23/01/2025
Morning

Memory Based
Answers & Solutions

Time : 3 hrs. **M.M. : 300**

for

JEE (Main)-2025 (Online) Phase-1

(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. Electric flux ϕ is related with linear charge density λ and surface charge density σ as $\phi = \alpha\lambda + \beta\sigma$ where α and β are of appropriate dimensions of $\left(\frac{\beta}{\alpha}\right)$ is

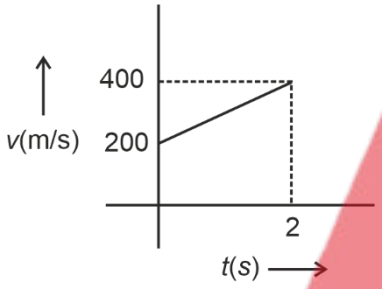
(1) Displacement (2) Area

(3) Electric field (4) Velocity

Answer (1)

Sol. $\alpha\lambda \equiv \beta\sigma \Rightarrow \frac{\beta}{\alpha} = \frac{\lambda}{\sigma} = \frac{Q/L}{Q/L^2} \equiv L$

2. For given velocity-time (v – t) graph, find distance travelled at 0.5 sec.



(1) 125 m (2) 112.5 m

(3) 137.5 m (4) 150 m

Answer (2)

Sol. $a = \frac{400 - 200}{2} = 100 \text{ m/s}^2$

$$S = ut + \frac{1}{2}at^2 = 200 \times 0.5 + \frac{1}{2} \times 100 \times \frac{1}{2} \times \frac{1}{2}$$

$$= 100 + 12.5 = 112.5 \text{ m}$$

3. The displacement of a particle as function of time is $x(t) = A\sin(t) + B\cos^2(t) + Ct^2 + D$. Find dimension of $\left[\frac{ABC}{D}\right]$

(1) L^2 (2) L^2T^{-2}

(3) LT^{-2} (4) L^3T

Answer (2)

Sol. $x(t) = A\sin(t) + B\cos^2(t) + Ct^2 + D$

We can say

$[D] = [L]$

$[C] = [LT^{-2}]$

$[B] = [L]$

$[A] = [L]$

So $\left[\frac{ABC}{D}\right] = \frac{L^3T^{-2}}{L} = [L^2T^{-2}]$

4. The ratio of electric force to gravitational force between two particles having charges q_1, q_2 and masses m_1 and m_2 respectively is (where symbols have their usual meanings)

(1) $\frac{4\pi\varepsilon_0 m_1 m_2 G}{q_1 q_2}$ (2) $\frac{4\pi\varepsilon_0 G m_1 m_2}{q_1 q_2 r^4}$

(3) $\frac{q_1 q_2 r^4}{4\pi\varepsilon_0 G m_1 m_2}$ (4) $\frac{q_1 q_2}{4\pi\varepsilon_0 G m_1 m_2}$

Answer (4)

Sol. $F_g = \frac{G m_1 m_2}{r^2}$

$$F_e = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$$

$$\frac{F_e}{F_g} = \frac{q_1 q_2}{4\pi\varepsilon_0 G m_1 m_2}$$

5. Match the column appropriately regarding thermodynamic process.

Column-I		Column-II	
(P)	When volume change is zero	(i)	$\Delta W = 0$
(Q)	When pressure is constant	(ii)	$\Delta Q = 0$
(R)	When no heat is exchanged	(iii)	Isobaric
(S)	Work done by the gas is equal to heat given to the gas	(iv)	Isothermal

(1) P(iv), Q(iii), R(i), S(ii)

(2) P(i), Q(iii), R(ii), S(iv)

(3) P(ii), Q(iii), R(iv), S(i)

(4) P(ii), Q(iii), R(i), S(iv)

Answer (2)

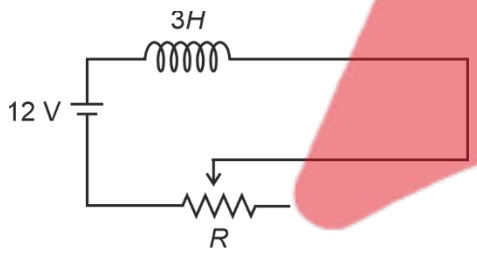
Sol. Volume change is zero $\rightarrow$ isochoric $\rightarrow \Delta W = 0$

Isobaric $\Rightarrow \Delta P = 0$

No heat exchange (adiabatic) $\Rightarrow \Delta Q = 0$

Heat given = $\Delta W \Rightarrow \Delta u = 0 \Rightarrow \Delta T = 0$

6. In given DC circuit, find current for $R = 12\ \Omega$ in steady state.



(1) 2 A (2) 1 A

(3) 3 A (4) 4 A

Answer (2)

Sol. $i = \frac{V}{R} = \frac{12}{12} = 1\ \text{A}$

7. **Statement-I :** Hot water is less viscous than of cold water.

Statement-II : Surface tension of soap bubble is more than that of a drop of water.

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

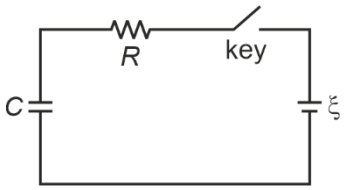
(2) Statement-I is true and statement-II false

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

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

Answer (2)

8. The key shown in the circuit is closed at $t = 0$.



Choose the incorrect option regarding the conditions at $t = 0$.

(1) Current in the circuit is zero

(2) Voltage across the capacitor is minimum

(3) Current in the circuit is maximum

(4) Voltage across resistance is maximum

Answer (1)

Sol. Immediately after closing the key the capacitor acts as a short circuit *i.e.* path of zero resistance. Hence, current is maximum at $t = 0$.

9. A uniform solid sphere of mass m rolls down from rest to achieve speed v_1 on an inclined plane of 30°. Sphere achieves speed v_2 on an inclined plane of 45° when released from same height then $\frac{v_1^2}{v_2^2}$ is

(assume no slipping)

(1) 1 (2) $\frac{5}{2}$

(3) $\frac{2}{5}$ (4) $\frac{\sqrt{3}}{\sqrt{2}}$

Answer (1)

Sol. $|\Delta U| = |\Delta K|$

$\Rightarrow \quad mgh = \frac{1}{2}(\gamma+1)mv^2$ where $\gamma = \frac{2}{5}$

Here v doesn't depend on θ so $\frac{v_1^2}{v_2^2} = 1$ for solid sphere

10. Find the equation of magnetic field for the give equation of electric field (for EM wave).

$E = E_0\left(4\hat{i} - 3\hat{j}\right)\cos(\omega t - kz)$

(1) $\vec{B} = \frac{E_0}{C}\left(3\hat{i} + 4\hat{j}\right)\cos\left(\omega t - kz\right)$

(2) $\vec{B} = \frac{E_0}{C}\left(-3\hat{i} - 4\hat{j}\right)\cos\left(\omega t - kz\right)$

(3) $\vec{B} = \frac{E_0}{C}\left(3\hat{i} - 4\hat{j}\right)\sin\left(\omega t - kz\right)$

(4) $\vec{B} = \frac{E_0}{C}\left(-3\hat{i} - 4\hat{j}\right)\sin\left(\omega t - kz\right)$

Answer (1)

Sol. Phase difference of magnetic field with electric field is zero.

Also $\left|\vec{B}\right| = \frac{\left|\vec{E}_0\right|}{C}$

$\Rightarrow \quad \left|\vec{B}\right| = \frac{\left|\vec{E}_0\right|5}{C}$

And propagation direction is along $\left(\vec{E}\times\vec{B}\right)$

So unit vector along $\vec{B}$ is $\left(\frac{3\hat{i}+4\hat{j}}{5}\right)$

So finally.

$\vec{B} = \frac{5\left|\vec{E}_0\right|}{C}\frac{\left(3\hat{i}+4\hat{j}\right)}{5}\cos(\omega t - kz)$

$\Rightarrow \quad \vec{B} = \frac{E_0}{C}(3\hat{i}+4\hat{j})\cos(\omega t - kz)$

11. Self-inductance depends on :

(1) Only on geometry

(2) Only on medium property

(3) Geometry and medium property

(4) Value of current through inductor

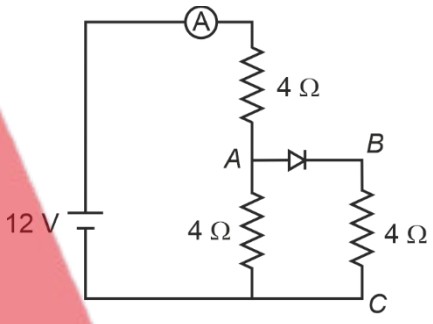
Answer (3)

Sol. $L = \mu_r\mu_0 n^2 V$

μ_r = relative permeability (medium)

V = Volume (geometry)

12. For the circuit shown below



(A) Current in ammeter is 2 A

(B) Net resistance is 8 Ω

(C) Voltage across BC is 4 V

(D) Current through diode is 1 A

Choose the correct option.

(1) Only ABC are correct

(2) Only ACD are correct

(3) Only ABD are correct

(4) Only AD are correct

Answer (2)

Sol. $R_{eq} = 6\ \Omega$

$i = \frac{12\text{ V}}{6\ \Omega} = 2\text{ A}$

$i_{AB} = 1\text{ A}$

$V_{BC} = 4\text{ V}$

13. Find the time period of a cube of side length 10 cm and mass 10 g oscillating in water. (density of water = 10^3 kg/m^3 and g = 10 m/s^2)

(1) $\frac{\pi}{25}$ second

(2) $\frac{\pi}{50}$ second

(3) $\frac{\pi}{100}$ second

(4) $\frac{2\pi}{25}$ second

Answer (2)

Sol. $a = -\frac{F}{m} = -\omega^2 x = \frac{-\Delta B}{m}$

$$= -\frac{(10\text{ cm})^2 x (10^3\text{ kg/m}^3)(10\text{ m/s}^2)}{(10\text{ g})} = -\frac{10^{-2}\times 10^3 \times 10}{10^{-2}} x$$

$a = -10^4 x$

$\Rightarrow \omega = 100$ rad/s

$T = \frac{2\pi}{\omega} = \frac{\pi}{50}$ s

14. Adiabatic constant of a gas is $\frac{3}{2}$. If volume of gas initially at 0°C is reduced to one fourth of the original volume then new temperature is

(1) 0 K

(2) 273 K

(3) 546°C

(4) 546 K

Answer (4)

Sol. $TV^{\gamma-1}$ = constant

$$273V^{\gamma-1} = T\left(\frac{V}{4}\right)^{\gamma-1}$$

$$273V^{1/2} = T\frac{V^{1/2}}{4^{1/2}}$$

$\Rightarrow T = 2 \times 273 = 546$ K

15. Two objects are equal distances from sphere of radius R & refractive index μ such that the image of one object forms on other object. Find the object distance from the surface of sphere.

(1) $\frac{R}{\mu}$

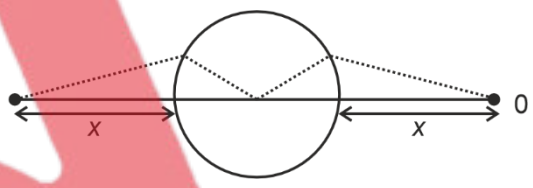
(2) $\frac{R}{\mu-1}$

(3) R

(4) $\frac{R}{\mu+1}$

Answer (2)

Sol.



$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

After first refraction the ray must become parallel to the line joining two objects.

So $v = \infty$

$\Rightarrow 0 - \frac{1}{u} = \frac{(\mu-1)}{R}$

$\Rightarrow |u| = \frac{R}{\mu-1}$

16. There is force field $\vec{F} = x^3y\hat{i} + y^2\hat{j}$ in which a particle moves along the line $x = y$. Find work done by the force as the particle moves from (0, 0) to (2, 2)

(1) $\frac{173}{15}$ (2) $\frac{136}{15}$

(3) $\frac{139}{17}$ (4) $\frac{171}{17}$

Answer (2)

Sol. $w = \int_0^2 x^4dx + \int_0^2 y^2dy = \frac{2^5}{5} + \frac{2^3}{3} = \frac{136}{15}$

17. In a radioactive decay, decay constant of element A_2 is 3 times that of element A_1. Find the ratio of nuclei of element 1 to element 2 after one half life of A_2

(Assume initial number of nuclei are same for both elements)

(1) $2^{1/3}$

(2) $2^{2/3}$

(3) 2

(4) $2^{5/3}$

Answer (2)

Sol. $N_1 = N_0e^{-\lambda_1 t}$

$N_2 = N_0e^{-\lambda_2 t}$

$\frac{N_1}{N_2} = e^{-(\lambda_1-\lambda_2)t}$

$e^{-(\lambda-3\lambda)\frac{\ln 2}{3\lambda}}$

$= e^{\frac{2}{3}\ln 2}$

$= 2^{2/3}$

18.

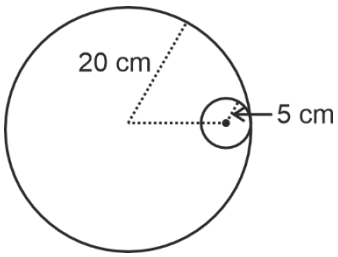
19.

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. From a uniform circular disc of radius 20 cm a circular portion of radius 5 cm is removed. The shift in the position of centre of mass (in cm).



Answer (1)

Sol. $X_{com} = \frac{-\frac{M}{16} \times 15 \text{ cm}}{M - \frac{M}{16}}$

$= \frac{-\frac{M}{16}}{15\frac{M}{16}} \times 15 \text{ cm}$

$= -1 \text{ cm}$

22. A bullet of kinetic energy of 125 J strikes a lead block where temperature rises by 50°C. If specific heat of lead is 0.1 J/g-°C then mass of lead block is (Assume half of kinetic energy of bullet is converted to heat) m gram then $2m$ is

Answer (25)

Sol. $Q = ms\Delta T \Rightarrow \frac{125}{2} = m \times 0.1 \times 50$

$m = \frac{125}{10} = 12.5 \text{ gm}$

23.

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. Which of the following compound can react with Hinsberg reagent?

(A) Aniline

(B) N,N-Dimethyl aniline

(C) Methyl amine

(D) N-phenyl aniline

(1) A only (2) A and C only

(3) A, C and D (4) A and B only

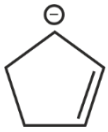
Answer (3)

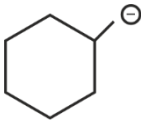
Sol. Primary and secondary amines reacts with Hinsberg reagent.

2. Among the following, the most stable carbanion is

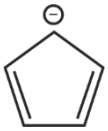
(1) 

(2) 

(3) 

(4) 

Answer (2)

Sol. Only  is aromatic in the given options hence most stable.

3. Which of the following compound can show fac-mer isomerism?

(1) $[Co(NH_3)_6]Cl_3$

(2) $[Co(NH_3)_3Cl_3]$

(3) $[Co(en)_2(NH_3)_2]Cl_3$

(4) $[Co(H_2O)_6]Cl_3$

Answer (2)

Sol. $[Ma_3b_3]$ type complex compound can show fac-mer isomerism. Where a, b are monodentate ligands.

4. Which of the following pair of ions have same colour?

(1) Ti^{4+}, V^{3+}

(2) Cr^{2+}, Cu^{2+}

(3) Cr^{3+}, Ni^{2+}

(4) Mn^{3+}, Fe^{2+}

Answer (2)

Sol. Ti^{4+} = Colourless, V^{3+} = Green ; Cr^{2+} = Blue, Cu^{2+} = Blue

Cr^{3+} = Violet, Ni^{2+} = Green ; Mn^{3+} = Violet, Fe^{2+} = Green

5. Which of the following does not belong to the same period in the modern periodic table?

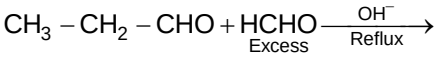
(1) Pd (2) Ir

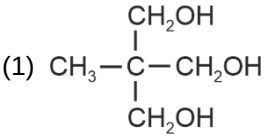
(3) Pt (4) Os

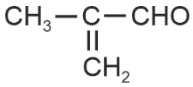
Answer (1)

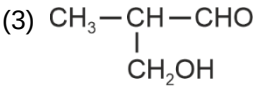
Sol. Os, Ir, Pt belongs to 6^{th} period, while Pd belongs to 5^{th} period of modern periodic table.

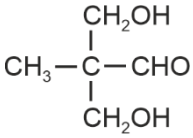
6. Identify the product formed in the following reaction



(1) 

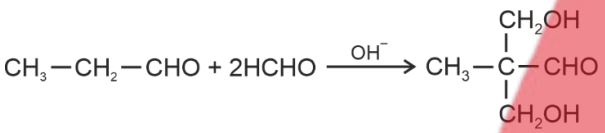
(2) 

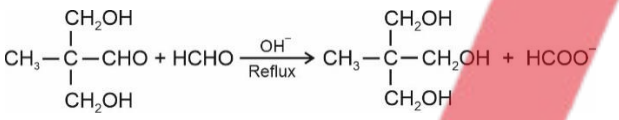
(3) 

(4) 

Answer (1)

Sol. Propanal undergoes aldol condensation with excess of HCHO in presence of OH^- ions to 2, 2-dihydroxymethylpropanal which further reacts with HCHO and undergoes Cannizzaro reaction to given 2, 2-dihydroxymethylpropan-1-ol.





7. Incorrect statement among the following is

(1) SO_2 act as oxidising agent but not reducing agent

(2) NO_2 exists as dimer

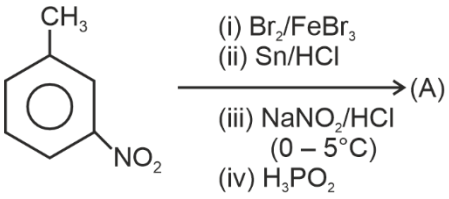
(3) PF_5 exists but NF_5 does not

(4) PH_3 has lower proton affinity than NH_3

Answer (1)

Sol. SO_2 is oxidising as well as reducing agent as sulphur exists in +4 oxidation state.

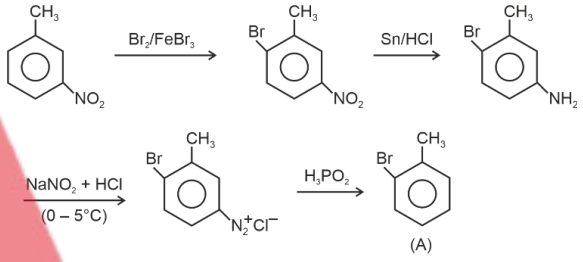
8. Consider the following sequence of reactions and find the molecular mass of the final product (A) formed in g mol^{-1}.



(1) 108 (2) 216

(3) 171 (4) 186

Answer (3)

Sol. 

Molecular mass of (A) = 171 g mol^{-1}

9. Match the Column I with Column II and choose the correct option.

	Column I		Column II
A.	BF_3	(i)	Odd e^- species
B.	CCl_4, CO_2	(ii)	Expanded octet
C.	PCl_5, BrF_5	(iii)	Complete octet
D.	NO	(iv)	Electron deficient

(1) A – (iii), B – (iv), C – (i), D – (ii)

(2) A – (iv), B – (ii), C – (iii), D – (i)

(3) A – (iv), B – (iii), C – (ii), D – (i)

(4) A – (i), B – (ii), C – (iii), D – (iv)

Answer (3)

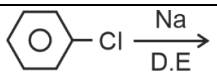
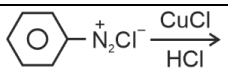
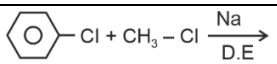
Sol. • $BF_3 \Rightarrow$ 6 e^- in central atom, octet incomplete, e^- deficient

- CCl_4, $CO_2 \Rightarrow 8e^-$ in central atom $\Rightarrow$ Complete octet
- $PCl_5 \Rightarrow 10e^-$ in central atom, $BrF_5 \Rightarrow 12e^-$ in central atom

  $\therefore$ PCl_5, BrF_5 = Expanded octet
- NO $\Rightarrow$ It is an odd electron species $\left[\cdot\ddot{\underset{\cdot}{N}}=O\right]$

  $\Rightarrow$ 1 odd e^- is present

10. Match the column and choose the correct option

	Column-I		Column-II
(A)		(P)	Sandmeyer reaction
(B)		(Q)	Fittig reaction
(C)		(R)	Wurtz-Fittig reaction
(D)	$CH_3 - Cl + AgF \rightarrow$	(S)	Swarts reaction

(1) (A) – (Q), (B) – (P), (C) – (R), (D) – (S)

(2) (A) – (Q), (B) – (P), (C) – (S), (D) – (R)

(3) (A) – (Q), (B) – (R), (C) – (S), (D) – (P)

(4) (A) – (P), (B) – (Q), (C) – (R), (D) – (S)

Answer (1)

Sol. $2Ph - Cl \xrightarrow[D.E]{Na} Ph - Ph$ (Fittig reaction)

$Ph - N_2Cl \xrightarrow[HCl]{CuCl} Ph - Cl$ (Sandmeyer reaction)

$Ph - Cl + CH_3Cl \xrightarrow[D.E]{Na} Ph - CH_3$ (Wurtz Fittig reaction)

$CH_3 - Cl + AgF \rightarrow CH_3F$ (Swarts reaction)

11. Co^{2+} is forming an octahedral complex with spin only magnetic moment 3.83 BM. The correct electronic configuration for cobalt in the complex is?

(1) $t_{2g}^5 e_g^2$

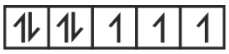
(2) $t_{2g}^6 e_g^1$

(3) $t_{2g}^4 e_g^3$

(4) $e^4 t_2^3$

Answer (1)

Sol. Since Co^{2+} has spin only magnetic moment = 3.83 BM

$Co^{2+} = 3d^7$; 

μ = 3.83 BM, means it has 3 unpaired electrons, so ligand should be WFL.

So electronic configuration is $t_{2g}^5 e_g^2$.

12. Given below are two statements :

Statement-I : During Lassaigne's test, covalent compound is converted to ionic compound.

Statement-II : $Na_4[Fe(CN)_6]$ gives Prussian blue colour on reaction with $Fe_2(SO_4)_3$.

(1) S-I is correct, S-II is incorrect

(2) S-I is incorrect, S-II is correct

(3) Both S-I and S-II are correct

(4) Both S-I and S-II are incorrect

Answer (3)

Sol. $3Na_4[Fe(CN)_6] + 2Fe_2(SO_4)_3 \rightarrow \underset{\text{(Prussian blue)}}{Fe_4[Fe(CN)_6]_3} + 6Na_2SO_4$

$\therefore$ Both S-I and S-II are correct.

13. $A(g) \rightarrow 2B(g)$

For the given reaction, initial pressure was 0.6 atm and rate constant is 4.606×10^{-2} sec^{-1}. Find the pressure at 100 sec

(1) 0.6 atm (2) 1.194 atm

(3) 0.594 atm (4) 0.006 atm

Answer (2)

Sol.

	A(g)	$\rightarrow$	2B(g)
$t = 0$	0.6		
$t = 100$ sec.	$0.6 - p$		2p

$$kt = 2.303 \log \frac{0.6}{0.6 - p}$$

$$4.606 \times 10^{-2} \times 100 = 2.303 \log \frac{0.6}{0.6 - p}$$

$$(0.6 - p)100 = 0.6$$

$$60 - 100p = 0.6$$

$$\boxed{p = 0.594 \text{ atm}}$$

Total pressure = 0.6 + p

= 0.6 + 0.594

= 1.194 atm

14. Consider the following statements and choose the correct option.

Statement-I: Fructose does not contain aldehyde group but it gives Tollen's test.

Statement-II: In disaccharides, if the reducing groups are bonded, these are non-reducing sugar e.g., sucrose. If these functional groups are free then they are reducing sugar e.g. maltose and Lactose.

(1) Statement-I and Statement-II are correct

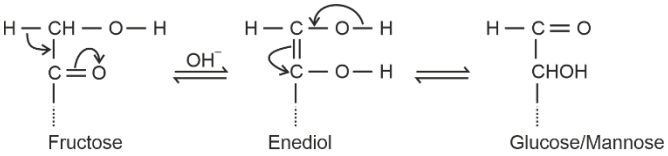
(2) Statement-I is correct and Statement-II is incorrect

(3) Statement-I in incorrect Statement-II is correct

(4) Statement-I and Statement-II both are incorrect

Answer (1)

Sol. Fructose has α-hydroxy ketone group which tautomerises to aldehyde group in presence of base. Therefore, it reduces Tollen's reagent.



Sucrose is non reducing sugar because the aldehyde group of glucose and ketonic group of function are bounded. Maltose and Lactose are reducing sugar.

15. For a sample of Hydrogen atom, the wavelength observed is 656 nm during a transition. The transition and corresponding series in hydrogen spectrum will be

(1) $3 \rightarrow 2$, Balmer (2) $4 \rightarrow 1$, Lyman

(3) $5 \rightarrow 2$, Balmer (4) $4 \rightarrow 3$, Paschen

Answer (1)

Sol. $$\frac{1}{\lambda} = R_H z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\frac{1}{656 \times 10^{-7}} = 109677 \times (1)^2 \times \left[\frac{1}{2^2} - \frac{1}{n_2^2}\right] cm^{-1}$$

$$0.139 = 0.25 - \frac{1}{n_2^2}$$

$$\frac{1}{n_2^2} = 0.111$$

$n_2 = 3$

16.

17.

18.

19.

20.

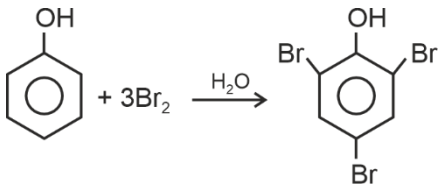
SECTION - B

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 2 g phenol is allowed to react with Br_2/H_2O. How much Br_2 (in g) will be required to produce 2, 4, 6 tribromophenol (Rounded off to nearest integer).

Answer (10)

Sol.



3 moles Br_2 will be required to react with 1 mole phenol.

Br_2 required for 2 g phenol $= \frac{2}{94} \times 160 \times 3$

$= 10.2$ g

22. When 10^{21} molecules are removed from x mg of CO_2(g), then 2.4×10^{-3} moles of CO_2 are left. Calculate the value of x. [Take $\Rightarrow N_A = 6 \times 10^{23}$]

Answer (179)

Sol. Number of moles of CO_2 removed

$$= \frac{10^{21}}{6 \times 10^{23}}$$

$= 0.167 \times 10^{-2}$ mol

Number of moles of CO_2 left $= 2.4 \times 10^{-3}$ mol

Total moles $= 2.4 \times 10^{-3} + 1.67 \times 10^{-3}$

$= 4.07 \times 10^{-3}$ mol

Mass of CO_2 present $= 4.07 \times 44 \times 10^{-3}$

$= 179 \times 10^{-3}$ g

$= 179$ mg

23. Consider the following Latimer diagram

$$FeO_4^{2-} \xrightarrow{2.0\ V} Fe^{3+} \xrightarrow{0.8\ V} Fe^{2+} \xrightarrow{-0.5\ V} Fe^0$$

Find $E^\circ_{FeO_4^{2-}/Fe^{2+}}$

Answer (2)

Sol. $FeO_4^{2-} + 4e^- \longrightarrow Fe^{2+}$

$\Delta G^\circ = -4 \times F \times E^0$

$FeO_4^{2-} + 3e^- \longrightarrow Fe^{3+}$

$\Delta G_1^\circ = -3 \times F \times (2)$

$Fe^{3+} + e^- \longrightarrow Fe^{2+}$

$\Delta G_2^\circ = -1 \times F \times (0.8)$

$\Delta G^\circ = \Delta G_1^\circ + \Delta G_2^\circ$

$-4 \times F \times E^0 = -3 \times F \times 2 + (-F \times 0.8)$

$-4E^\circ = -6.8$

$E^\circ = 1.7$ V

24. Consider the given values :

$\Delta H = 55$ kJ mol^{-1}

$\Delta S = 175$ J mol^{-1} K^{-1}

$T = 25°C$

Calculate the value of Gibbs free energy change (ΔG) in J mol^{-1}.

Answer (2850)

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

$\Delta G = 55000 - 298 \times 175$ J mol^{-1}

$\Delta G = 55000 - 52150$

$\Delta G = 2850$ J mol^{-1}

25. In estimation of sulphur by Carius method, 160 g of organic compound gives 466 g of Barium sulphate. % of sulphur in the organic compound is _____.

Answer (40)

Sol. 233 g of $BaSO_4$ contains 32 g of sulphur.

466 g of $BaSO_4$ will have 64 g of sulphur.

$\therefore$ % sulphur $= \frac{64}{160} \times 100 = 40\%$

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 for an arithmetic progression, if first term is 3 and sum of first four terms is equal to $\frac{1}{5}$ of the sum of next four terms, then the sum of first 20 terms is

(1) 1080 (2) 364

(3) –1080 (4) – 364

Answer (3)

Sol. Sum of first four term $=\frac{1}{5}$ sum of next four terms

$\Rightarrow \frac{4}{2}(2a+3d)=\frac{1}{5}(4a+22d)$

$\Rightarrow (4a + 6d)\cdot 5 = 4a + 22d$

$\Rightarrow 20a + 30d = 4a + 22d$

$\Rightarrow 16a = -8d \quad \Rightarrow \boxed{a=-\frac{d}{2}}$

$\Rightarrow \boxed{d=-6}\ \boxed{a=3}$

$\Rightarrow \frac{20}{2}[2(3)+19(-6)]=-10(18.6)$

$= -1080$

2. How many words can be formed from the word "DAUGHTER" such that any vowels are not together

(1) 34000 (2) 35000

(3) 36000 (4) 37000

Answer (3)

Sol. Total vowels together

$8! - 6! \times 3!$

$= 36{,}000$

3. Two biased dies are tossed. Die 1 has 1 on two faces, 2 on two faces, 3 and 4 on other faces, while die 2 has 2 on 2 faces, 4 on 2 faces and 1 and 3 on other faces. Then the probability that when throwing these dices we get sum of 4 or 5.

(1) $\frac{3}{7}$ (2) $\frac{2}{3}$

(3) $\frac{4}{9}$ (4) $\frac{8}{9}$

Answer (3)

Sol. Die 1 $\in \{1, 1, 2, 2, 3, 4\}$

Die 2 $\in \{2, 2, 4, 4, 1, 3\}$

P(Sum of faces is 4 or 5)

$= P(\text{sum} = 4) + P(\text{sum} = 5) - P(\text{sum} = 4 \text{ and sum} = 5)$

$=\begin{bmatrix}(D_1D_3)\\ D_2D_2\\ D_3D_1\end{bmatrix}+\begin{bmatrix}D_1D_4\\ D_2D_3\\ D_3D_2\\ D_4D_1\end{bmatrix}-$ (no cases)

$=\left[\left(\frac{2}{6}\times\frac{1}{6}\right)+\left(\frac{2}{6}\times\frac{2}{6}\right)+\left(\frac{1}{6}\times\frac{1}{6}\right)\right]+$

$\left[\frac{2}{6}\cdot\frac{2}{6}+\frac{2}{6}\cdot\frac{1}{6}+\frac{1}{6}\cdot\frac{2}{6}+\frac{1}{6}\times\frac{1}{6}\right]-0$

$=\frac{2}{36}+\frac{4}{36}+\frac{1}{36}+\frac{4}{36}+\frac{2}{36}+\frac{2}{36}+\frac{1}{36}=\frac{16}{36}=\frac{4}{9}$

4. Value of $\cos^{-1}\left[\frac{12}{13}\cos x+\frac{5}{13}\sin x\right]$ is

$\left(x\in\left[\frac{\pi}{2},\pi\right]\right)$

(1) $x+\tan^{-1}\frac{12}{13}$ (2) $x-\tan^{-1}\frac{12}{13}$

(3) $x-\tan^{-1}\frac{5}{12}$ (4) $x+\tan^{-1}\left(\frac{4}{5}\right)$

Answer (3)

Sol. $\frac{12}{13}\cos x + \frac{5}{13}\sin x$; Let $\tan\alpha = \frac{5}{12}, \alpha \in \left(0, \frac{\pi}{2}\right)$

$\Rightarrow \sin\alpha = \frac{5}{13}, \cos\alpha = \frac{12}{13}$

$\Rightarrow \frac{12}{13}\cos x + \frac{5}{13}\sin x = \cos\alpha\cos x + \sin\alpha\sin x$

$= \cos(x - \alpha)$

$\Rightarrow \cos^{-1}[\cos(x - \alpha)] = x - \alpha$

$= x - \tan^{-1}\left(\frac{5}{12}\right)$

5. A relation defined on set $A = \{1, 2, 3, 4\}$, then how many ordered pairs are added to

$R = \{(1, 2), (2, 3), (3, 3)\}$ so that it becomes equivalence relation?

(1) 10

(2) 9

(3) 7

(4) 8

Answer (3)

Sol. Ordered pairs to be added be

{(1, 1), (2, 2), (4, 4), (2, 1), (3, 2), (3, 1), (1, 3)}

So total 7 ordered pairs to be added.

6. The sum of all rational terms in the expansion of $\left(1 + 2^{\frac{1}{3}} + 3^{\frac{1}{2}}\right)^6$ is

(1) 638

(2) 728

(3) 528

(4) 729

Answer (1)

Sol. The general term of multinomial expansion is $\frac{6!}{\alpha!\beta!\gamma!}(1)^{\alpha}\left(2^{1/3}\right)^{\beta}\left(3^{1/2}\right)^{\gamma}$

For terms to be rational $3|\beta$ and $2|\gamma$

$\Rightarrow$

β	γ	α	Term
0	0	6	$1\cdot3^3 = 27$
0	2	4	$15\cdot3 = 45$
0	4	2	$15\cdot3^2 = 135$
0	6	0	$1\cdot3^3 = 27$
3	0	3	$20\cdot2 = 40$
3	2	1	$60\cdot2\cdot3 = 360$
6	0	0	$1\cdot4 = 4$

$\Rightarrow$ Sum of the rational term

$= 27 + 45 + 135 + 27 + 40 + 360 + 4 = 638$

7. If $\left|\frac{z}{z+i}\right| = 2$ represents a circle with centre P then distance of P from D is (where D : (1, 5) and $i = \sqrt{-1}$)

(1) $\sqrt{\frac{360}{9}}$

(2) $\sqrt{\frac{370}{9}}$

(3) $\frac{\sqrt{370}}{9}$

(4) $\frac{\sqrt{360}}{9}$

Answer (2)

Sol. Let $z = x + iy$

$|z| = 2|z + i|$

$\sqrt{x^2 + y^2} = 2\sqrt{x^2 + (y+1)^2}$

$x^2 + y^2 = 4(x^2 + (y + 1)^2)$

C: $3x^2 + 3y^2 + 8y + 4 = 0$

$\therefore \quad P\left(0, \frac{-4}{3}\right)$

Now PD : $\sqrt{1^2 + \left(5 + \frac{4}{3}\right)^2} = \sqrt{1 + \frac{361}{9}} = \sqrt{\frac{370}{9}}$

8. Consider the set $S = \{1, 2, 3, \ldots, 1000\}$. Then the number of arithmetic progression that can be formed using elements of set S such that first term is 1 and last term is 1000 is

(1) 8 (2) 12

(3) 15 (4) 4

Answer (1)

Sol. Let n be the last term

$\Rightarrow T_n = a + (n-1)d$

$\Rightarrow 1000 = 1 + (n-1)d$

$\Rightarrow (n-1)d = 999$

For all terms to be from S then

$d \mid 999 \Rightarrow d \mid 37 \times 27 = 37^1 \cdot 3^3$

Number of values of $d = (1+1)(3+1) = 8$

9. Let A and B are non-singular commutative matrices. Then $A[(\text{adj } A^{-1})\ (\text{adj}(B^{-1}))]^{-1} B$ is equal to

(1) $|A|\,|B|\,I_n$

(2) $\dfrac{I_n}{|A|\,|B|}$

(3) $\dfrac{I_n}{|A|}$

(4) $\dfrac{I_n}{|B|}$

Answer (1)

Sol. $= \boxed{(\text{adj}(A))^{-1} = \dfrac{A}{|A|}}$

$\because \quad A[(\text{adj } A^{-1}) \cdot (\text{adj } B^{-1})]^{-1} B$

$= A \cdot (\text{adj } B^{-1})^{-1} \cdot (\text{adj } A^{-1})^{-1} \cdot B$

$= A \cdot \dfrac{B^{-1}}{|B^{-1}|} \cdot \dfrac{A^{-1}}{|A^{-1}|} \cdot B$

$= (A \cdot B^{-1} \cdot A^{-1} \cdot B) \cdot |A| \cdot |B|$

$= (A \cdot A^{-1})\,(B \cdot B^{-1})\,|A|\,|B| = |A|\,|B|\,I_n.$

10. Let $f(x) = \log_e x$ and $g(x) = \left(\dfrac{2x^4 - 2x^3 - x^2 + 2x - 1}{2x^2 - 2x + 1}\right)$, then domain of $f(g(x))$ for $x > 0$ is

(1) $(1, \infty)$

(2) $(0, \infty)$

(3) $\left(\dfrac{1}{2}, \infty\right)$

(4) $(0, 1)$

Answer (1)

Sol. Clearly $2x^2 - 2x + 1 > 0\ \forall\ x \in R$

also ± 1 are roots of equation

$2x^4 - 2x^3 - x^2 - 1 = 0$

$\Rightarrow 2x^4 - 2x^3 - x^2 + 2x - 1 = (2x^2 - 2x + 1)(x-1)(x+1)$

$\Rightarrow g(x) = (x-1)(x+1)$

$f(g(x)) = \log_e(x^2 - 1) \Rightarrow (x^2 - 1) > 0$

$\Rightarrow x \in (-\infty, -1) \cup (1, \infty)$

11. If the curve satisfying the differential equation $\dfrac{dy}{dx} = \dfrac{6 - 2e^{2x}y}{1 + e^{2x}}$ passes through $(0, 0)$ and $(\ln 2, k)$, then k is

(1) $\dfrac{3}{5}\ln 3$

(2) $\dfrac{6}{5}\ln 2$

(3) $\dfrac{8}{9}\ln 3$

(4) $\dfrac{7}{2}\ln 2$

Answer (2)

Sol. $\dfrac{dy}{dx} = \dfrac{6 - 2e^{2x}y}{1 + e^{2x}}$

$\dfrac{dy}{dx} = \left(\dfrac{2e^{2x}}{1 + e^{2x}}\right)y = \dfrac{6}{1 + e^{2x}}$

If $= e^{\int \frac{2e^{2x}}{1+e^{2x}}dx}$

$= e^{\ln|1+e^{ex}|} = 1 + e^{2x}$

$$y(1+e^{2x}) = \int \frac{6}{\left(1+e^{2x}\right)} \cdot (1+e^{2x})dx$$

$y(1 + e^{2x}) = 6x + c$

Passes through (0, 0)

$\Rightarrow \quad c = 0$

$$\therefore \quad y = \frac{6x}{1+e^{2x}}$$

Now if passes through (ln2, k)

$$k = \frac{6\ln 2}{1+4} = \frac{6}{5}\ln 2$$

12. Let $I = \int \frac{dx}{(x-1)^{\frac{11}{13}} \cdot (x+15)^{\frac{15}{13}}}$, then I is

(1) $\frac{13}{32}\left(\frac{x-1}{x+15}\right)^{\frac{2}{13}} + C$

(2) $\frac{32}{13}\left(\frac{x-1}{x+15}\right)^{\frac{2}{13}} + C$

(3) $\frac{1}{32}\left(\frac{x+15}{x-1}\right)^{\frac{2}{13}} + C$

(4) $\frac{13}{32}\left(\frac{x+15}{x-1}\right)^{\frac{15}{13}} + C$

Answer (1)

Sol. $$I(x) = \int \frac{dx}{(x-1)^{\frac{11}{13}}(x+15)^{\frac{15}{13}}}$$

$$= \int \frac{dx}{(x-1)^2\left(\frac{x+15}{x-1}\right)^{\frac{15}{13}}}$$

Let $\frac{x+15}{x-1} = y$

$$\frac{(x-1)-(x+15)}{(x-1)^2} = \frac{dy}{dx}$$

$$\frac{-16dx}{(x-1)^2} = dy$$

$$I(x) = \int \frac{-\frac{1}{16}dy}{y^{\frac{15}{13}}}$$

$$= -\frac{1}{16}\left(\frac{y^{-\frac{15}{13}+1}}{\frac{-15}{13}+1}\right) + C$$

$$= \frac{13}{32}y^{-\frac{2}{13}} + C$$

$$= \frac{13}{32}\left(\frac{x-1}{x+15}\right)^{\frac{2}{13}} + C$$

13.

14.

15.

16.

17.

18.

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 $f(x)$ is continuous at $x = 0$, where

$$f(x) = \begin{cases} \frac{2}{x}(\sin(k_1+1)x + \sin(k_2+1)x) & x < 0 \\ 4 & x = 0 \\ \frac{2}{x}\log\left[\frac{k_2x+1}{k_1x+1}\right] & x > 0 \end{cases}$$

Then $k_1^2 + k_2^2$ is

Answer (2)

Sol. $\because$ $f(x)$ is continuous at $x = 0$

Then $\lim\limits_{x\to 0^-} f(x) = f(0) = \lim\limits_{x\to 0^+} f(x)$

$$\Rightarrow \lim_{x\to 0^-}\frac{2\left(\sin(k_1+1)x+\sin(x_2+1)x\right)}{x}=4$$

$$=\lim_{x\to 0^+}\frac{2\log\left(\frac{k_2x+1}{k_1x+1}\right)}{x}$$

$$\Rightarrow \lim_{h\to 0}2\left\{\frac{\sin(1+k_1)h}{(1+k_1)h}\cdot(1+k_1)+\frac{\sin(1+k_2)h}{(1+k_2)h}(1+k_2)\right\}=4$$

$$=\lim_{h\to 0}\frac{2\log\left(1+\frac{(k_2-k_1)h}{1+k_1h}\right)}{\frac{(k_2-k_1)h}{1+k_1h}}\cdot\left(\frac{k_2-k_1}{1+k_1h}\right)$$

$\Rightarrow 2(2 + k_1 + k_2) = 4 = 2(k_2 + k_1)$

$\therefore\ k_1 + k_2 = 0$ and $k_2 - k_1 = 2$

$\therefore\ k_1 = -1,\ k_2 = 1$

$\therefore\ k_1^2 + k_2^2 = 2$

22. If for the system of linear equations having infinite solutions

$(\lambda - 4)x + (\lambda - 2)y + \lambda z = 0$

$2x + 3y + 5z = 0$

$x + 2y + 6z = 0$

then $\lambda^2 + \lambda$ is

Answer (90)

Sol. For infinite solutions $\Delta = 0$

$$\begin{vmatrix}\lambda-4 & \lambda-2 & \lambda\\ 2 & 3 & 5\\ 1 & 2 & 6\end{vmatrix}=0$$

$\Rightarrow 2\lambda - 18 = 0$

$\lambda = 9$

Now $\lambda^2 + \lambda = 9^2 + 9 = 81 + 9 = 90$

23. If the equation $a(b - c)x^2 + b(c - a)x + c(a - b) = 0$ has equal roots and if $a + c = 5$ and $b = \frac{16}{5}$, then the value of $a^2 + c^2$ is equal to

Answer (9)

Sol. Clearly 1 satisfy $\Rightarrow$ other root is also 1.

$$\Rightarrow \frac{c(a-b)}{a(b-c)}=1 \qquad \text{(using product of roots)}$$

$\Rightarrow c(a - b) = a(b - c)$

$\Rightarrow 2ac = b(a + c)$

$$\Rightarrow 2ac=\left(\frac{16}{5}\right)(5)$$

$\Rightarrow 2ac = 16$

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

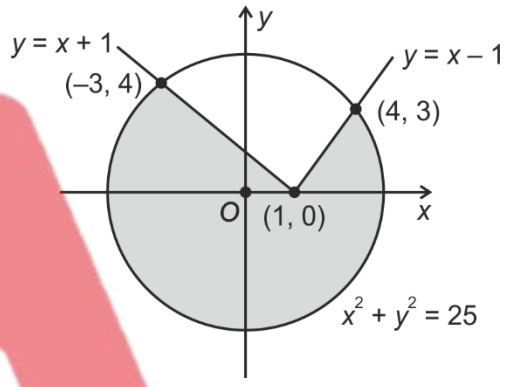
$= 25 - 16 = 9$

24. The area of larger portion enclosed by curves $y = |x - 1|$ and $x^2 + y^2 = 25$ is equal to $\frac{1}{4}(\alpha\pi + \beta)$ sq. units (where α, β are natural numbers), then $\alpha + \beta$ equals to

Answer (77)

Sol. Intersection points of

$y = |x - 1|$ and $x^2 + y^2 = 25$ are $(-3, 4)$ and $(4, 3)$



$$A=25\pi-\int_{-3}^{4}\left(\sqrt{25-x^2}-|x-1|\right)dx$$

$$=25\pi-\left[\frac{1}{2}x\sqrt{25-x^2}+\frac{25}{2}\sin^{-1}\frac{x}{5}\right]_{-3}^{4}+\left(8+\frac{9}{2}\right)$$

$$=25\pi+\frac{25}{2}-\left(6+\frac{25}{2}\sin^{-1}\frac{4}{5}+6+\frac{25}{2}\sin^{-1}\frac{3}{5}\right)$$

$$=25\pi+\frac{25}{2}-12-\frac{25\pi}{4}=\frac{75\pi}{4}+\frac{1}{2}$$

$$=\frac{1}{4}(75\pi+2)$$

$\Rightarrow \alpha = 75,\ \beta = 2$

$\alpha + \beta = 77$

25.

❑ ❑ ❑