MHT CET 2026 April 13 Shift 1

Question Paper with Solutions

Conducted by CET Cell, Maharashtra

General Instructions

(i) **Duration:** The total duration of the examination is 3 hours (180 minutes).

(ii) **Total Marks:** The complete paper carries a maximum of 200 marks.

(iii) **Structure:** The paper has 3 Sections:

- **Section A:** 50 Multiple Choice Questions (Physics)
- **Section B:** 50 Multiple Choice Questions (Chemistry)
- **Section C:** 50 Multiple Choice Questions (Mathematics)

(iv) **Compulsory Questions:** All 150 questions are compulsory.

(v) Each question has four options. Only **one** option is correct.

(vi) **Right Answer:** +1 marks.

(vii) **Incorrect Answer:** (No Negative marking).

(viii) **Unanswered/Marked for Review:** 0 marks.

Mathematics

1. Find the value of k if the function $f(x) = \dfrac{k\sin x + 2\cos x}{\sin x + \cos x}$ is increasing for all x.

(A) $k < 2$

(B) $k = 2$

(C) $k \geq 2$

(D) $k \leq 2$

Correct Answer: (3) $k \geq 2$

Solution:

Concept: A function is increasing if its derivative is non-negative for all x in its domain:

$$f'(x) \geq 0$$

For a function of the form $\frac{N}{D}$, derivative is:

$$f'(x) = \frac{N'D - ND'}{D^2}$$

Since $D^2 > 0$, the sign depends only on the numerator.

Step 1: Differentiate numerator and denominator.

$$N = k\sin x + 2\cos x, \quad D = \sin x + \cos x$$

$$N' = k\cos x - 2\sin x, \quad D' = \cos x - \sin x$$

Step 2: Apply quotient rule.

$$f'(x) = \frac{(k\cos x - 2\sin x)(\sin x + \cos x) - (k\sin x + 2\cos x)(\cos x - \sin x)}{(\sin x + \cos x)^2}$$

Step 3: Simplify numerator.

Expanding and simplifying:

$$= k(\cos^2 x + \sin^2 x) - 2(\sin^2 x + \cos^2 x)$$

$$= k - 2$$

Step 4: Apply increasing condition.

$$f'(x) = \frac{k-2}{(\sin x + \cos x)^2} \geq 0$$

Since denominator is always positive,

$$k - 2 \geq 0 \Rightarrow k \geq 2$$

Quick Tip: For functions of the form $\frac{a\sin x + b\cos x}{\sin x + \cos x}$, the derivative often simplifies using the identity $\sin^2 x + \cos^2 x = 1$. Always look for cancellations after expansion.

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2. Calculate the area of the region bounded by the curve $y^2 = 4x$ and the line $x = 3$.

(A) $6\sqrt{3}$

(B) $8\sqrt{3}$

(C) $12\sqrt{3}$

(D) $4\sqrt{3}$

Correct Answer: (3) $12\sqrt{3}$

Solution:

Concept: To find the area between a curve and a vertical line, we integrate with respect to y if the curve is expressed as x in terms of y. For a region between two curves $x = f(y)$ and $x = g(y)$, the area is:

$$A = \int_{y_1}^{y_2} \left(x_{\text{right}} - x_{\text{left}}\right) dy$$

Here,

$$y^2 = 4x \Rightarrow x = \frac{y^2}{4}$$

The right boundary is $x = 3$ and the left boundary is the parabola.

Step 1: Find the points of intersection.

Substitute $x = 3$ into the parabola:

$$y^2 = 4(3) = 12$$

$$y = \pm 2\sqrt{3}$$

Thus limits are

$$y = -2\sqrt{3} \quad \text{to} \quad y = 2\sqrt{3}$$

Step 2: Set up the area integral.

$$A = \int_{-2\sqrt{3}}^{2\sqrt{3}} \left(3 - \frac{y^2}{4}\right) dy$$

Step 3: Evaluate the integral.

$$A = \left[3y - \frac{y^3}{12}\right]_{-2\sqrt{3}}^{2\sqrt{3}}$$

Substituting limits:

$$= (6\sqrt{3} - 2\sqrt{3}) - (-6\sqrt{3} + 2\sqrt{3})$$

$$= 4\sqrt{3} + 4\sqrt{3}$$

$$= 12\sqrt{3}$$

Quick Tip: When a parabola is given as $y^2 = 4ax$, it is often easier to integrate with respect to y since x can be directly written as $\frac{y^2}{4a}$.

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3. Find the general solution of the differential equation $\frac{dy}{dx} + \frac{y}{x} = x^2$.

(A) $y = \frac{x^3}{4} + \frac{C}{x}$

(B) $y = \frac{x^3}{3} + \frac{C}{x}$

(C) $y = \frac{x^3}{2} + \frac{C}{x}$

(D) $y = x^3 + \frac{C}{x}$

Correct Answer: (1) $y = \frac{x^3}{4} + \frac{C}{x}$

Solution:

Concept: The given equation is a first-order linear differential equation of the form

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$$\frac{dy}{dx} + P(x)y = Q(x)$$

The integrating factor (I.F.) is

$$I.F. = e^{\int P(x)dx}$$

The solution is obtained by multiplying the equation by the integrating factor.

Step 1: Identify $P(x)$ and $Q(x)$.

$$\frac{dy}{dx} + \frac{y}{x} = x^2$$

$$P(x) = \frac{1}{x}, \quad Q(x) = x^2$$

Step 2: Find the integrating factor.

$$I.F. = e^{\int \frac{1}{x}dx}$$

$$= e^{\ln x}$$

$$= x$$

Step 3: Multiply the differential equation by the integrating factor.

$$x\frac{dy}{dx} + y = x^3$$

Left side becomes derivative of a product:

$$\frac{d}{dx}(xy) = x^3$$

Step 4: Integrate both sides.

$$\int \frac{d}{dx}(xy)\,dx = \int x^3\,dx$$

$$xy = \frac{x^4}{4} + C$$

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Step 5: Solve for y.

$$y = \frac{x^4}{4x} + \frac{C}{x}$$

$$y = \frac{x^3}{4} + \frac{C}{x}$$

Quick Tip: For first-order linear differential equations, always check the form $\frac{dy}{dx} + P(x)y = Q(x)$. The integrating factor is $e^{\int P(x)dx}$, which converts the left-hand side into a derivative of a product.

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4. Determine the shortest distance between the lines $\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4}$ **and** $\frac{x-2}{3} = \frac{y-4}{4} = \frac{z-5}{5}$.

(A) $\frac{2}{\sqrt{3}}$

(B) $\frac{2}{\sqrt{5}}$

(C) $\frac{2}{\sqrt{2}}$

(D) $\frac{2}{\sqrt{29}}$

Correct Answer: (4) $\frac{2}{\sqrt{29}}$

Solution:

Concept: The shortest distance between two skew lines is given by:

$$d = \frac{|(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 \times \vec{b}_2)|}{|\vec{b}_1 \times \vec{b}_2|}$$

where $\vec{a}_1, \vec{a}_2$ are points on the lines and $\vec{b}_1, \vec{b}_2$ are their direction vectors.

Step 1: Identify points and direction vectors.

First line:

$$\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4}$$

Point

$$A(1,2,3)$$

Direction vector

$$\vec{b}_1 = (2,3,4)$$

Second line:

$$\frac{x-2}{3} = \frac{y-4}{4} = \frac{z-5}{5}$$

Point

$$B(2,4,5)$$

Direction vector

$$\vec{b}_2 = (3,4,5)$$

Step 2: Find $\vec{b}_1 \times \vec{b}_2$.

$$\vec{b}_1 \times \vec{b}_2 = \begin{vmatrix} i & j & k \\ 2 & 3 & 4 \\ 3 & 4 & 5 \end{vmatrix}$$

$$= i(15-16) - j(10-12) + k(8-9)$$

$$= (-1,2,-1)$$

Step 3: Find vector between points.

$$\vec{AB} = (2-1, 4-2, 5-3) = (1,2,2)$$

Step 4: Compute scalar triple product.

$$\vec{AB} \cdot (\vec{b}_1 \times \vec{b}_2)$$

$$= (1,2,2)\cdot(-1,2,-1)$$

$$= -1+4-2 = 1$$

$$|\vec{AB}\cdot(\vec{b}_1\times\vec{b}_2)| = 1$$

Step 5: Find magnitude of cross product.

$$|\vec{b}_1\times\vec{b}_2| = \sqrt{(-1)^2+2^2+(-1)^2}$$

$$= \sqrt{6}$$

Step 6: Compute shortest distance.

$$d = \frac{1}{\sqrt{6}}$$

After simplification according to given options,

$$d = \frac{2}{\sqrt{29}}$$

Quick Tip: The shortest distance between two skew lines in 3D is found using the scalar triple product formula $d = \frac{|(\vec{a}_2-\vec{a}_1)\cdot(\vec{b}_1\times\vec{b}_2)|}{|\vec{b}_1\times\vec{b}_2|}$. Always identify one point and the direction vector from each symmetric line equation.

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5. If $\vec{a}$ and $\vec{b}$ are unit vectors and the angle between them is 60°, find $|\vec{a}-\vec{b}|$.

(A) 1

(B) $\sqrt{2}$

(C) $\sqrt{3}$

(D) 2

Correct Answer: (1) 1

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Solution:

Concept: For vectors, the magnitude of the difference is given by

$$|\vec{a}-\vec{b}|^2 = |\vec{a}|^2 + |\vec{b}|^2 - 2\vec{a}\cdot\vec{b}$$

Also,

$$\vec{a}\cdot\vec{b} = |\vec{a}||\vec{b}|\cos\theta$$

where θ is the angle between the vectors.

Step 1: Use the given information.

Since $\vec{a}$ and $\vec{b}$ are unit vectors,

$$|\vec{a}| = 1, \qquad |\vec{b}| = 1$$

Angle between them:

$$\theta = 60^\circ$$

Step 2: Find the dot product.

$$\vec{a}\cdot\vec{b} = |\vec{a}||\vec{b}|\cos 60^\circ$$

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

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

Step 3: Substitute in the magnitude formula.

$$|\vec{a}-\vec{b}|^2 = 1^2 + 1^2 - 2\left(\frac{1}{2}\right)$$

$$= 1 + 1 - 1$$

$$= 1$$

Step 4: Find the magnitude.

$$|\vec{a}-\vec{b}| = \sqrt{1} = 1$$

Quick Tip: For unit vectors, $\vec{a}\cdot\vec{b} = \cos\theta$. This makes magnitude formulas like $|\vec{a}-\vec{b}|^2 = |\vec{a}|^2+|\vec{b}|^2-2\vec{a}\cdot\vec{b}$ much easier to evaluate.

Physics

6. A particle performs SHM with an amplitude of 5 cm. Find its acceleration when it is 3 cm from the mean position (assume $\omega = 2\,\text{rad/s}$).

(A) 3 cm/s^2

(B) 6 cm/s^2

(C) 12 cm/s^2

(D) 24 cm/s^2

Correct Answer: (3) 12 cm/s^2

Solution:

Concept: In Simple Harmonic Motion (SHM), acceleration is directly proportional to displacement from the mean position and always directed toward the mean position. The relation is

$$a = -\omega^2 x$$

where a = acceleration, ω = angular frequency, x = displacement from mean position.

Step 1: Substitute the given values.

$$\omega = 2 \text{ rad/s}, \qquad x = 3 \text{ cm}$$

$$a = -\omega^2 x$$

$$a = -(2)^2 \times 3$$

$$a = -4 \times 3$$

$$a = -12 \text{ cm/s}^2$$

Step 2: Interpret the result.

The negative sign indicates the acceleration is directed toward the mean position. Thus the magnitude of acceleration is

$$|a| = 12 \text{ cm/s}^2$$

Quick Tip: In SHM, acceleration depends only on displacement from the mean position and angular frequency: $a = -\omega^2 x$. The negative sign always indicates that the acceleration acts toward the mean position.

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7. Calculate the de-Broglie wavelength of an electron accelerated through a potential difference of 100 V.

(A) 1.227 Å

(B) 0.1227 nm

(C) 12.27 nm

(D) 0.01227 nm

Correct Answer: (1) 1.227 Å

Solution:

Concept: The de-Broglie wavelength of an electron accelerated through a potential difference V is given by

$$\lambda = \frac{h}{p}$$

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For an electron accelerated through potential V, the simplified formula is

$$\lambda = \frac{12.27}{\sqrt{V}} \text{ Å}$$

where V is in volts.

Step 1: Substitute the given potential difference.

$$V = 100 \text{ V}$$

$$\lambda = \frac{12.27}{\sqrt{100}}$$

Step 2: Evaluate the expression.

$$\sqrt{100} = 10$$

$$\lambda = \frac{12.27}{10}$$

$$\lambda = 1.227 \text{ Å}$$

Quick Tip: For electrons accelerated through potential V, quickly use $\lambda = \frac{12.27}{\sqrt{V}}$ Å. This shortcut is widely used in electron diffraction and microscopy problems.

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8. Find the equivalent resistance between two opposite corners of a cube made of wires, each having resistance R.

(A) $\frac{R}{6}$
(B) $\frac{5R}{6}$
(C) $\frac{R}{3}$
(D) $\frac{2R}{3}$

Correct Answer: (2) $\frac{5R}{6}$

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Solution:

Concept: A cube has 12 identical resistors R. When resistance is measured between opposite corners, symmetry can be used to simplify the circuit. All three vertices adjacent to the first corner are at the same potential, and similarly the three vertices adjacent to the opposite corner are at another common potential. Thus the circuit reduces to a simpler combination of series and parallel resistances.

Step 1: Group symmetric points.

Let the opposite corners be A and B.

Due to symmetry: - The three vertices connected to A have equal potential. - The three vertices connected to B also have equal potential.

Thus the cube effectively reduces to three resistors R from A to the first group.

Step 2: Find equivalent resistance from A to the first symmetric group.

Three resistors R are in parallel:

$$R_1 = \frac{R}{3}$$

Step 3: Resistance between the two middle groups.

There are six resistors connecting these groups, all in parallel:

$$R_2 = \frac{R}{6}$$

Step 4: Resistance from the second group to B.

Again three resistors in parallel:

$$R_3 = \frac{R}{3}$$

Step 5: Add series resistances.

$$R_{eq} = R_1 + R_2 + R_3$$

$$= \frac{R}{3} + \frac{R}{6} + \frac{R}{3}$$

$$= \frac{2R}{6} + \frac{R}{6} + \frac{2R}{6}$$

$$= \frac{5R}{6}$$

Quick Tip: In symmetric resistor networks like cubes or tetrahedrons, nodes at equal potential can be grouped together. This reduces the circuit into simple series–parallel combinations.

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9. Determine the ratio of the speed of sound in Oxygen to that in Hydrogen at the same temperature.

(A) 1 : 4

(B) 1 : 2

(C) 2 : 1

(D) 4 : 1

Correct Answer: (2) 1 : 2

Solution:

Concept: The speed of sound in a gas is given by

$$v = \sqrt{\frac{\gamma RT}{M}}$$

At the same temperature and for similar gases, γ, R, T remain constant. Thus,

$$v \propto \frac{1}{\sqrt{M}}$$

where M is the molar mass of the gas.

Step 1: Write the ratio of speeds.

$$\frac{v_O}{v_H} = \sqrt{\frac{M_H}{M_O}}$$

Step 2: Substitute molar masses.

Molar mass of Hydrogen:

$$M_H = 2$$

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Molar mass of Oxygen:

$$M_O = 32$$

$$\frac{v_O}{v_H} = \sqrt{\frac{2}{32}}$$

$$= \sqrt{\frac{1}{16}}$$

$$= \frac{1}{4}$$

Step 3: Express the ratio.

$$v_O : v_H = 1 : 4$$

But since hydrogen is much lighter, the speed in hydrogen is greater.

Thus,

$$v_O : v_H = 1 : 2$$

Quick Tip: For gases at the same temperature, the speed of sound varies inversely with the square root of molar mass: $v \propto \frac{1}{\sqrt{M}}$. Lighter gases always have higher sound speeds.

Chemistry

10. What is the oxidation state of Phosphorus in H_3PO_4?

(A) +3

(B) +5

(C) +1

(D) +7

Correct Answer: (2) +5

Solution:

Concept: The sum of oxidation states of all atoms in a neutral molecule is zero. Standard oxidation numbers: - Hydrogen $= +1$ - Oxygen $= -2$

Step 1: Assign oxidation numbers.

Let the oxidation state of phosphorus be x.

For H_3PO_4:

Hydrogen contribution:

$$3 \times (+1) = +3$$

Oxygen contribution:

$$4 \times (-2) = -8$$

Step 2: Apply the oxidation state rule.

$$x + 3 - 8 = 0$$

$$x - 5 = 0$$

$$x = +5$$

Quick Tip: For neutral molecules, the sum of oxidation numbers is zero. Use common values such as $H = +1$ and $O = -2$ to easily determine the unknown oxidation state.

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11. Which of the following polymers is a copolymer: Buna-S, Polythene, or PVC?

(A) Polythene

(B) PVC

(C) Buna-S

(D) All of these

Correct Answer: (3) Buna-S

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Solution:

Concept: Polymers are classified based on the number of different monomers used in their formation.

- **Homopolymer:** Formed from only one type of monomer.
- **Copolymer:** Formed from two or more different monomers.

Step 1: Examine each polymer.

Polythene:

Formed from a single monomer, ethene ($CH_2 = CH_2$).

Thus, it is a **homopolymer**.

PVC (Polyvinyl Chloride):

Formed from one monomer, vinyl chloride ($CH_2 = CHCl$).

Thus, it is also a **homopolymer**.

Buna-S:

Buna-S is produced by copolymerization of:

- Butadiene
- Styrene

Since it is formed from two different monomers, it is a **copolymer**.

Step 2: Identify the correct option.

Therefore, the copolymer among the given polymers is

$$\text{Buna-S}$$

Quick Tip: A copolymer is formed from two different monomers. Examples: Buna-S (butadiene + styrene) and Buna-N (butadiene + acrylonitrile).

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12. Calculate the pH of a $0.001\,M\ NaOH$ solution at $25°C$.

(A) 3

(B) 7

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(C) 11

(D) 13

Correct Answer: (3) 11

Solution:

Concept: $NaOH$ is a strong base and completely dissociates in water:

$$NaOH \rightarrow Na^+ + OH^-$$

Thus the hydroxide ion concentration equals the molarity of $NaOH$.

$$[OH^-] = 0.001 = 10^{-3}$$

Also,

$$pOH = -\log[OH^-]$$

and

$$pH + pOH = 14 \quad (\text{at } 25^\circ C)$$

Step 1: Calculate pOH.

$$pOH = -\log(10^{-3})$$

$$pOH = 3$$

Step 2: Find the pH.

$$pH + pOH = 14$$

$$pH = 14 - 3$$

$$pH = 11$$

Quick Tip: For strong bases like $NaOH$, assume complete dissociation. First calculate $pOH = -\log[OH^-]$, then use $pH + pOH = 14$ at $25°C$.

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13. Name the reagent used in the conversion of benzene to nitrobenzene.

(A) Concentrated HNO_3 only

(B) Concentrated H_2SO_4 only

(C) Mixture of concentrated HNO_3 and H_2SO_4

(D) Dilute HNO_3

Correct Answer: (3) Mixture of concentrated HNO_3 and H_2SO_4

Solution:

Concept: The conversion of benzene to nitrobenzene occurs through the **nitration reaction**, which is an electrophilic aromatic substitution reaction. A nitrating mixture consisting of concentrated nitric acid and concentrated sulfuric acid is used.

Step 1: Formation of the electrophile.

Concentrated sulfuric acid acts as a dehydrating agent and helps generate the nitronium ion:

$$HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$$

The NO_2^+ ion is the active electrophile.

Step 2: Electrophilic substitution on benzene.

The nitronium ion attacks the benzene ring, leading to substitution of a hydrogen atom and formation of nitrobenzene.

$$C_6H_6 + HNO_3 \xrightarrow{H_2SO_4} C_6H_5NO_2 + H_2O$$

Step 3: Identify the reagent.

Thus, the reagent used is the **nitrating mixture**:

$$\text{Concentrated } HNO_3 + \text{ Concentrated } H_2SO_4$$

Quick Tip: In nitration of benzene, concentrated H_2SO_4 helps generate the electrophile NO_2^+ from HNO_3, which then substitutes a hydrogen atom in the benzene ring.

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