AP EAPCET 2026 May 15 Shift 1

Question Paper (Memory-Based) with Solutions

Conducted by JNTU, Kakinada

General Instructions

(i) The test is of 3 hours duration.

(ii) This test paper consists of 160 questions. The maximum marks are 160.

(iii) Physics and Chemistry contains 40 questions each and Mathematics contains 80 questions.

(iv) Each question carries +1 marks for correct answer and there is no negative marking for wrong answer.

1. The value of the integral $\int_{-\frac{\pi}{15}}^{\frac{\pi}{15}} \frac{\cos 5x}{1+e^{5x}}\,dx$ is equal to:

(A) $\frac{1}{5}$

(B) $\frac{\sqrt{3}}{10}$

(C) $\frac{1}{15}$

(D) $\frac{1}{10}$

Correct Answer: (B) $\frac{\sqrt{3}}{10}$

Solution:

Concept: The solution utilizes the property of definite integrals often referred to as King's Property. For an integral with symmetric limits $[-a, a]$:

- $\int_a^b f(x)\,dx = \int_a^b f(a+b-x)\,dx$
- This is particularly useful when the integrand contains an exponential term like e^{kx} in the denominator alongside an even function like $\cos x$.

Step 1: Applying the integral property $\int_a^b f(x)\,dx = \int_a^b f(a+b-x)\,dx$.

Let $I = \int_{-\pi/15}^{\pi/15} \frac{\cos 5x}{1+e^{5x}}\,dx \quad \cdots (1)$

Using the property, replace x with $(\frac{\pi}{15} - \frac{\pi}{15} - x) = -x$:

$$I = \int_{-\pi/15}^{\pi/15} \frac{\cos 5(-x)}{1 + e^{5(-x)}} dx = \int_{-\pi/15}^{\pi/15} \frac{\cos 5x}{1 + e^{-5x}} dx$$

Multiplying numerator and denominator by e^{5x}:

$$I = \int_{-\pi/15}^{\pi/15} \frac{e^{5x} \cos 5x}{e^{5x} + 1} dx \quad \cdots (2)$$

Step 2: Adding equations (1) and (2).

$$2I = \int_{-\pi/15}^{\pi/15} \left(\frac{\cos 5x}{1 + e^{5x}} + \frac{e^{5x} \cos 5x}{1 + e^{5x}} \right) dx$$

$$2I = \int_{-\pi/15}^{\pi/15} \frac{\cos 5x (1 + e^{5x})}{1 + e^{5x}} dx = \int_{-\pi/15}^{\pi/15} \cos 5x \, dx$$

Step 3: Evaluating the resulting integral.

Since $\cos 5x$ is an even function:

$$2I = 2\int_{0}^{\pi/15} \cos 5x \, dx \quad \Rightarrow \quad I = \int_{0}^{\pi/15} \cos 5x \, dx$$

$$I = \left[\frac{\sin 5x}{5} \right]_0^{\pi/15} = \frac{1}{5} \left(\sin \frac{5\pi}{15} - \sin 0 \right)$$

$$I = \frac{1}{5} \sin \frac{\pi}{3} = \frac{1}{5} \left(\frac{\sqrt{3}}{2} \right) = \frac{\sqrt{3}}{10}$$

Quick Tip: For any integral $\int_{-a}^{a} \frac{f(x)}{1+p^{g(x)}} dx$ where $f(x)$ is even and $g(x)$ is odd, the value is simply $\int_0^a f(x) dx$.

---

2. The value of the integral $\int_{-\frac{\pi}{8092}}^{\frac{\pi}{8092}} \frac{\sec(2023x)}{1+(2023)^{(2023x)}} dx$ is equal to:

(A) $\frac{1}{2023\sqrt{2}} + C$

(B) $\frac{\log(\sqrt{2}+1)}{2023} + C$

(C) $\frac{\log 2}{4046} + C$

(D) $\frac{\sqrt{2}}{2023} + C$

Correct Answer: (B) $\frac{\log(\sqrt{2}+1)}{2023} + C$

Solution:

Concept: For a definite integral with symmetric limits $[-a, a]$, we use the property:

- $\int_a^b f(x)\,dx = \int_a^b f(a+b-x)\,dx$
- In the form $\int_{-a}^{a} \frac{f(x)}{1+p^{g(x)}}\,dx$, if $f(x)$ is an even function and $g(x)$ is an odd function, the integral simplifies to $\int_0^a f(x)\,dx$.

Step 1: Applying the integral property.

Let $I = \int_{-\pi/8092}^{\pi/8092} \frac{\sec(2023x)}{1+(2023)^{(2023x)}}\,dx \quad \cdots(1)$

Replacing x with $-x$:

$$I = \int_{-\pi/8092}^{\pi/8092} \frac{\sec(2023(-x))}{1+(2023)^{(2023(-x))}}\,dx = \int_{-\pi/8092}^{\pi/8092} \frac{\sec(2023x)}{1+(2023)^{-2023x}}\,dx$$

Simplifying the denominator by multiplying top and bottom by $(2023)^{2023x}$:

$$I = \int_{-\pi/8092}^{\pi/8092} \frac{(2023)^{2023x}\sec(2023x)}{1+(2023)^{2023x}}\,dx \quad \cdots(2)$$

Step 2: Adding equations (1) and (2).

$$2I = \int_{-\pi/8092}^{\pi/8092} \frac{\sec(2023x)[1+(2023)^{2023x}]}{1+(2023)^{2023x}}\,dx$$

$$2I = \int_{-\pi/8092}^{\pi/8092} \sec(2023x)\,dx$$

Using the even property of the secant function ($\sec(-x) = \sec x$):

$$2I = 2\int_0^{\pi/8092} \sec(2023x)\,dx \quad \Rightarrow \quad I = \int_0^{\pi/8092} \sec(2023x)\,dx$$

Step 3: Integrating and applying limits.

Using the standard integral $\int \sec(mx)\,dx = \frac{1}{m}\log|\sec mx + \tan mx|$:

$$I = \left[\frac{1}{2023}\log|\sec(2023x) + \tan(2023x)|\right]_0^{\pi/8092}$$

Substituting the upper limit ($2023 \times \frac{\pi}{8092} = \frac{\pi}{4}$) and lower limit 0:

$$I = \frac{1}{2023}\left[\log(\sec\frac{\pi}{4} + \tan\frac{\pi}{4}) - \log(\sec 0 + \tan 0)\right]$$

$$I = \frac{1}{2023}[\log(\sqrt{2}+1) - \log(1+0)] = \frac{\log(\sqrt{2}+1)}{2023}$$

Quick Tip: The "King's Rule" effectively eliminates the non-symmetric part of the denominator (the exponential term) in symmetric intervals, reducing complex integrals to standard trigonometric forms.

---

3. The value of the integral $\int_0^{32\pi} \sqrt{1-\cos 4x}\, dx$ is equal to:

(A) $16\sqrt{2}$

(B) $32\sqrt{2}$

(C) $128\sqrt{2}$

(D) $64\sqrt{2}$

Correct Answer: (C) $128\sqrt{2}$

Solution:

Concept: The solution involves trigonometric simplification and the property of periodic functions in definite integrals:

- Half-angle formula: $1 - \cos\theta = 2\sin^2(\frac{\theta}{2})$.
- Identity: $\sqrt{x^2} = |x|$.
- Periodic Property: If $f(x)$ is periodic with period T, then $\int_0^{nT} f(x)\,dx = n\int_0^T f(x)\,dx$.

Step 1: Simplifying the integrand using trigonometric identities.

We know that $1 - \cos 4x = 2\sin^2(2x)$. Substituting this into the integral:

$$I = \int_0^{32\pi} \sqrt{2\sin^2(2x)}\,dx = \sqrt{2}\int_0^{32\pi} |\sin 2x|\,dx$$

Step 2: Applying the periodicity property.

The function $f(x) = |\sin 2x|$ is periodic. The period of $\sin x$ is 2π, so the period of $\sin 2x$ is $\frac{2\pi}{2} = \pi$.

However, the period of the absolute value function $|\sin 2x|$ is $\frac{\pi}{2}$.

We can express the upper limit 32π in terms of the period $\frac{\pi}{2}$:

$$32\pi = 64 \times \left(\frac{\pi}{2}\right)$$

Using the property $\int_0^{nT} f(x)\,dx = n\int_0^T f(x)\,dx$:

$$I = \sqrt{2} \times 64 \int_0^{\pi/2} |\sin 2x|\,dx$$

Step 3: Evaluating the definite integral.

In the interval $[0, \pi/2]$, $2x$ ranges from 0 to π. In this range, $\sin 2x$ is non-negative, so we can remove the modulus:

$$I = 64\sqrt{2} \int_0^{\pi/2} \sin 2x\,dx$$

$$I = 64\sqrt{2}\left[\frac{-\cos 2x}{2}\right]_0^{\pi/2} = \frac{64\sqrt{2}}{2}[-\cos(\pi) - (-\cos 0)]$$

$$I = 32\sqrt{2}[-(-1)+1] = 32\sqrt{2}[1+1] = 64\sqrt{2} \times 2 = 128\sqrt{2}$$

Quick Tip: The integral of $|\sin kx|$ or $|\cos kx|$ over one half-period is always $\frac{2}{k}$. For $|\sin 2x|$, the integral over $[0, \pi/2]$ is $\frac{2}{2} = 1$.

---

4. The value of the integral $\int_0^{\pi/2} \sin^6 x \cos^4 x\,dx$ is equal to:

(A) $\frac{\pi}{256}$

(B) $\frac{\pi}{512}$

(C) $\frac{3\pi}{512}$

(D) $\frac{5\pi}{512}$

Correct Answer: (C) $\frac{3\pi}{512}$

Solution:

Concept: To solve integrals of the form $\int_0^{\pi/2} \sin^m x \cos^n x\,dx$, we useWallis' Formula** (or the Gamma function approach):

- Formula: $\frac{[(m-1)(m-3)\cdots 1 \text{ or } 2]\times[(n-1)(n-3)\cdots 1 \text{ or } 2]}{(m+n)(m+n-2)\cdots 1 \text{ or } 2} \times K$

- If both m and n are even, $K = \frac{\pi}{2}$.

- Otherwise, $K = 1$.

Step 1: Identifying parameters m and n.

Given integral: $\int_0^{\pi/2} \sin^6 x \cos^4 x \, dx$ Here, $m = 6$ and $n = 4$. Since both 6 and 4 areeven numbers**, we will use $K = \frac{\pi}{2}$.

Step 2: Applying the reduction formula values.

Numerator terms for $m = 6$: $(6-1)(6-3)(6-5) = 5 \cdot 3 \cdot 1$ Numerator terms for $n = 4$: $(4-1)(4-3) = 3 \cdot 1$ Denominator terms for $m + n = 10$: $10 \cdot 8 \cdot 6 \cdot 4 \cdot 2$

Step 3: Calculating the final value.

$$I = \frac{(5 \cdot 3 \cdot 1) \cdot (3 \cdot 1)}{10 \cdot 8 \cdot 6 \cdot 4 \cdot 2} \times \frac{\pi}{2}$$

Simplifying the fractions:

$$I = \frac{15 \cdot 3}{3840} \times \frac{\pi}{2} = \frac{45}{3840} \times \frac{\pi}{2}$$

Dividing 45 and 3840 by 15:

$$I = \frac{3}{256} \times \frac{\pi}{2} = \frac{3\pi}{512}$$

Quick Tip: Wallis' Formula is the fastest "shortcut" for definite integrals of sine and cosine products with limits from 0 to $\pi/2$. Always check if both powers are even to decide the $\pi/2$ multiplier.

---

5. The value of the integral $\int_{-2\pi}^{2\pi} \sin^4 x \cos^6 x \, dx$ is equal to:

(A) $\frac{3\pi}{128}$

(B) $\frac{9\pi}{32}$

(C) $\frac{9\pi}{64}$

(D) $\frac{3\pi}{64}$

Correct Answer: (C) $\frac{9\pi}{64}$

Solution:

Concept: This problem combines symmetry properties of definite integrals with Wallis' Formula:

- Even Function Property: If $f(-x) = f(x)$, then $\int_{-a}^{a} f(x)\,dx = 2\int_0^a f(x)\,dx$.

- Periodic Property: If $f(x)$ is periodic with period T, then $\int_0^{nT} f(x)\,dx = n\int_0^T f(x)\,dx$.
- Wallis' Formula: Used for $\int_0^{\pi/2} \sin^m x \cos^n x\,dx$.

Step 1: Using symmetry and periodicity to reduce limits.

The integrand $f(x) = \sin^4 x \cos^6 x$ is an even function. Therefore:

$$I = 2\int_0^{2\pi} \sin^4 x \cos^6 x\,dx$$

The function $\sin^4 x \cos^6 x$ is periodic with period π. However, inside the squares/even powers, the behavior repeats every $\pi/2$ in terms of area under the curve. Specifically, $\int_0^{2\pi} = 4\int_0^{\pi/2}$:

$$I = 2 \times 4\int_0^{\pi/2} \sin^4 x \cos^6 x\,dx = 8\int_0^{\pi/2} \sin^4 x \cos^6 x\,dx$$

Step 2: Applying Wallis' Formula.

For $m = 4, n = 6$, both are even, so we multiply by $\frac{\pi}{2}$:

$$\int_0^{\pi/2} \sin^4 x \cos^6 x\,dx = \frac{(3\cdot1)\cdot(5\cdot3\cdot1)}{(10\cdot8\cdot6\cdot4\cdot2)} \times \frac{\pi}{2}$$

$$= \frac{45}{3840} \times \frac{\pi}{2} = \frac{3}{256} \times \frac{\pi}{2} = \frac{3\pi}{512}$$

Step 3: Final Calculation.

Substitute the value back into the expression from Step 1:

$$I = 8 \times \left(\frac{3\pi}{512}\right) = \frac{3\pi}{64}$$

Quick Tip: For $\int_0^{n\pi} \sin^m x \cos^n x\,dx$, if m, n are even, the integral is $2n \times \int_0^{\pi/2}$. For $\int_{-2\pi}^{2\pi}$, that is 4 full periods, or 8 half-periods.

---

6. A body cools from 80°C to 60°C in 5 minutes. Surrounding temperature is 20°C. Time to cool from 60°C to 40°C is:

(A) 5 min

(B) 10 min

(C) 15 min

(D) 20 min

Correct Answer: (B) 10 min

Solution:

Concept: This problem is solved usingNewton's Law of Cooling**, which states that the rate of change of temperature of an object is proportional to the difference between its own temperature and the surrounding temperature.

- Average form formula: $\frac{T_1-T_2}{t} = K\left(\frac{T_1+T_2}{2} - T_s\right)$
- T_1, T_2: Initial and final temperatures of the body.
- T_s: Temperature of the surroundings.
- t: Time taken.

Step 1: Applying the formula for the first case.

Case 1: Body cools from 80°C to 60°C in 5 minutes.

$$\frac{80-60}{5} = K\left(\frac{80+60}{2} - 20\right)$$

$$\frac{20}{5} = K(70-20) \quad \Rightarrow \quad 4 = 50K \quad \Rightarrow \quad K = \frac{4}{50} = \frac{2}{25} \quad \cdots(1)$$

Step 2: Applying the formula for the second case.

Case 2: Body cools from 60°C to 40°C in time t.

$$\frac{60-40}{t} = K\left(\frac{60+40}{2} - 20\right)$$

$$\frac{20}{t} = K(50-20) \quad \Rightarrow \quad \frac{20}{t} = 30K \quad \cdots(2)$$

Step 3: Substituting the value of K to find t.

Substitute $K = \frac{2}{25}$ from equation (1) into equation (2):

$$\frac{20}{t} = 30 \times \left(\frac{2}{25}\right)$$

$$\frac{20}{t} = \frac{60}{25} \quad \Rightarrow \quad \frac{20}{t} = \frac{12}{5}$$

Solving for t:

$$12t = 100 \quad \Rightarrow \quad t = \frac{100}{12} \approx 8.33 \text{ min}$$

Quick Tip: As a body gets closer to the surrounding temperature, its rate of cooling decreases. Therefore, it will always take more time to cover the same temperature drop at lower ranges.

---

7. A gas absorbs 500 J heat and does 200 J work. Change in internal energy is:

(A) 300 J

(B) 500 J

(C) 700 J

(D) -300 J

Correct Answer: (A) 300 J

Solution:

Concept: This problem is based on theFirst Law of Thermodynamics**, which is a statement of the law of conservation of energy. It relates the heat supplied to a system, the work done by the system, and the change in its internal energy.

- Formula: $\Delta U = Q - W$
- ΔU: Change in internal energy.
- Q: Heat added to the system (Positive if absorbed, Negative if released).
- W: Work done by the system (Positive if work is done by gas, Negative if work is done on gas).

Step 1: Identifying the given values with sign conventions.

Heat absorbed by the gas $(Q) = +500$ J (since energy is entering the system).

Work done by the gas $(W) = +200$ J (since the system is doing the work on surroundings).

Step 2: Applying the First Law of Thermodynamics.

Substitute the values into the formula:

$$\Delta U = Q - W$$

$$\Delta U = 500 \text{ J} - 200 \text{ J}$$

$$\Delta U = 300 \text{ J}$$

Step 3: Conclusion.

The internal energy of the gas increases by 300 J. This energy is stored within the gas, typically manifesting as an increase in temperature.

Quick Tip: Think of it like a bank account: 500 J is "deposited" (heat absorbed), and 200 J is "spent" (work done). The balance remaining in the account is the change in internal energy (300 J).

---

8. A gas expands from volume 2 m^3 to 6 m^3 at constant pressure 100 Pa. Work done is:

(A) 200 J

(B) 300 J

(C) 400 J

(D) 600 J

Correct Answer: (C) 400 J

Solution:

Concept: For an isobaric process (a process occurring at constant pressure), the work done by a gas during expansion or compression is given by the product of the constant pressure and the change in volume.

- Formula: $W = P\Delta V$
- P: Constant pressure.
- $\Delta V = V_f - V_i$: Change in volume (Final volume - Initial volume).

Step 1: Identifying the given parameters.

Constant Pressure $(P) = 100$ Pa

Initial Volume $(V_i) = 2 \text{ m}^3$

Final Volume $(V_f) = 6 \text{ m}^3$

Step 2: Calculating the change in volume.

$$\Delta V = V_f - V_i$$

$$\Delta V = 6 \text{ m}^3 - 2 \text{ m}^3 = 4 \text{ m}^3$$

Step 3: Substituting values into the work formula.

$$W = P \times \Delta V$$

$$W = 100 \text{ Pa} \times 4 \text{ m}^3$$

$$W = 400 \text{ J}$$

Quick Tip: On a Pressure-Volume (P-V) diagram, the work done is equal to the area under the curve. For constant pressure, this area is simply a rectangle with height P and width ΔV.

---

9. A Carnot engine operates between 600 K and 300 K. Efficiency is:

(A) 25%

(B) 50%

(C) 75%

(D) 100%

Correct Answer: (B) 50%

Solution:

Concept: The efficiency (η) of a Carnot engine, which is a theoretical ideal thermodynamic cycle, depends solely on the absolute temperatures of the hot reservoir (source) and the cold reservoir (sink).

- Formula: $\eta = 1 - \frac{T_L}{T_H}$
- Efficiency in percentage: $\eta\% = \left(1 - \frac{T_L}{T_H}\right) \times 100$
- T_H: Temperature of the hot reservoir (Source).
- T_L: Temperature of the cold reservoir (Sink).

Step 1: Identifying the given temperatures.

Temperature of the source $(T_H) = 600$ K

Temperature of the sink $(T_L) = 300$ K

Step 2: Substituting values into the efficiency formula.

$$\eta = 1 - \frac{300}{600}$$

$$\eta = 1 - \frac{1}{2} = 0.5$$

Step 3: Converting to percentage.

$$\eta\% = 0.5 \times 100 = 50\%$$

Quick Tip: To maximize the efficiency of a Carnot engine, you must either increase the temperature of the source (T_H) or decrease the temperature of the sink (T_L). A 100% efficient engine is theoretically impossible as it would require a sink at absolute zero (0 K).

---

10. For a gas, $C_p - C_v = R$. If $C_v = 2R$, then C_p is:

(A) R

(B) $2R$

(C) $3R$

(D) $4R$

Correct Answer: (C) $3R$

Solution:

Concept: The relationship between the molar specific heat capacity at constant pressure (C_p) and the molar specific heat capacity at constant volume (C_v) for an ideal gas is known asMayer's Relation**.

- Formula: $C_p - C_v = R$
- C_p: Molar specific heat at constant pressure.
- C_v: Molar specific heat at constant volume.
- R: Universal gas constant.

Step 1: Identifying the given information.

Relationship: $C_p - C_v = R$

Given value: $C_v = 2R$

Step 2: Substituting the value of C_v into Mayer's Relation.

$$C_p - (2R) = R$$

Step 3: Solving for C_p.

To find C_p, move $2R$ to the right side of the equation:

$$C_p = R + 2R$$

$$C_p = 3R$$

Quick Tip: Specific heat at constant pressure (C_p) is always greater than specific heat at constant volume (C_v) because at constant pressure, heat is used not only to increase internal energy but also to do work during expansion.

---

11. Match the water softening methods in List-1 with the chemicals/reagents in List-2:

List -1 (Method)	List -2 (Reagent)
(A) Calgon method	(I) RSO_3H
(B) Ion exchange method	(II) $Ca(OH)_2$
(C) Clark's method	(III) $NaAlSiO_4$
(D) Synthetic resin method	(IV) $Na_6(PO_3)_6$

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

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

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

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

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

Solution:

Concept: Water softening is the process of removing calcium, magnesium, and certain other metal cations in hard water. Various chemical and physical methods are used:

- **Calgon method:** Uses sodium hexametaphosphate to form complex soluble salts with calcium and magnesium ions.

- **Ion exchange method (Permutit):** Uses zeolites (hydrated sodium aluminum silicate) to exchange sodium ions with hardness-causing ions.

- **Clark's method:** A chemical method involving the addition of a calculated amount of lime to remove temporary hardness.

- **Synthetic resin method:** Uses organic polymers with acidic or basic groups (like sulfonic acid groups) for cation/anion exchange.

Step 1: Matching Calgon method.
Calgon is a trade name forSodium hexametaphosphate**, represented by the formula$Na_6(PO_3)_6$**. Therefore,A matches with IV**.
Step 2: Matching Ion exchange and Clark's method.
The Ion exchange method (Zeolite process) usesSodium aluminum silicate**, formula$NaAlSiO_4$**. Therefore,B matches with III**.
Clark's method specifically involves the addition ofSlaked lime**, formula$Ca(OH)_2$**, to precipitate carbonates. Therefore,C matches with II**.
Step 3: Matching Synthetic resin method.
Synthetic resins used for cation exchange are large organic molecules containing groups like-SO_3H** (sulfonic acid groups), represented asRSO_3H**. Therefore,D matches with I**.

Quick Tip: Remember:C**algon =C**omplex (Sodium hexametaphosphate),C**lark's =C**alcium hydroxide (Lime). This "C" mnemonic helps distinguish the two chemical methods.

---

12. Match the elements in List-1 with their characteristic flame colors in List-2:

List -1 (Element)	List -2 (Flame Color)
(A) Na	(I) Apple green
(B) Ca	(II) yellow
(C) Ba	(III) Brick red
(D) Li	(IV) Crimson red

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

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

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

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

Correct Answer: (b) A-II, B-III, C-I, D-IV

Solution:

Concept: TheFlame Test** is an analytical procedure used in chemistry to detect the presence of certain elements, primarily metal ions, based on each element's characteristic emission spectrum. When an element is heated, its electrons get excited to higher energy levels. As they drop back to the ground state, they emit energy in the form of light with specific wavelengths (colors).

- **Sodium (Na):** Emits a very strong and persistent characteristic yellow light.
- **Calcium (Ca):** Produces a distinctive brick-red (orange-red) flame.
- **Barium (Ba):** Known for its pale green or "apple green" flame color.
- **Lithium (Li):** Characterized by a bright crimson red flame.

Step 1: Matching Alkali Metals (Na and Li).

Sodium (**Na**) is well-known for producing a brilliantyellow** flame. Therefore,A matches with II**. Lithium (**Li**) produces a deepcrimson red** flame. Therefore,D matches with IV**.

Step 2: Matching Alkaline Earth Metals (Ca and Ba).

Calcium (**Ca**) gives abrick red** color to the flame. Therefore,B matches with III**. Barium (**Ba**) results in anapple green** flame. Therefore,C matches with I**.

Step 3: Final Verification.

Checking the combination: A-II, B-III, C-I, D-IV. This aligns perfectly with option (b).

Quick Tip: To remember the reds:L**ithium isL**ovely Crimson (purplish red), whileC**alcium is like aC**ommon brick (orange-red). For Barium, think of a greenBa**nana or apple.

---

13. In graphite, the C-C bond length within the layer is X pm and the distance between two adjacent layers is Y pm. X and Y respectively are:

(A) 340 , 141.5

(B) 141.5 , 340

(C) 141.5 , 154

(D) 143.5 , 340

Correct Answer: (B) 141.5 , 340

Solution:

Concept: Graphite has a unique layered structure consisting of hexagonal rings of carbon atoms. Understanding the bonding within and between these layers explains its physical properties:

- **Intra-layer bonding:** Carbon atoms within a layer are sp^2 hybridized and held together by strong covalent bonds. The bond length is shorter than a standard single bond (154 pm) due to partial double bond character.
- **Inter-layer bonding:** The planar layers are held together by weak van der Waals forces. This results in a much larger distance between the layers.

Step 1: Determining the intra-layer bond length (X).

In each hexagonal layer of graphite, the C-C distance is significantly shorter because the atoms are closely packed and covalently bonded. This value is standardly measured at141.5 pm**.

Step 2: Determining the inter-layer distance (Y).

Because the layers are held by weak forces rather than chemical bonds, they are spread further apart. This large gap allows the layers to slide over each other, making graphite a good lubricant. This distance is340 pm**.

Step 3: Arranging in the required order.

The question asks for X (bond length) and Y (layer distance) respectively:

$$X = 141.5 \text{ pm}$$

$$Y = 340 \text{ pm}$$

This matches option (B).

Quick Tip: Standard C-C single bond (diamond) is 154 pm. In graphite, the covalent bond is shorter (141.5 pm) because of sp^2 hybridization, but the "gap" between sheets is huge (340 pm) because there is no actual bond there.

---

14. Match the Xenon compounds in List-I with their molecular geometries in List-II:

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

List - I (Compound)	List - II (Geometry)
(A) XeF_2	(I) Trigonal pyramidal
(B) XeO_3	(II) Distorted octahedral
(C) XeF_6	(III) Linear
(D) $XeOF_4$	(IV) Square pyramidal

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

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

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

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

Solution:

Concept: Molecular geometry is determined using VSEPR (Valence Shell Electron Pair Repulsion) theory. We calculate the number of bonding pairs and lone pairs on the central Xenon atom (which has 8 valence electrons).

- **XeF_2:** 2 bond pairs + 3 lone pairs. Total 5 electron pairs (sp^3d). Lone pairs occupy equatorial positions, making the shape **Linear**.
- **XeO_3:** 3 bond pairs (double bonds) + 1 lone pair. Total 4 electron domains (sp^3). The shape is **Trigonal pyramidal**.
- **XeF_6:** 6 bond pairs + 1 lone pair. Total 7 electron pairs (sp^3d^3). The lone pair causes distortion, resulting in a **Distorted octahedral** geometry.
- **$XeOF_4$:** 5 bond pairs (4 F + 1 O) + 1 lone pair. Total 6 electron domains (sp^3d^2). The shape is **Square pyramidal**.

Step 1: Matching XeF_2 and XeO_3.

XeF_2 has a linear geometry because the three lone pairs cancel each other out in the equatorial plane. Thus,A matches with III**. XeO_3 is analogous to ammonia (NH_3) with one lone pair. Thus,B matches with I**.

Step 2: Matching XeF_6 and $XeOF_4$.

XeF_6 is the classic example of a capped or distorted octahedron. Thus,C matches with II**. $XeOF_4$ has an octahedral electron geometry, but with one oxygen and one lone pair, the atoms form a square pyramid. Thus,D matches with IV**.

Step 3: Final Match.

Combining these results gives the sequence A-III, B-I, C-II, D-IV, which corresponds to option (a).

Quick Tip: To quickly find the geometry of Xenon compounds, count valence electrons (8), subtract electrons used for bonds (1 per F, 2 per O), and divide the remainder by 2 to get lone pairs. Ex: $XeF_2 \rightarrow$ (8 - 2)/2 = 3 lone pairs.

---

15. 248 g of ethylene glycol ($C_2H_6O_2$) is added to 200 g of water to prepare antifreeze. What is the molality of the resultant solution?

(A) 5 m

(B) 10 m

(C) 20 m

(D) 40 m

Correct Answer: (C) 20 m

Solution:

Concept: Molality (m) is a measure of the concentration of a solute in a solution in terms of the amount of substance in a specified amount of mass of the solvent.

- Formula: Molality (m) $= \frac{\text{Number of moles of solute}}{\text{Mass of solvent in kg}}$
- Moles (n) $= \frac{\text{Given mass}}{\text{Molar mass}}$

Step 1: Calculating the molar mass of ethylene glycol ($C_2H_6O_2$).

Atomic masses: $C = 12, H = 1, O = 16$

$$\text{Molar mass} = (2 \times 12) + (6 \times 1) + (2 \times 16)$$

$$= 24 + 6 + 32 = 62 \text{ g/mol}$$

Step 2: Calculating the number of moles of solute.

Given mass of solute = 248 g

$$n = \frac{248}{62} = 4 \text{ moles}$$

Step 3: Substituting values into the molality formula.

Mass of solvent (water) = 200 g = 0.2 kg

$$m = \frac{4 \text{ moles}}{0.2 \text{ kg}}$$

$$m = \frac{40}{2} = 20 \text{ m}$$

Quick Tip: Always distinguish between Molality (m) and Molarity (M). Molality uses the mass of the **solvent** in kg, while Molarity uses the volume of the **solution** in liters. Molality is temperature-independent.
