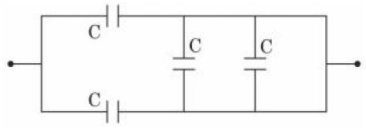
FINAL JEE–MAIN EXAMINATION – APRIL, 2023
Held On Monday 10th April, 2023
TIME : 09:00 AM to 12:00 PM

SECTION - A

31. The equivalent capacitance of the combination shown is



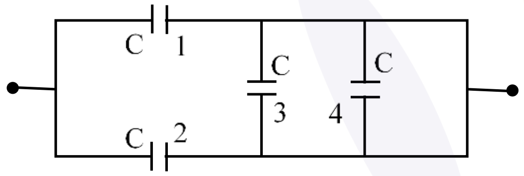
(1) 4C (2) $\frac{5}{3}C$ (3) $\frac{C}{2}$ (4) 2C

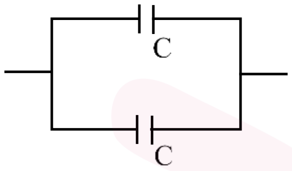
Sol. **(4)**

Capacitor (3) & (4) are short ckt

$\therefore$ C_1 & C_2 are in parallel

$C_{eq.} = C + C = 2C$





32. Match List I with List II :

List I	List II
(A) 3 Translational degrees of freedom	(I) Monoatomic gases
(B) 3 Translational, 2 rotational degrees of freedoms	(II) Polyatomic gases
(C) 3 Translational, 2 rotational and 1 vibrational degrees of freedom	(III) Rigid diatomic gases
(D) 3 Translational, 3 rotational and more than one vibrational degrees of freedom	(IV) Nonrigid diatomic gases

Choose the correct answer from the options given below :

(1) (A)-(I), (B)-(III), (C)-(IV), (D)-(II)
(2) (A)-(I), (B)-(IV), (C)-(III), (D)-(II)
(3) (A)-(IV), (B)-(II), (C)-(I), (D)-(III)
(4) (A)-(IV), (B)-(III), (C)-(II), (D)-(I)

Sol. **(1)**

Fact Based

Type of gas	No of degree of freedom
1 Monoatomic 2. Diatomic + rigid	3 (Translational) 3 (Translational + 2 Rotational = 5)
3. Diatomic + non – rigid	3 (Trans) + 2 (Rotational) + 1 (vibrational)
4. Polyatomic	3 (Trans) + 2(Rotational) + more than 1 (vibrational)

33. Given below are two statements :

Statements I : If the number of turns in the coil of a moving coil galvanometer is doubled then the current sensitivity becomes double.

Statements II : Increasing current sensitivity of a moving coil galvanometer by only increasing the number of turns in the coil will also increase its voltage sensitivity in the same ratio

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

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

Sol. **(3)**

$$I = \frac{k\theta}{NBA}$$

$$C \cdot S = \frac{\theta}{I} = \frac{NBA}{K}$$

$N \to 2N \quad C \cdot S \to 2CS$

But $V.S. = \frac{\theta}{V} = \frac{NBA}{KR}$

$N \to 2N C \cdot S \to 2CS$

But $V.S. = \frac{\theta}{v} = \frac{\theta}{IR} = \frac{NBA}{RK}$

As $N \to 2N, R \to 2R$ So V.S = constant

34. Given below are two statements :

Statement I : Maximum power is dissipated in a circuit containing an inductor, a capacitor and a resistor connected in series with an AC source, when resonance occurs

Statement II : Maximum power is dissipated in a circuit containing pure resistor due to zero phase difference between current and voltage.

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

(1) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are true

Sol. **(4)**

Power is more when total impendence of ckt in minimum

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$\because X_L = X_C$ (conductor of resonance)

$\therefore Z_{min} = R \quad \therefore V \,\&\, I$ in same phase

35. The range of the projectile projected at an angle of 15° with horizontal is 50 m. If the projectile is projected with same velocity at an angle of 45° with horizontal, then its range will be

(1) $100\sqrt{2}$m (2) 50 m (3) 100 m (4) $50\sqrt{2}$m

Sol. **(3)**

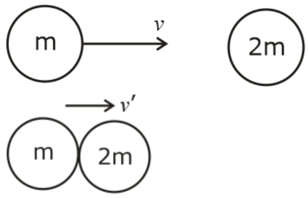
So $R = \frac{u^2 \sin(2 \times 15)}{g} = \frac{u^2}{2g} =$ So $\Rightarrow \frac{u^2}{g} = 100$

$$R' = \frac{u^2 \sin(2 \times 45)}{g} = \frac{u^2}{g} = 100\,m$$

36. A particle of mass m moving with velocity v collides with a stationary particle of mass 2m. After collision, they stick together and continue to move together with velocity

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

Sol. **(2)**



pi = pf $\Rightarrow$ mv + 2m (0) = 3m (v')

$$v' = \frac{v}{3}$$

37. Two satellites of masses m and 3m revolve around the earth in circular orbits of radii r & 3 r respectively. The ratio of orbital speeds of the satellites respectively is

(1) 3 : 1 (2) 1 : 1 (3) $\sqrt{3}:1$ (4) 9 : 1

Sol. **(3)**

$v=\sqrt{\frac{GM}{r}} \Rightarrow v \times \frac{1}{\sqrt{r}}$; M = mass of earth, r = radius of earth

$\frac{v_1}{v_2}=\sqrt{\frac{r_2}{r_1}}=\sqrt{\frac{3r}{r}}=\sqrt{3}$

38. Assuming the earth to be a sphere of uniform mass density, the weight of a body at a depth $d=\frac{R}{2}$ from the surface of earth, if its weight on the surface of earth is 200 N, will be :

(1) 500 N (2) 400 N (3) 100 N (4) 300 N

Sol. **(3)**

mg = 200 N

$g'=g\left(1-\frac{d}{R}\right)=g\left(1-\frac{R}{2\times R}\right)=\frac{g}{2}$

weight = $mg'=\frac{mg}{2}=\frac{200}{2}=100\,N$

39. The de Broglie wavelength of a molecule in a gas at room temperature (300 K) is λ_1. If the temperature of the gas is increased to 600 K, then the de Broglie wavelength of the same gas molecule becomes

(1) $2\lambda_1$ (2) $\frac{1}{\sqrt{2}}\lambda_1$ (3) $\sqrt{2}\lambda_1$ (4) $\frac{1}{2}\lambda_1$

Sol. **(2)**

$\lambda=\frac{h}{\sqrt{3mK(T)}}$

$\frac{\lambda_1}{\lambda_2}=\sqrt{\frac{T_2}{T_1}}$

$\lambda_2=\lambda_1\sqrt{\frac{T_1}{T_2}}$

$=\lambda_1\sqrt{\frac{300}{600}}=\frac{\lambda_2}{\sqrt{2}}$

40. A physical quantity P is given as

$P=\frac{a^2b^3}{c\sqrt{d}}$

The percentage error in the measurement of a, b, c and d are 1%, 2%, 3% and 4% respectively. The percentage error in the measurement of quantity P will be

(1) 14% (2) 13% (3) 16% (4) 12%

Sol. **(2)**

$\frac{dP}{P}\times 100=\left(2\frac{da}{a}+3\frac{db}{b}+\frac{dc}{c}+\frac{1}{2}\frac{d(d)}{d}\right)\times 100$

$= 2\times 1+3\times 2+3+\frac{1}{2}\times 4$

$= 2+6+3+2$

$= 13\%$

41. Consider two containers A and B containing monoatomic gases at the same Pressure (P), Volume (V) and Temperature (T). The gas in A is compressed isothermally to $\frac{1}{8}$ of its original volume while the gas in B is compressed adiabatically to $\frac{1}{8}$ of its original volume. The ratio of final pressure of gas in B to that of gas in A is

(1) 8 (2) 4 (3) $\frac{1}{8}$ (4) $8^{\frac{3}{2}}$

Sol. **(2)**

By Isothermal Process for (A)

$P_1V_1 = P_2V_2$

$PV = P_2\frac{V}{8}$

$P_2 = 8P$

For B adiabatically $\gamma_{mono} = \frac{5}{3}$

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$PV^{5/3} = P_2\left(\frac{V}{8}\right)^{5/3}$

$P_2 = (8)^{5/3}P$

$\frac{P_2}{P_1} = \frac{8^{5/3}}{8P} = (8)^{\frac{2}{3}} = 4$

42. Given below are two statements :

Statements I : Pressure in a reservoir of water is same at all points at the same level of water.

Statements II : The pressure applied to enclosed water is transmitted in all directions equally.

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

(1) Both Statements I and Statements II are false

(2) Both Statements I and Statements II are true

(3) Statements I is true but Statements II is false

(4) Statements I is false but Statements II is true

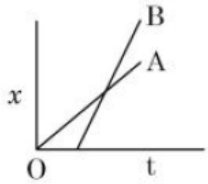
Sol. (2)

Both Statements I and Statements II are true

By Theory

By Pascal law, pressure is equally transmitted to in enclosed water in all direction.

43. The positon-time graphs for two students A and B returning from the school to their homes are shown in figure.



(A) A lives closer to the school

(B) B lives closer to the school

(C) A takes lesser time to reach home

(D) A travels faster than B

(E) B travels faster than A

Choose the correct answer from the options given below :

(1) (A) and (E) only (2) (A), (C) and (E) only

(3) (B) and (E) only (4) (A), (C) and (D) only

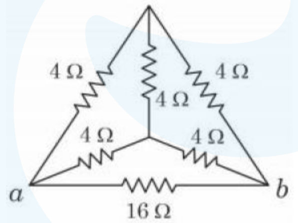
Sol. (1)

(A) and (E) only
Slope of A = V_A
Slope of B = V_B
$(slope)_B > (slope)_A$
$V_B > V_A$
$\therefore t_B < t_A$

44. The energy of an electromagnetic wave contained in a small volume oscillates with
(1) double the frequency of the wave
(2) the frequency of the wave
(3) zero frequency
(4) half the frequency of the wave

Sol. (1)
double the frequency of the wave
$E = E_0 \sin(wt - kx)$
Energy density $= \frac{1}{2}\varepsilon_0 E_{net}$
$= \frac{1}{2}\varepsilon_0 E_0^2 \sin^2(wt - kx)$
$= \frac{1}{4}\varepsilon_0 E_0^2 (1 - \cos(2wt - 2kx))$

45. The equivalent resistance of the circuit shown below between points a and b is :



(1) 20 Ω (2) 16 Ω (3) 24Ω (4) 3.2 Ω

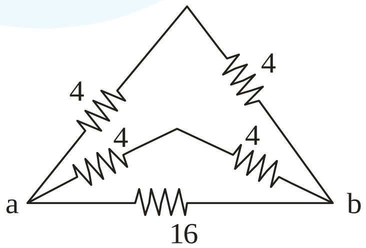
Sol. **(4)**

$\frac{1}{R_{ab}} = \frac{1}{16} + \frac{1}{8} + \frac{1}{8}$

$= \frac{1}{R_{ab}} = \frac{1+2+2}{16} = \frac{5}{16}$

$R_{ab} = \frac{16}{5} = 3.2$

Balanced WSB



46. A carrier wave of amplitude 15 V modulated by a sinusoidal base band signal of amplitude 3 V. The ratio of maximum amplitude to minimum amplitude in an amplitude modulated wave is

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

Sol. **(4)**
$V_C = 15$
$V_m = 3$
$V_{max} = 15 + 3 = 18$
$V_{min} = 15 - 3 = 12$
$V_{max} = \frac{18}{12} = \frac{3}{2} = 3 : 2$

47. A particle executes S.H.M. of amplitude A along x-axis. At t = 0, the position of the particle is $x = \frac{A}{2}$ and it moves along positives x-axis. The displacement of particle in time t is $x = A\sin(\omega t + \delta)$, then the value δ will be

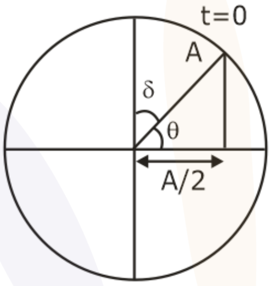
(1) $\frac{\pi}{4}$ (2) $\frac{\pi}{2}$ (3) $\frac{\pi}{3}$ (4) $\frac{\pi}{6}$

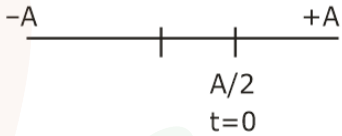
Sol. **(4)**

$\cos\theta = \frac{A}{2\times A} = \frac{1}{2}$

$\theta = \frac{\pi}{3}$

$\delta = \frac{\pi}{2} - \frac{\pi}{3} = \frac{\pi}{6}$





48. The angular momentum for the electron in Bohr's orbit is L. If the electron is assumed to revolve in second orbit of hydrogen atom, them the change in angular momentum will be

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

Sol. **(3)**

Angular momentum = $\frac{nh}{2\pi}$

$n = 1, L_1 = \frac{h}{2\pi} = L$

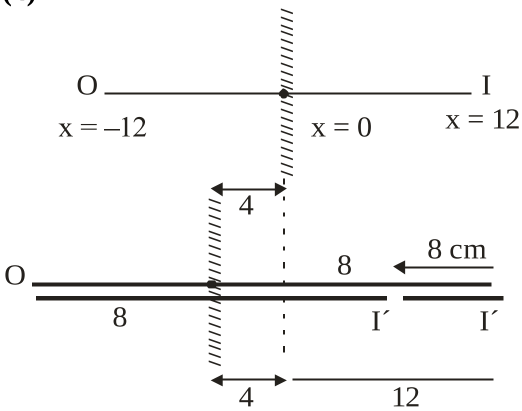
$n = 2, L_2 = \frac{2h}{2\pi} = 2L$

$\Delta L = 2L - L = L$

49. An object is placed at a distance of 12 cm in front of a plane mirror. The virtual and erect image is formed by the mirror. Now the mirror is moved by 4 cm towards the stationary object. The distance by which the position of image would be shifted, will be

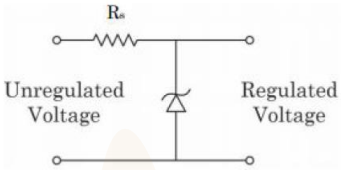
(1) 4 cm towards mirror (2) 8 cm away from mirror
(3) 2 cm towards mirror (4) 8 cm towards mirror

Sol. **(4)**



8 cm towards mirror
Image will be shifted 8 cm towards mirror.

50. A zener diode of power rating 1.6 W is be used as voltage regulator. If the zener diode has a breakdown of 8 V and it has to regulate voltage fluctuating between 3 V and 10 V. The value of resistance R_8 for safe operation of diode will be



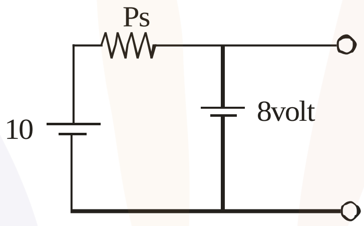
(1) 13.3 Ω (2) 13 Ω (3) 10 Ω (4) 12 Ω

Sol. **(3)**

$I_t = \frac{P_t}{V_t} = \frac{1.6}{8} = 0.2A$

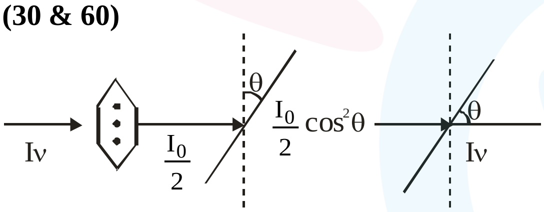
$R_s = \frac{10-8}{I}$

$\boxed{R_s = \frac{2}{0.2} = 10\Omega}$



51. Unpolarised light of intensity 32 Wm^{-2} passes through the combination of three polaroids such that the pass axis of the last polaroid is perpendicular to that of the pass axis of first polaroid. If intensity of emerging light is 3 Wm^{-2}, then the angle between pass axis of first two polaroids is ________°.

Sol. **(30 & 60)**



$I_{net} = 3 = \frac{32}{8}(\sin 2\theta)^2$ $\qquad = \frac{I_0}{2}\cos^2\theta \sin^2\theta$

$\text{Sin}(2\theta) = \frac{\sqrt{3}}{2} \Rightarrow 2\theta = 60 \; \& \; 120°$ $\qquad = \frac{I_0}{8}(\sin 2\theta)^2$

$\boxed{\theta = 30°}$ & 60°

52. If the earth suddenly shrinks to $\frac{1}{64}$th of its original volume with its mass remaining the same, the period of rotation of earth becomes $\frac{24}{x}h$. The value of x is __________ .

Sol. **(16)**

By AMC

$\frac{2}{5}MR^2\omega_1^2 = \frac{2}{5}M\left(\frac{R}{4}\right)^2 \omega_2$

$\frac{\omega_1}{\omega_2} = \frac{1}{16} = \frac{T_2}{T_1} = \frac{T_2}{24}$

$T_2 = \frac{24}{16}$ $\qquad \boxed{\therefore\ x = 16}$ Ans.

53. Three concentric spherical metallic shells X, Y and Z of radius a, b and c respectively [a < b < c] have surface charge densities σ, $-\sigma$ and σ, respectively. The shells X and Z are at same potential. If the radii of X & Y are 2 cm and 3 cm, respectively. The radius of shell Z is __________ cm.

Sol. **(5)**

$q_x = \sigma 4\pi a^2$

$q_y = -\sigma 4\pi b^2$

$q_z = \sigma 4\pi c^2$

Potential of y

$$\frac{q_x}{4\pi\varepsilon_0 a} + \frac{q_y}{4\pi\varepsilon_0 b} + \frac{q_z}{4\pi\varepsilon_0 c} = \frac{q_x}{4\pi\varepsilon_0 c} + \frac{q_y}{4\pi\varepsilon_0 c} + \frac{q_z}{4\pi\varepsilon_0 c}$$

$$\frac{\sigma 4\pi a^2}{a} - \frac{\sigma 4\pi b^2}{b} + \frac{\sigma 4\pi c^2}{c} = 4\pi\sigma\frac{(a^2 - b^2 + c^2)}{C}$$

$c(a - b + c) = a^2 - b^2 + c^2$

$c(a - b) + c^2 = (a + b)(a - b)$

$c(a - b) = (a + b)(a - b)$

$\boxed{c = a + b} = 2 + 3$

$\boxed{c = 5\text{ cm}}$ Ans.

54. A transverse harmonic wave on a string is given by

$y(x, t) = 5 \sin (6t + 0.003 x)$

where x and y are in cm and t in sec. The wave velocity is _________ ms^{-1}.

Sol. **(20)**

$$v = \frac{w}{k} = \frac{6}{.003 \times 10^2} = \frac{6}{.3} = \frac{60}{3} = 20 \text{ m/s.}$$

55. 10 resistors each of resistance 10 Ω can be connected in such as to get maximum and minimum equivalent resistance. The ratio of maximum and minimum equivalent resistance will be ______.

Sol. **(100)**

$R_{max} \Rightarrow$ in series $\Rightarrow$ $10R = 10 \times 10 = 100\Omega$

$R_{max} \Rightarrow$ in parallel $= \frac{R}{10} = \frac{10}{10} = 1\Omega$

$$\frac{R_{max}}{R_{min}} = \frac{100}{1} = 100 \text{ Ans.}$$

$R_{min} \Rightarrow \frac{100}{1} = 100$ Ans.

56. The decay constant for a radioactive nuclide is $1.5 \times 10^{-5}\ s^{-1}$. Atomic weight of the substance is 60 g $mole^{-1}$, ($N_A = 6 \times 10^{23}$). The activity of 1.0 μg of the substance is _________ $\times 10^{10}$ Bq.

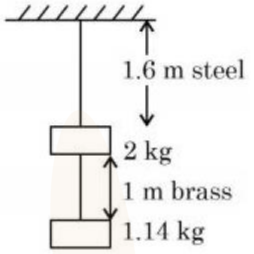
Sol. **(15)**

$$\text{No. of moles} = \frac{1 \times 10^{-6}}{60} = \frac{10^{-7}}{6}$$

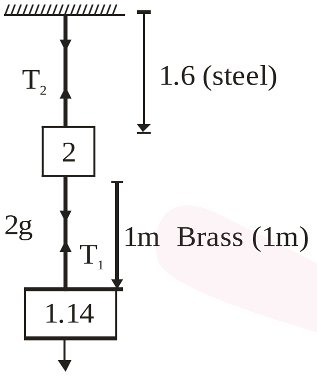
$$\text{No. of atom} = n(NA) = \frac{10^{-7}}{6} \times 6 \times 10^{23} = 10^{16}$$

at $(t = 0)$ $A_0 = N_0\lambda = 10^{16} \times 1.5 \times 10^{-5} = 15 \times 10^{10}$ Bq

57. Two wires each of radius 0.2 cm and negligible mass, one made of steel and the other made of brass are loaded as shown in the figure. The elongation of the steel wire is _______ $\times 10^{-6}$ m. [Young's modulus for steel = 2×10^{11} Nm^{-2} and g = 10 ms^{-2}



Sol. **(20)**



1.14 = 11.4

$T_2 = T_1 + 20 = 20 + 11.4$

$T_2 = 31.4$

$\therefore$ Elongation in steel wire

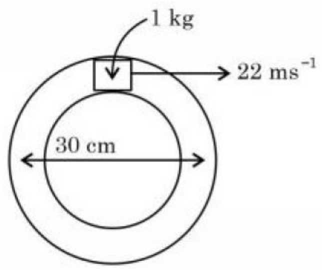
$$\Delta L = \frac{T_2 L}{AY}$$

$$= \frac{31.4 \times 1.6}{\pi(0.2 \times 10^{-2})^2 \times 2 \times 10^{11}}$$

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

$\boxed{\Delta L = 20 \times 10^{-6}\ m}$

58. A closed circular tube of average radius 15 cm, whose inner walls are rough, is kept in vertical plane. A block of mass 1 kg just fit inside the tube. The speed of block is 22 m/s, when it is introduced at the top of tube. After completing five oscillations, the block stops at the bottom region of tube. The work done by the tube on the block is _____ J. (Given : g = 10 m/s^2)



Sol. **(245)**

R_{arg} = 15cm = .15 m

By WET

$W_f + W_{gravity} = \Delta K = Kf - Ki$

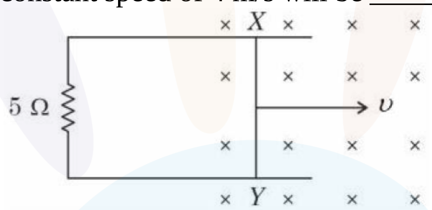
$W_f + 10 \times .3 = 0 - \frac{1}{2} \times 1 \times (22)^2$

$W_f = -3 - \frac{484}{2} = 3 - 242 = -245$

Work by friction = – 245

By NTA (+245)

59. A 1 m long metal rod XY completes the circuit as shown in figure. The plane of the circuit is perpendicular to the magnetic field of flux density 0.15 T. If the resistance of the circuit is 5 Ω, the force needed to move the rod in direction, as indicated, with a constant speed of 4 m/s will be ________ 10^{-3}N.



Sol. **(18)**

$F = I\ell B = \left(\frac{e}{R}\right)\ell B = \frac{(Bv\ell)B\ell}{R} = \frac{B^2\ell^2 v}{R}$

$= \frac{(\cdot 15)^2 \times (1)^2 \times 4}{5} = 180 \times 10^{-4}$

$=18 \times 10^{-3}$ = **18 Ans.**

60. The current required to be passed through a solenoid of 15 cm length and 60 turns in order to demagnetize a bar magnet of magnetic intensity 2.4×10^3 Am^{-1} is ________A.

Sol. **(6)**

$H = 2.4 \times 10^3$ A/m

$H = nI = \frac{N}{\ell} I$

$I = \frac{H\ell}{N} = \frac{2.4 \times 10^3 \times 15 \times 10^{-2}}{60}$

$\boxed{I = 6A}$