Question: If \( \vec{E} = \frac{3}{5} \hat{i} + \frac{4}{5} \hat{j} \), then find electric flux through an area of 0.4 m\(^2\) parallel to y-z plane.

Options:
(a) \( 0.12 \, \frac{Nm^2}{C} \)
(b) \( 0.24 \, \frac{Nm^2}{C} \)
(c) \( 0.36 \, \frac{Nm^2}{C} \)
(d) \( 0.48 \, \frac{Nm^2}{C} \)

Answer: (b)

Solution:
\[ \vec{E} = \frac{3}{5} \hat{i} + \frac{4}{5} \hat{j} \]
\[ \vec{A} = (0.4 \, m^2) \hat{i} \]
\[ \phi = \vec{E} \cdot \vec{A} \]
\[ \phi = \left( \frac{3}{5} \hat{i} + \frac{4}{5} \hat{j} \right) \cdot (0.4 \hat{i}) \]
\[ \phi = \frac{3}{5} \times 0.4 \times \frac{N \, m^2}{C} \]
\[ \phi = 0.24 \, \frac{Nm^2}{C} \]

Question: If amplitude of both the SHMs is same then find the ratio of maximum velocities of the two cases.

Options:
(a) \( \sqrt{\frac{k_2}{k_1}} \)
(b) \( \sqrt{\frac{k_1}{k_2}} \)
(c) \( \frac{k_2}{k_1} \)
(d) \( \frac{k_1}{k_2} \)

**Answer:** (b)

**Solution:**

\[
\begin{align*}
V_{1(\text{max})} &= A\omega_1 \\
\omega_1 &= \sqrt{\frac{k_1}{m}} \\
V_{1(\text{max})} &= A\sqrt{\frac{k_1}{m}} \quad \ldots(i) \\
V_{2(\text{max})} &= A\omega_2 \\
\omega_2 &= \sqrt{\frac{k_2}{m}} \\
V_{2(\text{max})} &= A\sqrt{\frac{k_2}{m}} \quad \ldots(ii) \\
\end{align*}
\]

**Question:** If the carrier wave is given by \( y_c = A_c \sin \omega_c t \) and message signal is \( y_m = A_s \sin \omega_s t \), find the bandwidth of the AM wave (in Hz)?

**Options:**
(a) \( \frac{\omega_c}{\pi} \)
(b) \( \frac{2\omega_s}{\pi} \)
(c) \( \frac{\omega_c - \omega_s}{\pi} \)
(d) \( \frac{2(\omega_c - \omega_s)}{\pi} \)

**Answer:** (a)

**Solution:**

Amplitude modulated signal contains frequencies.
\( (\omega_c - \omega_s) \) to \( (\omega_c + \omega_s) \)

Bandwidth = \( \omega_c + \omega_s - \omega_c + \omega_s \)

Frequency = \( \frac{2\omega_s}{2\pi} = \frac{\omega_s}{\pi} \)
**Question:** Particles on a string vibrate with amplitude of 6 cm, speed of wave is 300 m/s and angular frequency of oscillations is 245. Find wave equation of wave is travelling along positive x direction.

**Options:**

(a) \( y = 0.06 \sin \left( 245t - \frac{49}{60}x \right) \)

(b) \( y = 0.06 \sin \left( 245t + \frac{49x}{60} \right) \)

(c) \( y = 0.06 \sin (245t - 300x) \)

(d) \( y = 0.06 \sin (245t + 300x) \)

**Answer:** (a)

**Solution:**

From the question, 

\( A = 6 \text{ cm} = 0.06 \text{ m} \).

\( u = 300 \text{ m/s} \)

\( \omega = 245 \text{ m/s} \)

\[ k = \frac{\omega}{v} \]

\[ k = \frac{245}{300} \]

\[ k = \frac{49}{60} \]

General equation of wave traveling along +ve x-direction is given by \( y = A \sin (\omega t - kx) \)

So, \( y = 0.06 \sin \left( 245t - \frac{49}{60}x \right) \)

**Question:** Light of frequency \( f_1 \) and \( f_2 \) fall on same metal and the max speed of photo electron is \( V_1 \) and \( V_2 \) respectively and mass is \( m \). Find relation between \( V_1 \) and \( V_2 \)?

**Options:**

(a) \( V_2^2 - V_1^2 = \frac{h}{2m} (f_2 - f_1) \)

(b) \( V_2^2 - V_1^2 = \frac{h}{m} (f_2 - f_1) \)

(c) \( V_2^2 - V_1^2 = \frac{2h}{m} (f_2 - f_1) \)

(d) \( V_2 - V_1 = \frac{2h}{m} (f_2 - f_1) \)

**Answer:** (a)

**Solution:**

\[ (K.E)_{\text{max}} = hf - \phi \quad [\phi = \text{work function}] \]
\[ \frac{1}{2}mv_2^2 = hf_2 - \phi \] ... (i)
\[ \frac{1}{2}mv_1^2 = hf_1 - \phi \] ... (ii)

Equation (i)-(ii)
\[ \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 = (hf_2 - \phi) - (hf_1 - \phi) \]
\[ \frac{1}{2}m(v_2^2 - v_1^2) = hf_2 - hf_1 \]
\[ v_2^2 - v_1^2 = \frac{2h}{m}[f_2 - f_1] \]

**Question:** Find R such that potential difference across \( 2\varepsilon \) is zero?

**Options:**
(a) \( \frac{R_1 + R_2}{2} \)
(b) \( R_1 - 2R_2 \)
(c) \( \frac{R_1 - R_2}{2} \)
(d) \( \frac{R_1 - 2R_2}{2} \)

**Answer:** (d)

**Solution:**
\[ i = \frac{V_{eq}}{R_{eq}} \]
\[ = \frac{3\varepsilon}{R_1 + R_2 + R} \]
Now, \( V_A - 2\varepsilon + iR_1 = V_B \)
\[ \Rightarrow V_A - V_B = 2\varepsilon - iR_1 \]
According to question, \( 2\varepsilon - iR_1 = 0 \)
\[ \Rightarrow 2e = \frac{3e}{R_1 + R_2 + R} R_1 \]
\[ \Rightarrow 2R_1 + 2R_2 + 2R = 3R_1 \]
\[ \Rightarrow R = \frac{R_1 - 2R_2}{2} \]

**Question:** If \( \omega \) is doubled in purely inductive circuit. Find the effect on \( X_L \) and \( i \)?

**Options:**
(a) No change  
(b) Both are doubled  
(c) \( X_L \) is doubled, current is halved  
(d) \( X_L \) is halved, current is doubled  

**Answer:** (c)  
**Solution:**  
\[ X_L = \omega L \]
As \( \omega \) is doubled, so \( X_L \) will also be doubled.

Now, \[ i = \frac{V}{X_L} = \frac{V}{\omega L} \]
So, if \( \omega \) is doubled, then \( i \) will be halved.

**Question:** Match the following for AC circuits  

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) purely inductive</td>
<td>p) Voltage leads current</td>
</tr>
<tr>
<td>2) Purely capacitive</td>
<td>q) current and voltage in phase</td>
</tr>
<tr>
<td>3) Purely resistive</td>
<td>r) Current leads voltage</td>
</tr>
<tr>
<td>4) Series LCR</td>
<td>s) Current may lead or lag or be in phase of voltage</td>
</tr>
</tbody>
</table>

**Answer:**  
1 \( \rightarrow p \)  
2 \( \rightarrow r \)  
3 \( \rightarrow q \)  
4 \( \rightarrow s \)  

**Solution:**  
In purely inductive circuit current logs voltage by 90 degree. Or voltage leads current by 90 degree.  
In purely capacitive circuit current leads voltage by 90 degree.
In purely resistive circuit current and voltage are in phase.
In series LCR circuit current may lead or lag or be in phase of voltage depending upon \(X_L\)
and \(X_C\) value.

**Question:** Identify the equivalent logic gate.

**Options:**
(a) NOR
(b) NAND
(c) XOR
(d) NOT

**Answer:** (c)

**Solution:**
\[
\gamma = (A \cdot \overline{B}) + (A + B)
\]
\[
= (A + \overline{B}) + (A + B)
\]
\[
= AA + A\overline{B} + B\overline{A} + B\overline{B}
\]
\[
= A\overline{B} + \overline{A}B
\]
\[
= A \oplus B
\]
So, the given circuit is XOR Gate.

**Question:** If the velocity of a particle moving is \(V = a + gt + ft^2\) (a, g, f are constants). At \(t = 0\), body is at origin. Find the displacement after \(t = 1\) sec.

**Options:**
(a) \(a + g + f\)
(b) \(g + 2f\)
(c) \(a + \frac{g}{2} + \frac{f}{3}\)
(d) \(a + \frac{g}{2} + \frac{f}{4}\)

**Answer:** (c)

**Solution:**
Given that
\[V = a + gt + ft^2\]
So,
\[
\frac{dx}{dt} = a + gt + ft^2
\]
\[
\int_0^t dx = \int_0^1 (a + gt + ft^2) dt
\]
\[
(x - 0) = \left[ at + \frac{gt^2}{2} + \frac{ft^3}{3} \right]_0^1
\]
Question: If initial amplitude during a damped oscillation of mass m is 12 cm & after 2 minutes it reduces to 6 cm, then find the damping constant (b).

Options:
(a) \(m \ln 2\)
(b) \(2m \ln 2\)
(c) \(m^2 \ln 2\)
(d) \(\frac{1}{m^2} \ln 2\)

Answer: (a)

Solution:
\[ A = A_0 e^{-bt/2m} \]
\[ 6 = 12 e^{-\frac{2b}{2m}} \]
\[ \frac{1}{2} = e^{-\frac{b}{m}} \]
\[ e^{b/m} = 2 \]
\[ b/m = \ln 2 \]
\[ b = m \ln 2 \]

Question: In the fig shown, u-shaped wire, a current \(i\) is flowing as shown. Section PQR is a semi circle of radius \(a\). If O is origin then find magnetic field at O.

Options:
(a) \(\frac{\mu_0 i}{2\pi a} \hat{k} + \frac{\mu_0 i}{4a} \hat{k}\)
(b) \(\frac{\mu_0 i}{4a} \hat{k}\)
(c) \(-\frac{\mu_0 i}{2\pi a} \hat{k} + \frac{\mu_0 i}{4a} \hat{k}\)
(d) \(-\frac{\mu_0 i}{4a} \hat{k}\)

Answer: (a)

Solution:
Magnetic field due to two semi-infinite wire (B₁)
\[ \vec{B}_1 = \frac{\mu_0 i}{4\pi a} \hat{k} + \frac{\mu_0 i}{4\pi a} \hat{k} \]

Magnetic field due to semi-circular cell (B₂)
\[ \vec{B}_2 = \frac{\mu_0 i}{4a} \hat{k} \]

So, Net magnetic field at O (Bₙₑₙ)
\[ B_{\text{net}} = B_1 + B_2 \]
\[ = \left( \frac{\mu_0 i}{4\pi a} + \frac{\mu_0 i}{4\pi a} + \frac{\mu_0 i}{4a} \right) \hat{k} \]
\[ B_{\text{net}} = \left( \frac{\mu_0 i}{2\pi a} + \frac{\mu_0 i}{4a} \right) \hat{k} \]

**Question:** A sound wave travelling at 300 m/s, having frequency of 245 Hz, has maximum to and fro displacement of 6 cm. Find wavelength

**Options:**
(a) \(\frac{60}{49}\) m
(b) \(\frac{50}{49}\) m
(c) \(\frac{79}{50}\) m
(d) \(\frac{39}{29}\) m

**Answer:** (a)

**Solution:**
\[ V_{\text{sound}} = 300 \text{ m/s} \]
\[ f = 245 \text{ Hz} \]
\[ A = 6 \text{ cm} \]

We know
\[ V_{\text{sound}} = f \lambda \Rightarrow \lambda = \frac{V_{\text{sound}}}{f} \]
\[ \lambda = \frac{300}{245} \cdot \frac{60}{49} \]

\[ \lambda = \frac{60}{49} \text{ m} \]

**Question:** A sphere of radius 1 cm, moving with 1 m/s starts going up the plane performing pure rolling, on an inclined plane of inclination 30°. Find the total time taken by it to go up & come down the plane.
Options:
(a) $\frac{7}{25}$ sec
(b) $\frac{14}{25}$ sec
(c) $\frac{21}{25}$ sec
(d) 1 sec
Answer: (b)
Solution:
$$a = \frac{g \sin \theta}{1 + \frac{k^2}{R^2}}$$

For solid sphere $mk^2 = \frac{2}{5} mR^2$

$$k^2 = \frac{2}{5} R^2$$

$$a = \frac{g \sin 30^\circ}{1 + \frac{2}{5}} = \frac{5}{7} \times 10 \times \frac{1}{2} = \frac{25}{7} ms^{-2}$$

From 1st law of motion

$$-1 = 1 - \frac{25}{7} t \quad \text{(From energy conservation speed will be same when sphere came down)}$$

$$-2 = -\frac{25}{7} t$$

$$t = \frac{14}{25} \text{ sec}$$

**Question:** An object is taken to a depth of 2 km inside an ocean. Percentage change in volume is 1.36%. Find bulk modules of water

**Options:**
(a) $1.47 \times 10^9 N/m^2$
(b) $1.08 \times 10^9 N/m^2$
(c) $1.75 \times 10^9 N/m^2$
(d) $2.34 \times 10^9 N/m^2$

**Answer:** (a)
**Solution:**
\[
B = \frac{P}{\Delta v / v}
\]
\[
B = \frac{1000 \times g \times 2 \times 10^3}{1.36 / 100}
\]
\[
B = \frac{2 \times 10^{7/2}}{1.36} = 1.47 \times 10^9 N/m^2
\]

**Question:** Radius of planet is R and time for rotation is 24 hrs. A geostationary satellite is at an altitude of 11R. Find time period of a satellite which is at an altitude of 2R?

**Options:**
(a) 12 hrs
(b) 8 hrs
(c) 4 hrs
(d) 3 hrs

**Answer:** (d)

**Solution:**
We know that \( T^2 \propto R^3 \)
\[
T_1^2 = (11R + R)^3
\]
\[
T_2^2 = (2R + R)^3
\]
\[
\Rightarrow \frac{T_2}{T_1} = \left( \frac{3R}{12R} \right)^{3/2}
\]
\[
\Rightarrow T_2 = \frac{1}{8} \times 24 = 3 \text{ hour}
\]

**Question:** A ball falls from a height of 5 m and each time it rises by \( \frac{81}{100} \) of its initial height and so on. \((g = 10 \text{ m/s}^2)\). Find average speed for a long time?

**Options:**
(a) \( \frac{1000}{19} \)
(b) \( \frac{905}{361} \)
(c) \( \frac{1000}{361} \)
(d) \( \frac{100}{361} \)

**Answer:** (b)

**Solution:**
Total distance travelled
\[
H = 5 + 2 \times \left( 5 \times \frac{81}{100} + 5 \times \left( \frac{81}{100} \right)^2 + ... \right)
\]
Question: Mass of boy is 40 kg and block is 50 kg. Assume boy does not slip on block. Find the maximum force that the boy can apply so that block does not slip.

Options:
(a) $f = \frac{900}{2 + 2 \cos \theta + \sin \theta}$
(b) $f = \frac{900}{2 + 2 \cos \theta + 2 \sin \theta}$
(c) $f = \frac{900}{2 + \cos \theta + \sin \theta}$
(d) \( f = \frac{900}{2 + 3 \cos \theta + \sin \theta} \)

Answer: (a)

Solution:

For block to not move
\[
f \geq T + T \cos \theta
\]
\[
\mu N = T + T \cos \theta \quad \text{(i)}
\]
\[
T \sin \theta + N = 900 \quad \text{(ii)}
\]

From (i) and (ii)
\[
0.5 \times (900 - T \sin \theta) = T (1 + \cos \theta)
\]
\[
T = \frac{900}{2 + 2 \cos \theta + \sin \theta}
\]
\[
F_{\text{max}} = T = \frac{900}{2 + 2 \cos \theta + \sin \theta}
\]
Question: Match the following.

<table>
<thead>
<tr>
<th>Ores (Column I)</th>
<th>Chemical formula (Column II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Hematite</td>
<td>i) CuCO$_3$.Cu(OH)$_2$</td>
</tr>
<tr>
<td>(B) Magnetite</td>
<td>ii) Fe$_2$O$_3$</td>
</tr>
<tr>
<td>(C) Bauxite</td>
<td>iii) Fe$_3$O$_4$</td>
</tr>
<tr>
<td>(D) Malachite</td>
<td>iv) Al$_2$O$<em>3$.OH$</em>{2-x}$</td>
</tr>
</tbody>
</table>

Options:
(a) A → (iii); B → (ii); C → (iv); D → (i)
(b) A → (ii); B → (iii); C → (iv); D → (i)
(c) A → (iv); B → (iii); C → (ii); D → (i)
(d) A → (i); B → (iii); C → (ii); D → (iv)

Answer: (b)
Solution: Factual

Question: Which of the following pairs are neutral?
Options:
(a) NO, N$_2$O
(b) NO$_2$, N$_2$O$_3$
(c) N$_2$O, N$_2$O$_3$
(d) NO, N$_2$O$_3$

Answer: (a)
Solution: Nitrous oxide (N$_2$O) and nitric oxide (NO) are neutral. Dinitrogen trioxide (N$_2$O$_3$), nitrogen dioxide (NO$_2$) are acidic

NO → Neutral
N$_2$O → Neutral
NO$_2$ → Acidic
N$_2$O$_3$ → Acidic

Question: How many sigma bonds are present in mesityl oxide?
Options:
(a) 5
(b) 8
(c) 10
(d) 15
Answer: (d)
Solution:

\[
\begin{array}{c}
\text{CH}_3 \\
\text{C} & \text{O} \\
\text{CH}_3 & \text{CH}_3
\end{array}
\]

**Question:** Which of the following pairs is different from others?

**Options:**
(a) Li, Mg
(b) Be, Al
(c) B, Si
(d) Li, Na

Answer: (d)
Solution: All other pairs represent elements having diagonal relationship in periodic table.

**Question:** Fructose is an example of:

**Options:**
(a) Aldohexose
(b) Pyranose
(c) Ketohexose
(d) Ketopentose

Answer: (c)
Solution:
Fructose contain ketone as a main functional and having 6-carbon
So, known as Ketohexose

**Question:** In 1 g of KBr, $10^{-5}$ mole percent SrBr$_2$ is doped. Find number of cationic vacancies.

**Options:**
(a) $10^{15}$
(b) $5 \times 10^{15}$
(c) $6.023 \times 10^{16}$
(d) $5 \times 10^{14}$

**Answer:** (d)

**Solution:** Moles of KBr = \( \frac{1}{119} \)

\[
\frac{1}{119} \text{ moles of KBr will be doped with } \frac{10^{-5} \times 1}{100 \times \frac{1}{119}} \text{ moles of SrBr}_2
\]

One Sr$^{2+}$ ion will create one cationic vacancy

Thus, total number of cationic vacancies

\[
\frac{1}{119} \times 10^{-7} \times 6.023 \times 10^{23} = 0.05 \times 10^{16} = 5 \times 10^{14}
\]

**Question:** In solvay process, during restoration of NH$_3$, the by-product formed is:

**Options:**
(a) Ca(OH)$_2$
(b) CaCl₂
(c) NaHCO₃
(d) NH₄Cl

**Answer:** (b)

**Solution:** In solvay process, NH₃ is recovered when the solution containing NH₄Cl is treated with Ca(OH)₂. Calcium chloride is obtained as a by-product

\[
2\text{NH}_4\text{Cl} + \text{Ca(OH)}_2 \rightarrow 2\text{NH}_3 + \text{CaCl}_2 + \text{H}_2\text{O}
\]

**Question:** If colloid is negatively charged then, the one which coagulates most effectively is:

**Options:**
(a) Na⁺
(b) Ba²⁺
(c) PO₄³⁻
(d) SO₄²⁻

**Answer:** (b)

**Solution:** According to Hardy-Schulze rule, greater is the valency of Flocculating ion (having charge opposite to charge on colloid), greater is its coagulation causing power

**Question:** An aqueous solution of K₄[Fe(CN)₆] (α = 1) has molality = 1 molal. If the boiling point of this solution is same as that of aqueous solution of substance A having mass percentage of A = 19.1 %. Find the molar mass of A (in g/mol)

**Options:**
(a) 47.22
(b) 57.19
(c) 32.15
(d) 236.1

**Answer:** (a)

**Solution:** Since boiling point and the solvent is same for both solution

\[
(\Delta T_b)_1 = (\Delta T_b)_2
\]

\[
\Rightarrow i_1m_1 = i_2m_2
\]

\[
\Rightarrow 5 \times 1 = \frac{1 \times 19.1 \times 1000}{M \times 80.9}
\]

\[
\Rightarrow M = \frac{19.1 \times 1000}{5 \times 80.9} = 47.22 \text{ g/mol}
\]
**Question:** Fe is in its ground state. Find its spin magnetic moment.

**Options:**
(a) 1.9 B.M
(b) 2.5 B.M
(c) 3.1 B.M
(d) 4.9 B.M

**Answer:** (d)

**Solution:**

Fe = [Ar] 4s² 3d⁶

\[
\begin{array}{c}
\downarrow \\
1 \\
1 \\
1 \\
1 \\
1 \\
\end{array}
\]

n = 4

\[\mu = \sqrt{n(n + 2)} \text{ B.M}\]

\[= \sqrt{24} \text{ B.M}\]

\[= 4.9 \text{ B.M}\]

---

**Question:** Which of the following is linear molecule?

**Options:**
(a) N₂O
(b) ClO⁻
(c) N₃⁻
(d) All of these

**Answer:** (d)

**Solution:**

N₃⁻

\[
\left[ \begin{array}{c}
\tilde{N} \\
\equiv \\
N \\
\equiv \\
\tilde{N} \\
\end{array} \right]^- \\
\]

N₂O
Identify enzyme 1 and enzyme 2

Options:
(a) Invertase, Maltase
(b) Maltase, Zymase
(c) Invertase, Zymase
(d) Zymase, Invertase

Answer: (c)

Solution:
Sucrose $\xrightarrow{\text{Enzyme}_1}$ Fructose + Glucose
Glucose $\xrightarrow{\text{Enzyme}_2}$ Ethyl alcohol

Question: What are the common oxidation states of Chromium?
Options:
(a) +1 to +6
(b) +2 to +6
(c) +3 to +6
(d) +1 and +3
Answer: (b)

Solution: Chromium shows oxidation number +2 to +6, out of which +3 and +6 are most common.

Question: Which series in hydrogen line spectrum falls under visible region?
Options:
(a) Lyman
(b) Balmer
(c) Paschen
(d) Pfund
Answer: (b)
Solution: Factual

Question: Primary, secondary and tertiary amines can be distinguished by which test?
Options:
(a) KOH, CHCl₃
(b) Para toluene sulfonyl chloride
(c) Benzene sulfonic acid
(d) Hofmann mustard oil reaction
Answer: (b)
Solution: Hinsberg reagent

\[
\text{C}_6\text{H}_5\text{SO}_2\text{Cl} + \text{CH}_3\text{–CH}_2\text{–NH}_2 \xrightarrow{\text{HCl}} \text{C}_6\text{H}_5\text{SO}_2\text{N–CH}_3 \\
\text{(Base soluble compound)}
\]

\[
\text{C}_6\text{H}_5\text{SO}_2\text{Cl} + (\text{CH}_3\text{–CH}_2)_2\text{–NH} \xrightarrow{\text{HCl}} \text{C}_6\text{H}_5\text{SO}_2\text{N–CH}_2\text{–CH}_3 \\
\text{CH}_2\text{–CH}_3 \\
\text{(Base insoluble)}
\]

\[
\text{C}_6\text{H}_5\text{SO}_2\text{Cl} + (\text{CH}_3\text{–CH}_2)_3\text{–N} \rightarrow \text{No reaction}
\]

Question: Match the following:
<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) [Co(NH\textsubscript{3})\textsubscript{6}] [Cr(CN)\textsubscript{6}]</td>
<td>i) Linkage</td>
</tr>
<tr>
<td>(B) [Co(NH\textsubscript{3})\textsubscript{5}(NO\textsubscript{2})]Cl\textsubscript{2}</td>
<td>ii) Coordination</td>
</tr>
<tr>
<td>(C) [Cr(H\textsubscript{2}O)\textsubscript{6}]Cl\textsubscript{3}</td>
<td>iii) Optical</td>
</tr>
<tr>
<td>(D) Cis-[CrCl\textsubscript{2}en\textsubscript{2}]\textsuperscript{3-}</td>
<td>iv) Solvate</td>
</tr>
</tbody>
</table>

Options:

(a) A → (i); B → (ii); C → (iv); D → (iii)
(b) A → (ii); B → (i); C → (iv); D → (iii)
(c) A → (iii); B → (i); C → (iv); D → (ii)
(d) A → (iv); B → (ii); C → (iii); D → (i)

Answer: (b)

Solution:

A) [Co(NH\textsubscript{3})\textsubscript{6}] [Cr(CN)\textsubscript{6}]

Interchange of ligands is possible between coordinate entities. Thus, coordination isomerism

B) [Co(NH\textsubscript{3})\textsubscript{5}(NO\textsubscript{2})]Cl\textsubscript{2}

NO\textsubscript{2} is ambidentate and can be bind as –ONO. Thus, linkage isomerism

C) [Cr(H\textsubscript{2}O)\textsubscript{6}]Cl\textsubscript{3}

Water can also be present as free solvent molecule i.e., [Cr(H\textsubscript{2}O)\textsubscript{5}]Cl\textsubscript{2}.H\textsubscript{2}O. Thus solvate isomerism

D) Cis-[CrCl\textsubscript{2}en\textsubscript{2}]\textsuperscript{3-}

Since, non-superimposable mirror images are possible compound shows optical isomerism

Question: Which of the following is ambident nucleophile?

Options:

(a) KCN / AgCN
(b) KNO\textsubscript{2} / AgNO\textsubscript{2}
(c) KI / AgI
(d) Both (a) and (b)

**Answer:** (d)

**Solution:** The nucleophiles that can attack through two different sites are known as ambident nucleophiles. Ambident nucleophile are having 2 donor sites.

**Question:** Which of the following can be estimated by Kjeldahl's method?

**Options:**

(a) 

(b) 

(c) 

(d) 

**Answer:** (d)

**Solution:** The Kjeldahl's method is not applicable to nitro, diazogroups and compound in which nitrogen atom present in the ring.

Because in the above three case nitrogen atom can’t be converted to ammonium sulphate under the reaction conditions.
**Question:** Which of the following is wrong for eutrophication?

**Options:**
(a) Detergents increase it  
(b) Fertilizer increase it  
(c) Plant growth increase  
(d) Not enough nutrients for plants to grow

**Answer:** (c)

**Solution:** eutrophication decreases dissolved oxygen of water

**Question:** S1: 2-methyl butane is oxidized by KMnO₄ to 2-methyl-2-butanol. 
S2: n-alkane is easily oxidized to alcohol by KMnO₄

**Options:**
(a) Both S1 and S2 are correct  
(b) S1 is correct, S2 is wrong  
(c) S2 is correct, S1 is wrong  
(d) Both S1 and S2 are wrong

**Answer:** (b)

**Solution:** KMnO₄ oxidises alkanes containing tertiary hydrogen to corresponding alcohols

![Chemical reaction diagram]

So, S1 is correct while S2 is wrong

**Question:** In the reaction of aniline with HNO₃, meta product is formed as 47% because

**Options:**
(a) Anilinium ion is formed  
(b) NH₂ is meta directing  
(c) Of low temperature  
(d) NO₂ is meta directing

**Answer:** (a)

**Solution:**
In acidic medium Anilinium ion is formed which is meta directing in nature.

**Question:** Find the compound in which hydrolysis does not take place

**Options:**
(a) SF$_6$
(b) BF$_3$
(c) XeF$_4$
(d) XeF$_6$

**Answer:** (a)

**Solution:** In SF$_6$ the fluorine atoms attached to the sulphur act as shield, and that’s why SF$_6$ is chemically inert towards hydrolysis.

**Question:** [Fe(CN)$_6$]$^{3-}$ and [Cr(CN)$_6$]$^{3-}$. Find the hybridisation and magnetic character

**Options:**
(a) d$^2$sp$^3$, paramagnetic
(b) d$^2$sp$^3$, diamagnetic
(c) sp$^3$d$^2$, paramagnetic
(d) sp$^3$d$^2$, diamagnetic

**Answer:** (a)

**Solution:** Fe$^{3+}$ ⇒ [Ar] 3d$^5$
Since, CN$^-$ is a strong field ligand.
Thus, hybridization ⇒ d<sup>2</sup>sp<sup>3</sup>

Magnetic character ⇒ paramagnetic

**Question:**

\[ \text{MoO}_3 \xrightarrow{\text{HT/HP}} \]

**Options:**

(a) 

(b) 

(c) 

(d) 

Answer: (a)

Solution:
Alkanes having six to 10 carbon atoms are converted into benzene and its homologues at high pressure and temperature in presence of catalyst.
Question: \( 16(p \land q) \oplus (p \otimes q) \) is tautology, \( \oplus, \otimes = \)

Options:
(a) \( \rightarrow \rightarrow \)
(b) \( \land \rightarrow \)
(c) \( \lor \rightarrow \)
(d) \( \land \lor \)

Answer: (a)

Solution:
\[
(p \land q) \rightarrow (p \rightarrow q) \\
(p \land q) \rightarrow (\sim p \lor q) \\
(\sim p \lor \sim q) \lor (\sim p \lor q) \\
\Rightarrow \oplus \rightarrow \\
\Rightarrow \rightarrow
\]

Question: \( S_1 = \{ |z - 1| < \sqrt{2} \}, S_2 = \{ \text{Re}(z(1-i)) \} \geq 1, S_3 = \{ \text{Im}(z) < 1 \} \). Then \( S_1 \cap S_2 \cap S_3 \)

Options:
(a) is singleton set
(b) Has so many elements
(c) Has exactly 2 elements
(d) Is null set

Answer: (b)

Solution:
\[
S_1 = |z - 1| < \sqrt{2} \Rightarrow (x-1)^2 + y^2 < 2
\]
$S_2 = \text{Re}\left(z(1-i)\right) \geq 1 \Rightarrow x + y \geq 1$

$S_3 = \text{Im}(z) < 1 \Rightarrow y < -1$

$\Rightarrow S_1 \cap S_2 \cap S_3$ has so many elements

**Question:** $\sin^{-1}\left[x^2 + \frac{1}{3}\right] + \cos^{-1}\left[x^2 - \frac{2}{3}\right] = x^2$, number of solutions in $x \in (1, 1)$

**Options:**
(a) 0
(b) 2
(c) 3
(d) 4

**Answer:** (a)

**Solution:**
\[
\sin^{-1}\left[x^2 + \frac{1}{3}\right] + \cos^{-1}\left[x^2 + \frac{1}{3}\right] - 1 = x^2 \quad ; \quad x \in (-1, 1)
\]

$\Rightarrow \sin^{-1}(t) + \cos^{-1}(t - 1) = x^2$, where $t = \left[x^2 + \frac{1}{3}\right] = \text{Integer}$

\[\therefore t = 0, 1\]

(a) when $t = 0 \Rightarrow x^2 = \pi$ and $x^2 < \frac{2}{3}$

(b) when $t = 1 \Rightarrow x^2 = \pi$ and $\frac{2}{3} < x^2 < \frac{5}{3}$

No solution

**Question:** Variance of 3n observations is 4 mean of first 2n observations is 6 and mean of next n observations is 3. If 1 is added in first 2n observation and 1 is subtracted from last n observations than find new variance.

**Options:**
(a) 
(b) 
(c) 
(d) 

**Answer:** ()

**Solution:**
Given observation be
\[x_1, x_2, x_3, x_4 \ldots x_{2n}, x_{2n+1} \ldots x_{3n}\]

\[\therefore \frac{x_1 + x_2 + \ldots + x_{2n}}{2n} = 6\]

And \[\frac{x_{2n+1} + x_{2n+2} + \ldots + x_{3n}}{n} = 3\]

\[\therefore x_1 + x_2 + \ldots + x_{3n} = 15n\]

Thus mean of \(3n\) observation = \(\frac{15n}{3n} = 5\)

Now, given variance is 4

\[\sum_{i=1}^{3n} x_i^2 \quad \frac{3n}{3n} - (\bar{X})^2 = 4\]

\[\sum_{i=1}^{3n} x_i^2 = 4 + 25\]

\[\sum_{i=1}^{3n} x_i^2 = 87n\]

Now new mean will be \(\bar{X}'\)

\[= \frac{x_1 + x_2 + \ldots + x_{3n} + 2n(1) - (1 \times n)}{3n}\]

\[= \frac{x_1 + x_2 + \ldots + x_{3n}}{3n} + \frac{n}{3n}\]

\[\bar{X}' = \frac{16}{3}\]

Now, new variance

\[\left( \sum_{i=1}^{2n} (x_i + 1)^2 + \sum_{i=2n+1}^{2n} (x_i - 1)^2 \right) \frac{3n}{3n} - (\bar{X}')^2\]

\[= \left( \sum_{i=1}^{3n} x_i^2 + 2n(1) + n(1) + 2\sum_{i=1}^{2n} x_i - 2\sum_{i=2n+1}^{2n} x_i \right) \frac{3n}{3n} - (\bar{X}')^2\]

\[= \frac{87n + 3n + 2(12n) - 2(3n)}{3n} - \left( \frac{16}{3} \right)^2\]
\[
\frac{108}{3} - \frac{256}{3} = \frac{68}{9}
\]

**Question:** \( \sum_{r=0}^{6} ^6C_r \times ^6C_{6-r} = ? \)

**Options:**
(a)
(b)
(c)
(d)

**Answer:** ()

**Solution:**
\[\sum_{r=0}^{6} ^6C_r \times ^6C_{6-r} = 12 \cdot 6\]

**Question:** Probability of ‘0’ at odd position is \( \frac{1}{3} \) and probability of ‘0’ at even position is \( \frac{1}{2} \).
Find the probability that 10 is immediately followed by 01.

**Options:**
(a)
(b)
(c)
(d)

**Answer:** ()

**Solution:**
For 0110 \( \Rightarrow \) Probability = \( \frac{1}{3} \times \frac{1}{2} \times \frac{2}{3} \times \frac{1}{2} = \frac{1}{18} \)

**Question:** Find \( \lim_{\theta \to 0} \frac{\tan(\pi \cos^2 \theta)}{\sin(2\pi \sin^2 \theta)} \)

**Options:**
(a) \(-\frac{1}{4}\)
(b) \(\frac{1}{2}\)
(c) $\frac{-1}{2}$
(d) $\frac{1}{4}$

Answer: (c)

Solution:
\[
\lim_{\theta \to 0} \frac{\tan(\pi \cos^2 \theta)}{\sin(2\pi \sin^2 \theta)} = \lim_{\theta \to 0} \frac{\tan(\pi \cos^2 \theta)}{\sin(2\pi \cos^2 \theta)} = -\lim_{\theta \to 0} \frac{1}{2} \sec^2(\pi \cos^2 \theta) = -\frac{1}{2}
\]

Question: \( f(x) = \begin{cases} 
2 - \sin \frac{1}{2} &; x \neq 0 \\
0 &; x = 0 
\end{cases} \)

Options:
(a) Monotonic in \((-\infty, 0) \cup (0, \infty)\)
(b) non Monotonic in \((-\infty, 0) \cup (0, \infty)\)
(c)
(d)

Answer: (b)

Solution:
\[
f(x) = \begin{cases} 
2x - x \sin \frac{1}{x} &; x > 0 \\
-2x + x \sin \frac{1}{x} &; x < 0 
\end{cases}
\]
\[
f'(x) = \begin{cases} 
2 - \frac{d}{dx}\left[ x \sin \frac{1}{x} \right] &; x > 0 \Rightarrow f'(x) > 0 \\
-2 + \frac{d}{dx}\left[ x \sin \frac{1}{x} \right] &; x < 0 \Rightarrow f'(x) < 0 
\end{cases}
\]
\[
\Rightarrow f(x) \text{ is non-monotonic in } (-\infty, 0) \cup (0, \infty)
\]

Question: \( f(x) = e^{-x} \sin x \), \( F(x) = \int_0^x f(t) \, dt \). Find \( \int_0^1 e^x \left( F'(x) + f(x) \right) \, dx \) lie in
Options:
(a) \[\left(\frac{330}{360}, \frac{331}{360}\right)\]
(b) \[\left(\frac{327}{360}, \frac{329}{360}\right)\]
(c) \[\left(\frac{335}{360}, \frac{336}{360}\right)\]

Answer: (a)

Solution:
\[f(x) = e^{-x} \sin x; \quad f''(x) = f(x)\]

\[\therefore I = \left[ e^x \right]_0^1 \cdot 2 f(x) dx = 2 \left[ \sin x \right]_0^1 = -2 (\cos x)_0^1\]

\[= -2[\cos 1 - 1] = 2 - 2 \cos 1 = 0.9194 \in \left(\frac{330}{360}, \frac{331}{360}\right)\]

Question:  \[\lim_{n \to \infty} \frac{[r] + [2r] + \ldots + [nr]}{n^2}\]

Options:
(a)
(b)
(c)
(d)

Answer: ()

Solution:
\[\lim_{n \to \infty} \frac{(r+2r+\ldots nr)}{n^2} = \frac{\{r\} + \{2r\} + \{3r\} + \ldots + \{nr\}}{n^2}\]

\[= \lim_{n \to \infty} \frac{r \cdot n(n+1)}{2n^2} = \frac{r}{2}\]

Question: If angle between tangents is \(\tan^{-1}\left(\frac{12}{5}\right)\), ratio of \(ar \triangle PAB\) and \(ar \triangle CAB\) =
\[ x^2 - y^2 - 2x - 4y + 4 = 0 \]

**Options:**
(a) 
(b) 
(c) 
(d) 

**Answer:** ()

**Solution:**

\[ \text{Angle between tangents } = 2\theta = \tan^{-1}\left(\frac{12}{5}\right) \]

\[ \frac{2\tan\theta}{1 - \tan^2\theta} = \frac{17}{5} \implies r = 1 \]

\[ 6\tan^2\theta + 5\tan\theta - 6 = 0 \]

\[ 6\tan^2\theta + 9\tan\theta - 4\tan\theta - 6 = 0 \]

\[ 3\tan\theta(2\tan\theta + 3) - 2(\tan\theta + 3) = 0 \]

\[ \Rightarrow \tan\theta = \frac{2}{3} = \frac{AC}{AP} \]

\[ AP = \frac{3r}{2} = \frac{3}{2} = BP \]

\[ \therefore \quad \frac{Ar \triangle PAB}{Ar \triangle CAB} = \frac{PA.PB.PC}{AC.BC.CC} = \frac{\frac{9}{4} \left(\frac{12}{13}\right)}{\frac{1}{4} \left(\frac{12}{13}\right)} = \frac{9}{1} \]

**Question:** \( x^2 + y^2 = 25 \), tangent to it at (3, 4) meet axes at P and Q. A circle is drawn passing through origin with its center at incenter of \( \triangle OPQ \). Find radius of that circle

**Options:**
(a)
Equation of tangent $\Rightarrow 3x + 4y = 25$; $P\left(\frac{25}{3}, 0\right)$; $Q\left(0, \frac{25}{4}\right)$

Centre of circle $= \left(\frac{625}{12}, \frac{625}{12}, \frac{12}{300}, \frac{12}{300}, \frac{12}{300}\right)$

Centre $= \left(\frac{25}{12}, \frac{25}{12}\right)$

$\therefore$ Radius $= \frac{25\sqrt{2}}{12}$

**Question:** $\cos x (3 \sin x + \cos x + 3)\,dx = dx (1 + y \sin x (3 \sin x + \cos x + 3))\,y(0) = 0$. Find $y\left(\frac{\pi}{3}\right)$.

**Options:**
(a) 
(b) 
(c) 
(d) 

**Answer:** ()

**Solution:**

$\cos x (3 \sin x + \cos x + 3)\frac{dy}{dx} - y \sin x (3 \sin x + \cos x + 3) = 1$
\[ \frac{dy}{dx} - \tan xy = \frac{1}{\cos x(3 \sin x + \cos x + 3)} \]

\[ IF = e^{\int \tan x \, dx} = \cos x \]

\[ \therefore y \cos x = \int \frac{dx}{3 \sin x + \cos x + 3} = \int \frac{\sec^2 x \, dx}{6 \tan \frac{x}{2} + 1 - \tan \frac{x}{2} + 3 + 3 \tan^2 \frac{x}{2}} \]

\[ y \cos x = \int \frac{\sec^2 x \, dx}{2 \tan \frac{x}{2} + 6 \tan \frac{x}{2} + 4} \]

Let \( \tan \frac{x}{2} = t \Rightarrow \frac{1}{2} \sec^2 \frac{x}{2} \, dx = dt \)

\[ y \cos x = \int \frac{dt}{t^2 + 3t + 2} = \int \frac{-1}{(t + 2)^2} + \frac{1}{(t + 1)^2} \, dt \]

\[ y \cos x = \ln \left( \frac{t + 1}{t + 2} \right) + c \]

\[ y \cos x = \ln \left( 1 + \tan \frac{x}{2} \right) + c \Rightarrow c = \ln 2 \]

\[ y \cos x = \ln 2 \left( \frac{1 + \tan \frac{x}{2}}{2 + \tan \frac{x}{2}} \right) \]

At \( x = \frac{\pi}{3} \Rightarrow y = 2 \ln 2 \left[ \frac{1 + \frac{1}{\sqrt{3}}}{2 + \frac{1}{\sqrt{3}}} \right] = 2 \ln 2 \left( \frac{\sqrt{3} + 1}{2\sqrt{3} + 1} \right) \]

**Question:** \( A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}, B = \begin{bmatrix} \alpha \\ \beta \end{bmatrix} \) is non-zero matrix, \( AB = B, a + d = 2021 \) find \( ad - bc \)

**Answer:** 2020.00

**Solution:**

\[ AB = B \Rightarrow \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} \alpha \\ \beta \end{bmatrix} = \begin{bmatrix} \alpha \\ \beta \end{bmatrix} \]
aaα + bbβ = α \Rightarrow (a-1)α + bβ = 0

cα + ddβ = β \Rightarrow cα + (d - 1)β = 0

\Rightarrow \begin{vmatrix} a-1 & b \\ c & d-1 \end{vmatrix} = 0

\Rightarrow (a-1)(d-1)-bc = 0

\Rightarrow ad - (a + d) + 1 - bc = 0

\Rightarrow ad - bc = (a + d) - 1 = 2020

**Question:** \( y^2 = 4x - 20 \), tangent to this parabola at \((6, 2)\) is also tangent to \( \frac{x^2}{2} + \frac{y^2}{b} = 1 \), find \( b^2 \).

**Answer:** 196.00

**Solution:**
Equation of tangent to \( y^2 = 4x - 20 \) at \((6, 2)\) is

\[ 2y = 2(x + 6) - 20 \Rightarrow y = x - 4 \]

\[ \therefore \text{It is tangent to } \frac{x^2}{2} + \frac{y^2}{b} = 1 \]

\[ \Rightarrow 16 = 2 \times 1 + b \]

\[ \Rightarrow b = 14 \]

\[ \Rightarrow b^2 = 196 \]

**Question:** \( \int_0^1 \sin \left( \frac{2\pi x}{e^{-x}} \right) dx = \alpha e^{-\frac{1}{x}} + \beta e^{-\frac{1}{2}} + \gamma. \) Find \( \alpha + \beta + \gamma = ? \)

**Answer:** 0.00

**Solution:**
\[ I = \int_0^1 \frac{\sin (2\pi x)}{e^{x}} dx = 10 \int_0^1 e^{-x} \sin (2\pi x) dx \]

\[ = 10 \left[ \frac{e^{-x}}{1 + 4\pi^2} \left\{ -\sin (2\pi x) - 2\pi \cos (2\pi x) \right\} \right]_0^1 \]
\[
\frac{10}{1 + 4\pi^2} \left[ e^{-2\pi} - \frac{1}{e} \right] = \frac{20\pi}{1 + 4\pi^2} \left[ \frac{1}{e} - 1 \right]
\]

\Rightarrow \alpha = \frac{-20\pi}{1 + 4\pi^2}, \quad \beta = 0, \quad \gamma = \frac{20\pi}{1 + 4\pi^2}

\Rightarrow \alpha + \beta + \gamma = 0

**Question:** \( x + 2 \tan x = \frac{\pi}{2} \) find values of \( x \) is \( x \in [0, 2\pi] \)

**Answer:** 3.00

**Solution:**

\( x + 2 \tan x = \frac{\pi}{2} \Rightarrow \tan x = \frac{\pi}{4} - \frac{x}{2}; \quad x \in [0, 2\pi] \)

Graph of \( y = \tan x \) and \( y = \frac{\pi}{4} - \frac{x}{2} \) intersects at 3 points