AP EAPCET 2026 May 14 Shift 1

Question Paper (Memory-Based) with Solutions

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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. If the system of equations $2x + py + 6z = 8$, $x + 2y + qz = 5$ **and** $x + y + 3z = 4$ **has infinitely many solutions, then** $p =$

(A) -1

(B) 2

(C) 3

(D) -3

Correct Answer: (B) 2

Solution:

Concept: For a system of linear equations to have infinitely many solutions, the equations must be linearly dependent. This typically means that one equation can be expressed as a linear combination of the others, or the determinant of the coefficient matrix (Δ) and the determinants $\Delta_x, \Delta_y, \Delta_z$ must all be zero.

Step 1: Comparing Equation 1 and Equation 3

Equation 1: $2x + py + 6z = 8$

Equation 3: $x + y + 3z = 4$

Notice that if we multiply Equation 3 by 2, we get:

$$2(x+y+3z)=2(4) \quad \Rightarrow \quad 2x+2y+6z=8$$

Step 2: Equating the coefficients to find p.

For the system to have infinitely many solutions, Equation 1 and the modified Equation 3 must represent the same plane (or Equation 1 must be a multiple of Equation 3). Comparing $2x+py+6z=8$ with $2x+2y+6z=8$: Matching the coefficients of y:

$$p=2$$

Step 3: Verification with Equation 2 (Optional for p).

Although not required to find p, the value of q can be found by ensuring Equation 2 is also consistent. Subtracting Eq(3) from Eq(2):

$$(x+2y+qz)-(x+y+3z)=5-4$$

$$y+(q-3)z=1$$

Since we found from Eq(1) and Eq(3) that $y=1-3z+\text{const}$, the system remains consistent. Specifically, $p=2$ satisfies the primary dependency.

Quick Tip: Always look for proportional equations first! If the coefficients of x,z and the constant term in one equation are a direct multiple of another, the remaining coefficient must follow that same multiple for infinite solutions to be possible.

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2. If the system of simultaneous linear equations $x+\lambda y-2z=1$, $x-y+\lambda z=2$ and $x-2y+3z=3$ is inconsistent for $\lambda=\lambda_1$ and λ_2, then $\lambda_1+\lambda_2=$

(A) 5

(B) $\sqrt{5}$

(C) 1

(D) -1

Correct Answer: (C) 1

Solution:

Concept: A system of non-homogeneous linear equations is inconsistent if the determinant of the coefficient matrix (Δ) is zero, but at least one of the determinants Δ_x, Δ_y, or Δ_z is non-zero. For this problem, we first find the values of λ that make $\Delta = 0$.

Step 1: Find the values of λ for which the determinant $\Delta = 0$.

The coefficient matrix is:

$$\Delta = \begin{vmatrix} 1 & \lambda & -2 \\ 1 & -1 & \lambda \\ 1 & -2 & 3 \end{vmatrix}$$

Expanding along the first row:

$$\Delta = 1(-3+2\lambda) - \lambda(3-\lambda) - 2(-2+1) = 0$$

$$-3 + 2\lambda - 3\lambda + \lambda^2 + 2 = 0$$

$$\lambda^2 - \lambda - 1 = 0$$

Step 2: Apply the properties of quadratic equations.

The values λ_1 and λ_2 are the roots of the quadratic equation $\lambda^2 - \lambda - 1 = 0$. For any quadratic equation $a\lambda^2 + b\lambda + c = 0$, the sum of the roots is given by $-\frac{b}{a}$. Here, $a = 1$ and $b = -1$.

$$\lambda_1 + \lambda_2 = -\frac{-1}{1} = 1$$

Step 3: Verify inconsistency.

For inconsistency, we must ensure Δ_x, Δ_y, or $\Delta_z \neq 0$ for these roots.

$$\Delta_x = \begin{vmatrix} 1 & \lambda & -2 \\ 2 & -1 & \lambda \\ 3 & -2 & 3 \end{vmatrix} = 1(-3+2\lambda) - \lambda(6-3\lambda) - 2(-4+3)$$

$$\Delta_x = -3 + 2\lambda - 6\lambda + 3\lambda^2 + 2 = 3\lambda^2 - 4\lambda - 1$$

Substituting $\lambda^2 = \lambda + 1$ from our previous equation:

$$\Delta_x = 3(\lambda+1) - 4\lambda - 1 = 3\lambda + 3 - 4\lambda - 1 = 2 - \lambda$$

Since the roots of $\lambda^2 - \lambda - 1 = 0$ are $\frac{1\pm\sqrt{5}}{2}$, $\Delta_x \neq 0$. Thus, the system is inconsistent for these values.

Quick Tip: When a question asks for the sum or product of parameters that make a system inconsistent, don't waste time solving for the exact roots. Form the quadratic equation for $\Delta = 0$ and use Vieta's formulas (Sum $= -b/a$) to get the answer instantly.

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3. If [ ] denotes the greatest integer function, then $\int_1^2 [x^2]dx =$

(A) $5 + \sqrt{2} + \sqrt{3}$

(B) $5 + \sqrt{2} - \sqrt{3}$

(C) $5 - \sqrt{2} - \sqrt{3}$

(D) $5 - \sqrt{2} + \sqrt{3}$

Correct Answer: (C) $5 - \sqrt{2} - \sqrt{3}$

Solution:

Concept: The Greatest Integer Function $[f(x)]$ changes its value at points where $f(x)$ becomes an integer. To integrate such a function, we must split the interval of integration at these critical points and evaluate the constant value of the function within each sub-interval.

Step 1: Identify the critical points for $[x^2]$ in the interval $[1, 2]$.

As x varies from 1 to 2, x^2 varies from $1^2 = 1$ to $2^2 = 4$. The integers between 1 and 4 are $1, 2, 3$, and 4. The function $[x^2]$ will change at:

- $x^2 = 1 \Rightarrow x = 1$
- $x^2 = 2 \Rightarrow x = \sqrt{2}$
- $x^2 = 3 \Rightarrow x = \sqrt{3}$
- $x^2 = 4 \Rightarrow x = 2$

Step 2: Split the integral based on these intervals.

We can rewrite the integral as:

$$I = \int_1^{\sqrt{2}} [x^2]dx + \int_{\sqrt{2}}^{\sqrt{3}} [x^2]dx + \int_{\sqrt{3}}^{2} [x^2]dx$$

Step 3: Evaluate the constant values of $[x^2]$ in each sub-interval.

- For $1 \le x < \sqrt{2}$, $1 \le x^2 < 2$, so $[x^2] = 1$.
- For $\sqrt{2} \le x < \sqrt{3}$, $2 \le x^2 < 3$, so $[x^2] = 2$.
- For $\sqrt{3} \le x < 2$, $3 \le x^2 < 4$, so $[x^2] = 3$.

Step 4: Perform the integration.

$$I = \int_1^{\sqrt{2}} 1dx + \int_{\sqrt{2}}^{\sqrt{3}} 2dx + \int_{\sqrt{3}}^{2} 3dx$$

$$I = [x]_1^{\sqrt{2}} + [2x]_{\sqrt{2}}^{\sqrt{3}} + [3x]_{\sqrt{3}}^{2}$$

$$I = (\sqrt{2}-1) + (2\sqrt{3}-2\sqrt{2}) + (6-3\sqrt{3})$$

$$I = \sqrt{2}-1+2\sqrt{3}-2\sqrt{2}+6-3\sqrt{3}$$

$$I = 5-\sqrt{2}-\sqrt{3}$$

Quick Tip: For definite integrals involving $[x^2]$, the critical points are always the square roots of integers. The result of such an integral can be visualized as the sum of areas of rectangles with heights equal to the integer values of the function.

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4. The value of the integral $\int_0^4 ||x-2|-x|dx =$

(A) 2

(B) 3

(C) 6

(D) 12

Correct Answer: (C) 6

Solution:

Concept: To evaluate an integral involving absolute values, we must resolve the modulus signs by identifying where the expression inside the modulus changes sign. This requires splitting the interval of integration at the "critical points" where the internal expressions equal zero.

Step 1: Resolve the inner modulus $|x-2|$ based on the interval $[0,4]$.

The function is $f(x) = ||x-2|-x|$. The inner modulus $|x-2|$ behaves differently at $x = 2$:

- For $0 \le x < 2$, $|x-2| = -(x-2) = 2-x$.
- For $2 \le x \le 4$, $|x-2| = x-2$.

Step 2: Simplify the function in sub-intervals.

Case 1: $0 \le x < 2$

$$f(x) = |(2-x)-x| = |2-2x| = 2|1-x|$$

This further splits at $x = 1$:

- For $0 \le x < 1$, $f(x) = 2(1-x) = 2-2x$.
- For $1 \le x < 2$, $f(x) = 2(x-1) = 2x-2$.

Case 2: $2 \le x \le 4$

$$f(x) = |(x-2)-x| = |-2| = 2$$

Step 3: Evaluate the definite integral by splitting it.

$$I = \int_0^1 (2-2x)dx + \int_1^2 (2x-2)dx + \int_2^4 2dx$$

$$I = \left[2x - x^2\right]_0^1 + \left[x^2 - 2x\right]_1^2 + [2x]_2^4$$

$$I = (2-1) + (4-4-(1-2)) + (8-4)$$

$$I = 1 + (0-(-1)) + 4$$

$$I = 1+1+4 = 6$$

Quick Tip: For nested modulus functions, always work from the "inside out." Once the inner modulus is simplified for a specific range, the resulting expression is much easier to manage.

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5. The value of the integral $\int_0^2 x^2(2-x)^5\,dx$ is:

(A) $\frac{128}{21}$

(B) $\frac{64}{7}$
(C) $\frac{32}{21}$
(D) $\frac{16}{7}$

Correct Answer: (c) $\frac{32}{21}$

Solution:

Concept: Based on the problem, we utilize the specific property of definite integrals:

$$\int_0^a f(x)\,dx = \int_0^a f(a-x)\,dx$$

This substitution simplifies the term $(2-x)^5$ into x^5, making the polynomial expansion much easier to integrate. Alternatively, one can use the Beta function identity for $\int_0^a x^m(a-x)^n dx$.

Step 1: Applying the integral property.

Let $I = \int_0^2 x^2(2-x)^5\,dx$. Applying the property $\int_0^a f(x)\,dx = \int_0^a f(a-x)\,dx$, we substitute x with $(2-x)$:

$$I = \int_0^2 (2-x)^2(2-(2-x))^5\,dx$$

$$I = \int_0^2 (4-4x+x^2)x^5\,dx$$

Step 2: Expanding and integrating.

Distribute x^5 into the parentheses:

$$I = \int_0^2 (4x^5 - 4x^6 + x^7)\,dx$$

Integrating term by term:

$$I = \left[4\frac{x^6}{6} - 4\frac{x^7}{7} + \frac{x^8}{8}\right]_0^2$$

$$I = \left[\frac{2}{3}x^6 - \frac{4}{7}x^7 + \frac{1}{8}x^8\right]_0^2$$

Step 3: Calculating the final value.

Substitute the upper limit $x = 2$:

$$I = \frac{2}{3}(64) - \frac{4}{7}(128) + \frac{1}{8}(256)$$

$$I = \frac{128}{3} - \frac{512}{7} + 32$$

Using a common denominator of 21:

$$I = \frac{128(7) - 512(3) + 32(21)}{21}$$

$$I = \frac{896 - 1536 + 672}{21} = \frac{32}{21}$$

Quick Tip: For integrals of the form $\int_0^a x^m(a-x)^n dx$, you can use the shortcut:

$$\text{Result} = a^{m+n+1}\frac{m!n!}{(m+n+1)!}$$

Here, $2^{2+5+1}\frac{2!5!}{8!} = 256 \cdot \frac{2\times120}{40320} = \frac{256}{168} = \frac{32}{21}$.

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6. Pressure of 2×10^6 Pa causes volume decrease of 0.1% in a material. Bulk modulus is:

(A) 2×10^9 Pa

(B) 2×10^{10} Pa

(C) 1×10^{10} Pa

(D) 5×10^9 Pa

Correct Answer: (A) 2×10^9 Pa

Solution:

Concept: The problem relates to the elastic properties of matter. The Bulk modulus (B) is defined as the ratio of volumetric stress (pressure) to volumetric strain. It is a measure of how resistant a substance is to compression.

$$B = \frac{\Delta P}{-\frac{\Delta V}{V}}$$

Where:

- ΔP is the change in pressure.
- $\frac{\Delta V}{V}$ is the volumetric strain (fractional change in volume).

Step 1: Identify the given values.

From the question:

- Pressure $(\Delta P) = 2 \times 10^6$ Pa
- Percentage decrease in volume $= 0.1\%$

Calculating volumetric strain $(\frac{\Delta V}{V})$:

$$\frac{\Delta V}{V} = \frac{0.1}{100} = 10^{-3}$$

Step 2: Calculate the Bulk Modulus.

Using the formula:

$$B = \frac{\Delta P}{\frac{\Delta V}{V}}$$

$$B = \frac{2 \times 10^6}{10^{-3}}$$

$$B = 2 \times 10^6 \times 10^3$$

$$B = 2 \times 10^9 \text{ Pa}$$

Quick Tip: When the volume decrease is given as a percentage, the strain is simply $\frac{\%\text{ change}}{100}$. If $\Delta V/V$ is 10^{-n}, the exponent of 10 in the result will increase by n.

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7. A wire extends by 1 mm under 100 N. Extension under 300 N is:

(A) 1 mm

(B) 2 mm

(C) 3 mm

(D) 4 mm

Correct Answer: (C) 3 mm

Solution:

Concept: The problem is based on Hooke's Law, which states that within the elastic limit, the extension (ΔL) of a material is directly proportional to the force (F) applied to it.

$$F \propto \Delta L \quad \Rightarrow \quad F = k\Delta L$$

where k is the force constant of the wire.

Step 1: Establish the relationship between Force and Extension.

Since the same wire is used, the proportionality remains constant:

$$\frac{F_1}{\Delta L_1} = \frac{F_2}{\Delta L_2}$$

Step 2: Substitute the given values.

From the question:

- Initial force $(F_1) = 100$ N
- Initial extension $(\Delta L_1) = 1$ mm
- Final force $(F_2) = 300$ N

Plugging these into the ratio:

$$\frac{100}{1} = \frac{300}{\Delta L_2}$$

Step 3: Solve for the new extension.

$$\Delta L_2 = \frac{300 \times 1}{100}$$

$$\Delta L_2 = 3 \text{ mm}$$

Quick Tip: For linear relationships like Hooke's Law, if the force becomes 'n' times, the extension also becomes 'n' times. Here, since 300 N is 3 times 100 N, the extension is simply 3×1 mm $= 3$ mm.

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8. Water flows in a horizontal pipe. At a point where speed is 2 m/s, pressure is 2000 Pa. At another point, speed becomes 4 m/s. Find pressure at second point. (Density $= 1000$ kg/m^3)

(A) 8000 Pa

(B) 14000 Pa

(C) 2000 Pa

(D) -4000 Pa

Correct Answer: (D) -4000 Pa

Solution:

Concept: For a fluid flowing through a horizontal pipe, Bernoulli's principle states that the sum of pressure energy and kinetic energy per unit volume remains constant.

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

Where:

- P is the pressure.
- ρ is the density of the fluid.
- v is the velocity of the fluid.

Step 1: Identify the given values.

From the question:

- Initial pressure $(P_1) = 2000$ Pa
- Initial speed $(v_1) = 2$ m/s
- Final speed $(v_2) = 4$ m/s
- Density of water $(\rho) = 1000$ kg/m^3

Step 2: Apply Bernoulli's equation.

Rearrange the formula to solve for P_2:

$$P_2 = P_1 + \frac{1}{2}\rho(v_1^2 - v_2^2)$$

Substitute the values:

$$P_2 = 2000 + \frac{1}{2}(1000)(2^2 - 4^2)$$

$$P_2 = 2000 + 500(4 - 16)$$

Step 3: Calculate the final pressure.

$$P_2 = 2000 + 500(-12)$$

$$P_2 = 2000 - 6000$$

$$P_2 = -4000 \text{ Pa}$$

Quick Tip: In a horizontal pipe, as the speed of the fluid increases, the pressure must decrease to satisfy Bernoulli's principle. Since the speed doubled, the kinetic energy term increased fourfold, leading to a significant drop in pressure.

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9. A pipe has cross-sectional areas 4 cm^2 and 1 cm^2. If velocity in the wider section is 2 m/s, velocity in the narrower section is:

(A) 2 m/s

(B) 4 m/s

(C) 8 m/s

(D) 16 m/s

Correct Answer: (C) 8 m/s

Solution:

Concept: For an incompressible fluid flowing through a pipe of varying cross-section, the principle of continuity applies. It states that the mass flow rate remains constant throughout the pipe, which leads to the equation:

$$A_1 v_1 = A_2 v_2$$

Where:

- A is the cross-sectional area.
- v is the velocity of the fluid at that section.

Step 1: Identify the given values.

From the provided problem data:

- Area of wider section $(A_1) = 4$ cm^2
- Velocity in wider section $(v_1) = 2$ m/s
- Area of narrower section $(A_2) = 1$ cm^2

Step 2: Apply the Equation of Continuity.

Substitute the known values into the formula:

$$(4\ \text{cm}^2) \times (2\ \text{m/s}) = (1\ \text{cm}^2) \times v_2$$

$$8\ \text{cm}^2 \cdot \text{m/s} = 1\ \text{cm}^2 \cdot v_2$$

Step 3: Solve for the unknown velocity.

$$v_2 = \frac{8}{1}\ \text{m/s}$$

$$v_2 = 8\ \text{m/s}$$

Quick Tip: The velocity of a fluid is inversely proportional to the cross-sectional area ($v \propto 1/A$). If the area decreases by a factor of 4 (from 4 to 1), the velocity must increase by a factor of 4 ($2 \times 4 = 8$).

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10. A soap bubble of radius 1 cm has surface tension 0.03 N/m. Excess pressure inside is:

(A) 3 Pa

(B) 6 Pa

(C) 12 Pa

(D) 24 Pa

Correct Answer: (C) 12 Pa

Solution:

Concept: The excess pressure inside a soap bubble is due to surface tension. Unlike a liquid drop which has only one free surface, a soap bubble has two free surfaces (inner and outer). Therefore, the formula for excess pressure (ΔP) is:

$$\Delta P = \frac{4T}{R}$$

Where:

- T is the surface tension of the soap solution.
- R is the radius of the bubble.

Step 1: Identify and convert the given values.

From the question:

- Surface tension $(T) = 0.03$ N/m
- Radius $(R) = 1$ cm $= 0.01$ m (converting to SI units)

Step 2: Apply the excess pressure formula.

Substitute the values into the equation:

$$\Delta P = \frac{4 \times 0.03}{0.01}$$

$$\Delta P = \frac{0.12}{0.01}$$

Step 3: Calculate the final result.

$$\Delta P = 12 \text{ Pa}$$

Quick Tip: Always remember the difference between a liquid drop ($\frac{2T}{R}$) and a soap bubble ($\frac{4T}{R}$). The "double surface" of the soap bubble doubles the excess pressure compared to a drop of the same size and surface tension.

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11. An organic compound has the empirical formula CH_2O. Its vapour density is 45. The molecular formula of compound is

(A) CH_2O

(B) C_2H_5O

(C) $C_2H_4O_2$

(D) $C_3H_6O_3$

Correct Answer: (D) $C_3H_6O_3$

Solution:

Concept: The relationship between molecular formula and empirical formula is given by:

$$\text{Molecular Formula} = n \times (\text{Empirical Formula})$$

To find the multiplier n, we use the formula:

$$n = \frac{\text{Molecular Mass}}{\text{Empirical Formula Mass}}$$

Additionally, the molecular mass of a compound is twice its vapour density:

$$\text{Molecular Mass} = 2 \times \text{Vapour Density}$$

Step 1: Calculate the Empirical Formula Mass.

The empirical formula is CH_2O.

- Mass of C $= 1 \times 12 = 12$
- Mass of H $= 2 \times 1 = 2$
- Mass of O $= 1 \times 16 = 16$
- Empirical Formula Mass $= 12 + 2 + 16 = 30$

Step 2: Calculate the Molecular Mass.

Given vapour density is 45.

$$\text{Molecular Mass} = 2 \times 45 = 90$$

Step 3: Determine the value of n and the Molecular Formula.

$$n = \frac{90}{30} = 3$$

Now, multiply the empirical formula by n:

$$\text{Molecular Formula} = 3 \times (CH_2O) = C_3H_6O_3$$

Quick Tip: In competitive exams, if you've already calculated the molecular mass (90), you can quickly check the options to see which one sums to that mass. For (D): $(3 \times 12)+(6 \times 1)+(3 \times 16) = 36+6+48 = 90$.

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12. At 273 K the maximum work done when pressure on 10g of hydrogen is reduced from 10atm to 1 atm under isothermal, reversible conditions is

(A) -52.18kj

(B) +26.09kj

(C) -26.09kj

(D) +52.18kj

Correct Answer: (C) -26.09kj

Solution:

Concept: For an isothermal, reversible expansion of an ideal gas, the work done (W) is calculated using the formula:

$$W = -2.303\, nRT \log\left(\frac{P_1}{P_2}\right)$$

Where:

- n is the number of moles of the gas.
- R is the gas constant ($8.314\,\mathrm{J/mol \cdot K}$).
- T is the absolute temperature.
- P_1 and P_2 are the initial and final pressures.

Step 1: Calculate the number of moles of Hydrogen (H_2).

Given mass $= 10\,\mathrm{g}$. Molar mass of $H_2 = 2\,\mathrm{g/mol}$.

$$n = \frac{10}{2} = 5\,\mathrm{moles}$$

Step 2: Substitute values into the work formula.

Given $T = 273\,\text{K}$, $P_1 = 10\,\text{atm}$, and $P_2 = 1\,\text{atm}$.

$$W = -2.303 \times 5 \times 8.314 \times 273 \times \log\left(\frac{10}{1}\right)$$

$$W = -2.303 \times 5 \times 8.314 \times 273 \times 1$$

Step 3: Calculate the final value in kilojoules.

$$W \approx -26145\,\text{J}$$

Converting to kilojoules:

$$W \approx -26.145\,\text{kJ}$$

Based on the options, the closest value is $-26.09\,\text{kj}$.

Quick Tip: Work done by the system (expansion) is always negative according to IUPAC convention. Since pressure is reduced (expansion), you can immediately eliminate options (b) and (d).

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13. For the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, $\Delta H = ?$

(A) ΔE + 2RT

(B) ΔE - 2RT

(C) ΔH = RT

(D) ΔE - RT

Correct Answer: (B) ΔE - 2RT

Solution:

Concept: The relationship between enthalpy change (ΔH) and internal energy change (ΔE or ΔU) for a gaseous reaction is given by the formula:

$$\Delta H = \Delta E + \Delta n_g RT$$

Where:

- Δn_g is the change in the number of moles of gaseous products and reactants.

- R is the universal gas constant.
- T is the absolute temperature.

Step 1: Calculate Δn_g for the given reaction.

The chemical equation is:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

- Moles of gaseous products $(n_p) = 2$
- Moles of gaseous reactants $(n_r) = 1(\text{for } N_2) + 3(\text{for } H_2) = 4$

$$\Delta n_g = n_p - n_r = 2 - 4 = -2$$

Step 2: Substitute Δn_g into the relationship formula.

Using the formula $\Delta H = \Delta E + \Delta n_g RT$:

$$\Delta H = \Delta E + (-2)RT$$

$$\Delta H = \Delta E - 2RT$$

Quick Tip: To find Δn_g quickly, only sum the coefficients of substances in the gaseous state. If Δn_g is negative, $\Delta H < \Delta E$; if positive, $\Delta H > \Delta E$; and if zero, $\Delta H = \Delta E$.

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14. For which of the following process entropy change (ΔS) is negative ?

I) Sublimation of dry ice

II) Freezing of water

III) Crystallisation of the dissolved substance

IV) Burning of rocket fuel

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

Correct Answer: (B) II, III only

Solution:

Concept: Entropy (S) is a measure of the degree of randomness or disorder in a system. A negative entropy change ($\Delta S < 0$) indicates that the system is becoming more ordered.

- Gas > Liquid > Solid (Order increases → ΔS is negative)
- Solid > Liquid > Gas (Disorder increases → ΔS is positive)

Step 1: Analyze each process.

- **I) Sublimation of dry ice:** Solid CO_2 turns into gaseous CO_2. Disorder increases, so ΔS is positive.
- **II) Freezing of water:** Liquid water turns into solid ice. The molecules become fixed in a lattice, increasing order. Thus, ΔS is **negative**.
- **III) Crystallisation of the dissolved substance:** Solute particles move from a random state in a solution to a highly ordered crystalline solid. Thus, ΔS is **negative**.
- **IV) Burning of rocket fuel:** Chemical combustion typically releases a large volume of gases from solid or liquid propellants. Disorder increases significantly, so ΔS is positive.

Step 2: Conclusion.

Based on the analysis , processes II and III result in a decrease in randomness.

Quick Tip: To quickly determine the sign of ΔS, look at the change in physical state. Phase changes towards "Solid" (Freezing, Condensation, Deposition) usually have $-\Delta S$, while changes towards "Gas" (Melting, Evaporation, Sublimation) have $+\Delta S$.

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15. The signs of ΔH and Δs for a reaction to be spontaneous at all temperatures respectively are

(A) Positive , positive

(B) Positive , negative

(C) Negative , negative

(D) Negative , positive

Correct Answer: (D) Negative , positive

Solution:

Concept: The spontaneity of a chemical reaction is determined by the Gibbs free energy change (ΔG). A reaction is spontaneous only when $\Delta G < 0$. The relationship is given by the Gibbs-Helmholtz equation:

$$\Delta G = \Delta H - T\Delta S$$

Where:

- ΔH is the change in enthalpy.
- T is the absolute temperature (always positive in Kelvin).
- ΔS is the change in entropy.

Step 1: Determine the conditions for spontaneity at all temperatures.

To ensure ΔG is always negative regardless of the value of T:

1. The enthalpy term (ΔH) should be **negative** (exothermic).
2. The term $-T\Delta S$ should also be **negative**. Since T is always positive, ΔS must be **positive**.

Step 2: Evaluate the mathematical result.

If ΔH is negative ($-$) and ΔS is positive ($+$), then the equation becomes:

$$\Delta G = (-) - T(+)$$

$$\Delta G = (-) - (+) = \text{Always Negative}$$

Thus, based on the problem, the reaction will be spontaneous at any temperature.

Quick Tip: Think of it this way: Nature favors lower energy ($-\Delta H$) and higher disorder ($+\Delta S$). When both conditions are met, the reaction has no choice but to be spontaneous!

