25/01/2023
Evening

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Memory Based
Answers & Solutions
for
JEE (Main)-2023 (Online) Phase-1

Time : 3 hrs.   M.M. : 300

(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. A wire with resistance 5 ohms is redrawn to increase its length 5 times. What is the final resistance of the wire.

(1) 25 Ω (2) 16 Ω

(3) 125 Ω (4) 32 Ω

Answer (3)

Sol. $R = \rho\dfrac{l_0}{A_0} = 5\ \Omega$

Volume is constant so

$l_0A_0 = 5l_0A$

So $A = \dfrac{A_0}{5}$

$R' = \rho\dfrac{5l_0}{\frac{A_0}{5}} = 25\rho\dfrac{l_0}{A_0}$

$= 25R$

$= 125\ \Omega$

2. Find velocity of particle if position of the particle is given by $x = 2t^2$ at $t = 2$ sec.

(1) 8 m/s (2) 4 m/s

(3) 16 m/s (4) 32 m/s

Answer (1)

Sol. $x = 2t^2$

$\dfrac{dx}{dt} = 4t$

$v = 4t$

v at $t = 2$ sec = 8 m/s

3. A particle performing SHM with amplitude A starts from $x = 0$ and reaches $x = \dfrac{A}{2}$ in 2 s. Find time required for the particle to go from $x = \dfrac{A}{2}$ to $x = A$?

(1) 1.5 s (2) 4 s

(3) 6 s (4) 1 s

Answer (2)

Sol. $x = A\sin(\omega t)$

For $x = \dfrac{A}{2}$

$\Rightarrow \dfrac{A}{2} = A\sin(\omega t)$

$\omega t = \dfrac{\pi}{6}$

$t = \left(\dfrac{\pi}{6\omega}\right) = 2\text{ s} \Rightarrow \dfrac{\pi}{\omega} = 12\text{ s}$

When $x = A$, = $A\sin(\omega t)$

$\omega t = \dfrac{\pi}{2}$

$t = \left(\dfrac{\pi}{2\omega}\right) = \dfrac{1}{2}\times 12\text{ s} = 6\text{ s}$

Time taken from $\dfrac{A}{2}$ to A = 6 – 2 = 4 second.

4. An object of mass m is placed at a height R_e from surface of earth. Find the increase in potential energy of the object if the height of the object is increased to $2R_e$ from surface. (R_e: Radius of earth)

(1) $\dfrac{1}{3}mgR_e$ (2) $\dfrac{1}{6}mgR_e$

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

Answer (2)

Sol. $U_i = -\dfrac{GM_em}{2R_e}$

$U_f = -\dfrac{GM_em}{3R_e}$

$\Delta U = U_f - U_i = \dfrac{GM_em}{6R_e}$

$= \dfrac{mgR_e}{6}$

5. A charge of 10 μC is placed at origin. Where should a charge of 40 μC be placed on x-axis such that electric field is zero at $x = 2$?

(1) $x = -2$ (2) $x = 4$

(3) $x = 6$ (4) $x = 2$

Answer (3)

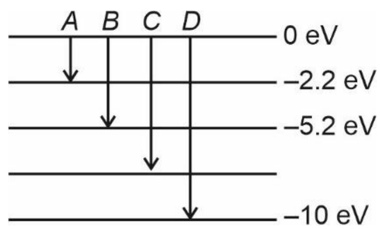
Sol. $E = 0$

$\Rightarrow \dfrac{1}{4\pi\varepsilon_0}\dfrac{10}{2^2} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{40}{(x_0-2)^2}$

$\Rightarrow x_0 - 2 = 4$

$\Rightarrow x_0 = 6$

6. The diagram shown represents different transitions of electron (A, B, C, D) between the energy levels with energies mentioned along. Among the shown transitions which transition will generate photon of wavelength 124.1 nm? (hc = 1241 eV-nm)



(1) A

(2) B

(3) C

(4) D

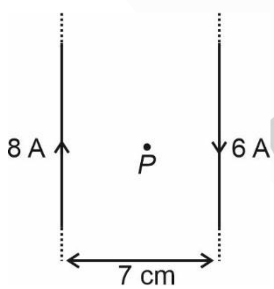
Answer (4)

Sol. So, energy of photon

$$\Delta E = \frac{hc}{\lambda} = \frac{1241}{124.1} = 10 \text{ eV}$$

Only D has energy to produce this wavelength.

7. Two straight infinite wires placed parallel to each other are carrying currents as shown



P is equidistant from the wires find magnetic field at point P. (Point P is in the plane of wire)

(1) 8×10^{-5} T

(2) 8×10^{-7} T

(3) 16×10^{-5} T

(4) 2×10^{-5} T

Answer 1)

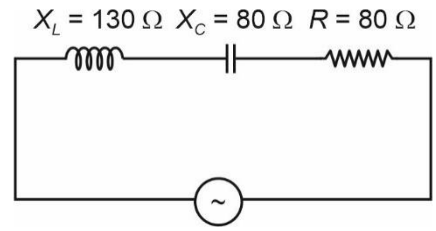
Sol. $B_{net} = \frac{\mu_0 i_1}{2\pi r_1} + \frac{\mu_0 i_2}{2\pi r_2}$

$$= 2\times10^{-7}\left[\frac{8}{\frac{3.5}{100}} + \frac{6}{\frac{3.5}{100}}\right]\text{T}$$

$$= \frac{2\times10^{-7}\times14\times100}{3.5}\text{T}$$

$= 8 \times 10^{-5}$ T

8. For an LCR series circuit $X_L = 130\ \Omega$, $X_C = 80\ \Omega$ and $R = 80\ \Omega$. The value of power factor of the circuit is equal to



(1) $\frac{\sqrt{54}}{9}$

(2) $\frac{8}{\sqrt{89}}$

(3) $\frac{8}{13}$

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

Answer (2)

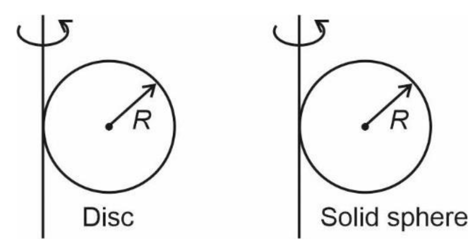
Sol. $\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{(X_L - X_C)^2 + R^2}}$

$$= \frac{80}{\sqrt{(130-80)^2 + 80^2}}$$

$$= \frac{80}{\sqrt{2500+6400}}$$

$$\cos\theta = \frac{8}{\sqrt{89}}$$

9. A disc and a solid sphere of same radius are rotated as shown in the figure. If mass of disc and solid sphere are 4 kg and 5 kg respectively then $\frac{I_{disc}}{I_{solid\ sphere}}$

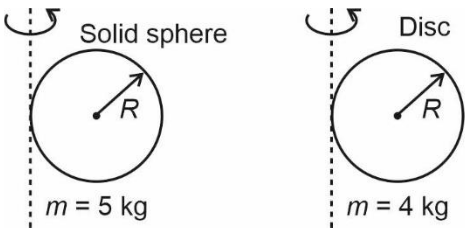


(1) $\frac{7}{5}$ (2) $\frac{25}{28}$

(3) $\frac{5}{7}$ (4) $\frac{28}{25}$

Answer (3)

Sol.



Using parallel axis theorem,

$$I_{\text{solid sphere}} = \left(\frac{2}{5}mR^2 + mR^2\right)$$

$$= \left(\frac{7}{5}mR^2\right) = 7R^2 \text{ (as } m = 5 \text{ kg)}$$

$$I_{\text{disc}} = \left(\frac{1}{4}mR^2 + mR^2\right) = \left(\frac{5}{4}mR^2\right) = 5R^2$$

(as m = 4 kg)

$$\frac{I_{\text{disc}}}{I_{\text{solid sphere}}} = \frac{5R^2}{7R^2} = \frac{5}{7}$$

10. Two projectiles are thrown at angle of projection α and β with the horizontal. If $\alpha + \beta = 90°$ then ratio of range of two projectiles on horizontal plane is equal to

(1) 1 : 1

(2) 2 : 1

(3) 1 : 2

(4) 1 : 3

Answer (1)

Sol. $R_1 = \dfrac{u^2 \sin 2\alpha}{g}$

$$R_2 = \frac{u^2 \sin 2(90 - \alpha)}{g} = \frac{u^2 \sin 2\alpha}{g}$$

So $R_1 = R_2$

$$\Rightarrow \frac{R_1}{R_2} = \frac{1}{1}$$

11. What will be molar specific heat capacity of an isochoric process of a diatomic gas if it has additional vibrational mode?

(1) $\frac{5}{2}R$ (2) $\frac{3}{2}R$

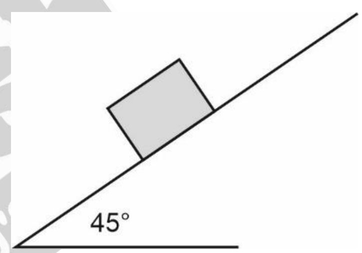
(3) $\frac{7}{2}R$ (4) $\frac{9}{2}R$

Answer (3)

Sol. For each additional vibrational mode degree of freedom is increased by 2 so new degree of freedom $f = 5 + 2 = 7$

So, $C_v = \frac{f}{2}R = \frac{7}{2}R$

12. A block is placed on a rough inclined plane with 45° inclination. If minimum force required to push the block up the incline is equal to 2 times the minimum force required to slide the block down the inclined plane, then find the value of coefficient of friction between block and incline?

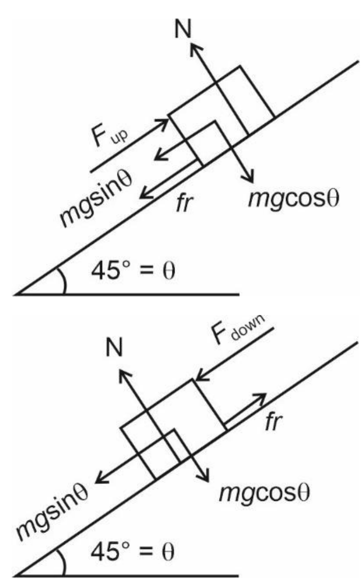


(1) 0.25 (2) 1

(3) 2 (4) 3

Answer (4)

Sol.



$F_{up} = mg\sin\theta + \mu mg\cos\theta$

$F_{down} = \mu mg\cos\theta - mg\sin\theta$

$F_{up} = 2F_{down}$

$\Rightarrow mg\sin\theta + \mu mg\cos\theta = 2\mu mg\cos\theta - 2mg\sin\theta$

$\Rightarrow 3\sin\theta = \mu\cos\theta$

$\mu = 3\tan\theta$

$\mu = 3$ as $\tan 45 = 1$, $\theta = 45°$

13. Correctly match the two lists

	List-I (Physical Quantity)		List-II (Dimensions)
P.	Young's Modulus	A.	$[ML^2T^{-1}]$
Q.	Planck's constant	B.	$[ML^{-1}T^{-2}]$
R.	Work function	C.	$[ML^{-1}T^{-1}]$
S.	Co-efficient of viscosity	D.	$[ML^2T^{-2}]$

(1) P–A, Q–B, R–C, S–D

(2) P–B, Q–A, R–D, S–C

(3) P–D, Q–A, R–C, S–B

(4) P–D, Q–A, R–B, S–C

Answer (2)

Sol. $Y = \dfrac{F/A}{\Delta L/L} \quad \Rightarrow \quad Y = ML^{-1}T^{-2}$

$E = hf \quad \Rightarrow \quad h = ML^2T^{-1}$

$hf = hf_0 - \phi \quad \Rightarrow \quad \phi = ML^2T^{-2}$

$F = \eta A\dfrac{dv}{dx} \quad \Rightarrow \quad \eta = ML^{-1}T^{-1}$

14. A big drop is divided into 1000 identical droplets. If the big drop had surface energy U_i and all small droplet together had a surface energy U_f, then $\dfrac{U_i}{U_f}$ is equal to

(1) $\dfrac{1}{100}$

(2) 10

(3) $\dfrac{1}{10}$

(4) 1000

Answer (3)

Sol. $\dfrac{4}{3}\pi R^3 = 1000\dfrac{4}{3}\pi r^3$

$R = 10r$

$U_i = 4\pi R^2T$

& $U_f = 1000 \times 4\pi r^2T = 40\pi R^2T$

So, $\dfrac{U_i}{U_f} = \dfrac{4\pi R^2T}{40\pi R^2T} = \dfrac{1}{10}$

15.

a.	Gauss law (electrostatic)	P.	$\oint \vec{B}\cdot\vec{dA} = 0$
b.	Amperes circuital law	Q.	$\oint \vec{B}\cdot\vec{dl} = \mu_0 i_{enc}$
c.	Gauss law (magnetism)	R.	$\oint \vec{E}\cdot\vec{dA} = \dfrac{q_{enc}}{\varepsilon_0}$
d.	Faraday's law	S.	$\varepsilon = \dfrac{-d\phi_B}{dt}$

(1) a-R, b-Q, c-S, d-P

(2) a-R, b-Q, c-P, d-S

(3) a-R, b-S, c-Q, d-P

(4) a-R, b-S, c-P, d-Q

Answer (2)

Sol. Gauss law for electrostatic = $\oint \vec{E}\cdot\vec{dA} = \dfrac{q_{enclosed}}{\varepsilon_0}$

Gauss law for magnetism = $\oint \vec{B}\cdot\vec{dA} = 0$

Ampere circuital law = $\oint \vec{B}\cdot\vec{dl} = \mu_0 i_{enclosed}$

Faraday's law = $\varepsilon_{induced} = \dfrac{-d\phi_B}{dt}$

16. A stationary nucleus breaks into 2 daughter nucleus having velocities in ratio 3 : 2. Find the radius of their nuclear sizes.

(1) $\left(\dfrac{2}{3}\right)^{1/2}$

(2) $\left(\dfrac{2}{3}\right)^{1/3}$

(3) $\left(\dfrac{4}{9}\right)^{1/3}$

(4) $\left(\dfrac{9}{4}\right)^{1/2}$

Answer (2)

Sol. Applying momentum conservation

$m_1v_1 = m_2v_2$

$\Rightarrow \dfrac{m_1}{m_2} = \left(\dfrac{v_2}{v_1}\right) = \dfrac{2}{3}$

$\Rightarrow \dfrac{A_1}{A_2} = \dfrac{2}{3}$

also, $\dfrac{R_1}{R_2} = \left(\dfrac{A_1}{A_2}\right)^{1/3}$

so, $\dfrac{R_1}{R_2} = \left(\dfrac{2}{3}\right)^{1/3}$

17. Match the two lists :

	List-I		List-II
P.	Adiabatic process	A.	No work done by or on gas
Q.	Isochoric process	B.	Some amount of heat given is converted into internal energy
R.	Isobaric process	C.	No heat exchange
S.	Isothermal process	D.	No change in internal energy

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

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

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

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

Answer (3)

Sol. Adiabatic $\Rightarrow \Delta Q = 0$

Isochoric $\Rightarrow W = 0$

Isothermal $\Rightarrow \Delta U = 0$

Isobaric $\Rightarrow \Delta Q = \Delta U + W$

(Both ΔU and W are non-zero)

18.

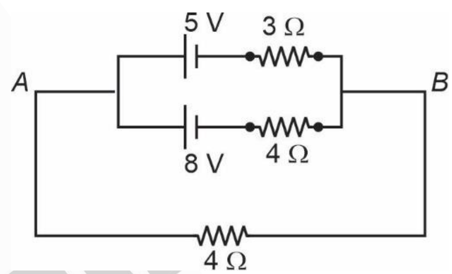
19.

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. In the circuit shown, the current (in *A*) through the 4 Ω resistor connected across *A* and *B* is $\dfrac{1}{n}$ amperes.



Find *n*

Answer (10)

Sol. $e_{\text{effective}} = \dfrac{8\times3-5\times4}{3+4}\text{ V}$

$= \dfrac{4}{7}\text{ V}$

$r_{\text{effective}} = \dfrac{3\times4}{3+4}\Omega = \dfrac{12}{7}\Omega$

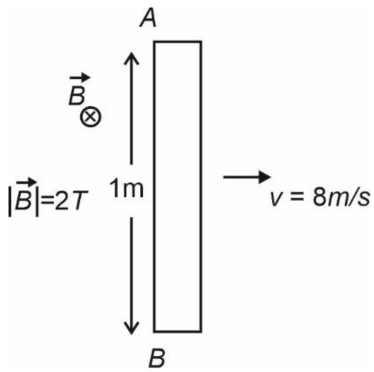
$\Rightarrow \quad i = \dfrac{\frac{4}{7}}{\frac{12}{7}+4}\text{ A}$

$= \dfrac{4}{12+28}\text{ A} = \dfrac{1}{10}\text{ A}$

22. A metal rod of length 1 m is moving perpendicular to its length with 8 m/s velocity along positive *x*-axis. If a magnetic field $B = 2T$ perpendicular to the plane of motion. Find the emf involved between the two ends of rod.

Answer (16.00)

Sol.

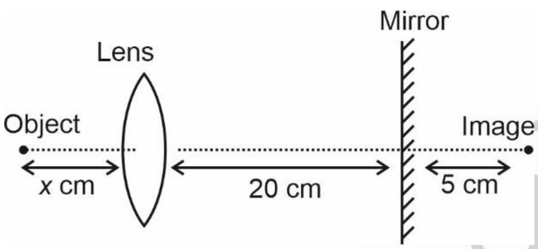


$|V_A - V_B| = Bvl$

$= 2 \times 8 \times 1$

$= 16\ v$

23. In the arrangement shown:



The image shown is formed after refraction from lens and reflection from mirror. If the length of lens is 10 cm, find x.

Answer (30)

Sol. Writing equation for lens:

$$\frac{1}{+15} - \frac{1}{-x} = \frac{1}{10} \Rightarrow \frac{1}{x} = \frac{1}{10} - \frac{1}{15}$$

$$\Rightarrow x = 30 \text{ cm}$$

24. A capacitor has a capacitance of 5 μF when the medium between the plates is air. Now, a material of dielectric constant 1.5 is filled in half the separation between the plates and area same as plates. The new capacitance in μF is ________

Answer (06)

Sol. $C_0 = \frac{\varepsilon_0 A}{d}$ ...(i)

$$C_{new} = \frac{\frac{1.5\,\varepsilon_0 A}{\frac{d}{2}} \times \frac{\varepsilon_0 A}{\frac{d}{2}}}{\frac{1.5\,\varepsilon_0 A}{\frac{d}{2}} + \frac{\varepsilon_0 A}{\frac{d}{2}}}$$

$$= \frac{1.5 \times \frac{\varepsilon_0 A}{d} \times 2}{1.5 + 1}$$

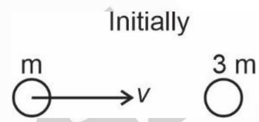
$$= \frac{6}{5}\frac{\varepsilon_0 A}{d}$$

$= 6\ \mu\text{F}$

25. A particle of mass 1 kg is moving with a velocity towards a stationary particle of mass 3 kg. After collision, the lighter particle returns along same path with speed 2 m/s. If the collision was elastic then speed of 1 kg particle before collision is _____ m/s.

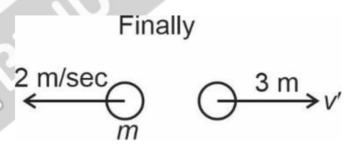
Answer (04.00)

Sol. Linear momentum is conserved.



So $mv = 3mv' - 2m$ ...(1)

Coefficient of restitution is 1 so



$$e = 1 = \frac{v' + 2}{v}$$

$v' = v - 2$ ...(2)

on solving

$v = 4\text{m/sec}$

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. If $[H^+]$ in concentration is increased by a factor of 1000. Then pH?
   (1) Decreased by 3
   (2) Increased by 3
   (3) There is no change in pH
   (4) Decreased by 1

Answer (1)

Sol. If $[H^+]$ is increased by 1000 times then pH will be decreased by 3.

2. Arrange the following elements in increasing order of metallic character

   Si, K, Mg and Be

   (1) Si < Mg < Be < K (2) Be < Mg < Si < K
   (3) Si < Be < Mg < K (4) K < Mg < Si < Be

Answer (3)

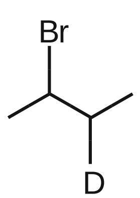
Sol. Based on the electronegativity of the given elements, the correct increasing order of metallic character is

Si < Be < Mg < K

3. Which of the following has two chiral centres
   (1) 2- Bromo - 3- deutro butane
   (2) 1- Bromo - 2- deutro butane
   (3) 1- Bromo - 3- deutro butane
   (4) 1- Bromo - 4- deutro butane

Answer (1)

Sol.



2 - Bromo - 3 deutro butane has two chiral centres.

4. **A :** Carbon form two oxides CO and CO_2, where CO is neutral while CO_2 is acidic.

   R : CO_2 will combine with water to give carbonic acid and CO is soluble in water

   (1) [A] and [R] both are correct and [R] is correct explanation of [A]
   (2) [A] and [R] both are correct and [R] is not correct explanation of [A]
   (3) [A] is correct while [R] is false
   (4) [A] is false while [R] is correct

Answer (2)

Sol. CO_2 will form carbonic acid with water and it is acidic in nature, while CO is neutral but there is no relation of neutrality with solubility.

5. Which of the following element is the weakest reducing agent in aqueous solution.

   (1) Na (2) K
   (3) Li (4) Rb

Answer (1)

Sol. As per the standard reduction potential values, Na is the weakest reducing agent.

6. Match **List-I** with **List-II**

(List-I) **Amine**	**List-II** **pK_b (Aqueous medium)**
(a) Aniline	1. 9.0
(b) Ethanamine	2. 3.29
(c) N-ethylethanamine	3. 3.25
(d) N, N-diethylethanamine	4. 3.0

   (1) $a \rightarrow 1$, $b \rightarrow 2$, $c \rightarrow 4$, $d \rightarrow 3$
   (2) $a \rightarrow 1$, $b \rightarrow 4$, $c \rightarrow 3$, $d \rightarrow 2$
   (3) $a \rightarrow 1$, $b \rightarrow 2$, $c \rightarrow 3$, $d \rightarrow 4$
   (4) $a \rightarrow 2$, $b \rightarrow 3$, $c \rightarrow 4$, $d \rightarrow 1$

Answer (1)

Sol. The order of basicity is:

c > d > b > a

$\therefore$ pK_b order is : $\rightarrow$ c < d < b < a

7. Select the correct match.

A. Hexan-2-one and hexan-3-one – Position isomers

B. Pentan-3-one and pentan-2-one – Functional isomers

C. 2-pentene and 1-pentene – Metamers

D. Pentanoic acid and hexanoic acid – Functional isomers

(1) A (2) B

(3) C (4) D

Answer (1)

Sol. Hexan-2-one and hexan-3-one are position isomers.

8. Chloride salt of M is treated with excess of $AgNO_3$. It forms curdly white precipitate ‘A’. When ‘A’ is treated with NH_4OH, it forms a soluble salt ‘B’. The A and B respectively is

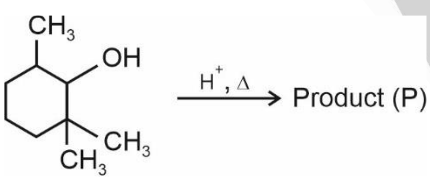
(1) AgCl, $[Ag(NH_3)_2]^+$ (2) AgBr, $[Ag(OH)_2]^-$

(3) AgCl, $[Ag(OH)_4]^{2-}$ (4) AgBr, $[Ag(OH)_4]^{2-}$

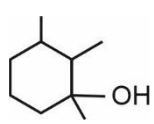
Answer (1)

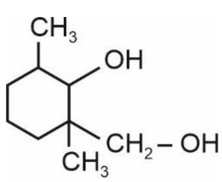
Sol. AgCl forms white ppt. which is soluble in NH_4OH. The correct answer of this question is (1).

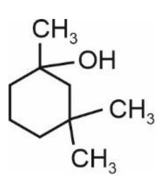
9. Consider the following reaction

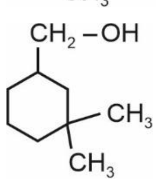


The correct product ‘P’ is

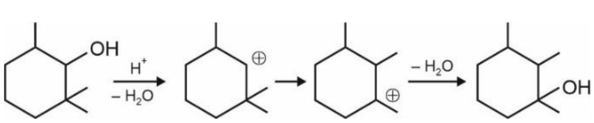
(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. 

10. Final oxidation number of Cr when $K_2Cr_2O_7$ is used in acidic medium during titration.

(1) +6 (2) +2

(3) +3 (4) +4

Answer (3)

Sol. $Cr_2O_7^{2-} + 14H^+ + 6\bar{e} \rightarrow 2Cr^{3+} + 7H_2O$

11. Match the following

(I)	Neoprene	(a)	Synthetic Wool
(II)	Acrolein	(b)	Paint
(III)	LDP	(c)	Flexible Pipes
(IV)	Glyptal	(d)	Gaskets

(1) II-(d), IV-(b), III-(a), I-(c)

(2) II-(d), IV-(b), III-(c), I-(a)

(3) II-(a), IV-(b), III-(c), I-(d)

(4) II-(b), IV-(c), III-(d), I-(a)

Answer (3)

Sol. Neoprene is a synthetic rubber. It is used for manufacturing of gaskets.

Acrolein is used for making synthetic wool. LDP is used for making flexible pipes. Glyptal is used for making paints.

12. **Assertion :** BHA is added to butter to increase shelf life.

Reason : BHA reacts with oxygen more than butter.

(1) Assertion is correct Reason is correct

(2) Assertion is correct Reason is incorrect

(3) Assertion is incorrect Reason is correct

(4) Assertion is incorrect Reason is incorrect

Answer (1)

Sol. Butylated hydroxy anisole (BHA) is an antioxidant. It is added to butter to increase its shelf life from months to years. BHA reacts with O_2 present in air in preference to butter. So, both the assertion and reason are correct.

13. A hydrocarbon is having molar mass 84 g mol^{-1} and 85.8% C by mass. Calculate the number of H atoms in the molecule?

(1) 8 (2) 10

(3) 12 (4) 14

Answer (3)

Sol. C 85.8% $\frac{85.8}{12} = 7 = 1$

H 14.2 $\frac{14.2}{1} = 14 = 2$

Empirical formula = CH_2

molecular formula = n × empirical formula

$$n = \frac{\text{molar mass}}{\text{empirical mass}} = \frac{84}{14} = 6$$

$\therefore$ molecular formula = C_6H_{12}

14. Which of the following options contains the correct match.

	List-I		List-II
(A)	Adiabatic	(P)	$\Delta T = 0$
(B)	Isothermal	(Q)	Heat exchange is zero
(C)	Isochoric	(R)	$\Delta P = 0$
(D)	Isobaric	(S)	Work done is zero

(1) A → Q; B → P; C → S; D → R

(2) A → P; B → Q; C → R; D → S

(3) A → S; B → R; C → Q; D → P

(4) A → P; B → R; C → S; D → Q

Answer (1)

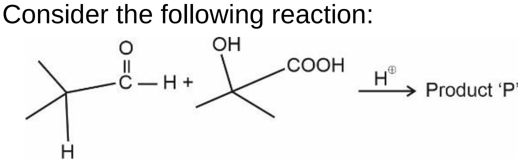
Sol. Adiabatic → Heat exchange is zero

Isothermal → $\Delta T = 0$

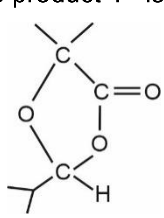
Isobaric → $\Delta P = 0$

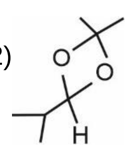
Isochoric → Work done is zero

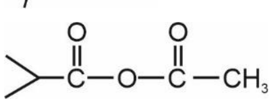
15. Consider the following reaction:

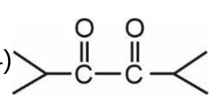


The product 'P' is

(1) 

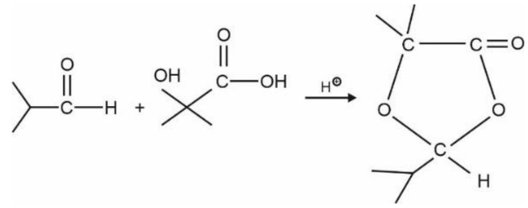
(2) 

(3) 

(4) 

Answer (1)

Sol.



16. Find out mass ratio of ethylene glycol (62 g) required to make 500 ml, 0.25 m and 250 M, 0.25 M solution.

(1) 1 : 1 (2) 1 : 2

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

Answer (3)

Sol. Millimoles of ethylene glycol in 1st case

= 500 × 0.25

Millimoles of ethylene glycol in second case

= 250 × 0.25

$\therefore$ Molar ratio = $\frac{50}{25} = \frac{10}{5}$

Mass ratio = $\frac{2}{1}$

17. **A :** Alkali metals show characteristic colour in reducing flame.

R : They can be identified by flame test

(1) Assertion is true and reason is false

(2) Assertion is false and reason is true

(3) Both assertion and reason are true reason is the correct explanation of assertion

(4) Both assertion and reason are true. But reason is not the correct explanation of assertion

Answer (2)

Sol. Alkali metals show characteristic colour in oxidising flame.

18. Which of the following option contains the correct match?

	List-I (Complex)		List-II (λ, absorbed)
(A)	$[Co(CN)_6]^{3-}$	(P)	535 nm
(B)	$[Co(NH_3)_6]^{3+}$	(Q)	375 nm
(C)	$[Co(NH_3)_5Cl]^{2+}$	(S)	600 nm

(1) A → S, B→ P, C→ Q

(2) A → P, B → Q, C → S

(3) A → Q, B → P, C → S

(4) A → S, B → Q, C → P

Answer (3)

Sol. The CFSE value order of the given complexes are:

$[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [Co(NH_3)_5Cl]^{2+}$

$\therefore$ λ, absorbed will be in the reverse order.

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. How many of the following orbitals is/are considered as axial orbital(s).

$p_x, p_y, p_z, d_{xy}, d_{yz}, d_{zx}, d_{x^2-y^2}, d_{z^2}$

Answer (5)

Sol. $p_x, p_y, p_z, d_{x^2-y^2}$ and d_{z^2} orbitals are called axial orbitals.

22. Consider the following cell :

Pt | H_2 (1 bar) | H^+ (1 M) || M^{3+} | M^+

If the value of $\frac{[M^{3+}]}{[M^+]}$ is 10^x, then find the value of 'x'. [Given : $E^o_{M^{3+}/M^+} = 2$ V and $E_{cell} = 1.1$ V]

Answer (30)

Sol. $1.1 = 2 - \frac{0.06}{2}\log\frac{[M^{3+}]}{[M^+]}$

$0.9 = 0.03\log\frac{[M^{3+}]}{[M^+]}$

$\therefore \frac{[M^{3+}]}{[M^+]} = 10^{30}$

$\therefore$ x = 30

23. For a reaction $A \longrightarrow B$

$k = 2 \times 10^{-3}\ s^{-1}$

Consider the following statements for the above reaction.

SI : The reaction is complete in 1000 sec.

SII : Half life of the reaction is 500 sec.

SIII : Units of rate constant is same as that of rate

SIV : Degree of dissociation is $(1 - e^{-kt})$

SV : It is a zero order reaction.

How many statements are incorrect?

Answer (4)

Sol. Except (4), all statements are incorrect

As $[B] = a(1 - e^{-kt})$

$\therefore, \left[\alpha = \frac{[B]}{a} = 1 - e^{-kt}\right]$

24. Consider a mixture of CH_4 and C_2H_4 having volume 16.8 L at 273 k and 1 atm.

It undergoes combustion to form CO_2 with total volume 28 L at the same temperature and pressure.

If the enthalpy of combustion of CH_4 is –900 kJ/mol and enthalpy of combustion of C_2H_4 is –1400 kJ/mol then find the magnitude of heat released on combustion of given mixture in kJ

Answer (925)

Sol. $\underset{x}{CH_4} + 2O_2 \longrightarrow \underset{x}{CO_2} + 2H_2O$

$\underset{16.8-x}{C_2H_4} + 3O_2 \longrightarrow \underset{2(16.8-x)}{2CO_2} + 2H_2O$

x + 2(16.8 – x) = 28

x = 5.6 L

$\therefore$ Heat released $= \frac{1}{4} \times 900 + \frac{1}{2} \times 1400$

= 225 + 700

= 925 kJ

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. The value of $\sum_{k=0}^{6} {}^{51-k}C_3$ is

(1) ${}^{52}C_4 - {}^{46}C_4$ (2) ${}^{52}C_4 - {}^{45}C_4$

(3) ${}^{51}C_4 - {}^{45}C_4$ (4) ${}^{51}C_4 - {}^{46}C_4$

Answer (2)

Sol. ${}^{51}C_3 + {}^{50}C_3 + {}^{49}C_3 .... \underbrace{{}^{45}C_3 + {}^{45}C_4}_{{}^{46}C_4} - {}^{45}C_4$

${}^{51}C_3 + {}^{50}C_3 + {}^{49}C_3 + {}^{48}C_3 + {}^{47}C_3 + \underbrace{{}^{46}C_3 + {}^{46}C_4}_{{}^{47}C_4} - {}^{45}C_4$

$\vdots$

$\Rightarrow\ {}^{52}C_4 - {}^{45}C_4$

2. If $f(x) = 2x^n + \lambda$ and $f(4) = 133$, $f(5) = 255$, then sum of positive integral divisors of $f(3) - f(2)$ is

(1) 60 (2) 22

(3) 40 (4) 6

Answer (1)

Sol. $2 \cdot 4^n + \lambda = 133$ ...(i)

$2 \cdot 5^n + \lambda = 255$ ...(ii)

$2(5^n - 4^n) = 122$

$n = 3$

$f(x) = 2x^3 + \lambda$

$f(3) - f(2) = 2(3^3 - 2^3)$

$= 38$

Divisors = 1, 2, 19, 38

3. If $\left|\dfrac{z+2i}{z-i}\right| = 2$ is a circle, then centre of the circle is

(1) (0, 0) (2) (0, 2)

(3) (2, 0) (4) (–2, 0)

Answer (2)

Sol. $(z+2i)(\bar{z}-2i) = 4(z-i)(\bar{z}+i)$

$\Rightarrow\ z\bar{z} + 2i\bar{z} - 2iz + 4 = 4z\bar{z} - 4i\bar{z} + 4iz + 4$

$\Rightarrow\ 3z\bar{z} - 6i\bar{z} + 6iz = 0$

$\Rightarrow\ z\bar{z} - 2i\bar{z} + 2iz = 0$

$\therefore$ Centre = $2i$ *i.e.*, (0, 2)

4. If $\dfrac{dy}{dt} + \alpha \cdot y = \gamma \cdot e^{-\beta t}$, then $\lim_{t\to\infty} y(t)$, where $\alpha > 0$, $\beta > 0$, $\gamma > 0$, $\alpha \ne \beta$, is equal to

(1) 0 (2) 1

(3) Does not exist (4) $\alpha\beta$

Answer (1)

Sol. $\dfrac{dy}{dt} + \alpha y = \gamma e^{-\beta t}$

Integrating factor (I.F.) = $e^{\alpha t}$

Solution of D.E.

$ye^{\alpha t} = \gamma \int e^{(\alpha-\beta)t} dt$

$\Rightarrow\ ye^{\alpha t} = \dfrac{\gamma}{\alpha-\beta} \cdot e^{(\alpha-\beta)t} + C$

$\Rightarrow\ y(t) = \dfrac{\gamma}{\alpha-\beta} \cdot \alpha^{-\beta t} + C \cdot e^{-\alpha t}$

$\lim_{t\to\infty} y(t) = 0$

5. If $(p \to q) \nabla (p \Delta q)$ is tautology, then operator ∇, Δ denotes

(1) $\Delta \to$ OR, $\nabla \to$ AND (2) $\Delta \to$ AND, $\nabla \to$ OR

(3) $\Delta \to$ AND, $\nabla \to$ AND (4) $\Delta \to$ OR, $\nabla \to$ OR

Answer (4)

Sol. $(p \to q) \nabla (p \Delta q) \equiv T$

Only if ∇ is OR and Δ is OR

6. Number of numbers between 5000 and 10000 by using the digits 1,3,5,7,9 without repetition is equal to

(1) 120 (2) 72

(3) 12 (4) 6

Answer (2)

Sol. The left most digit can be chosen in 3 ways i.e., 5, 7, 9.

Now, the digits can be chosen from remaining digits for remaining places in 4 ways, 3 ways, 2 ways and 1 way.

$\therefore$ $3 \times 4 \times 3 \times 2 \times 1 = 72$

7. If $f(x) = \log_{\sqrt{m}}\left(\sqrt{2}(\sin x - \cos x) + m - 2\right)$, the range of $f(x)$ is [0, 2], then the value of m is

(1) 3
(2) 4
(3) 5
(4) None

Answer (2)

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

$\therefore$ $\log_{\sqrt{m}}\left((\sin x - \cos x) + m - 2\right)$

$\in \left[\log_{\sqrt{m}}(m-4), \log_{\sqrt{m}} m\right]$

$\therefore$ $\log_{\sqrt{m}}(m-4) = 0$ and $\log_{\sqrt{m}} m = 2$

$\Rightarrow$ $m = 5$

8. If A be a symmetric matrix and B and C are skew symmetric matrices of same order, then

(1) $A^{13} \cdot B^{26} - B^{26} \cdot A^{13}$ is symmetric
(2) $AC - A$ is symmetric
(3) $A^{13}B^{26} - B^{26} \cdot A^{13}$ is skew symmetric
(4) $AC - A$ is skew symmetric

Answer (3)

Sol. A is symmetric $\Rightarrow$ A^{13} is symmetric

B is skew symmetric $\Rightarrow$ B^{26} is symmetric

Now,

Let $A^{13} = P$ and B^{26} is Q

$A^{13} \cdot B^{26} - B^{26} \cdot A^{13}$

$\Rightarrow$ $PQ - QP$

Now, $(PQ - QP)^T = (PQ)^T - (QP)^T$

$= Q^T \cdot P^T - P^T \cdot Q^T$

$= QP - PQ$

$= -(PQ - QP)$

$= -\left(A^{13}.B^{26} - B^{26}.A^{13}\right)$

$\Rightarrow$ $A^{13}.B^{26} - B^{26}.A^{13}$ is skew-symmetric matrix.

9. Consider the function

$$f(x) = \begin{cases} \left(1 + |\cos x|\right)^{\frac{\lambda}{|\cos x|}} & x < \frac{\pi}{2} \\ \mu & x = \frac{\pi}{2} \\ e^{\frac{\cot 6x}{\cot 4x}} & x > \frac{\pi}{2} \end{cases}$$

(1) $\lambda = \frac{2}{3}, \mu = e^{\frac{2}{3}}$
(2) $\lambda = e^{\frac{2}{3}}, \mu = \frac{2}{3}$
(3) $\lambda = \frac{3}{2}, \mu = e^{\frac{3}{2}}$
(4) $\lambda = e^{\frac{3}{2}}, \mu = \frac{3}{2}$

Answer (1)

Sol. $\lim\limits_{x \to \frac{\pi}{2}^-} f(x) = e^{\lim\limits_{x \to \frac{\pi}{2}^-} |\cos x| \cdot \frac{\lambda}{|\cos x|}} = e^{\lambda}$

$\boxed{\mu = e^{\lambda}}$

$\lim\limits_{x \to \frac{\pi}{2}^+} f(x) = e^{\left(\lim\limits_{x \to \frac{\pi}{2}^+} \frac{\cot 6x}{\cot 4x}\right)}$

$= e^{\left(\lim\limits_{h \to 0^+} \frac{\cot 6h}{\cot 4h}\right)}$

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

$\mu = e^{\frac{2}{3}}$, $\lambda = \frac{2}{3}$

10. Two dice are rolled. If the probability of the sum of the number on dice is n, where $\sqrt{n-2}, \sqrt{3n}, n+2$ are in geometric progression, is $\frac{x}{48}$, then the value of x is

(1) 4
(2) 12
(3) 7
(4) 3

Answer (1)

Sol. As given, $\left(\sqrt{3n}\right)^2 = (n-2)(n+2)$

$\Rightarrow$ $3n = n^2 - 4$

$\Rightarrow$ $n = 4$ $\quad n = -1$ (not possible)

Favourable outcomes (1, 2) (2, 1), (2, 2)

Total outcomes = 6 × 6 = 36

Given $\frac{3}{36} = \frac{x}{48}$

$\Rightarrow$ $x = 4$

11. Let $\vec{a} = -\hat{i} - \hat{j} + \hat{k}$ such that $\vec{a} \cdot \vec{b} = 1$ and $\vec{a} \times \vec{b} = \hat{i} - \hat{j}$ then $\vec{a} - 6\vec{b}$ equals

(1) $3\left(\hat{i} + \hat{j} + \hat{k}\right)$

(2) $\hat{i} + \hat{j} + \hat{k}$

(3) $2\left(\hat{i} + \hat{j} + \hat{k}\right)$

(4) $4\left(\hat{i} + \hat{j} + \hat{k}\right)$

Answer (1)

Sol. $\left(\vec{a} \times \vec{b}\right) = \hat{i} - \hat{j}$

$\Rightarrow \ \vec{a} \times \left(\vec{a} \times \vec{b}\right) = \left(-\hat{i} - \hat{j} + \hat{k}\right) \times \left(\hat{i} - \hat{j}\right)$

$\Rightarrow \ \left(\vec{a} \cdot \vec{b}\right)\vec{a} - \left(\vec{a} \cdot \vec{a}\right)\vec{b} = \hat{i} + \hat{j} + 2\hat{k}$

$\Rightarrow \ 3\vec{b} = -2\hat{i} - 2\hat{j} - \hat{k}$

$\therefore \ \vec{a} - 6\vec{b} = 3\hat{i} + 3\hat{j} + 3\hat{k}$

$= 3\left(\hat{i} + \hat{j} + \hat{k}\right)$

12. $16\int_1^2 \frac{dx}{x^3(x^2+2)^2}$ is equal to

(1) $\frac{11}{12} + \ln 4$

(2) $\frac{11}{12} - \ln 4$

(3) $\frac{11}{6} - \ln 4$

(4) $\frac{11}{6} + \ln 4$

Answer (3)

Sol. $I = \int \frac{dx}{x^3(x^2+2)^2}$

$= \frac{1}{4}\int \frac{x}{x^2+2}\,dx + \frac{1}{4}\int \frac{x}{(x^2+2)^2}\,dx - \frac{1}{4}\int \frac{1}{x}\,dx + \frac{1}{4}\int \frac{1}{x^3}\,dx$

$= \frac{\ln(x^2+2)}{8} - \frac{\ln x}{4} - \frac{1}{8(x^2+2)} - \frac{1}{8x^3}$

$16\int_1^2 \frac{dx}{x^3(x+2)^2} = 2\ln 6 - 2\ln 3 - 4\ln 2 + \frac{11}{6}$

13. If $A = \begin{bmatrix} \frac{3}{\sqrt{10}} & \frac{1}{\sqrt{10}} \\ \frac{-1}{\sqrt{10}} & \frac{3}{\sqrt{10}} \end{bmatrix}$ and $B = \begin{bmatrix} 1 & -i \\ 0 & 1 \end{bmatrix}$

If $M = A^TBA$, then the matrix $AM^{2023}A^T$ is

(1) $\begin{bmatrix} 1 & -2023i \\ 0 & 1 \end{bmatrix}$

(2) $\begin{bmatrix} 1 & 2023i \\ 0 & 1 \end{bmatrix}$

(3) $\begin{bmatrix} 1 & -2023i \\ 0 & -1 \end{bmatrix}$

(4) $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

Answer (1)

Sol. $AA^T = I$

$M = A^TBA$

$AM^{2023}A^T$

$= A\underbrace{\left(A^TBA\right)\left(A^TBA\right)\left(A^TBA\right).....\left(A^TBA\right)}_{2023 \text{ times}}A^T$

$= B^{2023}$

$B^2 = \begin{bmatrix} 1 & -i \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & -i \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & -2i \\ 0 & 1 \end{bmatrix}$

$B^3 = \begin{bmatrix} 1 & -2i \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & -i \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & -3i \\ 0 & 1 \end{bmatrix}$

$B^{2023} = \begin{bmatrix} 1 & -2023i \\ 0 & 1 \end{bmatrix}$

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. Find the remainder when $(2023)^{2023}$ is divided by 35.

Answer (7)

Sol. $2023 \equiv -7 (\text{mod } 35)$

$(2023)^2 \equiv 14 (\text{mod } 35)$

$(2023)^4 \equiv -14 (\text{mod } 35)$

$(2023)^{16} \equiv -14 (\text{mod } 35)$

$(2023)2020 \equiv -14 (\text{mod } 35)$

and $(2023)^3 \equiv 7 (\text{mod } 35)$

$\therefore (2023)^{2023} \equiv 7 (\text{mod } 35)$

$\therefore$ remainder = 7

22. $\int_{1/3}^{3} |\ln x|\, dx = \frac{m}{n} \ln\left(\frac{n^2}{e}\right)$ then value of $m^2 + n^2 - 5$

Answer (20)

Sol. $\int_{1/3}^{1} -\ln x dx + \int_{1}^{3} \ln x dx$

$= -(x\ln x - x)\Big|_{1/3}^{1} + (x\ln x - x)\Big|_{1}^{3}$

$= \frac{2}{3} + \frac{1}{3}\ln\frac{1}{3} + 3\ln 3 - 2$

$= \frac{4}{3}(\ln 9 - \ln e)$

$= \frac{4}{3}\ln\left(\frac{3^2}{e}\right)$

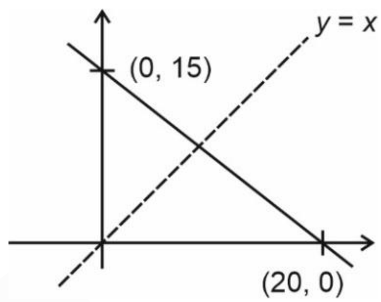
$m = 4, n = 3$

$m^2 + n^2 - 5 = 20$

23. A triangle is formed with x-axis, y-axis & line $3x + 4y = 60$. A point $P(a, b)$ lies strictly inside the triangle such that a is a positive integer and b is a multiple of 'a'. Find such number of points (a, b).

Answer (31)

Sol.



as b is multiple of a the required points will lie on line $y = kx$ ($k \in Z$)

$\therefore \quad 3x + 4kx = 60$

$\Rightarrow \quad x = \frac{60}{3+4k}$

If $k = 1$	8 integral values
$k = 2$	5 integral values
$k = 3$	3 integral values
$k = 4$	3 integral values
$k = 5$	2 integral values
$k = 6$	2 integral values
$k = 7$	1 integral values
$k = 8$	1 integral values
⋮	⋮
$k = 14$	1 integral values
$\therefore$	Total 31 points

24. If $a, b, \frac{1}{18}$ are in G.P. and $\frac{1}{10}, \frac{1}{a}, \frac{1}{b}$ are in A.P. then find value of $a + 180b$

Answer (20.00)

Sol. $b^2 = \frac{a}{18}, \frac{2}{a} = \frac{1}{10} + \frac{1}{b}$

$\Rightarrow \quad a = \frac{20b}{10+b}$

OR $18b^2 = \frac{20b}{10+b}$

$b = 0$ (rejcted)

OR $9b = \frac{10}{10+b}$

$90b + 9b^2 = 10$

$\Rightarrow \quad 9b^2 + 90b - 10 = 0$

$a + 180b = 18b^2 + 180b$

$= 20$

25. In a city, 25% of the population is smoker and a smoker has 27 times more than chance of being diagnosed with lung cancer. A person is selected at random and found to be diagnosed with lung cancer. If the probability of him being smoker is $\frac{K}{40}$, find the value of K.

Answer (36.00)

Sol. Probability of a person being smoker $= \frac{1}{4}$

Probability of a person being non smoker $= \frac{3}{4}$

$$P\left(\frac{\text{Person is smoker}}{\text{Person diagnosed with cancer}}\right) = \frac{\frac{1}{4}\cdot 27P}{\frac{1}{4}\cdot 27P + \frac{3}{4}P}$$

(P is probability that a non-smoker is diagnosed with cancer)

$= \frac{27}{30} = \frac{9}{10} = \frac{36}{40}$

26.

27.

28.

29.

30.

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