24/01/2025
Morning

Corporate Office : AESL, 3rd Floor, Incuspaze Campus-2, Plot-13, Sector-18, Udyog Vihar, Gurugram, Haryana-122018

Memory Based
Answers & Solutions

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

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. It $I = I_A \sin\omega t + I_B \cos\omega t$, then find rms value of current

(1) $I_{rms} = I_A + I_B$

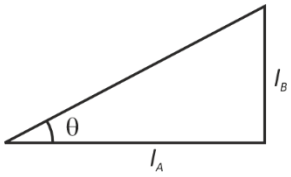
(2) $I_{rms} = \sqrt{I_A^2 + I_B^2}$

(3) $I_{rms} = \sqrt{\frac{I_A^2 + I_B^2}{2}}$

(4) $I_{rms} = \frac{1}{2}\sqrt{I_A^2 + I_B^2}$

Answer (3)

Sol.



$I = \sqrt{I_A^2 + I_B^2}\sin(\omega t + \theta)$

$\tan\theta = \left(\frac{I_B}{I_A}\right)$

as $I_{rms} = \frac{I_0}{\sqrt{2}} \Rightarrow I_{rms} = \sqrt{\frac{I_A^2 + I_B^2}{2}}$

2. What is relative shift of focal length of a lens when optical power is increased from 0.1 D to 2.5 D

(1) $\frac{24}{25}$

(2) $\frac{13}{10}$

(3) $\frac{21}{25}$

(4) $\frac{11}{10}$

Answer (1)

Sol. $f = \frac{1}{p}$

So, $f_1 = 10\text{ m} = \frac{1}{p_1}$

And $f_2 = \frac{1}{p_2} = \frac{10}{25}\text{m}$.

So $\frac{|\Delta f|}{f_1} = \frac{24}{25}$

3. Satellite *A* is launched in a circular orbit of radius *R*. Satellite *B* is launched in circular orbit of radius 1.03*R*. Time period of *B* is greater than *A* by approximately

(1) 9% (2) 4.5%

(3) 3% (4) 2.5%

Answer (2)

Sol. $T = 2\pi\sqrt{\frac{r^3}{Gm}}$

$\frac{\Delta T}{T} = \frac{3}{2}\frac{\Delta R}{R}$

$\frac{\Delta T}{T} \times 100 = \frac{3}{2} \times \frac{0.03R}{R} \times 100$

$= 4.5\%$

4. An electron jumps from principle quantum state *A* to *C* by releasing photon of wavelength 2000 Å and from state *B* to *C* by releasing of photon of wavelength 6000 Å, then final the wavelength of photon for transition from *A* to *B*.

(1) 3000 Å (2) 4000 Å

(3) 8000 Å (4) 2000 Å

Answer (1)

Sol. $E_{AC} = E_{AB} + E_{BC}$

$\frac{\hbar C}{2000\,\text{Å}} = \frac{\hbar C}{\lambda} + \frac{\hbar C}{6000\,\text{Å}} \Rightarrow \frac{3-1}{6000} = \frac{1}{\lambda}$

$\lambda = 3000\,\text{Å}$

5. An electron of mass m enters in a region of uniform electric field $\vec{E} = -E_0\hat{k}$ at t = 0 with an initial velocity $\vec{V} = V_0\hat{i}$. If the de-Broglie wavelength is λ_0 initially, the de-Broglie wavelength at a time t is

(1) $\lambda_0\sqrt{1+\frac{m^2V_0^2}{e^2E_0^2t^2}}$ (2) $\lambda_0\sqrt{1+\frac{e^2E_0^2t^2}{m^2V_0^2}}$

(3) $\frac{\lambda_0}{\sqrt{1+\frac{e^2E_0^2t^2}{m^2V_0^2}}}$ (4) $\frac{\lambda_0}{\sqrt{1+\frac{m^2V_0^2}{e^2E_0^2t^2}}}$

Answer (3)

Sol. $\lambda_0 = \frac{h}{mV_0}$ ...(i)

$\vec{V} = V_0\hat{i} + \frac{(-e)(-E_0\hat{k})}{m}t$

$\vec{V} = V_0\hat{i} + \frac{eE_0t\hat{k}}{m}$

$|\vec{V}| = \sqrt{V_0^2 + \frac{e^2E_0^2t^2}{m^2}}$

$|\vec{P}_f| = \frac{h}{\lambda} = m|\vec{V}|$

$\lambda = \frac{h}{m|\vec{V}|}$

$= \frac{h}{m\sqrt{V_0^2 + \frac{e^2E_0^2t^2}{m^2}}}$

$= \frac{h}{mV_0\sqrt{1+\frac{e^2E_0^2t}{m^2V_0^2}}}$

$= \frac{\lambda_0}{\sqrt{1+\frac{e^2E_0^2t^2}{m^2V_0^2}}}$

6. For an ideal mono atomic gas undergoing an isobaric process, the ratio of $\frac{\Delta Q}{\Delta U}$ is

(1) $\frac{5}{3}$

(2) $\frac{7}{5}$

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

(4) $\frac{5}{4}$

Answer (1)

Sol. In an isobaric process,

$\Delta Q = nC_p\Delta T$

$\Delta U = nC_V\Delta T$

$\frac{\Delta Q}{\Delta U} = \frac{C_p}{C_v} = \gamma = \frac{5}{3}$ for a monoatomic

7. In a process pressure of the gas is directly proportional to temperature then choose correct option.

A : Process is isochoric.

B : Work done in process is zero.

C : Internal energy increase with increase in temperature.

(1) A and B are correct

(2) A and C are correct

(3) A, B and C are correct

(4) B and C are correct

Answer (3)

Sol. $P \times T$

V is constant

Work = 0

ΔU is positive

8. If the distance two parallel plate of a capacitor is d, A is the area of each plate, and E is the electric field. Find the energy stored in capacitor

(1) $\frac{1}{2}E^2A\varepsilon_0 d$ (2) $\frac{1}{4}E^2A\varepsilon_0 d$

(3) $\frac{3}{4}E^2A\varepsilon_0 d$ (4) $E^2A\varepsilon_0 d$

Answer (1)

Sol. Δu = Energy density × volume = $\frac{1}{2}\varepsilon_0 E^2 \cdot Ad$

9. In YDSE, lights of wavelength 600 nm and 480 nm are used. What is the minimum order of bright fringe of 480 nm coincides with bright fringe of 600 nm.

(1) 8 (2) 7

(3) 6 (4) 5

Answer (4)

Sol. For 480 nm $w_1 = \frac{480D}{d}$

For 600 nm = $w_2 = \frac{600D}{d}$

So, 5th order of 480 nm natcher

Clearly $5\Delta w_1 = 4\Delta w_2$

10. A body of mass m is projected with initial velocity v_0 at 45° with horizontal. Find it's angular momentum at highest point about point of projection.

(1) $\frac{mv_0^3}{4g}$ (2) $\frac{mv_0^3}{4\sqrt{2}g}$

(3) $\frac{mv_0^2}{4\sqrt{2}g}$ (4) $\frac{mv_0}{2\sqrt{2}g}$

Answer (2)

Sol.

$L = \frac{mv_0}{\sqrt{2}}H$

$= \frac{mv_0}{\sqrt{2}} \cdot \frac{v_0^2 \cdot \frac{1}{2}}{2g}$

$L = = \frac{mv_0^3}{4\sqrt{2}g}$

11. A Plano convex lens of refractive index 1.5 & radius of curvature of curved surface of 20 cm present in air is having focal length of f_1. There is another Plano convex lens of refractive index of 1.5 & ROC of 30 cm placed in liquid of RI of 1.2 having focal length of f_2 the $\frac{f_1}{f_2}$ is

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

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

Answer (4)

Sol. $\frac{1}{f_1} = (1.5-1)\left\{\frac{1}{R}\right\} = \frac{0.5}{20}$

$f_1 = \frac{20}{0.5} = 40$

$\frac{1}{f_2} = \left(\frac{1.5}{1.2}-1\right)\left(\frac{1}{R}\right) = \frac{0.3}{1.2} \times \frac{1}{30} = \frac{1}{120}$

$\frac{f_1}{f_2} = \frac{40}{120} = \frac{1}{3}$

12. Acceleration of solid cylinder purely rolling an inclined plane of inclination of θ is

(1) $\frac{2}{5}g\sin\theta$ (2) $\frac{3}{2}g\sin\theta$

(3) $\frac{2}{3}g\sin\theta$ (4) $\frac{1}{3}g\sin\theta$

Answer (3)

Sol. $a = \frac{g\sin\theta}{1+\frac{k^2}{r^2}} = \frac{g\sin\theta}{1+\frac{1}{2}} = \frac{2}{3}g\sin\theta$

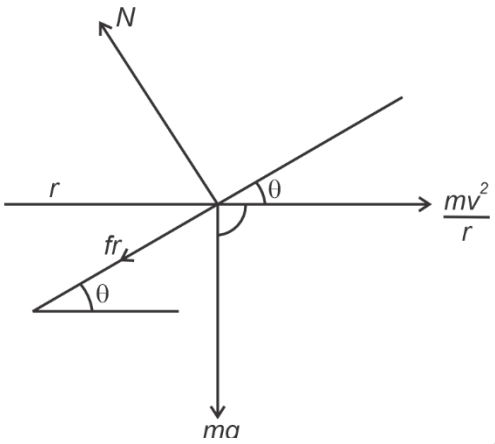
13. Find the maximum possible speed for the given angle of banking 'θ' on a curved road of radius r having coefficient of friction μ.

(1) $v_{max}=\sqrt{\frac{gr(\mu+\tan\theta)}{(1-\mu\tan\theta)}}$ (2) $v_{max}=\sqrt{\frac{gr(\mu-\tan\theta)}{(1-\mu\tan\theta)}}$

(3) $v_{max}=\sqrt{\frac{gr(1+\mu\tan\theta)}{(1-\mu\tan\theta)}}$ (4) $v_{max}=\sqrt{\frac{gr(\mu-\tan\theta)}{(1+\mu\tan\theta)}}$

Answer (1)

Sol.



$$\Rightarrow N=\frac{mv^2}{r}\sin\theta+mg\cos\theta$$

Also $\frac{mv^2}{r}\cos\theta=\mu N+mg\sin\theta$

$$\Rightarrow \frac{mv^2}{r}\cos\theta=\mu\frac{mv^2}{r}\sin\theta+\mu mg\cos\theta+mg\sin\theta$$

$$\Rightarrow v^2\left[\frac{\cos\theta}{r}-\frac{\mu\sin\theta}{r}\right]=g(r\cos\theta+\sin\theta)$$

$$\Rightarrow v=\sqrt{\frac{gr(\sin\theta+\mu\cos\theta)}{(\cos\theta-\mu\sin\theta)}}$$

$$v=\sqrt{\frac{gr(\tan\theta+\mu)}{(1-\mu\tan\theta)}}$$

14. In a parallel plate capacitor length l and width b are 3 cm and 1 cm respectively. Separation between plates d is 3 μm. By which of the following values capacitance increases by a factor of 10.

(A) l = 6 cm, b = 5 cm, d = 3 μm

(B) l = 5 cm, b = 2 cm, d = 1 μm

(C) l = 5 cm, b = 1 cm, d = 30 μm

(D) l = 1 cm, b = 1 cm, d = 30 μm

(1) A, B (2) A, C

(3) B, C (4) B, C, D

Answer (1)

Sol. $C=\frac{A\varepsilon_0}{d}$

$$C=\frac{lb\varepsilon_0}{d}$$

$$C_i=\frac{3\times1}{3}\varepsilon_0\times10^2=10^2\varepsilon_0$$

15. In SHM given by equation $x = A\sin\omega t$ of time period 2 sec and amplitude 1 cm, ratio of $\frac{\text{distance}}{\text{displacement}}$ in first 1.25 sec is

(1) $2\sqrt{2}+1$ (2) $2\sqrt{2}-1$

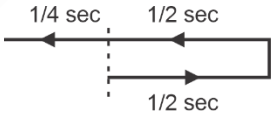
(3) $\frac{1}{\sqrt{2}}$ (4) $\frac{1}{2\sqrt{2}}$

Answer (1)

Sol. $x = A\sin\frac{2\pi}{2}\times1.25$

$X = A\sin\frac{5\pi}{4}$

$|s| = \frac{A}{\sqrt{2}}$



$d = 2A + \frac{A}{\sqrt{2}}$

$$\frac{d}{|s|}=(2\sqrt{2}+1)$$

16.

17.

18.

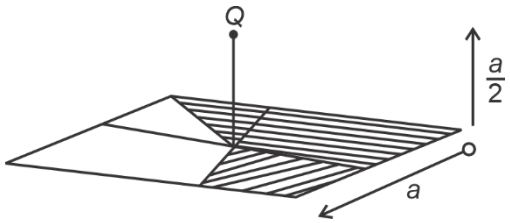
19.

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. The electric flux through the shaded area of square plate of side a due to point charge placed at distance of $\frac{a}{2}$ from it as shown in figure, is $\frac{NQ}{48\varepsilon_0}$. Then N is



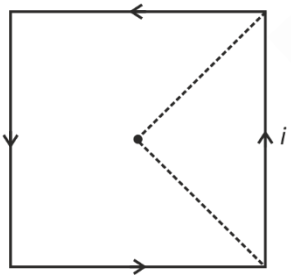
Answer (5)

Sol. $\left(\frac{Q}{6\varepsilon_0}\right)\frac{1}{4}+\left(\frac{Q}{6\varepsilon_0}\right)\frac{1}{4}+\left(\frac{Q}{6\varepsilon_0}\right)\frac{1}{4}\times\frac{1}{2}=\frac{5Q}{48}$

22. In a square loop of side length $\frac{1}{\sqrt{2}}$ m, a current of 5 A is flowing. Find magnetic field at its centre in (μT).

Answer (8)

Sol.



$$B=4\left(\frac{\mu_0 i}{4\pi\frac{1}{2\sqrt{2}}}\right)(\sin45°+\sin45°)$$

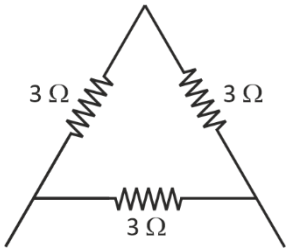
$$=4\left(\frac{4\pi\times10^{-7}\times5}{4\pi}\cdot2\sqrt{2}\sqrt{2}\right)$$

$= 8 \times 10^{-6}$ T

23. A wire of resistance 9 Ω is bent in form of an equilateral triangle. Find equivalent resistance between two vertices of triangle.

Answer (2)

Sol.



$R_{eq} = 3 \| 6$

$$R_{eq}=\frac{3\times6}{9}=2\ \Omega$$

24. Work done required to break a drop of radius R to 27 drops of equal radius is 10 J. Then work done to break drop of radius R in 64 drops of equal radii is X J, then X is

Answer (15)

Sol. For 27 $R \to \frac{R}{3}$; for 64 $R \to \frac{R}{4}$

$$\frac{S\left(27\,4\pi\left(\frac{R}{3}\right)^2-4\pi R^2\right)}{S\left(64\,4\pi\left(\frac{R}{4}\right)^2-4\pi R^2\right)}=\frac{10}{x}=\frac{2}{3}$$

$X = 15$ J

25. A particle moves on a straight line under the influence of a force $F = \alpha + \beta x^2$ where x is the displacement, and β = –12 SI units. If the total work done for a displacement x = 1m is 12 J, then α is _____ SI units.

Answer (16)

Sol. $w = \int_0^1 F_x\,dx$

$$=\int_0^1(\alpha+\beta x^2)dx$$

$$=\alpha+\frac{\beta}{3}$$

$$12=\alpha-\frac{12}{3}$$

$\alpha = 16$

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 is the strongest oxidising agent?
   (1) Eu^{2+}
   (2) Ce^{2+}
   (3) Ce^{4+}
   (4) Eu^{3+}

Answer (3)

Sol. $Ce^{4+}/Ce^{3+} \Rightarrow 1.74$ V, Ce^{4+} is strong oxidising agent where as Eu^{2+} is strong reducing agent as it converts to Eu^{3+}.

Since oxidising agent itself gets reduced, Ce^{4+} is most easily reduced among these.

2. The difference in melting point and boiling point of oxygen and sulphur can be explained by
   (1) Electronegativity
   (2) Electron gain enthalpy
   (3) Atomicity
   (4) Ionisation energy

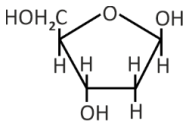
Answer (3)

Sol. It can be explained on basis of Atomicity as oxygen exists as O_2 while sulphur as S_8.

3. Ribose present in DNA is
   (A) A pentose sugar
   (B) Present in pyranose form
   (C) α anomeric carbon is present
   (D) Present in D configuration
   (E) A reducing sugar in free form
   Choose the correct statement :
   (1) A, C & E only
   (2) A, D & E only
   (3) A, B, C, D & E
   (4) A & E only

Answer (2)

Sol. Structure of Ribose is



β-D-2 deoxyribose

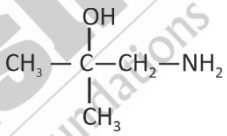
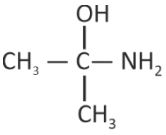
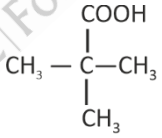
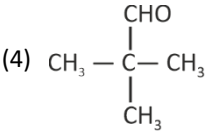
Statement A, D & E are correct

It is present in furanose form & β-anomeric C is present

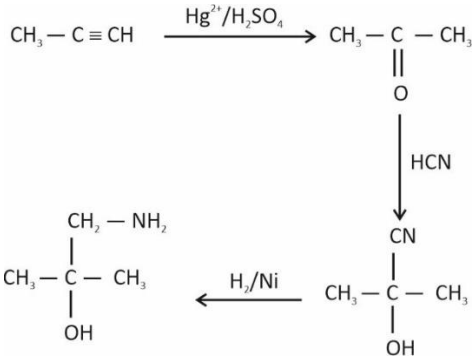
4. Consider the following reaction

$$CH_3-C\equiv CH \xrightarrow[(ii)\,HCN]{(i)\,Hg^{2+}/H_2SO_4} \xrightarrow[(iii)\,H_2/Ni]{} P$$

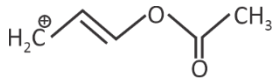
Product P is

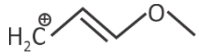
(1) 
(2) 
(3) 
(4) 

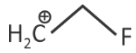
Answer (1)

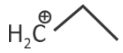
Sol. 

5. The most stable carbocation among the following is.

(1) 

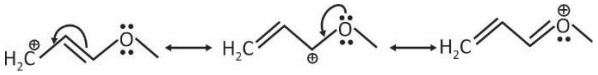
(2) 

(3) 

(4) 

Answer (2)

Sol. Among the given carbocations, the following carbocation is most stable due to extended conjugation and there is no destabilising factor.



6. Which of the following is most reactive towards nucleophilic addition reaction.

(1) Para-nitro benzaldehyde

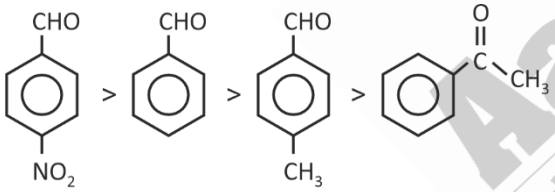
(2) Para-methyl benzaldehyde

(3) Benzaldehyde

(4) Acetophenone

Answer (1)

Sol. The order of reactivity will be dependent on hinderance and e^- deficiency (δ^+) on carbonyl carbon.



7. Consider the following statements about H_2O, NH_3 and CH_4

(A) All central atoms are sp^3 hybridised

(B) Order of dipole moment is $CH_4 < NH_3 < H_2O$

(C) NH_3 in H_2O is basic in nature, NH_3 and H_2O are Bronsted-Lowry acid and base respectively

(D) Bond angle of H_2O, NH_3 and CH_4 respectively are 104.5°, 107° and 109.5°

Which of the above statements are correct

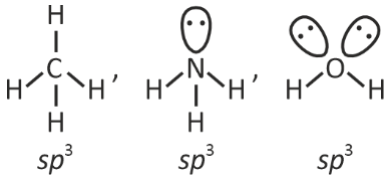
(1) A and B only

(2) A, B and C only

(3) A, B, C and D

(4) A, B and D only

Answer (4)

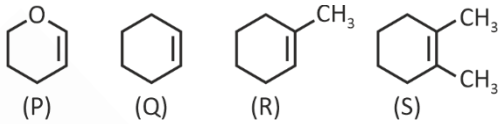
Sol. 

sp^3 sp^3 sp^3

Dipole moment of $H_2O > NH_3 > CH_4$

Bond angle of $CH_4 > NH_3 > H_2O \rightarrow 109.5 > 107° > 104.5°$

8. Which of the following is most reactive towards aq. HBr?



(P) (Q) (R) (S)

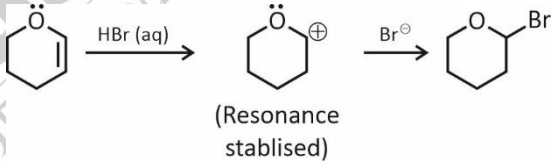
(1) (P)

(2) (Q)

(3) (R)

(4) (S)

Answer (1)

Sol. 

(Resonance stablised)

9. At the freezing point of water, process is non spontaneous, it becomes spontaneous at boiling point (Temperature varies linearly with pressure). The correct option is

(1) ΔH = +ve
ΔS = +ve

(2) ΔH = –ve
ΔH = –ve

(3) ΔH = +ve
ΔS = –ve

(4) ΔH = –ve
ΔS = +ve

Answer (1)

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

For process to be spontaneous $\Delta G < 0$

The given process becomes spontaneous on increasing temperature

So $\Delta H > 0$ and $\Delta S > 0$

10. In the preparation of potassium permanganate from pyrolusite ore (MnO_2), the fusion of pyrolusite ore is done with an alkali metal hydroxide like KOH in the presence of air or an oxidising agent like KNO_3, which first produces.

(1) K_2MnO_6

(2) K_2MnO_4

(3) $KMnO_4$

(4) K_2MnO

Answer (2)

Sol. $2MnO_2 + 4KOH + O_2 \xrightarrow{\Delta} \underset{\left(\text{Potassium Manganate}\right)}{2K_2MnO_4} + 2H_2O$

Potassium Manganate (k_2MnO_4) is produced.

11. S-I : Duma's method is used for estimation of nitrogen

S-II : In Duma's method N present in compound is converted to $(NH_4)_2SO_4$

(1) S-I is correct statement.
S-II is incorrect statement

(2) S-I is incorrect statement
S-II is also incorrect statement

(3) S-I is correct statement
S-II is also correct statement

(4) S-I is incorrect statement
S-II is correct statement

Answer (1)

Sol. Estimation of N is done by Dumas and Kjeldahl method. In Dumas method N is organic compound is converted to free N_2 when compound is heated with CuO in atmosphere of CO_2. Released N_2 is collected over an aqueous solution of KOH.

12. An electron jumps from A $\rightarrow$ C by emitting a wavelength of 2000 Å and also jumps from B $\rightarrow$ C by emitting a wavelength of 6000 Å, then wavelength of that electron; if it jumps from A $\rightarrow$ B

(1) 4000 Å

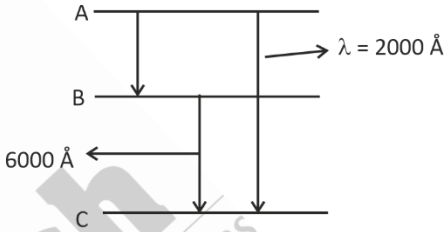
(2) 3000 Å

(3) 8000 Å

(4) 5000 Å

Answer (2)

Sol.



$$\left(\frac{hc}{\lambda}\right)_{AC} = \left(\frac{hc}{\lambda}\right)_{AB} + \left(\frac{hc}{\lambda}\right)_{BC}$$

$$\left(\frac{1}{\lambda}\right)_{AC} = \left(\frac{1}{\lambda}\right)_{AB} + \left(\frac{1}{\lambda}\right)_{BC}$$

$$\frac{1}{2000} = \frac{1}{\lambda_{AB}} + \frac{1}{6000}$$

$$\frac{1}{\lambda_{AB}} = \frac{1}{2000} - \frac{1}{6000}$$

$$\frac{1}{\lambda_{AB}} = \frac{6000 - 2000}{6000 \times 2000}$$

$$\frac{1}{\lambda_{AB}} = \frac{4000}{12 \times 10^6}$$

$$\frac{1}{\lambda_{AB}} = \frac{1}{3000}$$

$$\lambda_{AB} = 3000\,\text{Å}$$

13. Calculate the value of E°_{cell} for given cell based on given information

$Fe^{2+} + Ag^{+} \rightarrow Fe^{3+} + Ag$;

$Ag^{+} + e^{-} \rightarrow Ag$; $E^{\circ} = xV$

$Fe^{2+} + 2e^{-} \rightarrow Fe$; $E^{\circ} = yV$

$Fe^{3+} + 3e^{-} \rightarrow Fe$; $E^{\circ} = zV$

(1) $x + y - z$

(2) $x + 3y - 2z$

(3) $y - 2x$

(4) $x - 3z + 2y$

Answer (4)

Sol. $Fe^{2+} + 2e \rightarrow Fe \quad E^{\circ} = y$

$Fe \rightarrow Fe^{3+} + 3e^{-} \quad E^{\circ} = -z$

$Fe^{2+} \rightarrow Fe^{3+} + e^{-} \quad E^{\circ} = w$ (say)

$1 \times w = 2 \times y - 3z$

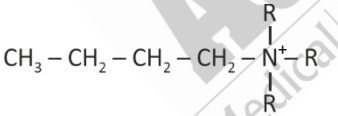
$w = 2y - 3z$

$Fe^{2+} + Ag^{+} \rightarrow Fe^{3+} + Ag$

$E^{\circ}_{Cell} = E^{\circ}_{Fe^{2+}/Fe^{3+}} + E^{\circ}_{Ag^{+}/Ag} = 2y - 3z + x$

14. Consider the given reactions and choose proper solvent.

Reaction-I: $CH_3 - CH_2 - CH_2 - CH_2 - Cl \xrightarrow{OH^-} CH_3 - CH_2 - CH_2 - CH_2 - OH$

Reaction -II: $CH_3 - CH_2 - CH_2 - CH_2 - Cl \xrightarrow{R_3N}$ 

(1) Reaction-I : polar protic, Reaction-II : polar aprotic

(2) Reaction-I : polar aprotic, Reaction-II : polar protic

(3) Reaction-I : polar aprotic, Reaction-II : polar aprotic

(4) Reaction-I : polar protic, Reaction-II : polar protic

Answer (3)

Sol. Both reactions proceeds through S_N2 mechanism and most suitable solvent would be polar aprotic solvent.

15. 2.32×10^3 kg of Fe_3O_4 reacts with 2.8×10^3 kg of CO according to the following reaction :

$Fe_3O_4 + CO \rightarrow CO_2 + Fe$

If x kg of Fe is formed. Find the value of x?

(1) 2000 kg

(2) 1680 kg

(3) 2780 kg

(4) 1500 kg

Answer (2)

Sol. Balanced reaction

$Fe_3O_4 + 4CO \rightarrow 4CO_2 + 3Fe$

Given mass of $Fe_3O_4 = 2.32 \times 10^3$ kg

Mol. Mass of $Fe_3O_4 = 232$ gm $= 0.232$ kg

Moles of $Fe_3O_4 = \frac{2.32 \times 10^3}{0.232} = 10^4$ mol

Given mass of CO $= 2.8 \times 10^3$ kg

Mol. Mass of CO $= 28$ gm $= 0.028$ kg

Moles of CO $= 10^5$ mol

According to balanced reaction

1 mol Fe_3O_4 requires 4 mol CO

$\therefore$ 10^4 mol Fe_3O_4 requires 4×10^4 mol CO

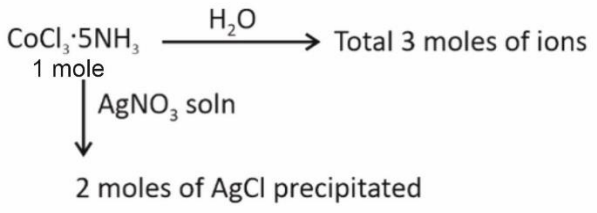
$\therefore$ CO is in excess

1 mol Fe_3O_4 gives 3 mol Fe

10^4 mol Fe_3O_4 will gives 3×10^4 mol Fe

$\therefore$ Mass of Fe formed $= 3 \times 10^4 \times \frac{56}{1000} = 1680$ kg

16. Consider the following reaction of a complex compound



The formula of complex is

(1) $[Co(NH_3)_5Cl]\ Cl_2$

(2) $[Co(NH_3)_6]\ Cl_3$

(3) $[Co(NH_3)_3Cl_3]\cdot 3NH_3$

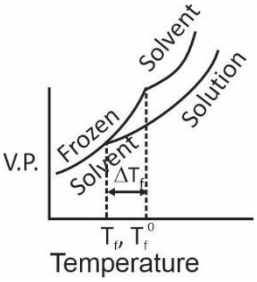
(4) $[Co(NH_3)_4Cl_2]\ Cl$

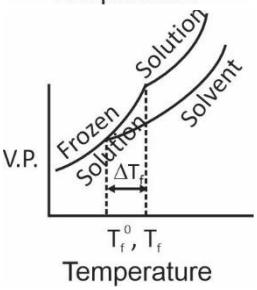
Answer (1)

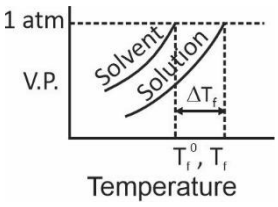
Sol. $\underset{\text{1 mole}}{\left[Co(NH_3)_5Cl\right]}Cl_2 \xrightarrow{H_2O} \underbrace{\left[Co(NH_3)_5Cl\right]^{2+} + 2Cl^-}_{\text{3 mole ions}}$

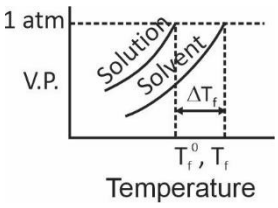
$\left[Co(NH_3)_5Cl\right]Cl_2 \xrightarrow[\text{soln}]{AgNO_3} \left[CO(NH_3)_5Cl\right](NO_3)_2 + 2AgCl\downarrow$

17. Consider the following plots of vapour pressure of a solution containing non-volatile solute versus temperature (in K) and choose the correct graph which represents depression in freezing of solvent.

(1)


(2)


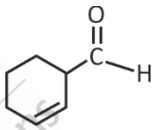
(3)


(4)


Answer (1)

Sol. Freezing point of a solvent is the temperature when vapour pressure of solid phase becomes equal to vapour pressure of liquid phase. The solute never freezes and always remains in solution. Graph (1) represents the correct plot for depression in freezing point.

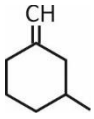
18. A student synthesised the compound given below

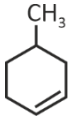


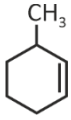
By using one of the following compounds available in the lab and using following reagents.

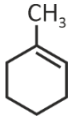
$\text{Reactant} \xrightarrow{NBS} \xrightarrow[Me_3COH]{Me_3CO^-K^+} \xrightarrow[(ii)\,H_2O_2/OH^-]{(i)\,B_2H_6/THF} \xrightarrow{PCC}$

Choose the suitable compound which can be used as reactant

(1)


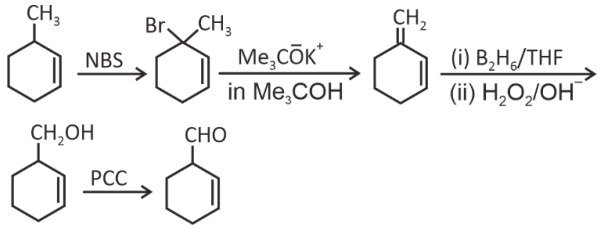
(2)


(3)


(4)


Answer (3)

Sol. 3-methylcyclohexene is likely to be the most appropriate reactant for the synthesis of the given compound.



19. Select the incorrect statements about the modern periodic table.

(1) The Physical and chemical properties of elements are periodic function of their atomic weight

(2) The Physical and chemical properties of elements are periodic function of their atomic numbers

(3) Non-metallic elements are lesser in number than metallic elements

(4) In periodic table, 18 groups are present

Answer (1)

Sol. According to modern periodic law, the physical and chemical properties of elements are periodic function of their atomic numbers.

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 the K_{sp} of $Cr(OH)_3$ is 1.6×10^{-30} M^4. The molar solubility of salt in water is 1.56×10^{-x}, then value of x is

Answer (8)

Sol. $Cr(OH)_3(s) \rightleftharpoons \underset{s}{Cr^{3+}}(aq) + \underset{3s}{3OH^-}(aq)$

$K_{sp} = s^1(3s)^3$

$K_{sp} = 27s^4$

$s^4 = \frac{1.6}{27} \times 10^{-30}\ M^4$

$s^4 = \frac{160}{27} \times 10^{-32} = 5.92 \times 10^{-32}$

$s = 1.56 \times 10^{-8}$

$\boxed{x = 8}$

22. When x g of Benzoic acid reacts with $NaHCO_3$, 11.2 L of CO_2 is released at 273 K and 1 atm pressure, calculate mass of benzoic acid in gram?

Answer (61)

Sol. $Ph-\overset{\overset{O}{||}}{C}-OH + NaHCO_3 \rightarrow Ph-\overset{\overset{O}{||}}{C}-ONa + H_2O + CO_2$

Moles of $CO_2 = \frac{11.2}{22.4} = 0.5\,mol$

Moles of Benzoic acid = 0.5 mol

Mass of benzoic acid = 0.5 × 122 g

= 61 g

23. How many of the following cation shows characteristic coloured ppt. with $K_4[Fe(CN)_6]$?

Cu^{2+}, Ca^{2+}, Ba^{2+}, Fe^{3+}, Zn^{2+}, Mg^{2+}, Mn^{2+}

Answer (3)

Sol. $Fe^{3+} + K_4[Fe(CN)_6] \rightarrow \underset{\text{(Prussian blue)}}{Fe_4[Fe(CN)_6]_3}$

$Cu^{2+} + K_4[Fe(CN)_6] \rightarrow \underset{\text{(Chocolate brown ppt.)}}{Cu_2[Fe(CN)_6]}$

$Zn^{2+} + K_4[Fe(CN)_6] \rightarrow \underset{\text{(White ppt.)}}{Zn_2[Fe(CN)_6]}$

$Mg^{2+} + K_4[Fe(CN)_6] \rightarrow$ No visible colour change

$Ca^{2+} + K_4[Fe(CN)_6] \rightarrow \underset{\text{(White ppt.)}}{Ca_2[Fe(CN)_6]}$

$Mn^{2+} + K_4[Fe(CN)_6] \rightarrow \underset{\text{(Pale pink coloured ppt.)}}{Mn_2[Fe(CN)_6]}$

$Ba^{2+} + K_4[Fe(CN)_6] \rightarrow$ No visible colour change

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 the 5th, 6th and 7th term of the binomial expansion of $(1 + x^2)^{n+4}$ are in A.P. Then the greatest binomial coefficient in the expansion of $(1 + x^2)^{n+4}$ is

(1) 10 (2) 35

(3) 25 (4) 14

Answer (2)

Sol. Binomial coefficient of $T_{r+1} = {}^{n+4}C_r$

${}^{n+4}C_4, {}^{n+4}C_5, {}^{n+4}C_6$ in A.P.

$\Rightarrow \frac{(n+4)!}{4!\,n!} + \frac{(n+4)!}{6!(n-2)!} = 2\frac{(n+4)!}{(n-1)!\,5!}$

$\Rightarrow$ Solving $n = 3$

$\Rightarrow$ Greatest binomial coefficient in the expansion of $(1 + x^2)^{n+4} = (1 + x^2)^7$

$\Rightarrow {}^7C_3 = {}^7C_4 \Rightarrow \frac{7!}{3!\,4!} = \frac{7\times6\times5}{6} = 35$

2. If A is 3 × 3 matrix such that det(A) = 2. Then $\det\left(adj\left(adj\left(adj\left(adjA\right)\right)\right)\right)$ is

(1) 2^{32} (2) 2^{16}

(3) 2^8 (4) 2^{12}

Answer (2)

Sol. $\det\underbrace{\left(adj\left(adj\left(adj\left(adjA\right)\right)\right)\right)}_{r \text{ times}} = |A|^{(n-1)^r}$

As $|A| = 2$

$\therefore \det\left(adj\left(adj\left(adj\left(adjA\right)\right)\right)\right) = |A|^{(3-1)^4}$

$= |A|^{2^4} = |A|^{16}$

$= 2^{16}$

3. Evaluate

$\lim\limits_{x\to0} \operatorname{cosec} x.\left(\sqrt{2\cos^2 x + 3\cos x} - \sqrt{\cos^2 x + \sin x + 4}\right)$

(1) 0 (2) 1

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

Answer (4)

Sol. $\lim\limits_{x\to0} \frac{\left(\sqrt{2\cos^2 x + 3\cos x} - \sqrt{\cos^2 x + \sin x + 4}\right)\left(\sqrt{2\cos^2 x + 3\cos x} + \sqrt{\cos^2 x + \sin x + 4}\right)}{(\sin x)\left(\sqrt{2\cos^2 x + 3\cos x} + \sqrt{\cos^2 x + \sin x + 4}\right)}$

$\frac{1}{2\sqrt{5}} \lim\limits_{x\to0} \frac{2\cos^2 x + 3\cos x - \cos^2 x - \sin x - 4}{\sin x}$

$\frac{1}{2\sqrt{5}} \lim\limits_{x\to0} \left[\frac{\cos^2 x + 3\cos x - \sin x - 4}{\sin x}\right]$

Apply L' Hopital

$\frac{1}{2\sqrt{5}} \lim\limits_{x\to0} \left[\frac{-2\cos x \sin x - 3\sin x - \cos x}{\cos x}\right]$

$= -\frac{1}{2\sqrt{5}}$

4. If $\vec{a} = \hat{i} + 2\hat{j} + 3\hat{k}$, $\vec{b} = 3\hat{i} + \hat{j} - \hat{k}$ and $\vec{c}$ is coplanar with $\vec{a}$ and $\vec{b}$. Also $\vec{a}\cdot\vec{c} = 5$ and $\vec{c}$ is perpendicular to $\vec{b}$. Then $|\vec{c}|$ is

(1) 18 (2) 16

(3) $\frac{\sqrt{5}}{14}$ (4) $\sqrt{\frac{11}{6}}$

Answer (4)

Sol. $\vec{a} = \hat{i} + 2\hat{j} + 3\hat{k}$

$\vec{b} = 3\hat{i} + \hat{j} - \hat{k}$

$\vec{c}$ coplanar with $\vec{a}$ and $\vec{b}$ (Let $\vec{c} = a_1\hat{i} + a_2\hat{j} + a_3\hat{k}$)

$\Rightarrow \left(\vec{a}\times\vec{b}\right)\cdot\vec{c}=0$

$\left(-5\hat{i}+10\hat{j}-5\hat{k}\right)\cdot\left(a_1\hat{i}+a_2\hat{j}+a_3\hat{k}\right)=0$

$\Rightarrow -5a_1+10a_2-5a_3=0$

$\Rightarrow \boxed{a_1+a_3=2a_2}$ ...(i)

$\vec{c}\cdot\vec{b}=0$ and $\vec{a}\cdot\vec{c}=5$

$\boxed{3a_1+a_2-a_3=0}$ ...(ii)

$(a_1+2a_2+3a_3)=5$ ...(ii)

Solving (i), (ii) and (iii)

$a_1=\frac{1}{6},\ a_2=\frac{2}{3},\ a_3=\frac{7}{6}$

$\Rightarrow \vec{c}=\frac{1}{6}\hat{i}+\frac{2}{3}\hat{j}+\frac{7}{6}\hat{k}$

$\Rightarrow \left|\vec{c}\right|=\sqrt{\frac{11}{6}}$

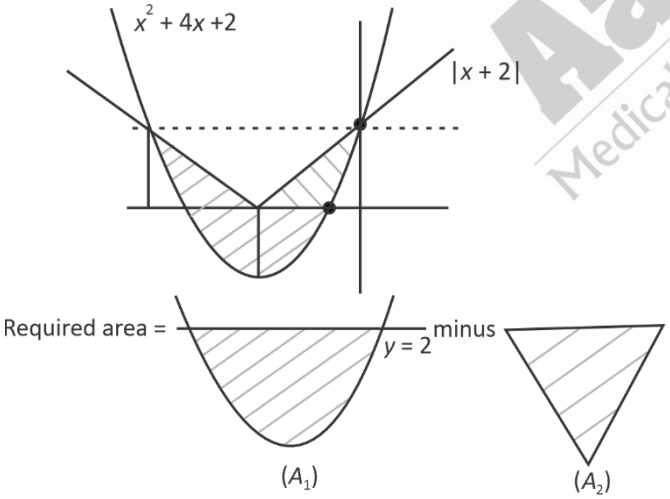
5. The area of the region bounded by $S(x, y)$ such that $S=\{(x, y): x^2+4x+2\le y\le |x+2|\}$ is (in sq. units)

(1) $\frac{24}{5}$ (2) 5

(3) $\frac{20}{3}$ (4) 7

Answer (3)

Sol. $x^2+4x+2\le y\le |x+2|$



$A_1=\int_{-4}^{0}[2-(x^2+4x+2)]dx-\frac{1}{2}\times 4\times 2$

$=\left(\frac{-x^3}{3}-2x^2\right)\Big|_{-4}^{0}-4$

$=0-\left(\frac{64}{3}-32\right)-4$

$=32-\frac{64}{3}-4=\frac{20}{3}$

6. If $\frac{dy}{dx}+\left(\frac{x}{1+x^2}\right)y=\frac{\sqrt{x}}{\sqrt{1+x^2}}$; $y(0)=0$, then $y(1)$ is

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

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

Answer (3)

Sol. $\frac{dy}{dx}-\left(\frac{x}{1+x^2}\right)y=\frac{\sqrt{x}}{\sqrt{1+x^2}}$

If $= e^{\int\frac{-x}{1+x^2}dx}=e^{\frac{1}{2}\ln(1+x^2)}=\sqrt{1+x^2}$

Solution will be $y\sqrt{1+x^2}=\int\frac{\sqrt{x}}{\sqrt{1+x^2}}\cdot\sqrt{1+x^2}dx$

$y\sqrt{1+x^2}=\frac{2x^{3/2}}{3}+c$

$y(0)=0\Rightarrow c=0$

$y=\frac{2}{3}\frac{x^{3/2}}{\sqrt{1+x^2}}$

Now $y(1)=\frac{\sqrt{2}}{3}$

7. If α and β are real numbers such that $\sec^2(\tan^{-1}(\alpha))+\text{cosec}^2(\cot^{-1}(\beta))=36$ and $\alpha+\beta=8$, then $(\alpha^2+\beta)$ is $(\alpha<\beta)$

(1) 23 (2) 14

(3) 24 (4) 27

Answer (2)

Sol. Let $\tan^{-1}\alpha = A \Rightarrow \tan A = \alpha$

$\cot^{-1}\beta = B \Rightarrow \cot B = \beta$

$\sec^2 A + \operatorname{cosec}^2 B = 36$

$(1 + \tan^2 A) + (1 + \cot^2 B) = 36$

$\Rightarrow 1 + \alpha^2 + 1 + \beta^2 = 36$

$\Rightarrow \alpha^2 + \beta^2 = 34$

$\alpha + \beta = 8$

$(\alpha + \beta)^2 = 34 + 2\alpha\beta = 64$

$\Rightarrow \alpha\beta = 15$

$\Rightarrow \alpha, \beta$ are roots of equation

$x^2 - 8x + 15 = 0$

$(x - 3)(x - 5) = 0$

$\Rightarrow x = 3, 5$

$\Rightarrow \alpha = 3, \beta = 5$

$\Rightarrow \alpha^2 + \beta = 14$

8. Two persons A and B throws a pair of dice alternatively. For A to win he should throw sum of 5 before B throws sum of 8. If A throws first, then the probability that A wins, is

(1) $\frac{8}{19}$ (2) $\frac{9}{19}$

(3) $\frac{8}{17}$ (4) $\frac{9}{17}$

Answer (2)

Sol. For sum 5, (1, 4), (2, 3) (3, 2), (4, 1) $\Rightarrow P(A) = \frac{4}{36}$

For sum 8, (2, 6), (3, 5) (4, 4), (5, 3), (6, 2) $\Rightarrow P(B) = \frac{5}{36}$

$\Rightarrow P(\overline{A}) = \frac{32}{36}, P(\overline{B}) = \frac{31}{36}$

P(A wins) =

$$P(A) + P(\overline{A})P(\overline{B})P(A) + P(\overline{A})P(\overline{B})P(\overline{A})P(\overline{B})P(A) + \ldots$$

$$= \frac{P(A)}{1 - P(\overline{A})P(\overline{B})} = \frac{\frac{4}{36}}{1 - \frac{32}{36}\cdot\frac{31}{36}} = \frac{9}{19}$$

9. For a distribution of 10 observations, $\sum_{i=1}^{10} x_i = 55$ and $\sum_{i=1}^{10} x_i^2 = 328$. If the observations 4 and 5 are replaced by 6 and 8 respectively, then the new variance is

(1) 2.5 (2) 2.7

(3) 3.4 (4) 3.6

Answer (2)

Sol. $x_1 + x_2 \ldots + x_8 + 4 + 5 = 55,$

$x_1^2 + x_2^2 \ldots + x_8^2 + 16 + 25 = 328$

$\mu = \frac{x_1 + x_2 \ldots + x_8 + 6 + 8}{10} = 6,$

$x_1^2 + x_2^2 + \ldots + x_8^2 + 36 + 64 = 387$

$\Rightarrow \sigma^2 = \frac{387}{10} - 36 = \frac{387 - 360}{10} = \frac{27}{10} = 2.7$

10. If S be the set of 10 distinct primes and let A be the set of products of two or more elements from the set S. If $P = \{(x, y) : x \in S$ and $y \in A$ and y is divided by $x\}$. Then $n(P)$ is equal to

(1) 5110 (2) 5000

(3) 5220 (4) 5420

Answer (1)

Sol. $S = \{P_1, P_2, P_3 \ldots, P_{10}\}$

A = {product of distinct elements of S}

If $P = \{(x, y) : x \in S, y \in A$ and y is divided by $x\}$ then $n(P)$ is

$\Rightarrow$ since $x \in S$.

Let $x = P_i \in S$., selected from S in $\left(10_{C_1}\right)$ ways.

Now, $x | y$ iff y contains P_i in product.

$\Rightarrow$ (P_i) is there and at rest one other element as a product

$\Rightarrow \left(10_{C_1}\right)\cdot\left[(1)\cdot(2^9 - 1)\right] = 10\cdot(511) = 5110$

11. If $I(m,n)=\int_0^1 x^{m-1}(1-x)^{n-1}dx$, $m, n>0$, then $I(9, 14) + I(10, 13)$ is equal to

(1) $I(1, 13)$

(2) $I(9, 1)$

(3) $I(9, 13)$

(4) $I(19, 29)$

Answer (3)

Sol. Beta function

$$\boxed{\beta(p,q)=\int_0^1 x^{p-1}(1-x)^{q-1}dx=\frac{(p-1)!(q-1)!}{(p+q-1)!}\ p,q\in I}$$

$$\Rightarrow\quad I(9,14)=\frac{8!\ 13!}{22!}$$

$$I(10,\ 13)=\frac{9!\cdot 12!}{22!}$$

$$\Rightarrow\quad I(9,\ 14)+I(10,\ 13)=\frac{1}{22!}(8!\ 13!+9!\cdot 12!)$$

$$\Rightarrow\quad =\frac{1}{22!}8!\cdot 12!(13+9)=\frac{8!\ 12!}{21!}$$

$$=\frac{(9-1)!(13-1)!}{(9+13-1)!}=I(9,\ 13)$$

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. The number of 3 digit numbers which is divisible by 2 and 3 but not divisible by 4 and 9?

Answer (125)

Sol. Total number divisible by 6

102, 108, ... 996

So total number = 150

Number divisible by 36

108, ..., 972

Total number = 25

Required number = (divisible by 6) – (divisible by 36)

= 150 – 25 = 125

22. The product of all real roots of equation $(x^2 - 9x + 11)^2 - (x - 4)(x - 5) = 2$ is

Answer (99)

Sol. $(x^2 - 9x + 11)^2 - (x - 4)(x - 5) = 2$

$(x^2 - 9x + 11)^2 - (x^2 - 9x + 20) = 2$

Let $x^2 - 9x + 11 = t$

$t^2 - (t + 9) = 2$

$t^2 - t - 11 = 0$

$$t=\frac{1\pm\sqrt{1+44}}{2}=\frac{1\pm\sqrt{45}}{2}$$

$$x^2-9x+11=\frac{1+\sqrt{45}}{2}$$

$$x^2-9x=\frac{\sqrt{45}-21}{2}$$

$$D_1: 81-4\left(\frac{\sqrt{45}-21}{2}\right)>0$$

Similarly,

$$x^2-9x+11=\left(\frac{1-\sqrt{45}}{2}\right)$$

$$\Rightarrow\quad D_2: 81-4\left(\frac{-21-\sqrt{45}}{2}\right)>0$$

$\Rightarrow$ All roots are real

$\Rightarrow$ Product of roots $= \left(\frac{\text{Constant term}}{1}\right)$

$= \left(\frac{121-(20)-2}{1}\right) = \frac{121-22}{1} = \boxed{99}$

23. If $S_n = \frac{1}{2}+\frac{1}{6}+\frac{1}{12}+...n$ terms. The sum of first six terms in A.P. with first term equal to $-p$ and common difference p is $\sqrt{2026.S_{2025}}$. The absolute value of difference between 20^{th} and 15^{th} terms in A.P. is

Answer (25)

Sol. $S_n = \frac{1}{1.2}+\frac{1}{2.3}+\frac{1}{3.4}+...\frac{1}{n(n+1)}$

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

$= 1-\frac{1}{n+1} = \frac{n}{n+1} \Rightarrow S_{2025} = \frac{2025}{2026}$

For A.P. $\frac{6}{2}(-2p+(6-1)p) = \sqrt{2026\times\frac{2025}{2026}} = 45$

$\Rightarrow \quad 3p = \frac{45}{3} \Rightarrow p = 5$

Now for A.P. $|a_{20}-a_{15}| = |19\times5-14\times5| = 25$

24. If f(x) satisfies the functional equation $f(x)+6f\left(\frac{1}{x}\right) = \frac{35}{3x}-\frac{7}{2}$, $x \in R-\{0\}$ and if $\lim\limits_{x\to0}\left(\frac{1}{\alpha x}+f(x)\right)$ exist finitely and is equal to β, then $(\alpha - 2\beta)$ is

Answer (2)

Sol. $f(x)+6f\left(\frac{1}{x}\right) = \frac{35}{3x}-\frac{7}{2}$

$f\left(\frac{1}{x}\right)+6f(x) = \frac{35x}{3}-\frac{7}{2}$

$36f(x)+6f\left(\frac{1}{x}\right) = 70x-21$

$35f(x) = (70x-21)-\left[\frac{35}{3x}-\frac{7}{2}\right]$

$35f(x) = 70x-\frac{35}{3x}-\frac{35}{2}$

$\Rightarrow \quad f(x) = 2x-\frac{1}{3x}-\frac{1}{2}$

$\lim\limits_{x\to0}\left(\frac{1}{\alpha x}+2x-\frac{1}{3x}-\frac{1}{2}\right) = \beta$

Limit exist finitely iff

$\alpha = 3 \Rightarrow \beta = -\frac{1}{2}$

$(\alpha-2\beta) = 3-2\left(-\frac{1}{2}\right) = 4$

25.

❑ ❑ ❑