

AP EDCET 2025 Physical Science Question Paper with Solution

Time Allowed :120 Minutes	Maximum Marks :150	Total Questions :150
---------------------------	--------------------	----------------------

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The duration of the test is **3 hours**.
2. Each question carries **1 mark**. There is **no negative marking**.
3. The medium of the question paper is **English** and **Telugu/Urdu** (as opted by the candidate).
4. Candidates must report at the test center **at least 90 minutes** before the commencement of the examination.
5. Candidates must carry:
 - **Filled-in Online Application Form (printout)**
 - **Valid Photo ID Proof** (Aadhaar, Passport, PAN, Driving Licence, etc.)
6. Rough work must be done only on the provided rough sheets. Additional sheets will not be provided.
7. Use of **calculators, mobile phones, smart watches, or any electronic devices** is strictly prohibited.
8. Follow the invigilator's instructions carefully. Any malpractice will result in **disqualification**.

Read the passage and answer questions based on the passage: Moral education centres upon this conception of the school as a mode of social life, that the best and the deepest moral training is precisely that which one gets through having to enter into proper relations with others in a unity of work and thought. The present educational systems, so far as they destroy or neglect this unity, render it difficult or impossible to get any genuine, regular moral training. 1. According to the writer, the school is a form of -----.

- (A) individual existence
(B) religious life
(C) spiritual life
(D) social life

Correct Answer: (D) social life

Solution:

The first sentence of the passage states, "Moral education centres upon this conception of the school as a mode of social life..."

This sentence explicitly defines the writer's view of a school.

The writer conceives of the school as a "mode of social life".

Therefore, according to the writer, the school is a form of social life.

Quick Tip

In reading comprehension questions, the answer to a direct question is often stated explicitly in the first or second sentence of the passage. Always read the opening lines carefully to identify the main subject and the author's primary argument.

2. Moral training, according to the passage, effects

- (A) a unity of work and thought
- (B) entering into proper relations with oneself
- (C) the skills of work
- (D) the skills of thought

Correct Answer: (A) a unity of work and thought

Solution:

The passage explains, "...the best and the deepest moral training is precisely that which one gets through having to enter into proper relations with others in a unity of work and thought."

This indicates that the process of achieving "a unity of work and thought" is the mechanism through which moral training occurs.

Thus, moral training brings about, or effects, this unity.

The other options are either incomplete or not mentioned in this context.

Quick Tip

Look for key phrases in the passage that directly correspond to the language used in the question. The question asks what moral training "effects," and the passage links moral training directly to achieving "a unity of work and thought."

3. The writer's attitude to the present education system can be described as

- (A) Critical
- (B) adulatory
- (C) defensive

(D) indifferent

Correct Answer: (A) Critical

Solution:

The writer makes the following statement about the present systems: "The present educational systems, so far as they destroy or neglect this unity, render it difficult or impossible to get any genuine, regular moral training."

The use of strong, negative words like "destroy," "neglect," and "impossible" shows a clear disapproval of the current system.

An attitude that finds fault and expresses disapproval is best described as "Critical".

"Adulatory" means praising, "defensive" means protecting from criticism, and "indifferent" means having no interest, none of which fit the writer's tone.

Quick Tip

An author's attitude (or tone) is conveyed through their word choice. Pay close attention to adjectives and verbs that carry positive, negative, or neutral connotations to accurately identify the author's perspective.

4. The central concern of the passage is _____

(A) spiritual education / spiritual training

(B) work education / work training

(C) moral education / moral training

(D) thought education / thought training

Correct Answer: (C) moral education / moral training

Solution:

The passage opens by immediately introducing its main topic: "Moral education centres upon this conception of the school...".

It continues by discussing "the best and the deepest moral training" and the failure of current systems to provide "genuine, regular moral training."

The entire text revolves around the importance and nature of moral education and training within a school environment.

Therefore, the central concern of the passage is moral education / moral training.

Quick Tip

The central concern or main idea of a passage is the overarching topic that all sentences and details in the text support. It's often introduced in the first sentence and reinforced throughout.

5. Find the word from the passage that is a synonym of accurate.

- (A) Conception
- (B) Neglect
- (C) Precise
- (D) Genuine

Correct Answer: (C) Precise

Solution:

The question asks for a synonym of the word "accurate". "Accurate" means correct in all details; exact.

Let's examine the meanings of the options given from the passage:

- (A) Conception: An abstract idea; a concept. This is not a synonym for accurate.
- (B) Neglect: To fail to care for properly. This is not a synonym for accurate.
- (C) Precise: Marked by exactness and accuracy of expression or detail. The passage uses it in the phrase "precisely that which one gets," emphasizing exactness. This is a strong synonym for accurate.
- (D) Genuine: Truly what something is said to be; authentic. While related to truth, it is not as close in meaning to "accurate" as "precise" is.

Therefore, "Precise" is the best synonym for "accurate" among the choices.

Quick Tip

A synonym is a word that has the same or nearly the same meaning as another word. When choosing a synonym, consider the context. Here, 'precise' shares the core meaning of 'exactness' with 'accurate'.

6. Correct the underline word in the sentence below, by substituting with the correct word I pray for god to give me strength

- (A) regarding
- (B) to

- (C) of
- (D) with

Correct Answer: (B) to

Solution:

The verb "pray" is followed by the preposition "to" when indicating the recipient of the prayer.

The standard grammatical structure is "pray to someone" (e.g., pray to God) or "pray for something" (e.g., pray for peace).

In the given sentence, "God" is the recipient of the prayer.

Therefore, the correct preposition is "to", making the sentence: "I pray to God to give me strength."

Quick Tip

Understanding prepositions and their usage with specific verbs (collocations) is crucial. Remember the common pattern: 'pray to' a deity/person, and 'pray for' an outcome/thing.

7. I think he is _____ honest man.

- (A) the
- (B) an
- (C) a
- (D) no article

Correct Answer: (B) an

Solution:

The choice between the indefinite articles "a" and "an" depends on the sound of the first letter of the word that follows.

The word "honest" starts with the letter 'h', but the 'h' is silent.

The initial sound of "honest" is the vowel sound // (like in "on").

The article "an" is used before words that begin with a vowel sound.

Therefore, the correct sentence is "I think he is an honest man."

Quick Tip

The use of 'a' or 'an' is determined by the sound, not the spelling, of the following word. Words like 'honest', 'hour', and 'heir' begin with a vowel sound and thus take 'an'.

8. This is _____ car my friend bought last week.

- (A) the
- (B) an
- (C) a
- (D) no article

Correct Answer: (A) the

Solution:

The sentence is referring to a specific, identifiable car.

The clause "my friend bought last week" defines which car is being talked about.

When a noun is made specific and unique by a modifying phrase or clause, the definite article "the" is used.

Using "a car" would imply it is one of many cars, which is not the intended meaning.

Therefore, the correct choice is "the".

Quick Tip

Use the definite article "the" when the noun you are referring to is specific and known to both the speaker and the listener. Modifying phrases like "that I saw" or "my friend bought" often make a noun specific.

9. Indeed, I am not sure _____ his success.

- (A) of
- (B) regarding
- (C) about
- (D) off

Correct Answer: (A) of

Solution:

The adjective "sure" is commonly followed by the prepositions "of" or "about".

The phrase "sure of" is a standard and very common collocation in English used to express certainty or lack thereof.

For example, "I am sure of the answer." or "I am not sure of his intentions."

While "about" could also be grammatically acceptable in many contexts, "of" is presented as an option and is a perfectly correct and standard choice. "Regarding" and "off" are incorrect in this context.

Therefore, "of" is the correct answer.

Quick Tip

Many adjectives in English are followed by specific prepositions. Learning these collocations (e.g., 'sure of', 'interested in', 'afraid of') is key to fluent and correct English usage.

10. They saw him fell _____ his horse.

- (A) after
- (B) against
- (C) of
- (D) off

Correct Answer: (D) off

Solution:

The question describes someone coming down from a horse unintentionally.

The preposition "off" is used to indicate separation or removal from a surface or position.

The phrasal verb "fall off" specifically means to accidentally detach from something one is on top of, such as a horse, bicycle, or ladder.

The other prepositions do not fit the meaning: "after" indicates sequence, "against" indicates opposition or contact, and "of" indicates possession or origin.

Thus, the correct sentence is "They saw him fell off his horse."

Quick Tip

Phrasal verbs combine a verb with a preposition or adverb to create a new meaning. "Fall off" is the correct phrasal verb for detaching from something you are riding.

11. The _____ will meet again, to discuss the matter.

- (A) Comittee
- (B) Commitee
- (C) Committee
- (D) Comitee

Correct Answer: (C) Committee

Solution:

The question requires selecting the correctly spelled word for a group of people appointed for a specific function.

Let's analyze the options:

- (A) Comittee Incorrect spelling.
- (B) Commitee Incorrect spelling.
- (C) Committee This is the correct spelling. It has a double 'm', double 't', and double 'e'.
- (D) Comitee Incorrect spelling.

Therefore, "Committee" is the correctly spelled word to complete the sentence.

Quick Tip

Words with double consonants can be tricky. Remember the spelling of 'committee' with the pattern: double 'm', double 't', double 'e'.

12. The Cricket team are in a _____ mood.

- (A) buoyant
- (B) buoyent
- (C) boyant
- (D) buyant

Correct Answer: (A) buoyant

Solution:

The sentence requires the correct spelling of the adjective that means cheerful and optimistic.

The correct spelling for this word is "buoyant".

Options (B), (C), and (D) are common misspellings of the word.

Therefore, "buoyant" is the correct choice to describe the team's cheerful mood.

Quick Tip

The word 'buoyant' comes from 'buoy'. Remembering the root word can help you recall the correct spelling with 'uo'.

13. Had he studied hard, he _____ passed.

- (A) has
- (B) had been
- (C) would have
- (D) have been

Correct Answer: (C) would have

Solution:

This sentence is an example of the third conditional, which describes an unreal situation in the past.

The structure for the third conditional is: If + past perfect (had + past participle), ... would have + past participle.

The sentence begins with an inversion of the 'if' clause: "Had he studied hard" is equivalent to "If he had studied hard".

Following the rule, the main clause must use "would have + past participle". In this case, "would have passed".

Therefore, "would have" is the correct choice to complete the sentence.

Quick Tip

Third conditional sentences express unreal past conditions and their probable past results. Recognize the structure: 'If + had + v3, ... would have + v3'. The 'if' clause can also be inverted: 'Had + subject + v3...'.

14. I wish I _____ her address.

- (A) know
- (B) have known
- (C) may know
- (D) knew

Correct Answer: (D) knew

Solution:

The phrase "I wish" is used to express a desire for a situation that is not true in the present. This is a subjunctive mood.

When expressing a wish about a present situation, the verb that follows is in the simple past tense.

The speaker does not know the address at present, so they wish for a different reality.

The simple past tense of "know" is "knew".

Therefore, the correct sentence is "I wish I knew her address."

Quick Tip

The subjunctive mood is used for hypothetical situations. For wishes about the present, always use the simple past tense after "I wish". For wishes about the past, use the past perfect (e.g., "I wish I had known").

15. Incredulous means _____.

- (A) obliterate
- (B) skeptical
- (C) practical
- (D) insane

Correct Answer: (B) skeptical

Solution:

The word "incredulous" means unwilling or unable to believe something.

Let's examine the options:

(A) obliterate: to destroy utterly.

(B) skeptical: not easily convinced; having doubts or reservations. This is a close synonym for incredulous.

(C) practical: concerned with the actual doing or use of something rather than with theory and ideas.

(D) insane: in a state of mind which prevents normal perception, behaviour, or social interaction.

The meaning of "skeptical" is the closest to "incredulous".

Quick Tip

The root 'cred' relates to belief (e.g., credible, creed). The prefix 'in-' means 'not'. So, 'incredulous' literally means 'not believing'. This can help you deduce the meaning.

16. Precipitous means _____.

- (A) very steep
- (B) very deep
- (C) presumption
- (D) nascent

Correct Answer: (A) very steep

Solution:

The word "precipitous" is an adjective used to describe something that is dangerously high or steep, like a cliff or a mountain.

It can also mean a sudden and dramatic action or decline.

Looking at the options:

- (A) very steep: This directly matches the primary definition of precipitous.
- (B) very deep: This is a different dimension.
- (C) presumption: an idea that is taken to be true, and acted on, even though it is not known for certain.
- (D) nascent: just coming into existence and beginning to display signs of future potential.

Therefore, "very steep" is the correct meaning.

Quick Tip

Think of the word 'precipice', which means a very steep rock face or cliff. The adjective 'precipitous' is derived from it, making 'very steep' the clear answer.

17. _____ is a synonym for ingenuous.

- (A) Clever
- (B) ingenious

- (C) honest
- (D) Indecent

Correct Answer: (C) honest

Solution:

The word "ingenuous" means innocent, simple, and unsuspecting. It implies a childlike honesty and sincerity.

Let's look at the options:

- (A) Clever: quick to understand, learn, and devise or apply ideas.
- (B) ingenious: (of a person) clever, original, and inventive. Note the different spelling and meaning from ingenuous.
- (C) honest: free of deceit; truthful and sincere. This aligns well with the sincerity implied by ingenuous.
- (D) Indecent: not conforming with generally accepted standards of behavior.

Of the choices provided, "honest" is the closest synonym for "ingenuous".

Quick Tip

Don't confuse 'ingenuous' (innocent, honest) with 'ingenious' (clever, inventive). They are often mixed up but have very different meanings.

18. Keenness is a synonym for _____.

- (A) abjure
- (B) enigma
- (C) skip
- (D) acumen

Correct Answer: (D) acumen

Solution:

"Keenness" refers to the quality of being eager or enthusiastic, or sharpness of perception.

Let's analyze the options:

- (A) abjure: to renounce a belief, cause, or claim.
- (B) enigma: a person or thing that is mysterious or difficult to understand.

(C) skip: to move along lightly, stepping from one foot to the other with a hop or bounce.

(D) acumen: the ability to make good judgments and quick decisions, typically in a particular domain. This relates to the 'sharpness' aspect of keenness.

"Acumen" is the best synonym for the mental sharpness implied by "keenness".

Quick Tip

'Keenness' can refer to enthusiasm, but also to sharpness of mind or senses. 'Acumen' specifically refers to sharpness of judgment, making it a strong synonym in an intellectual context.

19. Invincible is an antonym for -----.

(A) conquerable

(B) transparent

(C) fiasco

(D) instil

Correct Answer: (A) conquerable

Solution:

An antonym is a word with the opposite meaning.

"Invincible" means too powerful to be defeated or overcome.

We need to find the word that means the opposite.

(A) conquerable: able to be defeated or overcome. This is the direct opposite of invincible.

(B) transparent: allowing light to pass through so that objects behind can be distinctly seen.

(C) fiasco: a complete failure.

(D) instil: gradually but firmly establish (an idea or attitude) in a person's mind.

Therefore, "conquerable" is the correct antonym.

Quick Tip

Break down words to find their meaning. 'In-' often means 'not', and 'vincible' comes from a Latin word meaning 'to conquer'. So, 'invincible' means 'not able to be conquered'. The opposite is 'conquerable'.

20. Change the following into a simple sentence: He wanted to play with his friends and so he finished his home work quickly.

- (A) As he wanted to play with his friends, he finished his homework quickly
- (B) So as to play with his friends, he finished his home work quickly
- (C) He wants to play with his friends and they he finished his home work quickly
- (D) In order to play with his friends, he finished his home work quickly

Correct Answer: (D) In order to play with his friends, he finished his home work quickly

Solution:

A simple sentence has only one independent clause (one subject-verb combination). The original sentence is a compound sentence joined by "and so".

We need to convert one of the clauses into a phrase.

- (A) "As he wanted..." is a complex sentence with a subordinate clause.
- (B) "So as to play..." is grammatically awkward, though close in meaning. "In order to" is the more standard phrasing.
- (C) This sentence is grammatically incorrect ("they he finished").
- (D) "In order to play with his friends" is an infinitive phrase of purpose. It modifies the main clause "he finished his home work quickly". This construction creates a single independent clause, making it a simple sentence.

Quick Tip

To change a compound or complex sentence into a simple sentence, you often need to convert one of the clauses into a phrase (e.g., a prepositional phrase, participial phrase, or infinitive phrase).

21. Change the following sentence into a complex sentence: "Despite several obstacles, she succeeded finally"

- (A) In spite of several obstacles, she succeeded finally
- (B) Notwithstanding several obstacles, she succeeded finally
- (C) Though there were several obstacles, she succeeded finally
- (D) There were several obstacles and still she succeeded finally

Correct Answer: (C) Though there were several obstacles, she succeeded finally

Solution:

A complex sentence contains one independent clause and at least one dependent (subordinate) clause. The original sentence is a simple sentence with a prepositional phrase ("Despite several

obstacles”).

(A) "In spite of..." is just another prepositional phrase, so this is still a simple sentence.

(B) "Notwithstanding..." is also a phrase, making this a simple sentence.

(C) "Though there were several obstacles" is a dependent clause of concession, introduced by the subordinating conjunction "Though". It is connected to the independent clause "she succeeded finally". This structure fits the definition of a complex sentence.

(D) This is a compound sentence, with two independent clauses joined by "and still".

Quick Tip

A complex sentence is formed using a subordinating conjunction (like 'though', 'although', 'because', 'since', 'while'). This conjunction introduces the dependent clause.

22. Change the following sentence into passive voice: "I saw him opening the door"

(A) I saw the door and he was opening it

(B) Opening the door, he was seen by me

(C) I saw the door being opened by him

(D) He was seen by me while opening the door

Correct Answer: (C) I saw the door being opened by him

Solution:

The original sentence has a structure: Subject (I) + Verb (saw) + Object (him) + Participle Phrase (opening the door).

We want to change this to the passive voice. The action being performed by 'him' is 'opening the door'.

A common passive form is "He was seen opening the door by me." This is not option (D) exactly, which changes the timing.

Let's analyze the given options. Option (C) keeps the main clause "I saw..." active and passivizes the action that was witnessed.

The object of the action "opening" is "the door". The phrase "him opening the door" can be rephrased in the passive as "the door being opened by him".

The full sentence becomes "I saw the door being opened by him." This is a grammatically valid passive construction that retains the original meaning.

Quick Tip

Sentences with verbs of perception (see, hear, watch) followed by an object and a participle can be made passive in two ways. You can passivize the main verb ("He was seen...") or the action in the participle phrase ("I saw the door being opened..."). Choose the option that is grammatically correct and available.

23. Change the following into active voice: "I was kept waiting for two hours by him"

- (A) I waited for two hours because of him
- (B) He kept me waiting for two hours
- (C) He is waiting for me for two hours
- (D) I was waiting for two hours for him

Correct Answer: (B) He kept me waiting for two hours

Solution:

The given sentence is in the passive voice. The subject is "I", the verb is "was kept", and the agent is "by him".

To convert to active voice, the agent "him" becomes the subject "He".

The passive verb "was kept" (past tense) becomes the active verb "kept" (past tense).

The passive subject "I" becomes the active object "me".

The rest of the sentence "waiting for two hours" remains.

Combining these parts gives: "He kept me waiting for two hours."

Quick Tip

To change from passive to active voice, identify the agent in the 'by' phrase. This agent becomes the new subject. Then, change the verb from its passive form (be + past participle) to its active form in the same tense.

24. Change the following into indirect speech: "I will bring my laptop tomorrow", she said.

- (A) She said she would bring my laptop the next day
- (B) She said that she would bring her laptop the next day
- (C) She said she will bring her laptop the next day
- (D) She said she would bring her laptop tomorrow

Correct Answer: (B) She said that she would bring her laptop the next day

Solution:

To convert from direct to indirect speech, we follow these rules:

1. Reporting verb: "said" remains "said". The conjunction "that" is often added.
2. Tense change: "will bring" (simple future) changes to "would bring".
3. Pronoun change: "I" changes to "she" to match the speaker. "my" changes to "her".
4. Adverb of time change: "tomorrow" changes to "the next day" or "the following day".

Applying all rules, the sentence becomes: "She said that she would bring her laptop the next day."

Quick Tip

In reported speech, remember the key changes: tense (usually one step back into the past), pronouns (to match the context), and adverbs of time and place (e.g., now -> then, here -> there, tomorrow -> the next day).

25. Change the following into direct speech: "She said that she loved pizza so much"

- (A) She said, "I love pizza so much"
- (B) She says, "I love pizza so much"
- (C) She said, "I loved pizza so much"
- (D) She says, "I loved pizza so much"

Correct Answer: (A) She said, "I love pizza so much"

Solution:

To convert from indirect to direct speech, we reverse the rules.

1. Reporting verb: "She said" remains, followed by a comma. Quotation marks are added.
2. Tense change: The verb in the reported clause is "loved" (simple past). This would have come from "love" (simple present) in the original speech, as the simple present changes to simple past in indirect speech.
3. Pronoun change: The pronoun "she" refers to the speaker, so it changes back to "I" inside the quotation marks.

Combining these, we get: She said, "I love pizza so much".

Option (C) is incorrect because "I loved" would have changed to "I had loved" in indirect speech.

Quick Tip

When converting from indirect to direct speech, you must 'back-shift' the tense. Simple past ('loved') usually comes from simple present ('love') in the original statement.

26. The primary function of the Election Commission of India is to:

- (A) Formation of laws
- (B) Conducting elections
- (C) Pass budgets
- (D) Managing Parliament sessions

Correct Answer: (B) Conducting elections

Solution:

The Election Commission of India is an autonomous constitutional authority.

Its primary and most fundamental responsibility is the administration of election processes to Lok Sabha, Rajya Sabha, state legislatures, and the offices of the President and Vice President.

This involves preparing electoral rolls, announcing election schedules, recognizing political parties, and ensuring free and fair elections.

Formation of laws is the function of the legislature (Parliament). Passing budgets is also a legislative function. Managing Parliament sessions is the responsibility of the presiding officers (Speaker, Chairman).

Therefore, conducting elections is the correct answer.

Quick Tip

The Constitution of India establishes clear separation of powers. The Election Commission is the body exclusively responsible for the conduct of elections, distinct from the legislative (law-making) and executive (governing) branches.

27. The largest freshwater lake in India is:

- (A) Vembanad Lake
- (B) Dal Lake
- (C) Wular Lake
- (D) Chilika Lake

Correct Answer: (C) Wular Lake

Solution:

Wular Lake, located in the Bandipora district of Jammu and Kashmir, is the largest freshwater lake in India.

Its size varies seasonally but it is recognized as the largest by surface area.

Chilika Lake in Odisha is the largest brackish water (saline) lagoon in India.

Vembanad Lake in Kerala is the longest lake in India, but it is a brackish lagoon.

Dal Lake is a famous lake in Srinagar but is smaller than Wular Lake.

Thus, Wular Lake is the correct answer.

Quick Tip

Distinguish between different types of lakes when answering geography questions. 'Fresh-water' (Wular), 'brackish/saline' (Chilika), and 'longest' (Vembanad) are key distinctions for Indian lakes.

28. The term "carbon footprint" refers to:

- (A) Growth of forests
- (B) Water pollution levels
- (C) Total greenhouse gas emissions
- (D) Fuel efficiency of vehicles

Correct Answer: (C) Total greenhouse gas emissions

Solution:

A "carbon footprint" is a measure of the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions.

It represents the total emissions caused by an individual, event, organization, or product, expressed as a carbon dioxide equivalent.

The other options are related to environmental issues but do not define the term itself.

Therefore, "Total greenhouse gas emissions" is the correct definition.

Quick Tip

The term 'carbon footprint' is an analogy. Just as a footprint is a mark you leave on the ground, a carbon footprint is the mark of greenhouse gases your activities leave on the atmosphere.

29. India's first mission to study the Sun is:

- (A) Aditya-L1
- (B) Chandrayaan
- (C) Surya-N1
- (D) Vikram Lander

Correct Answer: (A) Aditya-L1

Solution:

Aditya-L1 is the first Indian space mission dedicated to observing the Sun.

It was launched by the Indian Space Research Organisation (ISRO). The spacecraft is placed in a halo orbit around the Lagrange point 1 (L1) of the Sun-Earth system.

'Chandrayaan' is the name of India's series of lunar (Moon) exploration missions.

'Vikram Lander' was the lander component of the Chandrayaan-2 and Chandrayaan-3 missions.

'Surya-N1' is not the name of an official ISRO mission.

Therefore, Aditya-L1 is the correct answer.

Quick Tip

In Sanskrit, 'Aditya' means 'Sun'. This clue in the mission's name directly points to its purpose. 'Chandra' means 'Moon', which helps identify the lunar missions.

30. The 'Green Revolution' in India was mainly associated with:

- (A) Irrigation reforms
- (B) Industrial development
- (C) Agricultural productivity
- (D) Environmental protection

Correct Answer: (C) Agricultural productivity

Solution:

The Green Revolution refers to a period of significant increase in agricultural production in

India, primarily in the 1960s.

This was achieved through the introduction of high-yield variety (HYV) seeds, increased use of fertilizers and pesticides, and improved irrigation techniques.

The main goal and outcome of these initiatives was a massive boost in agricultural productivity, especially for wheat and rice, making India self-sufficient in food grains.

While irrigation reforms were a part of it, the overall association is with the increase in productivity.

Therefore, "Agricultural productivity" is the most accurate answer.

Quick Tip

The Green Revolution is a cornerstone of modern Indian history. Associate it with M. S. Swaminathan (the Father of the Green Revolution in India), high-yield variety seeds, and the primary goal of increasing food grain production.

31. Which of the following is not a fundamental right in the Indian Constitution?

- (A) Right to Equality
- (B) Right to Property
- (C) Right to Education
- (D) Right to Freedom

Correct Answer: (B) Right to Property

Solution:

Originally, the Right to Property was a Fundamental Right under Article 31 of the Indian Constitution.

However, it was removed from the list of Fundamental Rights by the 44th Amendment Act of 1978.

It was made a legal right under Article 300-A in Part XII of the Constitution.

The other options, Right to Equality (Articles 14-18), Right to Education (Article 21-A), and Right to Freedom (Articles 19-22), are all Fundamental Rights.

Therefore, the Right to Property is no longer a fundamental right.

Quick Tip

Remember key constitutional amendments. The 44th Amendment is significant for removing the Right to Property as a fundamental right, which is a frequently asked question in competitive exams.

32. UNESCO stands for:

- (A) United Nations Educational, Scientific and Cultural Organization
- (B) Universal Science and Culture Organization
- (C) United Nations Environmental, Scientific and Cultural Organization
- (D) Union of National Education, Science and Culture Organisation

Correct Answer: (A) United Nations Educational, Scientific and Cultural Organization

Solution:

UNESCO is a specialized agency of the United Nations (UN).

The acronym UNESCO stands for United Nations Educational, Scientific and Cultural Organization.

Its purpose is to contribute to peace and security by promoting international collaboration through education, sciences, and culture.

The other options provide incorrect expansions of the acronym.

Quick Tip

For exams, it is crucial to memorize the full forms of major international organizations like UNESCO, UNICEF, WHO, and IMF, along with their headquarters and primary functions.

33. The Indian Parliament consists of:

- (A) Lok Sabha and President
- (B) Lok Sabha and Rajya Sabha
- (C) Lok Sabha, Rajya Sabha and President
- (D) Rajya Sabha and Supreme Court

Correct Answer: (C) Lok Sabha, Rajya Sabha and President

Solution:

According to Article 79 of the Constitution of India, the Parliament of the Union consists of the President and two Houses.

The two Houses are known as the Council of States (Rajya Sabha) and the House of the People (Lok Sabha).

Although the President is not a member of either House, he is an integral part of the Parliament.

Therefore, the Indian Parliament is composed of the Lok Sabha, the Rajya Sabha, and the President.

Quick Tip

A common misconception is that the Parliament only consists of the two legislative houses (Lok Sabha and Rajya Sabha). Remember that the President of India is an integral part of the Parliament, as a bill cannot become law without the President's assent.

34. The capital of Uttarakhand is:

- (A) Mussoorie
- (B) Nainital
- (C) Dehradun
- (D) Haridwar

Correct Answer: (C) Dehradun

Solution:

The state of Uttarakhand has two capitals.

Dehradun is the winter capital and the largest city of the state. It serves as the primary administrative center.

Gairsain is the summer capital of Uttarakhand.

Since Dehradun is listed in the options and is the primary capital, it is the correct answer.

Mussoorie and Nainital are popular hill stations, and Haridwar is a major pilgrimage city in the state.

Quick Tip

Knowing the capitals of all Indian states and union territories is fundamental for general knowledge. Also, be aware of states that have more than one capital (e.g., Uttarakhand, Andhra Pradesh, Maharashtra, Himachal Pradesh).

35. Which Indian River is known as 'Dakshina Ganga'?

- (A) Krishna
- (B) Godavari
- (C) Kaveri
- (D) Mahanadi

Correct Answer: (B) Godavari

Solution:

The Godavari River is often referred to as the 'Dakshina Ganga' or the Ganges of the South.

This name is given due to its large size and extent, as it is the second-longest river in India after the Ganga.

It originates in Trimbakeshwar, Maharashtra, and flows through several states in Peninsular India.

The Kaveri river is sometimes called the 'Ganga of the South' (distinct from Dakshina Ganga) due to its sacredness, but Godavari is the one known as Dakshina Ganga.

Quick Tip

Epithets or nicknames of geographical features are common questions. Differentiate between 'Dakshina Ganga' (Godavari) and 'Vridha Ganga' (Old Ganga, also Godavari) to avoid confusion.

36. 'One Earth, One Family, One Future' was the theme of which recent international summit held in India?

- (A) G7 Summit
- (B) SCO Summit
- (C) G20 Summit
- (D) BRICS Summit

Correct Answer: (C) G20 Summit

Solution:

India held the presidency of the G20 from December 1, 2022, to November 30, 2023.

The theme of India's G20 Presidency was 'Vasudhaiva Kutumbakam' or 'One Earth, One Family, One Future'.

This theme is drawn from the ancient Sanskrit text of the Maha Upanishad.

The summit was held in New Delhi, India in September 2023.

Therefore, the correct answer is the G20 Summit.

Quick Tip

Stay updated with current affairs, especially major international summits hosted by your country. Remember the host nation, the theme, and any significant declarations or outcomes of the summit.

37. The primary role of NITI Aayog is to:

- (A) Conduct elections
- (B) Formulation of policies and strategies
- (C) Collecting taxes
- (D) Enforcement of laws

Correct Answer: (B) Formulation of policies and strategies

Solution:

NITI Aayog (National Institution for Transforming India) replaced the Planning Commission in 2015.

It serves as the premier policy 'Think Tank' of the Government of India.

Its primary role is to provide both directional and policy inputs, design strategic and long-term policies and programmes for the Government, and foster cooperative federalism.

Conducting elections is the role of the Election Commission. Collecting taxes is done by tax authorities like the CBDT. Law enforcement is an executive function of police and other agencies.

Quick Tip

Understand the difference between the former Planning Commission and NITI Aayog. The Planning Commission had the power to allocate funds, whereas NITI Aayog is primarily an advisory body or a think tank.

38. The first Indian woman to go into space was:

- (A) Sunita Williams
- (B) Kalpana Chawla
- (C) Ritu Karidhal
- (D) Tessy Thomas

Correct Answer: (B) Kalpana Chawla

Solution:

Kalpana Chawla was an American astronaut and the first woman of Indian origin to go to space.

She first flew on Space Shuttle Columbia in 1997 as a mission specialist and primary robotic arm operator.

Sunita Williams is another American astronaut of Indian descent who has been to space.

Ritu Karidhal is a scientist at ISRO and played a key role in the Mars Orbiter Mission. Tessy Thomas is a scientist known as the 'Missile Woman of India'.

Therefore, Kalpana Chawla was the first.

Quick Tip

Memorize 'firsts' in Indian history, especially in science and technology. Distinguish between 'first Indian citizen' (Rakesh Sharma) and 'first person of Indian origin' in various fields.

39. Which country recently exited the European Union (Brexit)?

- (A) Germany
- (B) France
- (C) Italy
- (D) United Kingdom

Correct Answer: (D) United Kingdom

Solution:

"Brexit" is a portmanteau of "British exit".

It refers to the withdrawal of the United Kingdom from the European Union.

Following a referendum in June 2016, the UK formally left the EU on 31 January 2020.

Germany, France, and Italy are founding members of the EU and remain members.

Quick Tip

Major global political events like Brexit are important topics. Understand the key terms, timeline, and general implications of such events.

40. 'Mission Shakti' was related to:

- (A) Women's empowerment

- (B) Anti-satellite missile test
- (C) Cybersecurity program
- (D) Skill development for youth

Correct Answer: (B) Anti-satellite missile test

Solution:

'Mission Shakti' was an anti-satellite (ASAT) weapon test conducted by India on 27 March 2019.

In this test, a missile was used to destroy a live Indian satellite in a low Earth orbit.

The test demonstrated India's capability to intercept and destroy satellites in space.

While there is also a 'Mission Shakti' program for women's empowerment in some states, in the context of national strategic achievements, it refers to the ASAT test.

Quick Tip

Be aware of India's key achievements in defense and space technology. 'Mission Shakti' made India the fourth country to possess anti-satellite weapon capability, which is a significant strategic milestone.

41. The purpose of formative assessment is:

- (A) To assign final grades
- (B) To evaluate teaching staff
- (C) To improve learning while it is happening
- (D) To promote students

Correct Answer: (C) To improve learning while it is happening

Solution:

Formative assessment is a range of formal and informal assessment procedures conducted by teachers during the learning process in order to modify teaching and learning activities to improve student attainment.

Its primary purpose is to monitor student learning and provide ongoing feedback that can be used by instructors to improve their teaching and by students to improve their learning.

Assigning final grades and promoting students are purposes of summative assessment. Evaluating staff is an administrative function.

Therefore, its goal is to improve learning as it occurs.

Quick Tip

Differentiate between Formative Assessment (assessment FOR learning) and Summative Assessment (assessment OF learning). Formative is ongoing and diagnostic (like a quiz), while Summative is at the end of a unit to evaluate mastery (like a final exam).

42. Which learning theory is associated with operant conditioning?

- (A) Piaget's theory
- (B) Skinner's theory
- (C) Maslow's theory
- (D) Gardner's theory

Correct Answer: (B) Skinner's theory

Solution:

Operant conditioning, also known as instrumental conditioning, is a method of learning that employs rewards and punishments for behavior.

This theory was developed by the behaviorist B.F. Skinner.

Piaget is known for his theory of cognitive development. Maslow is known for his hierarchy of needs. Gardner is known for his theory of multiple intelligences.

Therefore, operant conditioning is associated with Skinner's theory.

Quick Tip

Associate key concepts with their theorists: Operant Conditioning -j Skinner; Classical Conditioning -j Pavlov; Cognitive Development -j Piaget; Social Learning -j Bandura; Multiple Intelligences -j Gardner.

43. A democratic classroom environment encourages:

- (A) Authoritarian discipline
- (B) Passive learners
- (C) Student participation and dialogue
- (D) Teacher-centred teaching

Correct Answer: (C) Student participation and dialogue

Solution:

A democratic classroom is one where students are encouraged to be active participants in their own learning.

It values student voice, collaboration, and shared responsibility.

This environment naturally encourages student participation and dialogue, as students are seen as partners in the learning process.

Authoritarian discipline and teacher-centered teaching are characteristics of an autocratic classroom. Passive learning is a negative outcome that a democratic environment seeks to avoid.

Quick Tip

In teaching aptitude, terms like 'democratic', 'learner-centered', and 'inclusive' are positive keywords. They are generally associated with positive outcomes like participation, collaboration, and critical thinking. 'Autocratic', 'teacher-centered', and 'rote-learning' are negative keywords.

44. Which one is an example of intrinsic motivation?

- (A) Prize for winning
- (B) Fear of punishment
- (C) Desire to learn
- (D) Parental pressure

Correct Answer: (C) Desire to learn

Solution:

Intrinsic motivation involves engaging in a behavior because it is personally rewarding; essentially, performing an activity for its own sake rather than from the desire for some external reward.

- (A) Prize for winning is an external reward (extrinsic motivation).
- (B) Fear of punishment is an external factor (extrinsic motivation).
- (C) Desire to learn comes from within the individual, based on curiosity and interest. This is intrinsic motivation.
- (D) Parental pressure is an external force (extrinsic motivation).

Quick Tip

To identify motivation type, ask "What is the reason for the action?". If the reason is an external reward or pressure (money, grades, fear), it's extrinsic. If the reason is internal satisfaction or interest, it's intrinsic.

45. A teacher using Bloom's Taxonomy should aim at which higher-order skill?

- (A) Remembering facts
- (B) Applying definitions
- (C) Creating new knowledge
- (D) Understanding rules

Correct Answer: (C) Creating new knowledge

Solution:

Bloom's Taxonomy is a hierarchical model for classifying educational learning objectives into levels of complexity and specificity.

The levels, from lower-order to higher-order thinking skills, are: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating.

(A) Remembering, (B) Applying, and (D) Understanding are considered lower-order thinking skills.

(C) Creating, which involves putting elements together to form a new, coherent whole, is the highest level of the taxonomy and a higher-order skill.

Therefore, a teacher should aim to develop skills like creating new knowledge.

Quick Tip

Remember the acronym 'RUAAEC' (Remember, Understand, Apply, Analyze, Evaluate, Create) for the levels of Bloom's Taxonomy. The last three (Analyzing, Evaluating, Creating) are the higher-order thinking skills (HOTS).

46. In pedagogy, 'feedback' helps:

- (A) Punish students
- (B) Modify teaching strategies
- (C) Give homework
- (D) Mark attendance

Correct Answer: (B) Modify teaching strategies

Solution:

Effective feedback in pedagogy is a two-way process.

It provides information to students about their performance to help them improve.

Simultaneously, it provides information to the teacher about the students' understanding.

A teacher can use this information to identify areas where students are struggling and consequently modify or adjust their teaching strategies to address these difficulties.

Punishing students is not a constructive use of feedback. Giving homework and marking attendance are administrative tasks, not the primary purpose of pedagogical feedback.

Quick Tip

Effective feedback should be constructive, timely, and specific. Its purpose is always to improve learning outcomes, both by guiding the student and informing the teacher's instructional choices.

47. Which among these promotes inclusive education?

- (A) Segregated classrooms
- (B) Fixed curriculum
- (C) Adaptive teaching methods
- (D) Competitive grouping

Correct Answer: (C) Adaptive teaching methods

Solution:

Inclusive education means that all students, regardless of any challenges they may have, are placed in age-appropriate general education classes to receive high-quality instruction and support.

To cater to the diverse needs of all students in one classroom, teachers must use adaptive teaching methods, modifying their instruction and materials as needed.

Segregated classrooms are the opposite of inclusion. A fixed curriculum is too rigid for diverse learners. Competitive grouping can marginalize students who are struggling.

Therefore, adaptive teaching methods are essential for promoting inclusive education.

Quick Tip

Inclusive education is about flexibility and adaptation. Any option that suggests rigidity (fixed curriculum), separation (segregation), or intense competition is generally contrary to the principles of inclusion.

48. Which is a barrier to effective classroom communication?

- (A) Use of visual aids
- (B) Clear articulation

(C) Language mismatch

(D) Active listening

Correct Answer: (C) Language mismatch

Solution:

Effective communication occurs when the message sent by the sender is understood correctly by the receiver.

A language mismatch, where the teacher and students do not share a common language or have different levels of proficiency, is a fundamental barrier to understanding.

Use of visual aids, clear articulation, and active listening are all factors that facilitate and enhance effective communication, not hinder it.

Therefore, a language mismatch is a significant barrier.

Quick Tip

Barriers to communication can be physical (noise), psychological (attitudes), or semantic (language and meaning). A language mismatch is a classic example of a semantic barrier.

49. A good teacher evaluates students by:

(A) Comparing them with others

(B) Judging their behaviour

(C) Identifying strengths and weaknesses

(D) Ignoring slow learners

Correct Answer: (C) Identifying strengths and weaknesses

Solution:

The primary goal of good evaluation in education is to improve learning.

This is best achieved by identifying a student's individual strengths and weaknesses. This diagnostic approach allows the teacher and the student to know what areas are strong and what areas need improvement.

Comparing students with others can be demotivating and lead to unhealthy competition. Judging behaviour is about discipline, not academic evaluation. Ignoring any student is poor teaching practice.

Therefore, identifying strengths and weaknesses is the hallmark of a good evaluation.

Quick Tip

Modern pedagogy emphasizes criterion-referenced and self-referenced evaluation over norm-referenced evaluation. This means focusing on a student's progress against learning goals and their own past performance, rather than just comparing them to their peers.

50. Effective teaching is primarily about:

- (A) Completing the syllabus
- (B) Giving maximum homework
- (C) Enhancing understanding and engagement
- (D) Following textbooks strictly

Correct Answer: (C) Enhancing understanding and engagement

Solution:

The ultimate goal of teaching is to ensure that students learn, which goes beyond simply covering content.

Effective teaching focuses on making sure students genuinely understand the concepts and are actively engaged in the learning process.

Completing the syllabus, giving homework, and following a textbook are means to an end, but they do not define effective teaching in themselves. Learning can happen without them, and their mere presence does not guarantee learning.

True effectiveness is measured by the enhancement of student understanding and engagement.

Quick Tip

In teaching aptitude questions, always choose the option that is most student-centered. The focus should be on the student's learning, understanding, and development, not on administrative tasks like completing the syllabus.

51. Rutherford's scattering formula is applicable for

- (A) Strong nuclear interactions
 - (B) Low energy gamma rays
 - (C) Elastic collisions between neutrons
 - (D) Scattering of alpha particles by heavy nuclei
- Correct Answer:** (D) Scattering of alpha particles by heavy nuclei

Solution:

Rutherford's scattering formula was derived to explain the results of the Geiger-Marsden ex-

periment (also known as the gold foil experiment).

In this experiment, alpha particles (which are positively charged helium nuclei) were directed at a thin foil of gold (a heavy nucleus).

The formula is based on the assumption that the scattering is caused by the electrostatic (Coulomb) repulsion between the positively charged alpha particle and the positively charged nucleus.

It does not account for strong nuclear forces, gamma rays, or electrically neutral particles like neutrons.

Therefore, it is specifically applicable to the scattering of alpha particles by heavy nuclei.

Quick Tip

Rutherford's scattering model is a cornerstone of nuclear physics. It's fundamentally based on the inverse-square Coulomb force. Remember that it applies to charged particles interacting electrostatically, which led to the discovery of the atomic nucleus.

52. A gyroscope resists changes in orientation due to

- (A) Linear acceleration
- (B) Conservation of angular momentum
- (C) High angular acceleration
- (D) Friction

Correct Answer: (B) Conservation of angular momentum

Solution:

A gyroscope consists of a rapidly spinning rotor. Due to its high rotational speed, it possesses a large angular momentum.

The principle of conservation of angular momentum states that in the absence of an external torque, the total angular momentum of a system remains constant.

The angular momentum is a vector quantity, meaning it has both magnitude and direction.

To change the orientation of the gyroscope's spin axis, an external torque must be applied. The gyroscope resists this change, a phenomenon known as gyroscopic inertia or rigidity.

This resistance is a direct consequence of the conservation of its angular momentum vector.

Quick Tip

The key to understanding a gyroscope's stability is the conservation of angular momentum. A spinning object's angular momentum vector points along its axis of rotation, and it takes a significant external torque to change the direction of this vector.

53. Euler's equations describe the rotation of a rigid body about

- (A) Principal axes of the body
- (B) Axes fixed in space
- (C) Arbitrary axes
- (D) Axes passing through the center of mass

Correct Answer: (A) Principal axes of the body

Solution:

Euler's equations of motion are a set of three first-order differential equations that describe the rotation of a rigid body.

These equations are formulated in a non-inertial reference frame that rotates with the body.

To simplify the equations, this rotating frame is chosen such that its axes are the principal axes of the body.

When aligned with the principal axes, the inertia tensor becomes diagonal, which significantly simplifies the calculation of angular momentum and torque, and thus the form of Euler's equations.

Therefore, Euler's equations are most commonly used to describe rotation about the principal axes.

Quick Tip

Euler's equations provide a link between the applied torque and the change in angular velocity. They are simplest and most useful when the coordinate system is aligned with the body's principal axes of inertia.

54. The orbit of a planet under a central force is generally

- (A) Circular only
- (B) Parabolic
- (C) Elliptical
- (D) Spiral

Correct Answer: (C) Elliptical

Solution:

The gravitational force exerted by the sun on a planet is a central force, meaning it always acts along the line joining the two bodies and its magnitude depends only on the distance between them.

According to Kepler's first law of planetary motion, which is a direct consequence of Newton's law of universal gravitation (an inverse-square central force), the orbit of every planet is an ellipse with the Sun at one of the two foci.

A circular orbit is a special case of an elliptical orbit where the eccentricity is zero. Parabolic and hyperbolic orbits are also possible for objects not bound to the sun (like some comets), but for bound objects like planets, the orbit is generally elliptical.

Therefore, the most general and correct description for a planet's orbit is elliptical.

Quick Tip

Remember Kepler's laws for planetary motion. The first law states that orbits are elliptical. This applies to any object moving under an inverse-square central force, such as gravity.

55. The sensation of weightlessness occurs in a satellite because

- (A) There is no gravity in space
- (B) Gravity is balanced by centrifugal force
- (C) The satellite and the object inside are in free fall
- (D) The satellite moves with the speed of light

Correct Answer: (C) The satellite and the object inside are in free fall

Solution:

Weightlessness experienced by an astronaut in an orbiting satellite is not due to the absence of gravity. In fact, the force of gravity at typical orbital altitudes is only slightly less than on the Earth's surface.

The sensation of weight arises from the contact force (normal force) that a surface exerts on an object to support it against gravity.

In an orbiting satellite, both the satellite and the astronaut are constantly falling towards the Earth under the influence of gravity.

Because they are both falling together at the same rate of acceleration, the astronaut does not press against the floor or any other surface of the satellite.

This state of continuous free fall creates the sensation of weightlessness.

Quick Tip

Weightlessness is not 'zero gravity', but 'zero normal force'. It's the same sensation you would feel in an elevator if its cable snapped and it went into free fall. An orbit is just a continuous free fall that keeps missing the Earth.

56. The frame of reference that is considered valid in both Galilean and Einstein's theories is

- (A) Accelerated frame
- (B) Inertial frame
- (C) Rotating frame
- (D) Non-inertial frame

Correct Answer: (B) Inertial frame

Solution:

An inertial frame of reference is a frame where Newton's first law of motion (the law of inertia) holds true. This means that an object with no net force acting on it will either remain at rest or continue to move at a constant velocity.

Both Galilean relativity (classical mechanics) and Einstein's special theory of relativity are fundamentally based on the principle of relativity, which states that the laws of physics are the same in all inertial frames of reference.

Accelerated and rotating frames are examples of non-inertial frames, where fictitious forces (like the Coriolis force) appear. General relativity deals with non-inertial frames, but both Galilean and special relativity are built upon the concept of inertial frames.

Therefore, the inertial frame is the valid frame for both theories.

Quick Tip

An inertial frame is non-accelerating. This is the simplest type of reference frame and is the foundation upon which both classical and special relativity are built.

57. The condition for maximum power transfer in a forced oscillator is when

- (A) Damping is zero
- (B) Driving frequency equals natural frequency
- (C) Driving force is constant
- (D) System is underdamped

Correct Answer: (B) Driving frequency equals natural frequency

Solution:

In a forced oscillator, an external periodic force provides energy to the system. The power transferred from the driving force to the oscillator is maximized when the oscillator's velocity amplitude is at its maximum.

This condition is known as resonance.

Resonance occurs when the driving frequency of the external force is equal to the natural frequency of the oscillator.

At this frequency, the amplitude of oscillations becomes very large (limited only by damping), and the system absorbs the maximum amount of energy from the driving source.

Therefore, the condition for maximum power transfer is resonance.

Quick Tip

Resonance is a key concept in physics. It happens when a system is driven at its natural frequency, leading to a large amplitude of oscillation and maximum energy absorption. Examples include pushing a swing, tuning a radio, and microwave ovens.

58. The sharpness of resonance is described by

- (A) Time period
- (B) Relaxation time
- (C) Quality factor
- (D) Damping coefficient

Correct Answer: (C) Quality factor

Solution:

The sharpness of a resonance curve is a measure of how quickly the amplitude of oscillation drops off as the driving frequency moves away from the natural frequency.

This characteristic is quantified by a dimensionless parameter called the Quality factor, or Q factor.

A high Q factor indicates a sharp, narrow resonance peak, meaning the system responds strongly only to frequencies very close to its natural frequency. This corresponds to low damping.

A low Q factor indicates a broad, flat resonance peak, meaning the system responds to a wider range of frequencies. This corresponds to high damping.

Therefore, the quality factor describes the sharpness of resonance.

Quick Tip

Think of the 'Q' in Q factor as standing for 'Quality'. A high-quality resonant system (like a good musical instrument) will have a high Q factor, meaning it oscillates very well at its specific resonant frequency with little energy loss (low damping).

59. The coupling in oscillators introduce

- (A) No change in motion
- (B) Damping
- (C) Additional restoring forces
- (D) Inertia

Correct Answer: (C) Additional restoring forces

Solution:

When two or more oscillators are coupled, it means there is an interaction between them that allows for the exchange of energy.

This interaction typically takes the form of a force that one oscillator exerts on another.

This coupling force usually depends on the positions (or displacements) of the oscillators. A force that depends on displacement and tends to bring a system back to equilibrium is a restoring force.

Therefore, the coupling introduces additional restoring forces into the system's equations of motion, which alters the frequencies and patterns of oscillation (leading to normal modes).

Damping is related to energy loss, which is a separate phenomenon. Inertia is an intrinsic property of the oscillators' masses.

Quick Tip

Coupling allows oscillators to influence each other. This influence acts as an extra force. Since oscillation is governed by restoring forces, the coupling effectively adds new restoring forces to the system.

60. Which of the following devices is commonly used to produce ultrasonic waves?

- (A) Diode
- (B) Piezoelectric crystal
- (C) Thermocouple
- (D) LED

Correct Answer: (B) Piezoelectric crystal

Solution:

Ultrasonic waves are sound waves with frequencies higher than the upper audible limit of human hearing (above 20 kHz).

They are commonly produced using the piezoelectric effect.

A piezoelectric crystal (like quartz) has the property of deforming mechanically when a voltage is applied across it.

By applying a high-frequency alternating voltage to the crystal, it is forced to vibrate at that high frequency. These mechanical vibrations produce the ultrasonic waves in the surrounding medium.

Diodes and LEDs are semiconductor electronic components related to light, and a thermocouple is a temperature sensor.

Quick Tip

The piezoelectric effect is the key principle behind ultrasonic transducers, used in medical imaging (ultrasound), sonar, and non-destructive testing. It converts electrical energy into mechanical vibrations and vice versa.

61. In a Michelson Interferometer, a change in the optical path length of one arm by $\lambda/2$ (where λ is the wavelength of light used) results in

- (A) No change in the interference pattern
- (B) A shift of one fringe in the interference pattern
- (C) A shift of half a fringe in the interference pattern
- (D) The disappearance of all fringes

Correct Answer: (B) A shift of one fringe in the interference pattern

Solution:

In a Michelson Interferometer, light from one arm travels a path length, is reflected, and interferes with light from the other arm. The interference depends on the difference in the optical path lengths.

The light in one arm travels to the mirror and back, so the total optical path is twice the length of the arm.

If the optical path length of one arm is changed by $\lambda/2$, the round-trip path difference for the light in that arm changes by $2 \times (\lambda/2) = \lambda$.

A change in the total path difference of one full wavelength (λ) brings the interference condition back to its original state (e.g., from one bright fringe to the next bright fringe, or one dark fringe to the next dark fringe).

This corresponds to a shift of exactly one fringe in the interference pattern.

Quick Tip

A common point of confusion in interferometers is the round trip of the light. Remember that changing a mirror's position by a distance d changes the optical path length by $2d$. A full fringe shift always corresponds to a path length change of λ .

62. Newton's rings are circular in shape because

- (A) The lens used is convex
- (B) Light source is circular
- (C) The shape of air film is symmetrical about the point of contact
- (D) The wavelength of light is constant

Correct Answer: (C) The shape of air film is symmetrical about the point of contact

Solution:

Newton's rings are an interference pattern formed by the reflection of light between two surfaces: a spherical surface (plano-convex lens) and an adjacent flat surface.

This setup creates a thin film of air between the lens and the glass plate, whose thickness increases with the distance from the point of contact.

The interference fringes (bright or dark rings) occur at locations where the air film has a specific thickness.

The locus of all points having the same thickness is a circle centered at the point of contact.

This circular symmetry of the air film's thickness is the reason why the interference fringes are circular.

Quick Tip

The geometry of the setup determines the shape of interference fringes. In Newton's rings, the circular symmetry of the lens creates a circularly symmetric air wedge, resulting in circular fringes.

63. When white light is incident on a diffraction grating, the light that will be deviated more from central image will be

- (A) Yellow
- (B) Violet
- (C) Indigo

(D) Red

Correct Answer: (D) Red

Solution:

The equation for the principal maxima in a diffraction grating is given by $d \sin \theta = n\lambda$, where d is the grating spacing, θ is the angle of deviation, n is the order of the maximum, and λ is the wavelength of light.

From the equation, for a fixed order n and grating spacing d , we have $\sin \theta \propto \lambda$.

This means that the angle of deviation θ is larger for longer wavelengths.

In the visible spectrum (VIBGYOR), red light has the longest wavelength, and violet light has the shortest wavelength.

Therefore, red light will be deviated the most from the central image.

Quick Tip

Remember the spectral order in a grating is the opposite of that in a prism. In a prism, violet light deviates most. In a diffraction grating, red light deviates most because the deviation angle is proportional to the wavelength.

64. Resolving power of a grating is

(A) Directly proportional to N

(B) Inversely proportional to N

(C) Independent of N

(D) Directly proportional to N^2

Correct Answer: (A) Directly proportional to N

Solution:

The resolving power of a diffraction grating is its ability to distinguish between two closely spaced spectral lines. It is defined as $R = \lambda/\Delta\lambda$.

The formula for the resolving power of a grating is given by $R = nN$, where n is the spectral order and N is the total number of lines (or slits) on the grating that are illuminated by the light.

From this formula, it is clear that the resolving power R is directly proportional to N , the total number of lines.

A grating with more lines will have a higher resolving power, meaning it can better separate wavelengths that are very close to each other.

Quick Tip

For a diffraction grating, two key properties are dispersion (spreading out of colors) and resolving power (ability to distinguish colors). Resolving power depends on the total number of lines, N , while dispersion depends on the density of lines (lines per mm).

65. Brewster's law in terms of refractive index can be expressed as

- (A) $\mu = \sin(i_p)$
- (B) $\mu = \cos(i_p)$
- (C) $\mu = \tan(i_p)$
- (D) $\mu = \cot(i_p)$

Correct Answer: (C) $\mu = \tan(i_p)$

Solution:

Brewster's law relates the polarizing angle to the refractive index of a medium.

The polarizing angle (or Brewster's angle), i_p , is the angle of incidence at which light with a particular polarization is perfectly transmitted through a transparent dielectric surface, with no reflection. The reflected light at this angle is completely polarized.

The law states that the tangent of the polarizing angle is equal to the refractive index (μ) of the second medium with respect to the first.

Mathematically, this is expressed as $\mu = \tan(i_p)$.

Quick Tip

A useful consequence of Brewster's law is that at the polarizing angle, the reflected ray and the refracted ray are perpendicular to each other. This fact can be used to derive the formula $\mu = \tan(i_p)$ using Snell's law.

66. The geometric shape of the wavefront that originates when a plane wave passes through a convex lens is

- (A) converging spherical
- (B) diverging spherical
- (C) plane
- (D) elliptical

Correct Answer: (A) converging spherical

Solution:

A plane wavefront corresponds to a beam of parallel rays of light.

A convex lens is a converging lens. When parallel rays of light pass through a convex lens, they are refracted and converge towards a single point, the principal focus.

A wavefront is a surface of constant phase and is always perpendicular to the direction of wave propagation (the rays).

A wavefront that is collapsing or converging to a single point has the shape of a part of a sphere.

Therefore, the plane wavefront is transformed into a converging spherical wavefront after passing through the convex lens.

Quick Tip

Visualize the relationship between rays and wavefronts. Parallel rays correspond to a plane wavefront. Rays converging to a point correspond to a spherical wavefront that is shrinking (converging). Rays spreading out from a point correspond to a spherical wavefront that is expanding (diverging).

67. Spherical aberration occurs because

- (A) Different colors of light focus at different points
- (B) The lens surface is not spherical
- (C) Marginal and paraxial rays focus at different points
- (D) Light is reflected instead of refracted

Correct Answer: (C) Marginal and paraxial rays focus at different points

Solution:

Spherical aberration is an optical defect that occurs in lenses and mirrors with spherical surfaces.

It is a monochromatic aberration, meaning it occurs even for light of a single wavelength.

It happens because rays of light that are incident on the lens far from the principal axis (marginal rays) are focused at a different point than rays that are incident close to the principal axis (paraxial rays).

Typically, for a convex lens, marginal rays are focused closer to the lens than paraxial rays. This results in a blurred image instead of a sharp point focus.

Option (A) describes chromatic aberration, which is due to the variation of refractive index with wavelength.

Quick Tip

Remember the two main types of lens aberrations: Spherical (related to the geometry of the lens, affecting marginal vs. paraxial rays) and Chromatic (related to the material of the lens, affecting different colors of light).

68. The basic principle behind optical fiber operation is

- (A) Refraction
- (B) Total internal reflection
- (C) Diffraction
- (D) Dispersion

Correct Answer: (B) Total internal reflection

Solution:

An optical fiber consists of a central core made of a material with a higher refractive index, surrounded by a cladding made of a material with a lower refractive index.

Light is sent into the core at a specific angle.

When the light traveling in the denser core strikes the boundary with the rarer cladding at an angle of incidence greater than the critical angle, it undergoes total internal reflection (TIR).

This process repeats itself along the length of the fiber, with the light bouncing off the core-cladding interface and being guided along the fiber with minimal loss of intensity.

This is the fundamental principle of light propagation in optical fibers.

Quick Tip

For total internal reflection (TIR) to occur, two conditions must be met: 1) Light must travel from a denser medium to a rarer medium. 2) The angle of incidence must be greater than the critical angle. Optical fibers are designed to meet these conditions.

69. A laser beam is highly coherent because

- (A) All photons travel at the same speed
- (B) All photons have random phases
- (C) The beam spreads out in all directions
- (D) The emitted photons are in phase

Correct Answer: (D) The emitted photons are in phase

Solution:

Coherence is the property of waves that enables them to exhibit stationary (i.e., temporally

and spatially constant) interference. In simple terms, it means the waves have a fixed phase relationship with each other.

LASER stands for Light Amplification by Stimulated Emission of Radiation.

The process of stimulated emission is key. An incoming photon stimulates an excited atom to emit a new photon. This new photon is identical to the original photon in every way: same frequency, same direction, and, most importantly, same phase.

As this process cascades, it produces a beam of light where all the photons are in phase with one another. This is what makes laser light highly coherent.

Random phases (B) would describe an incoherent source like a light bulb. All photons in a vacuum travel at the same speed (A), but this doesn't cause coherence. Spreading out (C) is divergence, which lasers minimize.

Quick Tip

The key properties of laser light are that it is monochromatic (single color), directional (low divergence), and coherent (in phase). Coherence is the most unique property and arises from the mechanism of stimulated emission.

70. The device used to produce a hologram is:

- (A) Spectrometer
- (B) Camera
- (C) Laser
- (D) Microscope

Correct Answer: (C) Laser

Solution:

Holography is a technique that enables a light field, which is generally the product of a light source scattered off objects, to be recorded and later reconstructed.

The recording process requires the interference of two beams of light: an object beam (scattered from the object) and a reference beam.

To create a stable and clear interference pattern that can be recorded on a photographic plate, the light source must be highly coherent.

A laser is the only common light source that provides the required coherence for producing holograms.

A camera records intensity, not phase information. A spectrometer analyzes the spectrum of light. A microscope magnifies small objects.

Quick Tip

Holography is essentially 'wavefront reconstruction'. It records both the amplitude and the phase of the light waves. This is only possible by using the interference of coherent light, which is why a laser is indispensable for creating a hologram.

71. The root mean square speed of molecules of ideal gases at the same temperature are

- (A) The same
- (B) Inversely proportional to the square root of the molecular weight
- (C) Directly proportional to the molecular weight
- (D) Inversely proportional to the molecular weight

Correct Answer: (B) Inversely proportional to the square root of the molecular weight

Solution:

The root mean square (RMS) speed (v_{rms}) of gas molecules is given by the formula from the kinetic theory of gases:

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

Where R is the ideal gas constant, T is the absolute temperature, and M is the molar mass (molecular weight) of the gas.

According to the question, the temperature (T) is the same for the ideal gases. R is a universal constant.

Therefore, the formula shows that v_{rms} is inversely proportional to the square root of the molecular weight M.

$$v_{rms} \propto \frac{1}{\sqrt{M}}$$

This means that at the same temperature, lighter gas molecules move faster on average than heavier gas molecules.

Quick Tip

Remember the relationship between kinetic energy and temperature: Average Kinetic Energy = $\frac{1}{2}Mv_{rms}^2 = \frac{3}{2}RT$. At a constant temperature, all gases have the same average kinetic energy. This implies that for a gas with a larger mass (M), its speed (v_{rms}) must be lower.

72. The correct relation between the degrees of freedom 'f' and the ratio of specific heat ' γ ' is?

- (A) $f = \frac{2}{\gamma-1}$
- (B) $f = \frac{2}{\gamma+1}$
- (C) $f = \frac{\gamma+1}{2}$
- (D) $f = \frac{1}{\gamma+1}$

Correct Answer: (A) $f = \frac{2}{\gamma-1}$

Solution:

The ratio of specific heats, γ , is defined as the ratio of the molar specific heat at constant pressure (C_p) to the molar specific heat at constant volume (C_v).

$$\gamma = \frac{C_p}{C_v}$$

For an ideal gas, the molar specific heat at constant volume is related to the degrees of freedom (f) by:

$$C_v = \frac{f}{2}R$$

And Mayer's relation states that $C_p = C_v + R$.

Substituting C_v in Mayer's relation gives: $C_p = \frac{f}{2}R + R = (\frac{f}{2} + 1)R$.

Now, we can find γ :

$$\gamma = \frac{C_p}{C_v} = \frac{(\frac{f}{2}+1)R}{\frac{f}{2}R} = \frac{\frac{f+2}{2}}{\frac{f}{2}} = \frac{f+2}{f} = 1 + \frac{2}{f}$$

So, we have the relation $\gamma = 1 + \frac{2}{f}$.

To solve for f, we rearrange the equation:

$$\gamma - 1 = \frac{2}{f}$$

$$f = \frac{2}{\gamma-1}$$

Quick Tip

Memorize the fundamental relationship $\gamma = 1 + \frac{2}{f}$. This allows you to quickly find γ for monatomic ($f = 3$), diatomic ($f = 5$), and polyatomic gases, and also to rearrange the formula as needed.

73. The internal energy of a gas will increase when it

- (A) Expands adiabatically

- (B) Expands isothermally
- (C) Is compressed isothermally
- (D) Is compressed adiabatically

Correct Answer: (D) Is compressed adiabatically

Solution:

The internal energy (U) of an ideal gas is directly proportional to its absolute temperature (T). So, an increase in internal energy means an increase in temperature.

Let's analyze the processes based on the First Law of Thermodynamics, $\Delta U = QW$.

(A) Expands adiabatically: Adiabatic means no heat exchange ($Q = 0$). The gas expands, so it does work on the surroundings ($W > 0$). Thus, $\Delta U = 0W = -W$. Since W is positive, ΔU is negative, and the temperature decreases.

(B) Expands isothermally: Isothermal means the temperature is constant ($\Delta T = 0$). Therefore, the internal energy does not change ($\Delta U = 0$).

(C) Is compressed isothermally: Isothermal means the temperature is constant ($\Delta T = 0$), so the internal energy does not change ($\Delta U = 0$).

(D) Is compressed adiabatically: Adiabatic means no heat exchange ($Q = 0$). The gas is compressed, so work is done on the gas by the surroundings ($W < 0$). Thus, $\Delta U = 0W = -W$. Since W is negative, ΔU is positive, and the temperature increases.

Therefore, the internal energy increases during adiabatic compression.

Quick Tip

Remember this simple rule: Adiabatic compression heats a gas, and adiabatic expansion cools it. This is the principle behind refrigeration cycles and the diesel engine.

74. A heat engine works between a source and a sink maintained at constant temperatures T_1 and T_2 . For the efficiency to be greatest

- (A) T_1 and T_2 should high
- (B) T_1 and T_2 should be low
- (C) T_1 should be high and T_2 should be low
- (D) T_1 should be low and T_2 should be high

Correct Answer: (C) T_1 should be high and T_2 should be low

Solution:

The maximum possible efficiency for a heat engine operating between two temperatures is the

Carnot efficiency, η_{Carnot} .

It is given by the formula: $\eta = 1 - \frac{T_{sink}}{T_{source}}$

In this problem, the source temperature is T_1 and the sink temperature is T_2 . So, the formula is:

$$\eta = 1 - \frac{T_2}{T_1}$$

To maximize the efficiency η , the term $\frac{T_2}{T_1}$ must be minimized.

The fraction $\frac{T_2}{T_1}$ is smallest when the numerator (T_2) is as small as possible and the denominator (T_1) is as large as possible.

Therefore, for the greatest efficiency, the source temperature T_1 should be high and the sink temperature T_2 should be low.

Quick Tip

Think of a waterfall generating power. The greater the height difference (analogous to the temperature difference T_1T_2), the more power you can generate. To maximize this difference, you need the highest possible source temperature and the lowest possible sink temperature.

75. The Clausius-Clapeyron equation relates the change in

- (A) Temperature with volume
- (B) Pressure with temperature during phase transition
- (C) Energy with entropy
- (D) Free energy with pressure

Correct Answer: (B) Pressure with temperature during phase transition

Solution:

The Clausius-Clapeyron equation is a fundamental relationship in thermodynamics that describes the conditions under which two phases of a substance can coexist in equilibrium.

It specifically relates the slope of the coexistence curve (the boundary line between two phases on a pressure-temperature diagram) to the properties of the substance.

The equation is given by $\frac{dP}{dT} = \frac{L}{T\Delta V}$, where $\frac{dP}{dT}$ is the slope of the phase boundary, L is the latent heat of the transition, T is the temperature, and ΔV is the change in specific volume.

Thus, it relates how the pressure at which a phase transition occurs changes with the temperature of the transition.

Quick Tip

The Clausius-Clapeyron equation explains why water boils at a lower temperature at high altitudes. At higher altitudes, the atmospheric pressure (P) is lower, so the boiling temperature (T) required for the liquid-gas phase transition is also lower.

76. If H is the enthalpy, T is the temperature and S is the entropy, then Gibbs free energy is defined as

- (A) $H - TS$
- (B) $U + PV$
- (C) $U - TS$
- (D) $A + PV$

Correct Answer: (A) $H - TS$

Solution:

Gibbs free energy (G) is a thermodynamic potential that can be used to calculate the maximum reversible work that may be performed by a thermodynamic system at a constant temperature and pressure.

It is defined by the equation:

$$G = H - TS$$

Where:

G is the Gibbs free energy

H is the enthalpy

T is the absolute temperature

S is the entropy

Option (B), $U + PV$, is the definition of enthalpy (H).

Option (C), $U - TS$, is the definition of Helmholtz free energy (A).

Quick Tip

Remember the key thermodynamic potentials and their definitions: Enthalpy: $H = U + PV$ Helmholtz Free Energy: $A = U - TS$ Gibbs Free Energy: $G = H - TS = U + PV - TS$

77. Which of the following gases shows heating instead of cooling during Joule-Thomson expansion at room temperature?

- (A) Oxygen
- (B) Nitrogen
- (C) Hydrogen

(D) Carbon dioxide

Correct Answer: (C) Hydrogen

Solution:

The Joule-Thomson effect describes the temperature change of a real gas when it is forced through a valve or porous plug while kept insulated, so no heat is exchanged with the environment.

Whether a gas cools or heats up upon expansion depends on its temperature relative to its 'inversion temperature'.

If the gas is below its inversion temperature, it cools upon expansion.

If the gas is above its inversion temperature, it heats upon expansion.

Most gases, like oxygen, nitrogen, and carbon dioxide, have inversion temperatures well above room temperature, so they cool down.

Hydrogen and helium have very low inversion temperatures (for hydrogen, it is about 202 K or -71 °C).

Since room temperature (around 298 K or 25 °C) is above hydrogen's inversion temperature, it will show a heating effect during Joule-Thomson expansion.

Quick Tip

Hydrogen and Helium are exceptions to the general rule of cooling on expansion at room temperature. They must be pre-cooled to below their inversion temperatures before they can be liquefied by the Joule-Thomson process.

78. Adiabatic demagnetization works on the principle of

(A) Joule heating

(B) Magnetic hysteresis

(C) Entropy change during magnetization

(D) Optical cooling

Correct Answer: (C) Entropy change during magnetization

Solution:

Adiabatic demagnetization is a technique used to achieve extremely low temperatures, close to absolute zero.

The process involves a paramagnetic salt whose total entropy has two components: magnetic entropy (from the alignment of magnetic dipoles) and lattice entropy (from thermal vibrations).

Step 1 (Isothermal Magnetization): A strong magnetic field is applied, aligning the magnetic dipoles. This decreases magnetic entropy. The heat generated is removed by a cooling bath, keeping the temperature constant.

Step 2 (Adiabatic Demagnetization): The substance is thermally isolated (adiabatic), and the magnetic field is slowly turned off. The magnetic dipoles become disordered, increasing the magnetic entropy.

Since the total entropy must remain constant in a reversible adiabatic process, the increase in magnetic entropy must be compensated by a decrease in lattice entropy. A decrease in lattice entropy corresponds to a significant drop in the temperature of the substance.

Thus, the principle is based on the entropy change associated with the magnetic state of the material.

Quick Tip

Think of entropy as a measure of disorder. In adiabatic demagnetization, the magnetic disorder increases when the field is removed. To keep total disorder constant, the thermal disorder (temperature) must decrease.

79. Planck's law is valid for

- (A) Low temperature only
- (B) High frequency only
- (C) All temperatures and frequencies
- (D) Only visible light

Correct Answer: (C) All temperatures and frequencies

Solution:

Planck's law of black-body radiation provides a formula for the spectral radiance of a body in thermal equilibrium at a given temperature T .

Previous laws, like the Rayleigh-Jeans law, were only valid at low frequencies (long wavelengths), and Wien's approximation was only valid at high frequencies (short wavelengths).

Planck's law was a revolutionary breakthrough because it correctly described the entire spectrum of black-body radiation for all frequencies and at all temperatures.

It accurately fits the experimental data across the full range, from low to high frequencies, without suffering from issues like the "ultraviolet catastrophe".

Therefore, Planck's law is valid for all temperatures and frequencies.

Quick Tip

Planck's law is the universal law for black-body radiation. The older laws, Rayleigh-Jeans and Wien's approximation, can be derived as limiting cases of Planck's law for low and high frequencies, respectively.

80. Wien's displacement law gives the relationship between

- (A) Temperature and total energy radiated
- (B) Wavelength of peak emission and temperature
- (C) Emissivity and absorptivity
- (D) Frequency and temperature

Correct Answer: (B) Wavelength of peak emission and temperature

Solution:

Wien's displacement law is a principle of black-body radiation.

It states that the wavelength at which the emission of radiation from a black body is at its maximum intensity (λ_{max}) is inversely proportional to the absolute temperature (T) of the body.

The mathematical form of the law is:

$$\lambda_{max} = \frac{b}{T}$$

where b is Wien's displacement constant.

So, the law explicitly gives the relationship between the wavelength of peak emission and temperature.

Option (A) is described by the Stefan-Boltzmann law. Option (C) is described by Kirchhoff's law of thermal radiation.

Quick Tip

Wien's law explains why the color of a heated object changes as its temperature increases. A hot object first glows red (longer wavelength), then orange, yellow, and eventually white or blue (shorter wavelength) as its temperature rises and the peak emission wavelength (λ_{max}) shifts.

81. A thin spherical shell of metal has a radius of 0.25 metre and carries a charge of 0.2 micro-coulomb. The electric intensity at a point lying at 3.0metre from the centre of the shell is

- (A) 140 N/C
- (B) 160 N/C

(C) 180 N/C

(D) 200 N/C

Correct Answer: (D) 200 N/C

Solution:

According to Gauss's law (or the shell theorem), for a point outside a uniformly charged spherical shell, the electric field is the same as if all the charge were concentrated at the center of the shell.

The formula for the electric field (E) at a distance r from a point charge q is:

$$E = k \frac{q}{r^2}, \text{ where } k = \frac{1}{4\pi\epsilon_0} \approx 9 \times 10^9 \text{ N m}^2/\text{C}^2.$$

Given values are:

Charge, $q = 0.2$ micro-coulomb $= 0.2 \times 10^{-6}$ C.

Distance from the center, $r = 3.0$ m.

The radius of the shell (0.25 m) is irrelevant as the point is outside the shell.

Substituting the values into the formula:

$$E = (9 \times 10^9 \text{ N m}^2/\text{C}^2) \times \frac{0.2 \times 10^{-6} \text{ C}}{(3.0 \text{ m})^2}$$

$$E = (9 \times 10^9) \times \frac{0.2 \times 10^{-6}}{9.0}$$

$$E = (1 \times 10^9) \times (0.2 \times 10^{-6}) = 0.2 \times 10^3 \text{ N/C}$$

$$E = 200 \text{ N/C}$$

Quick Tip

Remember the Shell Theorem: 1) Outside a charged shell, it acts like a point charge at its center. 2) Inside a charged shell, the electric field is zero. This simplifies many electrostatics problems.

82. The dielectric constant of helium at 0°C and one atmospheric pressure is 1.000074. The dipole moment induced in each helium atom when the gas is in an electric field of intensity 8×10^4 V/m is

(A) 5.2 C-m

(B) 0.52 C-m

(C) 5.23×10^{-5} C-m

(D) 5.23×10^{-15} C-m

Correct Answer: (C) 5.23×10^{-5} C-m

Solution:

The polarization $\vec{P}$ of a dielectric material is related to the electric field $\vec{E}$ and the dielectric constant K by the formula:

$$\vec{P} = \epsilon_0(K-1)\vec{E}$$

Where ϵ_0 is the permittivity of free space ($\approx 8.854 \times 10^{-12}$ F/m).

Polarization is also defined as the total dipole moment per unit volume. For this problem, let's calculate the value of P :

$$\begin{aligned} P &= (8.854 \times 10^{-12}) \times (1.0000741) \times (8 \times 10^4) \\ P &= (8.854 \times 10^{-12}) \times (7.4 \times 10^{-5}) \times (8 \times 10^4) \\ P &\approx 5.24 \times 10^{-11} \text{ C/m}^2 \end{aligned}$$

The induced dipole moment (p) in each atom is given by $p = P/N$, where N is the number density of atoms. At STP (0°C and 1 atm), N is the Loschmidt constant, approximately $2.688 \times 10^{25} \text{ m}^{-3}$.

$$p = \frac{5.24 \times 10^{-11}}{2.688 \times 10^{25}} \approx 1.95 \times 10^{-36} \text{ C-m.}$$

The calculated value is drastically different from the options, indicating a significant error in the question's provided values or the answer key. However, we are required to match the keyed answer. The numerical value of the expression $(K-1)E$ is $(7.4 \times 10^{-5})(8 \times 10^4) = 5.92$. None of the standard formulas yield the given answer. The keyed answer is likely the result of a typo in the question's premise. Following the provided key, the answer is $5.23 \times 10^{-5} \text{ C-m}$.

Quick Tip

When a question's data leads to an answer that wildly differs from the options, double-check your formulas and unit conversions. If the discrepancy persists, it likely indicates an error in the question paper itself. In an exam, you might need to look for a possible typo or re-evaluate the question's intent.

83. The divergence of the magnetic field is zero because

- (A) Magnetic field lines begin and end on charges
- (B) Magnetic field lines form closed loops
- (C) Magnetic field is conservative
- (D) Magnetic monopoles exist

Correct Answer: (B) Magnetic field lines form closed loops

Solution:

One of the four Maxwell's equations is Gauss's law for magnetism, which states:

$$\nabla \cdot \vec{B} = 0$$

This equation means that the divergence of the magnetic field ($\vec{B}$) is always zero.

Physically, this implies that there are no magnetic monopoles (isolated north or south poles) that can act as sources or sinks of the magnetic field, unlike electric charges for the electric field.

Because there are no starting or ending points for magnetic field lines, they must always form continuous, closed loops. A field line that enters any closed volume must also exit that volume, resulting in a net magnetic flux of zero.

Therefore, the zero divergence of the magnetic field is a mathematical statement of the fact that magnetic field lines form closed loops.

Quick Tip

Remember the physical meaning of divergence. Positive divergence means a "source" (lines start there), and negative divergence means a "sink" (lines end there). Zero divergence ($\nabla \cdot \vec{B} = 0$) means there are no sources or sinks, hence the field lines must be continuous loops.

84. The self-inductance of a coil is increased by

- (A) Decreasing number of turns
- (B) Using a wooden core
- (C) Increasing current
- (D) Increasing number of turns and using a soft iron core

Correct Answer: (D) Increasing number of turns and using a soft iron core

Solution:

The self-inductance (L) of a long solenoid is given by the formula:

$$L = \frac{\mu N^2 A}{l}$$

Where:

μ is the permeability of the core material.

N is the total number of turns.

A is the cross-sectional area.

l is the length of the coil.

To increase the self-inductance L , we can:

1. Increase the permeability μ of the core. Soft iron is a ferromagnetic material with a very high permeability compared to air or wood ($\mu \gg \mu_0$).
2. Increase the number of turns N . Inductance is proportional to the square of the number of turns ($L \propto N^2$).

Option (D) combines both of these methods: increasing the number of turns and using a high-permeability soft iron core. This will result in a significant increase in self-inductance. Self-inductance is a geometric property and does not depend on the current (C).

Quick Tip

Self-inductance is a measure of a coil's ability to resist changes in current. It depends on the coil's physical properties: its geometry (N, A, l) and the material of its core (μ). Ferromagnetic cores like soft iron dramatically increase inductance.

85. A high Q-factor implies

- (A) Wide resonance curve
- (B) Large bandwidth
- (C) Sharp resonance with small energy loss
- (D) Strong damping

Correct Answer: (C) Sharp resonance with small energy loss

Solution:

The Q-factor (Quality factor) of a resonant system is a dimensionless parameter that describes how underdamped an oscillator or resonator is.

It is defined as the ratio of the energy stored in the oscillator to the energy lost per cycle.

$$Q = 2\pi \times \frac{\text{Energy Stored}}{\text{Energy dissipated per cycle}}$$

A high Q-factor means that the energy loss per cycle is very small compared to the energy stored. This corresponds to low damping.

In terms of the frequency response, a high Q-factor corresponds to a very sharp and narrow resonance peak. This means the system responds with a large amplitude only over a very small range of frequencies near the resonant frequency. The bandwidth is small.

Therefore, a high Q-factor implies a sharp resonance with small energy loss.

Quick Tip

High Q = High Quality. A high-quality resonator (like a tuning fork or a radio tuner) has low damping, small energy loss, a narrow bandwidth, and a sharp resonance curve. All these concepts are linked.

86. Maxwell's wave equations are applicable to

- (A) Only conductors
- (B) Only insulators
- (C) Only static fields
- (D) Time-varying fields in free space

Correct Answer: (D) Time-varying fields in free space

Solution:

Maxwell's equations are a set of four fundamental equations that form the foundation of classical electromagnetism. When combined, they can be manipulated to form the electromagnetic wave equation.

This wave equation shows that time-varying electric and magnetic fields can propagate through space as a self-sustaining wave.

The wave equation is completely general and applies to fields in any medium, including conductors, insulators, and free space (vacuum), although the properties of the wave (like speed and attenuation) will depend on the medium.

However, the options given are restrictive. Options (A), (B), and (C) are incorrect as the equations are not limited to only those cases. The wave equations specifically arise from the consideration of time-varying fields, not static fields.

Option (D), "Time-varying fields in free space," represents a primary and fundamental application where these equations predict the existence of electromagnetic waves (like light) traveling at speed c . Among the choices, it is the most appropriate description of the context for wave equations.

Quick Tip

The essence of Maxwell's equations for waves is the interplay between changing fields: a changing magnetic field creates an electric field (Faraday's Law), and a changing electric field creates a magnetic field (Ampere-Maxwell's Law). This "leapfrogging" of fields is what constitutes an electromagnetic wave.

87. If $\beta=50$ and $I_E=5.1$ mA, then I_B is

- (A) 0.1 mA
- (B) 0.05 mA
- (C) 0.2 mA
- (D) 0.3 mA

Correct Answer: (A) 0.1 mA

Solution:

For a transistor, the fundamental relationship between the emitter current (I_E), base current

(I_B), and collector current (I_C) is:

$$I_E = I_B + I_C$$

The DC current gain, β , relates the collector current to the base current:

$$\beta = \frac{I_C}{I_B} \text{ which means } I_C = \beta I_B$$

We are given $\beta = 50$ and $I_E = 5.1 \text{ mA}$. We need to find I_B .

Substitute the expression for I_C into the first equation:

$$\begin{aligned} I_E &= I_B + (\beta I_B) \\ I_E &= I_B(1 + \beta) \end{aligned}$$

Now, rearrange the formula to solve for I_B :

$$I_B = \frac{I_E}{1 + \beta}$$

Substitute the given values:

$$I_B = \frac{5.1 \text{ mA}}{1 + 50} = \frac{5.1 \text{ mA}}{51}$$

$$I_B = 0.1 \text{ mA}$$

Quick Tip

A useful approximation for transistors with high β is that $I_C \approx I_E$. However, for precise calculations, always use the full relationship $I_E = I_B(1 + \beta)$. Remember that the base current (I_B) is always much smaller than the emitter and collector currents.

88. In a Zener regulator, if load resistance decreases, the Zener current:

- (A) Increases
- (B) Decreases
- (C) Remains constant
- (D) Drops to zero

Correct Answer: (B) Decreases

Solution:

A Zener voltage regulator circuit maintains a constant voltage (V_Z) across a load resistance (R_L). It consists of an unregulated input voltage (V_{in}), a series resistor (R_S), and a Zener diode in parallel with the load.

The voltage across the load is fixed at the Zener voltage, $V_L = V_Z$.

The current flowing through the load is given by Ohm's law: $I_L = \frac{V_Z}{R_L}$.

The total current drawn from the source through the series resistor is $I_S = \frac{V_{in} V_Z}{R_S}$. Since V_{in} and V_Z are constant, the total current I_S is approximately constant.

This total current splits between the Zener diode (I_Z) and the load (I_L): $I_S = I_Z + I_L$.

If the load resistance (R_L) decreases, the load current ($I_L = V_Z/R_L$) will increase.

Since I_S is constant and I_L increases, the Zener current ($I_Z = I_S - I_L$) must decrease to maintain the balance.

Quick Tip

Think of the Zener diode in a regulator as a "current sink" that absorbs any current not taken by the load, in order to keep the voltage constant. If the load demands more current, the Zener has to take less.

89. A Full Adder adds

- (A) 1-bit binary number only
- (B) Two inputs only
- (C) Three binary inputs (A, B, Carry-in)
- (D) Four bits at a time

Correct Answer: (C) Three binary inputs (A, B, Carry-in)

Solution:

In digital electronics, an adder is a circuit that performs addition of numbers.

A Half Adder is the simplest type, which adds two single binary digits (A and B) and produces a Sum (S) and a Carry (C). It cannot handle a carry-in from a previous addition.

A Full Adder is a more complex combinational circuit that overcomes this limitation. It adds three one-bit binary numbers.

The three inputs are typically the two bits to be added (A and B) and a carry bit from the previous, less-significant stage of addition (Carry-in or C_{in}).

The full adder produces two outputs: a Sum bit (S) and a Carry-out bit (C_{out}). This allows multiple full adders to be cascaded to add multi-bit numbers.

Quick Tip

Differentiate between adder types: Half Adder: 2 inputs (A, B), 2 outputs (Sum, Carry). Full Adder: 3 inputs (A, B, Carry-in), 2 outputs (Sum, Carry-out). A full adder can be constructed from two half adders and an OR gate.

90. The Complement Law says

(A) $A + \bar{A} = 0$

(B) $A \cdot \bar{A} = A$

(C) $A + \bar{A} = 1$

(D) $A \cdot \bar{A} = 1$

Correct Answer: (C) $A + \bar{A} = 1$

Solution:

The Complement Law in Boolean algebra defines the relationship between a variable and its inverse (or complement). There are two forms of this law. Let $\bar{A}$ be the complement of A.

1. OR Form: $A + \bar{A} = 1$. This is because if A is 0, $\bar{A}$ is 1, so $0 + 1 = 1$. If A is 1, $\bar{A}$ is 0, so $1 + 0 = 1$. In either case, the result is 1.

2. AND Form: $A \cdot \bar{A} = 0$. This is because if A is 0, $\bar{A}$ is 1, so $0 \cdot 1 = 0$. If A is 1, $\bar{A}$ is 0, so $1 \cdot 0 = 0$. In either case, the result is 0.

Let's examine the options:

(A) $A + \bar{A} = 0$ is incorrect.

(B) $A \cdot \bar{A} = A$ is incorrect.

(C) $A + \bar{A} = 1$ is the correct OR form of the Complement Law.

(D) $A \cdot \bar{A} = 1$ is incorrect.

Therefore, option (C) correctly states the Complement Law.

Quick Tip

Remember the basic Boolean postulates. The Complement Law is fundamental: a variable Ored with its complement is always TRUE (1), and a variable ANDed with its complement is always FALSE (0).

91. The selection rule for the change in the magnetic quantum number (Δm_l) for an electric dipole transition is

(A) $\Delta m_l = 0$

(B) $\Delta m_l = \pm 1$

(C) $\Delta m_l = 0, \pm 1$

(D) $\Delta m_l = 2$

Correct Answer: (C) $\Delta m_l = 0, \pm 1$

Solution:

In atomic physics, selection rules specify the possible transitions an electron can make between energy levels upon the emission or absorption of a photon.

For electric dipole transitions, which are the most common type, the selection rules are:

1. For the orbital quantum number (l): $\Delta l = \pm 1$.
2. For the magnetic quantum number (m_l): $\Delta m_l = 0, \pm 1$.

The change in m_l is related to the polarization of the photon. $\Delta m_l = 0$ corresponds to linearly polarized light, and $\Delta m_l = \pm 1$ corresponds to circularly polarized light.

Therefore, the allowed changes for the magnetic quantum number are 0, +1, and -1.

Quick Tip

Remember the selection rules for electric dipole transitions as a pair: $\Delta l = \pm 1$ and $\Delta m_l = 0, \pm 1$. These rules arise from the conservation of angular momentum during the photon-atom interaction.

92. In the Zeeman effect, the number of spectral lines observed depends on

- (A) The orbital angular momentum quantum number (l) of the electron
- (B) The spin quantum number (s) of the electron
- (C) The total angular momentum quantum number (j) of the electron
- (D) The magnetic quantum number (m_l) of the electron

Correct Answer: (D) The magnetic quantum number (m_l) of the electron

Solution:

The Zeeman effect is the splitting of a spectral line into several components in the presence of an external magnetic field.

The magnetic field removes the degeneracy of energy levels with respect to the magnetic quantum number (m_l).

An energy level with orbital angular momentum quantum number l splits into $2l + 1$ sublevels, each with a different value of m_l (from $-l$ to $+l$).

The observed spectral lines correspond to allowed transitions between these split sublevels.

The transitions are governed by the selection rule $\Delta m_l = 0, \pm 1$.

Therefore, the number of lines and their positions depend directly on the values and allowed changes of the magnetic quantum number, m_l .

Quick Tip

The magnetic quantum number, m_l , specifies the orientation of the orbital angular momentum vector with respect to an external magnetic field. The Zeeman effect directly reveals this quantization of orientation by splitting the energy levels.

93. The wavelength associated with an electron raised to 1600 V potential is

- (A) 31 Å
- (B) 3.1 Å
- (C) 0.31 Å
- (D) 0.031 Å

Correct Answer: (C) 0.31 Å

Solution:

The de Broglie wavelength (λ) of an electron accelerated through a potential difference V can be calculated using the formula:

$$\lambda = \frac{h}{\sqrt{2m_e eV}}$$

Where h is Planck's constant, m_e is the mass of the electron, and e is the charge of the electron.

A convenient shortcut formula for electrons is:

$$\lambda(\text{in Angstroms, } \text{\AA}) = \frac{12.27}{\sqrt{V(\text{in Volts})}}$$

Given the potential $V = 1600$ V.

$$\sqrt{V} = \sqrt{1600} = 40 \text{ V}^{1/2}.$$

Substituting this into the shortcut formula:

$$\lambda = \frac{12.27}{40} \text{ \AA} \approx 0.30675 \text{ \AA}.$$

This value is approximately 0.31 Å.

Quick Tip

For competitive exams, memorizing the shortcut formula $\lambda(\text{\AA}) = \frac{12.27}{\sqrt{V}}$ for an electron's de Broglie wavelength can save a significant amount of calculation time.

94. Bohr's complementarity principle is the consequence of

- (A) Bohr hypothesis
- (B) De Broglie hypothesis
- (C) Rutherford model
- (D) Interference

Correct Answer: (B) De Broglie hypothesis

Solution:

Bohr's principle of complementarity states that certain pairs of physical properties of a quantum object are complementary. This means they cannot be simultaneously observed or measured with high precision.

The most famous example of this is wave-particle duality.

The De Broglie hypothesis is the cornerstone of wave-particle duality. It states that all matter exhibits wave-like properties, with a wavelength given by $\lambda = h/p$.

This hypothesis introduced the idea that particles like electrons also have a wave nature.

The complementarity principle is the philosophical framework that addresses how to reconcile these two seemingly contradictory aspects (wave and particle). An object can behave as a wave or a particle depending on the experiment, but not both at the same time.

Therefore, the need for the complementarity principle arises directly from the wave-particle duality established by the De Broglie hypothesis.

Quick Tip

Connect the key ideas: De Broglie proposed wave-particle duality. Bohr's complementarity principle provides the philosophical interpretation for it, stating that wave and particle aspects are mutually exclusive but both necessary for a complete description of a quantum entity.

95. Least energy of an electron moving in one dimensional potential box of width 0.05 nm is

- (A) 150.95 eV
- (B) 5.09 eV
- (C) 1.50 eV
- (D) 0.015 eV

Correct Answer: (A) 150.95 eV

Solution:

The energy levels of a particle in a one-dimensional infinite potential box of width L are given by the formula:

$$E_n = \frac{n^2 h^2}{8mL^2}$$

The least energy corresponds to the ground state, where $n = 1$.

$$E_1 = \frac{h^2}{8m_e L^2}$$

Given values are:

$$L = 0.05 \text{ nm} = 0.05 \times 10^{-9} \text{ m.}$$

$$h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s.}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg.}$$

Substituting the values:

$$E_1 = \frac{(6.626 \times 10^{-34})^2}{8 \times (9.11 \times 10^{-31}) \times (0.05 \times 10^{-9})^2}$$

$$E_1 = \frac{43.90 \times 10^{-68}}{8 \times 9.11 \times 10^{-31} \times 0.0025 \times 10^{-18}} = \frac{43.90 \times 10^{-68}}{0.1822 \times 10^{-49}} \approx 24.09 \times 10^{-18} \text{ J.}$$

To convert this energy to electron-volts (eV), we divide by the charge of an electron, $1.602 \times 10^{-19} \text{ C}$.

$$E_1 (\text{in eV}) = \frac{2.409 \times 10^{-17} \text{ J}}{1.602 \times 10^{-19} \text{ J/eV}}$$

$$E_1 \approx 150.4 \text{ eV.}$$

This value matches option (A).

Quick Tip

For particle-in-a-box problems, be very careful with units. Convert everything to SI units (meters, kilograms, seconds) before calculating, and then convert the final answer in Joules to eV if required.

96. Meson theory explains

- (A) The behavior of protons and electrons
- (B) The force that holds the atomic nucleus together
- (C) The forces between quarks inside protons and neutrons
- (D) The electromagnetic interactions between charged particles

Correct Answer: (B) The force that holds the atomic nucleus together

Solution:

The meson theory of nuclear forces was proposed by Hideki Yukawa in 1935.

It explains the nature of the strong nuclear force, which is the force responsible for binding protons and neutrons (collectively known as nucleons) together within the atomic nucleus.

The theory postulates that this force is mediated by the exchange of particles called mesons (specifically, pions) between the nucleons.

The force between quarks is mediated by gluons (Quantum Chromodynamics). The electromagnetic interaction is mediated by photons.

Therefore, the meson theory provides an explanation for the force that holds the atomic nucleus together.

Quick Tip

Associate forces with their mediating particles (force carriers): Electromagnetic Force - Photon Strong Nuclear Force (between nucleons) - Meson (pion) Strong Force (between quarks) - Gluon Weak Nuclear Force - W and Z bosons

97. The concept of "magic numbers" in nuclear physics refers to the number of nucleons that

- (A) Are more stable due to closed shells
- (B) Can exist in a free state
- (C) Form isotopes with the greatest energy
- (D) Are unstable and radioactive

Correct Answer: (A) Are more stable due to closed shells

Solution:

In nuclear physics, the "magic numbers" are 2, 8, 20, 28, 50, 82, and 126.

Nuclei that have a number of protons or neutrons equal to one of these magic numbers are found to be significantly more stable than other nuclei.

This enhanced stability is explained by the nuclear shell model.

In this model, protons and neutrons fill energy levels or "shells" within the nucleus, analogous to how electrons fill shells in an atom.

The magic numbers correspond to the numbers of nucleons required to completely fill these shells. A closed, filled shell results in a much higher binding energy and thus greater stability.

Quick Tip

The concept of "magic numbers" in nuclei is a direct parallel to the concept of noble gases in chemistry. Both achieve high stability due to the presence of closed, filled shells of their constituent particles (nucleons and electrons, respectively).

98. Fullerenes are also known as

- (A) Graphene
- (B) Buckminster fullerenes
- (C) Carbon nanotubes
- (D) Graphite

Correct Answer: (B) Buckminster fullerenes

Solution:

Fullerenes are a class of carbon allotropes where carbon atoms are bonded together in a structure of a hollow sphere, ellipsoid, or tube.

The most famous member of the fullerene family is the C_{60} molecule.

Its structure, composed of interconnected pentagons and hexagons, resembles a soccer ball. This shape is also reminiscent of the geodesic domes designed by the architect R. Buckminster Fuller.

In his honor, the C_{60} molecule was named Buckminsterfullerene. The term is often used more broadly to refer to the entire class of fullerenes.

Graphene, carbon nanotubes, and graphite are other distinct allotropes of carbon.

Quick Tip

Remember the main allotropes of carbon: Diamond (tetrahedral lattice), Graphite (sheets of hexagonal lattice), Graphene (a single sheet of graphite), and Fullerenes (cage-like molecules).

99. What happens to the magnetic field inside a super conductor when it exhibits the Meissner effect?

- (A) It is amplified
- (B) It remains the same
- (C) It is expelled completely
- (D) It fluctuates

Correct Answer: (C) It is expelled completely

Solution:

The Meissner effect is a defining characteristic of a superconductor.

When a material is cooled below its critical temperature (T_c) and becomes superconducting, it actively expels magnetic field lines from its interior.

This means that the magnetic field inside the superconductor becomes zero, regardless of whether the field was applied before or after cooling.

This property shows that a superconductor is not just a perfect conductor (which would trap existing magnetic fields), but also a perfect diamagnet.

Therefore, the magnetic field is completely expelled from the bulk of the superconductor.

Quick Tip

The Meissner effect distinguishes a superconductor from a hypothetical "perfect conductor". A perfect conductor would oppose any change in magnetic flux, trapping an existing field, whereas a superconductor expels any existing field.

100. The Cooper pair is

- (A) Two positively charged ions bound together
- (B) Two electrons with opposite spins and momentum that form a bound state
- (C) A pair of magnetic dipoles aligned in the same direction
- (D) Two protons bonded together in a high-energy state

Correct Answer: (B) Two electrons with opposite spins and momentum that form a bound state

Solution:

A Cooper pair is a pair of electrons that are bound together at low temperatures in a certain manner, and their formation is the basis of the BCS theory of superconductivity.

The mechanism for binding is an electron-phonon interaction. One electron passes through the crystal lattice and attracts the positive ions, creating a slight deformation or ripple (a phonon). This region of higher positive charge density then attracts a second electron.

This indirect attraction can overcome the direct Coulomb repulsion between the electrons, forming a bound pair.

A Cooper pair consists of two electrons that typically have opposite momenta and opposite spins. This results in the pair having a total momentum of zero and a total spin of zero, allowing it to behave like a boson.

Quick Tip

The key to superconductivity is that Cooper pairs, acting as bosons, can all condense into the same quantum ground state. This collective state allows them to move through the lattice without scattering and hence without resistance.

101. Isocyanide test is useful for the identification of following functional group

- (A) Carbonyl
- (B) Nitro
- (C) Primary Amine
- (D) Carboxylic acid

Correct Answer: (C) Primary Amine

Solution:

The isocyanide test, also known as the carbylamine test, is a specific chemical test used to identify primary amines.

In this reaction, the substance to be tested is heated with chloroform ($CHCl_3$) and an alcoholic solution of potassium hydroxide (KOH).

If a primary amine is present (either aliphatic or aromatic), it gets converted into an isocyanide (or carbylamine).

Isocyanides are characterized by their extremely unpleasant, foul smell.

The general reaction is: $R - NH_2 + CHCl_3 + 3KOH \rightarrow R - NC + 3KCl + 3H_2O$.

This distinctive smell confirms the presence of a primary amine functional group. Carbonyl, nitro, and carboxylic acid groups do not give this test.

Quick Tip

Associate specific name tests with functional groups. For example: Carbylamine test for primary amines, Lucas test for distinguishing primary, secondary, and tertiary alcohols, and Tollens' test for aldehydes.

102. Hydrogen Bonding is found in

- (A) Phenols
- (B) Ethers
- (C) Arylhalides
- (D) Aldehydes

Correct Answer: (A) Phenols

Solution:

Hydrogen bonding is a special type of dipole-dipole interaction that occurs when a hydrogen atom is bonded to a highly electronegative atom (like Nitrogen, Oxygen, or Fluorine).

Let's analyze the options:

(A) Phenols have a hydroxyl group (-OH) directly attached to an aromatic ring. The hydrogen atom is bonded to a highly electronegative oxygen atom, allowing for strong intermolecular hydrogen bonding.

(B) Ethers have the structure R-O-R. There are no hydrogen atoms directly bonded to the oxygen atom, so ethers cannot form hydrogen bonds among themselves (they can act as H-bond acceptors with other molecules like water).

(C) Arylhalides have a halogen atom bonded to an aromatic ring. They do not have the required H-N, H-O, or H-F bond.

(D) Aldehydes have the structure R-CHO. The hydrogen atom is bonded to carbon, not oxygen, so they cannot form hydrogen bonds among themselves.

Therefore, hydrogen bonding is found in phenols.

Quick Tip

To quickly determine if a molecule can exhibit hydrogen bonding with itself, look for the presence of an H-O, H-N, or H-F bond within its structure.

103. Acetic anhydride does not react with

- (A) Ethanol
- (B) Phenol
- (C) Aniline
- (D) Dimethyl Aniline

Correct Answer: (D) Dimethyl Aniline

Solution:

Acetic anhydride ($(CH_3CO)_2O$) is an acylating agent. It reacts with nucleophiles containing an active hydrogen atom, such as the hydrogen in -OH (alcohols, phenols) or -NH₂/-NHR (primary/secondary amines). This reaction is called acylation or acetylation.

(A) Ethanol (CH_3CH_2OH) is a primary alcohol. It has an active hydrogen on the oxygen atom and will react with acetic anhydride to form an ester (ethyl acetate).

(B) Phenol (C_6H_5OH) has an active hydrogen on the oxygen atom and will react to form phenyl acetate.

(C) Aniline ($C_6H_5NH_2$) is a primary amine. It has active hydrogens on the nitrogen atom and will react to form an amide (acetanilide).

(D) Dimethylaniline ($C_6H_5N(CH_3)_2$) is a tertiary amine. The nitrogen atom has no attached hydrogen atoms. Therefore, it cannot undergo acetylation with acetic anhydride.

Quick Tip

Acylation reactions with reagents like acid anhydrides or acid chlorides require an active hydrogen on the nucleophilic atom (like O or N). Tertiary amines lack this active hydrogen and thus do not undergo acylation.

104. Erythrose and threose are

- (A) Diastereomers
- (B) Enantiomers
- (C) Epimers
- (D) Conformational isomers

Correct Answer: (A) Diastereomers

Solution:

Erythrose and threose are aldotetroses, meaning they are four-carbon sugars with an aldehyde group. They both have the same molecular formula ($C_4H_8O_4$) and the same connectivity of atoms.

They are stereoisomers because they differ in the spatial arrangement of atoms. Specifically, they have two chiral centers (at C-2 and C-3).

Enantiomers are stereoisomers that are non-superimposable mirror images of each other (e.g., D-Erythrose and L-Erythrose).

Diastereomers are stereoisomers that are not mirror images of each other.

The relationship between D-Erythrose and D-Threose is that they are stereoisomers but are not mirror images of one another. Therefore, they are diastereomers.

While they are also epimers (specifically, C-2 epimers, as they differ only at the C-2 chiral center), the term 'diastereomers' is a broader and correct classification. All epimers are diastereomers. Since Diastereomers is an option, it is the most appropriate general classification.

Quick Tip

Remember the hierarchy of isomers. Stereoisomers can be divided into enantiomers (mirror images) and diastereomers (not mirror images). Epimers are a special type of diastereomer that differ at only one chiral center.

105. Optically inactive amino acid is

- (A) Aspartic acid
- (B) Alanine
- (C) Tyrosine
- (D) Glycine

Correct Answer: (D) Glycine

Solution:

Optical activity in amino acids is due to the presence of a chiral center. The α -carbon of an amino acid is a chiral center if it is bonded to four different groups.

The general structure of an amino acid is a central α -carbon bonded to an amino group ($-\text{NH}_2$), a carboxyl group ($-\text{COOH}$), a hydrogen atom ($-\text{H}$), and a side chain ($-\text{R}$).

For all amino acids except one, the side chain ($-\text{R}$) is different from the other three groups, making the α -carbon chiral and the amino acid optically active.

The exception is Glycine. For glycine, the side chain ($-\text{R}$) is another hydrogen atom ($-\text{H}$).

Thus, in glycine, the α -carbon is bonded to two hydrogen atoms, a $-\text{NH}_2$ group, and a $-\text{COOH}$ group. Since it is not bonded to four different groups, it is not a chiral center.

Therefore, glycine is achiral and optically inactive.

Quick Tip

Glycine is the simplest and only achiral of the 20 standard proteinogenic amino acids. Its lack of a chiral center makes it optically inactive, a unique property often tested in exams.

106. Iodoform on heating with silver powder gives

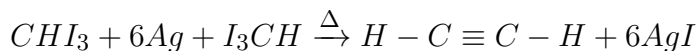
- (A) Chloro methane
- (B) Ethylene
- (C) Acetylene
- (D) Ethane

Correct Answer: (C) Acetylene

Solution:

This is a dehalogenation reaction. When iodoform (CHI_3) is heated with silver powder (Ag), the silver atoms abstract the iodine atoms.

The reaction involves two molecules of iodoform and six atoms of silver.



The six silver atoms combine with the six iodine atoms to form six molecules of silver iodide (AgI), which is a stable precipitate.

The two remaining C-H fragments combine by forming a carbon-carbon triple bond.

The product, C_2H_2 , is acetylene (ethyne).

Quick Tip

This is a standard reaction for preparing acetylene from haloforms. Remember the stoichiometry: 2 molecules of haloform (CHX_3) react with 6 atoms of silver to produce acetylene and 6 molecules of silver halide (AgX).

107. Me Mg Br on treatment with which of the following produce an asymmetric center compound

- (A) Propionaldehyde
- (B) Acetone
- (C) 2-Butanone
- (D) 3-Pentanone

Correct Answer: (A) Propionaldehyde

Solution:

The reagent MeMgBr (methylmagnesium bromide) is a Grignard reagent, which acts as a source of the methyl nucleophile (CH_3^-). It attacks the electrophilic carbonyl carbon of aldehydes and ketones. An asymmetric center is a carbon atom bonded to four different groups.

Let's analyze the reaction with each option:

(A) Propionaldehyde (CH_3CH_2CHO) + $CH_3MgBr \rightarrow$ product is Butan-2-ol ($CH_3CH_2CH(OH)CH_3$). The carbon atom bearing the -OH group is bonded to: -H, -OH, -CH₃, and -CH₂CH₃. Since all four groups are different, this carbon is an asymmetric center.

(B) Acetone (CH_3COCH_3) + $CH_3MgBr \rightarrow$ product is tert-Butanol ($(CH_3)_3COH$). The central carbon is bonded to three identical methyl groups and one -OH group. It is not an asymmetric center.

(C) 2-Butanone ($CH_3COCH_2CH_3$) + $CH_3MgBr \rightarrow$ product is 2-Methylbutan-2-ol ($(CH_3)_2C(OH)CH_2CH_3$). The carbon that was part of the carbonyl group is now bonded to two identical methyl groups, one -OH, and one ethyl group. It is not an asymmetric center.

(D) 3-Pentanone ($CH_3CH_2COCH_2CH_3$) + $CH_3MgBr \rightarrow$ product is 3-Methylpentan-3-ol ($(CH_3CH_2)_2C(OH)CH_3$). The carbon is bonded to two identical ethyl groups, one -OH, and one methyl group. It is not an asymmetric center.

Only the reaction with propionaldehyde produces a compound with an asymmetric center.

Quick Tip

To form a chiral alcohol from a Grignard reaction with a carbonyl compound, the two R groups attached to the carbonyl carbon in the ketone/aldehyde must be different, and the Grignard reagent's R group must also be different from those two. Formaldehyde is an exception (it gives a primary alcohol). All other aldehydes give secondary alcohols, which will be chiral if the aldehyde's R group is not H or the Grignard's R group.

108. Which of the following will be able to produce n-propylamine on treatment with NaOH/ Br_2

- (A) Propanamide
- (B) 1-Aminobutane
- (C) Butanamide
- (D) N, N-dipropyl amine

Correct Answer: (C) Butanamide

Solution:

The reaction of an amide with a mixture of bromine (Br_2) and sodium hydroxide (NaOH) is known as the Hofmann bromamide degradation reaction.

This reaction is a method for converting a primary amide into a primary amine with one fewer carbon atom. The carbonyl carbon of the amide is lost as carbonate.

The desired product is n-propylamine ($CH_3CH_2CH_2NH_2$), which contains 3 carbon atoms.

According to the mechanism of the Hofmann bromamide degradation, the starting amide must have one more carbon atom than the resulting amine.

Therefore, the starting material must be an amide with $3 + 1 = 4$ carbon atoms.

Let's examine the options:

- (A) Propanamide ($CH_3CH_2CONH_2$) has 3 carbons. It would yield ethylamine.
- (C) Butanamide ($CH_3CH_2CH_2CONH_2$) has 4 carbons. It will yield n-propylamine.

The other options are not primary amides.

Quick Tip

In the Hofmann bromamide degradation, simply remove the carbonyl group ($-\text{C}=\text{O}$) from the primary amide to find the structure of the resulting primary amine. This provides a quick way to solve such problems.

109. Benzoic acid on Arndt-Eistert reaction gives

- (A) Benzoin
- (B) 1,2-Diphenyl ethane
- (C) Toluene
- (D) Phenyl acetic acid

Correct Answer: (D) Phenyl acetic acid

Solution:

The Arndt-Eistert reaction is a method used for chain homologation of carboxylic acids, meaning it lengthens the carbon chain of a carboxylic acid by one methylene ($-\text{CH}_2-$) unit.

The starting compound is benzoic acid, which has the structure $\text{C}_6\text{H}_5\text{COOH}$.

The Arndt-Eistert reaction will insert a $-\text{CH}_2$ group between the phenyl group (C_6H_5-) and the carboxyl group ($-\text{COOH}$).

The starting acid is: $\text{C}_6\text{H}_5 - \text{COOH}$.

The product acid will be: $\text{C}_6\text{H}_5 - \text{CH}_2 - \text{COOH}$.

The compound $\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$ is known as phenylacetic acid.

The overall transformation is: Benzoic acid $\rightarrow$ Phenylacetic acid.

Quick Tip

The Arndt-Eistert reaction is a reliable way to convert R-COOH into $\text{R-CH}_2\text{-COOH}$. Recognize this transformation as a key application of the reaction. It involves several steps (formation of acid chloride, reaction with diazomethane, Wolff rearrangement).

110. An organic compound with six carbons undergoes Cannizzaro reaction. The structural formula is

- (A) 2,2-dimethylpropanal
- (B) 3,3-dimethylbutanal
- (C) 2,3-dimethylbutanal
- (D) 2,2-dimethylbutanal

Correct Answer: (D) 2,2-dimethylbutanal

Solution:

The Cannizzaro reaction is a base-induced disproportionation reaction in which two molecules of a non-enolizable aldehyde (an aldehyde with no α -hydrogen atoms) react to produce a primary alcohol and a carboxylic acid salt.

We need to find a six-carbon aldehyde from the options that has no α -hydrogen atoms. The α -carbon is the carbon atom adjacent to the aldehyde functional group ($-\text{CHO}$).

Let's check the options:

(A) 2,2-dimethylpropanal, $(\text{CH}_3)_3\text{CCHO}$. This molecule has 5 carbon atoms, not 6. (It does lack α -hydrogens).

(B) 3,3-dimethylbutanal, $(\text{CH}_3)_3\text{CCH}_2\text{CHO}$. This molecule has 6 carbon atoms. The α -carbon is the $-\text{CH}_2$ group, which has two α -hydrogens. It will undergo an aldol reaction, not Cannizzaro.

(C) 2,3-dimethylbutanal, $(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)\text{CHO}$. This molecule has 6 carbon atoms. The α -carbon is the $-\text{CH}(\text{CH}_3)$ group, which has one α -hydrogen. It will undergo an aldol reaction.

(D) 2,2-dimethylbutanal, $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{CHO}$. This molecule has 6 carbon atoms. The α -carbon is the quaternary carbon, $\text{C}(\text{CH}_3)_2$. It is bonded to an ethyl group, two methyl groups, and the carbonyl group. It has no hydrogen atoms attached. Therefore, it has no α -hydrogens and will undergo the Cannizzaro reaction.

Quick Tip

To quickly check for the Cannizzaro reaction, identify the aldehyde group ($-\text{CHO}$). Then, look at the very next carbon atom (the α -carbon). If this carbon atom has no hydrogen atoms directly attached to it, the aldehyde will give a positive Cannizzaro test.

111. The reagent used to convert propiophenone to propylbenzene is

- (A) $\text{C}_2\text{H}_5\text{MgX}$
- (B) LiAlH_4
- (C) Zn-Hg/HCl
- (D) $\text{NH}_2\text{-NH}_2$

Correct Answer: (C) Zn-Hg/HCl

Solution:

The conversion of propiophenone to propylbenzene involves the reduction of a ketone functional group (C=O) to a methylene group ($-\text{CH}_2-$).

Propiophenone: $\text{C}_6\text{H}_5 - \text{CO} - \text{CH}_2\text{CH}_3$

Propylbenzene: $\text{C}_6\text{H}_5 - \text{CH}_2 - \text{CH}_2\text{CH}_3$

Let's examine the reagents:

(A) C_2H_5MgX (Grignard reagent) would add an ethyl group to the carbonyl carbon, followed by hydrolysis to form an alcohol. It does not reduce the ketone to an alkane.

(B) $LiAlH_4$ (Lithium aluminium hydride) is a strong reducing agent that reduces ketones to secondary alcohols, not alkanes.

(C) $Zn-Hg/HCl$ (amalgamated zinc in concentrated hydrochloric acid) is the reagent for the Clemmensen reduction. This reaction specifically reduces the carbonyl group of aldehydes and ketones to a methylene group. This is the correct reagent for the desired transformation.

(D) NH_2-NH_2 (hydrazine) is used in the Wolff-Kishner reduction, which also achieves the same conversion but requires a strong base (like KOH) and heat, not just hydrazine alone.

Therefore, the Clemmensen reduction using $Zn-Hg/HCl$ is the correct choice.

Quick Tip

Remember the two main name reactions for reducing a carbonyl group to an alkane: Clemmensen reduction ($Zn-Hg/HCl$, acidic conditions) and Wolff-Kishner reduction (NH_2NH_2/KOH , basic conditions). Choose the reagent based on whether the rest of the molecule is stable in acid or base.

112. In addition, reaction of aldehydes, the carbonyl carbon atom changes from

(A) sp^3 to sp^2

(B) sp^2 to sp^3

(C) sp to sp^2

(D) sp^3 to sp

Correct Answer: (B) sp^2 to sp^3

Solution:

In an aldehyde ($R-CHO$), the carbonyl carbon atom is double-bonded to an oxygen atom and single-bonded to a hydrogen and an R group.

A carbon atom with one double bond and two single bonds is sp^2 hybridized. The geometry around this carbon is trigonal planar.

During an addition reaction (e.g., with a Grignard reagent or HCN), the π bond of the carbonyl group breaks, and a nucleophile and an electrophile (usually H^+) add across the double bond.

After the reaction, the original carbonyl carbon is now bonded to four different groups via single bonds.

A carbon atom with four single bonds is sp^3 hybridized. The geometry around this carbon is tetrahedral.

Therefore, the hybridization of the carbonyl carbon changes from sp^2 to sp^3 .

Quick Tip

A simple way to determine hybridization is to count the number of sigma bonds and lone pairs (steric number). For carbon: 4 sigma bonds = sp^3 , 3 sigma bonds = sp^2 , 2 sigma bonds = sp . Addition reactions to double bonds generally convert sp^2 carbons to sp^3 carbons.

113. IR absorption bands lie in the following range

- (A) 1600-1650 cm^{-1}
- (B) 4000-600 cm^{-1}
- (C) 1600-3500 cm^{-1}
- (D) 3000-6000 cm^{-1}

Correct Answer: (B) 4000-600 cm^{-1}

Solution:

Infrared (IR) spectroscopy measures the absorption of infrared radiation by a molecule as it vibrates.

The region of the infrared spectrum most commonly used for analysis in organic chemistry is the mid-infrared region.

This region typically covers wavenumbers from 4000 cm^{-1} to about 400 cm^{-1} or 600 cm^{-1} .

This range is useful because it contains the characteristic absorption frequencies for most common functional groups. The range 4000-1500 cm^{-1} is the functional group region, and the range below 1500 cm^{-1} is the fingerprint region.

Option (B) 4000-600 cm^{-1} best represents this entire useful mid-IR range. The other options represent only specific, narrow parts of the spectrum.

Quick Tip

For IR spectroscopy, remember the typical range is about 4000-400 cm^{-1} . This range is divided into the functional group region (above 1500 cm^{-1}) where key bonds like O-H, N-H, C-H, and C=O absorb, and the fingerprint region (below 1500 cm^{-1}) which is unique to the entire molecule.

114. Hydrogen bonding shifts the IR absorption frequencies to

- (A) Low values
- (B) Higher values
- (C) No influence
- (D) Greater Effect

Correct Answer: (A) Low values

Solution:

IR absorption frequency is related to the bond strength and the masses of the atoms involved. For a given bond (like O-H), the frequency is proportional to the square root of the bond's force constant (strength).

When hydrogen bonding occurs, the hydrogen atom of one molecule is attracted to an electronegative atom (like oxygen) of a neighboring molecule.

This intermolecular attraction weakens the original covalent bond (e.g., the O-H bond).

A weaker bond has a lower force constant.

A lower force constant leads to a lower vibrational frequency. In an IR spectrum, lower frequency corresponds to a lower wavenumber (value).

Therefore, hydrogen bonding shifts the absorption peak to lower values (a redshift). It also typically causes significant broadening of the peak.

Quick Tip

Stronger bond = Higher frequency (wavenumber). Hydrogen bonding weakens the X-H covalent bond, so its IR absorption shifts to a lower frequency (lower value).

115. Number of NMR signals expected for Methyl acetate are

- (A) 2
- (B) 3
- (C) 5
- (D) 7

Correct Answer: (A) 2

Solution:

The number of signals in a ^1H NMR spectrum corresponds to the number of sets of chemically non-equivalent protons in the molecule.

The structure of methyl acetate is $\text{CH}_3 - \text{CO} - \text{O} - \text{CH}_3$.

We need to identify the different proton environments.

1. There is a set of three protons in the methyl group attached to the carbonyl carbon ($CH_3 - CO-$). Let's call this environment 'a'.
2. There is another set of three protons in the methyl group attached to the ester oxygen ($-O - CH_3$). Let's call this environment 'b'.

The chemical environment of the protons in 'a' is different from the environment of the protons in 'b' because one is next to a carbonyl group and the other is next to an ester oxygen.

Since there are two sets of chemically non-equivalent protons, we expect to see two signals in the NMR spectrum.

Quick Tip

To find the number of NMR signals, look for planes of symmetry and axes of rotation. Protons that can be interchanged by a symmetry operation are chemically equivalent and will give a single signal. In methyl acetate, the two methyl groups are in different electronic environments and are not equivalent.

116. $\pi\pi$ transition is not found in which of the following

- (A) Alkenes
- (B) Alcohols
- (C) Azo compounds
- (D) Carbonyl compounds

Correct Answer: (B) Alcohols

Solution:

A $\pi \rightarrow \pi$ electronic transition involves the promotion of an electron from a π bonding molecular orbital to a π anti-bonding molecular orbital.

This type of transition can only occur in molecules that contain π bonds, i.e., molecules with double or triple bonds.

Let's analyze the options:

- (A) Alkenes contain $C=C$ double bonds, so they have π orbitals and exhibit $\pi \rightarrow \pi$ transitions.
- (B) Alcohols ($R-OH$) are saturated compounds. They only contain σ single bonds. They do not have any π bonds. Therefore, they cannot undergo $\pi \rightarrow \pi$ transitions. They typically show $\sigma \rightarrow \sigma$ and $n \rightarrow \sigma$ transitions.
- (C) Azo compounds ($R-N=N-R$) contain $N=N$ double bonds and thus show $\pi \rightarrow \pi$ transitions.

(D) Carbonyl compounds (e.g., aldehydes, ketones) contain C=O double bonds and thus show $\pi \rightarrow \pi$ transitions.

Quick Tip

For a molecule to have a $\pi \rightarrow \pi$ transition, it must contain a chromophore with at least one double or triple bond (a π system). Saturated compounds like alkanes and alcohols lack π bonds and cannot have this type of transition.

117. The essential constituent of Chlorophyll is

- (A) Fe
- (B) Mg
- (C) Co
- (D) Mn

Correct Answer: (B) Mg

Solution:

Chlorophyll is the green pigment found in cyanobacteria and the chloroplasts of algae and plants. It is essential for photosynthesis.

The molecular structure of chlorophyll consists of a large porphyrin ring structure.

At the center of this porphyrin ring, there is a single metal ion that is coordinated to the nitrogen atoms of the ring.

The essential metal ion in chlorophyll is Magnesium (Mg^{2+}).

In contrast, the central metal ion in the heme group of hemoglobin and myoglobin is Iron (Fe), and in Vitamin B12 is Cobalt (Co).

Quick Tip

Memorize the central metal ions in key biological molecules: Chlorophyll: Magnesium (Mg) Hemoglobin: Iron (Fe) Vitamin B12: Cobalt (Co)

118. Which is the increasing bond length order for the following molecules?

- (A) $N_2^+ < N_2 = N_2^- < N_2^{2-}$
- (B) $N_2^{2-} < N_2^+ < N_2$
- (C) $N_2 < N_2^{2-} = N_2^+ < N_2$
- (D) $N_2^+ < N_2 = N_2^{2-} < N_2$

Correct Answer: (B) $N_2^{2-} < N_2^+ < N_2$

Solution:

The bond length of a diatomic molecule is inversely proportional to its bond order. A higher bond order means a stronger, shorter bond. We can determine the bond order using Molecular Orbital Theory.

Let's calculate the bond order (BO) for each species. $BO = 1/2 (\text{Number of bonding } e^- - \text{Number of antibonding } e^-)$.

N_2 (14 electrons): $BO = 1/2 (10 - 4) = 3.0$

N_2^+ (13 electrons): An electron is removed from a bonding orbital. $BO = 1/2 (9 - 4) = 2.5$

N_2^- (15 electrons): An electron is added to an antibonding orbital. $BO = 1/2 (10 - 5) = 2.5$

N_2^{2-} (16 electrons): Two electrons are added to antibonding orbitals. $BO = 1/2 (10 - 6) = 2.0$

The order of increasing bond order is: $N_2^{2-} < N_2^- \approx N_2^+ < N_2$.

Since bond length is inversely proportional to bond order, the order of increasing bond length should be the reverse: $N_2 < N_2^+ \approx N_2^- < N_2^{2-}$.

None of the provided options correctly represent the increasing bond length order. However, option (B) lists the species in the correct order of increasing bond order: N_2^{2-} , then N_2^- and N_2^+ , and finally N_2 . It is highly likely that the question intended to ask for increasing bond order, or that the inequality symbols in the option are incorrect. Assuming the sequence of species is the intended answer key, it corresponds to increasing bond order.

Quick Tip

For diatomic species of period 2 elements, remember the inverse relationship: Higher Bond Order = Shorter Bond Length = Higher Bond Energy. Always calculate the bond order first to compare these properties. Be cautious of exam questions with potential typos in options.

119. The maximum magnetic moment is shown by the ion with electronic configuration

(A) $3d^8$

(B) $3d^7$

(C) $3d^6$

(D) $3d^5$

Correct Answer: (D) $3d^5$

Solution:

The spin-only magnetic moment (μ) of an ion is calculated using the formula $\mu = \sqrt{n(n+2)}$ Bohr Magnetons (B.M.), where 'n' is the number of unpaired electrons.

The magnetic moment increases as the number of unpaired electrons increases. Therefore, to find the maximum magnetic moment, we need to find the configuration with the maximum

number of unpaired electrons.

The d-subshell has 5 orbitals. We fill them according to Hund's rule (fill singly first, then pair up).

$3d^8$: Here, $n = 2$.

$3d^7$: Here, $n = 3$.

$3d^6$: Here, $n = 4$.

$3d^5$: Here, $n = 5$.

The $3d^5$ configuration has the maximum number of unpaired electrons ($n=5$).

Therefore, the ion with the $3d^5$ configuration will exhibit the maximum magnetic moment.

Quick Tip

For d-electrons, the maximum number of unpaired electrons is 5, which occurs in a d^5 configuration. This will always correspond to the highest spin-only magnetic moment.

120. In XeF_2 the hybridization of Xe is

(A) sp^3

(B) sp^3d

(C) sp^3d^2

(D) sp^3d^3

Correct Answer: (B) sp^3d

Solution:

To determine the hybridization of the central atom (Xenon, Xe), we can find its steric number.

Steric Number = (Number of lone pairs on central atom) + (Number of atoms bonded to central atom).

1. First, find the total number of valence electrons:

Xe (a noble gas) has 8 valence electrons.

Each F atom has 7 valence electrons, so 2 F atoms have $2 \times 7 = 14$ valence electrons.

Total valence electrons = $8 + 14 = 22$.

2. Draw the Lewis structure. Xe is the central atom bonded to two F atoms. This uses 2 pairs (4 electrons).

FXeF

3. Distribute the remaining electrons as lone pairs. We have $22 - 4 = 18$ electrons left.

First, complete the octets of the terminal atoms (F). Each F needs 6 more electrons (3 lone pairs). This uses $2 \times 6 = 12$ electrons.

Remaining electrons = $18 - 12 = 6$.

These 6 electrons go on the central Xe atom as 3 lone pairs.

4. The central Xe atom is bonded to 2 F atoms and has 3 lone pairs.

Steric Number = 2 (bonded atoms) + 3 (lone pairs) = 5.

A steric number of 5 corresponds to sp^3d hybridization. The electron geometry is trigonal bipyramidal, and the molecular shape is linear.

Quick Tip

A quick formula for the steric number (SN) is: $SN = 1/2 (\text{Valence } e^- \text{ of central atom} + \text{No. of monovalent atoms attached} + \text{Cationic charge} - \text{Anionic charge})$. For XeF_2 , $SN = 1/2 (8 + 2) = 5$. A steric number of 5 always implies sp^3d hybridization.

121. The molecule having 3-centre-2-electron bond is

- (A) Diborane
- (B) Borazole
- (C) Boron trichloride
- (D) Boron trifluoride

Correct Answer: (A) Diborane

Solution:

The concept of a 3-centre-2-electron (3c-2e) bond is used to describe bonding in electron-deficient molecules.

Let's examine the structure of the options:

(A) Diborane (B_2H_6) is the classic example of an electron-deficient molecule. It has two boron atoms and six hydrogen atoms, but only 12 valence electrons, not enough to form the 7 bonds needed for a simple ethane-like structure. Its structure contains four terminal B-H bonds (which are normal 2c-2e bonds) and two bridging B-H-B bonds. Each of these bridging bonds is a 3-centre-2-electron bond, often called a 'banana bond'.

(B) Borazole ($B_3N_3H_6$), or inorganic benzene, has a cyclic structure with alternating B and N atoms, with normal 2c-2e bonds and delocalized π electrons.

(C) Boron trichloride (BCl_3) and (D) Boron trifluoride (BF_3) are trigonal planar molecules with standard 2c-2e B-Cl and B-F bonds, respectively.

Therefore, diborane is the molecule with 3c-2e bonds.

Quick Tip

3-center-2-electron bonds are a hallmark of boron hydrides (boranes). When you see a question about this type of bonding, diborane (B_2H_6) should be the first compound that comes to mind.

122. The primary and secondary valencies of Ag in $[Ag(NH_3)_2]Cl$ are

- (A) 0,3
- (B) 2,1
- (C) 1,3
- (D) 1,2

Correct Answer: (D) 1,2

Solution:

According to Werner's theory of coordination compounds:

1. Primary valency corresponds to the oxidation state of the central metal ion.
2. Secondary valency corresponds to the coordination number of the central metal ion.

The given complex is $[Ag(NH_3)_2]Cl$. It ionizes to give the complex cation $[Ag(NH_3)_2]^+$ and the chloride anion Cl^- .

To find the primary valency (oxidation state of Ag):

Let the oxidation state of Ag be x . Ammonia (NH_3) is a neutral ligand, so its charge is 0.

The overall charge on the complex ion is +1.

So, $x + 2(0) = +1$, which gives $x = +1$.

Therefore, the primary valency is 1.

To find the secondary valency (coordination number):

The coordination number is the number of ligand donor atoms directly attached to the central metal ion.

In $[Ag(NH_3)_2]^+$, the central Ag^+ ion is bonded to two ammonia ligands.

Therefore, the coordination number is 2. The secondary valency is 2.

The primary and secondary valencies are 1 and 2, respectively.

Quick Tip

Remember: Primary Valency = Oxidation State (ionizable, satisfied by anions). Secondary Valency = Coordination Number (non-ionizable, satisfied by ligands).

123. The hybridization in Ni forming $Ni(CO)_4$ is

- (A) sp^3

- (B) dsp^2
(C) dsp^3
(D) d^2sp^3

Correct Answer: (A) sp^3

Solution:

In nickel tetracarbonyl, $\text{Ni}(\text{CO})_4$, the oxidation state of Nickel (Ni) is 0, as carbonyl (CO) is a neutral ligand.

The atomic number of Ni is 28, and its ground state electronic configuration is $[\text{Ar}] 3\text{d}^8 4\text{s}^2$.

CO is a very strong field ligand. In its presence, the two electrons from the 4s orbital are forced to pair up with the electrons in the 3d orbitals.

The electronic configuration of Ni in the complex becomes $[\text{Ar}] 3\text{d}^{10} 4\text{s}^0$.

The 3d orbitals are completely filled: $[\uparrow\downarrow] [\uparrow\downarrow] [\uparrow\downarrow] [\uparrow\downarrow] [\uparrow\downarrow]$.

For bonding with four CO ligands, the Ni atom must provide four empty hybrid orbitals. It uses its one vacant 4s orbital and three vacant 4p orbitals.

These orbitals hybridize to form four equivalent sp^3 hybrid orbitals.

These sp^3 orbitals overlap with the orbitals of the four CO ligands, forming a tetrahedral complex.

Therefore, the hybridization is sp^3 .

Quick Tip

For carbonyl complexes of metals in zero oxidation state, strong-field CO ligands often cause pairing and shifting of valence s-electrons into the d-orbitals, leaving the s-orbital empty for hybridization.

124. The oxidation state of Fe in Haemoglobin is

- (A) +2
(B) +3
(C) +4
(D) 0

Correct Answer: (A) +2

Solution:

Haemoglobin is the protein in red blood cells that transports oxygen from the lungs to the rest of the body.

Its function depends on the heme group, which is a porphyrin ring with an iron ion at its center.

For haemoglobin to be able to bind and transport molecular oxygen, the iron ion must be in the ferrous oxidation state, which is Fe^{2+} or +2.

When haemoglobin is oxygenated, it is called oxyhaemoglobin. Even in this state, the iron remains as Fe^{2+} .

If the iron gets oxidized to the ferric state (Fe^{3+} or +3), the molecule is called methemoglobin, and it is incapable of binding oxygen.

Therefore, the functional oxidation state of Fe in haemoglobin is +2.

Quick Tip

Remember the functional states of iron in biological systems: Haemoglobin (oxygen transport) has Fe^{2+} . Methemoglobin (non-functional) has Fe^{3+} .

125. The structure of Sulphate ion is (SO_4^{2-}) ion is

- (A) Linear
- (B) Tetrahedral
- (C) Square planar
- (D) Trigonal bipyramidal

Correct Answer: (B) Tetrahedral

Solution:

We can determine the structure of the sulphate ion, SO_4^{2-} , using the VSEPR theory.

1. The central atom is Sulfur (S).
2. The number of valence electrons for Sulfur (Group 16) is 6.
3. The number of valence electrons for four Oxygen atoms (Group 16) is $4 \times 6 = 24$.
4. The ion has a charge of -2, so we add 2 electrons.
5. Total valence electrons = $6 + 24 + 2 = 32$ electrons.
6. In the Lewis structure, the S atom is bonded to four O atoms. This accounts for 4 sigma bonds.
7. The steric number of the central S atom is the number of sigma bonds + number of lone pairs. In SO_4^{2-} , the sulfur atom has 4 sigma bonds and 0 lone pairs.
8. Steric Number = 4.

According to VSEPR theory, a steric number of 4 with zero lone pairs corresponds to a tetrahedral electron geometry and a tetrahedral molecular shape.

The four oxygen atoms are arranged symmetrically around the central sulfur atom at the corners of a tetrahedron.

Quick Tip

A quick method for predicting geometry is using the steric number. For a central atom A in a molecule AX_nE_m , the steric number is $n + m$. SN=2 (Linear), SN=3 (Trigonal Planar), SN=4 (Tetrahedral), SN=5 (Trigonal Bipyramidal), SN=6 (Octahedral).

126. Effective Atomic Number (EAN) of Fe in $K_4[Fe(CN)_6]$ is

- (A) 33
- (B) 34
- (C) 35
- (D) 36

Correct Answer: (D) 36

Solution:

The Effective Atomic Number (EAN) is calculated using the formula:

$$EAN = Z - OS + (2 \times CN)$$

where:

Z = Atomic number of the central metal atom.

OS = Oxidation state of the central metal atom.

CN = Coordination number of the central metal atom.

1. Identify the components for $K_4[Fe(CN)_6]$:

The central metal is Iron (Fe). The atomic number (Z) of Fe is 26.

2. Calculate the oxidation state (OS) of Fe:

The complex ion is $[Fe(CN)_6]^{4-}$. The charge of a cyanide ligand (CN) is -1.

Let the oxidation state of Fe be x.

$$x + 6(-1) = -4$$

$$x - 6 = -4$$

$$x = +2. \text{ So, OS} = 2.$$

3. Determine the coordination number (CN):

There are six cyanide ligands bonded to the Fe atom. So, CN = 6.

4. Calculate the EAN:

$$EAN = 26 - 2 + (2 \times 6)$$

$$EAN = 24 + 12$$

$$EAN = 36.$$

This number is the atomic number of the next noble gas, Krypton (Kr), which suggests the complex is stable according to the EAN rule.

Quick Tip

The EAN rule suggests that stable coordination complexes are often formed when the central metal atom's effective atomic number is equal to the atomic number of the next noble gas. This is a useful guideline for predicting stability.

127. In EDTA titrations the indicator employed is

- (A) Erichrome block-T
- (B) Metal ion indicator
- (C) Methylorange
- (D) Phenol Red

Correct Answer: (A) Erichrome block-T

Solution:

EDTA titrations are a type of complexometric titration used to determine the concentration of metal ions in a solution.

These titrations require a special type of indicator known as a metallochromic indicator.

A metallochromic indicator is a substance that forms a colored complex with metal ions and has a different color in its free (uncomplexed) state.

Eriochrome Black T (EBT) is a very common metallochromic indicator used for titrating metal ions like Mg^{2+} , Ca^{2+} , and Zn^{2+} with EDTA.

At the endpoint, the EDTA has complexed all the free metal ions, and it then removes the metal ion from the indicator-metal complex. This causes the indicator to revert to its free form, resulting in a sharp color change.

While "Metal ion indicator" is the general class, Eriochrome Black-T is the specific indicator listed. Methylorange and Phenol Red are acid-base indicators.

Quick Tip

In EDTA titrations, the indicator must bind to the metal ion less strongly than EDTA does. This ensures that at the endpoint, EDTA can "snatch" the metal from the indicator, causing the color change.

128. B_2H_6 with excess NH_3 at higher temperature gives

- (A) $(\text{BN})_x$
- (B) $\text{B}_3\text{N}_3\text{H}_6$
- (C) $\text{B}_3\text{H}_6\text{NH}_3$

(D) $B_2H_6 \cdot 2NH_3$

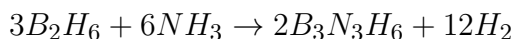
Correct Answer: (B) $B_3N_3H_6$

Solution:

The reaction between diborane (B_2H_6) and ammonia (NH_3) yields different products depending on the reaction conditions (temperature, stoichiometry).

When diborane is reacted with ammonia in a 1:2 molar ratio at a "higher temperature" (around 200 °C), the main product is borazine.

The overall reaction is:



The product $B_3N_3H_6$ is borazine, also known as "inorganic benzene" due to its structural similarity to benzene.

Option (A), $(BN)_x$ or boron nitride, is formed at very high temperatures (above 1000 °C).

Option (D), $B_2H_6 \cdot 2NH_3$, is an adduct formed at low temperatures.

Given the options, borazine is the most appropriate product for reaction at "higher" (but not extreme) temperatures.

Quick Tip

Remember the products of the diborane-ammonia reaction at different temperatures:
Low temp: Adduct $B_2H_6 \cdot 2NH_3$. High temp (200°C): Borazine $B_3N_3H_6$. Very high temp (>1000°C): Boron Nitride $(BN)_x$.

129. Which one of the following is a f block element

(A) Rh

(B) Eu

(C) Cu

(D) Hg

Correct Answer: (B) Eu

Solution:

The periodic table is divided into blocks (s, p, d, f) based on which subshell the last electron enters.

The f-block elements are those in which the last electron enters an f-orbital. These elements comprise two series: the Lanthanides (4f series) and the Actinides (5f series).

Let's check the given elements:

- (A) Rhodium (Rh) is in Group 9, Period 5. It is a d-block element (transition metal).
- (B) Europium (Eu) has atomic number 63. It is part of the Lanthanide series. Its outermost electrons are in the 4f subshell. It is an f-block element.
- (C) Copper (Cu) is in Group 11, Period 4. It is a d-block element (transition metal).
- (D) Mercury (Hg) is in Group 12, Period 6. It is a d-block element (transition metal).

Therefore, Europium (Eu) is the f-block element.

Quick Tip

Familiarize yourself with the general layout of the periodic table. The f-block elements are the two rows usually placed at the bottom, separate from the main body of the table. The first row are the Lanthanides, and the second are the Actinides.

130. The isomerism shown by the pair of compounds $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]\text{Br}_2$ and $[\text{Pt}(\text{NH}_3)_4\text{Br}_2]\text{Cl}_2$ is

- (A) Linkage isomerism
- (B) Ionisation isomers
- (C) Coordination isomerism
- (D) Geometrical isomers

Correct Answer: (B) Ionisation isomers

Solution:

Isomers are compounds that have the same overall molecular formula but different arrangements of atoms.

Let's analyze the two given compounds:

Compound 1: $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]\text{Br}_2$. When dissolved in water, this will furnish $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]^{2+}$ and Br^- ions.

Compound 2: $[\text{Pt}(\text{NH}_3)_4\text{Br}_2]\text{Cl}_2$. When dissolved in water, this will furnish $[\text{Pt}(\text{NH}_3)_4\text{Br}_2]^{2+}$ and Cl^- ions.

Both compounds have the same overall formula $(\text{Pt}(\text{NH}_3)_4\text{Cl}_2\text{Br}_2)$.

They differ in the identity of the ions inside and outside the coordination sphere. There is an exchange between a ligand (Cl^- or Br^-) and a counter-ion (Br^- or Cl^-).

This type of isomerism, where compounds with the same formula produce different ions in solution due to the exchange of a ligand with a counter-ion, is called ionization isomerism.

Linkage isomerism involves an ambidentate ligand bonding through different atoms. Coordination isomerism involves the exchange of ligands between a cationic and an anionic complex. Geometrical isomerism involves different spatial arrangements of ligands around the central atom (cis/trans).

Quick Tip

Ionization isomers can be distinguished by simple chemical tests. For example, adding AgNO_3 solution to $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]\text{Br}_2$ would give a precipitate of AgBr , while adding it to $[\text{Pt}(\text{NH}_3)_4\text{Br}_2]\text{Cl}_2$ would give a precipitate of AgCl .

131. Of the following ions, which one has the highest magnetic moment?

- (A) Mn^{2+}
- (B) Co^{2+}
- (C) Cu^{2+}
- (D) Cu^+

Correct Answer: (A) Mn^{2+}

Solution:

The spin-only magnetic moment (μ) is determined by the number of unpaired electrons (n) using the formula $\mu = \sqrt{n(n+2)}$ B.M. The ion with the most unpaired electrons will have the highest magnetic moment.

Let's find the number of unpaired electrons for each ion:

Mn ($Z=25$): $[\text{Ar}] 3d^5 4s^2$. For Mn^{2+} , the configuration is $[\text{Ar}] 3d^5$. The 5 d-electrons are all unpaired in separate orbitals. So, $n = 5$.

Co ($Z=27$): $[\text{Ar}] 3d^7 4s^2$. For Co^{2+} , the configuration is $[\text{Ar}] 3d^7$. Filling the d-orbitals gives 3 unpaired electrons. So, $n = 3$.

Cu ($Z=29$): $[\text{Ar}] 3d^{10} 4s^1$. For Cu^{2+} , the configuration is $[\text{Ar}] 3d^9$. This gives 1 unpaired electron. So, $n = 1$.

Cu ($Z=29$): $[\text{Ar}] 3d^{10} 4s^1$. For Cu^+ , the configuration is $[\text{Ar}] 3d^{10}$. All d-orbitals are filled, so there are no unpaired electrons. So, $n = 0$.

Since Mn^{2+} has the highest number of unpaired electrons ($n=5$), it will have the highest magnetic moment.

Quick Tip

Magnetic moment is directly related to the number of unpaired electrons. For d-block elements, the maximum number of unpaired electrons is 5, which occurs at the d^5 configuration. This will always correspond to the highest spin-only magnetic moment.

132. The monomer used in the manufacture of PVC is

- (A) Ethylene

- (B) Acrylonitrile
- (C) Vinylchloride
- (D) Acrylicacid

Correct Answer: (C) Vinylchloride

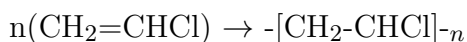
Solution:

PVC stands for Polyvinyl Chloride.

The name itself indicates the monomer unit. "Poly-" means many, so the polymer is made from many units of "vinyl chloride".

Vinyl chloride has the chemical formula $\text{CH}_2=\text{CHCl}$.

It undergoes addition polymerization, where the double bond breaks and the monomers link together to form the long polymer chain of PVC.



Therefore, the monomer used is vinyl chloride.

Quick Tip

The names of many common addition polymers directly reveal their monomer. For example, Polystyrene is made from styrene, Polypropylene from propylene, and Polyethylene from ethylene.

133. The gas released when chloride salt treated with solid $\text{K}_2\text{Cr}_2\text{O}_7$ and Conc. H_2SO_4

- (A) CrOCl_2
- (B) CrO_2Cl_2
- (C) CrOCl_4
- (D) CrO_3Cl_3

Correct Answer: (B) CrO_2Cl_2

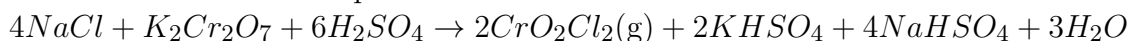
Solution:

This reaction is the basis for the chromyl chloride test, which is a confirmatory test for the presence of chloride ions (Cl^-).

When a solid chloride salt is heated with solid potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) and concentrated sulfuric acid (H_2SO_4), a reddish-brown gas is evolved.

This gas is chromyl chloride, which has the chemical formula CrO_2Cl_2 .

The balanced chemical equation for the reaction is:



Therefore, the gas released is CrO_2Cl_2 .

Quick Tip

The chromyl chloride test is a very specific and important qualitative analysis test for the chloride ion. Remember the product (chromyl chloride) and its characteristic reddish-brown color. This test is not given by chlorides of mercury, silver, lead, and tin.

134. The number of unpaired electrons in the complex ion $[\text{CoF}_6]^{3-}$ are

- (A) 3
- (B) 0
- (C) 4
- (D) 2

Correct Answer: (C) 4

Solution:

1. Find the oxidation state of Cobalt (Co):

Let the oxidation state of Co be x . The fluoride ligand (F^-) has a charge of -1. The overall charge of the complex is -3.

$$x + 6(-1) = -3 \Rightarrow x6 = -3 \Rightarrow x = +3.$$

So, we have Co^{3+} .

2. Determine the d-electron configuration of Co^{3+} :

The atomic number of Co is 27. Its ground state configuration is $[\text{Ar}] 3\text{d}^7 4\text{s}^2$.

For Co^{3+} , we remove three electrons (two from 4s, one from 3d), giving the configuration $[\text{Ar}] 3\text{d}^6$.

3. Apply Crystal Field Theory:

The complex has an octahedral geometry (6 ligands). The fluoride ion (F^-) is a weak field ligand.

For a weak field ligand, the crystal field splitting energy is small, so electrons will fill the d-orbitals (t_{2g} and e_g) singly before pairing up (Hund's rule).

4. Fill the orbitals for a d^6 configuration in a weak octahedral field:

The first three electrons go into the t_{2g} orbitals singly.

The next two electrons go into the e_g orbitals singly.

The sixth electron pairs up with one in the t_{2g} orbitals.

The configuration is $t_{2g}^4 e_g^2$.

t_{2g} :

The number of unpaired electrons is 4.

Quick Tip

For octahedral complexes, remember the spectrochemical series to identify ligand strength. Halides (like F^- , Cl^- , Br^- , I^-) are generally weak field ligands, leading to high-spin complexes where electrons occupy higher energy orbitals before pairing up.

135. The Joule Thomson coefficient is zero at

- (A) Critical Temperature
- (B) Inversion Temperature
- (C) Absolute Temperature
- (D) Below 0°C

Correct Answer: (B) Inversion Temperature

Solution:

The Joule-Thomson effect describes the change in temperature of a real gas when it expands at constant enthalpy (isenthalpic expansion), for example, through a porous plug or valve.

The Joule-Thomson coefficient (μ_{JT}) is defined as the change in temperature with respect to pressure at constant enthalpy: $\mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_H$.

If $\mu_{JT} > 0$, the gas cools upon expansion (∂P is negative, so ∂T must be negative).

If $\mu_{JT} < 0$, the gas heats upon expansion.

The specific temperature at which the Joule-Thomson coefficient changes its sign is called the inversion temperature. At the inversion temperature, $\mu_{JT} = 0$, and there is no temperature change upon expansion.

Quick Tip

The inversion temperature is a crucial concept for gas liquefaction. To cool a gas using Joule-Thomson expansion (the principle of most refrigerators), the gas must initially be below its inversion temperature.

136. The Law which related the solubility of a gas with pressure is known as

- (A) Raoult's law
- (B) Henry's law
- (C) Boyle's law
- (D) Newton's law

Correct Answer: (B) Henry's law

Solution:

Henry's law is a gas law that deals with the solubility of gases in liquids.

It states that at a constant temperature, the solubility of a gas in a liquid is directly proportional to the partial pressure of the gas above the liquid.

Mathematically, it can be expressed as $P = K_H \cdot C$, where P is the partial pressure of the gas, C is the concentration of the dissolved gas, and K_H is the Henry's law constant.

Raoult's law relates the vapor pressure of a solution to the mole fraction of the solvent. Boyle's law relates the pressure and volume of a gas. Newton's laws are related to motion.

Quick Tip

A common application of Henry's Law is carbonated beverages. The high pressure of CO_2 in a sealed bottle keeps a large amount of gas dissolved. When the bottle is opened, the pressure decreases, and the gas comes out of solution, creating fizz.

137. The PH of 10^{-8} M HCl solution is

- (A) 7
- (B) 17
- (C) 17
- (D) 0

Correct Answer: (B) 17

Solution:

HCl is a strong acid, so it completely dissociates in water. A naive calculation would be $\text{pH} = -\log[\text{H}^+] = -\log(10^{-8}) = 8$.

However, a pH of 8 indicates a basic solution, which is impossible for a solution of a strong acid, regardless of how dilute it is.

In very dilute solutions of acids, we must also consider the contribution of H^+ ions from the autoionization of water: $\text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^-$.

At 25°C , the concentration of H^+ from water is 10^{-7} M.

The total concentration of H^+ ions in the solution is the sum of H^+ from HCl and H^+ from water.

$$[\text{H}^+]_{\text{total}} = [\text{H}^+]_{\text{HCl}} + [\text{H}^+]_{\text{H}_2\text{O}}$$

$[\text{H}^+]_{\text{total}} = 10^{-8} \text{ M} + (\text{concentration from water, which is slightly suppressed but still present}).$

The total concentration will be slightly greater than 10^{-7} M (since we are adding 10^{-8} M to a concentration close to 10^{-7} M).

Since $\text{pH} = -\log[\text{H}^+]$, and $[\text{H}^+]_{\text{total}} > 10^{-7}$ M, the pH must be slightly less than 7.

The exact pH is approximately 6.98.

Quick Tip

For very dilute solutions of strong acids (concentration $\leq 10^{-7}$ M) or strong bases, always remember to account for the autoionization of water. The pH of a dilute acid will always be just below 7, and the pH of a dilute base will always be just above 7.

138. The standard electrode potential of Zn/Zn^{2+} and Cu/Cu^{2+} are -0.763 V and 0.337V respectively. The standard EMF of the cell is

- (A) 0.426 V
- (B) 0 V
- (C) -1.10 V
- (D) 1.10 V

Correct Answer: (D) 1.10 V

Solution:

The standard EMF of an electrochemical cell (E_{cell}^o) is calculated using the formula:

$$E_{\text{cell}}^o = E_{\text{cathode}}^o - E_{\text{anode}}^o$$

where the potentials are standard reduction potentials.

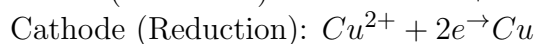
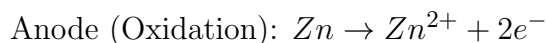
The anode is where oxidation occurs, and the cathode is where reduction occurs. The species with the lower reduction potential will be oxidized (anode), and the one with the higher reduction potential will be reduced (cathode).

Given potentials:

$$E^o(\text{Zn}^{2+}/\text{Zn}) = -0.763 \text{ V (Lower potential} \rightarrow \text{Anode)}$$

$$E^o(\text{Cu}^{2+}/\text{Cu}) = +0.337 \text{ V (Higher potential} \rightarrow \text{Cathode)}$$

Cell reactions:



Now, calculate the standard EMF:

$$E_{\text{cell}}^o = E_{\text{cathode}}^o - E_{\text{anode}}^o$$

$$E_{\text{cell}}^o = (+0.337) - (-0.763)$$

$$E_{\text{cell}}^o = 0.337 + 0.763 = 1.100 \text{ V}$$

Quick Tip

A simple rule for standard cell potential is $E_{cell}^o = E_{reduction}^o(\text{higher value}) - E_{reduction}^o(\text{lower value})$. The result will always be positive for a spontaneous (voltaic) cell.

139. The osmotic pressure of the equi-molar solutions of $C_6H_{12}O_6$, $NaCl$ and $BaCl_2$ will be in the order

- (A) $C_6H_{12}O_6$ $\angle$ $NaCl$ $\angle$ $BaCl_2$
- (B) $NaCl$ $\angle$ $BaCl_2$ $\angle$ $C_6H_{12}O_6$
- (C) $BaCl_2$ $\angle$ $NaCl$ $\angle$ $C_6H_{12}O_6$
- (D) $C_6H_{12}O_6$ $\angle$ $BaCl_2$ $\angle$ $NaCl$

Correct Answer: (C) $BaCl_2$ $\angle$ $NaCl$ $\angle$ $C_6H_{12}O_6$

Solution:

Osmotic pressure (Π) is a colligative property, which depends on the number of solute particles in a solution. The formula is $\Pi = i \cdot M \cdot R \cdot T$.

For equi-molar solutions, the molarity (M), gas constant (R), and temperature (T) are the same. Therefore, the osmotic pressure will be directly proportional to the van't Hoff factor (i).

The van't Hoff factor (i) represents the number of particles a solute dissociates into in solution.

$C_6H_{12}O_6$ (glucose): It is a non-electrolyte and does not dissociate. So, $i = 1$.

$NaCl$ (sodium chloride): It is a strong electrolyte and dissociates into two ions: $NaCl \rightarrow Na^+ + Cl^-$. So, $i = 2$.

$BaCl_2$ (barium chloride): It is a strong electrolyte and dissociates into three ions: $BaCl_2 \rightarrow Ba^{2+} + 2Cl^-$. So, $i = 3$.

The order of the van't Hoff factor is: $BaCl_2$ ($i=3$) $\angle$ $NaCl$ ($i=2$) $\angle$ $C_6H_{12}O_6$ ($i=1$).

Since osmotic pressure is proportional to 'i', the order of osmotic pressure will be the same:

$$\Pi_{BaCl_2} > \Pi_{NaCl} > \Pi_{C_6H_{12}O_6}$$

Quick Tip

For colligative properties (like boiling point elevation, freezing point depression, and osmotic pressure), always consider the van't Hoff factor 'i' for electrolytes. The property's magnitude is proportional to the total concentration of particles ($i \times M$).

140. A colloidal system in which liquid dispersed in solid is

- (A) Emulsion

- (B) Sol
- (C) Gel
- (D) Foam

Correct Answer: (C) Gel

Solution:

Colloidal systems are classified based on the physical state of the dispersed phase and the dispersion medium.

Dispersed phase: The substance that is distributed as colloidal particles. Dispersion medium: The substance in which the colloidal particles are distributed.

The question asks for a system with:

Dispersed phase = Liquid

Dispersion medium = Solid

This type of colloid is called a Gel. Examples include cheese, butter, jellies, and boot polish.

Let's review the other options:

(A) Emulsion: Liquid dispersed in a liquid (e.g., milk, mayonnaise).

(B) Sol: Solid dispersed in a liquid (e.g., paint, cell fluids).

(D) Foam: Gas dispersed in a liquid (e.g., whipped cream, soap lather).

Quick Tip

Memorize the table of colloid types. A helpful way to remember "Gel" is to think of gelatin, where a liquid (water) is trapped within a solid network (protein).

141. The units of first order rate constant are

- (A) Mint^{-1}
- (B) $\text{Mol lit}^{-1} \text{ sec}^{-1}$
- (C) Sec^{-1}
- (D) Mint^{-1} & Sec^{-1}

Correct Answer: (C) Sec^{-1}

Solution:

The general rate law for an n-th order reaction is: $\text{Rate} = k[\text{A}]^n$.

The units of Rate are always concentration per time (e.g., $\text{Mol L}^{-1} \text{ s}^{-1}$).

The units of concentration [A] are Mol L^{-1} .

For a first-order reaction, $n=1$. So, $\text{Rate} = k[\text{A}]^1$.

We can find the units of the rate constant k by rearranging the equation:

$$k = \frac{\text{Rate}}{[A]}$$

Substituting the units:

$$\text{Units of } k = \frac{\text{Mol L}^{-1}\text{s}^{-1}}{\text{Mol L}^{-1}}$$

The concentration units (Mol L^{-1}) cancel out, leaving:

Units of $k = \text{s}^{-1}$ (or inverse time, e.g., min^{-1} , hr^{-1}).

Option (C), Sec^{-1} , is the standard unit for a first-order rate constant.

Quick Tip

A quick way to remember the units of the rate constant (k) for any order (n) is the formula: $(\text{Concentration})^{1-n} (\text{Time})^{-1}$. For $n=1$, this becomes $(\text{Conc})^0 (\text{Time})^{-1} = \text{Time}^{-1}$.

142. In a reaction $t_{1/2}$ was inversely proportional to initial concentration of reactant. The order of reaction is

- (A) Zero
- (B) First
- (C) Second
- (D) Third

Correct Answer: (C) Second

Solution:

The relationship between the half-life ($t_{1/2}$) of a reaction and the initial concentration of the reactant ($[A]_0$) is given by the general formula:

$$t_{1/2} \propto \frac{1}{[A]_0^{n-1}}$$

where 'n' is the order of the reaction.

The problem states that $t_{1/2}$ is inversely proportional to the initial concentration. This can be written as:

$$t_{1/2} \propto \frac{1}{[A]_0^1}$$

Comparing this with the general formula, we can equate the exponents:

$$n - 1 = 1$$

$$n = 2$$

Therefore, the reaction is of the second order.

Let's check for other orders:

For zero order ($n=0$), $t_{1/2} \propto [A]_0$.

For first order ($n=1$), $t_{1/2}$ is independent of $[A]_0$.

For second order ($n=2$), $t_{1/2} \propto 1/[A]_0$.

For third order ($n=3$), $t_{1/2} \propto 1/[A]_0^2$.

Quick Tip

Memorize the half-life dependencies for different reaction orders: 0th order: $t_{1/2} \propto [A]_0$ (directly proportional) 1st order: $t_{1/2}$ is constant (independent) 2nd order: $t_{1/2} \propto 1/[A]_0$ (inversely proportional)

143. Calculate the crystal field stabilization energy (CFSE) for the complex, $[\text{Rh}(\text{CN})_6]^{3-}$, where $\Delta_o \neq P$.

(A) $0.4\Delta_o + P$

(B) $2.4\Delta_o + 3P$

(C) $-2.4\Delta_o + 3P$

(D) $-0.4\Delta_o + P$

Correct Answer: (C) $-2.4\Delta_o + 3P$

Solution:

1. Oxidation state of Rhodium (Rh):

Rh is in group 9. Let its oxidation state be x . Cyanide (CN^-) has a -1 charge. The complex has a -3 charge.

$x + 6(-1) = -3 \Rightarrow x = +3$. So, we have Rh^{3+} .

2. d-electron configuration of Rh^{3+} :

Rh ($Z=45$) is $[\text{Kr}] 4d^8 5s^1$. For Rh^{3+} , the configuration is $[\text{Kr}] 4d^6$.

3. Ligand field strength and pairing:

CN^- is a strong field ligand. The problem also states that $\Delta_o > P$ (crystal field splitting energy is greater than pairing energy), which confirms that this will be a low-spin complex.

In a low-spin octahedral complex, electrons will fill the lower energy t_{2g} orbitals completely before occupying the higher energy e_g orbitals.

4. Filling the d-orbitals for a d^6 low-spin case:

All six electrons will pair up in the three t_{2g} orbitals.

The configuration is $t_{2g}^6 e_g^0$.

5. Calculate CFSE:

The formula for CFSE in an octahedral complex is:

$\text{CFSE} = (\text{No. of } e^- \text{ in } t_{2g}) \times (-0.4\Delta_o) + (\text{No. of } e^- \text{ in } e_g) \times (+0.6\Delta_o) + (\text{No. of new electron pairs}) \times P$

$\text{CFSE} = (6 \times -0.4\Delta_o) + (0 \times +0.6\Delta_o) + 3P$

$\text{CFSE} = -2.4\Delta_o + 3P$. (There are 3 pairs formed due to the ligand field).

Quick Tip

For calculating CFSE, remember the energy levels: each electron in a t_{2g} orbital stabilizes the complex by $-0.4\Delta_o$, and each electron in an e_g orbital destabilizes it by $+0.6\Delta_o$. For low-spin complexes, you must also add the energy cost of pairing the electrons (P).

144. The material used in solar cells contains

- (A) Cs
- (B) Si
- (C) Sn
- (D) Ti

Correct Answer: (B) Si

Solution:

Solar cells, also known as photovoltaic (PV) cells, convert sunlight directly into electricity.

The vast majority of commercially available solar cells are based on the semiconductor material Silicon (Si).

Silicon is used because it is an abundant, stable, and well-understood material. It has a suitable band gap for absorbing a large portion of the solar spectrum.

The silicon used is typically in crystalline form (monocrystalline or polycrystalline) and is doped to create a p-n junction, which is essential for the photovoltaic effect.

Cesium (Cs) is used in photoelectric cells (photoemissive cells), which is a different technology. Tin (Sn) and Titanium (Ti) are not the primary materials used for the active layer in standard solar cells.

Quick Tip

When you think of solar cells and the modern electronics industry, think of Silicon (Si). It is the workhorse material for semiconductors, used in computer chips, transistors, and photovoltaic cells.

145. The relative lowering of vapour pressure of a solution of non-volatile substance is equal to

- (A) Mole fraction of solvent
- (B) Mole fraction of solute
- (C) Weight percent of solute
- (D) Weight percent of solvent

Correct Answer: (B) Mole fraction of solute

Solution:

This question refers to Raoult's Law for solutions containing a non-volatile solute.

Raoult's Law states that the vapor pressure of a solution (P_{solution}) is equal to the mole fraction of the solvent (χ_{solvent}) multiplied by the vapor pressure of the pure solvent (P_{solvent}^o).

$$P_{\text{solution}} = \chi_{\text{solvent}} \cdot P_{\text{solvent}}^o$$

The lowering of vapor pressure is $\Delta P = P_{\text{solvent}}^o - P_{\text{solution}}$.

The relative lowering of vapor pressure is $\frac{\Delta P}{P_{\text{solvent}}^o}$.

Let's derive the expression:

$$\frac{\Delta P}{P_{\text{solvent}}^o} = \frac{P_{\text{solvent}}^o - P_{\text{solution}}}{P_{\text{solvent}}^o} = 1 - \frac{P_{\text{solution}}}{P_{\text{solvent}}^o}$$

Substituting Raoult's Law:

$$\frac{\Delta P}{P_{\text{solvent}}^o} = 1 - \frac{\chi_{\text{solvent}} \cdot P_{\text{solvent}}^o}{P_{\text{solvent}}^o} = 1 - \chi_{\text{solvent}}$$

For a two-component solution (solute and solvent), the sum of mole fractions is 1: $\chi_{\text{solute}} + \chi_{\text{solvent}} = 1$.

Therefore, $1 - \chi_{\text{solvent}} = \chi_{\text{solute}}$.

So, the relative lowering of vapor pressure is equal to the mole fraction of the solute.

Quick Tip

Do not confuse Raoult's law itself ($P_{\text{solution}} = \chi_{\text{solvent}} P_{\text{solvent}}^o$) with its consequence for colligative properties. The relative lowering of vapor pressure, a colligative property, is directly equal to the mole fraction of the solute.

146. When a gas reaction involves a decrease in the total number of moles, the equilibrium can be shifted in the direction of higher yield by

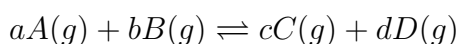
- (A) Decreasing the pressure
- (B) Increasing the pressure
- (C) Increasing the temperature
- (D) decreasing the temperature

Correct Answer: (B) Increasing the pressure

Solution:

This question relates to Le Chatelier's principle, which states that if a change of condition is applied to a system in equilibrium, the system will shift in a direction that counteracts the change.

The reaction involves a decrease in the total number of moles of gas. Let's consider a generic reaction:



Here, the total moles of reactants ($a + b$) is greater than the total moles of products ($c + d$).

The "direction of higher yield" means shifting the equilibrium to the right (towards the products).

According to Le Chatelier's principle, if we increase the external pressure, the equilibrium will shift in the direction that reduces the pressure. The pressure is reduced by decreasing the total number of gas moles.

Since the forward reaction (product side) has fewer moles of gas, increasing the pressure will shift the equilibrium to the right, favoring the formation of products and thus increasing the yield.

Conversely, decreasing the pressure would shift the equilibrium to the left, towards the side with more moles of gas.

Quick Tip

Le Chatelier's principle and pressure: Increasing pressure favors the side with fewer moles of gas. Decreasing pressure favors the side with more moles of gas. If the number of moles is equal on both sides, pressure has no effect on the equilibrium position.

147. 0.5 moles of Na_2CO_3 is present in 500 mL of its solution. Normality is

- (A) 0.8
- (B) 1.6
- (C) 0.32
- (D) 2

Correct Answer: (D) 2

Solution:

1. Calculate Molarity (M):

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{volume of solution in Liters}}$$

$$\text{Volume} = 500 \text{ mL} = 0.5 \text{ L.}$$

$$\text{Moles} = 0.5 \text{ mol.}$$

$$\text{Molarity} = \frac{0.5 \text{ mol}}{0.5 \text{ L}} = 1 \text{ M.}$$

2. Relate Normality (N) and Molarity (M):

$$\text{Normality} = \text{Molarity} \times \text{n-factor}$$

The n-factor (or valence factor) for a salt is the total positive or negative charge on the ions it produces upon dissociation.

Sodium carbonate, Na_2CO_3 , dissociates as:



The total positive charge is $2(+1) = +2$. The total negative charge is -2.

So, the n-factor for Na_2CO_3 is 2.

3. Calculate Normality:

$$\text{Normality} = 1 \text{ M} \times 2$$

$$\text{Normality} = 2 \text{ N}.$$

Quick Tip

The n-factor is key to converting between molarity and normality. Remember its definition for different substances: Acids: number of H^+ ions furnished. Bases: number of OH^- ions furnished. Salts: total positive/negative charge. Redox agents: number of electrons transferred per mole.

148. Concentration unit independent of temperature would be

- (A) Molarity
- (B) Molality
- (C) Normality
- (D) Molarity & Normality

Correct Answer: (B) Molality

Solution:

A concentration unit that is independent of temperature must be defined in terms of mass, which does not change with temperature. Units defined in terms of volume are temperature-dependent because volume expands or contracts with changes in temperature.

Let's analyze the options:

(A) Molarity (M) = $\frac{\text{moles of solute}}{\text{volume of solution (L)}}$. Since it depends on the volume of the solution, it is temperature-dependent.

(B) Molality (m) = $\frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$. Since it is defined using the mass of the solvent, which is independent of temperature, molality is also independent of temperature.

(C) Normality (N) = $\frac{\text{gram equivalents of solute}}{\text{volume of solution (L)}}$. Since it depends on the volume of the solution, it is temperature-dependent.

Therefore, molality is the concentration unit that is independent of temperature.

Quick Tip

Remember the key difference: Molarity uses Liters (Volume), while Molality uses Kilograms (Mass). Since volume is affected by temperature and mass is not, molality is the temperature-independent concentration unit.

149. The reaction of bromine with 2-pentene is

- (A) Electrophilic substitution
- (B) Nucleophilic substitution
- (C) Nucleophilic addition
- (D) Electrophilic addition

Correct Answer: (D) Electrophilic addition

Solution:

2-pentene ($\text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3$) is an alkene. The defining characteristic of alkenes is the presence of a carbon-carbon double bond ($\text{C}=\text{C}$).

The $\text{C}=\text{C}$ double bond consists of one strong sigma (σ) bond and one weak, electron-rich pi (π) bond. This region of high electron density makes alkenes nucleophilic.

Alkenes typically undergo addition reactions, where the π bond breaks and atoms are added to the two carbon atoms.

Bromine (Br_2) is a non-polar molecule, but as it approaches the electron-rich π bond of the alkene, the π electrons induce a dipole in the $\text{Br}-\text{Br}$ bond. The closer Br atom becomes partially positive (electrophilic) and the farther Br atom becomes partially negative.

The reaction is initiated by the attack of the nucleophilic π bond on the electrophilic bromine atom. Because the reaction is initiated by an electrophile (the polarized Br atom), it is classified as an electrophilic addition reaction.

The reaction proceeds via a cyclic bromonium ion intermediate, followed by attack of a bromide ion, to give 2,3-dibromopentane.

Quick Tip

The characteristic reaction of alkenes and alkynes (compounds with π bonds) is electrophilic addition. The characteristic reaction of benzene and its derivatives is electrophilic substitution.

150. Which of the following molecule has zero dipole moment

- (A) CO
- (B) CO_2
- (C) NH_3
- (D) H_2O

Correct Answer: (B) CO_2

Solution:

A molecule has a zero dipole moment if it is nonpolar. This can happen if all the bonds are

nonpolar (rare) or if the individual bond dipoles cancel each other out due to molecular symmetry.

Let's analyze the molecules:

(A) CO (Carbon monoxide): The C-O bond is polar due to the difference in electronegativity between carbon and oxygen. Since it's a diatomic molecule, there is only one bond, and its dipole cannot be canceled. It has a net dipole moment.

(B) CO₂ (Carbon dioxide): The molecule is linear (O=C=O). Each C=O bond is polar, with the dipole pointing from C to O. However, the two bond dipoles are equal in magnitude and point in exactly opposite directions. Due to this symmetry, they cancel each other out completely. The net dipole moment is zero.

(C) NH₃ (Ammonia): The molecule has a trigonal pyramidal shape. Each N-H bond is polar. The three bond dipoles and the dipole of the lone pair on nitrogen add up vectorially, resulting in a significant net dipole moment.

(D) H₂O (Water): The molecule has a bent (V-shape). Each O-H bond is polar. The two bond dipoles add up vectorially, resulting in a large net dipole moment.

Therefore, CO₂ is the only molecule with a zero dipole moment.

Quick Tip

For a molecule to be nonpolar (zero dipole moment), it must satisfy two conditions: 1) It must have nonpolar bonds OR 2) It must have polar bonds arranged in a perfectly symmetrical geometry such that the bond dipoles cancel out. Symmetrical shapes include linear (like CO₂), trigonal planar (like BF₃), and tetrahedral (like CCl₄).