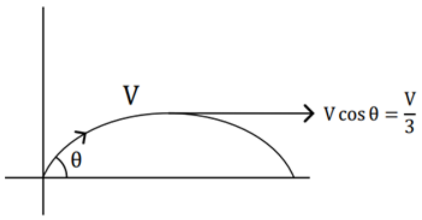
KEAM 2023 - PAPER I

1. A projectile is thrown at a speed V and at an angle θ with the horizontal. If the speed at its maximum height is $\frac{V}{3}$, then the value of $\tan\theta$ is :

(A) $\sqrt{3}$ (B) $\frac{1}{\sqrt{3}}$
(C) $2\sqrt{2}$ (D) 3
(E) $3\sqrt{3}$

Ans:C

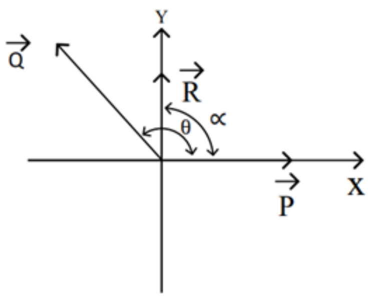


$$v\cos\theta = \frac{v}{3}$$
$$\cos\theta = \frac{1}{3}$$
$$\tan\theta = 2\sqrt{2}$$

2. Consider a vector addition $\vec{P} + \vec{Q} = \vec{R}$. If $\vec{P} = |\vec{P}|\hat{i}, |\vec{Q}| = 10$ and $\vec{R} = 3|\vec{P}|\hat{j}$, then $|\vec{P}|$ is :

(A) $\sqrt{10}$ (B) 30
(C) $\sqrt{30}$ (D) $2\sqrt{10}$
(E) $2\sqrt{20}$

Ans:A



$$\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}; \alpha = 90^\circ$$
$$\tan\alpha = \infty$$
$$P + Q\cos\theta = 0$$
$$\cos\theta = \frac{P}{-Q} = \frac{P}{-10}$$
$$R^2 = P^2 + Q^2 + 2PQ\cos\theta$$
$$9P^2 = P^2 + 100 + 2 \times P \times 10\frac{P}{-10}$$
$$= \mathrm{P}^2 + 100 - 2\mathrm{P}^2$$
$$10\mathrm{P}^2 - 100$$
$$\mathrm{P}^2 = 10$$

3. A car is moving with an initial speed of 5 m/s. A constant breaking force is applied and the car is brought to rest in a distance of 10 m. What is the average speed of the car during the deceleration process?

(A) 1 m/s (B) 2.5 m/s
(C) 4 m/s (D) 5 m/s
(E) 7 m/s

Ans:B

Since car is applied with constant breaking force, it experiences uniform retardation $V_{\text{avg}} = \frac{V_i + V_f}{2} = \frac{5+0}{2} = 2.5$ m/s

4. Consider a particle executing a simple harmonic motion. Let x, A, K and U are displacement, amplitude, kinetic energy and potential energy respectively, of the particle at certain instant of time. If $\frac{K}{U} = 3$,

then $\frac{x}{A}$ is :

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

(C) $\frac{2}{3}$ (D) $\frac{1}{9}$

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

Ans:B

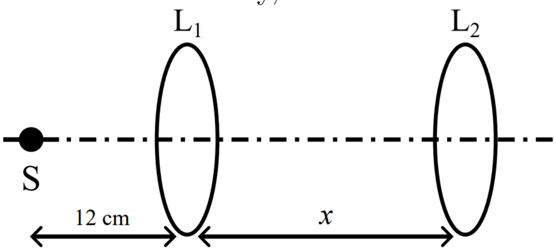
$$\frac{K}{U} = \frac{1/2KA^2\cos^2(\omega t)}{1/2KA^2\sin^2(\omega t)} = \frac{1}{\tan^2(\omega t)} = 3$$

$$\tan\omega t = \frac{1}{\sqrt{3}}, \omega t = 30^\circ$$

$$\therefore \quad x = A\sin(\omega t)$$

$$\frac{x}{A} = \sin(\omega t) = \sin 30 = \frac{1}{2}$$

5. Two thin convex lenses L_1 and L_2 have focal lengths 4 cm and 10 cm, respectively. They are separated by a distance of x cm as shown in the figure. A point source S is placed on the principal axis at a distance 12 cm to the left of L_1. If the image of S is formed at infinity, the value of x is :



(A) 6 (B) 16

(C) 14 (D) 24

(E) 10

Ans:B

For the image formed by L_2 to be at infinity, lens L_1 should make an image at the focus of L_2 ie.

At $(x-10)$cm

$\frac{-1}{u} + \frac{1}{v} = \frac{1}{f_1}$

$\frac{-1}{-12} + \frac{1}{x-10} = \frac{1}{4}$

$$\frac{1}{x-10} = \frac{1}{4} + \frac{1}{12} = \frac{1}{6}$$

$$x - 10 = 6$$

$$\therefore x = 16 \text{ cm}$$

6. What is the de Broglie wavelength corresponding to a ball of mass 100 g moving with a speed of 33 m/s ? (Plank's constant $= 6.6 \times 10^{-34}$ J/s)

(A) 1×10^{-34} m (B) 2×10^{-34} m

(C) 3×10^{-34} m (D) 1×10^{34} m

(E) 2×10^{34} m

Ans:B

$$\lambda = \frac{h}{mV} = \frac{6.6 \times 10^{-34}}{100 \times 10^{-3} \times 33}$$
$$= 2 \times 10^{-34} \text{ m}$$

7. A laser source emits light of wavelength 300 nm and has a power of 3.3 mW. The average number of photons emitted per second is : (Speed of light $= 3 \times 10^8$ m/s, Plank's constant $= 6.6 \times 10^{-34}$ J/s)

(A) 2×10^{15} (B) 1×10^{15}

(C) 5×10^{15} (D) 3×10^{15}

(E) 4×10^{15}

Ans:C

$$n = \frac{p\lambda}{hc} = \frac{3.3 \times 10^{-3} \times 300 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^8}$$
$$= 5 \times 10^{15} s^{-1}$$

8. A thin convex lens of refractive index 1.5 has a focal length of 10 cm in air. When the lens is immersed in a fluid, its focal length becomes 70 cm. The refractive index of the fluid is :

(A) 1.33 (B) 1.6

(C) 1.25 (D) 1.45

(E) 1.4

Ans:E

$$\frac{1}{f_{\text{air}}} = (\mu_g - 1)\frac{2}{R}$$

$$\therefore \frac{2}{R} = \frac{1}{f_{air}(\mu_g - 1)}$$

$$= \frac{1}{10 \times (1.5 - 1)} = \frac{1}{5}$$

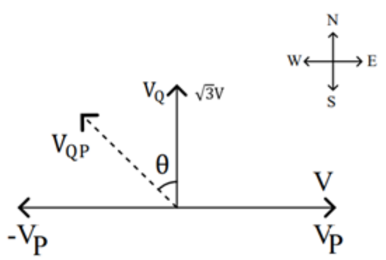
$$\therefore \frac{1}{f_{\text{fluid}}} = \left(\frac{\mu_g - \mu_f}{\mu_f}\right)\frac{2}{R}$$

$$\frac{1}{70} = \left(\frac{1.5 - \mu_f}{\mu_f}\right) \times \frac{1}{5}$$

$$\frac{1}{14} = \frac{1.5 - \mu_f}{\mu_f}$$
$\mu_f = 21 - 14\mu_f$
$\therefore \mu_f = \frac{21}{15} = 1.4$

9. For the hydrogen spectrum, the wavelength in Balmer series is given by $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$, where λ = wavelength and R is Rydberg constant. What are the values of n_1 and n_2 for the longest wavelength in the Balmer series ?
(A) $n_1 = 2, n_2 = 3$ (B) $n_1 = 2, n_2 = 4$
(C) $n_1 = 1, n_2 = 2$ (D) $n_1 = 2, n_2 = \infty$
(E) $n_1 = 3, n_2 = \infty$
Ans:A
For Balmer series, $n_1 = 2$
For a longer wavelength transition should happen from the next level
$\therefore n_2 = 3$

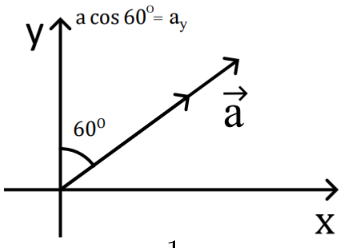
10. Car P is heading east with a speed V and car Q is heading north with a speed $\sqrt{3}$. What is the velocity of car Q with respect to car P ?
(A) $V\sqrt{3}$, heading north
(B) 2 V, 30° east of north
(C) $V\sqrt{3}, 60^\circ$ west of north
(D) 2 V, 30° west of north
(E) $V\sqrt{2}, 45^\circ$ west of north
Ans:D
(Question Mistake)



If we take the velocity of the car Q as $\sqrt{3}$ V then the solution will be

$V_{QP} = V_Q - V_P$
$V_{QP}^2 = V_Q^2 + V_P^2$
$= 3\ \mathrm{V}^2 + \mathrm{V}^2 = 4\ \mathrm{V}^2$
$\mathrm{V_{QP}} = 2\ \mathrm{V}$
$\tan\theta = \frac{V_P}{V_Q} = \frac{1}{\sqrt{3}}$
$\theta = 30^\circ$

11. A particle at rest starts from the origin with a constant acceleration $\vec{a}$ that makes an angle 60° with the positive y-axis. If its displacement along y-axis is 10 m in time 2 s, then the magnitude of $\vec{a}$ is :
(A) $10\ \mathrm{ms^{-2}}$ (B) $4\ \mathrm{ms^{-2}}$
(C) $8\ \mathrm{ms^{-2}}$ (D) $15\ \mathrm{ms^{-2}}$
(E) $20\ \mathrm{ms^{-2}}$
Ans:A



$S_y = U_y t + \frac{1}{2} a_y t^2$
$10 = \frac{1}{2} a \cos 60 \times 2^2$
$a = 10\ \mathrm{ms^{-2}}$

12. Suppose a force is given by the expression $= kx^2$; where x has the dimension of length. The dimension of k is :
(A) $\mathrm{ML^{-1}\ T^{-1}}$ (B) $\mathrm{MLT^{-1}}$
(C) $\mathrm{MT^{-2}}$ (D) $\mathrm{M^{-1}\ L^{-1}\ T}$
(E) $\mathrm{ML^{-1}\ T^{-2}}$
Ans:E
$[K] = \left[\frac{F}{x^2}\right] = \left[\frac{MLT^{-2}}{L^2}\right] = [ML^{-1}T^{-2}]$

13. A horizontal force is exerted on a 20 kg box to slide it up on an inclined plane with an angle of 30°. The frictional force retarding the motion is 80 N. If the box moves with a constant speed, then the

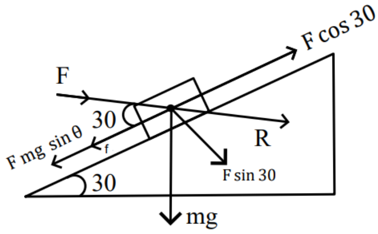
magnitude of the force is : (Take $g = 10\ ms^{-2}$)

(A) $50\sqrt{2}$ N (B) 100 N

(C) $80\sqrt{3}$ N (D) $100\sqrt{2}$ N

(E) $120\sqrt{3}$ N

Ans:E



For constant speed, $F_{\text{net}} = 0$

$F \cos 30 = mg \sin 30 + f$

$F \cos 30 = 180$

$F = \frac{180}{\sqrt{3}} \times 2 = \frac{60\times3\times2}{\sqrt{3}}$

$F = 120\sqrt{3}$ N

14. In a Young's double slit experiment which of the following statements is NOT true?

(1) Angular separation of the fringes remains constant when the screen is moved away from the plane of the slits.

(2) Fringe separation increases when the separation between the two slits decreases.

(3) Sharpness of the fringe pattern decreases when the source slit width increases.

(4) Distance between the fringes decreases when the separation between slits and the screen increases.

(5) The central fringe is white when the monochromatic source is replaced by a white light source.

Ans:D

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

when D increases β also increases

15. N capacitors, each with 1μF capacitance, are connected in parallel to store a charge of 1C. The potential across each capacitor is 100 V. If these N capacitors are now connected in series, the equivalent capacitance in the circuit will be :

(A) 10^{-4} F (B) 10^{-6} F

(C) 10^{-10} F (D) 5×10^{-8} F

(E) 10^{-2} F

Ans:C

$C_p = NC = N \times 10^{-6}$ F

$Q = C_p V$

$1 = N \times 10^{-6} \times 100$

$N = 10^4$

$$C_s = \frac{C}{N} = \frac{10^{-6}}{10^4} = 10^{-10}\ \text{F}$$

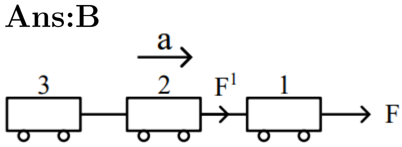
16. A train consists of an engine and 3 coaches, first coach is closest to the engine, third coach is farthest from engine. The train is moving with a constant acceleration a. The mass of each coach is M. The force exerted by the first coach on the second coach will be :

(A) Ma (B) $2Ma$

(C) 3Ma (D) 4Ma

(E) $\sqrt{2}Ma$

Ans:B



force exerted by first coach on the second coach

$F' = 2Ma$

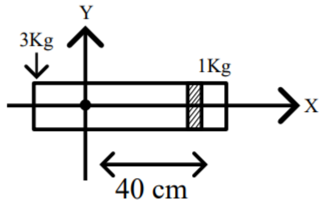
17. A uniform thin rod of mass 3 kg has a length of 1 m. If a point mass of 1 kg is attached to it at a distance of 40 cm from its center, the center of mass shifts by a distance of:

(A) 2.5 cm (B) 5 cm

(C) 8 cm (D) 10 cm

(E) 20 cm

Ans:D



Centre of mass of uniform rod

$x_1 = 0$

Centre of mass of uniform rod + point mass

$x_2 = \frac{0+1\times 40}{3+1} = 10$ cm

$\therefore$ shift $= \Delta x = x_2 - x_1 = 10$ cm

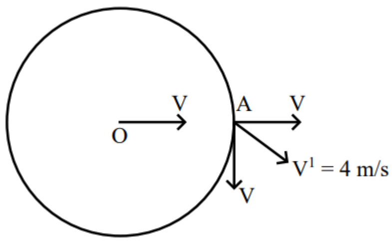
18. A wheel is rolling on a plane surface. A point on the rim of the wheel at the same level as the centre has a speed of 4 m/s. The speed of the centre of the wheel is :

(A) 4 m/s (B) 0

(C) $2\sqrt{2}$ m/s (D) 8 m/s

(E) $4\sqrt{2}$ m/s

Ans:C



$v' = \sqrt{2}v$

$v = v'/\sqrt{2} = 4/\sqrt{2}$

$= 2\sqrt{2}$ m/s.

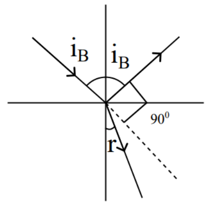
19. An unpolarised light is incident on a glass slab such that the reflected ray is totally polarised. If the angle of refraction is 30°, the refractive index of the glass is :

(A) 1.5 (B) 1.73

(C) 1.41 (D) 1.45

(E) 1.60

Ans:B



$\mu = \tan i_B$

$= \tan(90 - r)$

$= \tan 60$

$= 1.73$

20. A planet has an escape speed of 10 km/s. The radius of the planet is 10,000 km. The acceleration due to gravity of the planet at its surface is :

(A) 10 m/s^2 (B) 9.8 m/s^2

(C) 20 m/s^2 (D) 2.5 m/s^2

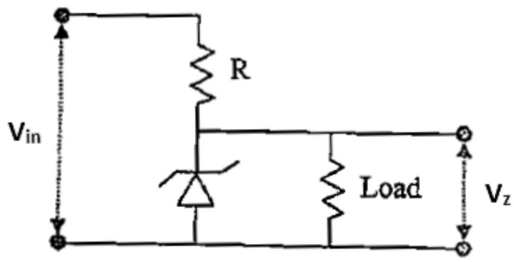
(E) 5 m/s^2

Ans:E

$ve = \sqrt{2gR}$

$$\therefore g = \frac{v_e^2}{2R} = \frac{(10\times 10^3)^2}{2\times 10000\times 10^3} = 5 \text{ ms}^{-2}$$

21. In a Zener regulated power supply circuit as shown in figure below, a Zener diode with Vz = 10 V is used for regulation. The load current, Zener current and unregulated input V_{in} are 5 mA, 35 mA and 20 V, respectively. The value of R is :

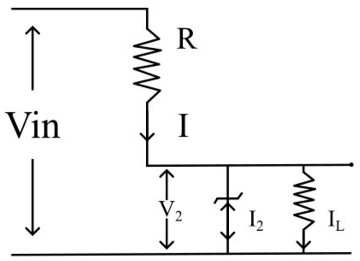


(A) 1000Ω (B) 750Ω

(C) 250Ω (D) 100Ω

(E) 500Ω

Ans:C



$I = I_z + I_L = 35 + 5 = 40$ mA
$V_z = 10$ V, $V_{\text{in}} = 20$ V
$V_R = 10$ V
$R = \frac{\text{V}}{I} = \frac{10}{40 \text{ mA}}$
$= 0.25 \times 10^3 \Omega = 250\Omega$

22. An average frictional force of 80 N is required to stop an object at a distance of 25 m. If the initial speed of the object is 20 m/s, the mass of the object is :
(A) 25 kg (B) 12 kg
(C) 30 kg (D) 40 kg
(E) 10 kg
Ans: E
$u = 20$ m/s
$F = 80$ N, $x = 25$ m
$v^2 - u^2 = 2a$ s $\Rightarrow a = -8$ m/s^2
$F =$ ma
$$\Rightarrow m = \frac{F}{a} = \frac{80}{8} = 10 \text{ kg}$$

23. An ideal gas is kept in a closed container. If the temperature is doubled and the volume of the container is reduced to half, the gas pressure is :
(A) unchanged
(B) halved
(C) doubled
(D) increased by 4 times
(E) increased by 16 times
Ans: D
$$PV = nRT \Rightarrow P = \frac{nRT}{V}$$
$$P'V' = nRT'$$
$$P' = \frac{nR(2T)}{(V/2)} = 4P$$

24. A metal wire of natural length 50 cm and cross-sectional area 4.0 mm^2 is fixed at one end. A mass of 2.4 kg is hung from the other end of the wire. If the elastic potential energy of the wire is 1.8×10^{-4} J, then its Young's modulus is : (Take g = 10 ms^{-2})
(A) 1.6×10^{11}Nm^{-2} (B) 2.4×10^{11}Nm^{-2}
(C) 3.2×10^{11}Nm^{-2} (D) 1.8×10^{11}Nm^{-2}
(E) 2.0×10^{11}Nm^{-2}
Ans: E
$$U = \frac{1}{2} \times \text{ stress } \times \text{ strain } \times \text{ volume}$$
$$= \frac{1}{2} \times \frac{(\text{ stress })^2}{Y} \times V$$
$$Y = \frac{1}{2} \times \left(\frac{F}{A}\right)^2 \times \frac{1}{u} \times A \cdot l.$$
$$= \frac{1}{2} \times \frac{F^2 l}{Au} = \frac{1}{2} \times \frac{(mg)^2 l}{Au}$$
$$= \frac{1}{2} \times \frac{(2.4 \times 10)^2 \times 0.5}{4 \times 10^{-6} \times 1.8 \times 10^{-4}}$$
$$= 2.0 \times 10^{11} \text{Nm}^{-2}$$

25. Select the incorrect statement about friction :
(A) Static friction force is always equal to μN, where μ is co-efficient of static friction and N is normal force.
(B) Friction is a non-conservative force.
(C) Friction arises from electro-magnetic force.
(D) Friction always opposes relative motion between two surfaces.
(E) Maximum value of static friction is μN, where μ is co-efficient of static friction and N is normal force.
Ans: A
Static friction is self adjusting and its maximum value is equal to μN. So option (A) is incorrect.

26. The angle of minimum deviation for a prism of apex angle 60° and refractive in-

dex of $\sqrt{2}$ is:

(A) 45° (B) 90°

(C) 30° (D) 60°

(E) 15°

Ans: C

$$\mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin(A/2)}$$

$$\Rightarrow \sin\left(\frac{A+D}{2}\right) = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}}$$

$$\frac{A+D}{2} = 45^\circ$$

$$D = 90^\circ - 60^\circ = 30^\circ,$$

27. An ideal diatomic gas is made up of molecules that do not vibrate. Its volume is compressed by a factor of 32 , without any exchange of heat. If the initial and final pressures are P_1 and P_2, respectively, the ratio $P_1 : P_2$ is :

(A) 7 : 5 (B) 128 : 1

(C) 1 : 32 (D) 32 : 1

(E) 1 : 128

Ans: E

For adiabatic process PV^γ = constand.

$P_1V_1^\gamma = P_2V_2^\gamma, \gamma = 7/5$ for diatomic molecule

$$\frac{p_1}{p_2} = \left(\frac{V_2}{V_1}\right)^\gamma = \left(\frac{1}{32}\right)^{7/5} = \frac{1}{128}$$

28. A body is moving in a straight line under the influence of a source of constant power. If its displacement at time $t = 0$ and 10 s are 0 and 10 m, respectively. The displacement at time $t = 20$ s is :

(A) 20 m (B) 40 m

(C) $10\sqrt{2}$ m (D) $20\sqrt{2}$ m

(E) $5\sqrt{10}$ m

Ans: D

Power = constand

$\left[ML^2T^{-3}\right]$ = constand.

L α $T^{3/2}$

$$\frac{x_1}{x_2} = \left(\frac{t_1}{t_2}\right)^{3/2}$$

$$\Rightarrow \frac{10}{x_2} = \left(\frac{10}{20}\right)^{3/2}$$

$$\Rightarrow x_2 = 20\sqrt{2} \text{ m}$$

29. A glass capillary of radius 0.15 mm is dipped into a liquid of density and surface tension 1600 kg/m^3 and 0.12Nm^{-1}, respectively. The liquid in the capillary rises by a height of 5.0 cm. The contact angle between liquid and glass will be : (Take $g = 10$ ms^{-2})

(A) 30° (B) 0°

(C) 45° (D) 75°

(E) 60°

Ans: E

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$\cos\theta = \frac{hr\rho g}{2T}$$

$$= \frac{5\times10^{-1}\times0.15\times10^{-3}\times1600\times10^\circ}{2\times0.12} = 1/2$$

$$\theta = 60^\circ$$

30. A gun fires N bullets per minute. The mass of each bullet is 10 g and every bullet travels with a speed of 600 m/s. If the power delivered by the gun is 9000 W, the value of N is :

(A) 300 (B) 400

(C) 360 (D) 420

(E) 250

Ans: A

$$P = \frac{W}{t} = \frac{\Delta K.E}{t} = N\frac{1/2mv^2}{t}$$

$$N = \frac{2Pt}{mv^2} = \frac{2\times9000\times60}{10^{-2}\times600\times600}$$

$$= \frac{2\times9\times100}{6} = 300$$

31. In an oil drop experiment, ' n ' numbers

of electrons are stripped from an oil drop to make it positively charged. A vertical electric field of magnitude 4.9×10^{14} N/C is applied to balance the force due to gravity on the oil drop. If the mass of oil drop is 80μg, the value of ' n ' will be : (Take g $=$ 9.8 m/s^2 and charge of an electron $= 1.6 \times 10^{-19}$C)

(A) 1 (B) 10
(C) 100 (D) 1000
(E) 10000

Ans: NA

$mg = qE \quad mg = neE$

$$n = \frac{mg}{eE}$$
$$= \frac{80 \times 10^{-9} \times 9.8}{1.6 \times 10^{-19} \times 4.9 \times 10^{14}}$$
$$= \frac{8 \times 9.8}{1.6 \times 4.9} \times 10^{-3}$$
$$= 10 \times 10^{-3}$$

32. A radioactive nuclei has a half life of 693 s. The activity of one mole of that nuclei sample is : (Avogadro's number $= 6.023 \times 10^{23}$ and $\ln(2) = 0.693$)

(A) 2×10^{10} Bq (B) 3.7×10^{10} Bq
(C) 6.023×10^{20} Bq (D) 0.5×10^{-10} Bq
(E) 1×10^{20} Bq

Ans: C

$t_{1/2} = 693$

$$\lambda = \frac{0.613}{t_{1/2}} = 10^{-3}$$
$$A = \frac{dN}{dt} = N\lambda = 6.023 \times 10^{23} \times 10^{-3}$$
$$= 6.023 \times 10^{20}$$

33. A projectile is thrown at an angle 60° above the horizontal and with kinetic energy 40 J. The kinetic energy of the projectile at the highest point of its trajectory will be :

(A) 10 J (B) 40 J
(C) 20 J (D) $20\sqrt{2}$ J
(E) $20\sqrt{3}$ J

Ans: A

$E = 1/2mu^2 = 40$ J

at highest point $KE = E\cos^2\theta =$
$40 \times 1/4 = 10$ J

34. A billiard ball B_1 moving with velocity V, collides with another billiard ball B_2 at rest. After the collision, ball B_1 is deflected by 60° and the angle between the velocities of these two balls is 90°. The speed of the ball B_2 after the collision is :

(A) $\frac{V}{2}$ (B) $\frac{3\ V}{2}$
(C) 2 V (D) $\frac{2\ V}{\sqrt{3}}$
(E) $\frac{\sqrt{3}\ V}{2}$

Ans: E

momentum conservation along x axis

$$m_1u_1 + 0 = m_1v_1\cos\theta_1 + m_2v_2\cos\theta_2$$
$$v = v_1\cos 60 + v_2\cos 30$$
$$V = \frac{v_1}{2} + v_2\frac{\sqrt{3}}{2}$$
$$\frac{v_1}{2} = v - v_2\sqrt{3}/2$$
$$v_1 = 2v - v_2\sqrt{3}$$

along y axis

$$0 = m_1v_1\sin 60 - m_2v_2\sin 30$$
$$v_2\sin 30 = v_1\sin 60$$
$$\frac{v_2}{2} = \frac{v_1\sqrt{3}}{2}$$
$$v_2 = \sqrt{3}v_1$$
$$= \sqrt{3}\left(2v - \sqrt{3}v_2\right)$$
$$v_2 = 2\sqrt{3}v - 3v_2$$
$$4v_2 = 2\sqrt{3}v$$
$$v_2 = \sqrt{3}/2v$$

35. Two satellites A and B are moving around the earth in a circular orbit of radius ' R ' and ' $2R$ ', respectively. If the kinetic energy of the satellite A is two-times the kinetic energy of the satellite B, the ratio

of their masses ($m_A : m_B$) is :

(A) 1 : 2 (B) 2 : 1

(C) 1 : 1 (D) 1 : 4

(E) 4 : 1

Ans: C

$r_1 = R$

$r_2 = 2R$

$KE = \frac{GMm}{2r}$

$m \propto KE(r)$

$\frac{m_A}{m_B} = \frac{KE_A}{KE_B} = \frac{r_A}{r_B} = 2 \times 1/2 = 1 : 1$

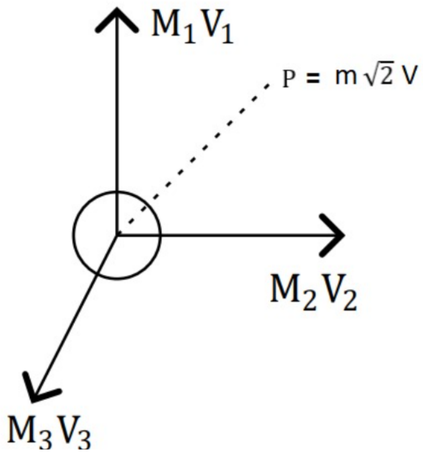
36. An object at rest suddenly explodes into three parts of equal masses. Two of them move away at right angles to each other with equal speed of 10 m/s. The speed of the third part just after the explosion will be :

(A) 10 m/s (B) 20 m/s

(C) $2\sqrt{10}$ m/s (D) 0

(E) $10\sqrt{2}$ m/s

Ans: E



$m_3v_3 = m\sqrt{2}V, \longrightarrow V_3 = 10\sqrt{2}$

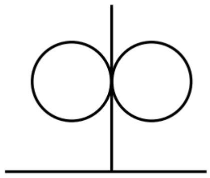
37. Two identical solid spheres, each of radius 10 cm, are kept in contact. If the moment of inertia of this system about the tangent passing through the point of contact is 0.14 $kg \cdot m^2$, then mass of each sphere is :

(A) 5 kg (B) 17.5 kg

(C) 35 kg (D) 2.5 kg

(E) 10 kg

Ans: A



For Solid sphere, along tangent moment of inertia is given by

$$= 7/5MR^2$$

$$I = I_1 + I_2 = 2 \times 7/5MR^2$$

$$M = \frac{5 \times I}{14R^2} = \frac{5 \times 0.14}{14 \times 10^{-2}}$$

$$= 5 \text{ kg}$$

38. A NOR gate has two input I_1 and I_2 and one output terminal Y. Which of the following configuration (truth table) is INCORRECT for the NOR gate?

(A) $I_1 = 0, \quad I_2 = 0, \quad Y = 1$

(B) $I_1 = 0, \quad I_2 = 0, \quad Y = 0$

(C) $I_1 = 1, \quad I_2 = 1, \quad Y = 0$

(D) $I_1 = 1, \quad I_2 = 0, \quad Y = 0$

(E) $I_1 = 0, \quad I_2 = 1, \quad Y = 0$

Ans: B

NOR

A	B	A + B	$y = \overline{A + B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

39. The kinetic energy of a particle of mass m_1 moving with a speed V is same as the kinetic energy of a solid sphere of mass m_2 rolling on the plane surface. If the speed of the centre of the sphere is also V, then $\frac{m_1}{m_2}$ is :

(A) $\frac{7}{10}$ (B) $\frac{1}{2}$

(C) $\frac{5}{7}$ (D) $\frac{7}{5}$

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

Ans: D

$KE_T = 1/2m_1v^2$

$KE_{(\text{total })} = KE_T + kE_R$

$= 1/2m_2v^2 + 1/2m_2v^2 \times K^2/R^2$

$1/2m_1v_1^2 = 1/2m_2v_2^2 + 1/2m_2v_2^2 \times K^2/R^2$

for solid sphere $K^2/R^2 = 2/5$

$$m_1 = m_2 + 2/5m_2$$

$$\frac{m_1}{m_2} = \frac{7}{5}$$

40. Line-of-sight communication happens by means of:

(A) Ground wave (B) Sky wave

(C) Surface wave (D) Space wave

(E) Seismic wave

Ans: D

Space wave

41. A ring of radius 1.75 m stands vertically. A small sphere of mass 1 kg rolls on the inside of this ring without slipping. If it has a velocity of 10 m/s at the bottom of the ring, then its velocity when it reaches the top is : (Take $g = 10$ m/s^2)

(A) $3\sqrt{2}$ m/s (B) $2\sqrt{3}$ m/s

(C) $8\sqrt{2}$ m/s (D) $2\sqrt{5}$ m/s

(E) $5\sqrt{2}$ m/s

Ans: E

$$\frac{1}{2}mv_1^2\left(1+\frac{4}{5}\right)$$

$$= mg \times 2R + \frac{1}{2}mv_2^2\left(1+\frac{4}{5}\right)$$

$$\frac{7}{10}mv_1^2 = mg2R + \frac{7}{10}mv_2^2$$

$$7v_1^2 = 20mgR + 7v_2^2$$

$$v_1^2 = v_2^2 + \frac{20}{7}gR$$

$$100 = v_2^2 + \frac{20}{7} \times 10 \times 1.75$$

$$v_2^2 = 100 - 50 = 50, v_2 = \sqrt{50} = 5\sqrt{2} \text{ m/s}$$

42. A signal of 5kHz frequency is amplitude modulated on a carrier wave of frequency 5MHz. The frequencies of the side bands are :

(A) 4.5MHz and 5.5MHz

(B) 4.95MHz and 5.05MHz

(C) 4.995MHz and 5.005MHz

(D) 4.9995MHz and 5.0005MHz

(E) 5MHz and 5kHz

Ans: C

Side band frequency $= f_c - f_m, f_c + f_m$

f_c−frequency of carrier wave

$f_m \rightarrow$ frequency of modulated wave

$= 5000\text{KHz} + 5\text{KHz}, 5000\text{KHz}, 5\text{KHz}$

$= 5005\text{KHz}, 4995\text{KHz}$

= 5.005 MHz, 4.995 MHz

43. A string clamped at both the ends has a mass 10gm, length 1 m and it is kept under tension of 1 N. It is vibrating in the fundamental mode with an amplitude of 1 cm. Assuming the standing wave pattern, the maximum acceleration seen in the string is :

(A) $4\pi^2$ m/s^2 (B) $2\pi^2$ m/s^2

(C) π^2 m/s^2 (D) 4πm/s^2

(E) 2πm/s^2

Ans: C

Frequency, $\nu = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

$$\frac{T}{\mu} = \frac{1}{\frac{10\times10^{-3}}{1}} = 10^2$$

$$frequency, \nu = \frac{1}{2\times1} \times \sqrt{10^2}$$

Amplitude $A = 1$ cm $= 10^{-2}$ m

Acceleration $a = \omega^2 A = (2\pi\nu)^2 \times A$

$$= 4\pi^2 \times 25 \times 10^{-2}$$

$$= \pi^2 \text{ m/s}^2$$

44. A spherical ball is subjected to a pressure of 100 atmosphere. If the bulk modulus of the ball is 10^{11} N/m^2, then change in the

volume is :

(A) $10^{-1}\%$ (B) $10^{-2}\%$

(C) $10^{-3}\%$ (D) $10^{-4}\%$

(E) $10^{-5}\%$

Ans: B

$B = \frac{P}{-(\frac{\Delta V}{V})}$

$\Rightarrow \frac{\Delta V}{V} = \frac{P}{B} = \frac{10^7}{10^{11}} = 10^{-4}$

$\rightarrow$ percentage charge in volume

$= 10^{-4} \times 100 = 10^{-2}\%$

45. A hollow sphere of radius ' r ' encloses an electric dipole composed of two charges +q and - q. The net flux of electric field through the surface of the sphere due to the enclosed dipole is :

(A) $\frac{2q}{\varepsilon_0}$ (B) $\frac{2q}{\varepsilon_0}.4\pi r^2$

(C) infinite (D) zero

(E) $\frac{q}{\varepsilon_o}$

Ans: D

Net charge is zero

46. The work done W is required by an agent to form a bubble of radius R. An extra amount of work ΔW is required to increase the radius by ΔR. If $\frac{\Delta R}{R} = 1\%$, then $\frac{\Delta W}{W}$ is :

(A) 2% (B) 1%

(C) 4% (D) 3%

(E) 0.5%

Ans: A

Work done, $W = 4\pi R^2 \times S$

$$\frac{\Delta W}{W} = 2 \times \frac{\Delta R}{R}$$
$$\frac{\Delta W}{W} \times 100 = 2 \times \frac{\Delta R}{R} \times 100$$
$$= 2 \times 1 = 2\%$$

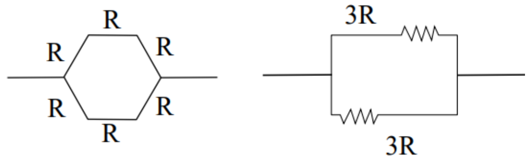
47. Each side of a regular hexagon has resistance R. The effective resistance between the two opposite vertices of the hexagon is :

(A) R (B) 2R

(C) $\frac{3R}{2}$ (D) $\frac{2R}{3}$

(E) $3R$

Ans: C



Effective resistance $= \frac{3R}{2}$

48. Two metallic solid spheres A and B, have radius R and $3R$, respectively. The solid spheres are charged and kept isolated. Then, the two spheres are connected to each other through a thin conducting wire. The ratio of the final charge on the spheres A to B is :

(A) 1 : 1 (B) 1 : 3

(C) 3 : 1 (D) 1 : 9

(E) 9 : 1

Ans: B

Since potential is same

$$\frac{Q_1}{Q_2} = \frac{C_1}{C_2} = \frac{R_1}{R_2} = \frac{R}{3R} = \frac{1}{3}$$

49. A heat engine operates between a cold reservoir and a hot reservoir. The engine takes 200 J of heat from the hot reservoir and has the efficiency of 0.4 . The amount of heat delivered to the cold reservoir in a cycle is :

(A) 100 J (B) 120 J

(C) 140 J (D) 160 J

(E) 80 J

Ans: B

$\eta = 1 - \frac{Q_2}{Q_1}$

$\frac{Q_2}{Q_1} = 1 - \eta$

$Q_1 = Q_1(1 - \eta)$

$= 200(1 - 0.4)$

$= 200 \times 0.6 = 1200$

$= 120$ J

50. A system of ideal gas undergoes a thermodynamic process in which the initial pressure and volume are equal to the final pressure and volume. Let ΔQ is the heat supplied to the system, ΔW is the work done by the system and ΔU is the change in internal energy. The correct option is :

(A) $\Delta Q = \Delta W$
(B) $\Delta U > 0$
(C) $\Delta U \neq 0$
(D) $\Delta U + \Delta Q + \Delta W = 0$
(E) $\Delta Q + \Delta W = 0$

Ans: A

$P_1V_1 = P_2V_2$

$T_1 = T_2$

51. The rms speed of a gas having diatomic molecules at temperature T (in Kelvin) is 200 m/s. If the temperature is increased to 4 T and the molecules dissociate into monoatomic atoms, the rms speed will become :

(A) 400 m/s (B) 200 m/s
(C) 800 m/s (D) $200\sqrt{2}$ m/s
(E) $400\sqrt{2}$ m/s

Ans: E

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

$\Delta U = 0,\ \Delta Q = \Delta W$

$$V = \sqrt{\frac{3RT}{M}}$$

diatomic $\rightarrow M$

monoatomic $\rightarrow$ M/2

$$V \propto \sqrt{\frac{T}{M}} \rightarrow 200 \propto \sqrt{\frac{T}{M}}$$

$$\frac{V}{200} = \sqrt{\frac{8TM}{MT}}$$

$$V \propto \sqrt{\frac{4T}{M/2}} \propto \sqrt{\frac{8T}{M}}$$

$V = 200 \times \sqrt{8} = 400\sqrt{2}$ m/s

52. A metallic bullet with an initial velocity of 500 m/s penetrates a solid object and melts. The initial temperature of the bullet is 30°C and its melting point is 280°C. The ratio of total heat generated to the initial kinetic energy of the bullet will be : [Latent heat of fusion of metal $= 3.0 \times 10^4$ J/kg and specific heat capacity of metal = 200 J/kg − K]

(A) 0.5 (B) 1.0
(C) 0.81 (D) 0.36
(E) 0.64

Ans: E

$$= \frac{mL_f + ms\Delta T}{\frac{1}{2}mv^2} = \frac{L_f + s\Delta \mathrm{T}}{\frac{1}{2}v^2}$$

$$= \frac{3 \times 10^4 + 200 \times 250}{\frac{500\times500}{2}}$$

$$= \frac{16}{25} = 0.64$$

53. Identify which type of electromagnetic wave is produced using Klystron or Magnetron valve :

(A) Gamma rays (B) Microwave
(C) Infrared rays (D) Ultraviolet rays
(E) X-rays

Ans: B

Microwave

54. A long wire carrying a current of 5 A lies along the positive z-axis. The magnetic field at the point with position vector $\vec{r} = (\hat{i} + 2\hat{j} + 2\hat{k})$m will be : $(\mu_0 = 4\pi \times 10^{-7}$ in SI units)

(A) $2\sqrt{5} \times 10^{-7}$ T (B) 5×10^{-7} T
(C) 0.33×10^{-7} T (D) 0.66×10^{-7} T
(E) $7\sqrt{5} \times 10^{-7}$ T

Ans: A

$$B=\frac{\mu_0 I}{2\pi x}=\frac{4\pi\times10^{-7}\times5}{2\pi\times\sqrt{5}}$$
$$=2\sqrt{5}\times10^{-7}$$

55. Which of the following scientific principle is used to produce the ultra-high magnetic fields ?
(A) Magnetic confinement of plasma
(B) Faraday's laws of electromagnetic induction
(C) Controlled nuclear fusion
(D) Motion of charged particles in electromagnetic fields
(E) Superconductivity
Ans: E
Superconductivity

56. A laser beam with an energy flux of 20 W/cm^2 is incident on a non-reflecting surface at normal incidence. If the surface has an area of 30 cm^2, the total momentum delivered by the laser in 30 minutes for complete absorption will be :
(A) 2.8×10^{-3} kg m/s
(B) 4.2×10^{-3} kg m/s
(C) 3.6×10^{-3} kg m/s
(D) 3.3×10^{-3} kg m/s
(E) 2.4×10^{-3} kg m/s
Ans: C
$$P=\frac{IA}{c}t=\frac{20\times30\times30\times60}{3\times10^8}$$
$$=3.6\times10^{-3}$$

57. A series LCR circuit consists of a variable capacitor connected to an inductor of inductance 50mH, resistor of resistance 100Ω and an AC source of angular frequency 500rad/s. The value of capacitance so that maximum current may be drawn into the circuit is :
(A) 60μF (B) 50μF
(C) 100μF (D) 80μF
(E) 25μF
Ans: D
$x_L=x_c$
$$\omega=\frac{1}{\sqrt{LC}}$$
$$C=\frac{1}{L\omega^2}$$
$$=\frac{1}{50\times10^{-3}\times500\times500}$$
$=80\mu$F

58. A magnetic field of $\left(10^{-4}\hat{k}\right)$ T exerts a force of $(4\hat{\imath}-3\hat{\jmath})\times10^{-12}$ N on a particle having a charge of 10^{-9}C. The speed of the particle is :
(A) 40 m/s (B) $40\sqrt{2}$ m/s
(C) 50 m/s (D) $50\sqrt{3}$ m/s
(E) $100\sqrt{2}$ m/s
Ans: C
$F=qv\times$B
$$(4\hat{\imath}-3\hat{\jmath})\times10^{-12}=10^{-9}$$
$$\left(\left(v_x\hat{\imath}+v_y\hat{\jmath}+v_2\hat{k}\right)\times10^{-4}\hat{k}\right).$$
$$40\hat{\imath}-3\hat{\jmath}=V_y\hat{\imath}-V_x\hat{\jmath}$$
$V_y=40$
$V_x=30$
$V=50$ m/s

59. A simple pendulum experiment is performed for the value of ' g ', the acceleration due to the Earth's gravity. The measured value of length of the pendulum is 25 cm with an accuracy of 1 mm and the measured time for 100 oscillations is found to be 100sec with an accuracy of 1sec. The percentage uncertainty in the determination of ' g ' is :
(A) 9.8 (B) 0.98
(C) 4.8 (D) 2.4
(E) 1.4
Ans: D

$g = 4\pi^2 \frac{l^2}{T^2}$

$\frac{\Delta g}{g} \times 100$

$= \frac{\Delta l}{l} \times 100 + 2\frac{\Delta \mathrm{T}}{T} \times 100$

$= \frac{10^{-3}}{25 \times 10^{-2}} \times 100 + 2 \times \frac{1}{100} \times 100$

$= \frac{10}{15} + 2 = 2 + 0.4 = 2.4$

60. A combination of two charges +1nC and −1nC are separated by a distance of 1μm. This constituted electric dipole is placed in an electric field of 1000 V/m at an angle of 45°. The torque and the potential energy on the electric dipole are :

(A) $\frac{1}{\sqrt{2}} \times 10^{-12}$ N.m and $\frac{1}{\sqrt{2}} \times 10^{-12}$ J

(B) $\frac{1}{\sqrt{2}} \times 10^{-12}$ N.m and $\sqrt{2} \times 10^{-12}$ J

(C) $\sqrt{2} \times 10^{-12}$ N.m and $\frac{1}{\sqrt{2}} \times 10^{-12}$ J

(D) $\sqrt{2} \times 10^{-12}$ N.m and $\sqrt{2} \times 10^{-12}$ J

(E) $\frac{\sqrt{3}}{2} \times 10^{-12}$ N.m and $\frac{\sqrt{3}}{2} \times 10^{-12}$ J

Ans: A

$\tau = PE \sin\theta$

$= 10^{-9} \times 10^{-6} \times 10^3 \times \frac{1}{\sqrt{2}}$

$= 10^{-12} \times \frac{1}{\sqrt{2}}$

$U = PE \cos\theta$

$= 10^{-9} \times 10^{-6} \times 10^3 \times \frac{1}{\sqrt{2}}$

$= 10^{-12} \times \frac{1}{\sqrt{2}}$

61. In a current carrying coil of inductance 60mH, the current is changed from 2.5 A in one direction to 2.5 A in the opposite direction in 0.10sec. The average induced EMF in the coil will be :

(A) 1.2 V (B) 2.4 V

(C) 3.0 V (D) 1.8 V

(E) 0.6 V

Ans: C

$\varepsilon = -L\frac{di}{dt}$

Given L = 60mH = 60×10^{-3}H

$$\frac{di}{dt} = \left(\frac{-2.5 - 2.5}{0.10}\right) = \frac{-5}{0.10} = -50 \text{ A/sec}$$

$\therefore E = 60 \times 10^3\text{H} \times 50$ A/sec

$= 3.0$ V

62. An inductor coil with an internal resistance of 50Ω stores magnetic field energy of 180 mJ and dissipates energy as heat at the rate of 200 W when a constant current is passed through it. The inductance of the coil will be :

(A) 90mH (B) 120mH

(C) 45mH (D) 30mH

(E) 60mH

Ans: A

Power in an L − C − R circuit,

$P = I_0^2 R$ given P = 200 W

$R = 50\Omega$

$\therefore I_0^2 = 4$

$I_o = 2A$

Energy stored in an inductor,

$$U = \frac{1}{2} L I_0^2$$

$$L = \frac{2U}{I_0^2}$$

$$\text{U} = 180 \text{ mJ}$$

$$L = \frac{2 \times 180 \text{ mJ}}{4} = 90\text{mH}$$

63. A current carrying long solenoid is formed by winding 200 turns per cm. If the number of turns per cm is increased to 201 keeping the current constant, then the magnetic field inside the solenoid will change by :

(A) 0.2% (B) 0.4%

(C) 0.5% (D) 1%

(E) 2%

Ans: C

Magnetic field,

$B=\mu_0 ni$ Given $n_1 = 200/\text{cm}$

$$n_2 = 201/\text{cm}$$
$$i_2 = i_0 = i$$

% of change in magnetic field

$=\left(\dfrac{B_2-B_1}{B_1}\right)\times 100$

$=\dfrac{201-200}{200}\times 100 = 0.5\%$

64. A metallic cylindrical wire ' A ' has length 10 cm and radius 3 mm. Another hollow cylindrical wire ' B ' of the same metal has length 10 cm, inner radius 3 mm and outer radius 4 mm. The ratio of the resistance of the wires A to B is :

(A) $\frac{7}{9}$ (B) $\frac{9}{7}$

(C) $\frac{9}{16}$ (D) $\frac{16}{9}$

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

Ans: A

1^{st} case : $R_1 = \dfrac{\rho l}{A_1}; A_1 = \pi r^2 = 9\pi$

2^{nd} case : $R_2 = \dfrac{\rho l}{A_2};$

$A_2 = \pi\left(r_0^2 - r_i^2\right) = \pi(16-9) = 7\pi$

$\therefore \frac{R_1}{R_2} = \frac{\rho l}{A_1}\times\frac{A_2}{\rho l} = \frac{7\pi}{9\pi} = \frac{7}{9}$

65. A small bar magnet lies along the x-axis with its centre fixed at the origin. If the magnetic field at point $(5\hat{\imath})$m due to this magnet is 4×10^{-6} T, then the magnetic field at point $(10\hat{\jmath})$m will be :

(A) 2.5×10^{-7} T (B) 2×10^{-6} T

(C) 1×10^{-6} T (D) 2.0×10^{-7} T

(E) 8.0×10^{-8} T

Ans: A

$B_{\text{axial}} = \dfrac{\mu_0}{4\pi}\dfrac{2m}{x^3} = 4\times10^{-6}; B_{Equ.} = \dfrac{\mu_0}{4\pi}\dfrac{m}{y^3}$

$y = 10\hat{\jmath}$

$4\times10^{-6} = \dfrac{\mu_0}{4\pi}\dfrac{2m}{5^3}$

$\therefore \dfrac{\mu_0}{4\pi} = \dfrac{125}{2m}\times4\times10^{-6}$

$B_{\text{equ.}} = \dfrac{\mu_0}{4\pi}\dfrac{m}{10^3}$

$=\left(\dfrac{125}{2m}\times4\times10^{-6}\right)\times\dfrac{m}{10^3}$

$\therefore B_{Equ.} = 2.5\times10^{-7}T$

66. An ideal gas is compressed in volume by a factor of 2 , while keeping its temperature constant. The speed of sound in it is :

(A) doubled

(B) unchanged

(C) reduced to half

(D) increased by 4 times

(E) reduced by 4 times

Ans: B

Unchanged

As the temperature is constant, so is the speed of the molecules

67. In the magnetic meridian of a certain plane, the horizontal component of earth's magnetic field is 0.36 Gauss and the dip angle is 60°. The magnetic field of the earth at this location is :

(A) 0.72 Gauss (B) 0.18 Gauss

(C) 0.42 Gauss (D) 0.56 Gauss

(E) 0.81 Gauss

Ans: A

$\cos\theta = \dfrac{H_e}{B_e}; \cos 60 = \dfrac{0.36\times10^{-4}}{B_e}$

$; B_e = \dfrac{0.36\times10^{-4}}{\left(\frac{1}{2}\right)}$

$= 0.72$ gauss

68. A resistance R is connected across an ideal battery. The total power dissipated in the circuit is P. If another resistance R is

added in series, the new total dissipated power is :

(A) 2P (B) 4P

(C) P (D) $\frac{P}{2}$

(E) $\frac{P}{4}$

Ans: D

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

If R is added new resistance = 2R

New power = $P' = \frac{V^2}{2R} = \frac{P}{2}$

69. A toroid with 500 turns of wire carries a current of (2π) Ampere. A metal ring inside the toroid provides the core and has susceptibility of 2×10^{-5}. If the magnetization is 5×10^{-2} A/m, then radius of the ring is :

(A) 50 cm (B) 20πcm

(C) $\frac{50}{\pi}$cm (D) 20 cm

(E) 60 cm

Ans: D

We have $\chi = \frac{I}{H}$ or

$H = \frac{I}{\chi}$

I =Magnetisation = 5×10^{-2} A/m

$\chi = 2 \times 10^{-5}$

$i = 2\pi A$

$\therefore H = \frac{5 \times 10^{-2}}{2 \times 10^{-5}}$

$= 2.5 \times 10^3$

$H = ni = \frac{N}{2\pi R}$;

$R = \frac{Ni}{2\pi H} = \frac{500 \times 2\pi}{2\pi \times 2.5 \times 10^3} = 20$ cm

70. When a vibrating tuning fork moves towards a stationary observer with a speed of 50 m/s, the observer hears a frequency of 350 Hz. The frequency of vibration of the fork is : (Take speed of sound = 350 m/s)

(A) 350 Hz (B) 400 Hz

(C) 200 Hz (D) 300 Hz

(E) 250 Hz

Ans: D

$V_0 = 0$;

$V_s = 50$ m/s

$v' = 350Hz; V = 350$ m/s

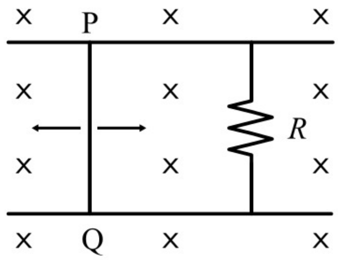
We have, $v' = v\left(\frac{V}{V-V_s}\right)$

$$350 = v\left(\frac{350}{350-50}\right)$$

$$\Rightarrow v = \frac{300}{350} \times 350$$

$$= 300 \text{ Hz}$$

71. The rod PQ slides along 2 parallel rails as shown in the figure. It has a length of 20 cm and is perpendicular to the 2 rails. It performs simple harmonic motion with amplitude 5 cm and frequency 10 Hz. The magnetic field is 10^{-4} T and is directed perpendicular to the plane of paper. What is the peak induced electromagnetic force?



(A) $2\pi \times 10^{-7}$ V (B) $4\pi^2 \times 10^{-3}$ V

(C) $2\pi \times 10^{-5}$ V (D) $4\pi \times 10^{-5}$ V

(E) $\pi^2 \times 10^{-4}$ V

Ans: C

Given

$l = 20$ cm, $A = 5$ cm, v = 10 Hz; $B = 10^{-4}$ T

$V_{\max} = A\omega$

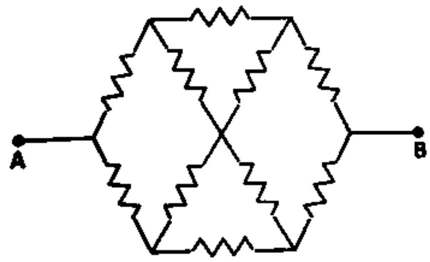
$= 5 \times 10^{-2} \times 2\pi \times 10$

$= \pi$

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

$= 2\pi \times 10^{-5}$ V

72. Find the effective resistance between points A and B. Each resistance is equal to R.



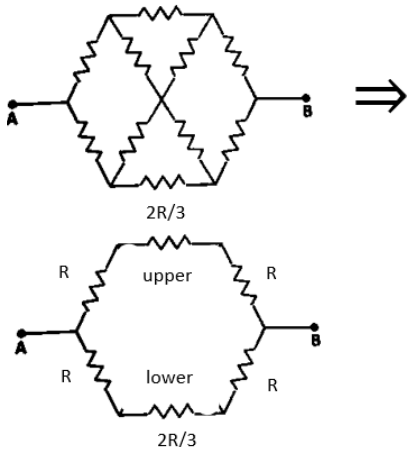
(A) 2R (B) $\frac{3}{4}R$

(C) $3R$ (D) $\frac{4}{3}R$

(E) $\frac{9}{5}R$

Ans: D

By symmetry, $I_A = I_B$. So its equivalent circuit



So at upper and lower branches

$$R = R + \frac{2R}{3} + R = \frac{8R}{3}$$
$$\therefore \frac{1}{R_e} = \frac{3}{8R} = \frac{6}{8R} = \frac{3}{4R}$$
$$\therefore R_e = \frac{4}{3}R$$

73. The number of electrons in one mole of methane :

(A) 6.023×10^{23} (B) 60.23×10^{23}

(C) 0.6023×10^{23} (D) 602.3×10^{23}

(E) 6023×10^{23}

Ans: B

no: of electrons in CH_4= 10 electrons

in 1 mole $CH_4 = 10 \times 6.023 \times 10^{23}$
$= 60.23 \times 10^{23}$ electrons

74. Which of the following statement cannot be explained by the proposals of Dalton's atomic theory ?

(A) Reorganisation of atoms in chemical reactions
(B) Identical properties of all atoms of given element
(C) The reason for combining of atoms
(D) Formation of compounds from the combination of elements in a fixed ratio
(E) Matter consists of individual atoms

Ans: C

75. The correct order of variation of first ionisation enthalpies is :

(A) Ne < Xe > Li > K < Cs
(B) Xe < Li < K < Cs < Ne
(C) Cs > K > Li > Xe > Ne
(D) Li > K > Cs > Ne > Xe
(E) Ne > Xe > Li > K > Cs

Ans: E

Down the group I.E decreases and across the period I.E increases

76. Which of the following statements is WRONG?

(A) The bond order of He_2 is zero; so He_2 molecule is unstable.
(B) Li_2 molecule is diamagnetic.
(C) O_2 molecule contains two unpaired electron and is paramagnetic.
(D) C_2 molecule is paramagnetic in vapour phase.
(E) H_2 molecule has no unpaired electrons.

Ans: D

D- there is no unpaired electrons in C_2 molecule, so it is diamagnetic

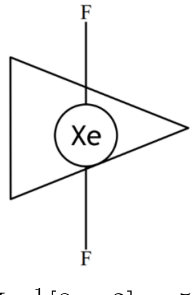
77. Find the WRONG statement from the following lists :
 (A) Dipole-dipole interaction exists in the HCl molecules.
 (B) Three states of matter are due to the balance between intermolecular forces and the thermal energy of the molecules.
 (C) According to kinetic theory of gases, the collisions of gas molecules are perfectly elastic.
 (D) Strength of hydrogen bond depends on the coulombic interaction between lone pair of electrons of one atom and the hydrogen atom.
 (E) Aqueous tension of water decreases with the increase in temperature.

 Ans: E

 Aqueous tension of water increases with increases in temperature

78. The hybridisation of Xe in XeF_2 is :
 (A) sp^3 (B) sp^3 d
 (C) sp^3 d^2 (D) sp^2 d
 (E) sp^2

 Ans: B



 H=$\frac{1}{2}[8+2]=5$, that is sp^3d

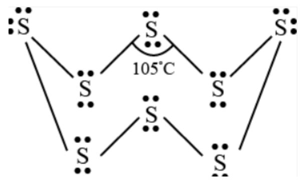
79. Which of the following compounds is known as inorganic benzene?
 (A) B_6H_6
 (B) C_5H_5 B
 (C) C_3 N_3H_3
 (D) B_3 N_3H_6
 (E) BF_3

 Ans: D

80. The number of S – S bonds and the number of lone pairs in S_8 molecule, respectively, are :
 (A) 8,8 (B) 8,16
 (C) 16,8 (D) 8,4
 (E) 4,8

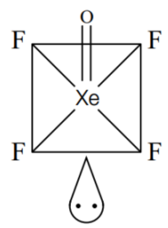
 Ans: B

 The crown like structure of S_8



81. The shape of $XeOF_4$ molecule is :
 (A) Square pyramid
 (B) Planar
 (C) Trigonal bipyramid
 (D) Pentagonal bipyramid
 (E) Linear

 Ans: A



82. The geometry of $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ ions are :
 (A) Both tetrahedral
 (B) Both square planar
 (C) Both octahedral
 (D) Square planar and tetrahedral, respectively

(E) Tetrahedral and square planar, respectively

Ans: E

$[NiCl_4]^{2-}$ – sp^3 tetrahedral

$[Ni(CN)_4]^2$ – dsp^2 square planar

83. Which of the following compounds extensively has Mg as an important element in the living world ?

(A) Haemoglobin

(B) ATP

(C) Florigen

(D) Ferritin

(E) Chlorophyll

Ans: E

84. The basic character of the hydrides of 15 group elements decreases in the order :

(A) $NH_3 > PH_3 > AsH_3 > SbH_3$

(B) $SbH_3 > AsH_3 > PH_3 > NH_3$

(C) $NH_3 > AsH_3 > PH_3 > SbH_3$

(D) $NH_3 > SbH_3 > PH_3 > AsH_3$

(E) $SbH_3 > PH_3 > AsH_3 > NH_3$

Ans: A

Down the 15^{th} group acidic nature increases, but basic character decreases

85. Which of the following contains sp hybridised carbon atom?

(A) $CH_3 - CH = CH - CH_3$

(B) $CH_3 - C \equiv C - CH_3$

(C) $CH_3 - CH_3$

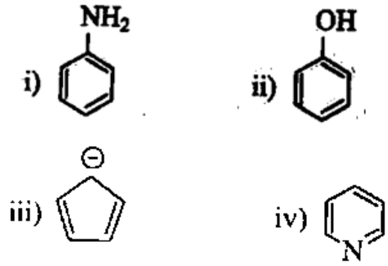
(D) $CHCl_3$

(E) $CH_3 - CH_2 - Cl$

Ans: B

Butyne contains two sp hybridised carbon atoms

86. Which are the non-benzenoid aromatic compounds in the following ?



(A) iii and iv

(B) i and iv

(C) ii and iv

(D) i and iv

(E) ii and iii

Ans: A

cyclopentadienyl carbanion and pyridine don't have benzenoid structure

87. Which of the following is the most stable carbocation?

(A) $CH_3 - \overset{\oplus}{C}H_2$

(B) $\overset{\oplus}{C}H_3$

(C) $CH_3 - \overset{\oplus}{C}H - CH_3$

(D) $(CH_3)_3\overset{\oplus}{C}$

(E) $CH_3 - CH_2 - \overset{\oplus}{C}H_2$

Ans: D

Number of hyperconjugative structures $\propto$ stability of carbocations.

88. Which of the following cannot act as a nucleophile?

(A) $CH_3\overset{\ominus}{O}$

(B) H_2O

(C) CH_3NH_2

(D) $(CH_3)_3\overset{\oplus}{C}$

(E) $CH_3CH_2\overset{\ominus}{O}$

Ans: D

D cannot act as nucleophile as it is a carbocation.

89. What are the products of the following reactions?

i) $CH_3 - CH_2 - Br + Na \xrightarrow{\text{Dry ether}}$

ii) $CH_3COONa + NaOH \xrightarrow[\triangle]{CaO}$

(A) i) $CH_3 - CH_3$ and ii) $CH_2 = CH_2$

(B) i) $CH_3 - CH_2 - CH_3$ and ii) $CH_3 - CH_3$

(C) i) $CH_3 - CH_2 - CH_3$ and ii) CH_4

(D) i) $CH_3 - CH_2 - CH_2 - CH_3$ and ii) $H - C \equiv C - H$

(E) i) $CH_3 - CH_2 - CH_2 - CH_3$ and ii) CH_4

Ans: E

(i) Wurtz reaction

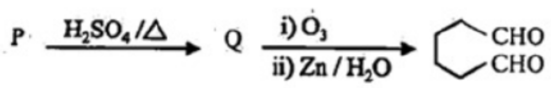
$CH_3 - CH_2 - Br + Na$

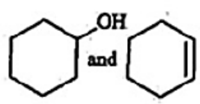
$\xrightarrow{Dry\ ether} CH_3 - CH_2 - CH_2 - CH_3 + NaBr$

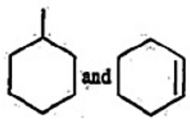
(ii)Decarboxylation $CH_3COONa + NaOH \xrightarrow[\Delta]{CaO}$

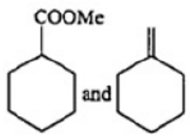
CH_4

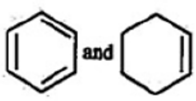
90. Find the compounds P and Q in the following reactions :

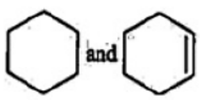


(A) 

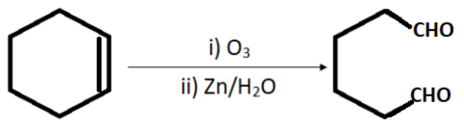
(B) 

(C) 

(D) 

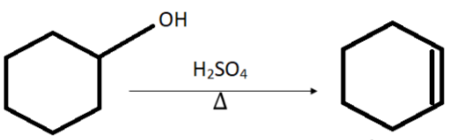
(E) 

Ans: A



Cyclohexene can be obtained by dehydration of cyclohexanol

∴ P is



91. Match the following complexes (P) with the geometry (Q) :

(P)	(Q)
a) $[Cu(NH_3)_4]^{2+}$	(i) Tetrahedral
b) $[Ag(NH_3)_2]^+$	(ii) Octahedral
c) $Fe(CO)_5$	(iii) Square planar
d) $[Cr(H_2O)_6]^{3+}$	(iv) Triagonal bipyramidal
e) $[NiCl_4]^{2-}$	(v) Linear

(A) a)-(ii); b)-(iii); c)-(i); d)-(iv); e)-(v)

(B) a)-(iii); b)-(v); c)-(iv); d)-(ii); e)-(i)

(C) a)-(iv); b)-(iii); c)-(v); d)-(i); e)-(ii)

(D) a)-(v);b)-(iv); c)-(ii); d)-(iii); e)-(i)

(E) a)-(iv); b)-(ii); c)-(iii); d)-(v); e)-(i)

Ans: B

$[Cu(NH_3)_4]^{2+}$ - square planner

$[Ag(NH_3)_2]^+$ – - Linear

$[Fe(CO)_5]$ - Triagonal bipyramidal

$[Cr(H_2O)_6]^{3+}$ – Octahedral

$[NiCl_4]^{2-}$ - Tetrahedral

92. The tetrahedral crystal field splitting is only of the octahedral splitting.

(A) $\frac{1}{9}$ (B) $\frac{2}{9}$

(C) $\frac{3}{9}$ (D) $\frac{4}{9}$

(E) $\frac{5}{9}$

Ans: D

$\Delta_t = \frac{4}{9}\Delta_0$

93. Which order is correct in spectrochemical series of ligands :

(A) $Cl^- < F^- < [C_2O_4]^{2-} < H_2O < CN^-$

(B) $Cl^- < F^- < CN^- < H_2O < [C_2O_4]^{2-}$

(C) $F^- < Cl^- < CN^- < H_2O < [C_2O_4]^{2-}$

(D) $F^- < Cl^- < H_2O < CN^- < [C_2O_4]^{2-}$

(E) $Cl^- < F^- < H_2O < [C_2O_4]^{2-} < CN^-$

Ans: A

Cynide is the strongest and water is the stronger ligand than oxalate ion hence

$$Cl^- < F^- < (C_2O_4)^{2-} < H_2O < CN^-$$

94. HF is a liquid unlike other hydrogen halides because :

(A) H – F bond is strong

(B) Hydrogen bonding is present

(C) HF is a weak acid

(D) F atom is smaller in size

(E) HF is a strong base

Ans: B

HF is a liquid due to the presence of strong intermolecular hydrogen bonding.

95. The order of acidity follows :

(A) HF > HCl > HBr > HI

(B) HF > HBr > HCl > HI

(C) HI > HCl > HF > HBr

(D) HI > HBr > HCl > HF

(E) HBr > HCl > HF > HI

Ans: D

For hydrogen halides, acidic character increases down the group.

96. The correct order of O – O bond length in O_3, O_2 and H_2O_2 is :

(A) $O_2 > H_2O_2 > O_3$

(B) $O_3 > H_2O_2 > O_2$

(C) $H_2O_2 > O_2 > O_3$

(D) $H_2O_2 > O_3 > O_2$

(E) $O_2 > O_3 > H_2O_2$

Ans: D

$H_2O_2 > O_3 > O_2$

Bond order $\alpha \frac{1}{\text{Bond length}}$

H_2O_2 O_3 O_2

B.O :1 1.5 2

97. Geometry, hybridisation and magnetic moment of $[MnBr_4]^{2-}$, $[FeF_6]^{4-}$ and $[Ni(CN)_4]^{2-}$ ions, respectively, are :

(A) Tetrahedral, square planar, octahedral; $sp^3, dsp^3, sp^3d^2; 5.9, 0, 4.9$

(B) Tetrahedral, octahedral, square planar; $sp^3, sp^3\ d^2, dsp^2; 5.9, 4.9, 0$

(C) Octahedral, square planar, tetrahedral; $sp^3d^2, dsp^2, sp^3; 4.9, 0, 5.9$

(D) Square planar, tetrahedral, octahedral; $sp^3d^2, sp^3, dsp^2; 0, 4.9, 5.9$

(E) Tetrahedral, octahedral; square planar; sp^3, sp^3d^2, $dsp^2; 0, 5.9, 4.9$

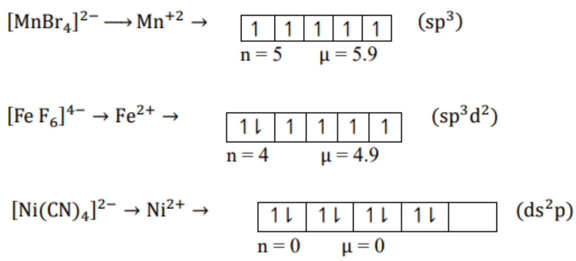
Ans: B

$Mn \rightarrow 3d^5 4s^2$

$Mn^{2+} \rightarrow 3d^5$

Magnetic moment $= \sqrt{5(5+2)}$

$= \sqrt{35}\ BM$



98. What is the probable ratio between the root mean square speed (rms), average speed (av) and the most probable speed (mp) ? (U = speed of the gas molecules)

(A) Ump : Urms : U_{av} :: 1.128 : 1 : 1.224

(B) Uav : Urms : U_{mp} :: 1 : 1.128 : 1.224

(C) Ump : Uav : U_{rms} :: 1 : 1.128 : 1.224

(D) Ump : Uav : U_{rms} :: 1.224 : 1 : 1.128

(E) Urms : Ump : U_{av} :: 1 : 1.128 : 1.224

Ans: C
$V_{rms} : V_{avg} : V_{mp}$

$\sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$

99. Which is the WRONG statement from the following lists ?
    (A) No work is done during free expansion of an ideal gas for both reversible and irreversible processes.
    (B) The density and pressure are extensive properties but the enthalpy and heat capacity are intensive properties.
    (C) The change in enthalpy (ΔH) is negative for exothermic reactions but is positive for endothermic reactions.
    (D) The difference between change in enthalpy (ΔH) and the internal energy (ΔU) is not significant for solids and liquids, but significant for gases.
    (E) The standard enthalpy change of fusion of CH_3COCH_3 is higher than that of N_2.

    Ans: B
    Density and pressure are intensive properties.

100. The magnitude of equilibrium constant for the gaseous reaction of $H_2(g)$ with $I_2(g)$ for the formation of 2HI(g) is 57 at a particular temperature. The molar concentrations, $[H_2] = 0.10M, [I_2] = 0.20M$ and $[HI] = 0.40M$ are found to be at the same temperature. Find the CORRECT statement about the reaction :
    (A) The mixture of $H_2(g), I_2(g)$ and HI(g) is at equilibrium.
    (B) More $H_2(g)$ and $I_2(g)$ will not react to form more HI(g).
    (C) The concentration of $H_2(g)$ and $I_2(g)$ will decrease till the equilibrium constant is equal to reaction quotient.
    (D) Reaction quotient is independent of concentration.
    (E) If reaction quotient is greater than equilibrium constant of the reaction, more HI(g) will be formed.

    Ans: C

$$H_2 + I_2 \longrightarrow 2HI$$

at eqm. $\quad 0 \cdot 10 \quad 0.20 \quad 0.40$

$$Q_c = \frac{[0.40]^2}{[0.10][0.20]} = 8$$

$Q_c < K_c$

101. The pKa of acetic acid is 4.76 . What will be the pKb of ammonium hydroxide, if the pH of ammonium acetate is 7.00 ?
    (A) 4.770 (B) 4.765
    (C) 4.755 (D) 4.750
    (E) 4.740

    Ans: B
    $P^H = 7 + \frac{1}{2}[Pk_a - Pk_b]$
    $P^H = 7$ For PH $= 7, Pk_a$ must be equal to Pk_b i.e, $Pk_a = 4.76$

102. In oligosaccharides, how many monosaccharides will be present?
    (A) 1 to 5 (B) 2 to 10
    (C) 4 to 5 (D) 1 to 15
    (E) 3 to 5

    Ans: B

103. In DNA molecule, the sugar part is.......... and in RNA molecule, the sugar part is............
    (A) $\beta - D - 2-$ ribose and $\alpha -$ L-ribose
    (B) $\beta - D - 2$-deoxy ribose and α-L-ribose
    (C) $\beta - D - 3$-deoxy ribose and α-D-ribose
    (D) $\alpha - D - 2$-deoxy ribose and $\beta - D$-ribose
    (E) $\beta - D - 2-$ deoxy ribose and $\beta - D$-ribose

Ans: E

In DNA- $\beta-D-2-$ deoxy ribose

In RNA - $\beta-D-$ Ribose

104. Which statement is correct in the following?

(A) Amylose is a polymer of $\alpha-$D-glucose.

(B) Amylose is a polymer of $\beta-$D-glucose.

(C) Cellulose is a polymer of $\alpha-$ D$-$ glucose.

(D) Cellulose is a polymer of $\beta-D$-galactose.

(E) Amylose is a polymer of $\alpha-$ D-galactose.

Ans: A

Amylose is a polymer of

$\alpha-D-$ glucose

105. Calculate the log of equilibrium constant ($\log K_c$) in reaction,

$$Mg(s)+2Ag^{+}(aq)\rightarrow Mg^{2+}(aq)+2Ag(s)$$

Given that E°_{cell} $=3.245$ V

(A) 100.5 (B) 110.5

(C) 10 (D) 100

(E) 110

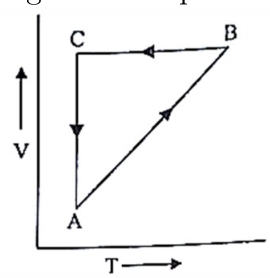
Ans:E

$$E^{\circ}_{cell}=\frac{0.0591}{n}\log k_c$$

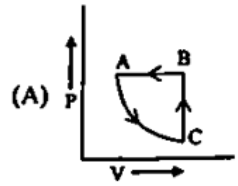
$$3.245=\frac{0.0591}{2}\log k_c$$

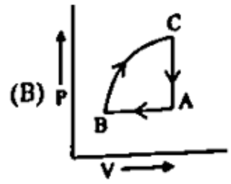
$$\log k_c\simeq 109.8$$

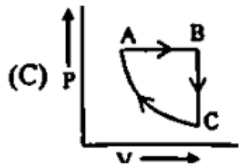
106. The following diagram shows the $V-T$ diagram for a process $ABCA$

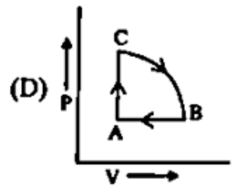


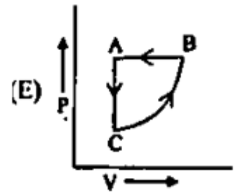
The corresponding P $-$ V diagram is :



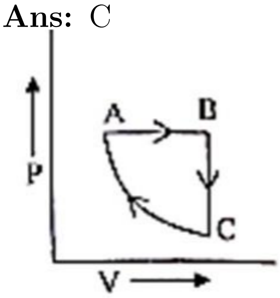








Ans: C



107. In which of the following, entropy decreases?

(A) Liquid water is converted to gas.

(B) Liquid water crystallizes to ice.

(C) $H_2(g)\rightarrow 2H(g)$

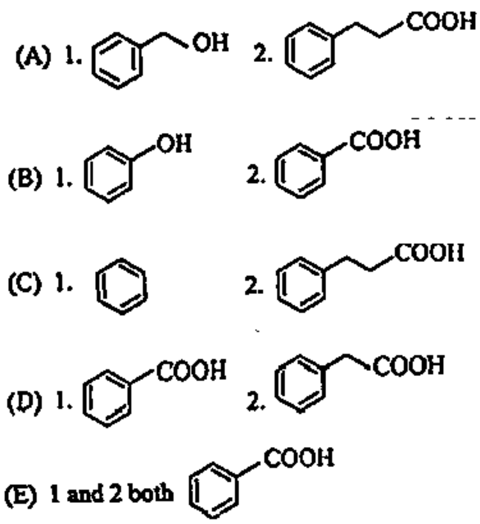
(D) $NH_4Cl(s)\rightarrow NH_3(g)+HCl(g)$

(E) Temperature of NaCl(s) raises from 298 to 517 K.

Ans: B

Entropy decreases as liquid converts to solid

108. Identify 1 and 2 in the following reactions:



Ans: E

Irrespection of the length of the side chain all alkyl benzenes except 3° alkyl benzene are oxidized to benzoic acid

109. In which of the following reactions, we will get new C – C bond ?

(A) Cannizzaro reaction and Aldol condensation reaction

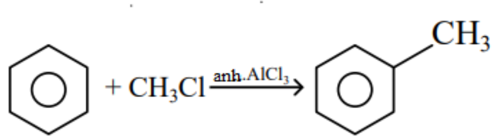
(B) Cannizzaro reaction and Sandmeyer's reaction

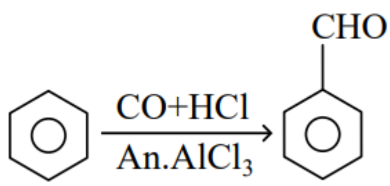
(C) Friedel-Crafts reaction and Gattermann-Koch reaction

(D) Cannizzaro reaction and Reimer-Tiemann reaction

(E) Sandmeyer's reaction and Aldol condensation reaction

Ans: C





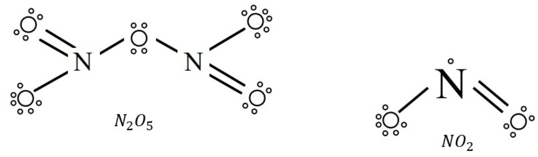
110. The nitrogen oxide that does not contain N – N bond is :

(A) N_2O_5 (B) N_2O_3

(C) NO_2 (D) N_2O_4

(E) N_2O

Ans: A & C



111. In a zero-order reaction, the reactant A disappeared with a rate of reaction k = 0.04Msec^{-1}. The initial concentration of A is 1M. What will be the concentration of A after 20 seconds ?

(A) 1.08M (B) 0.2M

(C) 0.8M (D) 0.002M

(E) 0.008M

Ans: B

$$\text{K} = \frac{C_0 - C_t}{t}$$

$$0.04 = \frac{1 - C_t}{20}$$

$\therefore \text{C}_\text{t} = 0.2\text{M}$

112. Following of which can be an empirical relationship between the quantity of gas adsorbed by unit mass of solid adsorbent and pressure at a particular temperature ? x = mass of the gas adsorbed on a mass ' m ' of the adsorbent at a pressure ' P '. k and n are constants, which depend on the nature of the adsorbent and the gas at a particular teraperature.

(A) $\log x + \log m = \log k + \frac{1}{n} \log P$

(B) $\log x + \log m = \log k - \frac{1}{n} \log P$

(C) $\log x + \log m = -\log k + \frac{1}{n} \log P$

(D) $\log x - \log m = \log k + \frac{1}{n} \log P$

(E) $\log x - \log m = \log k - \frac{1}{n} \log P$

Ans: D

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

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

113. In the following which can be used as an

antidepressant drug ?

(A)Salvarsan (B) Ofloxacin

(C) Erythromycin (D) Serotonin

(E) Chloroxylenol

Ans: D

114. $[Co(NH_3)_4(NO_2)_2]Cl$ exhibits :

(A) Linkage isomerism, ionisation isomerism and optical isomerism

(B) Linkage isomerism, geometrical isomerism and ionisation isomerism

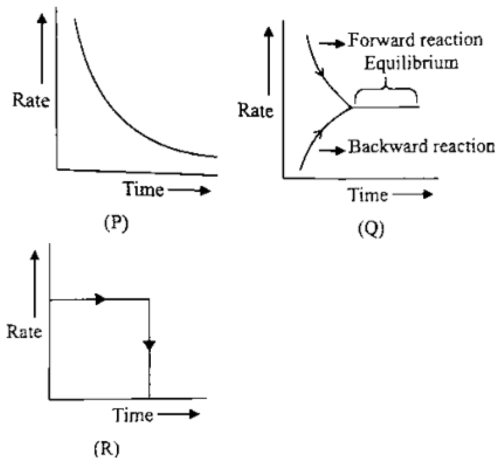
(C) Ionisation isomerism, geometrical isomerism and optical isomerism

(D) Linkage isomerism, geometrical isomerism and optical isomerism

(E) Optical isomerism, geometrical isomerism and ionisation isomerism

Ans: B

115. Find the correct combination about the following plots (P, Q and R) for the variation of rate of reaction with time.



(A) Q = Reversible; P = Zero order, R = Irreversible

(B) R = Zero order, P = Zero order, R = Irreversible

(C) Q = Irreversible; R = Reversible; P = Zero order

(D) P = Irreversible; Q = Reversible; R = Zero order

(E) P = Reversible; Q = Zero order, R = Irreversible

Ans: D

116. The resistance of the cell containing the aqueous solution of NaCl at 20°C is 60ohm. If the specific conductivity of this solution at 20°C is $0.04\text{ohm}^{-1}\ \text{cm}^{-1}$, what is the cell constant in cm^{-1}?

(A) 2.0 (B) 1.5

(C) 0.5 (D) 0.15

(E) 2.4

Ans: E

$G^* = R \times K$

$= 60\Omega \times 0.04\Omega^{-1}\ \text{cm}^{-1}$

$2.4\ \text{cm}^{-1}$

117. Match the following columns (P) with (Q) :

(P)	(Q)
a) Grignard reagent	(i) $AlCl_3$
b) Sandmeyer's reaction	(ii) Sodium metal
c) Cannizzaro reaction	(iii) Cu(I)
d) Friedel-Crafts reaction	(iv) CH_3MgBr
e) Wurte reaction	(v) NaOH

(A) a)-(iv); b)-(iii); c)-(ii); d)-(i); e)-(v)

(B) a)-(v); b)-(ii); c)-(iii); d)-(iv); e)-(i)

(C) a)-(iv); b)-(i); c)-(v); d)-(iii); e)-(ii)

(D) a)-(ii); b)-(iii); c)-(i); d)-(v); e)-(iv)

(E) a)-(iv); b)-(iii); c)-(v); d)-(i); e)-(ii)

Ans: E

a) Grignard reagent → (iv) CH_3MgBr

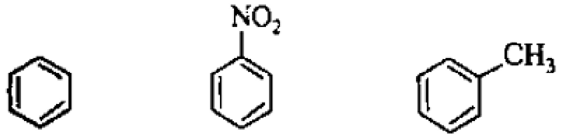
b) Sandmeyer's Reaction → (iii) Cu (I)

c) Cannizzaro Reaction → (v) NaOH

d) Friedel-Crafts Reaction → (i) $AlCl_3$

e) Wurtz reaction → (ii) Na metal

118. Which compound will not take part in the Friedel-Crafts acylation?



i ii iii

(A) ii and iii (B) only iii

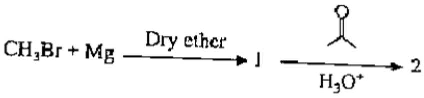
(C) i and iii (D) only ii

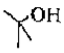
(E) only *i*

Ans: D

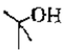
$-NO_2 \rightarrow$ Deactivating group

119. Identify 1 and 2 in the following reaction

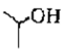


(A) H_3C-CH_3 and 

(B) CH_3MgBr and CH_3CHO

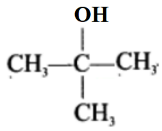
(C) CH_3MgBr and 

(D) CH_4 and CH_3CHO

(E) H_3C-CH_3 and 

Ans: C

$CH_3Br + Mg \xrightarrow{Dryether} \underset{CH_3MgBr}{(1)} \xrightarrow[H_3O^+]{CH_3-\overset{O}{\overset{\|}{C}}-CH_3}$



120. What is the major product in the following reaction?

$CH_3-CH_2-CH_2-CH=CH_2+HBr \longrightarrow$

(A) $CH_3-CH_2-CH_2-CH_2-CH_2-Br$

(B) $CH_3-CH_2-CH_2-\underset{Br}{CH}-CH_3$

(C) $CH_3-CH_2-CH_2-\underset{Br}{\overset{Br}{C}}-CH_3$

(D) $CH_3-CH_2-CH_2-\underset{Br}{CH}-CH_2-Br$

(E) $CH_3-CH_2-CH_2-CH_2-CH_3$

Ans: B

$$CH_3-CH_2-CH_2-CH=CH_2+HBr \longrightarrow CH_3-CH_2-CH_2-\underset{\text{Br}}{\underset{|}{CH}}-CH_3$$