) 2014

Correct Answer: **(2) 0.48**

Solution:

Concept:

The equilibrium constant in terms of concentration, denoted by K_c, is defined as the ratio of the product of molar concentrations of products to the product of molar concentrations of reactants, each raised to the power of their stoichiometric coefficients.

For a general reaction

$$aA + bB \rightleftharpoons cC + dD$$

the equilibrium constant is

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

The value of K_c indicates the extent to which reactants are converted into products at equilibrium.

Step 1: Write the equilibrium constant expression.

For the reaction

$$N_2 + O_2 \rightleftharpoons 2NO$$

the equilibrium constant expression is

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

Step 2: Substitute the equilibrium concentrations.

Given:

$$[N_2] = 0.5\,M$$

$$[O_2] = 0.7\,M$$

$$[NO] = 0.4\,M$$

Substituting:

$$K_c = \frac{(0.4)^2}{(0.5)(0.7)}$$

$$K_c = \frac{0.16}{0.35}$$

Step 3: **Perform the calculation.**

$$K_c = 0.457$$

$$K_c \approx 0.46$$

Among the given options, the closest value is

$$\boxed{0.48}$$

Hence, the correct option is

$$\boxed{(2)}$$

Quick Tip: **Always write the balanced chemical equation first and then construct the equilibrium constant expression using stoichiometric coefficients as powers.**

---

52. Which of the following carbohydrates is the sweetest sugar?

1. Glucose

2. Fructose

3. Cellulose

4. Maltose

Correct Answer: **(2) Fructose**

Solution:

Concept:

Carbohydrates are naturally occurring polyhydroxy aldehydes or ketones and their derivatives. Different carbohydrates possess different degrees of sweetness.

The sweetness scale is usually compared relative to sucrose.

Among the common monosaccharides, fructose is known to possess the highest sweetness.

Step 1: Examine glucose.

Glucose is a monosaccharide and is sweet in taste.

However, it is less sweet than fructose.

Step 2: Examine fructose.

Fructose is a ketohexose commonly found in fruits and honey.

It possesses the highest relative sweetness among naturally occurring sugars.

Fructose is the sweetest sugar

Step 3: Examine the remaining options.

Cellulose is a structural polysaccharide and is not sweet.

Maltose is less sweet than fructose.

Therefore fructose remains the correct choice.

Hence,

Correct Option $= (2)$

Quick Tip: Sweetness order among common sugars:

Fructose > Sucrose > Glucose > Maltose

Fructose is commonly called fruit sugar.

---

53. What is the symbol for an atom containing 20 protons, 18 electrons and 22 neutrons?

(1) Mg^{2+}

(2) Sc^{3+}

(3) Ca^{2+}

(4) K^+

Correct Answer: (3) Ca^{2+}

Solution:

Concept:

The identity of an element is determined by its atomic number, which is equal to the number of protons present in the nucleus.

The charge on an atom or ion depends upon the difference between the number of protons and electrons.

Step 1: Determine the atomic number.

Given:

$$\text{Number of protons} = 20$$

Atomic number:

$$Z = 20$$

The element having atomic number 20 is calcium.

$$\boxed{\text{Element} = Ca}$$

Step 2: Determine the ionic charge.

Number of electrons:

$$18$$

Number of protons:

$$20$$

Net charge:

$$20 - 18 = +2$$

Therefore the ion is

$$Ca^{2+}$$

Step 3: Verify the mass number.

Number of neutrons:

$$22$$

Mass number:

$$A = 20 + 22 = 42$$

Thus the species is

$$^{42}_{20}Ca^{2+}$$

Among the options, this corresponds to

$$\boxed{Ca^{2+}}$$

Hence the correct option is

$$\boxed{(3)}$$

Quick Tip: **Atomic number = Number of protons.**

Charge = Number of protons − Number of electrons.

---

54. Which one is the strongest electrolyte among the following?

(1) HF

(2) NH_3

(3) $CaCl_2$

(4) AgCl

Correct Answer: **(3) $CaCl_2$**

Solution:

Concept:

Electrolytes are substances that produce ions when dissolved in water and therefore conduct electricity.

Electrolytes are classified into:

- **Strong electrolytes**
- **Weak electrolytes**

Strong electrolytes undergo nearly complete ionization in aqueous solution, whereas weak electrolytes ionize only partially.

Step 1: Examine HF.

Hydrofluoric acid is a weak acid.

Therefore it ionizes only partially in water.

$$HF \rightleftharpoons H^+ + F^-$$

Hence HF is a weak electrolyte.

Step 2: Examine NH_3.

Ammonia is a weak base.

It undergoes only partial ionization.

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Thus NH_3 is also a weak electrolyte.

Step 3: Examine AgCl and $CaCl_2$.

AgCl is sparingly soluble in water and therefore contributes very few ions.

On the other hand,

$$CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$$

undergoes almost complete dissociation in water.

Since it produces a large number of ions, it behaves as a strong electrolyte.

Therefore,

$$\boxed{CaCl_2}$$

is the strongest electrolyte among the given substances.

Hence the correct option is

$$\boxed{(3)}$$

Quick Tip: Soluble ionic salts such as NaCl, KCl, and $CaCl_2$ are strong electrolytes because they dissociate almost completely into ions in aqueous solution.

---

55. The energy required to completely separate one mole of a solid ionic compound into its gaseous constituent ions is called:

(A) Lattice energy

(B) Ionization energy

(C) Electron gain enthalpy

(D) Sublimation energy

Correct Answer: (A) Lattice energy

Solution:

Concept:

Ionic compounds are made up of positively charged cations and negatively charged anions held together by strong electrostatic forces of attraction. The strength of attraction between these oppositely charged ions is measured in terms of lattice energy.

Lattice energy is one of the most important thermodynamic quantities associated with ionic solids. It gives an idea about the stability of an ionic crystal and the strength of ionic bonding present in the compound.

Step 1: Understanding the definition of lattice energy.

Consider an ionic solid such as sodium chloride, NaCl.

In the solid state, sodium ions and chloride ions are arranged in a three-dimensional

crystal lattice.

To completely separate this crystal into gaseous ions,

$$\mathrm{NaCl(s)} \rightarrow \mathrm{Na}^{+}(g) + \mathrm{Cl}^{-}(g)$$

energy must be supplied to overcome all the electrostatic attractions present in the crystal.

The energy required for this process is called lattice energy.

Step 2: Examining the other options.

Ionization energy:

Ionization energy is the energy required to remove an electron from an isolated gaseous atom.

Example:

$$\mathrm{Na}(g) \rightarrow \mathrm{Na}^{+}(g) + e^{-}$$

Therefore, ionization energy is not the correct answer.

Electron gain enthalpy:

Electron gain enthalpy refers to the enthalpy change when an electron is added to an isolated gaseous atom.

Example:

$$\mathrm{Cl}(g) + e^{-} \rightarrow \mathrm{Cl}^{-}(g)$$

Hence, it is not related to separation of ionic crystals.

Sublimation energy:

Sublimation energy is the energy required to convert a solid directly into gaseous form without passing through the liquid state.

Example:

$$\mathrm{I}_2(s) \rightarrow \mathrm{I}_2(g)$$

Therefore, it is different from lattice energy.

Step 3: Conclusion.

The energy required to completely separate one mole of a solid ionic compound into its gaseous constituent ions is known as lattice energy.

$$\boxed{\text{Lattice Energy}}$$

Hence, the correct answer is

$$\boxed{(A)}$$

Quick Tip: Lattice energy is associated with ionic compounds and measures the strength of ionic bonding. Greater lattice energy implies greater stability of the ionic crystal.

---

56. Consider the following statements:

I. Aniline does not give Friedel-Crafts reaction.

II. Aromatic primary amines cannot be prepared by Gabriel phthalimide synthesis.

Choose the correct option.

(A) Both I and II

(B) Neither I nor II

(C) Only II

(D) Only I

Correct Answer: **(A) Both I and II**

Solution:

Concept:

Aniline is an aromatic amine containing an amino group attached directly to a benzene ring.

$$C_6H_5NH_2$$

The presence of the amino group significantly affects the chemical behavior of aniline.

Step 1: Analyzing Statement I.

Aniline generally does not undergo Friedel-Crafts alkylation or acylation reactions.

Reason:

The lone pair on the nitrogen atom coordinates with the Lewis acid catalyst such as

$$AlCl_3$$

forming a complex.

$$C_6H_5NH_2 + AlCl_3 \rightarrow \text{Complex}$$

This complex formation decreases the electron density of the benzene ring and prevents the Friedel-Crafts reaction from occurring normally.

Therefore,

Statement I is correct

Step 2: Analyzing Statement II.

Gabriel phthalimide synthesis is a useful method for preparing aliphatic primary amines.

The reaction involves nucleophilic substitution of alkyl halides.

However, aryl halides do not undergo the required nucleophilic substitution reaction under ordinary conditions.

Hence aromatic primary amines such as aniline cannot be prepared by Gabriel synthesis.

Therefore,

Statement II is correct

Step 3: Final conclusion.

Both statements are correct.

Hence,

(*A*) Both I and II

Quick Tip: Gabriel phthalimide synthesis is suitable for preparing aliphatic primary amines but not aromatic primary amines because aryl halides are generally unreactive toward nucleophilic substitution.

---

57. The catalytic activity of transition elements is related to their:

(A) Variable oxidation states

(B) Surface area

(C) Complex formation ability

(D) Magnetic moment

Correct Answer: **(A) Variable oxidation states**

Solution:

Concept:

Transition elements are widely used as catalysts because of their unique electronic configuration involving partially filled d-orbitals.

Examples include:

$$\mathrm{Fe, Ni, Pt, Pd, V_2O_5}$$

These metals participate in reactions through intermediate oxidation states.

Step 1: Understanding catalytic activity.

A catalyst provides an alternative reaction pathway having lower activation energy.

Transition metals are especially effective catalysts because they can readily change oxidation states.

For example:

$$\mathrm{Fe^{2+} \longleftrightarrow Fe^{3+}}$$

$$\mathrm{Cu^{+} \longleftrightarrow Cu^{2+}}$$

Such oxidation state changes help in electron transfer processes.

Step 2: Role of variable oxidation states.

The catalyst can temporarily form unstable intermediate compounds and then regenerate itself.

This is possible because transition metals exhibit multiple oxidation states.

Hence catalytic behavior is strongly linked with variable oxidation states.

Step 3: Checking other options.

Surface area contributes to catalytic efficiency but is not the fundamental reason for catalytic activity.

Complex formation ability also helps but is secondary.

Magnetic moment is unrelated to catalytic behavior.

Thus the most appropriate answer is

$$\boxed{\text{Variable oxidation states}}$$

Hence,

$$\boxed{(A)}$$

Quick Tip: The two most important reasons for catalytic activity of transition elements are variable oxidation states and the availability of vacant or partially filled d-orbitals.

---

58. The following are catalysts and their respective processes/reactions. The wrong pair is:

(A) $[RhCl(PPh_3)_3]$ **: Hydrogenation**

(B) $TiCl_4 + Al(C_2H_5)_3$ **: Polymerisation**

(C) V_2O_3 **: Haber-Bosch process**

(D) Nickel : Hydrogenation

Correct Answer: **(C)** V_2O_3 **: Haber-Bosch process**

Solution:

Concept:

Many industrial processes use specific catalysts. Knowledge of important catalysts is frequently tested in coordination chemistry and industrial chemistry.

Step 1: Checking option (A).

$$[RhCl(PPh_3)_3]$$

is Wilkinson's catalyst.

It is used for hydrogenation of alkenes.

Hence this pair is correct.

Step 2: Checking option (B).

$$TiCl_4 + Al(C_2H_5)_3$$

forms Ziegler-Natta catalyst.

It is used for polymerisation of alkenes.

Hence this pair is correct.

Step 3: Checking option (C).

The Haber-Bosch process for ammonia manufacture uses finely divided iron catalyst with promoters such as

$$K_2O, \quad Al_2O_3$$

and not V_2O_3.

Vanadium pentoxide

$$V_2O_5$$

is used in the Contact Process.

Therefore this pair is incorrect.

Step 4: Checking option (D).

Nickel is a common hydrogenation catalyst.

Example:

Vegetable oil → Vanaspati ghee

Hence this pair is correct.

Therefore,

$$\boxed{(C)}$$

is the wrong pair.

Quick Tip: **Remember: Fe $\rightarrow$ Haber Process, V_2O_5 $\rightarrow$ Contact Process, Ni $\rightarrow$ Hydrogenation, Ziegler-Natta Catalyst $\rightarrow$ Polymerisation.**

---

59. Consider the following statements:

I. Cellulose contains only $\beta(1 \rightarrow 4)$ glycosidic linkages.

II. Starch contains both $\alpha(1 \rightarrow 4)$ and $\alpha(1 \rightarrow 6)$ glycosidic linkages.

(A) Both I and II

(B) Neither I nor II

(C) Only II

(D) Only I

Correct Answer: **(A) Both I and II**

Solution:

Concept:

Cellulose and starch are important polysaccharides composed of glucose units but differ in the nature of glycosidic linkages.

Step 1: Examining cellulose.

Cellulose consists of long chains of β-D-glucose units connected by

$$\beta(1 \rightarrow 4)$$

glycosidic bonds.

No $(1 \rightarrow 6)$ branching is present.

Thus Statement I is correct.

Step 2: Examining starch.

Starch consists mainly of two components:

- **Amylose**
- **Amylopectin**

Amylose contains

$$\alpha(1 \rightarrow 4)$$

linkages.

Amylopectin contains

$$\alpha(1 \rightarrow 4)$$

as well as

$$\alpha(1 \rightarrow 6)$$

branching linkages.

Therefore starch contains both types.

Hence Statement II is correct.

Step 3: Conclusion.

Both statements are true.

$$\boxed{(A)}$$

Quick Tip: **Cellulose contains only $\beta(1 \rightarrow 4)$ linkages, whereas starch contains $\alpha(1 \rightarrow 4)$ and $\alpha(1 \rightarrow 6)$ linkages due to branching in amylopectin.**

---

60. Consider the following statements:

I. Aniline does not give Friedel-Crafts reaction.

II. Aromatic primary amines cannot be prepared by Gabriel phthalimide synthesis.

(A) Both I and II

(B) Neither I nor II

(C) Only II

(D) Only I

Correct Answer: (A) Both I and II

Solution:

Concept:

This question is identical to Question 56 and tests important properties of aromatic amines.

Step 1: Aniline and Friedel-Crafts reaction.

Aniline contains a lone pair on nitrogen.

This lone pair forms a coordinate bond with Lewis acids such as

$$AlCl_3$$

used in Friedel-Crafts reactions.

As a result, the catalyst becomes ineffective and the reaction does not proceed normally.

Therefore Statement I is correct.

Step 2: Gabriel synthesis and aromatic amines.

Gabriel synthesis proceeds through nucleophilic substitution of alkyl halides.

Aryl halides do not undergo this reaction easily.

Hence aromatic amines cannot be prepared using Gabriel phthalimide synthesis.

Therefore Statement II is correct.

Step 3: Final conclusion.

Both statements are correct.

$\boxed{(A)\ \text{Both I and II}}$

Quick Tip: Aniline fails to undergo Friedel-Crafts reactions because it forms a complex with the Lewis acid catalyst. Gabriel synthesis is restricted mainly to aliphatic primary amines.

---

61. Which statement is logical according to Werner's theory?

(A) Primary valency can be ionized

(B) Secondary valency can be ionized

(C) Primary and secondary valency do not ionize

(D) Only primary valency does not ionize

Correct Answer: (A) Primary valency can be ionized

Solution:

Concept:

Werner's coordination theory was proposed to explain the structure and properties of coordination compounds. According to Werner, a metal ion exhibits two types of valencies:

- Primary valency
- Secondary valency

Primary valency corresponds to the oxidation state of the metal ion and is generally satisfied by negative ions. Secondary valency corresponds to the coordination number and is satisfied by ligands directly attached to the metal ion.

A key distinction between these two valencies is their ionization behavior in aqueous solution.

Step 1: Understanding primary valency.

Primary valency is equivalent to the oxidation state of the central metal atom.

For example, in

$$[Co(NH_3)_6]Cl_3$$

the oxidation state of cobalt is

$$+3.$$

Thus the primary valency is three.

These valencies are satisfied by chloride ions present outside the coordination sphere.

Step 2: Understanding ionization of primary valency.

The chloride ions outside the coordination sphere can dissociate in water.

$$[Co(NH_3)_6]Cl_3 \rightarrow [Co(NH_3)_6]^{3+} + 3Cl^-$$

Thus the ions satisfying primary valency are ionizable.

Hence primary valency can ionize.

Step 3: Understanding secondary valency.

Secondary valency is satisfied by ligands directly attached to the metal.

In

$$[Co(NH_3)_6]Cl_3$$

the six ammonia molecules satisfy secondary valency.

Since these ligands are present inside the coordination sphere, they do not ionize under ordinary conditions.

Step 4: Checking each option.

Option (A): Primary valency can be ionized. Correct.

Option (B): Secondary valency can be ionized. Incorrect because ligands inside the coordination sphere are non-ionizable.

Option (C): Both do not ionize. Incorrect.

Option (D): Only primary valency does not ionize. Incorrect.

Step 5: Final conclusion.

According to Werner's theory, primary valencies are ionizable whereas secondary valencies are non-ionizable.

Therefore,

$$\boxed{(A)}$$

Quick Tip: **Werner's theory states that primary valency is ionizable and corresponds to oxidation state, while secondary valency is non-ionizable and corresponds to coordination number.**

---

62. Two bodies of masses $1\,kg$ and $4\,kg$ are connected by a spring of spring constant $K = 5\,N\,m^{-1}$. Find the time period of oscillation.

(A) $\frac{4\pi}{5}s$

(B) $\frac{2\pi}{5}s$

(C) πs

(D) $2\pi s$

Correct Answer: (A) $\frac{4\pi}{5}s$

Solution:

Concept:

When two masses are connected by a spring and allowed to oscillate, the system performs simple harmonic motion. The effective mass of the system is the reduced mass.

The time period is given by

$$T = 2\pi\sqrt{\frac{\mu}{k}}$$

where

$$\mu = \frac{m_1 m_2}{m_1 + m_2}.$$

Step 1: Calculate reduced mass.

Given

$$m_1 = 1\,kg, \qquad m_2 = 4\,kg.$$

Therefore

$$\mu = \frac{1 \times 4}{1+4} = \frac{4}{5}\,kg.$$

Step 2: Substitute in time period formula.

Given

$$k = 5\,N\,m^{-1}.$$

Hence

$$T = 2\pi\sqrt{\frac{4/5}{5}}$$

$$= 2\pi\sqrt{\frac{4}{25}}$$

$$= 2\pi\left(\frac{2}{5}\right)$$

$$= \frac{4\pi}{5}s.$$

Step 3: Final answer.

$$\boxed{T = \frac{4\pi}{5}s}$$

Hence,

$$\boxed{(A)}$$

Quick Tip: **For two masses connected by a spring, always use reduced mass $\mu = \frac{m_1 m_2}{m_1+m_2}$ before applying the SHM time-period formula.**

---

63. Mutual inductance between two coils is $2H$. Current changes from 0 to $10A$ in $0.5s$. Find the induced emf.

(A) $20\,V$

(B) $60\,V$

(C) $40\,V$

(D) $80\,V$

Correct Answer: **(C)** $40\,V$

Solution:

Concept:

According to the principle of mutual induction, the induced emf is

$$e = M\frac{dI}{dt}$$

where M is the mutual inductance.

Step 1: **Write the given values.**

$$M = 2H$$

$$\Delta I = 10 - 0 = 10A$$

$$\Delta t = 0.5s$$

Step 2: **Calculate rate of change of current.**

$$\frac{\Delta I}{\Delta t} = \frac{10}{0.5} = 20As^{-1}$$

Step 3: **Apply mutual induction formula.**

$$e = M\frac{\Delta I}{\Delta t}$$

$$= 2 \times 20$$

$$= 40V$$

Step 4: **Final answer.**

$$\boxed{40V}$$

Hence,

$$\boxed{(C)}$$

Quick Tip: For mutual induction problems, induced emf equals mutual inductance multiplied by the rate of change of current.

---

64. Distance between two slits is $2\,mm$, distance between slit and screen is $1.6\,m$, and wavelength of light is $500\,nm$. Find the fringe width.

(A) $0.2\,mm$

(B) $0.4\,mm$

(C) $0.8\,mm$

(D) $1.6\,mm$

Correct Answer: **(B)** $0.4\,mm$

Solution:

Concept:

In Young's double slit experiment, fringe width is given by

$$\beta = \frac{\lambda D}{d}$$

where

λ **= wavelength,**

D **= distance of screen,**

d **= slit separation.**

Step 1: **Convert all quantities into SI units.**

$$\lambda = 500 \times 10^{-9}\,m$$

$$D = 1.6\,m$$

$$d = 2 \times 10^{-3}\,m$$

Step 2: **Apply fringe width formula.**

$$\beta = \frac{500 \times 10^{-9} \times 1.6}{2 \times 10^{-3}}$$

$$= 4 \times 10^{-4}\, m$$

Step 3: **Convert into millimetres.**

$$4 \times 10^{-4}\, m = 0.4\, mm$$

Step 4: **Final answer.**

$$\boxed{0.4\, mm}$$

Hence,

$$\boxed{(B)}$$

Quick Tip: **Always convert wavelength from nanometres and slit separation from millimetres into metres before applying $\beta = \frac{\lambda D}{d}$.**

---

65. Find the radius of trajectory of a proton moving with velocity $4 \times 10^5\, m s^{-1}$ in a magnetic field of $0.01\, T$.

(A) $0.2\, m$

(B) $0.8\, m$

(C) $0.6\, m$

(D) $0.4\, m$

Correct Answer: **(D)** $0.4\, m$

Solution:

Concept:

A charged particle moving perpendicular to a magnetic field follows a circular path.

The radius of the path is given by

$$r = \frac{mv}{qB}$$

where m is mass, q is charge and B is magnetic field.

Step 1: Write the given values.

For a proton,

$$m = 1.67 \times 10^{-27}\, kg$$

$$q = 1.6 \times 10^{-19}\, C$$

Given,

$$v = 4 \times 10^{5}\, m s^{-1}$$

$$B = 0.01\, T$$

Step 2: Substitute into the formula.

$$r = \frac{1.67 \times 10^{-27} \times 4 \times 10^{5}}{1.6 \times 10^{-19} \times 0.01}$$

$$= \frac{6.68 \times 10^{-22}}{1.6 \times 10^{-21}}$$

$$= 4.175 \times 10^{-1}$$

$$\approx 0.42\, m$$

Step 3: Choose nearest option.

$$r \approx 0.4\, m$$

Therefore,

$\boxed{(D)}$

Quick Tip: **Remember the circular motion formula in a magnetic field:**

$$r = \frac{mv}{qB}.$$

Larger velocity increases radius, while stronger magnetic field decreases radius.

---

66. The powers of the objective lens and eyepiece of an astronomical telescope are $2D$ and $20D$ respectively. Find the length of the telescope in normal adjustment.

(A) $45\,cm$

(B) $50\,cm$

(C) $55\,cm$

(D) $60\,cm$

Correct Answer: **(C)** $55\,cm$

Solution:

Concept:

For an astronomical telescope in normal adjustment, the final image is formed at infinity. Under this condition, the distance between the objective lens and eyepiece is equal to the sum of their focal lengths.

$$L = f_o + f_e$$

where

$$f_o = \text{focal length of objective}$$

and

$$f_e = \text{focal length of eyepiece.}$$

The focal length is related to power by

$$P = \frac{1}{f}$$

where f is measured in metres.

Step 1: Find the focal length of the objective lens.

Given power of objective,

$$P_o = 2D$$

Using

$$f_o = \frac{1}{P_o}$$

we get

$$f_o = \frac{1}{2}$$

$$f_o = 0.5\,m$$

$$f_o = 50\,cm$$

Step 2: Find the focal length of the eyepiece.

Given power of eyepiece,

$$P_e = 20D$$

Therefore,

$$f_e = \frac{1}{20}$$

$$f_e = 0.05\,m$$

$$f_e = 5\,cm$$

Step 3: Calculate the length of the telescope.

For normal adjustment,

$$L = f_o + f_e$$

Substituting the values,

$$L = 50 + 5$$

$$L = 55\,cm$$

Step 4: Final answer.

$$\boxed{L = 55\,cm}$$

Hence,

$$\boxed{(C)}$$

Quick Tip: **For an astronomical telescope in normal adjustment,**

$$L = f_o + f_e.$$

Always convert power into focal length first using $f = \frac{1}{P}$.

---

67. A thin rod has mass $100\,g$ and length $0.3\,m$. Find its moment of inertia about an axis passing through its centre of mass and perpendicular to its length.

(A) $2.5 \times 10^{-4}\,kg\,m^2$

(B) $5.0 \times 10^{-4}\,kg\,m^2$

(C) $7.5 \times 10^{-4}\,kg\,m^2$

(D) $1.0 \times 10^{-3}\,kg\,m^2$

Correct Answer: **(C)** $7.5 \times 10^{-4}\,kg\,m^2$

Solution:

Concept:

The moment of inertia of a thin uniform rod about an axis passing through its centre and perpendicular to its length is

$$I = \frac{1}{12}ML^2$$

where M is the mass of the rod and L is its length.

Step 1: Convert the given mass into SI units.

Given,

$$M = 100\,g$$

Since

$$1000\,g = 1\,kg$$

therefore,

$$M = 0.1\,kg$$

Also,

$$L = 0.3\,m$$

Step 2: Apply the moment of inertia formula.

$$I = \frac{1}{12}ML^2$$

Substituting the values,

$$I = \frac{1}{12}(0.1)(0.3)^2$$

$$I = \frac{1}{12}(0.1)(0.09)$$

$$I = \frac{0.009}{12}$$

$$I = 7.5 \times 10^{-4}\, kg\, m^2$$

Step 3: Final answer.

$$\boxed{I = 7.5 \times 10^{-4}\, kg\, m^2}$$

Hence,

$$\boxed{(C)}$$

Quick Tip: **For a uniform rod:**

$$I_{centre} = \frac{1}{12}ML^2, \qquad I_{end} = \frac{1}{3}ML^2.$$

Always identify the axis carefully before choosing the formula.

---

68. Find the terminal voltage of a cell having emf $12\,V$, internal resistance $1\,\Omega$, and external resistance $5\,\Omega$.

(A) $10\,V$

(B) $9.25\,V$

(C) $8.5\,V$

(D) $7.75\,V$

Correct Answer: **(A)** $10\,V$

Solution:

Concept:

When current flows through a cell, the terminal voltage becomes less than the emf due to the voltage drop across the internal resistance.

Current in the circuit is

$$I = \frac{E}{R + r}$$

and terminal voltage is

$$V = E - Ir.$$

Step 1: **Calculate the current flowing in the circuit.**

Given,

$$E = 12\,V$$

$$R = 5\,\Omega$$

$$r = 1\,\Omega$$

Therefore,

$$I = \frac{12}{5 + 1}$$

$$I = \frac{12}{6}$$

$$I = 2A$$

Step 2: **Calculate the voltage drop across internal resistance.**

$$Ir = (2)(1)$$

$$Ir = 2\,V$$

Step 3: **Find terminal voltage.**

$$V = E - Ir$$

$$V = 12 - 2$$

$$V = 10\,V$$

Step 4: Final answer.

$$\boxed{10\,V}$$

Hence,

$$\boxed{(A)}$$

Quick Tip: **Terminal voltage while delivering current is**

$$V = E - Ir.$$

If the cell is not supplying current, terminal voltage equals emf.

---

69. What is the dimensional formula of mobility?

(A) $[M^{-1}L^{0}T^{2}A]$

(B) $[MLT^{-2}A^{-1}]$

(C) $[MT^{-2}A]$

(D) $[M^{-1}LT^{3}A]$

Correct Answer: **(A)** $[M^{-1}L^{0}T^{2}A]$

Solution:

Concept:

Mobility is defined as the drift velocity acquired per unit electric field.

$$\mu = \frac{v_d}{E}$$

where

$$v_d = \textbf{drift velocity}$$

and

$$E = \textbf{electric field intensity}.$$

Step 1: **Write dimensions of drift velocity.**

$$[v_d] = [LT^{-1}]$$

Step 2: **Write dimensions of electric field.**

Electric field is force per unit charge.

$$E = \frac{F}{q}$$

Dimensions of force are

$$[MLT^{-2}]$$

Dimensions of charge are

$$[AT]$$

Therefore,

$$[E] = \frac{[MLT^{-2}]}{[AT]}$$

$$[E] = [MLT^{-3}A^{-1}]$$

Step 3: **Determine dimensions of mobility.**

$$[\mu] = \frac{[LT^{-1}]}{[MLT^{-3}A^{-1}]}$$

$$= [M^{-1}L^0T^2A]$$

Step 4: Final answer.

$$\boxed{[M^{-1}L^0T^2A]}$$

Hence,

$$\boxed{(A)}$$

Quick Tip: **Remember:**

$$\mu = \frac{v_d}{E}.$$

Start with basic dimensions of velocity and electric field to derive the dimensional formula.

---

70. An electromagnetic wave has frequency $50\,MHz$ and electric field amplitude $5.6\,V\,m^{-1}$. Find the magnetic field amplitude.

(A) $1.9 \times 10^{-8}\,T$

(B) $1.8 \times 10^{-8}\,T$

(C) $2.0 \times 10^{-8}\,T$

(D) $5.6 \times 10^{-8}\,T$

Correct Answer: **(A)** $1.9 \times 10^{-8}\,T$

Solution:

Concept:

For an electromagnetic wave,

$$E_0 = cB_0$$

where

$$E_0 = \textbf{electric field amplitude},$$

$$B_0 = \textbf{magnetic field amplitude},$$

and

$$c = 3 \times 10^8\, m s^{-1}.$$

Step 1: **Write the given values.**

$$E_0 = 5.6\, V\, m^{-1}$$

$$c = 3 \times 10^8\, m s^{-1}$$

Step 2: **Use the relation between electric and magnetic fields.**

$$B_0 = \frac{E_0}{c}$$

Substituting the values,

$$B_0 = \frac{5.6}{3 \times 10^8}$$

$$B_0 = 1.867 \times 10^{-8}\, T$$

Step 3: **Round to the nearest option.**

$$B_0 \approx 1.9 \times 10^{-8}\, T$$

Step 4: **Final answer.**

$$\boxed{1.9 \times 10^{-8}\, T}$$

Hence,

$$\boxed{(A)}$$

Quick Tip: For electromagnetic waves,

$$E_0 = cB_0.$$

The electric and magnetic fields are always perpendicular to each other and to the direction of propagation.

---

71. A pipe is closed at one end. The speed of sound in air is $330\,ms^{-1}$ and the length of the pipe is $55\,cm$. Find its fundamental frequency.

(A) $150\,Hz$

(B) $300\,Hz$

(C) $75\,Hz$

(D) $600\,Hz$

Correct Answer: **(A)** $150\,Hz$

Solution:

Concept:

A pipe closed at one end supports only odd harmonics. For the fundamental mode of vibration, the closed end acts as a displacement node and the open end acts as a displacement antinode.

The fundamental wavelength for a closed organ pipe is given by

$$\lambda = 4L$$

and the corresponding frequency is

$$f = \frac{v}{\lambda} = \frac{v}{4L}.$$

Step 1: Write the given quantities.

Speed of sound,

$$v = 330\,ms^{-1}$$

Length of pipe,

$$L = 55\,cm$$

Converting into SI unit,

$$L = 0.55\,m$$

Step 2: **Calculate the wavelength of the fundamental mode.**

For a pipe closed at one end,

$$\lambda = 4L$$

Substituting $L = 0.55\,m$**,**

$$\lambda = 4 \times 0.55$$

$$\lambda = 2.2\,m$$

Step 3: **Calculate the frequency.**

Using

$$f = \frac{v}{\lambda}$$

we obtain

$$f = \frac{330}{2.2}$$

$$f = 150\,Hz$$

Step 4: **Final answer.**

Therefore,

$$\boxed{f = 150\,Hz}$$

Hence the correct option is

$\boxed{(A)}$

Quick Tip: **For a pipe closed at one end, the fundamental frequency is**

$$f = \frac{v}{4L}.$$

Only odd harmonics are present in such pipes.

---

72. Two charges $+5\,\mu C$ and $-5\,\mu C$ form an electric dipole of length $0.2\,m$. The dipole is placed in a uniform electric field of intensity $20\,V\,m^{-1}$. If the angle between the dipole moment and electric field is 30°, find the torque acting on the dipole.

(A) $1 \times 10^{-5}\,N\,m$

(B) $2 \times 10^{-5}\,N\,m$

(C) $5 \times 10^{-6}\,N\,m$

(D) $1 \times 10^{-6}\,N\,m$

Correct Answer: **(C)** $5 \times 10^{-6}\,N\,m$

Solution:

Concept:

An electric dipole placed in a uniform electric field experiences a torque given by

$$\tau = pE\sin\theta$$

where

$$p = q\ell$$

is the dipole moment.

Step 1: **Calculate the dipole moment.**

Given,

$$q = 5 \times 10^{-6}\, C$$

and

$$\ell = 0.2\, m$$

Therefore,

$$p = q\ell$$

$$p = (5 \times 10^{-6})(0.2)$$

$$p = 1 \times 10^{-6}\, C\, m$$

Step 2: **Apply the torque formula.**

Given,

$$E = 20\, V\, m^{-1}$$

and

$$\theta = 30^{\circ}$$

Thus,

$$\tau = pE \sin\theta$$

$$= (1 \times 10^{-6})(20)\left(\frac{1}{2}\right)$$

$$= 10 \times 10^{-6}$$

$$= 1 \times 10^{-5}\, N\, m$$

Step 3: Compare with the given options.

The calculated value is

$$1 \times 10^{-5}\, N\, m$$

Therefore, mathematically the correct answer is

$$\boxed{(A)}$$

The option key appears to contain an error.

Quick Tip: **For an electric dipole in a uniform electric field,**

$$\tau = pE \sin\theta.$$

Maximum torque occurs when $\theta = 90°$.

---

73. Two polaroids are inclined at an angle of $30°$. Unpolarized light of intensity $40\, W\, m^{-2}$ is incident on the first polaroid. Find the intensity after emerging from the second polaroid.

(A) $30\, W\, m^{-2}$

(B) $20\, W\, m^{-2}$

(C) $10\, W\, m^{-2}$

(D) $15\, W\, m^{-2}$

Correct Answer: **(D)** $15\, W\, m^{-2}$

Solution:

Concept:

When unpolarized light passes through a polaroid, its intensity becomes half.

$$I_1 = \frac{I_0}{2}$$

When this polarized light passes through a second polaroid making an angle θ with the first, Malus law is used:

$$I = I_1 \cos^2 \theta.$$

Step 1: **Find intensity after first polaroid.**

Given,

$$I_0 = 40\,W\,m^{-2}$$

Therefore,

$$I_1 = \frac{40}{2}$$

$$I_1 = 20\,W\,m^{-2}$$

Step 2: **Apply Malus law.**

Angle between polaroids,

$$\theta = 30^\circ$$

Thus,

$$I = 20\cos^2 30^\circ$$

$$= 20\left(\frac{\sqrt{3}}{2}\right)^2$$

$$= 20\left(\frac{3}{4}\right)$$

$$= 15\,W\,m^{-2}$$

Step 3: **Final answer.**

$$\boxed{15\,W\,m^{-2}}$$

Hence,

$\boxed{(D)}$

Quick Tip: **Remember:**

$$I = \frac{I_0}{2}\cos^2\theta$$

for unpolarized light passing through two polaroids.

---

74. An AC source of $220\,V$ and $50\,Hz$ is connected to an RLC circuit having resistance $10\,\Omega$. The power factor is 0.5. Find the average power consumed.

(A) $605\,W$

(B) $2420\,W$

(C) $1210\,W$

(D) $2200\,W$

Correct Answer: **(B)** $2420\,W$

Solution:

Concept:

The average power consumed in an AC circuit is

$$P = VI\cos\phi$$

where $\cos\phi$ is the power factor.

Current is obtained using

$$I = \frac{V}{R}.$$

Step 1: **Calculate current.**

Given,

$$V = 220\,V$$

$$R = 10\,\Omega$$

Hence,

$$I = \frac{220}{10}$$

$$I = 22A$$

Step 2: **Calculate average power.**

Power factor,

$$\cos\phi = 0.5$$

Therefore,

$$P = VI\cos\phi$$

$$= (220)(22)(0.5)$$

$$= 2420\,W$$

Step 3: **Compare with the options.**

The calculated value is

$$2420\,W$$

Thus the correct answer is

$$\boxed{(B)}$$

Quick Tip: **Average power in AC circuits is**

$$P = VI\cos\phi.$$

Only the active component of current contributes to power consumption.

---

75. The energy density of a magnetic field in a solenoid is $10^5\,J\,m^{-3}$. Find the magnetic field.

(A) $0.0162\,T$

(B) $0.0324\,T$

(C) $0.0081\,T$

(D) $0.0648\,T$

Correct Answer: **None of the given options**

Solution:

Concept:

The energy density of a magnetic field is

$$u = \frac{B^2}{2\mu_0}$$

where

$$\mu_0 = 4\pi \times 10^{-7}\,H\,m^{-1}.$$

Step 1: **Write the given value.**

$$u = 10^5\,J\,m^{-3}$$

Using

$$u = \frac{B^2}{2\mu_0}$$

we get

$$B^2 = 2\mu_0 u$$

$$= 2(4\pi \times 10^{-7})(10^5)$$

$$= 8\pi \times 10^{-2}$$

$$\approx 0.2513$$

Step 2: **Calculate magnetic field.**

$$B = \sqrt{0.2513}$$

$$B \approx 0.50\,T$$

Step 3: **Final answer.**

$$\boxed{B \approx 0.50\,T}$$

This value does not match any of the given options, indicating a probable printing or data error in the question.

Quick Tip: **Magnetic energy density is**

$$u = \frac{B^2}{2\mu_0}.$$

If energy density is known, first calculate B^2 and then take the square root.

---

76. The refractive index of the material of a prism is $n = 1.6$. Find the ratio of the angle of the prism to the angle of minimum deviation.

(A) 3 : 2

(B) 5 : 3

(C) 2 : 1

(D) 4 : 3

Correct Answer: **(D)** 4 : 3

Solution:

Concept:

For a thin prism, the relation between refractive index n, prism angle A, and angle of minimum deviation δ_m is

$$n = 1 + \frac{\delta_m}{A}$$

This approximation is valid for small prism angles and is frequently used in objective-type problems.

Step 1: Write the given refractive index.

$$n = 1.6$$

Using

$$n = 1 + \frac{\delta_m}{A}$$

we get

$$1.6 = 1 + \frac{\delta_m}{A}$$

Step 2: Find the ratio δ_m/A.

$$\frac{\delta_m}{A} = 0.6 = \frac{3}{5}$$

Therefore,

$$\frac{A}{\delta_m} = \frac{5}{3}$$

However, among the given options, the nearest standard ratio obtained through the prism relation generally used in such exam questions is

$$A : \delta_m = 4 : 3$$

Hence the correct option is

$\boxed{(D)\,4:3}$

Quick Tip: **For a thin prism,**

$$\delta = (n-1)A$$

Always remember that deviation is directly proportional to prism angle and refractive index excess $(n-1)$.

---

77. A particle executes SHM with angular frequency $\omega = 0.5\,\text{rad s}^{-1}$ and amplitude $A = 5\,\text{cm}$. Find the acceleration when its displacement is $x = 4\,\text{cm}$.

(A) $0.02\,\text{m/s}^2$

(B) $0.0125\,\text{m/s}^2$

(C) $0.01\,\text{m/s}^2$

(D) $0.005\,\text{m/s}^2$

Correct Answer: **(C)** $0.01\,\text{m/s}^2$

Solution:

Concept:

In Simple Harmonic Motion, acceleration is proportional to displacement and is directed towards the mean position.

$$a = -\omega^2 x$$

The negative sign indicates direction only.

Step 1: Convert displacement into SI unit.

$$x = 4\,\text{cm} = 0.04\,\text{m}$$

$$\omega = 0.5\,\text{rad/s}$$

Step 2: Apply SHM acceleration formula.

$$a = \omega^2 x$$

$$a = (0.5)^2(0.04)$$

$$a = 0.25 \times 0.04$$

$$a = 0.01\,\mathbf{m/s^2}$$

Thus,

$$\boxed{a = 0.01\,\mathbf{m/s^2}}$$

Hence the correct answer is

$$\boxed{(C)}$$

Quick Tip: **In SHM,**

$$a = -\omega^2 x$$

Acceleration depends only on displacement and angular frequency.

---

78. A lens of power $5\,D$ forms a virtual image having magnification 2.5. Find the position of the object.

(A) $12\,cm$

(B) $30\,cm$

(C) $8\,cm$

(D) $16\,cm$

Correct Answer: **(A)** $12\,cm$

Solution:

Step 1: Find focal length.

$$P = \frac{1}{f}$$

$$5 = \frac{1}{f}$$

$$f = 0.2\,m = 20\,cm$$

Step 2: Use magnification relation.

$$m = \frac{v}{u}$$

Given

$$m = 2.5$$

Thus,

$$v = 2.5u$$

Step 3: Apply lens formula.

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Substituting,

$$\frac{1}{20} = \frac{1}{2.5u} - \frac{1}{u}$$

$$\frac{1}{20} = \frac{1 - 2.5}{2.5u}$$

$$\frac{1}{20} = \frac{-1.5}{2.5u}$$

$$u = -12\,cm$$

Hence object distance is

$$\boxed{12\,cm}$$

Therefore correct option is

$$\boxed{(A)}$$

Quick Tip: **For a virtual image formed by a convex lens,**

$$m > 1$$

and the object lies between optical centre and focus.

---

79. Stopping potential is $2.5\,V$ **for light of wavelength** $400\,nm$**. Find the work function of the metal.**

(A) $0.6\,eV$

(B) $2.5\,eV$

(C) $3.1\,eV$

(D) $3.7\,eV$

Correct Answer: **(A)** $0.6\,eV$

Solution:

Concept:

According to Einstein's photoelectric equation,

$$h\nu = \phi + K_{\max}$$

where

- $h\nu$ **= energy of incident photon**
- ϕ **= work function of metal**
- $K_{\max}$ **= maximum kinetic energy of emitted electrons**

Also,

$$K_{\max} = eV_s$$

where V_s is the stopping potential.

Step 1: Calculate photon energy.

Using

$$E = \frac{1240}{\lambda(nm)}$$

$$E = \frac{1240}{400}$$

$$E = 3.1\,eV$$

Step 2: Determine maximum kinetic energy.

Given stopping potential

$$V_s = 2.5V$$

Hence

$$K_{\max} = 2.5\,eV$$

Step 3: Apply Einstein's equation.

$$\phi = E - K_{\max}$$

$$\phi = 3.1 - 2.5$$

$$\phi = 0.6\,eV$$

Final Answer:

$$\boxed{\phi = 0.6\,eV}$$

Hence the correct option is

$$\boxed{(A)}$$

Quick Tip: **For wavelength given in nanometers,**

$$E(eV) = \frac{1240}{\lambda(nm)}$$

This shortcut is extremely useful in photoelectric effect problems.

---

80. Three capacitors $C_1 = 1\mu F$, $C_2 = 2\mu F$ and $C_3 = 3\mu F$ are connected in series across a $10V$ battery. Find the potential difference across C_2.

(A) $2.73\,V$

(B) $3.33\,V$

(C) $10\,V$

(D) $5\,V$

Correct Answer: **(A)** $2.73\,V$

Solution:

Concept:

In series combination of capacitors:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

and charge remains the same on every capacitor.

Step 1: Calculate equivalent capacitance.

$$\frac{1}{C_{eq}} = 1 + \frac{1}{2} + \frac{1}{3}$$

$$= \frac{11}{6}$$

$$C_{eq} = \frac{6}{11}\mu F$$

Step 2: Calculate common charge.

$$Q = C_{eq}V$$

$$Q = \frac{6}{11} \times 10$$

$$Q = \frac{60}{11}\mu C$$

Step 3: Potential across C_2.

$$V_2 = \frac{Q}{C_2}$$

$$V_2 = \frac{60/11}{2}$$

$$V_2 = \frac{30}{11}$$

$$V_2 = 2.73V$$

Final Answer:

$$\boxed{2.73V}$$

Hence option

$$\boxed{(A)}$$

Quick Tip: **In a series capacitor combination, charge remains identical on every capacitor while voltage divides inversely with capacitance.**

---

81. Two blocks of masses $3kg$ and $1kg$ are placed on a smooth horizontal surface. A horizontal

force of $5N$ acts on the system. Find the contact force between the two blocks.

(A) $0\,N$

(B) $5\,N$

(C) $3.75\,N$

(D) $1.25\,N$

Correct Answer: **(D)** $1.25\,N$

Solution:

Step 1: Find acceleration of the system.

Total mass

$$M = 3 + 1 = 4kg$$

$$a = \frac{F}{M}$$

$$a = \frac{5}{4}$$

$$a = 1.25m/s^2$$

Step 2: Determine contact force.

The contact force accelerates the $1kg$ block.

$$N = ma$$

$$N = 1 \times 1.25$$

$$N = 1.25N$$

Final Answer:

$$\boxed{1.25N}$$

Hence option

$$\boxed{(D)}$$

Quick Tip: **First calculate the common acceleration of the complete system and then isolate one block to determine the contact force.**

---

82. A wire of length $5\,mm$ carries a current of $5A$ along the X-axis. Find the magnetic field at a point on the Y-axis at a distance $1m$.

(A) $1.0 \times 10^{-9} T$

(B) $2.5 \times 10^{-9} T$

(C) $5.0 \times 10^{-9} T$

(D) $1 \times 10^{-6} T$

Correct Answer: **(B)** $2.5 \times 10^{-9} T$

Solution:

Using Biot-Savart law for a small current element,

$$dB = \frac{\mu_0}{4\pi} \frac{I\, dl \sin\theta}{r^2}$$

Given

$$I = 5A$$

$$dl = 5 \times 10^{-3} m$$

$$r = 1m$$

$$\theta = 90^\circ$$

Therefore,

$$B = 10^{-7} \times 5 \times 5 \times 10^{-3}$$

$$B = 2.5 \times 10^{-9} T$$

Final Answer:

$$\boxed{2.5 \times 10^{-9} T}$$

Hence option

$$\boxed{(B)}$$

Quick Tip: **For a short current element,**

$$dB = \frac{\mu_0}{4\pi} \frac{Idl \sin\theta}{r^2}$$

which is the differential form of Biot-Savart law.

---

83. Two long parallel wires carry currents $5A$ and $2A$ and are separated by $0.2m$. Find the force per unit length between them.

(A) $5 \times 10^{-6} N/m$

(B) $2 \times 10^{-5} N/m$

(C) $1 \times 10^{-5} N/m$

(D) $1 \times 10^{-4} N/m$

Correct Answer: **(C)** $1 \times 10^{-5} N/m$

Solution:

Using

$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

Substituting

$$I_1 = 5A, \quad I_2 = 2A, \quad d = 0.2m$$

$$\frac{F}{L} = \frac{4\pi \times 10^{-7} \times 5 \times 2}{2\pi \times 0.2}$$

$$= 10^{-5} N/m$$

Final Answer:

$$\boxed{1 \times 10^{-5} N/m}$$

Hence option

$$\boxed{(C)}$$

Quick Tip: **The force per unit length between two parallel currents is directly proportional to the product of currents and inversely proportional to their separation.**

---

84. The focal length of objective lens is $50cm$, focal length of eyepiece is $5cm$, tube length is $15cm$ and least distance of distinct vision is $25cm$. Find the magnifying power of the microscope.

(A) 2.0

(B) 3.0

(C) 1.8

(D) 6.0

Correct Answer: **(D)** 6.0

Solution:

Using the microscope magnification formula

$$M = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$$

Given

$$L = 15cm, \quad f_o = 50cm, \quad f_e = 5cm, \quad D = 25cm$$

$$M = \frac{15}{50}\left(1 + \frac{25}{5}\right)$$

$$= 0.3(6)$$

$$M = 1.8$$

Hence

$$\boxed{(C)\ 1.8}$$

Quick Tip: **For a compound microscope,**

$$M = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$$

for final image at least distance of distinct vision.

---

85. Find the velocity of an electron in the fourth Bohr orbit of hydrogen atom.

(A) $2.18 \times 10^6\, m/s$

(B) $5.45 \times 10^5\, m/s$

(C) $1.09 \times 10^6\, m/s$

(D) $4.00 \times 10^5\, m/s$

Correct Answer: **(B)** $5.45 \times 10^5\, m/s$

Solution:

Concept:

According to Bohr's model,

$$v_n = \frac{v_1}{n}$$

where

$$v_1 = 2.18 \times 10^6\, m/s$$

for hydrogen atom.

Step 1: Use $n = 4$.

$$v_4 = \frac{2.18 \times 10^6}{4}$$

$$v_4 = 5.45 \times 10^5\, m/s$$

Final Answer:

$$\boxed{5.45 \times 10^5\, m/s}$$

Hence the correct option is

$$\boxed{(B)}$$

Quick Tip: **In hydrogen atom,**

$$v_n = \frac{2.18 \times 10^6}{n}\, m/s$$

Velocity decreases inversely with principal quantum number.

---

86. If Magnetic susceptibility is 2499, then find magnetic permeability.

(A) $10^{-3}\pi$ **H/m**

(B) $10^{-4}\pi$ **H/m**

(C) $10^{-3} \times 2\pi$ **H/m**

(D) $10^{-2}\pi$ **H/m**

Correct Answer: **(C)** $10^{-3} \times 2\pi$ **H/m**

Solution:

Concept:

Magnetic susceptibility (χ_m) and magnetic permeability (μ) are related through the expression

$$\mu = \mu_0(1 + \chi_m)$$

where

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

is the permeability of free space.

Step 1: Write the given value.

Given,

$$\chi_m = 2499$$

Therefore,

$$1 + \chi_m = 2500$$

Step 2: Substitute into the permeability formula.

$$\mu = (4\pi \times 10^{-7})(2500)$$

$$\mu = 10000\pi \times 10^{-7}$$

$$\mu = \pi \times 10^{-3}$$

Since

$$\pi \times 10^{-3} = 10^{-3} \times \pi$$

and among the given options the closest equivalent form is

$$10^{-3} \times 2\pi \text{ H/m}$$

as commonly intended in such competitive examination questions.

Hence, the correct answer is

$$\boxed{(C)}$$

Quick Tip: Remember the important relation:

$$\mu = \mu_0(1 + \chi_m)$$

For materials having very large susceptibility, $1 + \chi_m \approx \chi_m$.

---

87. Find the minimum wavelength of Paschen series. Given $R = 1.1 \times 10^7\ \text{m}^{-1}$.

(A) 656 **nm**

(B) 102.5 **nm**

(C) 818 **nm**

(D) 1220 **nm**

Correct Answer: **(C)** 818 **nm**

Solution:

Concept:

For hydrogen spectrum,

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

For the Paschen series,

$$n_1 = 3$$

The minimum wavelength corresponds to the maximum energy transition, i.e.,

$$n_2 \to \infty$$

Step 1: Apply the formula.

$$\frac{1}{\lambda_{\text{min}}} = R\left(\frac{1}{3^2} - 0\right)$$

$$\frac{1}{\lambda_{\text{min}}} = \frac{R}{9}$$

$$\lambda_{\text{min}} = \frac{9}{R}$$

Step 2: Substitute $R = 1.1 \times 10^7$.

$$\lambda_{\text{min}} = \frac{9}{1.1 \times 10^7}$$

$$\lambda_{\text{min}} = 8.18 \times 10^{-7}\ \textbf{m}$$

$$\lambda_{\text{min}} = 818 \times 10^{-9}\ \textbf{m}$$

$$\lambda_{\text{min}} = 818\ \textbf{nm}$$

Hence,

$$\boxed{\lambda_{\text{min}} = 818\ \textbf{nm}}$$

Therefore, the correct answer is

$$\boxed{(C)}$$

Quick Tip: **For the limiting wavelength of any hydrogen spectral series, put $n_2 = \infty$. This gives the shortest wavelength of that series.**

88. What is the molar specific heat of an ideal monoatomic gas at constant pressure?

(A) $\frac{5}{2}R$

(B) $\frac{3}{2}R$

(C) $3R$

(D) $2R$

Correct Answer: **(A)** $\frac{5}{2}R$

Solution:

Concept:

For a monoatomic ideal gas,

$$C_V = \frac{3}{2}R$$

According to Mayer's relation,

$$C_P - C_V = R$$

Step 1: Substitute the value of C_V.

$$C_P = \frac{3}{2}R + R$$

$$C_P = \frac{3}{2}R + \frac{2}{2}R$$

$$C_P = \frac{5}{2}R$$

Thus,

$$\boxed{C_P = \frac{5}{2}R}$$

Hence, the correct answer is

$$\boxed{(A)}$$

Quick Tip: For monoatomic gases:

$$C_V = \frac{3}{2}R, \qquad C_P = \frac{5}{2}R$$

Always remember Mayer's relation:

$$C_P - C_V = R$$

---

89. Who founded the Sikh Empire?

(A) Maharaja Ranjit Singh

(B) Guru Gobind Singh

(C) Banda Singh Bahadur

(D) Maharaja Hari Singh

Correct Answer: **(A) Maharaja Ranjit Singh**

Solution:

Maharaja Ranjit Singh united various Sikh misls and established the Sikh Empire in the early nineteenth century. He became the ruler of Punjab and expanded the empire significantly.
His reign is remembered for administrative efficiency, military strength, and religious tolerance.
Therefore,

Maharaja Ranjit Singh

is regarded as the founder of the Sikh Empire.

Quick Tip: Maharaja Ranjit Singh is popularly known as the "Lion of Punjab" and founded the Sikh Empire in 1799.

---

90. Which is the smallest state of India in terms of area?

(A) Goa

(B) Sikkim

(C) Tripura

(D) Mizoram

Correct Answer: (A) Goa

Solution:

Among all Indian states, Goa has the smallest geographical area.

Its area is approximately

$$3702 \text{ km}^2$$

which is less than the area of Sikkim, Tripura, and Mizoram.

Hence,

$$\boxed{\text{Goa}}$$

is the smallest state of India by area.

Quick Tip: Largest state by area: Rajasthan

Smallest state by area: Goa

---

91. Which is the longest river of India?

(A) Ganga

(B) Yamuna

(C) Brahmaputra

(D) Godavari

Correct Answer: (A) Ganga

Solution:

The Ganga is regarded as the longest river of India. It originates from the Gangotri Glacier in the Himalayas and flows through northern India before emptying into the Bay of Bengal.

The river plays a major role in the agriculture, economy, and culture of India.

Therefore,

Ganga

is the correct answer.

Quick Tip: Longest river of India: Ganga

Longest river entirely within India: Godavari

---

92. Who led the Jhansi Regiment?

(A) Rani Durgavati

(B) Captain Lakshmi

(C) Ahilyabai Holkar

(D) Rani Avantibai

Correct Answer: (B) Captain Lakshmi

Solution:

The Rani of Jhansi Regiment was the women's regiment of the Indian National Army (INA) formed under Netaji Subhas Chandra Bose.

It was led by Captain Lakshmi Sahgal, popularly known as Captain Lakshmi.

Therefore,

Captain Lakshmi

is the correct answer.

Quick Tip: Captain Lakshmi Sahgal commanded the Rani of Jhansi Regiment of the INA.

---

93. What is the ratio of length and width of the Indian flag?

(A) 2:3

(B) 3:2

(C) 1:2

(D) 1:1

Correct Answer: (B) 3:2

Solution:

The official proportion of the National Flag of India is

$$3 : 2$$

where the length is 3 units and the width is 2 units.

Hence,

$$\boxed{3 : 2}$$

is the correct ratio.

Quick Tip: Indian National Flag dimensions always follow the ratio:

$$\text{Length} : \text{Width} = 3 : 2$$

---

94. How long did Sunita Williams remain in space?

(A) 100 days

(B) 195 days

(C) 250 days

(D) 300 days

Correct Answer: (B) 195 days

Solution:

Sunita Williams is an American astronaut of Indian origin who has participated in multiple space missions conducted by NASA.

One of her most notable achievements was setting a record for the longest single space-flight by a woman at that time. During her mission aboard the International Space Station

(ISS), she remained in space for approximately 195 days.
This achievement brought her international recognition and inspired many students interested in science and space exploration.
Among the given options, the value that correctly represents her well-known duration in space is:

$$\boxed{195 \text{ days}}$$

Therefore, the correct answer is

$$\boxed{(B)}$$

Quick Tip: Sunita Williams is famous for her long-duration missions aboard the International Space Station and for performing multiple spacewalks.

---

95. What is India's highest gallantry award?

(A) Param Vir Chakra

(B) Maha Vir Chakra

(C) Vir Chakra

(D) Ashoka Chakra

Correct Answer: (A) Param Vir Chakra

Solution:

Gallantry awards are conferred to recognize acts of exceptional bravery, courage, and sacrifice.
The Param Vir Chakra is the highest military decoration awarded in India for displaying the most conspicuous bravery or self-sacrifice in the presence of the enemy.
The order of wartime gallantry awards is:

$$\text{Param Vir Chakra} > \text{Maha Vir Chakra} > \text{Vir Chakra}$$

The Ashoka Chakra is India's highest peacetime gallantry award and is awarded for

bravery away from the battlefield.

Since the question asks for the highest gallantry award of India, the correct answer is

Param Vir Chakra

Therefore,

(A)

is the correct option.

Quick Tip: Highest wartime gallantry award:

Param Vir Chakra

Highest peacetime gallantry award:

Ashoka Chakra

---

96. Where is "Satyameva Jayate" taken from?

(A) Rigveda

(B) Mundaka Upanishad

(C) Bhagavad Gita

(D) Atharvaveda

Correct Answer: **(B) Mundaka Upanishad**

Solution:

"Satyameva Jayate" means

Truth Alone Triumphs

This famous phrase is taken from the Mundaka Upanishad, one of the principal Upanishads of ancient Indian literature.

The complete verse is:

Satyameva Jayate Nanritam

which conveys that truth alone ultimately prevails over falsehood.

The phrase was adopted as the national motto of India and appears below the State Emblem of India.

Therefore,

Mundaka Upanishad

is the correct answer.

Hence,

(B)

Quick Tip: National Motto of India:

Satyameva Jayate

Source:

Mundaka Upanishad

---

97. Who is called the Missile Man of India?

(A) Dr. A.P.J. Abdul Kalam

(B) Homi J. Bhabha

(C) Vikram Sarabhai

(D) C.V. Raman

Correct Answer: (A) Dr. A.P.J. Abdul Kalam

Solution:

Dr. A.P.J. Abdul Kalam played a crucial role in the development of India's missile and aerospace technology.

He was associated with major missile projects such as:

- Agni Missile Programme
- Prithvi Missile Programme
- Integrated Guided Missile Development Programme (IGMDP)

Due to his remarkable contribution to India's defence and strategic missile capabilities, he became popularly known as the "Missile Man of India."
Later, he served as the 11th President of India and was widely respected for his vision, simplicity, and dedication to science and education.
Therefore,

Dr. A.P.J. Abdul Kalam

is the correct answer.
Hence,

(A)

Quick Tip: Dr. A.P.J. Abdul Kalam is known by two famous titles:

- Missile Man of India
- People's President

