

24th Feb. 2021 | Shift - 2

PHYSICS

1. Zener breakdown occurs in a p-n junction having p and n both :

- (1) lightly doped and have wide depletion layer.
- (2) heavily doped and have narrow depletion layer.
- (3) heavily doped and have wide depletion layer.
- (4) lightly doped and have narrow depletion layer.

Ans. (2)

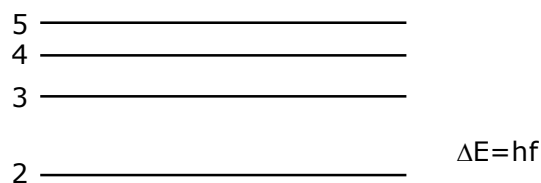
Sol. The zener breakdown occurs in the heavily doped p-n junction diode. Heavily doped p-n junction diodes have narrow depletion region.

2. According to Bohr atom model, in which of the following transitions will the frequency be maximum?

- (1) $n=2$ to $n=1$ (2) $n=4$ to $n=3$ (3) $n=5$ to $n=4$ (4) $n=3$ to $n=2$

Ans. (1)

Sol.



1 _____
f is more for transition from $n = 2$ to $n = 1$.

3. An X-ray tube is operated at 1.24 million volt. The shortest wavelength of the produced photon will be :

- (1) 10^{-2} nm (2) 10^{-3} nm (3) 10^{-4} nm (4) 10^{-1} nm

Ans. (2)

Sol. $\lambda_{\min} = \frac{hc}{eV}$
 $\lambda_{\min} = \frac{1240 \text{ nm} \cdot \text{eV}}{1.24 \times 10^6}$
 $\lambda_{\min} = 10^{-3} \text{ nm}$

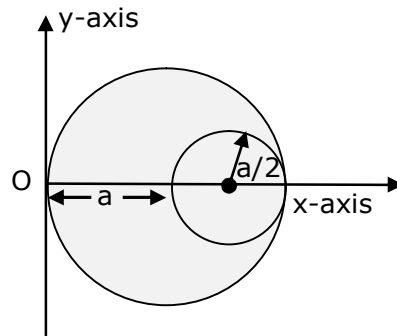
4. On the basis of kinetic theory of gases, the gas exerts pressure because its molecules:

- (1) suffer change in momentum when impinge on the walls of container.
- (2) continuously stick to the walls of container.
- (3) continuously lose their energy till it reaches wall.
- (4) are attracted by the walls of container.

Ans. (1)

Sol. On the basis of kinetic theory of gases, the gas pressure is due to the molecules suffering change in momentum when impinge on the walls of container.

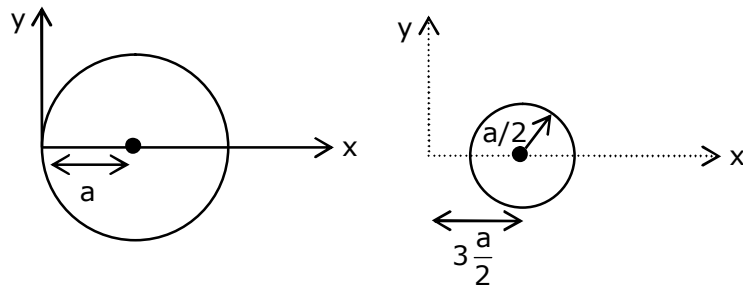
5. A circular hole of radius $\left(\frac{a}{2}\right)$ is cut out of a circular disc of radius 'a' shown in figure. The centroid of the remaining circular portion with respect to point 'O' will be :



- (1) $\frac{10}{11}a$ (2) $\frac{2}{3}a$ (3) $\frac{1}{6}a$ (4) $\frac{5}{6}a$

Ans. (4)

Sol. Let σ is the surface mass density of disc.



$$X_{\text{com}} = \frac{(\sigma \times \pi a^2 \times a) - (\sigma \frac{\pi a^2}{4} \times \frac{3a}{2})}{\sigma \pi a^2 - \frac{\sigma \pi a^2}{4}}$$

$$X_{\text{com}} = \frac{a - 3\frac{a}{8}}{1 - \frac{1}{4}}$$

$$X_{\text{com}} = \frac{\frac{5a}{8}}{\frac{3}{4}}$$

$$X_{\text{com}} = \frac{5a}{6}$$

6. Given below are two statements :
- Statement I** : PN junction diodes can be used to function as transistor, simply by connecting two diodes, back to back, which acts as the base terminal.
- Statement II** : In the study of transistor, the amplification factor β indicates ratio of the collector current to the base current.
- In the light of the above statements, choose the correct answer from the options given below.
- (1) Statement I is false but Statement II is true.
 - (2) Both Statement I and Statement II are true
 - (3) Statement I is true but Statement II is false.
 - (4) Both Statement I and Statement II are false

Ans. (1)
Sol. S-1

Statement 1 is false because in case of two discrete back to back connected diodes, there are four doped regions instead of three and there is nothing that resembles a thin base region between an emitter and a collector.

S-2

Statement-2 is true, as

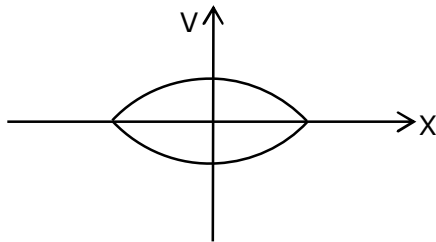
$$\beta = \frac{I_C}{I_B}$$

7. When a particle executes SHM, the nature of graphical representation of velocity as a function of displacement is :
- (1)elliptical
 - (2)parabolic
 - (3)straight line
 - (4)circular

Ans. (1)

Sol. We know that is SHM;

$$V = \omega\sqrt{A^2 - x^2}$$



elliptical

8. Match List - I with List - II.

List - I

- (a) Source of microwave frequency
- (b) Source of infrared frequency
- (c) Source of Gamma Rays
- (d) Source of X-rays

List - II

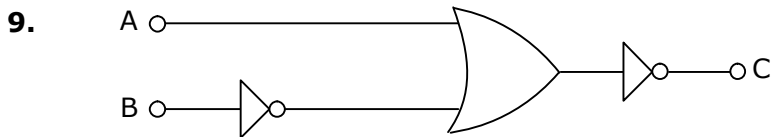
- (i) Radioactive decay of nucleus
- (ii) Magnetron
- (iii) Inner shell electrons
- (iv) Vibration of atoms and molecules
- (v) LASER
- (vi) RC circuit

Choose the correct answer from the options given below :

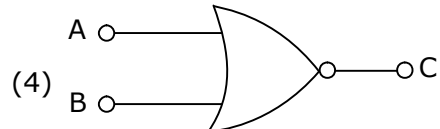
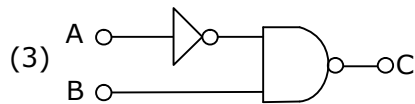
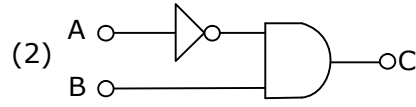
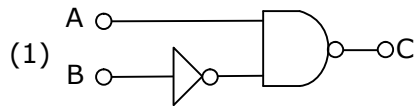
- (1) (a)-(ii),(b)-(iv),(c)-(i),(d)-(iii)
- (2) (a)-(vi),(b)-(iv),(c)-(i),(d)-(v)
- (3) (a)-(ii),(b)-(iv),(c)-(vi),(d)-(iii)
- (4) (a)-(vi),(b)-(v),(c)-(i),(d)-(iv)

Ans. (1)

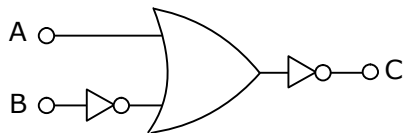
- Sol.**
- (a) Source of microwave frequency – (ii) Magnetron
 - (b) Source of infra red frequency – (iv) Vibration of atom and molecules
 - (c) Source of gamma ray – (i) Radio active decay of nucleus
 - (d) Source of X-ray – (iii) inner shell electron



The logic circuit shown above is equivalent to :



Ans. (2)
Sol.



$$C = \overline{A + \bar{B}}$$

$$C = \bar{A}.B$$

10. If the source of light used in a Young's double slit experiment is changed from red to violet:
 (1) the fringes will become brighter.
 (2) consecutive fringe lines will come closer.
 (3) the central bright fringe will become a dark fringe.
 (4) the intensity of minima will increase.

Ans. (2)

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

As $\lambda_v < \lambda_R$

$\Rightarrow \beta_v < \beta_R$

\therefore Consecutive fringe line will come closer.

\therefore (2)

11. A body weighs 49 N on a spring balance at the north pole. What will be its weight recorded on the same weighing machine, if it is shifted to the equator?

[Use $g = \frac{GM}{R^2} = 9.8 \text{ ms}^{-2}$ and radius of earth, $R = 6400 \text{ km}$.]

(1) 49 N

(2) 49.83 N

(3) 49.17 N

(4) 48.83 N

Ans. (4)

Sol. At north pole, weight

$Mg = 49$

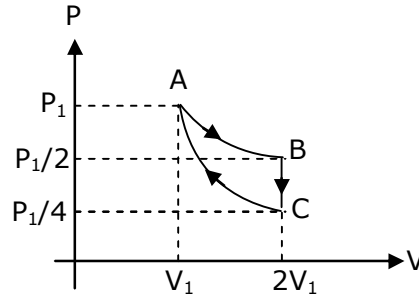
Now, at equator

$g' = g - \omega^2 R$

$\Rightarrow Mg' = M(g - \omega^2 R)$

\Rightarrow weight will be less than Mg at equator.

- 12.** If one mole of an ideal gas at (P_1, V_1) is allowed to expand reversibly and isothermally (A to B) its pressure is reduced to one-half of the original pressure (see figure). This is followed by a constant volume cooling till its pressure is reduced to one-fourth of the initial value (B→C). Then it is restored to its initial state by a reversible adiabatic compression (C to A). The net workdone by the gas is equal to :



- (1) 0 (2) $-\frac{RT}{2(\gamma-1)}$ (3) $RT \left[\ln 2 - \frac{1}{2(\gamma-1)} \right]$ (4) $RT \ln 2$

Ans. (3)

Sol. AB → Isothermal process

$$W_{AB} \rightarrow nRT \ln 2 = RT \ln 2$$

BC → Isochoric process

$$W_{BC} = 0$$

CA → Adiabatic process

$$W_{CA} = \frac{P_1 V_1 - \frac{P_1}{4} \times 2V_1}{1 - \gamma} = \frac{P_1 V_1}{2(1 - \gamma)} = \frac{RT}{2(1 - \gamma)}$$

$$W_{ABCA} = RT \ln 2 + \frac{RT}{2(1 - \gamma)}$$

$$= RT \left[\ln 2 - \frac{1}{2(\gamma - 1)} \right]$$

- 13.** The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of 'L' is 1.0 m from meter scale having a minimum division of 1 mm and time of one complete oscillation is 1.95 s measured from stopwatch of 0.01 s resolution. The percentage error in the determination of 'g' will be :

- (1) 1.33 % (2) 1.30 % (3) 1.13 % (4) 1.03 %

Ans. (3)

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

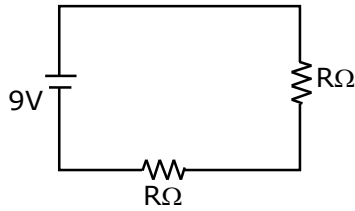
$$T^2 = 4\pi^2 \left[\frac{\ell}{g} \right]$$

$$g = 4\pi^2 \left[\frac{\ell}{T^2} \right]$$

$$\frac{\Delta g}{g} = \frac{\Delta \ell}{\ell} + \frac{2\Delta T}{T}$$

$$= \left[\frac{1\text{mm}}{1\text{m}} + \frac{2(10 \times 10^{-3})}{1.95} \right] \times 100$$

$$= 1.13 \%$$



Given : $v = 9\text{v}$

From $V = IR$

$$I = \frac{V}{R}$$

$$R_{\text{eq.}} = 2 + 2 = 4\Omega$$

$$I = \frac{9}{4} = 2.25 \text{ A}$$

- 16.** The de Broglie wavelength of a proton and α -particle are equal. The ratio of their velocities is :
 (1) 4:2 (2) 4:1 (3) 1:4 (4) 4:3

Ans. (2)

Sol. From De-broglie's wavelength :-

$$\lambda = \frac{h}{mv}$$

Given $\lambda_p = \lambda_\alpha$

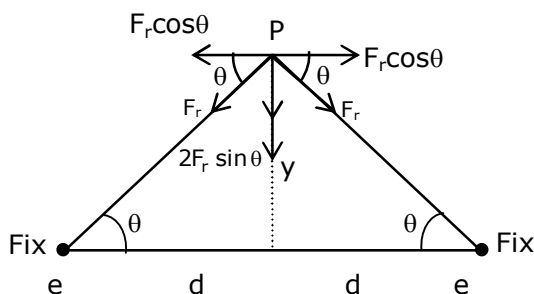
$$v \propto \frac{1}{m}$$

$$\frac{v_p}{v_\alpha} = \frac{m_\alpha}{m_p} = \frac{4m_p}{m_p} = 4$$

- 17.** Two electrons each are fixed at a distance '2d'. A third charge proton placed at the midpoint is displaced slightly by a distance x ($x \ll d$) perpendicular to the line joining the two fixed charges. Proton will execute simple harmonic motion having angular frequency:
 (m = mass of charged particle)

(1) $\left(\frac{q^2}{2\pi\epsilon_0 md^3}\right)^{\frac{1}{2}}$ (2) $\left(\frac{\pi\epsilon_0 md^3}{2q^2}\right)^{\frac{1}{2}}$ (3) $\left(\frac{2\pi\epsilon_0 md^3}{q^2}\right)^{\frac{1}{2}}$ (4) $\left(\frac{2q^2}{\pi\epsilon_0 md^3}\right)^{\frac{1}{2}}$

Ans. (1)



Sol.

Restoring force on proton :-

$$F_r = \frac{2Kq^2y}{[d^2 + y^2]^{\frac{3}{2}}}$$

$$Y \ll d$$

$$F_r = \frac{2kq^2y}{d^3} = \frac{q^2y}{2\pi\epsilon_0 d^3} = ky$$

$$K = \frac{q^2}{2\pi\epsilon_0 d^3}$$

Angular Frequency :-

$$\omega = \sqrt{\frac{k}{m}}$$

$$\omega = \sqrt{\frac{q^2}{2\pi\epsilon_0 md^3}}$$

- 18.** A soft ferromagnetic material is placed in an external magnetic field. The magnetic domains :
- (1) decrease in size and changes orientation.
 - (2) may increase or decrease in size and change its orientation.
 - (3) increase in size but no change in orientation.
 - (4) have no relation with external magnetic field.

Ans. (2)

Sol. Atoms of ferromagnetic material in unmagnetised state form domains inside the ferromagnetic material. These domains have large magnetic moment of atoms. In the absence of magnetic field, these domains have magnetic moment in different directions. But when the magnetic field is applied, domains aligned in the direction of the field grow in size and those aligned in the direction opposite to the field reduce in size and also its orientation changes.

- 19.** Which of the following equations represents a travelling wave?

- (1) $y = Ae^{-x^2}(vt + \theta)$
- (2) $y = A \sin(15x - 2t)$
- (3) $y = Ae^x \cos(\omega t - \theta)$
- (4) $y = A \sin x \cos \omega t$

Ans. (2)

Sol. $Y = F(x, t)$

For travelling wave y should be linear function of x and t and they must exist as $(x \pm vt)$

$Y = A \sin(15x - 2t) \rightarrow$ linear function in x and t .

- 20.** A particle is projected with velocity v_0 along x -axis. A damping force is acting on the particle which is proportional to the square of the distance from the origin i.e. $ma = -\alpha x^2$. The distance at which the particle stops :

- (1) $\left(\frac{2v_0}{3\alpha}\right)^{\frac{1}{3}}$
- (2) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{2}}$
- (3) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{3}}$
- (4) $\left(\frac{2v_0^2}{3\alpha}\right)^{\frac{1}{2}}$

Ans. Bonus

Sol. $a = \frac{v dv}{dx}$

$$\int_{v_i}^{v_f} v dv = \int_{x_i}^{x_f} a dx$$

Given :- $v_i = v_0$
 $v_f = 0$
 $x_i = 0$
 $x_f = x$

From Damping Force : $a = -\frac{\alpha x^2}{m}$

$$\int_{v_0}^0 v dv = -\int_0^x \frac{\alpha x^2}{m} dx$$

$$-\frac{v_0^2}{2} = \frac{-\alpha}{m} \left[\frac{x^3}{3} \right]$$

$$x = \left[\frac{3mv_0^2}{2\alpha} \right]^{\frac{1}{3}}$$

- 1.** A uniform metallic wire is elongated by 0.04 m when subjected to a linear force F. The elongation, if its length and diameter is doubled and subjected to the same force will be _____ cm.

Ans. 2



$$y = \frac{F/A}{\Delta l / l}$$

$$\Rightarrow \frac{F}{A} = y \frac{\Delta l}{l}$$

$$\Rightarrow \frac{F}{A} = y \times \frac{0.04}{l} \quad \dots(1)$$

When length & diameter is doubled.

$$\Rightarrow \frac{F}{4A} = y \times \frac{\Delta l}{2l} \quad \dots(2)$$

$$(1) \div (2)$$

$$\frac{F/A}{F/4A} = \frac{y \times \frac{0.04}{l}}{y \times \frac{\Delta l}{2l}}$$

$$4 = \frac{0.04 \times 2}{\Delta l}$$

$$\Delta l = 0.02$$

$$\Delta l = 2 \times 10^{-2}$$

$$\therefore x = 2$$

$$\text{MOI of AB about P : } I_{ABP} = \frac{M \left(\frac{\ell}{6}\right)^2}{12}$$

MOI of AB about O,

$$I_{ABO} = \left[\frac{M \left(\frac{\ell}{6}\right)^2}{12} + \frac{M \left(\frac{\ell \sqrt{3}}{6 \cdot 2}\right)^2}{12} \right]$$

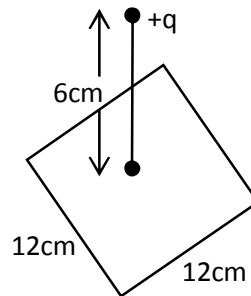
$$I_{\text{Hexagon}_0} = 6I_{ABO} = M \left[\frac{\ell^2}{12 \times 36} + \frac{\ell^2}{36} \times \frac{3}{4} \right]$$

$$= \frac{6}{100} \left[\frac{24 \times 24}{12 \times 36} + \frac{24 \times 24}{36} \times \frac{3}{4} \right]$$

$$= 0.8 \text{ kgm}^2$$

$$= 8 \times 10^{-2} \text{ kg/m}^2$$

5. A point charge of $+12 \mu\text{C}$ is at a distance 6 cm vertically above the centre of a square of side 12 cm as shown in figure. The magnitude of the electric flux through the square will be _____ $\times 10^3 \text{ Nm}^2/\text{C}$.



Ans. 226

Sol. Using Gauss law, it is a part of cube of side 12 cm and charge at centre so;

$$\phi = \frac{Q}{6\epsilon_0} = \frac{12\mu\text{C}}{6\epsilon_0} = 2 \times 4\pi \times 9 \times 10^9 \times 10^{-6}$$

$$= 226 \times 10^3 \text{ Nm}^2/\text{C}$$

6. Two solids A and B of mass 1 kg and 2 kg respectively are moving with equal linear momentum. The ratio of their kinetic energies $(\text{K.E.})_A : (\text{K.E.})_B$ will be $\frac{A}{1}$. So the value of A will be _____.

Ans. 2

Sol. Given that, $\frac{M_1}{M_2} = \frac{1}{2}$

$$\text{Also, } p_1 = p_2 = p$$

$$\Rightarrow M_1 V_1 = M_2 V_2 = p$$

Also, we know that

$$K = \frac{p^2}{2M} \Rightarrow K_1 = \frac{p^2}{2M_1} \text{ \& } \Rightarrow K_2 = \frac{p^2}{2M_2}$$

$$\Rightarrow \frac{K_1}{K_2} = \frac{p^2}{2M_1} \times \frac{2M_2}{p^2} \Rightarrow \frac{K_1}{K_2} = \frac{M_2}{M_1} = \frac{2}{1}$$

$$\Rightarrow \frac{A}{1} = \frac{2}{1} \Rightarrow \therefore A = 2$$

7. The root mean square speed of molecules of a given mass of a gas at 27°C and 1 atmosphere pressure is 200 ms⁻¹. The root mean square speed of molecules of the gas at 127°C and 2 atmosphere pressure is $\frac{x}{\sqrt{3}}$ ms⁻¹. The value of x will be _____.

Ans. 400 m/s

Sol. $V_{\text{rms}} = \sqrt{\frac{3RT_1}{M_0}}$

$$200 = \sqrt{\frac{3R \times 300}{M_0}} \quad \dots(1)$$

Also, $\frac{x}{\sqrt{3}} = \sqrt{\frac{3R \times 400}{M_0}} \quad \dots(2)$

(1) ÷ (2)

$$\frac{200}{x / \sqrt{3}} = \sqrt{\frac{300}{400}} = \sqrt{\frac{3}{4}}$$

$$\Rightarrow x = 400 \text{ m/s}$$

8. A series LCR circuit is designed to resonate at an angular frequency $\omega_0 = 10^5 \text{ rad/s}$. The circuit draws 16W power from 120 V source at resonance. The value of resistance 'R' in the circuit is _____ Ω.

Ans. 900

Sol. $P = \frac{V^2}{R}$

$$16 = \frac{120^2}{R} \Rightarrow R = \frac{14400}{16}$$

$$\Rightarrow R = 900 \Omega$$

9. An electromagnetic wave of frequency 3 GHz enters a dielectric medium of relative electric permittivity 2.25 from vacuum. The wavelength of this wave in that medium will be _____ × 10⁻² cm.

Ans. 667

Sol. $f = 3\text{GHz}$, $\epsilon_r = 2.25$

$$v = \lambda f \Rightarrow \lambda = \frac{v}{f}$$

$$C = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

$$v = \frac{1}{\sqrt{\mu_0 \mu_r \epsilon_0 \epsilon_r}} \Rightarrow \lambda = \frac{1}{f \cdot \sqrt{\mu_0 \epsilon_0} \cdot \sqrt{\mu_r \epsilon_r} \cdot f}$$

$$\Rightarrow \lambda = \frac{C}{f \cdot \sqrt{\mu_r} \cdot \sqrt{\epsilon_r}} \Rightarrow \lambda = \frac{3 \times 10^8}{3 \times 10^9 \times \sqrt{1} \times \sqrt{2.25}}$$

$$\Rightarrow \lambda = 667 \times 10^{-2} \text{ cm}$$

10. A signal of 0.1 kW is transmitted in a cable. The attenuation of cable is -5 dB per km and cable length is 20 km. the power received at receiver is 10^{-x}W . The value of x is _____.

$$[\text{Gain in dB} = 10 \log_{10} \left(\frac{P_0}{P_i} \right)]$$

Ans. 8

Sol. Power of signal transmitted : $P_i = 0.1 \text{ Kw} = 100\text{w}$

Rate of attenuation = -5 dB/Km

Total length of path = 20 km

Total loss suffered = $-5 \times 20 = -100\text{dB}$

$$\text{Gain in dB} = 10 \log_{10} \frac{P_0}{P_i}$$

$$-100 = 10 \log_{10} \frac{P_0}{P_i}$$

$$\Rightarrow \log_{10} \frac{P_i}{P_0} = 10$$

$$\Rightarrow \log_{10} \frac{P_i}{P_0} = \log_{10} 10^{10}$$

$$\Rightarrow \frac{100}{P_0} = 10^{10}$$

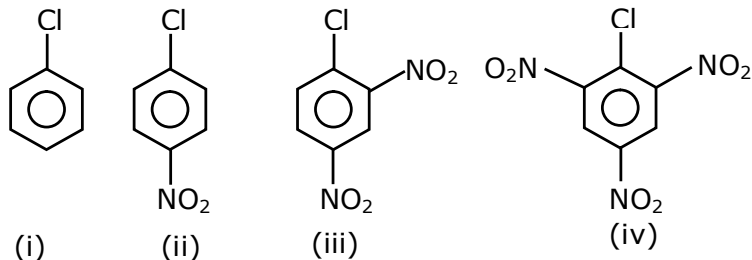
$$\Rightarrow P_0 = \frac{1}{10^8} = 10^{-8}$$

$$\therefore x = 8$$

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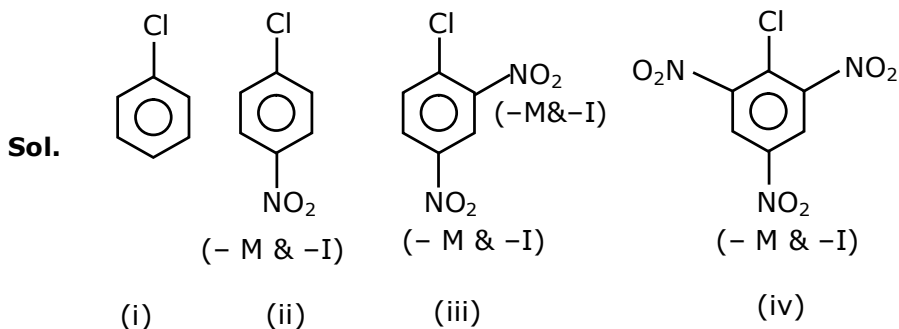
CHEMISTRY

1. The correct order of the following compounds showing increasing tendency towards nucleophilic substitution reaction is :



- (1) (iv) < (i) < (iii) < (ii) (2) (iv) < (i) < (ii) < (iii)
 (3) (i) < (ii) < (iii) < (iv) (4) (iv) < (iii) < (ii) < (i)

Ans. (3)



Reactivity \propto - m group present at O/P position.

2. Match List-I with List-II

List- I	List-II
(Metal)	(Ores)
(a) Aluminium	(i) Siderite
(b) Iron	(ii) Calamine
(c) Copper	(iii) Kaolinite
(d) Zinc	(iv) Malachite

Choose the correct answer from the options given below :

- (1) (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i) (2) (a)-(i), (b)-(ii), (c)-(iii), (d)-(iv)
 (3) (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii) (4) (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

Ans. (3)

Sol.

Siderite	FeCO ₃
Calamine	ZnCO ₃
Kaolinite	Si ₂ Al ₂ O ₅ (OH) ₄ or Al ₂ O ₃ .2SiO ₂ .2H ₂ O
Malachite	CuCO ₃ .Cu(OH) ₂

3. Match List-I with List-II

List- I	List-II
(Salt)	(Flame colour wavelength)
(a) LiCl	(i) 455.5 nm
(b) NaCl	(ii) 970.8 nm
(c) RbCl	(iii) 780.0 nm
(d) CsCl	(iv) 589.2 nm

Choose the correct answer from the options given below :

- (1) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii) (2) (a)-(ii), (b)-(iv), (c)-(iii), (d)-(i)
(3) (a)-(iv), (b)-(ii), (c)-(iii), (d)-(i) (4) (a)-(i), (b)-(iv), (c)-(ii), (d)-(iii)

Ans. (2)

Sol. Range of visible region : - 390nm – 760nm

VIBGYOR
Violet Red

LiCl Crimson Red
NaCl Golden yellow
RbCl Violet
CsCl Blue

So LiCl Which is crimson have wave length closed to red in the spectrum of visible region which is as per given data is.

4. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : Hydrogen is the most abundant element in the Universe, but it is not the most abundant gas in the troposphere.

Reason R : Hydrogen is the lightest element.

In the light of the above statements, choose the correct answer from the given below

- (1) A is false but R is true
(2) Both A and R are true and R is the correct explanation of A
(3) A is true but R is false
(4) Both A and R are true but R is NOT the correct explanation of A

Ans. (2)

Sol. Hydrogen is most abundant element in universe because all luminous body of universe i.e. stars & nebulae are made up of hydrogen which acts as nuclear fuel & fusion reaction is responsible for their light.

5. Given below are two statements :

Statement I : The value of the parameter "Biochemical Oxygen Demand (BOD)" is important for survival of aquatic life.

Statement II : The optimum value of BOD is 6.5 ppm.

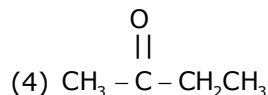
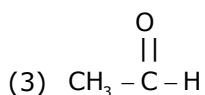
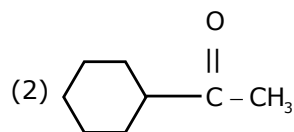
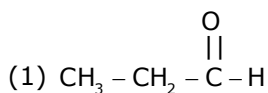
In the light of the above statements, choose the most appropriate answer from the options given below.

- (1) Both Statement I and Statement II are false
- (2) Statement I is false but Statement II is true
- (3) Statement I is true but Statement II is false
- (4) Both Statement I and Statement II are true

Ans. (3)

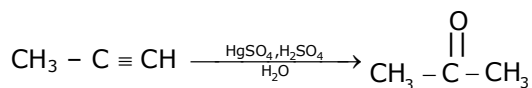
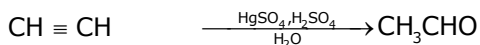
Sol. For survival of aquatic life dissolved oxygen is responsible its optimum limit 6.5 ppm and optimum limit of BOD ranges from 10-20 ppm & BOD stands for biochemical oxygen demand.

6. Which one of the following carbonyl compounds cannot be prepared by addition of water on an alkyne in the presence of HgSO_4 and H_2SO_4 ?



Ans. (1)

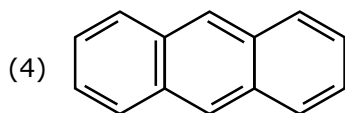
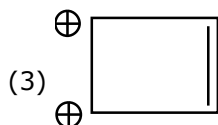
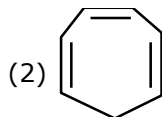
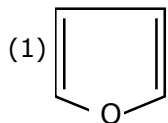
Sol. Reaction of Alkyne with HgSO_4 & H_2SO_4 follow as



Hence, by this process preparation of $\text{CH}_3\text{CH}_2\text{CHO}$

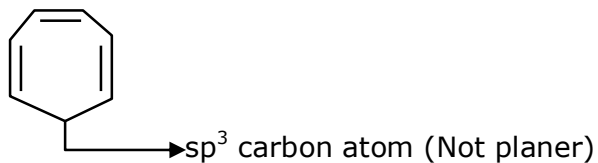
Can't possible.

7. Which one of the following compounds is non-aromatic ?



Ans. (2)

Sol.



Hence It is non-aromatic.

8. The incorrect statement among the following is :

- (1) VOSO_4 is a reducing agent (2) Red colour of ruby is due to the presence of CO^{3+}
(3) Cr_2O_3 is an amphoteric oxide (4) RuO_4 is an oxidizing agent

Ans. (2)

Sol. Red colour of ruby is due to presence of CrO_3 or Cr^{+6} not CO^{3+}

9. According to Bohr's atomic theory :

(A) Kinetic energy of electron is $\propto \frac{Z^2}{n^2}$

(B) The product of velocity (v) of electron and principal quantum number (n). 'vn' $\propto Z^2$.

(C) Frequency of revolution of electron in an orbit is $\propto \frac{Z^3}{n^3}$.

(D) Coulombic force of attraction on the electron is $\propto \frac{Z^3}{n^4}$.

Choose the most appropriate answer from the options given below:

(1) (C) only

(2) (A) and (D) only

(3) (A) only

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

Ans. (2) Correction on NTA

Sol. (A) $KE = -TE = 13.6 \times \frac{Z^2}{n^2} \text{ eV}$

$$KE \propto \frac{Z^2}{n^2}$$

(B) $V = 2.188 \times 10^6 \times \frac{Z}{n} \text{ m/sec.}$

So, $Vn \propto Z$

(C) Frequency = $\frac{V}{2\pi r}$

So, $F \propto \frac{Z^2}{n^3}$ $\left[\because r \propto \frac{n^2}{Z} \text{ and } v \propto \frac{Z}{n} \right]$

(D) Force $\propto \frac{Z}{r^2}$

So, $F \propto \frac{Z^3}{n^4}$

So, only statement (A) is correct

10. Match List-I with List-II

List- I

List-II

(a) Valium

(i) Antifertility drug

(b) Morphine

(ii) Pernicious anaemia

(c) Norethindrone

(iii) Analgesic

(d) Vitamin B₁₂

(iv) Tranquilizer

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

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

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

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

Ans. (4)

Sol. (a) Valium

(iv) Tranquilizer

(b) Morphine

(iii) Analgesic

(c) Norethindrone

(i) Antifertility drug

(d) Vitamin B₁₂

(ii) Pernicious anaemia

11. The Correct set from the following in which both pairs are in correct order of melting point is :

- (1) LiF > LiCl ; NaCl > MgO (2) LiF > LiCl ; MgO > NaCl
 (3) LiCl > LiF ; NaCl > MgO (4) LiCl > LiF ; MgO > NaCl

Ans. (2)

Sol. Generally

$$\text{M.P.} \propto \text{Lattice energy} = \frac{KQ_1Q_2}{r^+ + r^-}$$

\propto (packing efficiency)

12. The calculated magnetic moments (spin only value) for species $[\text{FeCl}_4]^{2-}$, $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$ and MnO_4^{2-} respectively are :

- (1) 5.92, 4.90 and 0 BM (2) 5.82, 0 and 0 BM
 (3) 4.90, 0 and 1.73 BM (4) 4.90, 0 and 2.83 BM

Ans. (3)

Sol. $[\text{FeCl}_4]^{2-}$ $\text{Fe}^{2+} 3d^6 \rightarrow 4$ unpaired electron. as Cl^- in a weak field ligand.

$$\mu_{\text{spin}} = \sqrt{24} \text{ BM}$$

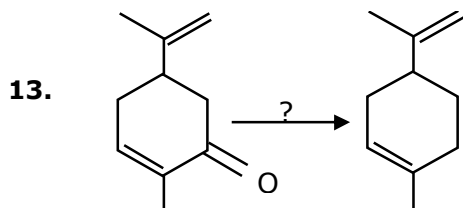
$$= 4.9 \text{ BM}$$

$[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$ $\text{Co}^{3+} 3d^6 \rightarrow$ for Co^{3+} with coordination no. 6 $\text{C}_2\text{O}_4^{2-}$ is strong field ligand & causes pairing & hence no. unpaired electron

$$\mu_{\text{spin}} = 0$$

$[\text{MnO}_4]^{2-}$ Mn^{+6} it has one unpaired electron.

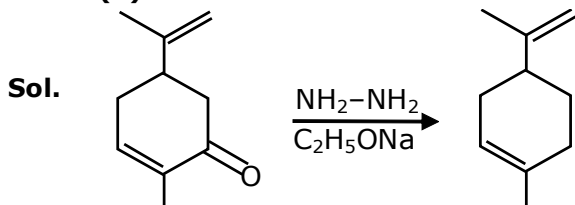
$$\mu_{\text{spin}} = \sqrt{3} \text{ BM}$$



Which of the following reagent is suitable for the preparation of the product in the above reaction.

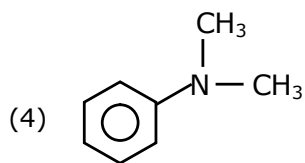
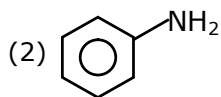
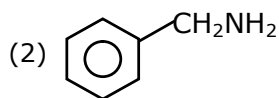
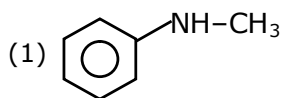
- (1) Red P + Cl_2 (2) $\text{NH}_2\text{-NH}_2/\text{C}_2\text{H}_5\text{ONa}^{\ominus\oplus}$
 (3) Ni/H_2 (4) NaBH_4

Ans. (2)

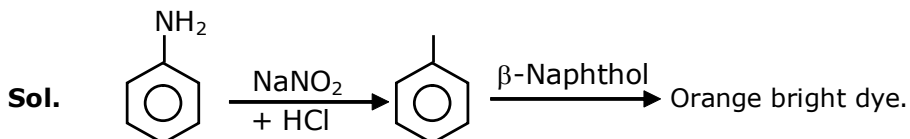


It is wolf-kishner reduction of carbonyl compounds.

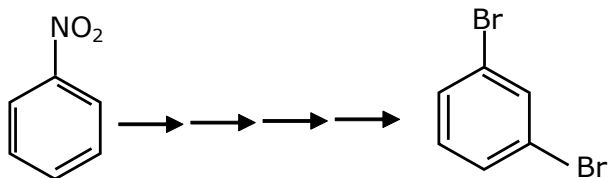
14. The diazonium salt of which of the following compounds will form a coloured dye on reaction with β -Naphthol in NaOH ?



Ans. (3)

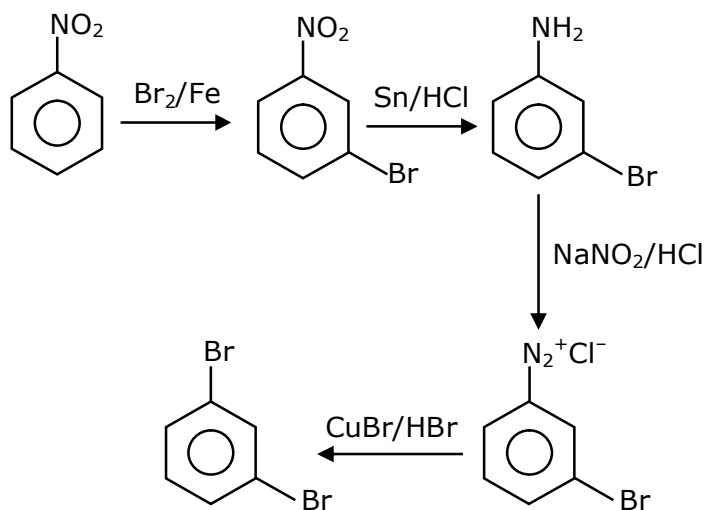


15. What is the correct sequence of reagents used for converting nitrobenzene into m-dibromobenzene ?



- (1) $\text{Sn/HCl} \rightarrow / \text{Br}_2 \rightarrow / \text{NaNO}_2 \rightarrow / \text{NaBr} \rightarrow$
(2) $\text{Sn/HCl} \rightarrow / \text{KBr} \rightarrow / \text{Br}_2 \rightarrow / \text{H}^+ \rightarrow$
(3) $\text{NaNO}_2 \rightarrow / \text{HCl} \rightarrow / \text{KBr} \rightarrow / \text{H}^+ \rightarrow$
(4) $\text{Br}_2/\text{Fe} \rightarrow / \text{Sn/HCl} \rightarrow / \text{NaNO}_2/\text{HCl} \rightarrow / \text{CuBr/HBr} \rightarrow$

Ans. (4)



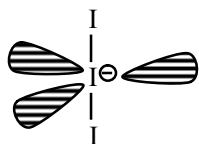
Sol.

16. The correct shape and I-I-I bond angles respectively in I_3^- ion are :

- (1) Trigonal planar; 120°
- (2) Distorted trigonal planar; 135° and 90°
- (3) Linear; 180°
- (4) T-shaped; 180° and 90°

Ans. (3)

Sol. I_3^- sp^3d hybridisation (2BP + 3L.P.) Linear geometry



17. What is the correct order of the following elements with respect to their density ?

- (1) $\text{Cr} < \text{Fe} < \text{Co} < \text{Cu} < \text{Zn}$
- (2) $\text{Cr} < \text{Zn} < \text{Co} < \text{Cu} < \text{Fe}$
- (3) $\text{Zn} < \text{Cu} < \text{Co} < \text{Fe} < \text{Cr}$
- (4) $\text{Zn} < \text{Cr} < \text{Fe} < \text{Co} < \text{Cu}$

Ans. (4)

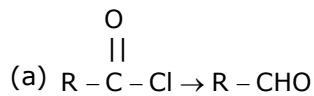
Sol. Fact Based

Density depend on many factor like atomic mass. atomic radius and packing efficiency.

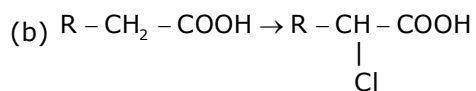
18. Match List-I and List-II.

List - I

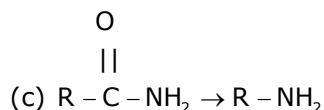
List-II



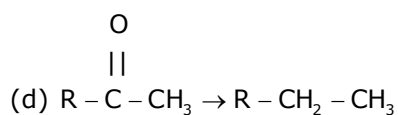
(i) Br_2/NaOH



(ii) $\text{H}_2/\text{Pd-BaSO}_4$



(iii) Zn(Hg)/Conc. HCl



(iv) $\text{Cl}_2/\text{Red P, H}_2\text{O}$

Choose the correct answer from the options given below :

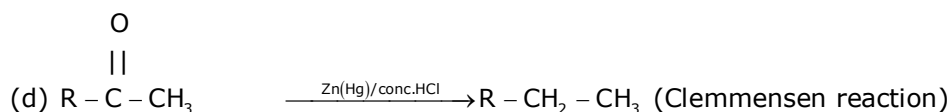
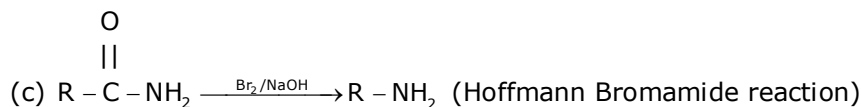
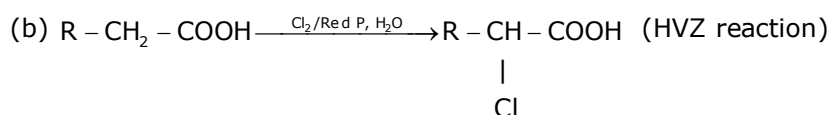
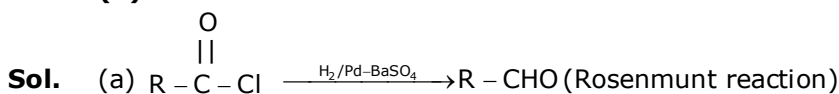
(1) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)

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

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

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

Ans. (4)



19. In polymer Buna-S ; 'S' stands for :

(1) Styrene

(2) Sulphur

(3) Strength

(4) Sulphonation

Ans. (1)

Sol. Buna-S is the co-polymer of buta- 1, 3 diene & styrene.

20. Most suitable salt which can be used for efficient clotting of blood will be :

(1) $\text{Mg(HCO}_3)_2$

(2) FeSO_4

(3) NaHCO_3

(4) FeCl_3

Ans. (4)

Sol. Blood is a negative sol. According to hardy-Schulz's rule, the cation with high charge has high coagulation power. Hence, FeCl_3 can be used for clotting blood.

Section -B

1. The magnitude of the change in oxidising power of the $\text{MnO}_4^- / \text{Mn}^{2+}$ couple is $x \times 10^{-4}$ V, if the H^+ concentration is decreased from 1M to 10^{-4} M at 25°C. (Assume concentration of MnO_4^- and Mn^{2+} to be same on change in H^+ concentration). The value of x is _____.

(Rounded off to the nearest integer)

$$\left[\text{Given : } \frac{2303RT}{F} = 0.059 \right]$$

Ans. 3776

Sol. $5e^- + \text{MnO}_4^- + 8\text{H}^+ \longrightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$

$$Q = \frac{[\text{Mn}^{2+}]}{[\text{H}^+]^8 [\text{MnO}_4^-]} \Rightarrow E_1 = E^\circ - \frac{0.059}{5} \log(Q_1)$$

$$E_2 = E^\circ - \frac{0.059}{5} \log(Q_2) \Rightarrow E_2 - E_1 = \frac{0.059}{5} \log\left(\frac{Q_1}{Q_2}\right)$$

$$= \frac{0.059}{5} \log\left\{ \frac{[\text{H}^+]_{\text{II}}}{[\text{H}^+]_{\text{I}}} \right\}^8 \Rightarrow = \frac{0.059}{5} \log\left(\frac{10^{-4}}{1}\right)^8$$

$$(E_2 - E_1) = \frac{0.059}{5} \times (-32) \Rightarrow |(E_2 - E_1)| = 32 \times \frac{0.059}{5} = x \times 10^{-4}$$

$$= \frac{32 \times 590}{5} \times 10^{-4} = x \times 10^{-4} \Rightarrow = 3776 \times 10^{-4} \quad x = 3776$$

2. Among the following allotropic forms of sulphur, the number of allotropic forms, which will show paramagnetism is _____.

(1) α -sulphur (2) β -sulphur (3) S_2 -form

Ans. (1)

Sol. S_2 is like O_2 i.e paramagnetic as per molecular orbital theory.

3. C_6H_6 freezes at 5.5°C. The temperature at which a solution of 10 g of C_4H_{10} in 200 g of C_6H_6 freeze is _____°C. (The molal freezing point depression constant of C_6H_6 is) 5.12°C/m)

Ans. 1

Sol. $\Delta T_f = i \times K_f \times m$

$$= (1) \times 5.12 \times \frac{10/58}{200} \times 1000 \quad \Rightarrow \quad \Delta T_f = \frac{5.12 \times 50}{58} = 4.414$$

$$T_{f(\text{solution})} = T_{K(\text{solvent})} - \Delta T_f$$

$$= 5.5 - 4.414$$

$$= 1.086^\circ\text{C}$$

$$\approx 1.09^\circ\text{C} = 1 \text{ (nearest integer)}$$

- 4.** The volume occupied by 4.75 g of acetylene gas at 50°C and 740 mmHg pressure is _____L.
(Rounded off to the nearest integer)
(Given $R = 0.0826 \text{ L atm K}^{-1} \text{ mol}^{-1}$)

Ans. 5

Sol. $T = 50^\circ\text{C} = 323.15 \text{ K}$

$$P = 740 \text{ mm of Hg} = \frac{740}{760} \text{ atm}$$

$$V = ?$$

$$\text{moles (n)} = \frac{4.75}{26}$$

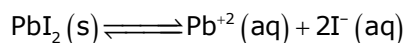
$$V = \frac{4.75}{26} \times \frac{0.0821 \times 323.15}{740} \times 760$$

$$V = 4.97 \approx 5 \text{ Lit}$$

- 5.** The solubility product of PbI_2 is 8.0×10^{-9} . The solubility of lead iodide in 0.1 molar solution of lead nitrate is $x \times 10^{-6} \text{ mol/L}$. The value of x is _____ (Rounded off to the nearest integer)
[Given $\sqrt{2} = 1.41$]

Ans. 141

Sol. $K_{sp}(\text{PbI}_2) = 8 \times 10^{-9}$



$$S + 0.1 \quad 2S$$

$$K_{sp} = [\text{Pb}^{+2}][\text{I}^{-}]^2$$

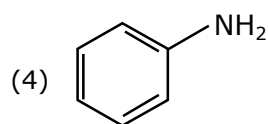
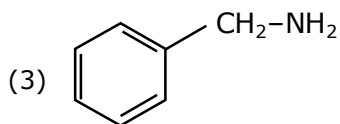
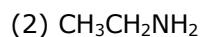
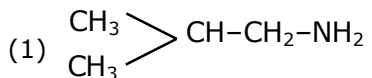
$$8 \times 10^{-9} = (S + 0.1)(2S)^2 \Rightarrow 8 \times 10^{-9} \approx 0.1 \times 4S^2$$

$$\Rightarrow S^2 = 2 \times 10^{-8}$$

$$S = 1.414 \times 10^{-4} \text{ mol/Lit}$$

$$= x \times 10^{-6} \text{ mol/Lit} \quad \therefore x = 141.4 \approx 141$$

6. The total number of amines among the following which can be synthesized by Gabriel synthesis is _____.

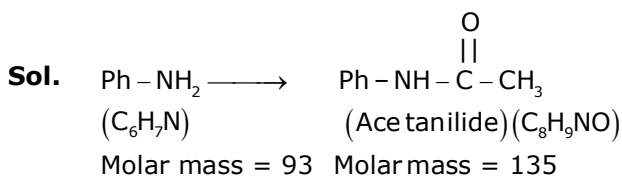


Ans. (3)

Sol. Only aliphatic amines can be prepared by Gabriel synthesis.

7. 1.86 g of aniline completely reacts to form acetanilide. 10% of the product is lost during purification. Amount of acetanilide obtained after purification (in g) is $____ \times 10^{-2}$.

Ans. 243



93 g Aniline produce 135 g acetanilide

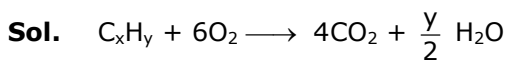
$$1.86 \text{ g produce } \frac{135 \times 1.86}{93} = 2.70 \text{ g}$$

At 10% loss, 90% product will be formed after purification.

$$\therefore \text{Amount of product obtained} = \frac{2.70 \times 90}{100} = 2.43 \text{ g} = 243 \times 10^{-2} \text{ g}$$

8. The formula of a gaseous hydrocarbon which requires 6 times of its own volume of O_2 for complete oxidation and produces 4 times its own volume of CO_2 is C_xH_y . The value of y is

Ans. 8



Applying POAC on 'O' atoms

$$6 \times 2 = 4 \times 2 + \frac{y}{2} \times 1$$

$$\frac{y}{2} = 4 \Rightarrow y = 8$$

9. Sucrose hydrolyses in acid solution into glucose and fructose following first order rate law with a half-life of 3.33 h at 25°C. After 9h, the fraction of sucrose remaining is f. The value of $\log_{10} \left(\frac{1}{f} \right)$ is _____ $\times 10^{-2}$ (Rounded off to the nearest integer)
[Assume: $\ln 10 = 2.303$, $\ln 2 = 0.693$]

Ans. 81

Sol. Sucrose $\xrightarrow{\text{Hydrolysis}}$ Glucose + Fructose

$$t_{1/2} = 3.33\text{h} = \frac{10}{3}\text{h} \quad \Rightarrow \quad C_t = \frac{C_0}{2^{t/t_{1/2}}}$$

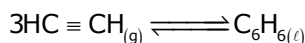
$$\text{Fraction of sucrose remaining} = f = \frac{C_t}{C_0} = \frac{1}{2^{t/t_{1/2}}}$$

$$\frac{1}{f} = 2^{t/t_{1/2}}$$

$$\log(1/f) = \log(2^{t/t_{1/2}}) = \frac{t}{t_{1/2}} \log(2)$$

$$= \frac{9}{10/3} \times 0.3 = \frac{8.1}{10} = 0.81 = x \times 10^{-2} \quad x = 81$$

10. Assuming ideal behaviour, the magnitude of $\log K$ for the following reaction at 25°C is $x \times 10^{-1}$. The value of x is _____. (Integer answer)



[Given : $\Delta_f G^\circ(\text{HC} \equiv \text{CH}) = -2.04 \times 10^5 \text{ J mol}^{-1}$; $\Delta_f G^\circ(\text{C}_6\text{H}_6) = -1.24 \times 10^5 \text{ J mol}^{-1}$;
 $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$]

Ans. 855

Sol. $3\text{HC} \equiv \text{CH}_{(g)} \rightleftharpoons \text{C}_6\text{H}_6(\ell)$

$$\Delta G_r^\circ = \Delta G_f^\circ[\text{C}_6\text{H}_6(\ell)] - 3 \times \Delta G_f^\circ[\text{HC} \equiv \text{CH}]$$

$$= [-1.24 \times 10^5 - 3 \times (-2.04 \times 10^5)]$$

$$= 4.88 \times 10^5 \text{ J/mol}$$

$$\Delta G_r^\circ = -RT \ln(K_{\text{eq}})$$

$$\log(K_{\text{eq}}) = \frac{-\Delta G_r^\circ}{2.303RT}$$

$$= \frac{-4.88 \times 10^5}{2.303 \times 8.314 \times 298}$$

$$= -8.55 \times 10^1 = 855 \times 10^{-1}$$

24th Feb. 2021 | Shift - 2

MATHEMATICS

1. Let $a, b \in \mathbb{R}$. If the mirror image of the point $P(a, 6, 9)$ with respect to the line $\frac{x-3}{7} = \frac{y-2}{5} = \frac{z-1}{-9}$ is $(20, b, -a-9)$, then $|a+b|$ is equal to :

- (1) 86 (2) 88 (3) 84 (4) 90

Ans. (2)

Sol. $P(a, 6, 9), Q(20, b, -a-9)$

$$\text{mid point of } PQ = \left(\frac{a+20}{2}, \frac{b+6}{2}, -\frac{a}{2} \right)$$

lie on line

$$\frac{\frac{a+20}{2}-3}{7} = \frac{\frac{b+6}{2}-2}{5} = \frac{-\frac{a}{2}-1}{-9}$$

$$\frac{a+20-6}{14} = \frac{b+6-4}{10} = \frac{-a-2}{-18}$$

$$\frac{a+14}{14} = \frac{a+2}{18}$$

$$18a + 252 = 14a + 28$$

$$4a = -224$$

$$\boxed{a = -56}$$

$$\frac{b+2}{10} = \frac{a+2}{18}$$

$$\frac{b+2}{10} = \frac{-54}{18}$$

$$\frac{b+2}{10} = -3 \Rightarrow b = -32$$

$$|a+b| = |-56-32| = 88$$

2. Let f be a twice differentiable function defined on \mathbb{R} such that $f(0) = 1, f'(0) = 2$ and $f'(x) \neq 0$

for all $x \in \mathbb{R}$. If $\begin{vmatrix} f(x) & f'(x) \\ f'(x) & f''(x) \end{vmatrix} = 0$, for all $x \in \mathbb{R}$ then the value of $f(1)$ lies in the interval:

- (1) (9, 12) (2) (6, 9) (3) (3, 6) (4) (0, 3)

Ans. (2)

Sol. Given $f(x) f''(x) - (f'(x))^2 = 0$

$$\text{Let } h(x) = \frac{f(x)}{f'(x)}$$

$$\Rightarrow h'(x) = 0 \quad \Rightarrow h(x) = k$$

$$\Rightarrow \frac{f(x)}{f'(x)} = k \quad \Rightarrow f(x) = k f'(x)$$

$$\Rightarrow f(0) = k f'(0) \quad \Rightarrow 1 = k(2) \Rightarrow k = \frac{1}{2}$$

$$\text{Now } f(x) = \frac{1}{2} f'(x) \Rightarrow \int 2 dx = \int \frac{f'(x)}{f(x)} dx$$

$$\Rightarrow 2x = \ln|f(x)| + C$$

$$\text{As } f(0) = 1 \Rightarrow C = 0$$

$$\Rightarrow 2x = \ln|f(x)| \Rightarrow f(x) = \pm e^{2x}$$

$$\text{As } f(0) = 1 \Rightarrow f(x) = e^{2x} \Rightarrow f(1) = e^2$$

3. A possible value of $\tan\left(\frac{1}{4} \sin^{-1} \frac{\sqrt{63}}{8}\right)$ is:

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

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

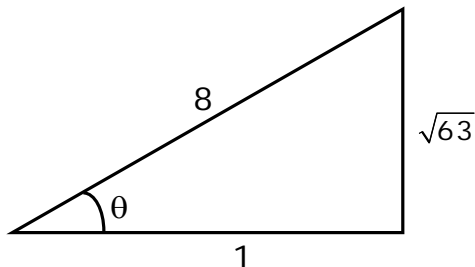
(3) $\sqrt{7} - 1$

(4) $2\sqrt{2} - 1$

Ans. (2)

Sol. $\tan\left(\frac{1}{4} \sin^{-1} \frac{\sqrt{63}}{8}\right)$

$$\text{Let } \sin^{-1}\left(\frac{\sqrt{63}}{8}\right) = \theta \quad \sin \theta = \frac{\sqrt{63}}{8}$$



$$\cos \theta = \frac{1}{8}$$

$$2 \cos^2 \frac{\theta}{2} - 1 = \frac{1}{8}$$

$$\cos^2 \frac{\theta}{2} = \frac{9}{16}$$

$$\cos \frac{\theta}{2} = \frac{3}{4}$$

$$\frac{1 - \tan^2 \frac{\theta}{4}}{1 + \tan^2 \frac{\theta}{4}} = \frac{3}{4}$$

$$\tan \frac{\theta}{4} = \frac{1}{\sqrt{7}}$$

4. The probability that two randomly selected subsets of the set $\{1,2,3,4,5\}$ have exactly two elements in their intersection, is:

(1) $\frac{65}{2^7}$

(2) $\frac{135}{2^9}$

(3) $\frac{65}{2^8}$

(4) $\frac{35}{2^7}$

Ans. (2)

Sol. Required probability

$$= \frac{{}^5C_2 \times 3^3}{4^5}$$

$$= \frac{10 \times 27}{2^{10}} = \frac{135}{2^9}$$

5. The vector equation of the plane passing through the intersection of the planes $\vec{r} \cdot (\hat{i} + \hat{j} + \hat{k}) = 1$ and $\vec{r} \cdot (\hat{i} - 2\hat{j}) = -2$, and the point $(1,0,2)$ is :

(1) $\vec{r} \cdot (\hat{i} - 7\hat{j} + 3\hat{k}) = \frac{7}{3}$

(2) $\vec{r} \cdot (\hat{i} + 7\hat{j} + 3\hat{k}) = 7$

(3) $\vec{r} \cdot (3\hat{i} + 7\hat{j} + 3\hat{k}) = 7$

(4) $\vec{r} \cdot (\hat{i} + 7\hat{j} + 3\hat{k}) = \frac{7}{3}$

Ans. (2)

Sol. Plane passing through intersection of plane is

$$\{\vec{r} \cdot (\hat{i} + \hat{j} + \hat{k}) - 1\} + \lambda \{\vec{r} \cdot (\hat{i} - 2\hat{j}) + 2\} = 0$$

Passes through $\hat{i} + 2\hat{k}$, we get

$$(3 - 1) + \lambda(1 + 2) = 0 \Rightarrow \lambda = -\frac{2}{3}$$

Hence, equation of plane is $3\{\vec{r} \cdot (\hat{i} + \hat{j} + \hat{k}) - 1\} - 2\{\vec{r} \cdot (\hat{i} - 2\hat{j}) + 2\} = 0$

$$\Rightarrow \vec{r} \cdot (\hat{i} + 7\hat{j} + 3\hat{k}) = 7$$

6. If P is a point on the parabola $y = x^2 + 4$ which is closest to the straight line $y = 4x - 1$, then the co-ordinates of P are :

(1) $(-2, 8)$

(2) $(1, 5)$

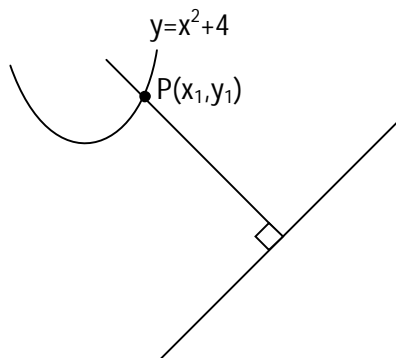
(3) $(3, 13)$

(4) $(2, 8)$

Ans. (4)

Sol. $\frac{dy}{dx} \Big|_P = 4$

$$\therefore 2x_1 = 4$$



$$\Rightarrow x_1 = 2$$

\therefore Point will be $(2, 8)$

7. Let a, b, c be in arithmetic progression. Let the centroid of the triangle with vertices $(a, c), (2, b)$ and (a, b) be $\left(\frac{10}{3}, \frac{7}{3}\right)$. If α, β are the roots of the equation $ax^2 + bx + 1 = 0$, then the value of $\alpha^2 + \beta^2 - \alpha\beta$ is:

(1) $\frac{71}{256}$ (2) $-\frac{69}{256}$ (3) $\frac{69}{256}$ (4) $-\frac{71}{256}$

Ans. (4)

Sol. $2b = a + c$

$$\frac{2a+2}{3} = \frac{10}{3} \text{ and } \frac{2b+c}{3} = \frac{7}{3}$$

$$a = 4, \left. \begin{array}{l} 2b+c=7 \\ 2b-c=4 \end{array} \right\}, \text{ solving}$$

$$b = \frac{11}{4}$$

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

$$\therefore \text{ Quadratic Equation is } 4x^2 + \frac{11}{4}x + 1 = 0$$

$$\therefore \text{ The value of } (\alpha + \beta)^2 - 3\alpha\beta = \frac{121}{256} - \frac{3}{4} = -\frac{71}{256}$$

8. The value of the integral, $\int_1^3 [x^2 - 2x - 2] dx$, where $[x]$ denotes the greatest integer less than or equal to x , is:

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

Ans. (3)

Sol. $I = \int_1^3 -3dx + \int_1^3 [(x-1)^2] dx$

Put $x - 1 = t$; $dx = dt$

$$I = (-6) + \int_0^2 [t^2] dt$$

$$I = -6 + \int_0^1 0 dt + \int_1^{\sqrt{2}} 1 dt + \int_{\sqrt{2}}^{\sqrt{3}} 2 dt + \int_{\sqrt{3}}^2 3 dt$$

$$I = -6 + (\sqrt{2} - 1) + 2\sqrt{3} - 2\sqrt{2} + 6 - 3\sqrt{3}$$

$$I = -1 - \sqrt{2} - \sqrt{3}$$

9. Let $f : \mathbf{R} \rightarrow \mathbf{R}$ be defined as

$$f(x) = \begin{cases} -55x, & \text{if } x < -5 \\ 2x^3 - 3x^2 - 120x, & \text{if } -5 \leq x \leq 4 \\ 2x^3 - 3x^2 - 36x - 336, & \text{if } x > 4 \end{cases}$$

Let $A = \{x \in \mathbf{R} : f \text{ is increasing}\}$. Then A is equal to :

(1) $(-5, -4) \cup (4, \infty)$

(2) $(-5, \infty)$

(3) $(-\infty, -5) \cup (4, \infty)$

(4) $(-\infty, -5) \cup (-4, \infty)$

Ans. (1)

Sol. $f(x) = \begin{cases} -55 & ; \quad x < -5 \\ 6(x^2 - x - 20) & ; \quad -5 < x < 4 \\ 6(x^2 - x - 6) & ; \quad x > 4 \end{cases}$

$$f(x) = \begin{cases} -55 & ; \quad x < -5 \\ 6(x-5)(x+4) & ; \quad -5 < x < 4 \\ 6(x-3)(x+2) & ; \quad x > 4 \end{cases}$$

Hence, $f(x)$ is monotonically increasing in interval $(-5, -4) \cup (4, \infty)$

10. If the curve $y = ax^2 + bx + c, x \in \mathbf{R}$, passes through the point (1,2) and the tangent line to this curve at origin is $y = x$, then the possible values of a,b,c are :

(1). $a = 1, b = 1, c = 0$

(2) $a = -1, b = 1, c = 1$

(3) $a = 1, b = 0, c = 1$

(4) $a = \frac{1}{2}, b = \frac{1}{2}, c = 1$

Ans. (1)

Sol. $2 = a + b + c \dots\dots(i)$

$$\frac{dy}{dx} = 2ax + b \Rightarrow \left. \frac{dy}{dx} \right|_{(0,0)} = 1$$

$\Rightarrow b = 1 \Rightarrow a + c = 1$

(0,0) lie on curve

$\therefore c = 0, a = 1$

11. The negation of the statement

$\sim p \wedge (p \vee q)$ is :

- (1) $\sim p \wedge q$ (2) $p \wedge \sim q$ (3) $\sim p \vee q$ (4) $p \vee \sim q$

Ans. (4)

Sol.

p	q	$\sim p$	$p \vee q$	$(\sim p) \wedge (p \vee q)$	$\sim q$	$p \vee \sim q$
T	T	F	T	F	F	T
T	F	F	T	F	T	T
F	T	T	T	T	F	F
F	F	T	F	F	T	T

$\therefore \sim p \wedge (p \vee q) \equiv p \vee \sim q$

12. For the system of linear equations:

$$x - 2y = 1, x - y + kz = -2, ky + 4z = 6, k \in \mathbf{R}$$

consider the following statements:

- (A) The system has unique solution if $k \neq 2, k \neq -2$.
 (B) The system has unique solution if $k = -2$.
 (C) The system has unique solution if $k = 2$.
 (D) The system has no-solution if $k = 2$.
 (E) The system has infinite number of solutions if $k \neq -2$.

Which of the following statements are correct?

- (1) (B) and (E) only (2) (C) and (D) only
 (3) (A) and (D) only (4) (A) and (E) only

Ans. (3)

Sol. $x - 2y + 0.z = 1$

$x - y + kz = -2$

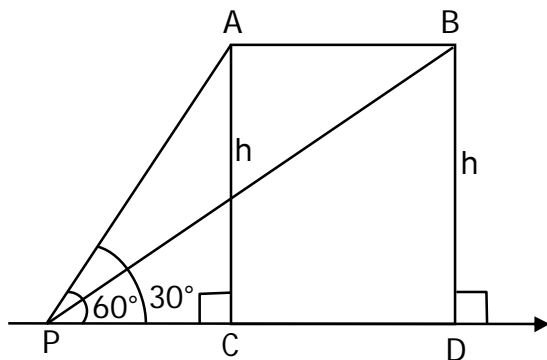
$0.x + ky + 4z = 6$

14. The angle of elevation of a jet plane from a point A on the ground is 60° . After a flight of 20 seconds at the speed of 432 km/ hour, the angle of elevation changes to 30° . If the jet plane is flying at a constant height, then its height is:

- (1) $1200\sqrt{3}\text{m}$ (2) $1800\sqrt{3}\text{m}$ (3) $3600\sqrt{3}\text{m}$ (4) $2400\sqrt{3}\text{m}$

Ans. (1)

Sol.



$$v = 432 \times \frac{1000}{60 \times 60} \text{ m/sec} = 120 \text{ m/sec}$$

$$\text{Distance } AB = v \times 20 = 2400 \text{ meter}$$

In ΔPAC

$$\tan 60^\circ = \frac{h}{PC} \Rightarrow PC = \frac{h}{\sqrt{3}}$$

In ΔPBD

$$\tan 30^\circ = \frac{h}{PD} \Rightarrow PD = \sqrt{3}h$$

$$PD = PC + CD$$

$$\sqrt{3}h = \frac{h}{\sqrt{3}} + 2400 \Rightarrow \frac{2h}{\sqrt{3}} = 2400$$

$$h = 1200 \sqrt{3} \text{ meter}$$

15. For the statements p and q , consider the following compound statements:

(a) $(\sim q \wedge (p \rightarrow q)) \rightarrow \sim p$

(b) $((p \vee q) \wedge \sim p) \rightarrow p$

Then which of the following statements is correct?

- (1) (a) is a tautology but not (b) (2) (a) and (b) both are not tautologies.
 (3) (a) and (b) both are tautologies. (4) (b) is a tautology but not (a).

Ans. (3)

	p	q	$\sim q$	$p \rightarrow q$	$\sim q \wedge (p \rightarrow q)$	$\sim p$	$(\sim q) \wedge (p \rightarrow q) \rightarrow \sim p$
Sol. (a)	T	T	F	T	F	F	T
	T	F	T	F	F	F	T
	F	T	F	T	F	T	T
	F	F	T	T	T	T	T

(a) is tautologies

	p	q	$p \vee q$	$\sim p$	$(p \vee q) \wedge \sim p$	$((p \vee q) \wedge \sim p) \rightarrow q$
(b)	T	T	T	F	F	T
	T	F	T	F	F	T
	F	T	T	T	T	T
	F	F	F	T	F	T

(b) is tautologies

\therefore a & b are both tautologies.

16. Let A and B be 3×3 real matrices such that A is symmetric matrix and B is skew-symmetric matrix. Then the system of linear equations $(A^2 B^2 - B^2 A^2)X = O$, where X is a 3×1 column matrix of unknown variables and O is a 3×1 null matrix, has :

- (1) a unique solution (2) exactly two solutions
 (3) infinitely many solutions (4) no solution

Ans. (3)

Sol. $A^T = A, B^T = -B$

Let $A^2B^2 - B^2A^2 = P$

$$P^T = (A^2B^2 - B^2A^2)^T = (A^2B^2)^T - (B^2A^2)^T$$

$$= (B^2)^T (A^2)^T - (A^2)^T (B^2)^T$$

$$= B^2A^2 - A^2B^2$$

$\Rightarrow P$ is skew-symmetric matrix

$$\begin{bmatrix} 0 & a & b \\ -a & 0 & c \\ -b & -c & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\therefore ay + bz = 0 \quad \dots(1)$$

$$-ax + cz = 0 \quad \dots(2)$$

$$-bx - cy = 0 \quad \dots(3)$$

From equation 1,2,3

$$\Delta = 0 \text{ \& } \Delta_1 = \Delta_2 = \Delta_3 = 0$$

\therefore equation have infinite number of solution

17. If $n \geq 2$ is a positive integer, then the sum of the series

${}^{n+1}C_2 + 2({}^2C_2 + {}^3C_2 + {}^4C_2 + \dots + {}^nC_2)$ is :

$$(1) \frac{n(n+1)^2(n+2)}{12}$$

$$(2) \frac{n(n-1)(2n+1)}{6}$$

$$(3) \frac{n(n+1)(2n+1)}{6}$$

$$(4) \frac{n(2n+1)(3n+1)}{6}$$

Ans. (3)

Sol. ${}^2C_2 = {}^3C_3$

$$S = {}^3C_3 + {}^3C_2 + \dots + {}^nC_2 = {}^{n+1}C_3$$

$$\therefore {}^nC_r + {}^nC_{r-1} = {}^{n+1}C_r$$

$$\therefore {}^{n+1}C_2 + {}^{n+1}C_3 + {}^{n+1}C_3 = {}^{n+2}C_3 + {}^{n+1}C_3$$

$$= \frac{(n+1)!}{3!(n-1)!} + \frac{(n+1)!}{3!(n-2)!}$$

$$= \frac{(n+2)(n+1)n}{6} + \frac{(n+1)(n)(n-1)}{6} = \frac{n(n+1)(2n+1)}{6}$$

18. If a curve $y = f(x)$ passes through the point $(1,2)$ and satisfies $x \frac{dy}{dx} + y = bx^4$, then for what value of $b, \int_1^2 f(x)dx = \frac{62}{5}$?
- (1) 5 (2) $\frac{62}{5}$ (3) $\frac{31}{5}$ (4) 10

Ans. (4)

Sol. $\frac{dy}{dx} + \frac{y}{x} = bx^3$, I.F. = $e^{\int \frac{dx}{x}} = x$

$\therefore yx = \int bx^4 dx = \frac{bx^5}{5} + C$

Passes through $(1,2)$, we get

$2 = \frac{b}{5} + C$ (i)

Also, $\int_1^2 \left(\frac{bx^4}{5} + \frac{c}{x} \right) dx = \frac{62}{5}$

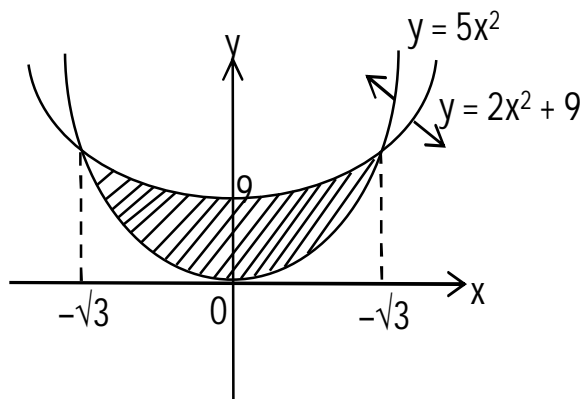
$\Rightarrow \frac{b}{25} \times 32 + C \ln 2 - \frac{b}{25} = \frac{62}{5} \Rightarrow C = 0$ & $b = 10$

19. The area of the region : $R = \{(x, y) : 5x^2 \leq y \leq 2x^2 + 9\}$ is:

- (1) $9\sqrt{3}$ square units (2) $12\sqrt{3}$ square units (3) $11\sqrt{3}$ square units (4) $6\sqrt{3}$ square units

Ans. (2)

Sol.



Required area

$$\begin{aligned} &= 2 \int_0^{\sqrt{3}} (2x^2 + 9 - 5x^2) dx \\ &= 2 \int_0^{\sqrt{3}} (9 - 3x^2) dx \\ &= 2 [9x - x^3]_0^{\sqrt{3}} = 12\sqrt{3} \end{aligned}$$

20. Let $f(x)$ be a differentiable function defined on $[0,2]$ such that $f'(x) = f'(2-x)$ for all $x \in (0,2)$, $f(0) = 1$ and $f(2) = e^2$. Then the value of $\int_0^2 f(x) dx$ is:

- (1) $1 + e^2$ (2) $1 - e^2$ (3) $2(1 - e^2)$ (4) $2(1 + e^2)$

Ans. (1)

Sol. $f'(x) = f'(2-x)$

On integrating both side $f(x) = -f(2-x) + c$

put $x = 0$

$$f(0) + f(2) = c \quad \Rightarrow c = 1 + e^2$$

$$\Rightarrow f(x) + f(2-x) = 1 + e^2 \dots\dots(i)$$

$$I = \int_0^2 f(x) dx = \int_0^1 \{f(x) + f(2-x)\} dx = (1 + e^2)$$

Section B

1. The number of the real roots of the equation $(x+1)^2 + |x-5| = \frac{27}{4}$ is _____.

Ans. 2

Sol. $x \geq 5$

$$(x+1)^2 + (x-5) = \frac{27}{4}$$

$$\Rightarrow x^2 + 3x - 4 = \frac{27}{4}$$

$$\Rightarrow x^2 + 3x - \frac{43}{4} = 0$$

$$\Rightarrow 4x^2 + 12x - 43 = 0$$

$$x = \frac{-12 \pm \sqrt{144 + 688}}{8}$$

$$x = \frac{-12 \pm \sqrt{832}}{8} = \frac{-12 \pm 28.8}{8}$$

$$= \frac{-3 \pm 7.2}{2}$$

$$= \frac{-3 + 7.2}{2}, \frac{-3 - 7.2}{2} \text{ (Therefore no solution)}$$

For $x \leq 5$

$$(x+1)^2 - (x-5) = \frac{27}{4}$$

$$x^2 + x + 6 - \frac{27}{4} = 0$$

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

$$x = \frac{-4 \pm \sqrt{16 + 48}}{8}$$

$$x = \frac{-4 \pm 8}{8} \Rightarrow x = -\frac{12}{8}, \frac{4}{8}$$

\therefore 2 Real Root's

2. The students S_1, S_2, \dots, S_{10} are to be divided into 3 groups A, B and C such that each group has at least one student and the group C has at most 3 students. Then the total number of possibilities of forming such groups is_____.

Ans. 31650

Sol.

$$C \rightarrow 1 \quad 9 \begin{bmatrix} A \\ B \end{bmatrix}$$

$$C \rightarrow 2 \quad 8 \begin{bmatrix} A \\ B \end{bmatrix}$$

$$C \rightarrow 3 \quad 7 \begin{bmatrix} A \\ B \end{bmatrix}$$

$$= {}^{10}C_1 [2^9 - 2] + {}^{10}C_2 [2^8 - 2] + {}^{10}C_3 [2^7 - 2]$$

$$\begin{aligned}
&= 2^7 [{}^{10}C_1 \times 4 + {}^{10}C_2 \times 2 + {}^{10}C_3] - 20 - 90 - 240 \\
&= 128 [40 + 90 + 120] - 350 \\
&= (128 \times 250) - 350 \\
&= 10[3165] = 31650
\end{aligned}$$

3. If $a + \alpha = 1, b + \beta = 2$ and $af(x) + \alpha f\left(\frac{1}{x}\right) = bx + \frac{\beta}{x}, x \neq 0$, then the value of the expression

$$\frac{f(x) + f\left(\frac{1}{x}\right)}{x + \frac{1}{x}} \text{ is } \underline{\hspace{2cm}}.$$

Ans. 2

Sol. $af(x) + \alpha f\left(\frac{1}{x}\right) = bx + \frac{\beta}{x}$ (i)

$$x \rightarrow \frac{1}{x}$$

$$af\left(\frac{1}{x}\right) + \alpha f(x) = \frac{b}{x} + \beta x$$
(ii)

(i) + (ii)

$$(a + \alpha) \left[f(x) + f\left(\frac{1}{x}\right) \right] = \left(x + \frac{1}{x} \right) (b + \beta)$$

$$\frac{f(x) + f\left(\frac{1}{x}\right)}{x + \frac{1}{x}} = \frac{2}{1} = 2$$

4. If the variance of 10 natural numbers $1, 1, 1, \dots, 1, k$ is less than 10, then the maximum possible value of k is _____.

Ans. 11

Sol. $\sigma^2 = \frac{\sum x^2}{n} - \left(\frac{\sum x}{n}\right)^2$

$$\sigma^2 = \frac{(9+k^2)}{10} - \left(\frac{9+k}{10}\right)^2 < 10$$

$$(90 + k^2) 10 - (81 + k^2 + 8k) < 1000$$

$$90 + 10k^2 - k^2 - 18k - 81 < 1000$$

$$9k^2 - 18k + 9 < 1000$$

$$(k-1)^2 < \frac{1000}{9} \Rightarrow k-1 < \frac{10\sqrt{10}}{3}$$

$$k < \frac{10\sqrt{10}}{3} + 1$$

Maximum integral value of k = 11

5. Let λ be an integer. If the shortest distance between the lines $x - \lambda = 2y - 1 = -2z$ and

$x = y + 2\lambda = z - \lambda$ is $\frac{\sqrt{7}}{2\sqrt{2}}$, then the value of $|\lambda|$ is

Ans. 1

Sol. $\frac{x-\lambda}{1} = \frac{y-\frac{1}{2}}{\frac{1}{2}} = \frac{z}{-\frac{1}{2}}$

$$\frac{x-\lambda}{2} = \frac{y-\frac{1}{2}}{1} = \frac{z}{-1} \quad \dots(1)$$

$$\text{Point on line} = \left(\lambda, \frac{1}{2}, 0\right)$$

$$\frac{x}{1} = \frac{y+2\lambda}{1} = \frac{z-\lambda}{1} \quad \dots(2)$$

$$\text{Point on line} = (0, -2\lambda, \lambda)$$

$$\text{Distance between skew lines} = \frac{[\vec{a}_2 - \vec{a}_1 \quad \vec{b}_1 \quad \vec{b}_2]}{|\vec{b}_1 \times \vec{b}_2|}$$

$$\begin{vmatrix} \lambda & \frac{1}{2} + 2\lambda & -\lambda \\ 2 & 1 & -1 \\ 1 & 1 & 1 \end{vmatrix}$$

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 1 & -1 \\ 1 & 1 & 1 \end{vmatrix}$$

$$= \frac{\left| -5\lambda - \frac{3}{2} \right|}{\sqrt{14}} = \frac{\sqrt{7}}{2\sqrt{2}} \text{ (given)}$$

$$= |10\lambda + 3| = 7 \Rightarrow \lambda = -1$$

$$\Rightarrow |\lambda| = 1$$

6. Let $i = \sqrt{-1}$. If $\frac{(-1+i\sqrt{3})^{21}}{(1-i)^{24}} + \frac{(1+i\sqrt{3})^{21}}{(1+i)^{24}} = k$, and $n = [k]$ be the greatest integral part of $|k|$.

Then $\sum_{j=0}^{n+5} (j+5)^2 - \sum_{j=0}^{n+5} (j+5)$ is equal to_____.

Ans. 310

Sol.
$$\frac{\left(2e^{\frac{i2\pi}{3}}\right)^{21}}{\left(\sqrt{2}e^{-\frac{i\pi}{4}}\right)^{24}} + \frac{\left(2e^{\frac{i\pi}{3}}\right)^{21}}{\left(\sqrt{2}e^{\frac{i\pi}{4}}\right)^{24}}$$

$$\Rightarrow \frac{2^{21} \cdot e^{i14\pi}}{2^{12} \cdot e^{-i6\pi}} + \frac{2^{21} (e^{i7\pi})}{2^{12} (e^{i6\pi})}$$

$$\Rightarrow 2^9 e^{i(20\pi)} + 2^9 e^{i\pi}$$

$$\Rightarrow 2^9 + 2^9(-1) = 0$$

$$n = 0$$

$$\sum_{j=0}^5 (j+5)^2 - \sum_{j=0}^5 (j+5)$$

$$\begin{aligned} &\Rightarrow [5^2 + 6^2 + 7^2 + 8^2 + 9^2 + 10^2] - [5 + 6 + 7 + 8 + 9 + 10] \\ &\Rightarrow [(1^2 + 2^2 + \dots + 10^2) - (1^2 + 2^2 + 3^2 + 4^2)] - [(1 + 2 + 3 + \dots + 10) - (1 + 2 + 3 + 4)] \\ &\Rightarrow (385 - 30) - [55 - 10] \\ &\Rightarrow 355 - 45 \Rightarrow 310 \text{ ans.} \end{aligned}$$

7. Let a point P be such that its distance from the point (5,0) is thrice the distance of P from the point (-5,0). If the locus of the point P is a circle of radius r, then $4r^2$ is equal to

Ans. 56.25

Sol. Let P(h,k)

Given

$$PA = 3PB$$

$$PA^2 = 9PB^2$$

$$\Rightarrow (h-5)^2 + k^2 = 9[(h+5)^2 + k^2]$$

$$\Rightarrow 8h^2 + 8k^2 + 100h + 200 = 0$$

\therefore Locus

$$x^2 + y^2 + \left(\frac{25}{2}\right)x + 25 = 0$$

$$\therefore c \equiv \left(\frac{-25}{4}, 0\right)$$

$$\therefore r^2 = \left(\frac{-25}{4}\right)^2 - 25$$

$$= \frac{625}{16} - 25$$

$$= \frac{225}{16}$$

$$\therefore 4r^2 = 4 \times \frac{225}{16} = \frac{225}{4} = 56.25$$

8. For integers n and r , let $\binom{n}{r} = \begin{cases} {}^n C_r, & \text{if } n \geq r \geq 0 \\ 0, & \text{otherwise} \end{cases}$

The maximum value of k for which the sum

$$\sum_{i=0}^k \binom{10}{i} \binom{15}{k-i} + \sum_{i=0}^{k+1} \binom{12}{i} \binom{13}{k+1-i}$$
 exists, is equal to _____.

Ans. 12

Sol. $(1+x)^{10} = {}^{10}C_0 + {}^{10}C_1x + {}^{10}C_2x^2 + \dots + {}^{10}C_{10}x^{10}$

$$(1+x)^{15} = {}^{15}C_0 + {}^{15}C_1x + \dots + {}^{15}C_{k-1}x^{k-1} + {}^{15}C_kx^k + {}^{15}C_{k+1}x^{k+1} + \dots + {}^{15}C_{15}x^{15}$$

$$\sum_{i=0}^k ({}^{10}C_i)({}^{15}C_{k-i}) = {}^{10}C_0 \cdot {}^{15}C_k + {}^{10}C_1 \cdot {}^{15}C_{k-1} + \dots + {}^{10}C_k \cdot {}^{15}C_0$$

Coefficient of x_k in $(1+x)^{25}$
 $= {}^{25}C_k$

$$\sum_{i=0}^{k+1} ({}^{12}C_i)({}^{13}C_{k+1-i}) = {}^{12}C_0 \cdot {}^{13}C_{k+1} + {}^{12}C_1 \cdot {}^{13}C_k + \dots + {}^{12}C_{k+1} \cdot {}^{13}C_0$$

Coefficient of x^{k+1} in $(1+x)^{25}$
 $= {}^{25}C_{k+1}$
 ${}^{25}C_k + {}^{25}C_{k+1} = {}^{26}C_{k+1}$

For maximum value

$$k+1 = 13$$

$$k = 12$$

9. The sum of first four terms of a geometric progression (G.P.) is $\frac{65}{12}$ and the sum of their respective reciprocals is $\frac{65}{18}$. If the product of first three terms of the G.P. is 1, and the third term is α , then 2α is _____.

Ans. 3

Sol. a, ar, ar^2, ar^3

$$a + ar + ar^2 + ar^3 = \frac{65}{12} \quad \dots\dots\dots(1)$$

$$\frac{1}{a} + \frac{1}{ar} + \frac{1}{ar^2} + \frac{1}{ar^3} = \frac{65}{18}$$

$$\frac{1}{a} \left(\frac{r^3 + r^2 + r + 1}{r^3} \right) = \frac{65}{18} \quad \dots\dots\dots(2)$$

$$\frac{(i)}{(ii)}, a^2 r^3 = \frac{18}{12} = \frac{3}{2}$$

$$a^3 r^3 = 1 \Rightarrow a \left(\frac{3}{2} \right) = 1 \Rightarrow a = \frac{2}{3}$$

$$\frac{4}{9} r^3 = \frac{3}{2} \Rightarrow r^3 = \frac{3^3}{2^3} \Rightarrow r = \frac{3}{2}$$

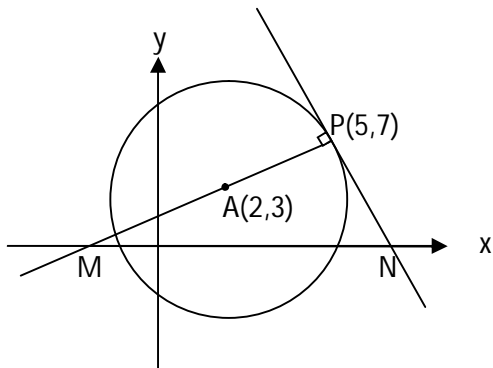
$$\alpha = ar^2 = \frac{2}{3} \cdot \left(\frac{3}{2} \right)^2 = \frac{3}{2}$$

$$2\alpha = 3$$

10. If the area of the triangle formed by the positive x-axis, the normal and the tangent to the circle $(x-2)^2 + (y-3)^2 = 25$ at the point $(5,7)$ is A, then $24A$ is equal to_____.

Ans. 1225

Sol.



Equation of normal at P

$$(y - 7) = \left(\frac{7 - 3}{5 - 2} \right) (x - 5)$$

$$3y - 21 = 4x - 20$$

$$\Rightarrow 4x - 3y + 1 = 0 \quad \dots\dots\dots(i)$$

$$\Rightarrow M \left(-\frac{1}{4}, 0 \right)$$

Equation of tangent at P

$$(y - 7) = -\frac{3}{4}(x - 5)$$

$$4y - 28 = -3x + 15$$

$$\Rightarrow 3x + 4y = 43 \quad \dots\dots\dots(ii)$$

$$\Rightarrow N\left(\frac{43}{3}, 0\right)$$

$$\text{Hence ar } (\Delta PMN) = \frac{1}{2} \times MN \times 7$$

$$\lambda = \frac{1}{2} \times \frac{175}{12} \times 7$$

$$\Rightarrow 24\lambda = 1225$$