AP EAPCET 2026 May 12 Shift 2

Question Paper (Memory-Based) with Solutions

Conducted by JNTU, KAKINADA on behalf of APSCHE

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 x and y be the distances of the object and images formed by a concave mirror from its focus and f be the focal length then:

(A) $xf = y^2$
(B) $xy = f^2$
(C) $\frac{x}{y} = f$
(D) $\frac{x}{y} = f^2$

Correct Answer: (B) $xy = f^2$

Solution:

Concept: In ray optics, Newton's formula relates the object distance, image distance, and focal length of a spherical mirror when the distances are measured from the principal focus instead of the pole. This often provides a faster way to solve mirror problems.

Step 1: Defining the coordinates from the pole.

Let the distances measured from the pole of the concave mirror be:

- Object distance, $u = -(f + x)$
- Image distance, $v = -(f + y)$
- Focal length, $= -f$

Step 2: Applying the spherical mirror formula.

The standard mirror formula is:

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

Step 3: Substituting values and simplifying.

Substituting the values from Step 1:

$$\frac{1}{-(f+y)} + \frac{1}{-(f+x)} = \frac{1}{-f}$$

Multiplying the entire equation by -1:

$$\frac{1}{f+y} + \frac{1}{f+x} = \frac{1}{f}$$

Taking the LCM on the left side:

$$\frac{(f+x)+(f+y)}{(f+x)(f+y)} = \frac{1}{f}$$

$$\frac{2f+x+y}{(f+x)(f+y)} = \frac{1}{f}$$

Cross-multiplying:

$$f(2f+x+y) = (f+x)(f+y)$$

$$2f^2 + fx + fy = f^2 + fy + fx + xy$$

Canceling common terms (fx and fy) and subtracting f^2:

$$2f^2 - f^2 = xy$$

 © Collegedunia.com

$$f^2 = xy$$

Step 4: Selecting the correct option.

From the calculation above, we get:

$$\boxed{xy = f^2}$$

Therefore, the correct option is:

$$\boxed{\text{Option (B)}}$$

Quick Tip: Newton's Formula $xy = f^2$ is valid for both concave and convex mirrors, provided that the distances x (object distance) and y (image distance) are strictly measured from the **principal focus**, not the pole.

---

2. A particle is executing SHM of amplitude 4 cm and time period 4 s. The time taken by it to move from positive extreme position to half the amplitude is

(A) 1 s

(B) $\frac{1}{3}$ s

(C) $\frac{2}{3}$ s

(D) $\sqrt{\frac{2}{3}}$ s

Correct Answer: (C) $\frac{2}{3}$ s

Solution:

Concept: For a particle executing Simple Harmonic Motion (SHM) starting from the positive extreme position, its displacement x at any time t is given by the cosine function:

$$x = A\cos(\omega t)$$

where A is the amplitude and ω is the angular frequency.

Step 1: Identifying given parameters and calculating angular frequency.

Given:

- Amplitude, $A = 4$ cm
- Time period, $T = 4$ s

Angular frequency ω is:

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{4} = \frac{\pi}{2} \text{ rad/s}$$

The target position is half the amplitude:

$$x = \frac{A}{2} = \frac{4}{2} = 2 \text{ cm}$$

Step 2: Applying the displacement equation.

Since the particle starts from the positive extreme, we use:

$$x = A\cos(\omega t)$$

Substitute the values of x, A, and ω:

$$2 = 4\cos\left(\frac{\pi}{2}t\right)$$

$$\cos\left(\frac{\pi}{2}t\right) = \frac{2}{4} = \frac{1}{2}$$

Step 3: Solving for time t.

We know that $\cos\left(\frac{\pi}{3}\right) = \frac{1}{2}$. Therefore:

$$\frac{\pi}{2}t = \frac{\pi}{3}$$

Solving for t:

$$t = \frac{\pi}{3} \times \frac{2}{\pi}$$

$$t = \frac{2}{3} \text{ s}$$

 © Collegedunia.com

Step 4: Selecting the correct option.

From the calculation above, the time taken is:

$$\boxed{\frac{2}{3}\ \text{s}}$$

Therefore, the correct option is:

$$\boxed{\text{Option (C)}}$$

Quick Tip: Standard SHM time intervals to memorize:

- Mean position (0) to half amplitude ($A/2$): $t = T/12$
- Half amplitude ($A/2$) to extreme (A): $t = T/6$
- Extreme (A) to half amplitude ($A/2$): $t = T/6$

Here, the particle moves from A to $A/2$, so $t = T/6 = 4/6 = 2/3$ s.

---

3. The masses of two particles having same kinetic energies are in the ratio $2:1$. Then their de Broglie wavelengths are in the ratio.

(A) $2:1$

(B) $1:2$

(C) $\sqrt{2}:1$

(D) $1:\sqrt{2}$

Correct Answer: (D) $1:\sqrt{2}$

Solution:

Concept: The de Broglie wavelength λ of a particle is related to its momentum p by the equation $\lambda = \frac{h}{p}$, where h is Planck's constant. Momentum can be expressed in terms of kinetic energy K and mass m as $p = \sqrt{2mK}$.

Step 1: Establishing the relationship between wavelength, mass, and kinetic energy.

Substituting $p = \sqrt{2mK}$ into the de Broglie equation gives:

$$\lambda = \frac{h}{\sqrt{2mK}}$$

Step 2: Formulating the ratio based on constant parameters.

The problem states that both particles have the same kinetic energy ($K_1 = K_2 = K$). Since h and K are constants, the wavelength is inversely proportional to the square root of the mass:

$$\lambda \propto \frac{1}{\sqrt{m}}$$

Therefore, the ratio of their wavelengths is:

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2}{m_1}}$$

Step 3: Substituting the given mass ratio.

The given mass ratio is $m_1 : m_2 = 2 : 1$, which means:

$$\frac{m_1}{m_2} = \frac{2}{1} \implies \frac{m_2}{m_1} = \frac{1}{2}$$

Substitute this into the wavelength ratio equation:

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{1}{2}}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{1}{\sqrt{2}}$$

Step 4: Selecting the correct option.

The ratio of their de Broglie wavelengths is:

$$\boxed{1 : \sqrt{2}}$$

 © Collegedunia.com

Therefore, the correct option is:

$$\boxed{\text{Option (D)}}$$

Quick Tip: Proportionalities for de Broglie wavelength λ:

- For same velocity v: $\lambda \propto \frac{1}{m}$
- For same kinetic energy K: $\lambda \propto \frac{1}{\sqrt{m}}$
- For same accelerating potential V: $\lambda \propto \frac{1}{\sqrt{mq}}$

---

4. The coordinates of a particle moving in x-y plane at any instant of time t is $x = 4t^2$; $y = 3t^2$. The speed of the particle at that instant is:

(A) $10t$
(B) $5t$
(C) $3t$
(D) $2t$

Correct Answer: (A) $10t$

Solution:

Concept: The velocity vector of a particle in a 2D plane is the time derivative of its position vector. The components of velocity are $v_x = \frac{dx}{dt}$ and $v_y = \frac{dy}{dt}$. The speed of the particle is the magnitude of the resultant velocity vector, given by $v = \sqrt{v_x^2 + v_y^2}$.

Step 1: Finding the x and y components of velocity.

Given the coordinates:

$$x = 4t^2$$

$$y = 3t^2$$

 © Collegedunia.com

Differentiate with respect to time t to find velocity components:

$$v_x = \frac{dx}{dt} = \frac{d}{dt}(4t^2) = 8t$$

$$v_y = \frac{dy}{dt} = \frac{d}{dt}(3t^2) = 6t$$

Step 2: Calculating the resultant speed.

The magnitude of velocity (speed) is:

$$v = \sqrt{v_x^2 + v_y^2}$$

Substitute the values of v_x and v_y:

$$v = \sqrt{(8t)^2 + (6t)^2}$$

$$v = \sqrt{64t^2 + 36t^2}$$

$$v = \sqrt{100t^2}$$

$$v = 10t$$

Step 3: Selecting the correct option.

From the calculation above, the speed is:

$$\boxed{10t}$$

Therefore, the correct option is:

$$\boxed{\text{Option (A)}}$$

© Collegedunia.com

Quick Tip: Notice that $x \propto t^2$ and $y \propto t^2$. This means the particle is undergoing constant acceleration in both the x and y directions. Also, by dividing the equations we get $\frac{y}{x} = \frac{3}{4}$, indicating the particle travels in a straight line trajectory.

---

5. A thin metal disc of radius r floats on water surface and bends the surface downwards along the perimeter making an angle θ with vertical edge of the disc. If the disc displaces a weight of water W and surface tension of water is T, then the weight of metal disc is

(A) $2\pi rT + W$
(B) $2\pi r \cos\theta - W$
(C) $2\pi rT \cos\theta + W$
(D) $W - 2\pi rT \cos\theta$

Correct Answer: (C) $2\pi rT \cos\theta + W$

Solution:

Concept: For a body floating in equilibrium on a liquid surface, the net force acting on it must be zero. The downward force is the weight of the object. The upward forces opposing it consist of the buoyant force (upthrust) and the vertical component of the surface tension force.

Step 1: Identifying the forces in equilibrium.

Downward force:

- Weight of the metal disc $= W_{\text{disc}}$

Upward forces:

- Buoyant force (weight of water displaced) $= W$
- Total upward force due to surface tension $= F_T$

Equating downward and upward forces:

$$W_{\text{disc}} = W + F_T$$

 © Collegedunia.com

Step 2: Calculating the upward force due to surface tension (F_T).

Surface tension T acts tangentially to the liquid surface. Since the surface bends downwards, the liquid pulls back upwards on the disc. The force acts along the entire perimeter of the disc ($L = 2\pi r$).

The angle made with the vertical edge is θ. Thus, the vertical component of the surface tension force per unit length is $T\cos\theta$.

Total upward force from surface tension:

$$F_T = \text{Perimeter} \times \text{Vertical component of } T$$

$$F_T = (2\pi r)(T\cos\theta)$$

Step 3: Finding the total weight of the disc.

Substitute F_T into the equilibrium equation:

$$W_{\text{disc}} = W + 2\pi r T\cos\theta$$

Step 4: Selecting the correct option.

Rearranging the terms to match the options:

$$\boxed{2\pi r T\cos\theta + W}$$

Therefore, the correct option is:

$$\boxed{\text{Option (C)}}$$

Quick Tip: Always analyze the geometry of the "bend" to determine the direction of the surface tension force. Since the disc bends the surface *downwards*, the elastic nature of the water surface tries to pull it *upwards* to restore flatness.

© Collegedunia.com

6. If $I = \int \frac{\sin x + \sin^3 x}{\cos 2x} dx = P \cos x + Q \log \left| \frac{\sqrt{2}\cos x - 1}{\sqrt{2}\cos x + 1} \right|$ (where c is a constant of integration), then values of P and Q are respectively

(A) $\frac{1}{2}, \frac{3}{4\sqrt{2}}$
(B) $\frac{1}{2}, \frac{-3}{4\sqrt{2}}$
(C) $\frac{1}{2}, \frac{3}{2\sqrt{2}}$
(D) $\frac{1}{2}, \frac{-3}{2\sqrt{2}}$

Correct Answer: (B) $\frac{1}{2}, \frac{-3}{4\sqrt{2}}$

Solution:

Concept: To solve this integral, we express the numerator and denominator in terms of $\cos x$ to facilitate a substitution $u = \cos x$.

Step 1: Simplifying the integrand.

The integral is:

$$I = \int \frac{\sin x(1 + \sin^2 x)}{2\cos^2 x - 1} dx$$

Substitute $\sin^2 x = 1 - \cos^2 x$:

$$I = \int \frac{\sin x(2 - \cos^2 x)}{2\cos^2 x - 1} dx$$

Step 2: Using substitution.

Let $\cos x = t$, then $-\sin x dx = dt \implies \sin x dx = -dt$. The integral becomes:

$$I = \int \frac{-(2 - t^2)}{2t^2 - 1} dt = \int \frac{t^2 - 2}{2t^2 - 1} dt$$

Step 3: Performing partial fraction decomposition.

Perform polynomial division or manipulation:

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

Integrate:

$$I = \frac{1}{2}t - \frac{3}{2}\int \frac{1}{2t^2-1}dt$$

Using the formula $\int \frac{dx}{x^2-a^2} = \frac{1}{2a}\log\left|\frac{x-a}{x+a}\right|$:

$$I = \frac{1}{2}\cos x - \frac{3}{4}\int \frac{1}{t^2-(1/\sqrt{2})^2}dt$$

$$I = \frac{1}{2}\cos x - \frac{3}{4}\cdot\frac{1}{2(1/\sqrt{2})}\log\left|\frac{t-1/\sqrt{2}}{t+1/\sqrt{2}}\right|$$

$$I = \frac{1}{2}\cos x - \frac{3}{4\sqrt{2}}\log\left|\frac{\sqrt{2}\cos x-1}{\sqrt{2}\cos x+1}\right|$$

Step 4: Comparing with the given form.

Comparing with $P\cos x + Q\log|\ldots|$:

$$P = \frac{1}{2}, \quad Q = -\frac{3}{4\sqrt{2}}$$

Quick Tip: Whenever the integrand contains $\sin x$ and $\cos x$ where one has an odd power, try substituting the other function. Here, $\sin x$ is essentially factored out, making $\cos x = t$ the ideal substitution.

---

7. In a triangle $\triangle ABC$, if a, b, and c are in arithmetic progression, then $\cos A + 2\cos B + \cos C =$

(A) 1

(B) 2

(C) 3/2

(D) $\sqrt{3}+1$

Correct Answer: (B) 2

Solution:

Concept: For sides in A.P., $2b = a + c$. We use the Sine Rule ($a = 2R\sin A$, etc.) and Projection

© Collegedunia.com

Formulae to relate the angles.

Step 1: Using the A.P. condition.

Given a, b, c in A.P.:

$$a + c = 2b$$

Step 2: Applying the Sine Rule.

$$2R\sin A + 2R\sin C = 2(2R\sin B)$$

$$\sin A + \sin C = 2\sin B$$

Using sum-to-product:

$$2\sin\left(\frac{A+C}{2}\right)\cos\left(\frac{A-C}{2}\right) = 4\sin\left(\frac{B}{2}\right)\cos\left(\frac{B}{2}\right)$$

Since $\frac{A+C}{2} = 90^\circ - \frac{B}{2}$, then $\sin\left(\frac{A+C}{2}\right) = \cos\left(\frac{B}{2}\right)$:

$$\cos\left(\frac{A-C}{2}\right) = 2\sin\left(\frac{B}{2}\right)$$

Step 3: Evaluating the expression.

$\cos A + \cos C + 2\cos B$

$$= 2\cos\left(\frac{A+C}{2}\right)\cos\left(\frac{A-C}{2}\right) + 2\cos B$$

$$= 2\sin\left(\frac{B}{2}\right)[2\sin\left(\frac{B}{2}\right)] + 2(1 - 2\sin^2\left(\frac{B}{2}\right))$$

$$= 4\sin^2\left(\frac{B}{2}\right) + 2 - 4\sin^2\left(\frac{B}{2}\right) = 2$$

Quick Tip: In any triangle where sides are in A.P., specific trigonometric relations like $\tan(A/2)\tan(C/2) = 1/3$ hold true.

 © Collegedunia.com

8. If the area of triangle ABC is $b^2-(c-a)^2$, then $\tan B =$

(A) 1

(B) 13/15

(C) 1/4

(D) 8/15

Correct Answer: (D) 8/15

Solution:

Step 1: Expanding the given area expression carefully.

The area of the triangle is given as:

$$\Delta = b^2-(c-a)^2$$

Expand the square term:

$$(c-a)^2 = c^2+a^2-2ac$$

Therefore,

$$\Delta = b^2-c^2-a^2+2ac$$

Now apply the cosine rule in $\triangle ABC$:

$$b^2 = a^2+c^2-2ac\cos B$$

Substituting this value of b^2 into the area expression:

$$\Delta = (a^2+c^2-2ac\cos B)-c^2-a^2+2ac$$

Simplifying:

$$\Delta = -2ac\cos B+2ac$$

$$\Delta = 2ac(1-\cos B)$$

Using the identity:

$$1-\cos B = 2\sin^2\frac{B}{2}$$

Hence,

$$\Delta = 2ac\left(2\sin^2\frac{B}{2}\right)$$

$$\Delta = 4ac\sin^2\frac{B}{2}$$

Step 2: Using the standard area formula of a triangle.

We know that the area of a triangle can also be written as:

$$\Delta = \frac{1}{2}ac\sin B$$

Using:

$$\sin B = 2\sin\frac{B}{2}\cos\frac{B}{2}$$

we get:

$$\Delta = \frac{1}{2}ac\left(2\sin\frac{B}{2}\cos\frac{B}{2}\right)$$

Thus,

$$\Delta = ac\sin\frac{B}{2}\cos\frac{B}{2}$$

Now equate both expressions of area:

$$ac\sin\frac{B}{2}\cos\frac{B}{2} = 4ac\sin^2\frac{B}{2}$$

Cancel ac from both sides:

$$\sin\frac{B}{2}\cos\frac{B}{2} = 4\sin^2\frac{B}{2}$$

Divide by $\sin\frac{B}{2}$:

$$\cos\frac{B}{2} = 4\sin\frac{B}{2}$$

Therefore,

$$\tan\frac{B}{2} = \frac{1}{4}$$

Step 3: Applying the double-angle formula for tangent.

Use the identity:

$$\tan B = \frac{2\tan(B/2)}{1-\tan^2(B/2)}$$

Substitute:

$$\tan\frac{B}{2} = \frac{1}{4}$$

Then,

$$\tan B = \frac{2\left(\frac{1}{4}\right)}{1-\left(\frac{1}{4}\right)^2}$$

$$= \frac{\frac{1}{2}}{1-\frac{1}{16}}$$

$$= \frac{\frac{1}{2}}{\frac{15}{16}}$$

$$= \frac{1}{2} \times \frac{16}{15}$$

$$= \frac{8}{15}$$

Hence,

$$\boxed{\tan B = \frac{8}{15}}$$

Quick Tip:

Whenever expressions like $1-\cos\theta$ appear in triangle problems, immediately convert them using the half-angle identity:

$$1-\cos\theta = 2\sin^2\frac{\theta}{2}$$

This transformation is extremely useful in simplifying area and trigonometric relation questions.

---

9. In a $\triangle ABC$, $a = 1, b = \sqrt{3}$ and $\angle C = \frac{\pi}{6}$. Then the measure of the third side $c =$

(A) 4

(B) 3

(C) 1

(D) 2

Correct Answer: (C) 1

Solution:

Step 1: Using the cosine rule in the triangle.

For any triangle,

$$c^2 = a^2 + b^2 - 2ab\cos C$$

Substitute the given values:

$$a = 1, \qquad b = \sqrt{3}, \qquad C = \frac{\pi}{6} = 30^\circ$$

Therefore,

$$c^2 = 1^2 + (\sqrt{3})^2 - 2(1)(\sqrt{3})\cos 30^\circ$$

Now simplify step-by-step:

$$1^2 = 1$$

and

$$(\sqrt{3})^2 = 3$$

Also,

$$\cos 30^\circ = \frac{\sqrt{3}}{2}$$

Substituting:

$$c^2 = 1 + 3 - 2\sqrt{3}\left(\frac{\sqrt{3}}{2}\right)$$

The 2 cancels:

$$c^2 = 4 - \sqrt{3}\cdot\sqrt{3}$$

Since,

$$\sqrt{3}\cdot\sqrt{3} = 3$$

we get:

$$c^2 = 4 - 3$$

$$c^2 = 1$$

© Collegedunia.com

Taking positive square root because side length is positive:

$$c = 1$$

Hence,

$$\boxed{c = 1}$$

Quick Tip:

Whenever two sides and the included angle of a triangle are given, the cosine rule is the fastest and most direct method to find the third side:

$$c^2 = a^2 + b^2 - 2ab\cos C$$

Always substitute standard trigonometric values like

$$\cos 30^\circ = \frac{\sqrt{3}}{2}$$

carefully to avoid arithmetic mistakes.

---

10. The value of

$$\lim_{n\to\infty} \left\{ \frac{1}{n+m} + \frac{1}{n+2m} + \frac{1}{n+3m} + \cdots + \frac{1}{n+nm} \right\}$$

is:

(A) $\dfrac{\log_e(m)}{m}$

(B) $\dfrac{\log_e(1+m)}{1+m}$

(C) $\dfrac{\log_e(1+m)}{m}$

(D) $\dfrac{\log_e(1+m)}{1-m}$

Correct Answer: (C) $\dfrac{\log_e(1+m)}{m}$

 © Collegedunia.com

Solution:

Concept:

Limits involving large summations are often evaluated using the concept of **Riemann sums**. The standard result is:

$$\lim_{n\to\infty}\frac{1}{n}\sum_{r=1}^{n} f\left(\frac{r}{n}\right)=\int_0^1 f(x)\,dx$$

Thus, the main objective is to rewrite the given expression in the form:

$$\frac{1}{n}\sum f\left(\frac{r}{n}\right)$$

so that it can be converted into a definite integral.

Step 1: Writing the expression in sigma notation.

The given summation is:

$$S=\lim_{n\to\infty}\sum_{r=1}^{n}\frac{1}{n+rm}$$

Now factor out n from the denominator:

$$S=\lim_{n\to\infty}\sum_{r=1}^{n}\frac{1}{n\left(1+\frac{rm}{n}\right)}$$

$$S=\lim_{n\to\infty}\frac{1}{n}\sum_{r=1}^{n}\frac{1}{1+m\left(\frac{r}{n}\right)}$$

Now the expression is in standard Riemann sum form.

Step 2: Converting the summation into a definite integral.

Compare with:

$$\frac{1}{n}\sum_{r=1}^{n} f\left(\frac{r}{n}\right)$$

Here,

$$f(x)=\frac{1}{1+mx}$$

Therefore,

$$S = \int_0^1 \frac{1}{1+mx}\,dx$$

Step 3: Evaluating the integral.

We evaluate:

$$I = \int_0^1 \frac{1}{1+mx}\,dx$$

Using the standard integral:

$$\int \frac{1}{a+bx}\,dx = \frac{1}{b}\log_e(a+bx)$$

we get:

$$I = \left[\frac{1}{m}\log_e(1+mx)\right]_0^1$$

Substituting the limits:

$$I = \frac{1}{m}\left[\log_e(1+m) - \log_e(1)\right]$$

Since,

$$\log_e(1) = 0$$

therefore,

$$I = \frac{\log_e(1+m)}{m}$$

Step 4: Final conclusion.

Hence,

$$\boxed{\lim_{n\to\infty}\left(\frac{1}{n+m} + \frac{1}{n+2m} + \cdots + \frac{1}{n+nm}\right) = \frac{\log_e(1+m)}{m}}$$

Therefore, the correct answer is:

© Collegedunia.com

$$(C)\ \frac{\log_e(1+m)}{m}$$

Quick Tip: Whenever a limit contains a summation with terms involving:

$$\frac{r}{n}$$

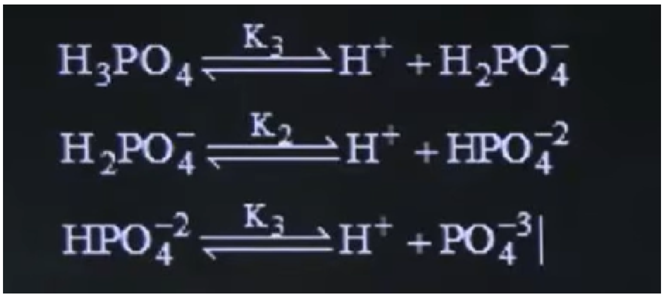
try converting it into a Riemann integral using:

$$\frac{1}{n}\sum f\left(\frac{r}{n}\right) \to \int_0^1 f(x)\,dx$$

Factoring out n from the denominator is usually the key first step.

---

11. Consider the equilibrium reactions:



The equilibrium constant, K_c, for the overall dissociation

$$H_3PO_4 \rightleftharpoons 3H^+ + PO_4^{3-}$$

is:

(A) $\dfrac{K_1}{K_2K_3}$
(B) $K_1K_2K_3$
(C) $\dfrac{K_2}{K_1K_3}$
(D) $K_1 + K_2 + K_3$

Correct Answer: (B) $K_1K_2K_3$

 © Collegedunia.com

Solution:

Concept:
Phosphoric acid (H_3PO_4) is a polybasic acid and dissociates stepwise. Each dissociation step possesses its own equilibrium constant.
Whenever individual chemical reactions are added to obtain an overall reaction, the equilibrium constants are multiplied.
Thus:

$$K_{\text{overall}} = K_1 \times K_2 \times K_3$$

Step 1: Writing the equilibrium constant expressions.

For the first dissociation:

$$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$$

$$K_1 = \frac{[H^+][H_2PO_4^-]}{[H_3PO_4]}$$

For the second dissociation:

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$$

$$K_2 = \frac{[H^+][HPO_4^{2-}]}{[H_2PO_4^-]}$$

For the third dissociation:

$$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$$

$$K_3 = \frac{[H^+][PO_4^{3-}]}{[HPO_4^{2-}]}$$

Step 2: Multiplying the three equilibrium constants.

$$K_1K_2K_3 = \left(\frac{[H^+][H_2PO_4^-]}{[H_3PO_4]}\right)\left(\frac{[H^+][HPO_4^{2-}]}{[H_2PO_4^-]}\right)\left(\frac{[H^+][PO_4^{3-}]}{[HPO_4^{2-}]}\right)$$

Intermediate species cancel out:

$$[H_2PO_4^-] \text{ and } [HPO_4^{2-}]$$

Hence,

$$K_1K_2K_3 = \frac{[H^+]^3[PO_4^{3-}]}{[H_3PO_4]}$$

Step 3: Comparing with the overall equilibrium expression.

For the overall reaction:

$$H_3PO_4 \rightleftharpoons 3H^+ + PO_4^{3-}$$

the equilibrium constant is:

$$K_c = \frac{[H^+]^3[PO_4^{3-}]}{[H_3PO_4]}$$

Therefore,

$$\boxed{K_c = K_1K_2K_3}$$

Hence, the correct answer is:

$$\boxed{(B)\ K_1K_2K_3}$$

Quick Tip: Important rules of equilibrium constants:

- When reactions are added $\rightarrow$ multiply equilibrium constants.
- When a reaction is reversed $\rightarrow$ take reciprocal of K.
- When coefficients are multiplied by $n \rightarrow$ raise K to the power n.

---

12. Identify the correct set of molecules with zero dipole moment:

 © Collegedunia.com

(a) CO_2, NH_3, H_2O

(b) NH_3, NF_3, BF_3

(c) PF_3, NH_3, CH_4

(d) CH_4, BF_3, CO_2

Correct Answer: (d) CH_4, BF_3, CO_2

Solution:

Concept:

A molecule possesses zero dipole moment when the vector sum of all bond dipoles becomes zero. This generally occurs in highly symmetrical molecules.

Step 1: Analyzing molecules in option (d).

CH_4 (Methane):

- Geometry: Tetrahedral
- Hybridization: sp^3
- All four hydrogen atoms are identical.

The bond dipoles cancel due to perfect symmetry.

$$\mu = 0$$

BF_3 (Boron trifluoride):

- Geometry: Trigonal planar
- Hybridization: sp^2
- Three identical fluorine atoms arranged symmetrically.

All bond dipoles cancel.

$$\mu = 0$$

CO_2 (Carbon dioxide):

- Geometry: Linear
- Hybridization: *sp*
- Two equal and opposite C=O dipoles.

Therefore,

$$\mu = 0$$

Step 2: Checking why the other molecules are polar.

NH_3:

Trigonal pyramidal geometry due to one lone pair.

$$\mu \neq 0$$

H_2O:

Bent shape due to two lone pairs.

$$\mu \neq 0$$

NF_3 and PF_3:

Both possess lone pairs and pyramidal geometry.

Hence they are polar molecules.

Step 3: Final conclusion.

Only:

$$CH_4,\ BF_3,\ CO_2$$

have symmetrical structures with complete dipole cancellation.

Therefore, the correct answer is:

$$\boxed{(d)\ CH_4,\ BF_3,\ CO_2}$$

© Collegedunia.com

Quick Tip: Symmetrical molecules with identical surrounding atoms and no lone pairs usually possess zero dipole moment.

Examples:

- Linear (AX_2)
- Trigonal planar (AX_3)
- Tetrahedral (AX_4)

---

13. Which of the following sets are correctly matched?

Set	Molecule	Geometry
I	BrF_5	Square pyramidal
II	XeF_6	Distorted octahedral
III	SF_4	Square planar
IV	$PbCl_2$	Linear

(a) I and II

(b) II and III

(c) III and IV

(d) I and IV

Correct Answer: (a) I and II

Solution:

Concept:

Using VSEPR theory, molecular geometry depends upon:

- Number of bond pairs
- Number of lone pairs
- Steric number of the central atom

Step 1: Analyzing BrF_5.

- Bromine forms 5 bonds and possesses 1 lone pair.

 © Collegedunia.com

- Steric number = 6
- Hybridization = sp^3d^2
- Geometry = square pyramidal

Hence Set I is correct.

Step 2: Analyzing XeF_6.

- Xenon forms 6 bonds and contains 1 lone pair.
- Steric number = 7
- Hybridization = sp^3d^3
- Shape = distorted octahedral

Hence Set II is correct.

Step 3: Analyzing SF_4.

- Sulfur forms 4 bonds and has 1 lone pair.
- Steric number = 5
- Geometry = seesaw

It is not square planar.

Hence Set III is incorrect.

Step 4: Analyzing $PbCl_2$.

- Lead contains one lone pair.
- Geometry becomes bent.

Therefore it is not linear.

Hence Set IV is incorrect.

Step 5: Final conclusion.

 © Collegedunia.com

Only Sets I and II are correctly matched.

Therefore, the correct answer is:

$$\boxed{(a) \text{ I and II}}$$

Quick Tip: Remember common VSEPR shapes:

- $AX_5E \rightarrow$ Square pyramidal
- $AX_4E \rightarrow$ Seesaw
- $AX_2E \rightarrow$ Bent
- $AX_6E \rightarrow$ Distorted octahedral

---

14. The energy of the second bohr orbit of the hydrogen atom is -328 kJ mol^{-1}; hence the energy of the fourth bohr orbit would be:

(a) -41 kJ/mol
(b) -82 kJ/mol
(c) -164 kJ/mol
(d) -1312 kJ/mol

Correct Answer: (b) -82 kJ/mol

Solution:

Concept:
According to Bohr's atomic theory, the energy of an electron present in the n^{th} orbit of a hydrogen atom is given by the relation:

$$E_n = \frac{-13.6}{n^2} \text{ eV}$$

or in general proportional form,

$$E_n \propto \frac{-1}{n^2}$$

This means that the energy of an electron becomes less negative as the orbit number increases. The negative sign indicates that the electron is bound to the nucleus.

For two different orbits of the same atom, we can write:

$$\frac{E_1}{E_2} = \frac{n_2^2}{n_1^2}$$

or equivalently,

$$E_n \propto \frac{1}{n^2}$$

Since the question provides the energy of the second orbit and asks for the energy of the fourth orbit, we directly apply Bohr's energy relation.

Step 1: Writing the given information.

From the question:

$$E_2 = -328 \text{ kJ mol}^{-1}$$

We need to calculate:

$$E_4 = ?$$

where,

$$n_1 = 2$$

and

$$n_2 = 4$$

Step 2: Using the Bohr orbit energy relation.

Using the proportional relation:

© Collegedunia.com

$$\frac{E_4}{E_2} = \frac{n_1^2}{n_2^2}$$

Substituting the values:

$$\frac{E_4}{-328} = \frac{2^2}{4^2}$$

$$\frac{E_4}{-328} = \frac{4}{16}$$

$$\frac{E_4}{-328} = \frac{1}{4}$$

Step 3: Calculating the energy of the fourth orbit.

Multiplying both sides by −328:

$$E_4 = -328 \times \frac{1}{4}$$

$$E_4 = -82 \text{ kJ mol}^{-1}$$

Step 4: Final conclusion.

Therefore, the energy associated with the fourth Bohr orbit of hydrogen atom is:

$$\boxed{-82 \text{ kJ mol}^{-1}}$$

Hence, the correct answer is:

$$\boxed{(b)\ -82 \text{ kJ/mol}}$$

Quick Tip: For hydrogen atom problems based on Bohr's model, always remember:

$$E_n \propto \frac{1}{n^2}$$

If the orbit number becomes twice, the energy becomes one-fourth.

Here:

$$2 \rightarrow 4$$

So,

$$E_4 = \frac{E_2}{4}$$

which gives:

$$-328/4 = -82$$

---

15. Identify the correct set of molecules with zero dipole moment:

(a) CO_2, NH_3, H_2O

(b) NH_3, NF_3, BF_3

(c) PF_3, NH_3, CH_4

(d) CH_4, BF_3, CO_2

Correct Answer: (d) CH_4, BF_3, CO_2

Solution:

Concept:

Dipole moment (μ) is a measure of the separation of positive and negative charges in a molecule. It depends on two important factors:

- The polarity of individual bonds.
- The geometry (shape) of the molecule.

Even if a molecule contains polar bonds, the overall dipole moment can become zero if the molecule possesses a highly symmetrical geometry such that all bond dipoles cancel one another

 © Collegedunia.com

vectorially.
Therefore, molecules having:

- identical surrounding atoms,
- symmetrical geometry,
- and no lone pair distortion

generally show zero dipole moment.

Step 1: Analyzing the molecules in Option (d).

We examine each molecule one by one.

(i) CH_4 (Methane)

In methane:

- Carbon is the central atom.
- Carbon undergoes sp^3 hybridization.
- The geometry is tetrahedral.
- All four hydrogen atoms are identical.

Although each C–H bond has a small bond dipole, the tetrahedral symmetry ensures complete cancellation of all dipole vectors.
Hence,

$$\mu = 0$$

Thus, methane is a non-polar molecule.

(ii) BF_3 (Boron trifluoride)

In boron trifluoride:

- Boron is sp^2 hybridized.
- The geometry is trigonal planar.

- The three fluorine atoms are arranged symmetrically at 120°.

Each B–F bond is highly polar because fluorine is very electronegative. However, due to perfect trigonal planar symmetry, the bond dipoles cancel completely.
Therefore,

$$\mu = 0$$

Hence, BF_3 is non-polar.

(iii) CO_2 (Carbon dioxide)

In carbon dioxide:

- Carbon is sp hybridized.
- The molecule is linear.
- The two oxygen atoms lie opposite to each other at 180°.

The two C=O bonds are polar, but the dipoles act in opposite directions with equal magnitude. Therefore, they cancel each other completely.
Hence,

$$\mu = 0$$

Thus, carbon dioxide is also non-polar.
Step 2: Checking why the other options are incorrect.

Now we analyze the molecules present in the remaining options.

NH_3 (Ammonia)

- Nitrogen possesses one lone pair.
- Geometry becomes trigonal pyramidal.
- Bond dipoles do not cancel.

 © Collegedunia.com

Hence ammonia is polar.

$$\mu \neq 0$$

H_2O (Water)

- Oxygen contains two lone pairs.
- Geometry becomes bent or V-shaped.
- O–H dipoles cannot cancel.

Therefore water is highly polar.

$$\mu \neq 0$$

NF_3 and PF_3

Both molecules:

- contain one lone pair on the central atom,
- possess trigonal pyramidal geometry,
- and therefore have non-zero resultant dipole moments.

Thus they are polar molecules.

Step 3: Final conclusion.

Among all the given options, only:

$$CH_4,\ BF_3,\ CO_2$$

have perfectly symmetrical geometries causing complete cancellation of bond dipoles.

Hence all these molecules possess zero dipole moment.

Therefore, the correct answer is:

$$\boxed{(d)\ CH_4,\ BF_3,\ CO_2}$$

 © Collegedunia.com

Quick Tip: A quick way to identify non-polar molecules is to check:

- Is the geometry symmetrical?
- Are all surrounding atoms identical?
- Does the central atom contain no lone pair?

If the answer is yes, the molecule usually has:

$$\mu = 0$$

Common non-polar shapes are:

- Linear (AX_2)
- Trigonal planar (AX_3)
- Tetrahedral (AX_4)

© Collegedunia.com