JEE (Main)-2026

Session-1

22 January 2026 Shift-2

Memory-Based Answers & Solutions

(Physics, Chemistry, and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks
are 300.

(3) This question paper contains Three Parts. Part-A is Physics, Part-B is Chemistry and Part-C is Mathematics. Each part has only two sections: Section-A and Section-B.

(4) Section - A : Attempt all questions.

(5) Section - B : Attempt all questions.

(6) Section - A (01 – 20) contains 20 multiple choice questions which have only one correct answer. Each question carries +4 marks for correct answer and –1 mark for wrong answer.

(7) Section - B (21 – 25) contains 5 Numerical value based questions. The answer to each question should be rounded off to the nearest integer. Each question carries +4 marks for correct answer and –1 mark for wrong answer.

PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Find the dimensions of the expression $\frac{\varepsilon_0 E}{T}$, where ε_0, E and T are permittivity, electric field and time.

(1) AL (2) AL^{-2}

(3) $MA^{-1}L$ (4) MLA^2

Answer (2)

Sol. $EA = \frac{q}{\varepsilon_0}; \varepsilon_0 = \frac{q}{EA}$

$\Rightarrow \quad \varepsilon_0 E = \frac{q}{A}$

$\frac{q}{AT} = \frac{AT}{L^2 T}$

2. In an open organ pipe 3rd and 6th harmonic frequency differ by 3200 Hz. Find the length of organ pipe (speed of sound = 320 m/s)

(1) 5 cm (2) 10 cm

(3) 15 cm (4) 20 cm

Answer (3)

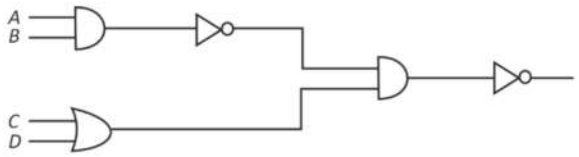
Sol. $\frac{6C}{2l} - \frac{3C}{2l} = 2200$

$\Rightarrow \quad \frac{3C}{2l} = 3200$

$\Rightarrow \quad \frac{3 \times 320}{2l} = 3200 = 10$

$\frac{3}{20}$ = 0.15 m or 15 cm

3. For the given logic gate find output functions.



(1) $\bar{A} \cdot \bar{B} + C + D$

(2) $\bar{A} + \bar{B} + \bar{C} \cdot \bar{D}$

(3) $AB + CD$

(4) $AB + \bar{C} \cdot \bar{D}$

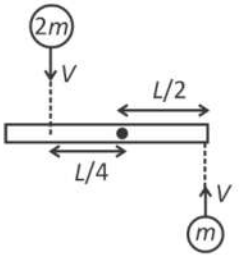
Answer (4)

Sol. $\overline{\overline{AB} \cdot (C + D)}$

= $\overline{\overline{AB}} + \overline{C + D}$

= $AB + \bar{C} \cdot \bar{D}$

4. Two balls of mass $2m$ and m collides with rod of mass m and length L as shown, balls stick to the rod after collision. Find $\frac{V}{\omega}$ if rod is hinged at centre. ($L = 8m$)



(1) $\frac{11}{2}$ (2) $\frac{11}{3}$

(3) $\frac{11}{4}$ (4) $\frac{9}{4}$

Answer (2)

Sol. $2mV\frac{L}{4}+\frac{mVL}{2} = \left(\frac{ml^2}{12}+\frac{mL^2}{4}+\frac{2mL^2}{16}\right)\omega$

$$mVL=\frac{11}{24}mL^2\omega$$

$$\frac{V}{\omega}=\frac{11}{24}L$$

$$= \frac{11}{3}$$

5. A gas undergoes a process in which state variable changes from (1 atm, 60ml, 27°C) to (*P* atm, 30 ml, 77°C) then *P* is

(1) 3 atm (2) $\frac{5}{4}$ atm

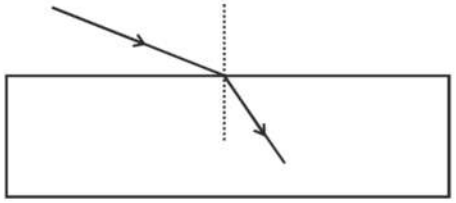
(3) $\frac{7}{3}$ atm (4) $\frac{4}{3}$ atm

Answer (3)

Sol. $\frac{1\times60}{300}-\frac{P\times30}{350}$

$$\Rightarrow \quad P=2\times\frac{7}{6}=\frac{7}{3}\text{ atm}$$

6. A light ray incident on a slab of refractive index $\frac{3}{2}$. If wavelength of refracted ray is 520 nm. Find wavelength of incident ray.



(1) 460 nm (2) 780 nm

(3) 360 nm (4) 560 nm

Answer (2)

Sol. $V = f\lambda$

$$\lambda_{slab}=\frac{\lambda}{\mu}$$

$$\lambda = 520\times\frac{3}{2} = 780\text{ nm}$$

7. Which of the following is/are true for YDSE experiment?

i. Fringe width increases if slit distance is constant & wavelength increased

ii. Fringe width increases if slit distance is constant & wavelength decreased

iii. Fringe width increases if slit distance is increased & wavelength constant

iv. Fringe width increases if slit distance is decreased & wavelength constant.

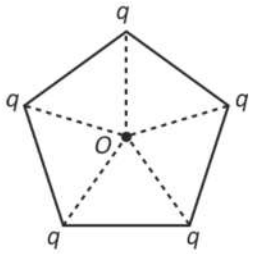
(1) i, iii (2) i, iv

(3) ii, iii (4) ii, iv

Answer (2)

Sol. $\beta=\frac{\lambda D}{d}$

8. For the given arrangement of charges find the strength of electric field *E* and potential V at geometrical center *O*.



(1) $E = 0; V = 0$

(2) $E = 0$; V = Non-zero

(3) E = Non-zero; V = Non-zero

(4) E = Non-zero; $V = 0$

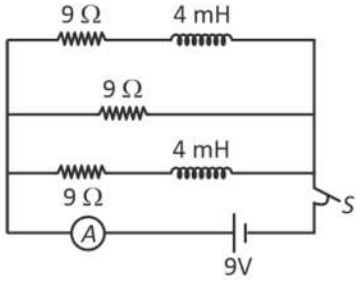
Answer (2)

Sol. $E = 0$

$$V = 5 \cdot \frac{kq}{r}$$

So $E = 0$; $V \neq 0$

9. For the given circuit, find reading of ammeter just after key(s) is closed.



(1) 1 A (2) 3 A

(3) $\frac{3}{2}$ A (4) $\frac{1}{2}$ A

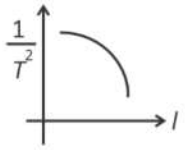
Answer (1)

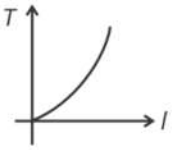
Sol. At $t = 0$, inductor will behave like open circuit.

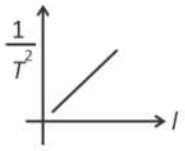
So,

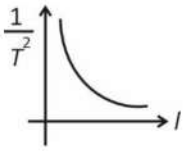
$$I = \frac{9}{9} = 1\text{ A}$$

10. Choose the correct graph between time period T and length of pendulum l.

(1) 

(2) 

(3) 

(4) 

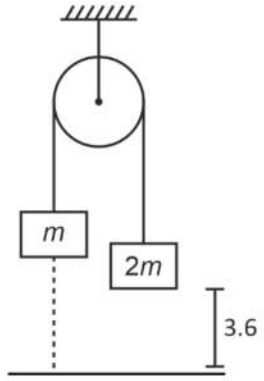
Answer (4)

Sol. $T = 2\pi\sqrt{\frac{l}{g}}$

$$l \cdot \frac{1}{T^2} = k$$

$$T^2 = kl$$

11. If the string connecting m and ground is cut find the speed with which $2m$ block hits the ground as shown. ($g = 10\text{ m/s}^2$)



(1) 3 m/s (2) 4 m/s

(3) $2\sqrt{6}$ m/s (4) $6\sqrt{2}$ m/s

Answer (3)

Sol. $a = \frac{2m - m}{2m + m} g = \frac{g}{3}\text{ m/s}^2$

$$v = \sqrt{2as} = \sqrt{7.2 \times \frac{g}{3}} = \sqrt{24}\text{ m/s}$$

12. In hydrogen type atom, shortest wavelength in Lyman series is given as 91 nm. Then longest wavelength in Paschen series of this atom shall be

(1) 31.82 nm (2) 113.3 nm

(3) 1.87 μm (4) 2.31 μm

Answer (3)

Sol. Lowest Lyman $\frac{1}{\lambda_1} = RZ^2\{1\}$

Highest Paschen $\frac{1}{\lambda_2} = RZ^2\left(\frac{1}{9} - \frac{1}{16}\right)$

$\frac{\lambda_2}{\lambda_1} = \frac{144}{7}$

$\lambda_2 = \frac{144}{7} \times 9 = 1872$

13. **Statement-1:** Kinetic energy of system = $\frac{1}{2}m_1v_1^2$ + $\frac{1}{2}m_2v_2^2$ ... $\frac{1}{2}m_nv_n^2$

Statement-2: Kinetic energy of system = Kinetic energy of center of mass + kinetic energy with respect to center of mass

(1) Statement I is true
Statement II is true

(2) Statement I is true
Statement II is false

(3) Statement I is false
Statement II is true

(4) Statement I is false
Statement II is false

Answer (1)

Sol. KE = $KE_0 + KE$

14. Find the percentage change in height risen by liquid if density of fluid, radius of capillary and surface tension of liquid are decreased by 1%. Assume contact angle doesn't change and capillary is of sufficient length.

(1) +1% (2) –1%

(3) +3% (4) –3%

Answer (1)

Sol. $\frac{2S\cos\theta}{r} = h\rho g$

$h = \frac{2S\cos\theta}{\rho g r}$

$\frac{\Delta h}{h} = \frac{\Delta S}{S} = \frac{\Delta\rho}{\rho} - \frac{\Delta r}{r}$

= –1% + 1% + 1%

= 1%

15. A capacitor of capacitance 10 μF is connected with a battery of emf 6V. Now battery is disconnected and another uncharged capacitor of capacitance 20 μF is connected to the capacitor. Find charge on 20 μF capacitor.

(1) $\frac{30}{4}$ μC (2) 10 μC

(3) $\frac{20}{3}$ μC (4) 40 μC

Answer (4)

Sol. $V = \frac{c_1 v}{c_1 + c_2} = \frac{60}{30} = 2$ Volt

$q_2 = 20 \times 2 = 40$ μC

16. **Statement-1:** Time period of simple pendulum is increased if density of material of pendulum is increased.

Statement-2: Time a period of simple pendulum is $T = 2\pi\sqrt{\frac{l}{g}}$.

(1) Statement I is true
Statement II is true

(2) Statement I is true
Statement II is false

(3) Statement I is false
Statement II is true

(4) Statement I is false
Statement II is false

Answer (3)

Sol. Conceptual

17. For the given statements below mark the correct option.

Statement-I: Work done by a conservative force f, from $\vec{r}_1$ to $\vec{r}_2$ is given by $W = -\int_{r_1}^{r_2} f \cdot dr$.

Statement-II: Work done by conservative force is path dependent.

(1) Statement-I and statement-II is true

(2) Statement-I is true and statement-II is false

(3) Statement-I is false and statement-II is true

(4) Statement-I and statement-II is false

Answer (4)

Sol. $W = \int_{r_1}^{r_2} f \cdot dr$, is path independent.

18. Electromagnetic wave with intensity $I = 4 \times 10^{14}$ watt/m^2 is propagating in free space. Find the amplitude of magnetic field B_0.

(Use $c = 3 \times 10^8$ m/s, $\varepsilon_0 = 8.85 \times 10^{-12}$ c^2/N.m^2)

(1) 1.83 Tesla (2) 0.5 Tesla

(3) 4.5 Tesla (4) 1 Tesla

Answer (1)

Sol. $E_0 = CB_0$

And $I = \frac{1}{2}\varepsilon_0 E_0^2 \times c$

$\Rightarrow I = \frac{1}{2}\varepsilon_0 c^3 \cdot B_0^2$

$\Rightarrow \frac{2I}{\varepsilon_0 c^3} = B_0^2 = 3.35$

$\Rightarrow B_0 = 1.83$ Tesla

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

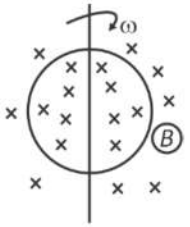
21. Three identical liquid drops each carrying same charges coalesce to form single drop. Ratio of potential of large drop and single smaller drop is $3^{N/3}$ then N is

Answer (2)

Sol. $\frac{4}{3}\pi r^3 \, 3 = \frac{4}{3}\pi R^3 \Rightarrow R = 3^{1/3} r$

$v = \frac{q}{4\pi\varepsilon_0 r} \quad V = \frac{3q}{4\pi\varepsilon_0 R} \quad V = \frac{3}{3^{1/3}} = 3^{2/3}$

22. A circular coil is rotating in magnetic field of magnitude $0.25T$ with angular speed 6 rpm about its diameter. At $t = 0$ coil's configuration is given as shown. If induced emf after coil rotated by angle 30° is 1.6 mV. Find radius of the coil (in cm). ($\pi^2 = 10$)



Answer (8)

Sol. $\sum = BA\omega \sin(\cos t)$

$B\pi R^2 \cdot \frac{6 \times 2\pi}{60} \frac{1}{2} = 16 \times 10^{-4}$

$R^2 = \frac{16 \times 10^{-4}}{0.25}$

$R = 8$ cm

23. A metallic conductor of length $2m$ and cross-sectional area 0.2 mm^2 carries steady current of 1.2A when a potential difference of 2V is applied across it. ($e = 1.6 \times 10^{-19}$, charge density = 7.5×10^{28} m^{-3})

Then the mobility of charge carrier is $x \times 10^{-4}$ SI units. Find x

Answer (5)

Sol. $\mu = \frac{v_d}{E} = \frac{Il}{neA(El)} = \frac{Il}{neAV}$

$= 5 \times 10^{-4}$ m^{2}V^{-1}S^{-1}

24.

25.

CHEMISTRY

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. The correct order of electron gain enthalpy (magnitude only) for group 16 elements is

   (1) Te > Se > S > O

   (2) S > Se > Te > O

   (3) O > S > Se > Te

   (4) S > O > Se > Te

Answer (2)

Sol.

	O	S	Se	Te
ΔH_{eg} (kJ/mol)	–141	–200	–195	–190

2. 100 g 98% by weight H_2SO_4 is mixed with 100 g 49% by weight H_2SO_4. Mole fraction of H_2SO_4 in the solution is

   (1) 0.9 (2) 0.1

   (3) 0.67 (4) 0.33

Answer (4)

Sol. (I) Mass of H_2SO_4 = 98 g

Mass of H_2O = 2 g

(II) Mass of H_2SO_4 = 49 g

Mass of H_2O = 51 g

Total mass of H_2SO_4 = 98 + 49 = 147 g

$n_{H_2SO_4} = 1.5$ mol

Mass of H_2O = 53 g

$n_{H_2O} \approx 3$ mol

$$X_{H_2SO_4} = \frac{1.5}{4.5} = \frac{1}{3}$$

3. Correct order of ionisation enthalpy is

   (1) F > Cl > Cl^- > F^- (2) F^- > Cl^- > F > Cl

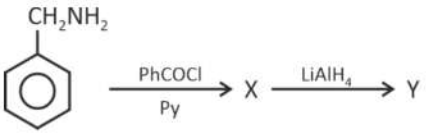
   (3) Cl > F > Cl^- > F^- (4) F > Cl > F^- > Cl^-

Answer (1)

Sol.

				kJ/mol
Cl(17)	→	2, 8, 7	→	1256
F(9)	→	2, 7	→	1680
F^-(9 + 1)	→	2, 8	→	+328
Cl^-(17+1)	→	2, 8, 8	→	+349

4. Consider the following reaction.



The correct structure of Y is

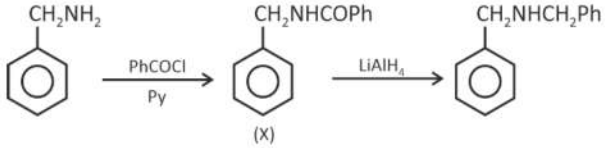
(1) $PhCH_2NHCOPh$

(2) $Ph–CH_2NHCH_2Ph$

(3) $PhNH_2CH_2Ph$

(4) $PhCH_3$

Answer (2)

Sol. 

5. Which of the following is a mixed oxide?

(1) Fe_2O_3 (2) PbO_2

(3) Pb_3O_4 (4) BaO_2

Answer (3)

Sol. Pb_3O_4 is a mixed oxide of PbO and PbO_2

6. Which of following is basic buffer?

(1) NaOH + CH_3COONa

(2) NaOH + Na_2SO_4

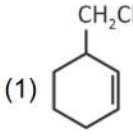
(3) K_2SO_4 + H_2SO_4

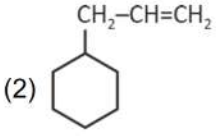
(4) NH_4OH + NH_4Cl

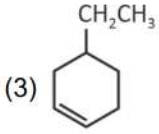
Answer (4)

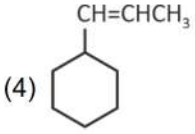
Sol. NH_4OH is weak base and NH_4Cl is its salt with strong base

7. An alkene on reductive ozonolysis gives methanal as one of the products. It's structure is

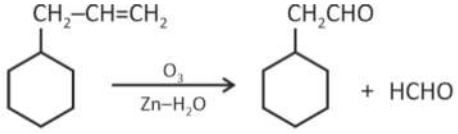
(1) 

(2) 

(3) 

(4) 

Answer (2)

Sol. 

To get HCHO as one of the product, alkene should contain $=CH_2$ as group.

8. Consider the following data :

$Na(s)+\frac{1}{2}Cl_2(g)\rightarrow NaCl(s)$ $\Delta H^\circ = -411$ kJ/mole

$Na(s)\rightarrow Na(g)$ $\Delta H^\circ = 107$ kJ/mole

$Cl_2(g)\rightarrow 2Cl(g)$ $\Delta H^\circ = 242$ kJ/mole

$Cl(g)+e^-\rightarrow Cl^-(g)$ $\Delta H^\circ = -355$ kJ/mole

$Na(g)\rightarrow Na^+(g)+e^-$ $\Delta H^\circ = 502$ kJ/mole^{-1}

Find out lattice energy of NaCl(s).

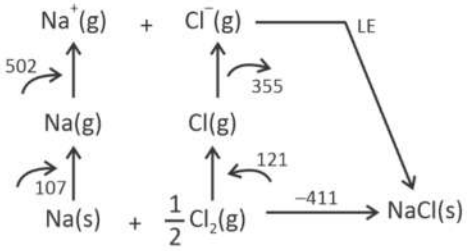
(1) –786 kJ mole^{-1}

(2) –628 kJ mol^{-1}

(3) –428 kJ mole^{-1}

(4) –393 kJ mole^{-1}

Answer (1)

Sol. 

–411 = 107 + 502 + 121 – 355 + LE

LE = –786 kJ mole^{-1}

9. Which of the following will behave as best reducing agent?

Given $Al^{3+} + 3e^- \rightarrow Al$ $E^\circ = -1.66$ V

$Co^{3+} + e^- \rightarrow Co^{2+}$ $E^\circ = 1.81$ V

$Fe^{3+} + e^- \rightarrow Fe^{2+}$ $E^\circ = 0.77$ V

$Cd^{2+} + 2e^- \rightarrow Cd$ $E^\circ = -0.4$ V

(1) Al (2) Co^{2+}

(3) Fe^{2+} (4) Cd

Answer (1)

Sol. Smaller the value of E°, lesser will be the tendency to reduce $Al^{3+} + e^- \rightarrow Al$ have smallest E°, so Al will have high tendency to oxidise.

10. $Br_2CH-CH_2-CH_2-CH_3 \xrightarrow[NaNH_2]{2\text{ Equivalent}} X \xrightarrow[\text{II. 1 Eq. } CH_3CHBrCH_3]{\text{I. 1 Eq. } NaNH_2} Y$

(1) 2-Methylhex-3-yne

(2) 2-Methylhex-2-ene

(3) 2-Pentyne

(4) 3-Methylhex-2-yne

Answer (1)

Sol.

$$Br_2CH-CH_2-CH_2-CH_3 \xrightarrow[NaNH_2]{2\text{ Eq.}} CH\equiv C-C_2H_5(x)$$

$$\downarrow \text{I. 1 Eq. } NaNH_2$$

$$CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-C\equiv C-CH_2CH_3 \xleftarrow[1\text{ Eq. } CH_3CHBrCH_3]{\text{II.}} Na^{\oplus}\,^{\ominus}C\equiv C-C_2H_5$$

2-Methyl hex-3-yne

11. Given below are two statements.

Statement I : First ionisation enthalpy of Cr is greater than that of Mn.

Statement II : Second and third ionisation enthalpies of Cr are less than that of Mn.

In the light of above statements, choose the correct option.

(1) Both statement I and statement II are correct

(2) Both statement I and statement II are incorrect

(3) Statement I is correct but statement II is incorrect

(4) Statement I is incorrect but statement II is correct

Answer (2)

Sol.

	Cr	Mn
IE_1 (kJ/mol)	653	717
IE_2 (kJ/mol)	1592	1509
IE_3 (kJ/mol)	2990	3260

12. Which of the following is the correct IUPAC name of complex $[Ni(PPh_3)_3(H_2O)_3]Cl_2$?

(1) Triaquatris(triphenylphosphine)nickel(II) chloride

(2) Tris(triphenyphosphine)triaquanickel(II) chloride

(3) Triaquatris(triphenylphosphine)nickelate(II) chloride

(4) Triaquatris(triphenylphosphine)nickel(III) chloride

Answer (1)

Sol. Correct IUPAC name is triaquatris(triphenyl phosphine) nickel(II) chloride

13. Match the two columns : based on the reaction

Glucose + 'X' $\rightarrow$ 'P'

	List-I (Reagent-X)		**List-II (Product-P)**
A.	Br_2/water	(i)	Glucose oxime
B.	Acetic anhydride (excess)	(ii)	Saccharic acid

C.	Conc. HNO_3	(iii)	Glucose pentaacetate
D.	NH_2OH	(iv)	Gluconic acid

(1) A – iv, B – ii, C – iii, D – i

(2) A – ii, B – iv, C – iii, D – i

(3) A – ii, B – iii, C – iv, D – i

(4) A – iv, B – iii, C – ii, D – i

Answer (4)

Sol. (1) Glucose + Br_2-water $\rightarrow$ Gluconic acid

(2) Glucose + Acetic anhydride $\rightarrow$ Glucose pentaacetate

(3) Glucose + Conc. $HNO_3 \rightarrow$ Saccharic acid

(4) Glucose + $NH_2OH \rightarrow$ Glucose oxime

14. Consider two reactions having same pre-exponential factor (A) occuring at same temperature (T).

$A \xrightarrow{E_{a_1}} B$

$C \xrightarrow{E_{a_2}} D$

$E_{a_1} = 5E_{a_2}$

Find out the correct expression?

(1) $\frac{k_1}{k_2} = e^{-\frac{E_{a_2}}{RT}}$ (2) $\frac{k_1}{k_2} = e^{-\frac{4E_{a_1}}{RT}}$

(3) $\frac{k_1}{k_2} = e^{-\frac{4E_{a_1}}{5RT}}$ (4) $\frac{k_1}{k_2} = e^{-\frac{4E_{a_2}}{5RT}}$

Answer (3)

Sol. $k_1 = Ae^{-\frac{E_{a_1}}{RT}}$

$k_2 = Ae^{-\frac{E_{a_2}}{RT}}$

$\frac{k_1}{k_2} = e^{-\left(\frac{E_{a_1} - E_{a_2}}{RT}\right)}$

$= e^{-\frac{\left(5E_{a_2} - E_{a_2}\right)}{RT}}$

$= e^{-\frac{4E_{a_2}}{RT}}$

$= e^{-\frac{4E_{a_1}}{5RT}}$

Option (3) is correct

15. Consider the given species

H_2S, H_2O, NH_3, NF_3, $CHCl_3$

The number of lone pair on central atom which has lowest dipole moment.

(1) 0

(2) 1

(3) 2

(4) 3

Answer (2)

Sol.

Molecules		Dipole Moment (D)
NH_3	$\rightarrow$	1.47
NF_3	$\rightarrow$	0.23
H_2O	$\rightarrow$	1.85
H_2S	$\rightarrow$	0.95
$CHCl_3$	$\rightarrow$	1.04

16. Consider the statements below

Statement I: BCl_3 is covalent in nature

Statement II: BCl_3 undergoes hydrolysis to form $[B(OH)_4]^-$ and BH_2^+

In the light of above statements choose the correct option.

(1) Statement I and statement II both are correct

(2) Statement I and statement II both are incorrect

(3) Statement I correct statement II incorrect

(4) Statement I incorrect statement II correct

Answer (3)

Sol. BCl_3 is covalent in nature

$BCl_3 + H_2O \rightarrow H_3BO_3 + HCl$

17. Energy of first Balmer line of H-atom is x kJ

The energy of second Balmer line of H-atom is ___

(1) x

(2) 1.35 x

(3) 2x

(4) x/1.35

Answer (2)

Sol. $E_{Balmer\ 1^{st}} \propto 13.6 \times \left(\frac{1}{2^2} - \frac{1}{3^2}\right) \propto 13.6 \times \frac{5}{36} \propto x$ ...(i)

$(n_1 = 2, n_2 = 3)$

$E_{Balmer\ 2^{nd}} \propto 13.6 \times \left(\frac{1}{2^2} - \frac{1}{4^2}\right) \propto 13.6 \times \frac{3}{16}$ ...(ii)

$$(ii)/(i) \Rightarrow E_{Balmer\ 2^{nd}} = \frac{13.6 \times \frac{3}{16}}{13.6 \times \frac{5}{36}} \times x = x \times 1.35$$

18. 36 g of A reacts with 54 g of B to form AB_2, if molar mass of A and B is respectively 60 and 80, then choose correct option from following.

(1) Limiting Reagent is A

(2) 90 g of AB_2 formed

(3) Limiting Reagent is B

(4) 50 g of AB_2 formed

Answer (3)

Sol. $n_A = \frac{36}{60} = 0.6,\ n_B = \frac{54}{80} = 0.675$

$$\underset{0.6\,mol}{1A} + \underset{0.675\,mol}{2B} \rightarrow 1AB_2$$

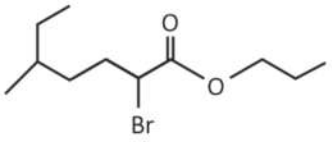
$$\frac{0.6}{1} = 0.6 \qquad \frac{0.675}{2} = 0.3375$$

So, limiting reagent is B

Mole of AB_2 formed = 0.3375

W of AB_2 = 0.3375 × 220 = 74.25 g

19. The correct IUPAC nomenclature of the following compound is



(1) Propyl-2-bromo-6-methyl heptanoate

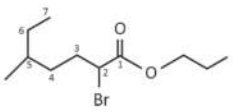
(2) 2-Bromo-5-methyl-1-propyl heptanoate

(3) Propyl-2-bromo-5-ethyl hexanoate

(4) Propyl-2-bromo-5-methyl heptanoate

Answer (4)

Sol. Ester is the principal functional group in this molecule.



⟶ Propyl-2-bromo-5-methyl heptanoate

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

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21. Volume ratio of decimolar NH_4OH and decimolar HCl to give a solution of pH = 9.26 at 25°C is x : 1. Find x.

pK_b of NH_4OH = 4.74

Answer (2)

Sol. Assume $V_{NH_4OH} = xL$ and $V_{HCl} = 1L$

NH_4OH	+	HCl	→	NH_4Cl	+	H_2O
0.1x		0.1		–		–
0.1x – 0.1		0		0.1		

$$pOH = pK_b + \log\frac{[salt]}{[base]}$$

$$4.74 = 4.74 + \log\frac{(0.1x - 0.1)/V}{0.1/V}$$

0.1x – 0.1 = 0.1

x = 2

22. 5.8 g Aniline is converted into benzanilide with some reaction sequences.

Calculate mass of benzanilide formed, if percentage yield of reaction is 82%.

$$Ph - COCl + PhNH_2 \xrightarrow{Py} \text{Benzanilide}$$

Answer (10)

Sol. $Ph-\overset{\overset{O}{\|}}{C}-Cl + PhNH_2 \xrightarrow{Py} Ph-\overset{\overset{O}{\|}}{C}-NH-Ph$

Benzanilide

Mole of aniline

$$= \frac{5.8}{93}\text{ mol}$$

Mole of $Ph-\overset{\overset{O}{\|}}{C}-NH-Ph$ will be formed of yield is 100%

$$= \frac{5.8}{93}\text{ mol}$$

$$\text{mole of } Ph-\overset{\overset{O}{\|}}{C}-NHPh = \frac{5.8}{93} \times 0.82 = 0.0511\text{ mol}$$

mass = 10.07 ≈ 10 g

23. A cycloalkene (X) is treated with Br_2 and compound (Y) is formed with C : Br ratio 3 : 1. One mole of X required 1 mol of Br_2. Find composition of 'Br' in Y compound (percentage).

Answer (66)

Sol. Cycloalkene (X) $\Rightarrow C_nH_{2n-2}$

After reaction with Br_2 compound Y is formed

$\Rightarrow C_nH_{2n-2}Br_2$

If ration of C : Br = 3 : 1

MF of Y should be $C_6H_{10}Br_2$

$$\% \text{ of Br} = \frac{2\times 80}{242}\times 100 = 66.11\% \approx 66$$

24.

25.

MATHEMATICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. If complex numbers $Z_1, Z_2, \ldots Z_n$ satisfy the equation $4Z^2 + \bar{Z} = 0$, then $\sum_{i=1}^{n} |Z_i|^2$ is equal to

(1) $\frac{3}{16}$ (2) $\frac{3}{64}$

(3) $\frac{9}{64}$ (4) $\frac{1}{16}$

Answer (1)

Sol. $4z^2 + \bar{z} = 0$

If $z = 0$ then it is a solution

$\Rightarrow |z| = 0$

Now, $z \neq 0$

Multiplying by z we get

$4z^3 + |z|^2 = 0$

$\Rightarrow 4z^3 = -|z|^2$

Taking modulus both sides

$4|z|^3 = |z|^2 \Rightarrow |z|^2(4|z| - 1) = 0$

$\Rightarrow |z| = \frac{1}{4}$

$\Rightarrow 4z^3 = \frac{-1}{16} \Rightarrow z^3 = \frac{-1}{64}$

$\Rightarrow z = \frac{-1}{4}, \frac{-1}{4}w, \frac{-1}{4}w^2$

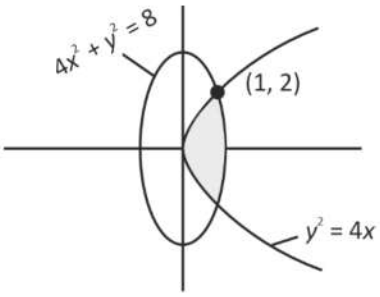
2. Area enclosed by $4x^2 + y^2 \leq 8$ and $y^2 \leq 4x$ is (in square unit) is

(1) $\left(\pi + \frac{4}{3}\right)$ sq. unit (2) $\left(\pi - \frac{4}{3}\right)$ sq. unit

(3) $\left(\pi + \frac{2}{3}\right)$ sq. unit (4) $\left(\pi - \frac{2}{3}\right)$ sq. unit

Answer (3)

Sol.



$$\text{Area} = 2\int_0^2 \sqrt{\frac{8-y^2}{4}} - \frac{y^2}{4}\,dx$$

$$= \int_0^2 \left(\sqrt{8-y^2} - \frac{y^2}{2}\right)dy$$

$$= 4\sin^{-1}\left(\frac{y}{2^{3/2}}\right) + \frac{y\sqrt{8-y^2}}{2} - \frac{y^3}{6}\Bigg]_0^1$$

$$= 4\sin^{-1}\left(\frac{1}{\sqrt{2}}\right) + \frac{2\times 2}{2} - \frac{8}{6}$$

$$= \frac{4\pi}{4} + 2 - \frac{4}{3}$$

$$= \left(\pi + \frac{2}{3}\right) \text{sq. unit}$$

3. Mean deviation about median for k, $2k$, $3k$,……, $1000k$ is 500, then the value of k^2 is

(1) 4

(2) 9

(3) 16

(4) 1

Answer (1)

Sol. data set

$k, 2k, 3k, \ldots\ldots, 1000k$.

$$\text{Median} = \frac{500k + 501k}{2} = 500.5k$$

Mean-deviation about median

$$500=\frac{|500.5k-k|+|500.5k-2k|+...+|1000k-500.5k|}{1000}$$

$$=\frac{2[499.5k+498.5k+...+0.5k]}{1000}$$

$$250000=\frac{500}{2}[0.5+499.5]k$$

$$\Rightarrow \boxed{k=2}$$

$$\boxed{k^2=4}$$

4. If $4x^2 + y^2 < 52$, $x, y \in I$ then number of ordered pairs (x, y) is

(1) 67 (2) 87
(3) 77 (4) 38

Answer (3)

Sol. $4x^2 + y^2 < 52$, $x, y \in I$

$\Rightarrow 4x^2 < 52 \Rightarrow x^2 < 13 \Rightarrow x^2 \in \{0, 1, 4, 9\}$

If $x^2 = 0 \Rightarrow y^2 < 52 \Rightarrow y^2 \in \{0, 1, 4, 9, 16, 25, 36, 49\}$

$1 \times (1 + 2 \times 7) = 15$

If $x^2 = 1 \Rightarrow y^2 < 48 \Rightarrow y^2 \in \{0, 1, 4, 9, 16, 25, 36\}$

$2 \times (1 + 2 \times 6) = 26$

If $x^2 = 4 \Rightarrow y^2 < 36 \Rightarrow y^2 \in \{0, 1, 4, 9, 16, 25\}$

$2 \times (1 + 2 \times 5) = 22$

If $x^2 = 9 \Rightarrow y^2 < 16 \Rightarrow y^2 \in \{0, 1, 4, 9\}$

$2 \times (1 + 2 \times 3) = 14 \quad \Rightarrow 77$ pairs

5. $x - ny + z = 6$

$x - (n - 2)y + (n + 1)z = 8$

$(n - 1)y + z = 1$

Let n = number on the dies when rolled randomly then P (that system equation has unique solution) $= \frac{k}{6}$, then sum of value of k and all possible value of n is

(1) 22 (2) 21
(3) 20 (4) 24

Answer (4)

Sol. For system of equation to have unique solution

$\Delta \neq 0$

$$\begin{vmatrix} 1 & -n & 1 \\ 1 & 2-n & n+1 \\ 0 & n-1 & 1 \end{vmatrix} \neq 0$$

$\Rightarrow n^2 - n - 2 \neq 0$

$(n - 2)(n + 1) \neq 0$

$\Rightarrow n \neq 2$

$\therefore$ possible values of n is {1, 3, 4, 5, 6}

P(unique solution) $= \frac{5}{6} = \frac{k}{6}$

$\Rightarrow k = 5$

$\therefore$ sum of all possible value of n and k is

$1 + 3 + 4 + 5 + 6 + 5 = 24$

6. If $\lim\limits_{x\to 0} \frac{e^{(a-1)x} + 2\cos(bx) + e^{-x}(c-1)}{x\cos x - \ln(1+x)} = 2$

Then the value of $a^2 + b^2 + c^2$ is

(1) 8 (2) 9
(3) 10 (4) 11

Answer (3)

Sol. $$\lim_{x\to 0}\left(1+x(a-1)+\frac{(x(a-1))^2}{2!}+...\right)+2\left(1-\frac{b^2x^2}{2!}+\frac{b^4x^4}{4!}\right)$$

$$+\frac{\left(1-x+\frac{x^2}{2!}-\frac{x^3}{3!}+...\right)(c-1)}{x\left(1-\frac{x^2}{2!}+\frac{x^4}{4!}+...\right)-\left(x-\frac{x^2}{2}+\frac{x^3}{3}+...\right)}$$

$$\Rightarrow \frac{(1+2+(c-1))+x(a-1-c+1)+x^2\left(\frac{(a-1)^2}{2!}-b^2+(c-1)\frac{1}{2}\right)+...}{\frac{x^2}{2}-\frac{5}{6}x^3+...}$$

$3 + c - 1 = 0$

$\boxed{c = -2}$ $\qquad a - c = 0$

$\Rightarrow a = c = -2$

$$\frac{\frac{9}{2}-b^2-\frac{3}{2}}{\frac{1}{2}}=2$$

$\Rightarrow \frac{9}{2}-\frac{3}{2}-b^2=1$

$\Rightarrow \boxed{b^2=2}$

$a^2 + b^2 + c^2 = 4 + 4 + 2 = 10$

7. If $P\left(10,2\sqrt{15}\right)$ lies on hyperbola $\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$ and length of latus rectum = 8, then the square of area of ΔPS_1S_2 is [where S_1 & S_2 are the focii of the hyperbola]

(1) 2700 (2) 2400

(3) 1750 (4) 3600

Answer (1)

Sol. $\frac{100}{a^2}-\frac{60}{b^2}=1$

Also $\frac{2b^2}{a}=8$

$\Rightarrow b^2 = 4a$

$\frac{100}{a^2}-\frac{60}{4a}=1$

$100 - 15a = a^2$

$a^2+15a-100=0$

$(a+20)(a-5)=0$

$a = -20, 5$

$\because b^2=4a \Rightarrow a$ cannot be negative

$\Rightarrow \boxed{a=5}$

$\boxed{b^2=20}$

Now $H:\frac{x^2}{25}-\frac{y^2}{20}=1$

$e^2=1+\frac{20}{25}\Rightarrow e=\frac{3}{\sqrt{5}}$

$F:(\pm 3\sqrt{5},0)$ i.e S_1 & S_2

Area $PS_1S_2=\frac{1}{2}\begin{vmatrix} 10 & 2\sqrt{15} \\ 3\sqrt{5} & 0 \\ -3\sqrt{5} & 0 \\ 10 & 2\sqrt{15} \end{vmatrix} = \frac{1}{2}\left[-6\sqrt{75}-6\sqrt{75}\right]$

$=6\sqrt{75}$

Area^2 = 2700

8. If a, b, c are in A.P where $a + b + c = 1$ and a, $2b$, c are in G.P., then the value of $9(a^2 + b^2 + c^2)$ is equal to

(1) 3 (2) –3

(3) 4 (4) –4

Answer (2)

Sol. $a, b, c \rightarrow AP$ Þ

$a, 2b, c \rightarrow$ GP $\Rightarrow 4b^2 = ac$

$a + b + c = 1$

$2b = a + c$

$\Rightarrow b=\frac{1}{3}$

$a+c=\frac{2}{3}$

$4b^2=ac$

$\frac{4}{9}=ac$

$a^2 + b^2 + c^2$

$\Rightarrow \frac{1}{9}+(a+c)^2-2ac$

$\Rightarrow \frac{1}{9}+\frac{4}{9}-2\left(\frac{4}{9}\right)=\frac{-1}{3}$

Here $a=\frac{1}{3}+\frac{i}{\sqrt{3}}\quad b=\frac{1}{3}\quad c=\frac{1}{3}-\frac{i}{\sqrt{3}}$

$\therefore a^2 + b^2 + c^2$ is negative

9. Let the domain of function

$$f(x)=\log_3\log_5(7-\log_2(x^2-10x+15))+\sin^{-1}\left(\left|\frac{3x-7}{17-x}\right|\right)$$

be $(\alpha,\beta]$, then $\alpha+\beta$ is equal to

(1) 6 (2) 7

(3) 8 (4) 9

Answer (4)

Sol. $\log_5(7-\log_2(x^2-10x+85))>0$

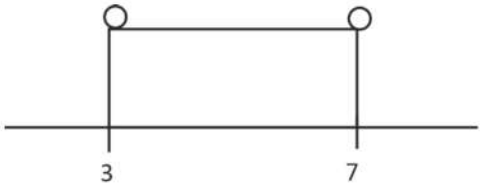
$\Rightarrow 7-\log_2(x^2-10x+85)>1$

$\Rightarrow \log_2(x^2-10x+85)<6$

$\Rightarrow x^2-10x+85<64$

$\Rightarrow x^2-10x+21<0$

$(x-7)(x-3)<0$



$\Rightarrow x \in (3, 7)$

$\left|\frac{3x-7}{17-x}\right|\le 1$

$\Rightarrow |3x-7|\le|17-x|$

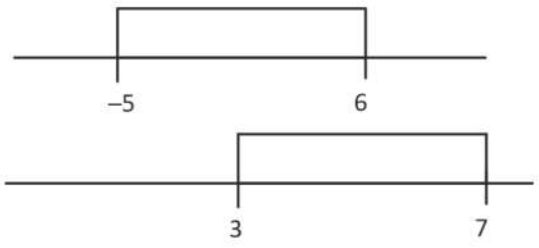
$\Rightarrow 9x^2+49-42x\le 289+x^2-34x$

$\Rightarrow 8x^2-8x-240\le 0$

$\Rightarrow x^2-x-30\le 0$

$(x-6)(x+5)\le 0$

$x\in[-5,\ 6]$



$x \in (3, 6]$

10. Let $\vec{a}=\sqrt{2}\hat{i}$ and $\vec{b}=5\hat{j}+\hat{k}$. If $\vec{c}=\vec{a}\times\vec{b}$ and $\vec{d}$ which lie on *y-z* plane such that $|\vec{d}|=2$. Then the maximum value of $|\vec{c}\cdot\vec{d}|^2$ is equal to

(1) 104 (2) 52

(3) 208 (4) 120

Answer (3)

Sol. $|\vec{a}\times\vec{b}|=\sqrt{52}=|\vec{c}|$

The maximum value of $|\vec{c}\cdot\vec{d}|^2$

$=\left(\sqrt{52}\cdot(2)\cos\theta\right)^2=208\cos^2\theta$

The maximum value of $|\vec{c}\cdot\vec{d}|^2=208$

11. If $\int_0^{64}\left(x^{\frac{1}{3}}+\text{floor}\left(x^{1/3}\right)\right)dx=\alpha$ and

$\int_0^{\frac{\pi}{2}}\frac{\sin^2x}{\sin^6x+\cos^6x}dx=\pi\beta$, then the value of ab^2 is equal to

(1) 87 (2) 77

(3) 67 (4) 57

Answer (1)

Sol. $I_1=\int_0^{64}\left(x^{\frac{1}{3}}+\text{floor}\left(x^{\frac{1}{3}}\right)\right)dx$

$=\frac{x^{\frac{4}{3}}}{\frac{4}{3}}\Bigg|_0^{64}+\int_0^1 0\,dx+\int_1^8(1)\,dx+\int_8^{27}2\,dx+\int_{27}^{64}(3)\,dx$

$= 192 + 0 + (8 - 1) + 2) + 2(27 - 8) + 3(64 - 27) = 348$

$I_2=\int_0^{\frac{\pi}{2}}\frac{\sin^2x}{\sin^6x+\cos^6x}dx$

$$\Rightarrow I_2 = \int_0^{\frac{\pi}{2}} \frac{\cos^2 x}{\sin^6 x + \cos^6 x} dx$$

$$\Rightarrow 2I_2 = \int_0^{\frac{\pi}{2}} \frac{1}{\sin^6 x + \cos^6 x} dx = \int_0^{\frac{\pi}{2}} \frac{\sec^2 x}{1 + \tan^6 x} dx$$

$$\Rightarrow I_2 = \frac{\pi}{2} \Rightarrow \beta = \frac{1}{2},\ \alpha = 348$$

$$\alpha\beta^2 = 348 \times \frac{1}{4} = 87$$

12.

13.

14.

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. If α, β are roots of equation $12x^2 - 20x + 3\lambda = 0$, $\lambda \in I$. If $\frac{1}{2} \le |\beta - \alpha| \le \frac{3}{2}$, then the sum of all possible values of λ is

Answer (03.00)

Sol. $|\beta - \alpha|^2 \in \left[\frac{1}{4}, \frac{9}{4}\right]$

$$(\alpha^2 + \beta^2 - 2\alpha\beta) = (\alpha + \beta)^2 - 4\alpha\beta \in \left[\frac{1}{4}, \frac{9}{4}\right]$$

$$= \left(\frac{20}{12}\right)^2 - 4\left(\frac{3\lambda}{12}\right) \in \left[\frac{1}{4}, \frac{9}{4}\right]$$

$$\Rightarrow \frac{25}{9} - \lambda \in \left[\frac{1}{4}, \frac{9}{4}\right]$$

$$\Rightarrow 100 - 36\lambda \in [9, 81]$$

$$36\lambda - 100 \in [-81, -9]$$

$$36\lambda \in [19, 91]$$

$$\lambda \in \left[\frac{19}{36}, \frac{91}{36}\right]$$

then integral values of λ is 1, 2

$\Rightarrow$ Sum of integral values of λ is 1 + 2 = 3

22. If $\cos(\alpha + \beta) = -\frac{1}{10}$ and $\sin(\alpha - \beta) = \frac{3}{8}$, where $0 < \alpha < \frac{\pi}{3}$ and $0 < \beta < \frac{\pi}{4}$, if $\tan 2\alpha = \frac{3\left(1 - r\sqrt{55}\right)}{\sqrt{11}\left(s + \sqrt{5}\right)}$ and $r, s \in N$, then $r^2 + s$ is

Answer (20)

Sol. $0 < \alpha < \beta < \frac{7\pi}{12}$

$\because \cos(\alpha + \beta) = -\frac{1}{10}$ $\Rightarrow \alpha + \beta \in$ II[nd] quadrant

$$\sin(\alpha + \beta) = \frac{\sqrt{99}}{10}$$

$\sin(\alpha - \beta) = \frac{3}{8}$ $\alpha + \beta \in$ I quadrant

$$\cos(\alpha - \beta) = \frac{\sqrt{55}}{8}$$

$$\tan\left((\alpha + \beta) + (\alpha - \beta)\right) = \frac{\tan(\alpha + \beta) + \tan(\alpha - \beta)}{1 - \tan(\alpha + \beta)\tan(\alpha - \beta)}$$

$$\tan 2\alpha = \frac{-\sqrt{99}+\frac{3}{\sqrt{55}}}{1+3\sqrt{\frac{99}{55}}} = \left[\frac{-3\sqrt{11.55}+3}{\sqrt{55}+9\sqrt{11}}\right]$$

$$= \frac{3-3\sqrt{11}\cdot\sqrt{55}}{\sqrt{55}+9\sqrt{11}} = \frac{3(1-\sqrt{11}\sqrt{55})}{\sqrt{11}(\sqrt{5}+9)}$$

$r^2 = 11$

$s = 9$

$r^2 + s = 20$

23.

24.

25.

❑ ❑ ❑