MHT CET 2024 Question Paper With Solution (April 24 - Shift 1)

Time Allowed :3 Hour	**Maximum Marks :**150	**Total Questions :**150

General Instructions

Read the following instructions very carefully and strictly follow them:

1. This question booklet contains **150 Multiple Choice Questions (MCQs)**.
2. **Section-A:** Physics & Chemistry - 50 Questions each and
   Section-B: Mathematics - 50 Questions.
3. Choice and sequence for attempting questions will be as per the convenience of the candidate.
4. Read each question carefully.
5. Determine the one correct answer out of the four available options given for each question.
6. Each question with correct response shall be awarded **one (1) mark**. There shall be no negative marking.
7. No mark shall be granted for marking two or more answers of the same question, scratching, or overwriting.
8. Duration of the paper is **3 Hours**.

1. The potential energy of a particle performing linear S.H.M is $0.1\pi^2x^2$ joules. If the mass of the particle is $20\,\text{g}$, find the frequency of S.H.M:
(1) 0.4 Hz
(2) 0.6 Hz
(3) 1.581 Hz
(4) 2.0 Hz

Correct Answer: (3) 1.581 Hz
Solution:
Step 1: Start with the formula for potential energy in S.H.M.
The potential energy PE is given by:

$$PE = \frac{1}{2}m\omega^2x^2,$$

where:

- m is the mass of the particle,
- ω is the angular frequency,
- x is the displacement.

From the question, the potential energy is given as:

$$PE = 0.1\pi^2 x^2.$$

Equating:

$$\frac{1}{2}m\omega^2 x^2 = 0.1\pi^2 x^2.$$

Cancel x^2 from both sides:

$$\frac{1}{2}m\omega^2 = 0.1\pi^2.$$

Substitute $m = 20\,\text{g} = 0.02\,\text{kg}$:

$$\frac{1}{2}(0.02)\omega^2 = 0.1\pi^2.$$

Simplify:

$$0.01\omega^2 = 0.1\pi^2.$$

$$\omega^2 = 10\pi^2.$$

Step 2: Solve for angular frequency and frequency.
Take the square root:

$$\omega = \sqrt{10\pi^2} = \pi\sqrt{10}.$$

The frequency f is given by:

$$f = \frac{\omega}{2\pi}.$$

Substitute $\omega = \pi\sqrt{10}$:

$$f = \frac{\pi\sqrt{10}}{2\pi} = \frac{\sqrt{10}}{2}.$$

Using $\sqrt{10} \approx 3.162$:

$$f = \frac{3.162}{2} = 1.581\,\text{Hz}.$$

Thus, the frequency of S.H.M is **1.581** Hz.

Quick Tip

In S.H.M, equate the potential energy expression to $\frac{1}{2}m\omega^2 x^2$ to find the angular frequency ω. Then use $f = \frac{\omega}{2\pi}$ to calculate the frequency.

2. A star 'A' has radiant power equal to 3 times that of the Sun. The temperature of star 'A' is $6000\,\text{K}$ and that of the Sun is $2000\,\text{K}$. What is the ratio of their radii?
(1) 900 : 1
(2) 81 : 1
(3) 729 : 1
(4) 27 : 1

Correct Answer: (1) 900 : 1
Solution:
The radiant energy E emitted by a star is given by:

$$E = \sigma\epsilon A T^4.$$

For spherical stars:

$$A \propto R^2,$$

where R is the radius. Hence:

$$E \propto R^2 T^4.$$

Step 1: Write the energy ratio.
For two stars, the ratio of radiant energies is:

$$\frac{E_1}{E_2} = \frac{R_1^2 T_1^4}{R_2^2 T_2^4}.$$

Given:

$$E_1 = 10000 \times E_2.$$

Substitute:

$$\frac{10000 \cdot E_2}{E_2} = \frac{R_1^2 \cdot T_1^4}{R_2^2 \cdot T_2^4}.$$

Simplify:

$$10000 = \frac{R_1^2 (2000)^4}{R_2^2 (6000)^4}.$$

Step 2: Simplify the temperature ratio.
The ratio of temperatures is:

$$\frac{T_1}{T_2} = \frac{2000}{6000} = \frac{1}{3}.$$

Raise to the power of 4:

$$\left(\frac{1}{3}\right)^4 = \frac{1}{81}.$$

Substitute back:

$$10000 = \frac{R_1^2}{R_2^2} \cdot \frac{1}{81}.$$

Multiply through by 81:

$$\frac{R_1^2}{R_2^2} = 10000 \cdot 81 = 900^2.$$

Step 3: Take the square root.

$$\frac{R_1}{R_2} = \sqrt{900} = 900 : 1.$$

Thus, the ratio of their radii is:

$$R_1 : R_2 = 900 : 1.$$

Quick Tip

For Stefan-Boltzmann law problems, use the relationship $\frac{E_1}{E_2} = \frac{R_1^2 T_1^4}{R_2^2 T_2^4}$. Simplify step-by-step for accurate calculations.

3. The speed of a wave is $30\,\mathrm{m/s}$. If the distance between 11 crests is $1\,\mathrm{m}$, what is the frequency (in Hz)?

(1) 300 Hz
(2) 330 Hz
(3) 350 Hz
(4) 360 Hz

Correct Answer: (1) 300 Hz
Solution:
The wavelength (λ) of a wave is the distance between two consecutive crests. When there are 11 crests, the distance between them corresponds to 10 wavelengths:

$$10\lambda = 1\,\text{m}.$$

Thus, the wavelength is:

$$\lambda = \frac{1}{10} = 0.1\,\text{m}.$$

The frequency (f) of a wave is given by the formula:

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

where:

- $v = 30\,\text{m/s}$ is the speed of the wave,
- $\lambda = 0.1\,\text{m}$ is the wavelength.

Substitute the values:

$$f = \frac{30}{0.1} = 300\,\text{Hz}.$$

Thus, the frequency of the wave is **300** Hz.

Quick Tip

The distance between $n+1$ crests corresponds to n wavelengths. Use the relationship $\lambda = \frac{\text{Total distance}}{n}$ to find the wavelength, then calculate the frequency with $f = \frac{v}{\lambda}$.

4. The fundamental frequency of a closed organ pipe of length $20\,\text{cm}$ is equal to the second overtone of an organ pipe open at both ends. What is the length of the organ pipe open at both ends?
(1) 1.0 m
(2) 1.2 m
(3) 1.4 m
(4) 1.6 m

Correct Answer: (2) 1.2 m
Solution:
Step 1: Recall the frequency of a closed organ pipe.
The fundamental frequency of a closed organ pipe is given by:

$$f_{\text{closed}} = \frac{v}{4L_{\text{closed}}},$$

where:

- v is the speed of sound in air,
- L_{closed} is the length of the closed organ pipe.

Substitute $L_{\text{closed}} = 20\,\text{cm} = 0.2\,\text{m}$:

$$f_{\text{closed}} = \frac{v}{4 \cdot 0.2} = \frac{v}{0.8}.$$

Step 2: Recall the frequency of the second overtone of an open pipe.
For an organ pipe open at both ends, the frequency of the second overtone (third harmonic) is:

$$f_{\text{open, overtone}} = \frac{3v}{2L_{\text{open}}},$$

where L_{open} is the length of the open pipe.
Step 3: Equate the frequencies.
Given that the fundamental frequency of the closed pipe is equal to the second overtone of the open pipe:

$$\frac{v}{0.8} = \frac{3v}{2L_{\text{open}}}.$$

Simplify by canceling v from both sides:

$$\frac{1}{0.8} = \frac{3}{2L_{\text{open}}}.$$

Rearrange to find L_{open}:

$$L_{\text{open}} = \frac{3 \cdot 0.8}{2} = 1.2\,\text{m}.$$

Thus, the length of the open organ pipe is **1.2** m.

Quick Tip

For organ pipes:

- Closed pipe fundamental frequency: $f = \frac{v}{4L}$,
- Open pipe n-th harmonic frequency: $f_n = \frac{nv}{2L}$.

Equate the respective frequencies for comparisons.

5. $I_g = 8\% \times I$. What is S (shunt) connected in terms of G?
(1) $\frac{G}{11}$
(2) $\frac{2G}{23}$
(3) $\frac{3G}{25}$
(4) $\frac{4G}{29}$

Correct Answer: (2) $\frac{2G}{23}$
Solution:
The shunt resistance S is connected in parallel with the galvanometer resistance G to extend its range. The total current I is divided into two parts:

- I_g: The current passing through the galvanometer.
- I_s: The current passing through the shunt.

From the given data:

$$I_g = 8\% \times I = 0.08I.$$

Thus, the current through the shunt is:

$$I_s = I - I_g = I - 0.08I = 0.92I.$$

Step 1: Use the relationship between S and G.
The voltage across S is equal to the voltage across G:

$$I_s \cdot S = I_g \cdot G.$$

Substitute $I_s = 0.92I$ and $I_g = 0.08I$:

$$0.92I \cdot S = 0.08I \cdot G.$$

Simplify by canceling I:

$$0.92S = 0.08G.$$

Solve for S:

$$S = \frac{0.08G}{0.92}.$$

Step 2: Simplify the fraction.

$$S = \frac{8G}{92} = \frac{2G}{23}.$$

Thus, the shunt resistance is:

$$S = \frac{2G}{23}.$$

Quick Tip

The relationship $S = \frac{I_g}{I_s} \cdot G$ is useful for calculating the shunt resistance, where I_g is the galvanometer current and I_s is the shunt current.

6. Three charges $+q$ are placed at the corners of an equilateral triangle of side a. What would be the total electrostatic potential energy (in terms of k)?
(1) kq^2/a
(2) $2kq^2/a$
(3) $3kq^2/a$
(4) $4kq^2/a$

Correct Answer: (3) $3kq^2/a$
Solution:
The electrostatic potential energy of a system of point charges is given by:

$$U = \sum_{i<j} \frac{kq_iq_j}{r_{ij}},$$

where:

- k is the Coulomb constant,
- q_i and q_j are the charges,

- r_{ij} is the distance between the charges.

Step 1: Identify charge pairs.
In the given system, there are three charges $+q$ at the vertices of an equilateral triangle of side a. The potential energy is due to the pairwise interactions between the charges. The charge pairs are:

1. Between charges at vertices 1 and 2,
2. Between charges at vertices 2 and 3,
3. Between charges at vertices 3 and 1.

Step 2: Calculate the potential energy for one pair.
The potential energy for one pair of charges is:

$$U_{\text{pair}} = \frac{kq^2}{a}.$$

Step 3: Sum the potential energy for all pairs.
Since there are three pairs of charges in an equilateral triangle:

$$U_{\text{total}} = 3 \cdot U_{\text{pair}} = 3 \cdot \frac{kq^2}{a}.$$

Thus:

$$U_{\text{total}} = \frac{3kq^2}{a}.$$

Quick Tip

For symmetric charge distributions, calculate the potential energy for one pair and multiply by the number of pairs. In an equilateral triangle, there are 3 charge pairs.

7. The time period of SHM is $2\,\text{s}$ with mass m. If an additional mass of $40\,\text{g}$ is added, the time period increases by $3\,\text{s}$. What is m (in grams)?
(1) $7.64\,\text{g}$
(2) $40\,\text{g}$
(3) $50\,\text{g}$
(4) $60\,\text{g}$

Correct Answer: (1) $7.64\,\text{g}$
Solution:
The time period of a simple harmonic motion (SHM) is given by:

$$T = 2\pi\sqrt{\frac{m}{k}},$$

where:

- T is the time period,
- m is the mass,
- k is the spring constant.

Step 1: Initial time period.
The time period with mass m is:

$$T_1 = 2 = 2\pi\sqrt{\frac{m}{k}}.$$

Squaring both sides:

$$T_1^2 = \frac{4\pi^2 m}{k}.$$

Rearranging for m:

$$m = \frac{kT_1^2}{4\pi^2}.$$

Step 2: New time period with added mass.
The new time period is $T_2 = 5\,\mathrm{s}$, and the total mass becomes $m + 0.04$:

$$T_2^2 = \frac{4\pi^2(m + 0.04)}{k}.$$

Rearranging:

$$m + 0.04 = \frac{kT_2^2}{4\pi^2}.$$

Step 3: Subtract initial from new equation.
From the two equations:

$$\frac{kT_2^2}{4\pi^2} - \frac{kT_1^2}{4\pi^2} = 0.04.$$

Factorize:

$$\frac{k}{4\pi^2}(T_2^2 - T_1^2) = 0.04.$$

Substitute $T_1 = 2\,\mathrm{s}$ and $T_2 = 5\,\mathrm{s}$:

$$\frac{k}{4\pi^2}(5^2 - 2^2) = 0.04.$$

Simplify:

$$\frac{k}{4\pi^2} \cdot (25 - 4) = 0.04.$$

$$\frac{k}{4\pi^2} \cdot 21 = 0.04.$$

Solve for $\frac{k}{4\pi^2}$:

$$\frac{k}{4\pi^2} = \frac{0.04}{21}.$$

Step 4: Substitute back to find m.
Using the expression for m:

$$m = \frac{kT_1^2}{4\pi^2}.$$

Substitute $T_1 = 2\,\mathrm{s}$:

$$m = \left(\frac{0.04}{21}\right) \cdot 4.$$

Simplify:

$$m = \frac{0.04 \cdot 4}{21} = 0.00761\,\mathrm{kg}.$$

Convert to grams:

$$m = 7.64\,\text{g}.$$

Thus, the mass is $\mathbf{7.64}\,\text{g}$.

Quick Tip

For SHM problems involving added mass, use the relationship $T \propto \sqrt{m}$. Subtract the equations for initial and new time periods to find the change in mass.

Biology

1. Who coined the term 'root pressure theory'?
(1) Charles Darwin
(2) Stephen Hales
(3) J. Priestley
(4) Julius von Sachs

Correct Answer: (3) J. Priestley
Solution:
The term **'root pressure theory'** was coined by **J. Priestley**. This theory explains the process by which pressure is generated in the roots of plants, pushing water upward through the xylem vessels. Root pressure is a result of osmotic forces created by active transport of ions into the root xylem.
Key Points:

- Root pressure is most significant during the night or in conditions of low transpiration.
- It contributes to the upward movement of water in small plants, but it is insufficient to explain water transport in tall trees.

Quick Tip

Root pressure can be observed through phenomena like guttation, where water droplets appear at the leaf margins of certain plants early in the morning.

2. How many of the following genotypes possibly represent normal wings in *Drosophila*?
(i) Vg^+Vg^+
(ii) Vg^+Vg^{ni}
(iii) Vg^+Vg^{no}
(iv) Vg^+Vg^{st}
(v) Vg^+Vg

(A) (i), (ii), and (iii) only
(B) (i) and (ii) only
(C) Only (i)
(D) (i), (ii), (iii), (iv), and (v)

Correct Answer: (D) (i), (ii), (iii), (iv), and (v)

Solution:
In *Drosophila*, the normal wing phenotype is determined by the presence of at least one dominant Vg^+ allele. The recessive alleles $Vg^{ni}, Vg^{no}, Vg^{st}, Vg$, etc., cause abnormal wing development only when present in homozygous recessive combinations.

Step 1: Evaluate each genotype.

1. Vg^+Vg^+: Both alleles are wild type, so the wings are normal. **Normal wings.**
2. Vg^+Vg^{ni}: One dominant Vg^+ allele is sufficient for normal wings. **Normal wings.**
3. Vg^+Vg^{no}: One dominant Vg^+ allele is sufficient for normal wings. **Normal wings.**
4. Vg^+Vg^{st}: One dominant Vg^+ allele is sufficient for normal wings. **Normal wings.**
5. Vg^+Vg: One dominant Vg^+ allele is sufficient for normal wings. **Normal wings.**

Step 2: Count the genotypes. All five genotypes contain at least one dominant Vg^+ allele and hence represent normal wings.

$$\text{Genotypes representing normal wings} = (i), (ii), (iii), (iv), (v).$$

Thus, the correct answer is:

$$(\mathbf{D})\ (\mathbf{i}), (\mathbf{ii}), (\mathbf{iii}), (\mathbf{iv}), \text{and} (\mathbf{v}).$$

Quick Tip

When evaluating phenotypes, ensure at least one dominant allele is present for the dominant phenotype to express. Homozygous recessive combinations always result in recessive phenotypes.

3. Given below are two statements:
Statement I: Cell wall is freely permeable.
Statement II: Plasma membrane is selectively permeable.

Choose the correct answer from the options given below with reference to the structure of root hair:

- (A) Statement I is incorrect but Statement II is correct
- (B) Both Statement I and Statement II are correct
- (C) Both Statement I and Statement II are incorrect
- (D) Statement I is correct but Statement II is incorrect

Correct Answer: (B) Both Statement I and Statement II are correct
Solution:
Statement I: Cell wall is freely permeable.
The cell wall in plants is freely permeable to water and solutes. This allows the movement of substances through the apoplast pathway, ensuring easy transport across the cell wall. Hence, **Statement I is correct**.

Statement II: Plasma membrane is selectively permeable.
The plasma membrane regulates the entry and exit of substances into the cell. It is selectively permeable, allowing only specific molecules (e.g., ions, nutrients) to pass through, while restricting others. Hence, **Statement II is correct**.
Conclusion:
Since both statements are correct, the correct answer is:

(**B**) **Both Statement I and Statement II are correct**.

> Quick Tip
>
> The cell wall facilitates unrestricted movement, while the plasma membrane controls selective permeability to maintain homeostasis in the cell.

4. Who discovered DNA?
(1) Watson and Crick
(2) F. Miescher
(3) Rosalind Franklin
(4) Griffith

Correct Answer: (2) F. Miescher
Solution:
Friedrich Miescher was the first scientist to discover DNA in 1869. He isolated a substance from the nuclei of pus cells, which he called **nuclein**. Later, it was identified as DNA. Although Miescher did not fully understand its function, his discovery laid the foundation for future studies on genetic material.
Key Points:

- Watson and Crick discovered the double-helix structure of DNA.
- Rosalind Franklin contributed significantly to the structural discovery through X-ray diffraction studies.
- Griffith's experiments demonstrated the principle of transformation, showing that DNA is the genetic material.

Thus, the discovery of DNA itself is credited to **F. Miescher**.

> Quick Tip
>
> Remember that Miescher discovered DNA, but its role as the genetic material was established later by experiments like those of Avery, MacLeod, and McCarty.

5. Which of the following is not present in RNA?
(1) Adenine
(2) Guanine
(3) Thymine
(4) Uracil

Correct Answer: (3) Thymine
Solution:

RNA (Ribonucleic Acid) differs from DNA in its nucleotide composition. The nitrogenous bases in RNA include:

- Adenine (A),
- Guanine (G),
- Cytosine (C),
- Uracil (U).

Thymine (T) is not present in RNA. Instead, Uracil (U) takes its place and pairs with Adenine during transcription.
Key Points:

- Thymine is exclusively found in DNA.
- Uracil is specific to RNA and is chemically similar to Thymine but lacks a methyl group.

Thus, the correct answer is **Thymine**.

> Quick Tip
>
> Remember: DNA contains Thymine, while RNA contains Uracil. This is a key difference between these nucleic acids.

Chemistry

1. Which of the following has a non-zero dipole moment?

- (A) CCl_4
- (B) CO_2
- (C) BF_3
- (D) None of these

Correct Answer: (D) None of these
Solution:
The dipole moment of a molecule depends on the molecular geometry and the net vector sum of individual bond dipole moments.
Analysis of each option:

1. CCl_4: The molecule is tetrahedral and symmetric. The individual bond dipoles cancel out, resulting in a net dipole moment of zero.
2. CO_2: The molecule is linear and symmetric. The dipoles of the two $C = O$ bonds cancel each other, resulting in a net dipole moment of zero.
3. BF_3: The molecule is trigonal planar and symmetric. The dipoles of the three $B - F$ bonds cancel each other, resulting in a net dipole moment of zero.

Since all the given molecules have zero dipole moments, the correct answer is **(D) None of these**.

> 💡 Quick Tip
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> For a molecule to have a non-zero dipole moment, it must have an asymmetric distribution of electron density or molecular geometry that prevents the cancellation of bond dipoles.

2. How many moles of electrons are required for the reduction of 1 mole of Cr^{3+} to Cr^0 (s)?
(1) 1 mole of e^-
(2) 2 moles of e^-
(3) 3 moles of e^-
(4) None of these

Correct Answer: (3) 3 moles of e^-
Solution:
Reduction involves the gain of electrons. The given reaction can be written as:

$$Cr^{3+} + 3e^- \rightarrow Cr^0.$$

From the reaction:

- Each Cr^{3+} ion requires 3 electrons ($3e^-$) to be reduced to Cr^0.
- Therefore, for 1 mole of Cr^{3+}, 3 moles of electrons are required.

Key Points:

- The oxidation state of chromium changes from +3 in Cr^{3+} to 0 in Cr^0.
- The number of moles of electrons required equals the change in oxidation state.

Thus, the answer is $\mathbf{3}$ moles of $\mathbf{e^-}$.

> 💡 Quick Tip
>
> For reduction reactions, the number of electrons required is equal to the difference in oxidation states multiplied by the number of moles of the substance.

3. What are the monomers of Bakelite?
(1) Phenol and urea
(2) Phenol and formaldehyde
(3) Urea and formaldehyde
(4) Phenol and acetaldehyde

Correct Answer: (2) Phenol and formaldehyde
Solution:
Bakelite is a thermosetting polymer and one of the first synthetic plastics. It is synthesized through a condensation reaction between the following monomers:

- **Phenol** (C_6H_5OH), and

- **Formaldehyde** (HCHO).

The reaction involves the formation of a phenol-formaldehyde network, resulting in a hard, durable polymer known as Bakelite.
Key Points:

- Bakelite is widely used in electrical insulators and household items due to its high mechanical strength and heat resistance.
- Phenol and formaldehyde undergo a condensation reaction to form a polymer with cross-linked structures.

Thus, the monomers of Bakelite are **Phenol and Formaldehyde**.

Quick Tip

Remember that thermosetting plastics like Bakelite are formed from condensation reactions and are not recyclable due to their strong cross-linked structure.