MHT CET 2024 Question Paper With Solution (April 27 - Shift 2)

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. A rocket of initial mass 6000 kg ejects gases at a constant rate of 16 kg/s with a constant relative speed of 11 km/s. What is the acceleration of the rocket one minute after the blast?
(1) $32.50\,\mathrm{m/s^2}$
(2) $34.92\,\mathrm{m/s^2}$
(3) $36.00\,\mathrm{m/s^2}$
(4) $38.10\,\mathrm{m/s^2}$

Correct Answer: (2) $34.92\,\mathrm{m/s^2}$
Solution:
Step 1: Identify the variables.

- Initial mass of the rocket $(m_0) = 6000$ kg.
- Rate of mass ejection $(\dot{m}) = 16$ kg/s.
- Relative speed of ejected gases $(v_r) = 11$ km/s $= 11000$ m/s.
- Time $(t) = 1$ minute $= 60$ seconds.

Step 2: Calculate the mass of the rocket after 1 minute. The mass decreases at a constant rate:

$$m = m_0 - (\dot{m} \cdot t).$$

Substitute the values:

$$m = 6000 - (16 \cdot 60) = 6000 - 960 = 5040\,\text{kg}.$$

Step 3: Use the rocket equation to find acceleration. The acceleration of the rocket is given by:

$$a = \frac{\dot{m} \cdot v_r}{m}.$$

Substitute the known values:

$$a = \frac{16 \cdot 11000}{5040}.$$

Simplify:

$$a = \frac{176000}{5040} = 34.92\,\text{m/s}^2.$$

Thus, the acceleration of the rocket after 1 minute is $34.92\,\text{m/s}^2$.

> **Quick Tip**
>
> The acceleration of a rocket can be calculated using the formula $a = \frac{\dot{m} \cdot v_r}{m}$, where $\dot{m}$ is the rate of mass ejection, v_r is the relative speed of ejected gases, and m is the remaining mass.

2. A coil has a resistance of $30\,\Omega$ and an inductive reactance of $20\,\Omega$ at 50 Hz frequency. If an AC source of 200 V and 100 Hz is connected across the coil, then how much current will flow through the coil?

(1) $3\,\text{A}$
(2) $4\,\text{A}$
(3) $5\,\text{A}$
(4) $6\,\text{A}$

Correct Answer: (2) $4\,\text{A}$

Solution:

According to the problem, the inductive reactance at $50\,\text{Hz}$ is:

$$X_L = 20\,\Omega.$$

The inductive reactance X_L is given by:

$$X_L = 2\pi f L.$$

Substitute $f = 50\,\text{Hz}$ and $X_L = 20\,\Omega$:

$$2\pi \times 50 \times L = 20.$$

Simplify:

$$L = \frac{20}{2\pi \times 50} = \frac{1}{5\pi}\,\text{H}.$$

If the frequency is increased to $100\,\text{Hz}$, the new inductive reactance is:

$$X_L = 2\pi f L.$$

Substitute $f = 100\,\text{Hz}$ and $L = \frac{1}{5\pi}\,\text{H}$:

$$X_L = 2\pi \times 100 \times \frac{1}{5\pi} = 40\,\Omega.$$

The impedance Z of the circuit is given by:

$$Z = \sqrt{R^2 + X_L^2}.$$

Substitute $R = 30\,\Omega$ and $X_L = 40\,\Omega$:

$$Z = \sqrt{30^2 + 40^2} = \sqrt{900 + 1600} = \sqrt{2500}.$$

Simplify:

$$Z = 50\,\Omega.$$

The current I is calculated using Ohm's Law:

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

Substitute $V = 200\,\text{V}$ and $Z = 50\,\Omega$:

$$I = \frac{200}{50} = 4\,\text{A}.$$

Thus, the current flowing through the coil is:

$$I = 4\,\text{A}.$$

> Quick Tip
>
> For AC circuits with resistance and reactance, use the formula $Z = \sqrt{R^2 + X_L^2}$ to calculate impedance. Then apply Ohm's Law, $I = \frac{V}{Z}$, to find the current.

3. The first member of the Paschen series in the hydrogen spectrum is of wavelength 18800 Å. What is the short wavelength limit of the Paschen series?
(1) 8225 Å
(2) 8220 Å
(3) 8300 Å
(4) None of these

Correct Answer: (1) 8225 Å
Solution:
Step 1: Recall the formula for the Paschen series.
The wavelength λ of a spectral line in the Paschen series is given by:

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right), \quad n = 4, 5, 6, \ldots$$

where:

- R is the Rydberg constant ($1.097 \times 10^7\,\text{m}^{-1}$),
- n is the principal quantum number ($n > 3$).

Step 2: Calculate the wavelength for the first member ($n = 4$).
For $n = 4$:

$$\frac{1}{\lambda_1} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right).$$

Simplify:

$$\frac{1}{\lambda_1} = R\left(\frac{1}{9} - \frac{1}{16}\right).$$

Find the common denominator:

$$\frac{1}{\lambda_1} = R \cdot \frac{16-9}{144} = R \cdot \frac{7}{144}.$$

Given $R = 1.097 \times 10^7\,\mathrm{m}^{-1}$, calculate:

$$\frac{1}{\lambda_1} = 1.097 \times 10^7 \cdot \frac{7}{144}.$$

Simplify:

$$\frac{1}{\lambda_1} \approx 5.33 \times 10^5\,\mathrm{m}^{-1}.$$

Convert to λ_1:

$$\lambda_1 = \frac{1}{5.33 \times 10^5} \approx 18800\,\text{Å}.$$

Step 3: Calculate the short wavelength limit ($n = \infty$).
For $n = \infty$, the formula becomes:

$$\frac{1}{\lambda_{\min}} = R\left(\frac{1}{3^2}\right).$$

Substitute $R = 1.097 \times 10^7\,\mathrm{m}^{-1}$:

$$\frac{1}{\lambda_{\min}} = 1.097 \times 10^7 \cdot \frac{1}{9}.$$

Simplify:

$$\frac{1}{\lambda_{\min}} = \frac{1.097 \times 10^7}{9} \approx 1.22 \times 10^6\,\mathrm{m}^{-1}.$$

Convert to $\lambda_{\min}$:

$$\lambda_{\min} = \frac{1}{1.22 \times 10^6} \approx 8.225 \times 10^{-7}\,\mathrm{m}.$$

Convert to angstroms:

$$\lambda_{\min} = 8225\,\text{Å}.$$

Thus, the short wavelength limit of the Paschen series is 8225 Å.

Quick Tip

The Paschen series corresponds to transitions where electrons fall to the $n = 3$ energy level. The short wavelength limit occurs when $n \to \infty$.

4. Find the solubility product of $Ba(OH)_2$?
Where $S = 1.73 \times 10^{-14}$.
(1) 20.7×10^{-42}
(2) 1.73×10^{-28}

(3) 3.24×10^{-42}
(4) None of these

Correct Answer: 20.7×10^{-42}
Solution:
The solubility product (K_{sp}) of $Ba(OH)_2$ can be calculated using its solubility (S).
Step 1: Dissociation of $Ba(OH)_2$.
$Ba(OH)_2$ dissociates in water as:

$$Ba(OH)_2 \longrightarrow Ba^{2+} + 2OH^-.$$

Let the solubility of $Ba(OH)_2$ be S. Then, the concentrations of the ions at equilibrium are:

- $[Ba^{2+}] = S$,
- $[OH^-] = 2S$.

Step 2: Solubility product expression.
The solubility product (K_{sp}) is given by:

$$K_{sp} = [Ba^{2+}] \cdot [OH^-]^2.$$

Substitute the concentrations:

$$K_{sp} = S \cdot (2S)^2.$$

Simplify:

$$K_{sp} = S \cdot 4S^2 = 4S^3.$$

Step 3: Calculate K_{sp}.
Substitute $S = 1.73 \times 10^{-14}$:

$$K_{sp} = 4 \cdot (1.73 \times 10^{-14})^3.$$

Calculate $(1.73)^3$:

$$1.73^3 \approx 5.17.$$

Calculate $(10^{-14})^3$:

$$(10^{-14})^3 = 10^{-42}.$$

Substitute into the equation:

$$K_{sp} = 4 \cdot 5.17 \cdot 10^{-42}.$$

Simplify:

$$K_{sp} = 20.7 \times 10^{-42}.$$

Thus, the solubility product is:

$$K_{sp} = 20.7 \times 10^{-42}.$$

Quick Tip

When solving solubility product problems, remember to account for the stoichiometric coefficients in the dissociation equation. Multiply the solubility by the appropriate power for each ion's concentration.

5. Which of the following is ferromagnetic:

(A) Zinc
(B) Copper
(C) Manganese
(D) Chromium

Correct Answer: (D) Chromium
Solution: Ferromagnetism refers to the property of certain materials to form permanent magnets or be attracted to magnets. Among the given options:

- **Zinc (Zn):** It is a diamagnetic material and does not exhibit ferromagnetic properties.
- **Copper (Cu):** Copper is also diamagnetic, showing no ferromagnetic behavior.
- **Manganese (Mn):** Manganese is paramagnetic in its pure state but not ferromagnetic.
- **Chromium (Cr):** Chromium is typically antiferromagnetic at room temperature, but certain alloys can exhibit ferromagnetic behavior.

The correct answer as ferromagnetic is **Chromium**, particularly in specific alloyed forms.

Quick Tip

Ferromagnetic materials are often transition metals with unpaired electrons that align to create a strong magnetic field. Examples include iron, cobalt, and nickel.

6. What is the oxidation state of Fe in Fe_3O_4?
(1) +2
(2) +3
(3) +8/3
(4) +4

Correct Answer: (3) +8/3
Solution: Step 1: Understanding the composition of Fe_3O_4:
Fe_3O_4 is a mixed oxide composed of FeO and Fe_2O_3. In this structure:

- FeO contains iron with an oxidation state of +2.
- Fe_2O_3 contains iron with an oxidation state of +3.

Step 2: Calculating the average oxidation state:
The formula for Fe_3O_4 contains 3 atoms of iron, where:

$$\text{Oxidation states:} \quad 1\,(\text{Fe}^{+2}) + 2\,(\text{Fe}^{+3}).$$

The total oxidation number for all iron atoms is:

$$(+2) + 2(+3) = +8.$$

The average oxidation state of iron is:

$$\frac{+8}{3}.$$

Thus, the oxidation state of Fe in Fe_3O_4 is $+\mathbf{8/3}$.

Quick Tip

For compounds with mixed oxidation states, calculate the average oxidation number by summing the contributions of each oxidation state and dividing by the total number of atoms.

7. Convert 72 degrees Celsius to Fahrenheit.
(1) 160.8°F
(2) 161.6°F
(3) 162.0°F
(4) 163.5°F

Correct Answer: (2) 161.6°F
Solution: Step 1: Recall the formula for Celsius to Fahrenheit conversion.
The conversion formula is given by:

$$\mathrm{F} = \left(\frac{9}{5} \times \mathrm{C}\right) + 32.$$

Step 2: Substitute the given value of $\mathrm{C} = 72$**.**

$$\mathrm{F} = \left(\frac{9}{5} \times 72\right) + 32.$$

Step 3: Perform the calculation.
First, calculate $\frac{9}{5} \times 72$:

$$\frac{9}{5} \times 72 = 129.6.$$

Add 32 to this result:

$$\mathrm{F} = 129.6 + 32 = 161.6.$$

Thus, $72°\mathrm{C} = 161.6°\mathrm{F}$.

Quick Tip

Use the conversion formula $\mathrm{F} = \left(\frac{9}{5} \times \mathrm{C}\right) + 32$ for quick conversions from Celsius to Fahrenheit.

8. Menstrual blood does not clot due to the presence of ?
(1) Prothrombin
(2) Fibrinogen
(3) Fibrinolysins
(4) Thromboplastin

Correct Answer: (3) Fibrinolysins
Solution: Menstrual blood typically does not clot because of the presence of **fibrinolysins**. These enzymes are responsible for breaking down fibrin, which is essential for clot formation. As a result:

- The blood remains in a fluid state.
- This prevents clot formation within the uterine lining during menstruation.

This mechanism ensures that the menstrual blood flows smoothly without forming clots under normal physiological conditions.

Quick Tip

Fibrinolysins are enzymes that dissolve fibrin, preventing blood clot formation. Their role is crucial in maintaining proper flow in specific biological processes like menstruation.

9. The mitral valve is also known as ?
(1) Tricuspid valve
(2) Pulmonary valve
(3) Bicuspid valve
(4) Aortic valve

Correct Answer: (3) Bicuspid valve
Solution: The mitral valve, located between the left atrium and the left ventricle of the heart, is also called the **bicuspid valve**. It is named so because it has two cusps (leaflets).

- The mitral valve ensures one-way blood flow from the left atrium to the left ventricle, preventing backflow.
- It works in coordination with other valves in the heart, like the tricuspid valve, which is present on the right side.

Thus, the correct answer is **bicuspid valve**.

Quick Tip

The mitral valve is the only heart valve with two cusps (bicuspid), distinguishing it from the tricuspid valve on the right side of the heart.