28/07/2022
Evening

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Memory Based
Answers & Solutions

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

JEE (Main)-2022 (Online) Phase-2

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

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

(2) The Test Booklet consists of 90 questions. The maximum marks are 300.

(3) There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.

(i) **Section-A:** This section 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.

(ii) **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10.** The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

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. Time period of simple pendulum on earth surface is 4 sec and above earth surface at h height is 6 sec find the value of h. If (R = 6400 km)

(1) 3200 km (2) 1200 km

(3) 16000 km (4) 6400 km

Answer (1)

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

$\Rightarrow T \propto \dfrac{l}{\sqrt{g}}$

or $\dfrac{T_1}{T_2} = \sqrt{\dfrac{g_2}{g_1}}$

$\dfrac{4}{6} = \dfrac{R_e}{R_e + h}$

$\Rightarrow h = \dfrac{R_e}{2} = 3200$ km

2. A bullet of mass 200 gm with initial kinetic energy equal to 90 J hits a block and after moving for 1 second its kinetic energy reduces to 40 J. After how long further the bullet will stop. Assume constant retardation.

(1) 2 s (2) 4 s

(3) 9 s (4) 12 s

Answer (1)

Sol. $\dfrac{1}{2}mv_0^2 = 90$

$\Rightarrow v_0 = 30$ m/sec

Let the retardation is a then after 1 sec

$\dfrac{1}{2}m(30 - a)^2 = 40$

$30 - a = 20$

$a = 10$ m/sec^2

So it will move further for time t then t = 2 sec

3. The energy of a photon is 5 times the work function and in second case the energy of photon is 10 times the work function. The ratio of maximum speed in first case to second case for the electron with maximum kinetic energy is

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

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

Answer (1)

Sol. $KE_1 = h\gamma_1 - \phi = 4\phi$

And $KE_2 = h\gamma_2 - \phi = 9\phi$

$\dfrac{KE_1}{KE_2} = \dfrac{4}{9}$

So $\left(\dfrac{v_1}{v_2}\right)^2 = \dfrac{4}{9}$

$\Rightarrow \dfrac{v_1}{V_2} = \dfrac{2}{3}$

4. The efficiency of a Carnot engine is $\eta = \dfrac{\alpha\beta}{\sin\theta}\log\left(\dfrac{\beta\alpha}{kT}\right)$, ($x$ is length T is temperature and k is Boltzmann constant) Then

(1) β has dimension of force

(2) $\dfrac{x}{\alpha}$ has dimension of power

(3) α and β have same dimension

(4) $\dfrac{\beta}{\eta}$ is dimensionless

Answer (1)

Sol. $[\beta x] = [kT]$

So $[\beta] = \dfrac{[kT]}{[x]}$

$= [MLT^{-2}]$

$[\alpha]\,[\beta] = [M^0L^0T^0]$

So $[\beta] = \dfrac{1}{[\alpha]}$

So $\dfrac{[x]}{[\alpha]} = [\beta] \times [x]$

$= [ML^2T^{-2}]$

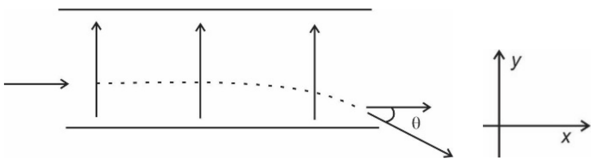
5. An electron moving along x-axis with speed of 2 m/s enters an electric field $\vec{E}=\frac{8m}{e}\hat{j}$, crosses a region of width 1 m (m is mass of electron while e is charge on electron). The angle of deviation of electron in the region is

(1) $\tan^{-1}(\sqrt{2})$ (2) $\tan^{-1}(2)$

(3) $\tan^{-1}(3)$ (4) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

Answer (2)

Sol. $\vec{E}=\frac{8m}{e}\hat{j}$



π is the angle of deviation.

time taken to cross the region of 1 m is

$t=\frac{1}{2}\text{sec}$

velocity attained along y-axis is $\frac{1}{2}$ sec is

$v=\frac{qE}{m}t=e\frac{8m}{em}\times\frac{1}{2}$ = 4 m/sec

so angle of deviation

$\tan\pi=\frac{4}{2}=2$

or tanπ = tan^{-1}(2)

6. Magnetic field at centre of a loop carrying current is B_1 while at a distance of $\sqrt{3}R$ (R is radius of loop) on axis from the on axis from the centre magnetic field is B_2. Then $B_1 : B_2$ is equal to

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

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

Answer (2)

Sol. $B_1=\frac{\mu_0 i}{2R}$

and $B_2=\frac{\mu_0 iR^2}{2(R^2+3R^2)^{\frac{3}{2}}}=\frac{\mu_0 i}{16R}$

So $\frac{B_1}{B_2}=\frac{16}{2}=\frac{8}{1}$

7. The area of cross section of wire is 0.4 mm^2 and its length is equal to 0.5 m. A mass of 2 kg suspended at the end is revolved around in vertical circle. The speed at lowest point is 5 m/s. Change in length at lowest point is (y = 2 × 1011 N/m^2)

(1) 0.3250 mm (2) 1.5 mm

(3) 0.75 mm (4) 0.50 mm

Answer (3)

Sol. Tension in the wire at lowest point is

$T-mg=\frac{mv^2}{l}$

$T=20+\frac{2\times5^2}{0.5}$

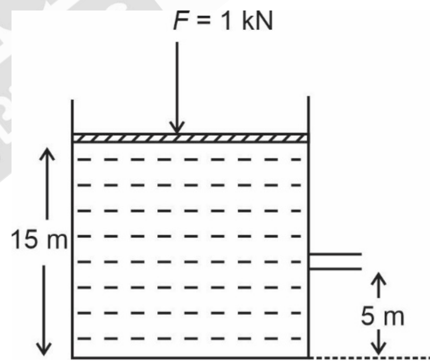
= 120 N

So $\Delta l=\frac{Fl}{YA}=\frac{120\times0.5}{2\times10^{11}\times0.4\times10^{-6}}$

Δl = 7.5 × 10^{-4} m

Or 0.75 mm

8. Find the speed of water coming out of the orifice shown 5 m above the bottom of container with water filled upto a height of 15 m. The piston on top of water level is being pressed downwards with a force of 1000 N. (Area of piston = 100 cm^2)



(1) 10 m/sec (2) $\sqrt{200}$ m/sec

(3) 20 m/sec (4) 30 m/sec

Answer (3)

Sol. Using Bernoullis equation

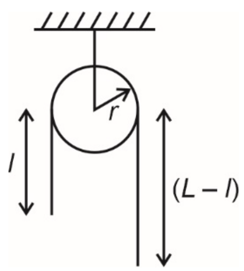
$P_0+\frac{F}{A}+\rho gh=P_0+\frac{1}{2}\rho v^2$

$\Rightarrow\quad v=\sqrt{2\left[\frac{E}{A\rho}+gh\right]}$

$v=\sqrt{2\left[\frac{1000}{10^{-2}\times10^3}+10\times10\right]}$

= 20 m/sec

9. A uniform chain of length passes over a small pulley ($L >> r$). If with length $l = \frac{L}{x}$, acceleration of system is $\frac{g}{2}$ then value of x is

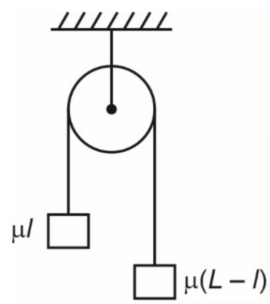


(1) 1 (2) 3

(3) 2 (4) 4

Answer (4)

Sol. The system can be compared to an Atwood machine as shown



$$\frac{\mu(L-l)-\mu l}{\mu(L-l)+\mu l}g = \frac{g}{2}$$

So, $l = \frac{L}{4}$

10. Water is ejecting from a pipe of cross-sectional area 10 cm^2 at a speed of 20 m/s and strikes a vertical wall. The water molecules falls down without any bounce-back. The force exerted on wall is equal to

(1) 200 N (2) 100 N

(3) 400 N (4) 500 N

Answer (3)

Sol. $F = \frac{p_f - p_i}{\Delta t}$

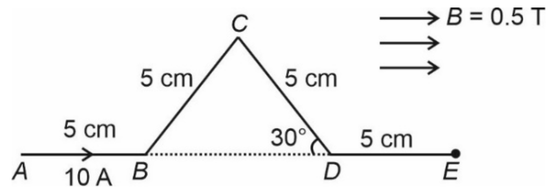
$p_i = (\rho A v \Delta t)v = \rho A v^2 \Delta t$

And $p_f = 0$

So $|F| = \rho A v^2$

$= 10^3 \times 10 \times 10^{-4} \times 20^2$

$= 400$ N

11. 

A wire segment $ABCDE$ carrying current of 10 A is placed in a uniform magnetic field B as shown. The force experienced by segment CD is equal to

(1) 0.216 N (2) 0.245 N

(3) 0.125 N (4) 0.148 N

Answer (3)

Sol. Force on segment CD is

$F = iBl\sin\theta$

$= 10 \times 0.5 \times 5 \times 10^{-2} \times \sin 30°$

$= 0.125$ N

12. 14 gm of nitrogen at initial temperature 27°C is having RMS velocity v. If at a new temperature after heating the velocity becomes $4v$ then value of internal energy gained is equal to

(1) 13104 J (2) 22261 J

(3) 37470 J (4) 46766 J

Answer (4)

Sol. $v = \sqrt{\frac{3RT}{M_0}}$

The rms velocity becomes 4 times at

Temperature T then

$v' = 4v = \sqrt{\frac{3RT}{M_0}}$

So, $T = 16 \times 300 = 4800$ K

Thus $\Delta U = nC_V\Delta T$

$= \frac{14}{28} \times \frac{5}{2} R \times 4500$

$= 46766.25$ J

13. The refractive index of a biconvex lens is $\frac{3}{2}$ and power is 1.25. The radius of curvature of surfaces are 20 cm and 40 cm. The refractive index of surrounding material is

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

(3) $\frac{9}{7}$ (4) $\frac{5}{3}$

Answer (3)

Sol. Form lens maker formula

$$\frac{1}{f}=\left(\frac{\mu}{\mu_s}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1.25}{100}=\left(\frac{3}{2\mu_s}-1\right)\left(\frac{1}{20}-\frac{1}{40}\right)$$

$$\frac{1}{80}=\left(\frac{3}{2\mu_s}-1\right)\frac{3}{40}$$

$$\frac{3}{2\mu_s}=1+\frac{1}{6}=\frac{7}{6}$$

so $\mu_s=\frac{9}{7}$

14. A particle located at point (0, 0, 7) has it x-coordinate and y-coordinate varying with time as $x = 3t$, $y = 5t^3$. Acceleration of particle at $t = 1$ second is. (All unit in SI)

(1) $-30\hat{j}$ (2) $30\hat{j}$

(3) $30\hat{i}+5\hat{j}+7\hat{k}$ (4) $30\hat{i}$

Answer (2)

Sol. $\frac{dx}{dt}=3$ $\frac{dy}{dt}=15t^2$

$\frac{d^2x}{dt^2}=0$ $\frac{d^2y}{dt^2}=30t$

So, $\vec{a}\Big|_{t=1}=\frac{d^2x}{dt^2}\hat{i}+\frac{d^2y}{dt^2}\hat{j}=30\hat{j}$

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. A particle is thrown vertically upwards form top of building with speed 19.6 m/s particle reaches ground after 6 sec. Max height attained by particle from ground (g = 9.8 m/s^2) is $\frac{k}{5}$ m. Find k.

Answer (392)

Sol. The particle reaches at top most point after 2 s

$\Rightarrow$ Height of top most point = $\frac{1}{2}\times 9.8\times(4)^2$

$= 8\times 9.8$ m

$=\frac{392}{5}$ m

$\Rightarrow$ $k = 392$

22. Potential energy of a particle (m = 1 kg) is $U=4(1-\cos 4x)$. The time period of small oscillations of the particle about point of stable equilibrium is $\frac{\pi}{k}$. The value of k is

Answer (4)

Sol. $U=4(1-\cos 4x)$

$\Rightarrow$ $F=-16\sin 4x$

$\Rightarrow$ For x to be too small

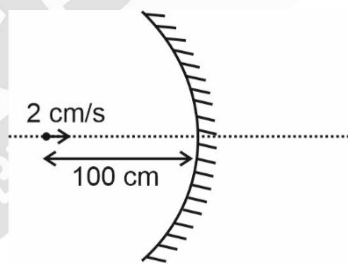
$F = -64x$ as $\sin 4x \cong 4x$

or $T=2\pi\sqrt{\frac{m}{64}}$

$T=\frac{\pi}{4}$

$k = 4$

23.



An object moves towards a concave mirror of focal length 20 cm as shown at an instance. The position of image after 20 seconds from the given instance is equal to _____ cm away from mirror.

Answer (30)

Sol. After 20 sec particle is at a distance of 60 cm from mirror. Using mirror formula

$$\frac{1}{v}+\frac{1}{-60}=-\frac{1}{20}$$

v = – 30cm

24.

25.

26.

27.

28.

29.

30.

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. 0.2 M, 2L H_2SO_4 and 0.1 M, 2L NaOH, find molarity of Na_2SO_4.

   (1) 0.05 M

   (2) 0.03 M

   (3) 0.04 M

   (4) 0.025 M

Answer (4)

Sol.

	H_2SO_4	+ 2NaOH	→ Na_2SO_4	+ $2H_2O$
Initial moles	0.4	0.2	–	–
Final moles	0.3	–	0.1	

Molarity of Na_2SO_4 = $\frac{0.1}{4}$ = 0.025 M

2. Correct order of metallic character

   (1) Na > Mg > Be > Si > P

   (2) Be > Na > Mg > Si > P

   (3) Na < Mg < Si < Be < P

   (4) P > Mg > Na > Si > Na

Answer (1)

Sol. Metallic character is inversely proportional to electronegativity. As we move from left to right along a period. Electronegativity increases and hence metallic character decreases. As we move from top to bottom in a group, electronegativity generally decreases and hence metallic character increases. The correct decreasing order of metallic character is

Na > Mg > Be > Si > P

3. Match the compounds/species given in Column-I with hybridisation of central metal in Column-II.

	Column-I		Column-II
a.	$[Ni(CO)_4]$	(i)	sp^3
b.	$[Ni(CN)_4]^{2-}$	(ii)	dsp^2
c.	$[CoF_6]^{3-}$	(iii)	sp^3d^2
d.	$[Co(CN)_6]^{3-}$	(iv)	d^2sp^3

   (1) a(i), b(ii), c(iii), d(iv)

   (2) a(ii), b(i), c(iii), d(iv)

   (3) a(iii), b(i), c(ii), d(iv)

   (4) a(i), b(iv), c(iii), d(ii)

Answer (1)

Sol. The correct match is

	Column-I (Complex species)		Column-II (Hybridisation of central metal)
a.	$[Ni(CO)_4]$	(i)	sp^3
b.	$[Ni(CN)_4]^{2-}$	(ii)	dsp^2
c.	$[CoF_6]^{3-}$	(iii)	sp^3d^2
d.	$[Co(CN)_6]^{3-}$	(iv)	d^2sp^3

4. Match Column-I with Column-II.

	Column-I		Column-II
A.	Natural rubber	(1)	Thermosetting
B.	$\left[CH_2-\underset{\displaystyle |}{\overset{\displaystyle Cl}{CH}}\right]_n$	(2)	Fibre
C.	Nylon 6,6	(3)	Elastomer
D.	Bakelite	(4)	Thermoplastic

   (1) A(1), B(2), C(3), D(4)

   (2) A(3), B(4), C(2), D(1)

   (3) A(2), B(1), C(3), D(4)

   (4) A(4), B(2), C(1), D(3)

Answer (2)

Sol. Natural rubber is elastomer.

Bakelite is thermosetting.

Nylon-66 is fibre.

PVC – Polyvinylchloride is thermoplastic

5. The temp at which the rms speed of gas molecules becomes double its value at 0°C

   (1) 819°C (2) 760°C

   (3) 273°C (4) 224°C

Answer (1)

Sol. $2\left(V_{rms}(0°C)\right) = (V_{rms}(T°C))$

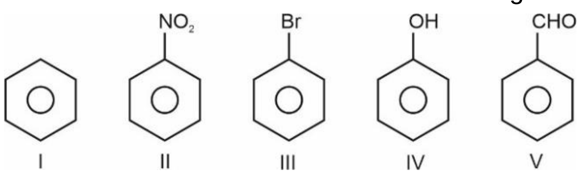
$$2\sqrt{\frac{3R(273)}{M}} = \sqrt{\frac{3RT}{M}}$$

$4 \times 273 = T$

$T = 1092$ K

$= 819°C$

6. The correct order of nitration in the following



(1) II < V < I < III < IV

(2) II < V < III < I < IV

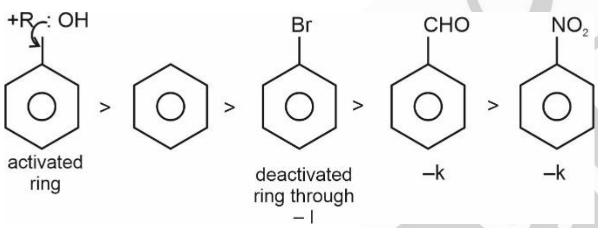
(3) V < II < IV < I < III

(4) IV < III < II < I < V

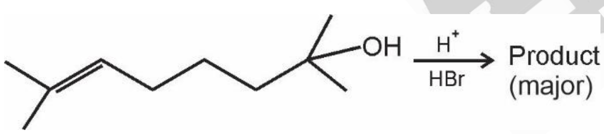
Answer (2)

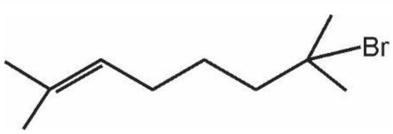
Sol. Rate of nitration is directly proportional to the electron density on the benzene ring

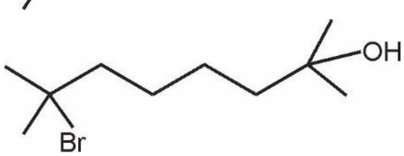
$\therefore$ correct order is

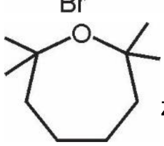


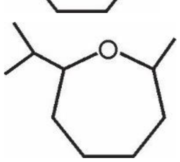
–R effect of $–NO_2$ > – CHO

7. 

(1) 

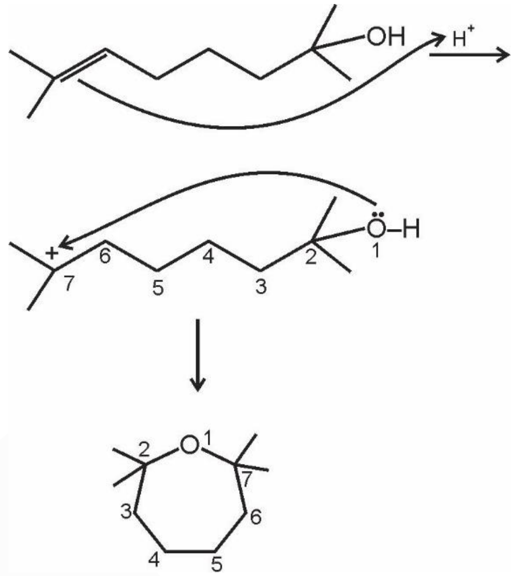
(2) 

(3)  z

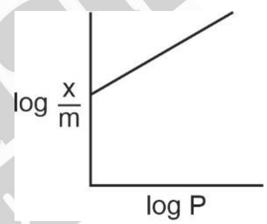
(4) 

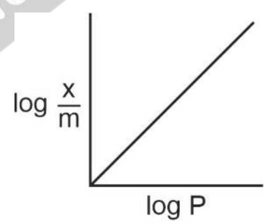
Answer (3)

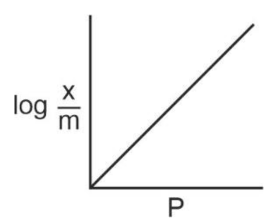
Sol.

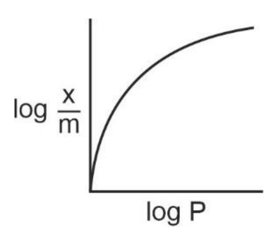


8. Which of the following is correct as per Freundlich adsorption isotherm?

(1) 

(2) 

(3) 

(4) 

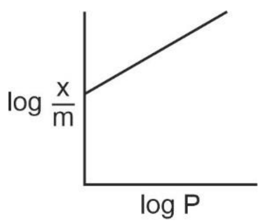
Answer (1)

Sol. According to Freundlich adsorption isotherm, the extent of adsorption (x/m) at a given temperature is related to pressure (P) of the gas as

$$\frac{x}{m} = K(P)^{1/n}$$

$$\log\frac{x}{m} = \log K + \frac{1}{n}\log P$$

The correct plot of $\log\frac{x}{m}$ versus logP is



9. I_2 reacts with concentrated HNO_3 as per the following reaction:

I_2 + Conc. $HNO_3 \rightarrow$ Products of the reaction are:

(1) HIO_4, NO_2, H_2O

(2) HIO_3, N_2O, H_2O

(3) HIO_3, NO_2, H_2O

(4) HIO_4, N_2O, H_2O

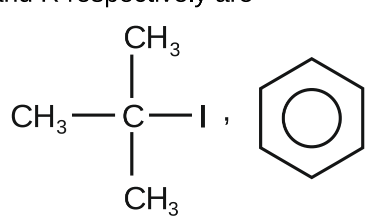
Answer (3)

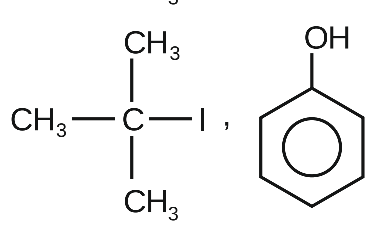
Sol. I_2 + conc. $10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$

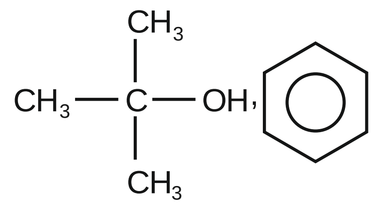
10. $PhO—C(CH_3)_3 \xrightarrow{HI}$ P + Q

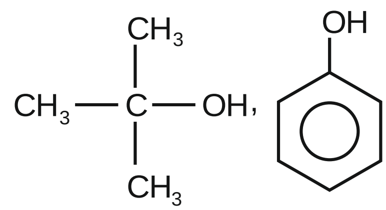
P (aromatic) $\xrightarrow{Zn,\ \Delta}$ R

Q and R respectively are

(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. $PhO—C(CH_3)_3 \xrightarrow{HI}$ Ph – OH + $(CH_3)_3C – I$

(P) (Q)

$\downarrow$ Zn/Δ

 + ZnO

(R)

11. Which of the following salts are formed in Clark's method used for removal of temporary hardness.

(1) $Ca(OH)_2$, $Mg(OH)_2$ (2) $Ca(OH)_2$, $MgCO_3$

(3) $CaCO_3$, $Mg(OH)_2$ (4) $CaCO_3$, $MgCO_3$

Answer (3)

Sol. Clark's method is used for removal of temporary hardness.

In this method a calculated amount of lime is added to hard water precipitating out calcium carbonate and magnesium hydroxide as depicted in reaction below.

$$Mg(HCO_3)_2 + 2Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + Mg(OH)_2\downarrow + 2H_2O$$

12. **Statement I :** During nitration of aniline all products (ortho, meta and para) are formed.

Statement II : The solution mixture is highly acidic in nature.

(1) Both statement I and II are correct

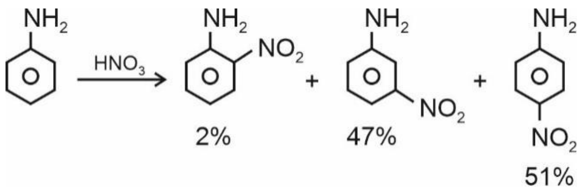
(2) Statement I is correct and statement II is incorrect

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

(4) Both statement I and II are incorrect

Answer (1)

Sol.



Due to the presence of HNO_3, the solution is also highly acidic in nature.

13. Consider the following statements :

Statement-I : Reduction of metal oxide in liquid state is more easier as compared to the reduction in solid state.

Statement-II : In liquid state, we get more negative value of ΔG, due to increase in entropy in liquid state.

(1) Both statement-I and statement-II are correct

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

(3) Both statement-I and statement-II are incorrect

(4) Statement-I is incorrect and statement-II is correct

Answer (1)

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

When metal is obtained in liquid state, then ΔS increases resulting in more negative value of ΔG. Hence, the reduction process becomes easier.

Both statement-I and statement-II are correct.

14. $\underset{\text{(White phosphorus)}}{P_4} + \underset{\text{(Thionyl chloride)}}{SOCl_2} \longrightarrow$ Products are

(1) PCl_3, SO_2, S_2Cl_2

(2) PCl_5, SO_3, S_2Cl_2

(3) PCl_5, SO_2 Cl_2

(4) PCl_3, SO_2, Cl_2

Answer (1)

Sol. The reaction is

$$\underset{\text{(White phosphorus)}}{P_4} + \underset{\text{(Thionyl chloride)}}{8SOCl_2} \rightarrow 4PCl_3 + 4SO_2 + 2S_2Cl_2$$

15. **Statement I :** Thin layer chromatography is a type of adsorption chromatography.

Statement II : In thin layer chromatography, a thin layer of an adsorbent such as silica gel is spread over a glass plate of suitable size.

(1) Both Statement (I) & (II) are correct

(2) Both Statement (I) & II are incorrect

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

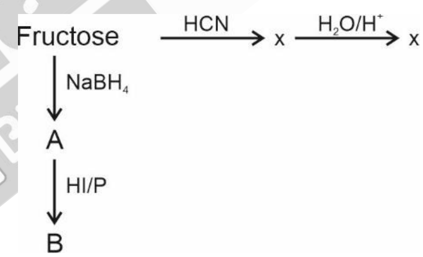
(4) Statement (I) is incorrect and statement (II) is correct

Answer (1)

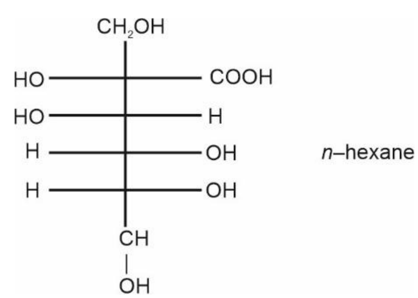
Sol. Thin layer chromatography is a type of adsorption chromatography which involves separation of substance over a thin layer of an adsorbent coated on glass plate.

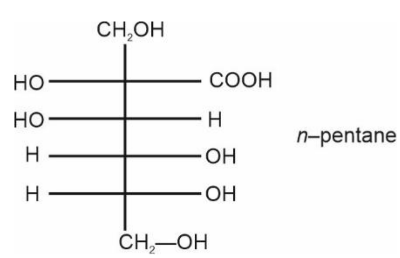
Silica gel or alumina could be used as adsorbents.

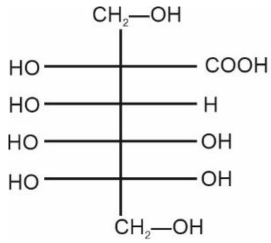
Hence, both statement (I) and (II) are correct.

16. 

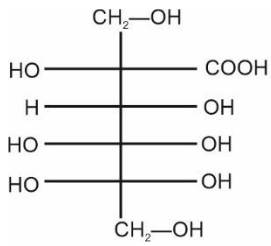
y and B respectively are

(1) 

(2) 

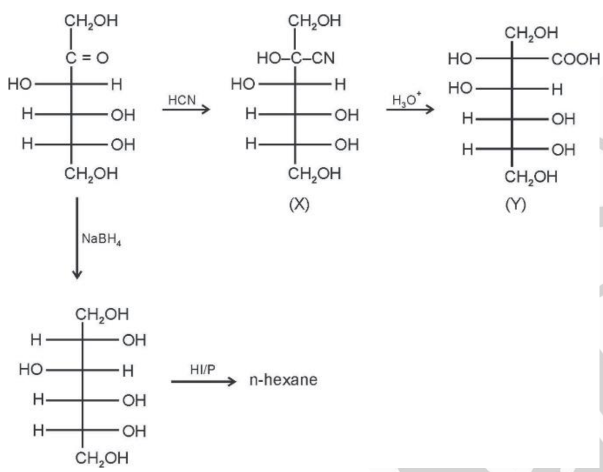
(3) 

n–pentane

(4) 

n–hexane

Answer (1)

Sol. 

17. Dinitrogen does not react with dioxygen at room temperature due to

(1) Unstable nature of oxides

(2) Reaction is endothermic

(3) Inert nature

(4) Reaction is highly exothermic

Answer (3)

Sol. Dinitrogen is inert at room temperature due to very high bond dissociation enthalpy

Dinitrogen combines with O_2 only at very high temperature (at about 2000 K) to form NO

$$N_2 + O_2 \xrightarrow{2000\,K} 2NO$$

18. Identify pair of isoelectronic species among the following lanthanides (ions).

(1) Eu^{4+}, Tm^{3+}

(2) Tb^{4+}, Gd^{3+}

(3) Lu^{3+}, Yb^{3+}

(4) Dy^{3+}, Tb^{4+}

Answer (2)

Sol. Atomic number of the given lanthanide ions are

	Atomic numbers	**Number of electrons**
Eu	63	59 (Eu^{4+})
Tm	69	66 (Tm^{3+})
Tb	65	61 (Tb^{4+})
Gd	64	61 (Gd^{3+})
Lu	71	68 (Lu^{3+})
Yb	70	67 (Yb^{3+})
Dy	66	63 (Dy^{3+})
Tb	65	61 (Tb^{4+})

19. **Assertion :** Drugs inhibit the attachment of substrate on active site of enzymes.

Reason : When inhibitor binds to active site of enzymes, a covalent bond is formed between inhibitor and enzyme.

(1) Both Assertion and Reason are correct

(2) Assertion is correct but Reason is incorrect

(3) Assertion is incorrect but Reason is correct

(4) Both Assertion and Reason are incorrect.

Answer (1)

Sol. Drugs compete with the inhibitors to attach themselves with the active sites of enzymes. So, Assertion is correct.

Some inhibitors bind themselves with the active sites of enzymes forming strong covalent bonds. So, Reason is also correct.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. In the reaction

$$N_2 + O_2 \rightleftharpoons 2NO$$

If initial moles of N_2 and O_2 are 2 moles and 1 moles respectively, find the value of K_C, if moles of O_2 at equilibrium is 0.6 moles.

Answer (0.67)

Sol.

	N_2	+ O_2	$\rightleftharpoons$ 2NO
Initial mol	2	1	0
Moles at eq.	2-0.4	1-0.4	0.8

$$K_C = \frac{[NO]^2}{[N_2][O_2]} = \frac{\left(\frac{0.8}{V}\right)^2}{\left(\frac{1.6}{V}\right)\left(\frac{0.6}{V}\right)} = 0.67$$

22. A and B form an ideal solution. A and B are volatile liquids. The vapour pressure of the solution on mixing A and B is 0.8 atm. It is given that mole fraction of A in liquid phase is 0.2 and mole fraction of A in vapour phase is 0.5. Calculate the vapour pressure of pure liquid A (in atm).

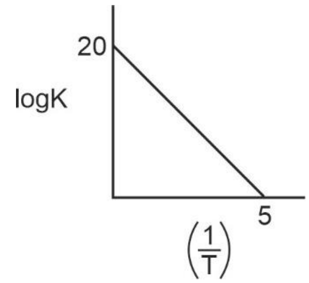
Answer (02.00)

Sol. $P_A^o X_A = y_A P_T$

$$P_A^o(0.2) = (0.5) \times 0.8$$

$$P_A^o = (2.5) \times 0.8 = 2 \text{ atm}$$

23. The plot of logK versus $\left(\frac{1}{T}\right)$ for a reaction is given as



where K is the rate constant of the reaction and T is the temperature in Kelvin. Find out the energy of activation of the reaction in cal mol^{-1}. Use R = 2 cal mol^{-1} K^{-1}

Answer (18.42)

Sol. Arrhenius equation is

$$K = Ae^{-E_a/RT}$$

$$\log K = \log A - \frac{E_a}{2.303R}\left(\frac{1}{T}\right)$$

$$\text{Slope} = -\frac{20}{5} = -4$$

$$\therefore \frac{E_a}{2.303R} = 4$$

$$E_a = 2.303 \times 2 \times 4$$

$$= 18.42 \text{ cal mol}^{-1}$$

24. How many of the following are the state functions?

Internal energy, Heat, Enthalpy, Volume, Entropy, Gibbs free energy, Pressure

Answer (06.00)

Sol. The state functions are

Internal energy, Enthalpy, Volume, Entropy, Gibbs free energy, Pressure

25.

26.

27.

28.

29.

30.

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 $P\left(B/A\right)=\frac{5}{7}$; $P\left(A/B\right)=\frac{7}{9}$ and $P(A\cap B)=\frac{1}{9}$

   Given, $S_1 = P(A'\cup B)=\frac{5}{6}$

   $S_2 = P(A'\cap B)=\frac{1}{18}$, then

   (1) Both S_1 and S_2 are correct

   (2) S_1 is true and S_2 is false

   (3) S_1 is false and S_2 is true

   (4) S_1 is false and S_2 is false

Answer (4)

Sol. Given $\frac{P(A\cap B)}{P(A)}=\frac{5}{7}$ & $\frac{P(A\cap B)}{P(B)}=\frac{7}{9}$

as $P(A\cap B)=\frac{1}{9}$ we get $P(A)=\frac{7}{45}$ & $P(B)=\frac{1}{7}$

Now $P(A'\cap B')=1-P(A\cup B)$

$$=1-\left(\frac{7}{45}+\frac{1}{7}-\frac{1}{9}\right)=\frac{256}{315}$$

$\therefore$ S_2 is wrong

Also, $P(A\cup B)=1-(P(A)-P(A\cap B))$

$$=1-\left(\frac{7}{45}-\frac{1}{9}\right)=\frac{43}{45}$$

$\therefore$ S_1 is wrong

2. Absolute maximum value of $f(x) = \tan^{-1}(\sin x - \cos x)$ is

   (1) 0 (2) $\tan^{-1}\frac{1}{\sqrt{2}}-\frac{\pi}{4}$

   (3) $\frac{\pi}{4}$ (4) $\tan^{-1}\sqrt{2}$

Answer (4)

Sol. $\because$ $\sin x - \cos x \in \left[-\sqrt{2},\sqrt{2}\right]$

Solving maximum value of tan–1 (sin x – cos x) is

$\tan^{-1}\sqrt{2}$.

3. The value of λ for which the lines $\frac{x-1}{1}=\frac{y-2}{2}=\frac{z+3}{\lambda^2}$ and $\frac{x-3}{1}=\frac{y-2}{\lambda^2}=\frac{z-1}{2}$ are coplanar.

   (1) $\pm\sqrt{3}$ (2) $\pm\sqrt{5}$

   (3) ± 2 (4) $\pm\sqrt{2}$

Answer (4)

Sol. Given lines are

$$\frac{x-1}{1}=\frac{y-2}{2}=\frac{z+3}{\lambda^2}$$

and $\frac{x-3}{1}=\frac{y-2}{\lambda^2}=\frac{z-1}{2}$

for coplanarity

$$\begin{vmatrix}1 & 2 & \lambda^2\\ 1 & \lambda^2 & 2\\ 2 & 0 & 4\end{vmatrix}=0$$

$\Rightarrow$ $1(4\lambda^2) - 2(0) + \lambda^2(-2\lambda^2) = 0$

$\Rightarrow$ $-2\lambda^4 + 4\lambda^2 = 0$

$\Rightarrow$ $\lambda^2(\lambda^2 - 2) = 0$

$\Rightarrow$ $\lambda = 0, \pm\sqrt{2}$

4. From point (2, 0) tangents are drawn on $2y^2 = -x$. These tangents also touches the circle $(x-5)^2 + y^2 = r^2$. The value of $17r^2$ is

   (1) 1 (2) 12

   (3) 9 (4) 4

Answer (3)

Sol. $P \equiv y^2 = -\frac{x}{2}$

Equation of tangent $\equiv y = mx + \left(-\frac{1}{8\,m}\right)$

$\downarrow (2,0)$

$16m^2 = 1 \Rightarrow m = \pm\frac{1}{4}$

$\therefore$ Tangents are $y = \frac{1}{4}x - \frac{1}{2}$ & $y = -\frac{x}{4} + \frac{1}{2}$

Equation of tangent to $(x-5)^2 + y^2 = r$ are

$x - 2 = 4y$ and $4y + x = 2$

using $d_c = r$ we get

$\left(\frac{5-0-2}{\sqrt{17}}\right) = r$ or $\left|\frac{5+0-2}{\sqrt{17}}\right| = r$

$\therefore\ r^2 = \frac{9}{17} \Rightarrow 17r^2 = 9$

5. Let $f(x) = \lim\limits_{n\to\infty} \frac{\cos 2\pi x - x^{2n}\sin(x-1)}{1+x^{2n+1}-x^{2n}}$, is continuous at

(1) $R - \{1\}$ (2) $R - \{-1, 1\}$

(3) $R - \{0, 1\}$ (4) $R - \{0\}$

Answer (2)

Sol. For $|x| < 1, f(x) = \cos 2\pi x$

For $|x| < 1, f(x) = -\frac{\sin(x-1)}{x-1}$

For $|x| < 1, f(x) = \begin{cases} 1 & \text{if } x = 1 \\ \frac{1+\sin 2}{-1} & \text{if } x = -1 \end{cases}$

$\lim\limits_{x\to 1^+} f(x) = 1, \lim\limits_{x\to 1^-} f(x) = 1,$

so f is discontinuous at $x = 1$

$\lim\limits_{x\to 1^+} f(x) = 1, \lim\limits_{x\to 1^-} f(x) = -\sin 2,$

so $f(x)$ is discontinuous at $x = -1$

6. Let $y = y(x)$ be the solution of the differential equation $\frac{dy}{dx} + \frac{y}{x^2-1} = \left(\frac{x-1}{x+1}\right)^{1/2}$ and $y(2) = \frac{1}{\sqrt{3}}$, then $\sqrt{7}\,y(8)$ is equal to

(1) 19 – 6 ln3 (2) 19 + 6 ln3

(3) 9 – 6 ln3 (4) 9 + 6 ln3

Answer (1)

Sol. I.F. = $e^{\int \frac{dx}{x^2-1}} = e^{\frac{1}{2}\ln\left(\frac{x-1}{x+1}\right)} = \sqrt{\frac{x-1}{x+1}}$

$$y\sqrt{\frac{x-1}{x+1}} = \int \frac{x-1}{x+1}dx + c = x - 2\ln(x+1) + c$$

Now put $x = 8$

$\frac{\sqrt{7}\,y(8)}{3} = 8 - 4\ln 3 + 2\ln 3 - \frac{5}{3}$

$\Rightarrow \sqrt{7}\,y(8) = 19 - 6\ln 3$

7. Let $f(x) = xe^{x(1-x)}$ then $f(x)$ is

(1) Increasing in $\left(-\infty, \frac{1}{2}\right) \cup (1, \infty)$

(2) Increasing in $\left(\frac{-1}{2}, 1\right)$

(3) Decreasing in $\left(\frac{-1}{2}, 1\right)$

(4) Decreasing in R

Answer (2)

Sol. $f(x) = xe^{x(1-x)}$

$f'(x) = xe^{x(1-x)}(1-2x) + e^{x(1-x)}$

$= -e^{x(1-x)}(2x^2 - x - 1)$

$= -e^{-x(1-x)}(2x+1)(x-1)$

$\therefore$ $f(x)$ is decreasing in $\left(-\infty, \frac{-1}{2}\right) \cup (1, \infty)$

And increasing in $\left(\frac{-1}{2}, 1\right)$

8. If $x = 2\sqrt{2}\cos t\sqrt{\sin 2t}$ and $y = 2\sqrt{2}\sin t\sqrt{\sin 2t}$, then $\left(1+\frac{dy}{dx}\right)^2 \frac{d^2y}{dx^2}$ at $t = \frac{\pi}{4}$, is

(1) 0 (2) $\frac{1}{3}$

(3) 2 (4) 1

Answer (1)

Sol. $\because\ x^2 + y^2 = 8\sin 2t$ and $\frac{y}{x} = \tan t$ at $t = \frac{\pi}{4}$,

$(x, y) = (2, 2)$

So, $x^2 + y^2 = \frac{16\left(\frac{y}{x}\right)}{1+\left(\frac{y}{x}\right)^2} \Rightarrow \left(x^2+y^2\right)^2 = 16xy$

Differentiating w.r.t. x, we get

$$2\left(x^2+y^2\right)\cdot\left(2x + 2y\frac{dy}{dx}\right) = 16\left(x\frac{dy}{dx} + y\right)$$

$$\left.\frac{dy}{dx}\right|_{(2,\,2)} = -1$$

$\because\ 1 + \frac{dy}{dx} = 0 \Rightarrow \left(1+\frac{dy}{dx}\right)^2 \cdot \frac{d^2y}{dx^2} = 0$

9. The differential equation of circle passing through (0, 2) and (0, –2) is

(1) $x^2 + 2xyy' - y^2 + 4 = 0$

(2) $2xyy' + y^2 - 4 + x^2 = 0$

(3) $2xyy' - x^2 - y^2 - 4 = 0$

(4) $2xyy' + x^2 + y^2 + 4 = 0$

Answer (1)

Sol. Let circle be $x^2 + y^2 + 2yx + 2 + y + c = 0$

$f(0, 2)$ & $(0, -2)$

$\therefore$ $f = 0$ & $c = -4$

$\therefore$ $c \equiv x^2 + y^2 + 2gx - 4 = 0$

Forming D.E.

$$\frac{x^2+y^2-4}{x} = 2g$$

Different both sides we get

$$x(2x + 2yy') - (x^2 + y^2 - 4) = 0$$

$$x^2 + 2xyy' - y^2 + 4 = 0$$

10. If A is symmetric and B is skew symmetric matrix then which of the following is not correct?

(1) $A^4 + B^4$ is symmetric

(2) $AB - BA$ is symmetric

(3) $A^5 - B^5$ is skew symmetric

(4) $AB + BA$ is skew symmetric

Answer (3)

Sol. $\because$ $A^T = A$ and $B^T = -B$

(1) $\left(A^4 + B^4\right)^T = A^4 + (-B)^4 = A^4 + B^4$

(Symmetric)

(2) $(AB - BA)^T = B^T \cdot A^T - A^T B^T = -BA + AB$

(Symmetric)

(3) $\left(A^5 - B^5\right)^T = A^5 - (-B)^5 = A^5 + B^5$

(neither symmetric nor skew symmetric)

(4) $(AB + BA)^T = B^T A^T + A^T B^T = -(AB + BA)$

(skew symmetric)

11.

12.

13.

14.

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. A class have B boys and G girls, 3 boys and 2 girls selected at random and no. of ways of selecting 3 boys and 2 girls are 168. Then $B + 3G$ is equal to

Answer (17)

Sol. Given that ${}^{B}C_3 \cdot {}^{G}C_2 = 168$

$$\frac{B(B-1)(B-2)}{6} \cdot \frac{G(G-1)}{2} = 168$$

$\Rightarrow$ $B(B - 1)(B - 2)\, G(G - 1) = 7.6.4.3.2.2$

$= 8.7.6.\;\; 3.2$

$\therefore$ $B = 8$ and $G = 3$

$B + 3G = 8 + 9 = 17$

22. Let $f(x) = ax^2 + bx + c$ and $f(1) = 3$, $f(-2) = \lambda$, $f(3) = 4$, then value of λ for which $f(0) + f(1) + f(-2) + f(3) = 14$

Answer (4)

Sol. $\because$ $f(1) = a + b + c = 3$ …(1)

$f(-2) = 4a - 2b + c = \lambda$ …(2)

and $f(3) = 9a + 3b + c = 4$ …(3)

Now $f(0) + f(1) + f(-2) + f(3) = 14$

$c + 3 + \lambda + 4 = 14$

from (1), (2) and (3) we get $c = \dfrac{\lambda + 11}{5}$

$$\Rightarrow \lambda + \frac{\lambda+11}{5} = 7$$

$\Rightarrow$ $\lambda = 4$

23. The value of $\int_0^{\frac{\pi}{2}} \frac{60\sin(6x)}{\sin x}dx$ is

Answer (104)

Sol. Let $I_n = \int_0^{\frac{\pi}{2}} \frac{\sin 2nx}{\sin x}dx$

$$I_n - I_{n-1} = \int_0^{\frac{\pi}{2}} \frac{\sin 2nx - \sin(2n-2)x}{\sin x}dx = \int_0^{\frac{\pi}{2}} 2\cos(2n-1)x\,dx$$

$$= \left.\frac{2\sin(2n-1)x}{(2n-1)}\right|_0^{\frac{\pi}{2}}$$

$$= \frac{2(-1)^{n-1}}{2n-1}$$

Also $I_1 = \int_0^{\frac{\pi}{2}} \frac{\sin 2x}{\sin x}dx = 2\sin x\int_0^{\frac{\pi}{2}} = 2$

$I_2 - I_1 = -\frac{2}{3}$ and $I_3 - I_2 = \frac{2}{5}$

So, $I_3 - I_2 = \frac{2}{5} - \frac{2}{3} = \frac{-4}{15}$

$\Rightarrow \quad I_3 = 2 - \frac{4}{15} = \frac{26}{15}$

$\Rightarrow \quad 60\, I_3 - 104$

24. If $\frac{6}{3^{12}} + \frac{10}{3^{11}} + \frac{20}{3^{10}} + \frac{40}{3^9} + \ldots + \frac{10240}{3} = 2^m \cdot n$, $n \in$ odd, then $m + n$ is equal to

Answer (13)

Sol. Given series is $\frac{1}{3^{12}} + \left(\frac{5}{3^{12}} + \frac{10}{3^{11}} + \frac{20}{3^{10}} + \frac{40}{3^9} + \ldots + \frac{10240}{3}\right)$

Series in bracket is a GP with $CR = 6$

Required sum $= \frac{1}{3^{12}} + \frac{\frac{5}{3^{12}}\left(6^{12}-1\right)}{6-1}$

$= \frac{1}{3^{12}} + \frac{6^{12}-1}{3^{12}}$

$= \frac{6^{12}}{3^{12}}$

$= 2^{12} \cdot 1$

$= 2^m \cdot n$

$\Rightarrow \quad m = 12, n = 1$

$\boxed{m + n = 13}$

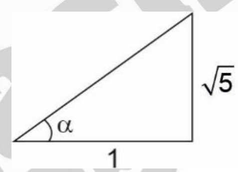
25. Number of solutions of the equation $\tan\theta\left(1+\sqrt{5}\tan 2\theta\right) = \sqrt{5} - \tan 2\theta$, in $\left[-\pi, \frac{\pi}{2}\right]$ is

Answer (5)

Sol. Let $\tan\theta = \sqrt{5}, \quad \alpha \in \left(\frac{\pi}{3}, \frac{\pi}{2}\right)$

So, $\tan\theta = \frac{\tan\theta - \tan 2\theta}{1 + \tan\theta \cdot \tan 2\theta}$

$\Rightarrow \quad \tan\theta = \tan(\alpha - 2\theta)$



$\Rightarrow \quad \theta = n\pi + \alpha - 2\theta$

$\Rightarrow \quad \theta = \frac{1}{3}(n\pi + \alpha), n \in Z$

Here n can be – 3, –2, – 1, 0 and 1.

So total 5 solutions possible.

26.

27.

28.

29.

30.

❑ ❑ ❑