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JEE (Main)

PAPER-1 (B.E./B. TECH.)

2021

COMPUTER BASED TEST (CBT)

Memory Based Questions & Solutions

Date: 27 July, 2021 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

SUBJECT: PHYSICS

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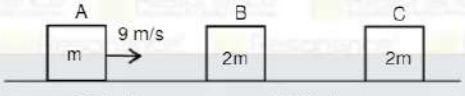
PART : PHYSICS

1. In the given arrangement, block A of mass m moving with speed 9m/s, strikes with block B of mass 2m elastically. Then block B strikes with block C of mass 2m perfect in-elastically. Find the final speed of block C?



(1) 3 m/s (2) 4 m/s (3) 5 m/s (4) 6 m/s

Ans. (1)

Sol. $9m = mv_A + 2mv_B$

$9 = v_A + 2v_B$ ....(1)

$9 = v_B - v_A$ ....(2)

Thus $v_B = 6$ m/s

Collision between B & C

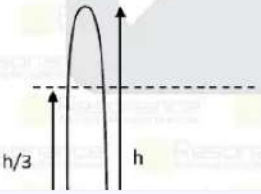
$v_C = 3$ m/s

2. A particle is thrown upward at t = 0. It attains maximum height of h. It is found at height h/3 at $t = t_1$ & $t = t_2$. Find t_1/t_2 :

(1) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ (2) $\frac{1}{3}$ (3) $\frac{\sqrt{6}-\sqrt{5}}{\sqrt{6}+\sqrt{5}}$ (4) $\frac{1}{2}$

Ans. (3)

Sol.



$V = \sqrt{2gh}$

$\frac{h}{3} = \sqrt{2gh}t - \frac{1}{2}gt^2$

$gt^2 - 2\sqrt{2gh}t + \frac{2h}{3} = 0$

$t = \frac{2\sqrt{2gh} \pm \sqrt{8gh - 4g \times \frac{2h}{3}}}{2g} = \frac{2\sqrt{2gh} \pm \sqrt{\frac{16gh}{3}}}{2g}$

$= \frac{2\sqrt{2gh} \pm 4\sqrt{\frac{gh}{3}}}{2g}$

$\frac{t_1}{t_2} = \frac{2\sqrt{2gh} - 4\sqrt{\frac{gh}{3}}}{2\sqrt{2gh} + 4\sqrt{\frac{gh}{3}}}$

$2\sqrt{2} - \frac{4}{\sqrt{3}}$ $\sqrt{3} - \sqrt{2}$

3. In YDSE, if the light-used is shifted from orange to blue then which of the following is correct.

(1) Fringe width first increases then decreases (2) Fringe width increase

(3) Fringe width decreases (4) Fringe width first decreases than increases

Ans. (3)

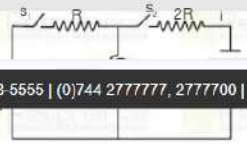
Sol. $\beta = \frac{\lambda D}{d}$

Sol. $p = \frac{\quad}{d}$

$\lambda_{blue} < \lambda_{orange}$

$\beta_{blue} < \beta_{orange}$

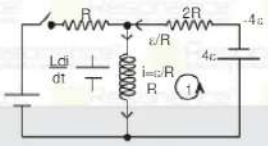
4. In the circuit shown in the figure, S_1 remains closed for a long time and S_2 remains open. Now S_2 is closed and S_1 is opened. Find out the di/dt just after that moment.



(1) $-\frac{4\varepsilon}{L}$ (2) $-\frac{6\varepsilon}{L}$ (3) $-\frac{2\varepsilon}{L}$ (4) $-\frac{\varepsilon}{L}$

Ans. **(2)**

Sol. Before S_2 is closed and S_1 is opened current in the left part of the circuit = $\frac{\varepsilon}{R}$. Now when S_2 closed S_1 opened, current through the inductor cannot change suddenly, current $\frac{\varepsilon}{R}$ will continue to move in the inductor.



Applying KVL in loop 1.

$L\frac{di}{dt} + \frac{\varepsilon}{R}(2R) + 4\varepsilon = 0$

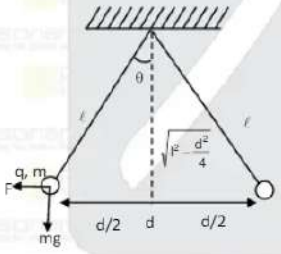
$\frac{di}{\quad} = \frac{6\varepsilon}{\quad}$

5. Two identical tennis balls of mass m and charge q are hinged by a common support with the help of a string of length 'ℓ'. If the system is in equilibrium, then find the distance between the balls? Ignore gravitational interactions between balls. (θ is very small)

(1) $\left(\frac{kq^2\ell}{mg}\right)^{1/3}$ (2) $\left(\frac{3kq^2\ell}{mg}\right)^{1/3}$ (3) $\left(\frac{2kq^2\ell}{mg}\right)^{1/3}$ (4) $\left(\frac{3kq^2\ell}{2mg}\right)^{1/3}$

Ans. **(3)**

Sol.



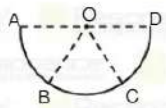
$$\tan\theta = \frac{\frac{kq^2}{d^2}}{mg} \approx \sin\theta$$

$\frac{kq^2}{\quad} = \frac{d}{\quad}$

$$mgd^{<} \quad 2\ell$$

$$d^3 = \frac{2kq^2\ell}{mg} \quad \Rightarrow \quad d = \left(\frac{2kq^2\ell}{mg}\right)^{1/3}$$

6. For the given semicircle with centre O. choose the correct relation? If A, B, C & D are points on the semicircle such that $|\overrightarrow{AB}| = |\overrightarrow{BC}| = |\overrightarrow{CD}|$.



(1) $2|\overrightarrow{BO}| = 2|\overrightarrow{AO}| = |\overrightarrow{AD}|$ (2) $|\overrightarrow{BO}| = 2|\overrightarrow{AO}| = |\overrightarrow{AD}|$ (3) $2|\overrightarrow{BO}| = |\overrightarrow{AO}| = |\overrightarrow{AD}|$ (4) $|\overrightarrow{BO}| = |\overrightarrow{AO}| = |\overrightarrow{AD}|$

Ans. (1)

Sol. For the given semicircle

$|\overrightarrow{AB}| = |\overrightarrow{BC}| = |\overrightarrow{CD}|$ = Table of circle

$|\overrightarrow{AD}|$ = Diameter of circle

$|\overrightarrow{AD}| = 2|\overrightarrow{AO}| = 2|\overrightarrow{BO}|$

7. A monoatomic gas is kept in a 1 litre container at pressure 1 atm. If average energy per molecule is 2×10^{-9} J, find no. of molecules in the container :

(1) 0.75×10^{-6} (2) 0.75×10^{9} (3) 0.5×10^{11} (4) 0.75×10^{11}

Ans. (4)

Sol. Total energy $= \frac{f}{2}nRT = \frac{3}{2}PV$

According to question $\frac{3}{2}PV = N \times 2 \times 10^{-9}$ J

$\frac{3}{2} \times 10^5 \times 1000 \times 10^{-6} = N \times 2 \times 10^{-9}$

$N = \frac{3}{4} \times \frac{10^{-6}}{10^{-9}} = \frac{3}{4} \times 10^{11} = 0.75 \times 10^{11}$

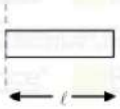
8. The relative permittivity of distilled water is 81. The velocity of light in it will be ($\mu_r = 1$)

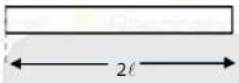
(1) 3.3×10^7 (2) 5.3×10^7 (3) 4.3×10^7 (4) None

Ans. (1)

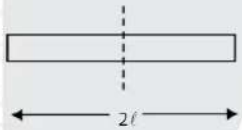
Sol. $v = \frac{c}{\sqrt{\mu_r \varepsilon_r}}$

9. Match the following column if all the rods have same density and same radius.

(i)  (a) $\frac{M\ell^2}{12}$

(ii)  (b) $\frac{M\ell^2}{3}$

(iii)  (c) $\frac{2M\ell^2}{3}$

(iv)  (d) $\frac{8M\ell^2}{3}$

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

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

Ans. (1)

Sol. (1) $\frac{M\ell^2}{3}$ (a)

(2) $\frac{2M(2\ell)^2}{3} \Rightarrow \frac{8M\ell^2}{3}$ (b)

$\frac{M\ell^2}{}$

(4) $\frac{2M4\ell^2}{12} \Rightarrow \frac{2M\ell^2}{3}$ (d)

10. A particle executing SHM having maximum kinetic energy 'E' and amplitude 'A'. Find displacement from mean position when its kinetic energy is $\frac{3E}{4}$:

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

Ans. (1)

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Sol. $V = A\omega$, $KE_{max} = \frac{1}{2}m\omega^2A^2$

$V = \omega\sqrt{A^2 - x^2}$ $KE_x = \frac{1}{2}m\omega^2(A^2 - x^2)$

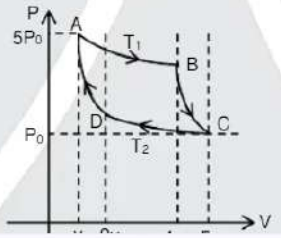
$\frac{3}{4}KE_{max} = KE_x$

$\frac{3}{4}\frac{1}{2}m\omega^2A^2 = \frac{1}{2}m\omega^2(A^2 - x^2)$

$$x^2 = \frac{A^2}{4}$$

$$x = \pm \frac{A}{2}$$

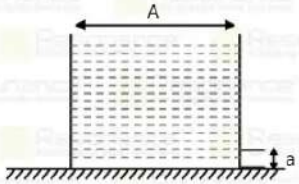
11. For given PV diagram AB is isothermal at T_1 temperature, CD is also isothermal at T_2 temperature. given that $T_1 > T_2$. Then which one of the following is correct.



(1) $W_{AB} > W_{BC}$ (2) $W_{BC} = W_{AD}$ (3) $W_{AB} < W_{BC}$ (4) $W_{AB} = W_{BC}$

Ans. (1)

12. A container of area 'A' filled with liquid, a small hole of area 'a' is made at the bottom of curved surface as shown. Find the coefficient of friction between container and ground in order to prevent it from sliding.



(1) $\frac{a}{A}$ (2) $\frac{2a}{A}$ (3) $\frac{a}{2A}$ (4) $\frac{3a}{2A}$

Ans. (2)

Sol. Force exerted by leaving water on the container,

$$F = \left(\frac{dm}{dt}\right)v = (\rho a v)v$$

$$= \rho a v^2$$

By conservation of energy $v = \sqrt{2gh}$

$$\mu\rho(Ah)g = \rho a 2gh$$

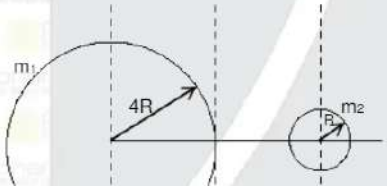
$$\mu = \frac{2a}{A}$$

13. Two solid spheres of radius 4R and R and having same mass density ρ kept at a distance of 8 R. Find Moment of Inertia of the system about the axis passes through centre of line joining their centres.

(1) $\frac{9660}{5}\pi\rho R^5$ (2) $\frac{5800}{3}\pi\rho R^5$ (3) $\frac{9664}{4}\pi\rho R^5$ (4) $\frac{9664}{3}\pi\rho R^5$

Ans. (2)

Sol.



Let mass density = ρ

$$m_2 = \frac{4}{3}\pi R^3\rho$$

$$m_1 = \frac{4}{3}\pi(4R)^3\rho$$

$m_1 = 64\ m_2$

$I_{final} = [I_2 + m_2(4R)^2] + [I_1 + m_1(4R)^2]$

$$= \frac{2}{5}m_2R^2 + 16m_2R^2 + \frac{2}{5}m_1(4R)^2 + m_1(4R)^2$$

$$= \frac{2}{5}m_2R^2 + 16m_2R^2 + \frac{2}{5}64m_2(4R)^2 + 64\,m_2(4R)^2 = \frac{5800}{3}\pi\rho R^5$$

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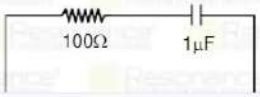
14. For the given circuit, switch is closed at t = 0 find time after which voltage across capacitor becomes 50 V



(1) 69.3 μsec (2) 60 μsec (3) 50 μsec (4) 40 μsec

Ans. **(1)**

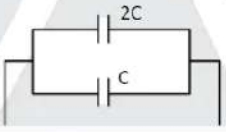
Sol. $V = V_0 e^{\frac{t}{RC}}$

$50 = 100e^{-\frac{t}{RC}}$

$t = RC\ \ell n\ 2$

$= 100 \times 10^{-6}\ \ell n\ 2 = 10^{-4} \times 0.693$ sec $= 69.3$ μsec

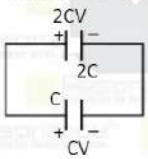
15. Figure shows two capacitors in steady state. Now the cell is removed and a dielectric of dielectric constant k is inserted between the plates of the capacitor of capacitance C. Find new potential difference across any of the capacitors :



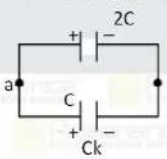
(1) $\frac{V}{2+k}$ (2) $\frac{2V}{2+k}$ (3) $\frac{3V}{2+k}$ (4) $\frac{V}{1+2k}$

Ans. **(3)**

Sol. Just after removing cell



After inserting dielectric



Conservation of charge

$2CV + CV = 2C.\ V_{ab} + Ck\ V_{ab}$

$\therefore \quad V_{ab} = \frac{3CV}{2C + CK}$

$$V_{ab} = \frac{3V}{2+K}$$

16. A particle of mass 9.1×10^{-31} kg is moving with velocity 6 m/s. Momentum of photon is 2×10^{-27} kg m/s. If de–Broglie wavelength of the particle is K times of the wavelength of photon. Find value of K :

Sol. De–Broglie wavelength of particle

$$\lambda = \frac{h}{p} = \frac{h}{9.1\times10^{-31}\times6}$$

Wavelength of photon

$$\lambda_{photon} = \frac{h}{p} = \frac{h}{2\times10^{-27}}$$

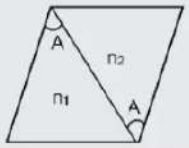
From question

$$K\lambda_{photon} = \lambda_{particle}$$

$$\Rightarrow \quad K = \frac{2\times10^{-27}}{9.1\times10^{-31}\times6} = 366$$

17. Two prism of same angle of refraction are arranged as shown. If the light incident, on the system goes undeviated. Then find wave length of incident light

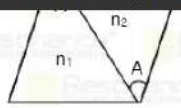
$$\left(\eta_2 = 1.45 + \frac{1.8\times10^{-14}}{\lambda^2}\right)$$



(1) 600 nm (2) 675 nm (3) 575 nm (4) 475 nm

Ans. (1)

Sol.



$\delta_{net} = A(n_1 - 1) - A(n_2 - 1) = 0$

$\Rightarrow \quad n_1 = n_2$

$\Rightarrow \quad 1.2 + \frac{10.8\times10^{-14}}{\lambda^2} = 1.45 + \frac{1.8\times10^{-14}}{\lambda^2}$

$\lambda^2 = \frac{(10.8-1.8)\times10^{-14}}{(1.45-1.2)}$

$\lambda = 600$ nm.

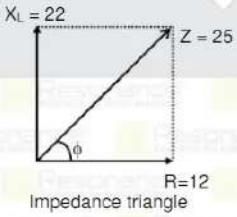
18. For the given circuit find current 'I' and the phase difference between V and I :

(1) 8.8A, $\tan^{-1}1.83$ (2) 6.8A, $\tan^{-1}2.83$ (3) 5.8A, $\tan^{-1}0.83$ (4) 7.8A, $\tan^{-1}2.53$

Ans. **(1)**

Sol. $\omega = 2\pi f = 100\pi$

Thus $x_L = \omega_L = 100 \times \frac{22}{7} \times 0.07 = 22\Omega$



Impedance triangle

Thus, $z = \sqrt{R^2 + x_L^2}$

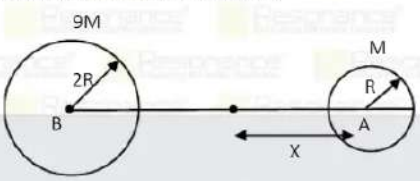
$z = \sqrt{(12)^2 + (22)^2}$

$z \approx 25.00$

$I = \frac{220}{\quad}$

$\tan\phi = 22/12 = 1.83$

the velocity of projection such that particle reaches to another planet 'B', which is at a distance of 8R from planet 'A'. Planet 'B' has mass 9M and radius 2R.



(1) $\sqrt{\frac{1}{5}\frac{GM}{R}}$ (2) $\sqrt{\frac{4}{7}\frac{GM}{R}}$ (3) $\sqrt{\frac{2}{5}\frac{GM}{R}}$ (4) $\sqrt{\frac{7}{3}\frac{GM}{R}}$

Ans. **(2)**

Sol. Let at a distance 'X' from planet 'A', the net gravitational field becomes zero

$$\frac{GM}{X^2} = \frac{G\times 9M}{(8R-X)^2}$$

$$X = 2R$$

Now, Particle should be projected such that it covers a minimum distance of '2R'.

Thus

$$\frac{1}{2}mv^2 - \frac{GMm}{R} - \frac{G(9M)m}{7R} = -\frac{GMm}{2R} - \frac{G(9M)m}{6R}$$

$$\frac{1}{2}v^2 = \frac{2}{7}\frac{GM}{R} \Rightarrow v = \sqrt{\frac{4}{7}\frac{GM}{R}}$$

20. Circular scale divisions of a screw gauge is 50. Five full rotations advances circular scale by 5mm.

Statement-1 : Least count of screw gauge is 0.001 cm

Statement-2 : Least count $= \frac{\text{pitch}}{\text{Total no. of divisions}}$

(1) Statement-1 & 2 both are true

(2) Statement-1 & 2 both are true statement-2 is correct explant of statement-1

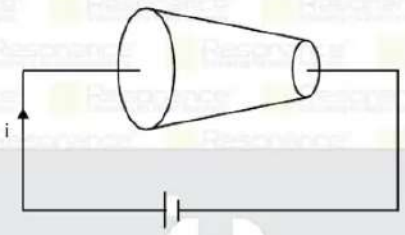
(3) Statement-1 is false Statement-2 is true

Ans. **(3)**

Sol. LC = 1mm/50 = 0.02 mm

Statement –1 is wrong. Statement–2 is right

21. Figure shows a conductor of tapered cone shape. As one goes from left to right on conductor, choose correct option



(1) current decreases (2) drift velocity of electron increases

(3) electric field inside conductor decreases (4) All of the above

Ans. **(2)**

Sol. $i = nAev_d$

$\therefore$ v_d increases as area A decrease

22. A body cools down from 61°C to 49°C in 4 min. and the surrounding temperature is 30°C. Find the time taken by this body to cool down from 49°C to 37°C.

(1) 1.62 min (2) 1.25 min (3) 7.69 min (4) 0.92 min.

Ans. **(3)**

Sol. $\frac{61-49}{4} = K\left[\frac{61+49}{2} - 30\right]$ ...(1)

$$\frac{49-37}{t} = k\left[\frac{49+37}{2} - 30\right] \quad \ldots(2)$$

Dividing (1) and (2)

$$\frac{t}{4} = \frac{25}{13}$$

$$t = \frac{4\times 25}{13} = 7.69$$

23. A bar–magnet of magnetic moment 9.85 A–m^2 and moment of inertia I = 10^{-6} kg–m^2 makes

(Take π^2 = 9.85)

(1) 20 μT (2) 25 μT (3) 16 μT (4) 10 μT

Ans. **(3)**

Sol. $T = 2\pi\sqrt{\frac{I}{MB}}$

$$\frac{1}{2} = 2\pi\sqrt{\frac{10^{-6}}{9.85\times B}} = 2\pi\sqrt{\frac{10^{-6}}{\pi^2\times B}}$$

$B = 16 \times 10^{-6}$ T

$= 16\ \mu$T

24. If two discs are of same mass density but having different radii R and r.

I_1 = Moment of inertia of disc of radius R, about an axis perpendicular to the plane of disc and passing through its centre.

I_2 = Moment of inertia of disc of radius r. about one of its diameter. Then choose correct option

(1) $\frac{I_1}{I_2} = \frac{2r^4}{R^2}$ (2) $\frac{I_1}{I_2} = \frac{2R^4}{r^4}$ (3) $\frac{I_1}{I_2} = \frac{2r^2}{R^2}$ (4) $\frac{I_1}{I_2} = \frac{2r}{R}$

Sol. Let mass density be σ

$M_1 = \pi R^2\sigma$, $M_2 = \pi r^2\sigma$

$$I_1 = \frac{1}{2}M_1R^2 = \frac{\pi\sigma R^4}{2}$$

$$I_2 = \frac{1}{4}M_2r^2 = \frac{\pi\sigma r^4}{4}$$

$$\frac{I_1}{I_2} = \frac{2R^4}{r^4}$$

25. Find the equivalent capacitance of shown arrangement if all the plates are identical having surface area A.

(1) $\frac{24}{15}\frac{A\varepsilon_0 d}{K}$ (2) $\frac{17}{15}\frac{A\varepsilon_0 d}{K}$ (3) $\frac{15}{34}\frac{A\varepsilon_0 d}{K}$ (4) $\frac{34}{15}\frac{A\varepsilon_0 d}{4K}$

Ans. (3)

Sol.

$$C_1 = \frac{A\varepsilon_0 K}{d} \quad C_2 = \frac{3KA\varepsilon_0}{2d} \quad C_3 = \frac{5KA\varepsilon_0}{3d}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$= \frac{d}{A\varepsilon_0 K} + \frac{2d}{3A\varepsilon_0 K} + \frac{3d}{5A\varepsilon_0 K}$$

$$= \frac{d}{A\varepsilon_0 K}\left(1 + \frac{2}{3} + \frac{3}{5}\right) = \frac{34}{15}\frac{d}{A\varepsilon_0 K}$$

Thus

$$\frac{15\,A\varepsilon_0 d}{34\,K}$$

26. An electron is revolving in a circular orbit of radius 0.5 m. with a speed of 2.2×10^{-6} m/s. Find equivalent current ?

(1) 1.12×10^{-25} A (2) 2.15×10^{-25} A (3) 1.12×10^{-15} A (4) 2.15×10^{-13} A

Ans. (1)

Sol. $i = \frac{q}{t} = \frac{q}{2\pi r/v}$

$$= \frac{1.6\times10^{-19}\times2.2\times10^{-6}}{2\pi\times0.5} = 1.12 \times 10^{-25}\,A$$

27. A capacitor (C = 100 μF) discharging against a resistor R, at same time a radioactive substance decays with mean life 30 ms, if the ratio of charge on capacitor and activity of substance remain same for all the time then, find the resistance :

(1) 300 Ω (2) 432 Ω (3) 450 Ω (4) 250 Ω

Ans. (1)

Sol. $q = q_0 e^{\frac{-t}{RC}}$ ...(1)

$A = A_0 e^{-\lambda t}$ ...(2)

Divide (1) & (2)

$$\Rightarrow \frac{q}{A} = \frac{q_0}{A_0}\frac{e^{\frac{-t}{RC}}}{e^{-\lambda t}} \Rightarrow -\lambda t = -\frac{t}{RC}$$

$RC = 1/\lambda = 30 \times 10^{-3}$ sec

$R = 300$

28. A wire of length 0.1 m and area of cross section 0.04×10^{-4} m^2 is stretched by 0.001 m, its young's modulus is 0.5×10^9 pa. The energy stored in this wire is transferred completely as kinetic energy to a particle of mass 20 grams. Find speed of this particle.

(1) 0.5 m/s (2) 1 m/s (3) 1.5 m/s (4) 10 m/s

Ans. (2)

Sol. $U = \frac{1}{2}Kx^2$

$= \frac{1}{2} \times \frac{AY}{L} \times (0.001)^2$

$\frac{1}{2} \frac{0.04 \times 10^{-4} \times 0.5 \times 10^9}{0.1} \times 10^{-6} = \frac{1}{2} \times 20 \times 10^{-3} \times v^2$

$\Rightarrow \quad v^2 = \frac{0.04 \times 10^{-4} \times 0.5 \times 10^3}{0.1 \times 20 \times 10^{-3}} = 1 \text{ m/s}$

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PAPER-1 (B.E./B. TECH.)

2021

COMPUTER BASED TEST (CBT)

Memory Based Questions & Solutions

Date: 27 July, 2021 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

SUBJECT: CHEMISTRY

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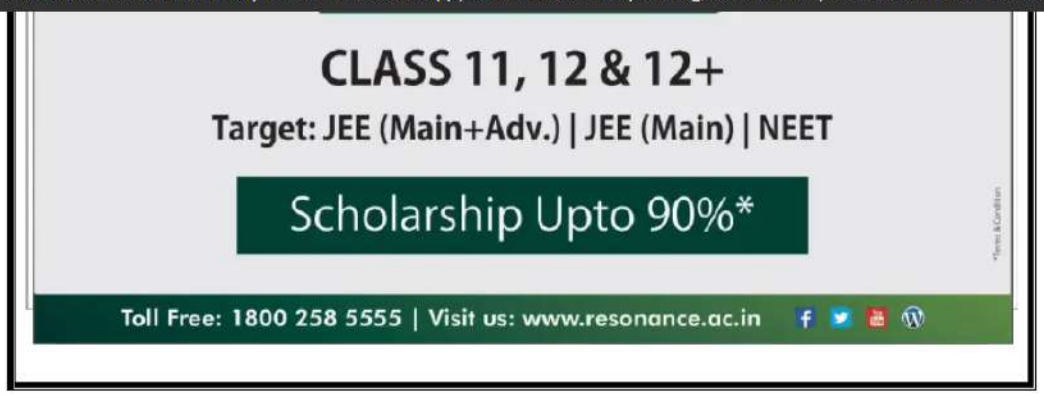

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PART : CHEMISTRY

1. A weak acid HA of concentration 0.001 mole/litre have conductance 2×10^{-5} Scm^{-1} and molar conductivity at infinite dilution is 190 Scm^2 mole^{-1} then value of Ka of weak acid is [**x**] $\times 10^{-6}$, then value of **x** in nearest integer is :

Ans. 11.00

Sol. $\lambda_M^C = \frac{K \times 1000}{M} = \frac{2 \times 10^{-5} \times 10^3}{10^{-3}} = 20$ Scm^{3}mole^{-1}

For weak acid $(\alpha) = \frac{\lambda_M^C}{\lambda_M^\infty} = \frac{20}{190} = \frac{2}{19}$

$Ka = \frac{C\alpha^2}{1-\alpha} \cong C\alpha^2 = 10^{-3} \times \left(\frac{2}{19}\right)^2 = 0.011 \times 10^{-3} = 11 \times 10^{-6}$

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2.

	List –I		List –II
(a)	NaOH	(i)	Acid
(b)	$Be(OH)_2$	(ii)	Base
(c)	$Ca(OH)_2$	(iii)	Amphoteric
(d)	$Al(OH)_3$		

(e) $B(OH)_3$

Correct Matching of List–I and List –II is :

(1) (a) – (ii), (b) – (iii), (c) – (ii), (d) – (iii), (e) – (i)

(2) (a) – (ii), (b) – (ii), (c) – (iii), (d) – (iii), (e) – (iii)

(3) (a) – (ii), (b) – (i), (c) – (iii), (d) – (ii), (e) – (i)

(4) (a) – (ii), (b) – (iii), (c) – (ii), (d) – (ii), (e) – (ii)

Ans. (1)

Sol.

	Species	Nature
(i)	NaOH	Base

(iii)	$Be(OH)_2$	Amphoteric
(iv)	$Al(OH)_3$	Amphoteric
(v)	$B(OH)_3$	Acidic

3. Lattice Parameter for a crystal Lattice is $a \neq b \neq c$ and $\alpha = 90°$, $\gamma = 90$ and $\beta = 120°$ this represent which type of Bravais Lattice.

(1) Monoclinic (2) Triclinic (3) Hexagonal (4) Orthorhombic

Ans. (1)

Sol.

	Unit Cell	Lattice Parameter
(i)	Monoclinic	$a \neq b \neq c$ & $\alpha = 90, \gamma = 90$ & $\beta = 120°$

Seven Crystal System

S.No.	Crystal System	Edge length	Angles
1	**C**ubic	a = b = c	$\alpha = \beta = \gamma = 90°$
2	**T**etragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$
3	**O**rthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$
4	**M**onoclinic	$a \neq b \neq c$	$\beta \neq 120°$, $\neq 90°$, $\neq 60°$
5	**H**exagonal	$a = b \neq c$	$\alpha = \beta = 90°$ $\gamma \neq 120°$
6	**R**hombohedral or **T**rigonal	a = b = c	$\alpha = \beta = \gamma \neq 90°$
7	Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$

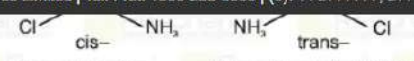
4. Number of Geometrical isomers of complex's $[Ni(CO)_4]$, $[PtCl_2(NH_3)_2]$, $[RuCl_3(NH_3)_3]$, are respectively :

(1) 0, 2, 2 (2) 2, 2, 2 (3) 0, 1, 2 (4) 0, 0, 2

Ans. (1)

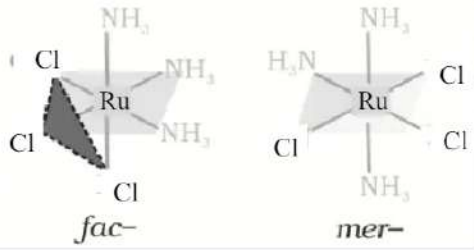
Sol.

	Complex	Number of G.I.
(1)	$[Ni(CO)_4]$	0
(2)	$[PtCl_2(NH_3)_2]$	2



Geometrical isomers (cis and trans) of $Pt(NH_3)_2Cl_2$

(3) $[RuCl_3(NH_3)_3]$ 2



5. Identify the correct hybridisation and Magnetic nature of complex $[MnCl_6]^{3-}$

(1) sp^3d^2, Diamagnetic (2) sp^3d^2, Paramagnetic

(3) d^2sp^3, Paramagnetic (4) d^2sp^3, Diamagnetic

Ans. (2)

Sol. $[MnCl_6]^{3-}$

$\Rightarrow Mn^{3+} \Rightarrow 3d^4 \Rightarrow t_{2g}^{1,1,1}, e_g^{1,0} \Rightarrow sp^3d^2$ Hybridisation $\Rightarrow$ Paramagnetic

6. Difference between bond order of CO and NO^+ is $\left(\frac{x}{2}\right)$, then value of 'x' to the nearest integer

Ans. 0

Sol.

Species	Bond order
(i) CO	3
(ii) NO^+	3

So value of x = 0

7. The value of $(\Delta H - \Delta U)$ for vaporisation of water at 100°C is 'x' × 10^2 J/mole, assume water vapour to be an ideal gas [Take R = 8.31 J/mole.K]

[report your answer to nearest integer]

Ans. 31.00

Sol. $H_2O(\ell) \longrightarrow H_2O(g)$

$\Delta H^\circ = \Delta U^\circ + \Delta n_g RT$

$\Delta H^\circ - \Delta U^\circ = \Delta n_g RT$

$= 1 \times 8.3 \times 373$

$= 3099.63$ J/Mole

$= 30.9963 \times 10^2$ J/Mole

$= 31 \times 10^2$ J/Mole

8. Density of aqueous solution of NaOH is 1.2 g/cm^3, then find its molality

Ans. 05.00

Sol. Let volume of solution is x one

So mass of solution = 1.2 x

& mass of water (solvent) = x gram

So mass of solute = 0.2 x gram

$$\text{Molality} = \frac{W_{solute} \times 1000}{GMM_{solute} \times W_{solvent}}$$

$$= \frac{0.2x \times 1000}{40 \times x} = \frac{200}{40} = 5m$$

Ans = 5m

9. Identify the wrong statement from following about Ellingham diagram

(1) It gives rate of reaction (2) It tells about the stability of oxide

(3) It gives idea about reduction of metal oxide (4) It gives idea about free energy of reduction.

Ans. (4)

10. The main product of electrolysis of conc. H_2SO_4 is

(1) SO_3 (2) $HO_3SO - OSO_3H$

(3) $HO_2SO - OSO_2H$ (4) O_2

Ans. (2)

Sol. Main product of electrolysis of conc. H_2SO_4 is $H_2S_2O_8$ that is $HO_3SO-OSO_3H$

11. Oxidation number of P in $H_4P_2O_7$, $H_4P_2O_5$ and $H_4P_2O_6$ are respectively:

(1) 5, 3, 4 (2) 3, 4, 5 (3) 5, 4, 3 (4) 5, 4, 5

Ans. (1)

Sol.

Compound	Oxidation number of P
(i) $H_4P_2O_7$	5
(ii) $H_4P_2O_5$	3
(iii) $H_4P_2O_6$	4

Statement–II : Bohr's model is not in accordance with heisenberg's uncertainty principle

(1) Both statements are true

(2) Both statement are false

(3) Statement–I is true and Statement–II is false

(4) Statement–I is false and Statement–II is true

Ans. (1)

Sol. Theory Based

13. Statement–I : Generally halides of Li are covalent

Statement–II : Lithium has high polarising power

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

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

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

(4) Both Statement–I and Statement–II are incorrect

Ans. (1)

14. Unit of rate constant of n^{th} order reaction is :

(1) $mole^{1-n}$ $Lit.^{n-1}$ Sec^{-1} (2) $mole^{x}$ $Lit.^{-n}$ Sec^{-1}

(3) $mole^{-n}$ $Lit.^{n}$ Sec^{-1} (4) $mole^{n-1}$ $Lit.^{1-n}$ Sec^{-1}

Ans. (1)

Sol. Rate = $k[A]^n$

$$\frac{mole}{Lit \times Sec} = k\left[\frac{mole}{Lit}\right]^n$$

$\Rightarrow$ Unit of k = $(mole)^{1-n}$ $Lit.^{n-1}$ Sec^{-1}

15. Equilibrium constant K_C for dissociation of PCl_5 according to $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ is 1.844. Initially 3 mole of PCl_5 is present in a flask of 1 Lit., then number of moles of PCl_5 after equilibrium is set Up. Is :

Ans. 1.60

Sol.

	$PCl_5(g)$	$\rightleftharpoons$	$PCl_3(g)$	+	$Cl_2(g)$	$K_C = 1.844$
Initially	3		0		0	

$$K_C = \frac{x^2}{3-x} = 1.844$$

$x^2 = 1.844\,(3 - x)$

$x^2 = 5.532 - 1.844x$

$x^2 + 1.844x - 5.532 = 0$

$$x = \frac{-1.844 \pm \sqrt{(1.844)^2 - 4(1)(-5.532)}}{2}$$

On solving

x = 1.60

So at equilibrium number moles of PCl_5 = 1.60

16. According to Freundlich adsorption isotherm $\left(\frac{x}{m}\right) = k(P)^{\frac{1}{n}}$ when pressure increased 2 times, then extent

of adsorption becomes 64 times. Find the value of $\left|\frac{1}{n}\right|$.

Sol. $\left(\frac{x}{m}\right) = k(P)^{\frac{1}{n}}$ ..... (i)

$64\left(\frac{x}{m}\right) = k(2P)^{\frac{1}{n}}$ ..... (ii)

From equation (i) to (ii)

So $\frac{1}{n} = 6$

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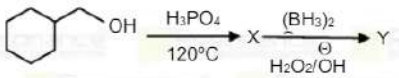
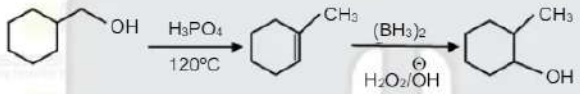
17. 

Product (Y) is :

Ans. (2)

Sol. 

18. $CH_4 + I_2 \xrightarrow{h\nu} CH_3I + HI$

What shall be added so the reaction proceeds in one direction-

(1) Con.HIO_3 (2) HOCl (3) NH_3 (4) HNO_2

Ans. (1)

Sol. $CH_4 + I_2 \rightleftharpoons CH_3I + HI$

Reaction is reversible due to reducing nature of HI. Oxidising agent like HNO_3, HIO_3 should be added to make it irreversible (one direction).

(1) Iodine test (2) Seliwanoff test (3) Barfoed test (4) Tollen's test

Ans. (3)

Sol. Carbohydrates are polyhydroxy aldehydes and ketones. Carbohydrates may have an aldehyde group (aldoses) or ketose group. Barfoed's test distinguishes monosaccharides from disaccharides. In this test, copper acetate in dilute acid is reduced in 30 seconds by monosaccharides whereas disaccharides take several minutes.

20. In DNA complementary base Thymine is-

(1) Uracil (2) Adenine (3) Cytosine (4) Guanine

Ans. (2)

Sol. In DNA thymine bind with adenine by to hydrogen bonding.

21. **Statement-1:** Aniline is less basic then Acetamide

Statement-2: In Aniline, the lone pair delocalised so electron density reduce.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(4) Statement -1 is False, Statement-2 is False.

Ans. (2)

22. Which of the following given statements on Eutrophication are not correct?

(1) Eutrophication decrease oxygen level in water.

(2) <6ppm oxygen fishes can't survive.

(3) Eutrophication involve anaerobic respiration.

(4) Eutrophication increase oxygen level in water.

Ans. (4)

23. **Match the column:**

	Column-I		Column-II
(i)	Furacine	(a)	Antiseptic
(ii)	Dimetane	(b)	Synthetic antihistamine

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

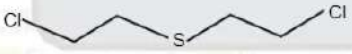
(2) (i) - a, (ii) - b, (iii) - d, (iv) - c

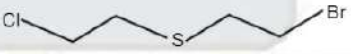
(3) (i) - a, (ii) - d, (iii) - c, (iv) – b

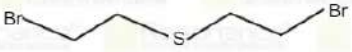
(4) (i) - c, (ii) - d, (iii) - a, (iv) - b

Ans. (2)

24. What is formula of mustard gas-

(1) 

(2) 

(3) 

(4) 

Ans. (1)

25. Stability of given molecules is:

(i)

(ii)

(iii)

(iv)

(1) i > ii > iv > iii (2) i > ii > iii > iv (3) i > ii > iii > iv (4) iv > iii > i > ii

Ans. (1)

26. Staggered and eclipsed form of ethane are

(1) Enantiomer (2) Anomer (3) Epimer (4) Rotamer

Ans. (4)

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Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

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1. If $\vec{a}=\hat{i}+\hat{j}+\hat{k}$, $\vec{b}=2\hat{i}+\hat{j}-\hat{k}$ and $\vec{c}=4\hat{i}+3\hat{j}+\hat{k}$ then the value of $\left(\left(\vec{a}+\vec{b}\right)\times\left(\vec{a}-\left(\vec{a}-\vec{b}\right)\times\vec{b}\right)\right)\times\vec{c}$ is :

(1) $\left(30\hat{i}-34\hat{j}+36\hat{k}\right)$ (2) $\left(30\hat{i}+34\hat{j}+36\hat{k}\right)$

(3) $\left(30\hat{i}+34\hat{j}-36\hat{k}\right)$ (4) None of these

Ans. (1)

Sol. $\vec{a}+\vec{b}=3\hat{i}+2\hat{j}=\vec{r}_1$

$\vec{r}_2=\vec{a}-\left(\vec{a}-\vec{b}\right)\times\vec{b}\ =\ \vec{r}_2=\left(\hat{i}+\hat{j}+\hat{k}\right)-\left(-\hat{i}+2\hat{k}\right)\times\left(2\hat{i}+\hat{j}-\hat{k}\right)$

$\left(\hat{i}+\hat{j}+\hat{k}\right)-\left(-\hat{k}-\hat{j}+4\hat{j}-2\hat{i}\right)=\left(3\hat{i}-2\hat{j}+2\hat{k}\right)$

$= \left(\vec{r}_1.\vec{c}\right)\vec{r}_2-\left(\vec{r}_2.\vec{c}\right)\vec{r}_1$

$= 18\left(3\hat{i}-2\hat{j}+2\hat{k}\right)-8\left(3\hat{i}+2\hat{j}\right)$

$=\left(30\hat{i}-34\hat{j}+36\hat{k}\right)$ Ans.

2 Which of the following is logically equivalent to $(p\vee q)\wedge(\sim p\rightarrow q)$ is :

(1) $(p \vee q)$ (2) $(p \wedge q)$

(3) $\sim p \vee q$ (4) $p \wedge \sim q$

Ans. (1)

Sol. We know $p \to q = \sim p \vee q$

$\Rightarrow (p \vee q) \wedge (p \vee q) = p \vee q$ **Ans.**

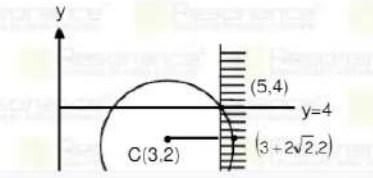
3. If $S_1 = \{z : |z-3-2i|^2 = 8\}$ and $S_2 = \{z : |z-\bar{z}| = 8\}$ and $S_3 = \{z : re(z) \geq 5\}$ then $S_1 \cap S_2 \cap S_3$ has

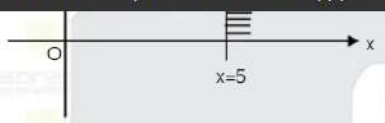
(1) Infinite many element (2) Only one element

(3) No any element (4) Two element

Ans. (2)

Sol. Let $z = x+iy$





$S_2 \Rightarrow |2iy| = 8 \Rightarrow |y| = 4$

$y = \pm 4$

$S_3 \Rightarrow x \geq 5$

$S_1 \Rightarrow |z-3-2i|^2 = 8 = (x-3)^2 + (y-2)^2 = 8$

Is a circle with centre (3,2) and radius = $2\sqrt{2}$

$\because$ Circle passes through (5,4)

$\Rightarrow$ There is exactly one point (5,4) in $S_1 \cap S_2 \cap S_3$

$\alpha e^8 - 224$

Ans. 16.00

Sol. Put $x = 3 \Rightarrow f(3) = 0$

$e^{-x}[t^3 + t^2 + 4(F(t)e^x] = F(x)$

$e^{-x}(x^3 + x^2 + 4F(x) - (27 + 9 + 4F(3) = F(x)$

$\Rightarrow F(x) = e^{-x}(x^3 + x^2 - 36 + 4F(x))$

$\Rightarrow e^x F(x) = x^3 + x^2 - 36 + 4F(x)$

$$F(x) = \frac{x^3 + x^2 - 36}{(e^x - 4)}$$

$$F'(x) = \frac{(3x^2 + 2x)(e^x - 4) - (e^x)(x^3 + x^2 - 36)}{(e^x - 4)^2}$$

$$F'(4) = \frac{56(e^4 - 4) - e^4(44)}{(e^4 - 4)^2}$$

$$F'(4) = \frac{12e^4 - 224}{(e^4 - 4)^2}$$

Hence $\alpha = 12$ and $\beta = 4$

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5. The coefficient of x^7 and x^{-7} in the expansion of $\left(x^2+\frac{1}{bx}\right)^{11}$ and $\left(x+\frac{1}{bx^2}\right)^{11}$ respectively are equal then the value of b is :

(1) 1 (2) –1 (3) 0 (4) 2

Ans. (1)

Sol. $\left(x^2+\frac{1}{bx}\right)^{11}$

$T_{r+1} = {}^{11}C_r\,(x^2)^{11-r}\left(\frac{1}{bx}\right)^r = {}^{11}C_r\,(x)^{22-3r}\left(\frac{1}{b}\right)^r$

for $x^4 \Rightarrow 22 - 3r = 7 \Rightarrow r = 5$

$\therefore$ coefficient of $x^7 = {}^{11}C_5\left(\frac{1}{b}\right)^5$

similarly $\left(x+\frac{1}{bx^2}\right)^{11}$

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For $x^{-7} \Rightarrow 11 - 3r = -7 \Rightarrow r = 6$

$\therefore$ coefficient $x^{-7} = {}^{11}C_6\left(\frac{1}{b}\right)^6$

${}^{11}C_6\left(\frac{1}{b}\right)^6 = {}^{11}C_5\left(\frac{1}{b}\right)^5 \Rightarrow b = 1$

6. Evaluate $\lim\limits_{x\to2}\frac{x^2f(2)-4f(x)}{x-2}$, if $f(2) = 4$ & $f'(2) = 1$

Ans. (12)

Sol. $\lim\limits_{x\to2}\frac{x^2f(2)-4f(x)}{x-2} = \lim\limits_{x\to2}\frac{2xf(2)-4f'(x)}{1} = 2\cdot(2)\cdot f(2) - 4f'(2) = 16 - 4 = 12$

7. If $\sin\theta + \cos\theta = \frac{1}{2}$, then the value of $16(\sin2\theta + \cos4\theta + \sin6\theta)$ is :

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Sol. $(\sin\theta + \cos\theta)^2 = \frac{1}{4}$

$1 + \sin2\theta = \frac{1}{4}$

$\sin2\theta = \frac{-3}{4}$

$16(\sin2\theta + \cos4\theta + \sin6\theta) = 16\,(\sin2\theta + 1 - 2\sin^2 2\theta + 3\sin2\theta - 4\sin^3 2\theta)$

$= 16\,(4\sin2\theta + 1 - 2\sin^2 2\theta - 4\sin^3 2\theta) = -23$

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8. If mean and variance of eight observation 10, 13, 6, 7, a, 12, b, 12 are 9 and $\frac{37}{4}$ respectively, then the value of $(a-b)^2$ is s

(1)25 (2) 36 (3) 16 (4) 49

Ans. (3)

Sol. $9 = \frac{10+13+6+7+a+12+b+12}{8}$

$\sum x_i^2 = 100+169+36+49+a^2+144+b^2+144$

$= a^2 + b^2 + 642$

$\sigma^2 = \frac{\sum x_i^2}{8} - (\bar{x})^2 = \frac{37}{4}$

$\frac{a^2+b^2+642}{8} - 81 = \frac{37}{4}$

$\Rightarrow a^2 + b^2 = 80 \Rightarrow a^2 + (12-a)^2 = 80 \Rightarrow a^2 - 12a + 32 = 0$

$\Rightarrow a = 4$ or $a = 8$

$b = 8$ or $b = 4$

$\Rightarrow (a-b)^2 = 16$ Ans.

9. If matrix $A = \begin{bmatrix} 2 & 4 \\ -1 & 1 \end{bmatrix}$ and $A^{-1} = \alpha I + \beta A$, $\alpha, \beta \in R$. Then the value of $(\alpha - 6\beta)$ is equal to :

Ans. (1)

Sol. Equation of $|A-\lambda I| = 0$

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

$\Rightarrow (2-\lambda)(1-\lambda) + 4 = 0 \Rightarrow \lambda^2 - 3\lambda + 2 + 4 = 0 \Rightarrow \lambda^2 - 3\lambda + 6 = 0$

$A^2 - 3A + 6I = 0$

Multiply both side by A^{-1}

$A - 3I + 6A^{-1} = 0$

$A^{-1} = \frac{-A}{6} + \frac{I}{2}$ .....(1)

$A^{-1} = \alpha I + \beta A$ .....(2)

Comparing equation (1) and (2)

$\alpha = \frac{1}{2}, \beta = \frac{-1}{6}$

10. If α and β are the roots of the equation $x^2 - 20^{1/4}x + 5^{1/2} = 0$, then the value of $\alpha^8 + \beta^8$ is equal to :

(1) 25 (2) 50 (3) 75 (4) 100

Ans. (2)

Sol. $x^2 - 20^{1/4}x + 5^{1/2} = 0$

$(x^2 + \sqrt{5})^2 = \sqrt{20}\,x^2$

$x^4 + 5 + 2\sqrt{5}x^2 = 2\sqrt{5}x^2$

$x^4 = -5$

$x^8 = 25$

$\alpha^8 = 25, \beta^8 = 25$

11. Let n be a two digit natural number. If n is selected at random then find the probability such that $2^n - 2$ is a multiple of 3.

(1) $\frac{1}{4}$ (2) $\frac{1}{3}$ (3) $\frac{1}{2}$ (4) 0

Ans. **(3)**

Sol. Total number of cases = $^{90}C_1 = 90$

Now $2^n - 2 = (3-1)^n - 2$

$= {}^nC_0\, 3^n - {}^nC_1\, 3^{n-1} + \ldots\ldots + (-1)^{n-1}\, {}^nC_{n-1}\, 3 + (-1)^n\, {}^nC_n - 2$

$= 3(3^{n-1} - n\, 3^{n-2} + \quad + (-1)^{n-1} n) + (-1)^n - 2$

So number of favourable cases = 45, Hence required probability = $\frac{45}{90} = \frac{1}{2}$

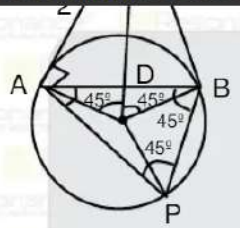
12. If tangents to the circle $(x-1)^2 + (y-3)^2 = 2^2$ are drawn from the point $(-1, 1)$ such that the points of contact of tangents are A and B. Also a point P lies on the circle such that AB = AP, then the area of ΔABP is :

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

Ans. **(3)**

Sol.

Q



$AQ = \sqrt{S_1} = \sqrt{(-1-1)^2 + (1-3)^2 - 4} = 2$

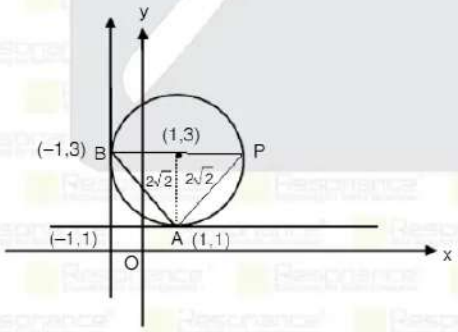
$AD = 2\sin 45^\circ$

$AB = 4\sin 45^\circ$

$AP = 4\sin 45^\circ$

$= 4$

Alternate :



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13. If $\log_3 2, \log_3(2^x - 5), \log_3\left(2^x - \frac{7}{2}\right)$ are in A.P. then the value of x is

(1) 4 (2) 2 (3) 3 (4) 5

Ans. (3)

Sol. $2\log_3(2^x - 5) = \log_3 2 + \log_3\left(2^x - \frac{7}{2}\right)$

$\Rightarrow \log_3(2^x - 5)^2 = \log_3\left(2\left(2^x - \frac{7}{2}\right)\right)$

$\Rightarrow (2^x)^2 - 10(2^x) + 25 = 2(2^x) - 7$

$\Rightarrow (2^x)^2 - 12(2^x) + 32 = 0$

$\Rightarrow 2^x = 4$ or 8

$\Rightarrow x = 2$ or 3

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$\Rightarrow x = 3$

14. If $\sec y \frac{dy}{dx} = \sin(x+y) + \sin(x-y)$; $y(0) = 0$ then the value of $5y'\left(\frac{\pi}{2}\right)$ is

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

Ans. **(3)**

Sol. $\sec y \frac{dy}{dx} = 2\sin(x)\cos(y)$ .....(1)

$\int \sec^2 y \, dy = \int 2\sin x \, dx$

$\tan y = -2\cos x + c$

When $x = 0, y = 0 \Rightarrow c = 2$

$\tan y = -2\cos x + 2$ .....(2)

$\because \sec^2 y \frac{dy}{dx} = 2\sin x$

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$(1 + \tan^2 y)\frac{dy}{dx} = 2\sin x$ .....(3)

By equation (2) & (3)

$\frac{dy}{dx} = \frac{2\sin x}{1 + (2 - 2\cos x)^2}$

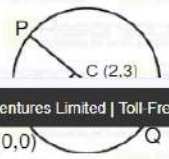
$f'\left(\frac{\pi}{2}\right) = \frac{2}{1 + (2)^2} = \frac{2}{5} \Rightarrow 5f'\left(\frac{\pi}{2}\right) = 2$

15. A circle with centre (2, 3) passes through the origin. A diameter PQ is such that it is perpendicular to the line joining the centre of circle and origin. The coordinates of points P and Q are :

(1) (–1, 5) & (5, 1) (2) (–2, 5) & (–5, 1) (3) (3, 6) & (5, 1) (4) (–1, 1) & (5, –1)

Ans. (1)

Sol. $(x-2)^2 + (y-3)^3 = 13$



$y = \frac{3}{2}x$

line perpendicular to the above line and passing through (2,3) is $3y + 2x = 13$

Coordinates of P,Q $\Rightarrow \left(2 \pm \sqrt{13}\cos\theta, 3 \pm \sqrt{13}\sin\theta\right)$

$$\Rightarrow \left(2 \pm \sqrt{13}\left(\frac{-3}{\sqrt{13}}\right), 3 \pm \sqrt{13}\left(\frac{2}{\sqrt{13}}\right)\right)$$

$\Rightarrow$ (–1, 5) & (5, 1)

16. Evaluate $\lim\limits_{n\to\infty} \frac{1}{n} \sum\limits_{j=1}^{n} \frac{((2j-1)+8n)}{((2j-1)+4n)}$

Ans. (1)

Sol. $\lim\limits_{n\to\infty} \frac{1}{n} \sum\limits_{j=1}^{n} \frac{\left(2\frac{j}{n} - \frac{1}{n} + 8\right)}{\left(2\frac{j}{n} - \frac{1}{n} + 4\right)} \cdot \frac{1}{n}$

$$= \int_0^1 \frac{2x+8}{2x+4} dx$$

$$= \int_0^1 dx + \int \frac{4}{2x+4} dx$$

$$= 1 + 4.\frac{1}{2}[\ln(2x+4)]_0^1$$

$$= 1 + 2[\ln 6 - \ln 4]$$

$= 1 + 2\ln\left(\frac{3}{2}\right)$

17. If $f(x) = \begin{cases} (1+|\sin x|)^{\frac{a}{|\sin x|}} & -\frac{\pi}{4} < x < 0 \\ b & x = 0 \\ e^{\frac{\cot(4x)}{\cot(2x)}} & 0 < x < \frac{\pi}{4} \end{cases}$ is continuous, then find the value of $(a + \ell nb)$.

Ans. (1)

Sol. $RHL = f(0^+) = \lim\limits_{x\to 0^+} e^{\frac{\cot 4x}{\cot 2x}} = \lim\limits_{x\to 0^+} e^{\frac{\tan 2x}{\tan 4x}} = e^{\frac{1}{2}}$

$LHL = f(0^-) = \lim\limits_{x\to 0^-} (1-\sin x)^{\frac{a}{-\sin x}}$

$= e^{\lim\limits_{x\to 0^-} \frac{-a}{\sin x}(-\sin x)} = e^a$

$f(0^+) = f(0^-) = f(0)$

$\Rightarrow e^{\frac{1}{2}} = e^a = b \Rightarrow a = \frac{1}{2}$ & $b = e^{\frac{1}{2}} \Rightarrow \ell nb = \frac{1}{2}$

$\Rightarrow a + \ell nb = 1$

18. Evaluate $I = \int_{-\pi/4}^{\pi/4} \frac{dx}{(1+e^{x\cos x})(\sin^4 x + \cos^4 x)}$

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

Ans. (2)

Sol. $f(a + b - x) = f(x)$

$I = \int_{-\pi/4}^{\pi/4} \frac{e^{x\cos x}}{(1+e^{x\cos x})(\sin^4 x + \cos^4 x)} dx$

$2I = \int_{-\pi/4}^{\pi/4} \frac{dx}{\sin^4 x + \cos^4 x}$

$2I = \int_{-\pi/4}^{\pi/4} \frac{1}{1-\frac{1}{2}\sin^2 2x} dx$

$2I = \int_{-\pi/4}^{\pi/4} \frac{2\sec^2 2x}{\sec^2 2x + 1} dx$ (put $\tan 2x = t$

$2I = \frac{4}{2}\int_0^{\infty} \frac{dt}{2+t^2} = \left(\frac{1}{\sqrt{2}} \tan^{-1} \frac{t}{\sqrt{2}}\right)_0^{\infty}$

$I = \frac{\pi}{2\sqrt{2}}$

19. If the domain of the function $f(x) = \log_5(\log_4(\log_3(18x - x^2 - 77)))$ is (a,b), then find the value of $\int_a^b \frac{\sin^3 x\, dx}{\sin^3 x + \sin^3(a+b-x)}$

Sol. $\log_4 \log_3 (18x - x^2 - 77) > 0$

$18x - x^2 - 77 > 3$

$x^2 - 18x + 80 < 0$

$(x-8)(x-10) < 0$

$x \in (8, 10)$

$\therefore a = 8$ and $b = 10$

$$\therefore I = \int_a^b \frac{\sin^3 x\,dx}{\sin^3 x + \sin^3(a+b-x)} = \int_8^{10} \frac{\sin^3 x\,dx}{\sin^3 x + \sin^3(a+b-x)}$$

Using the property

$\int_a^b f(x)dx = \int_a^b f(a+b-x)dx$, we get

$$\int_8^{10}$$

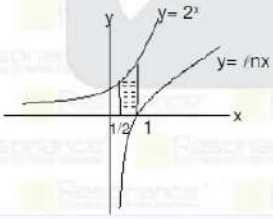
$\therefore I = 1$ Ans.

20. Find area bounded by $y = \max\{0, \ell nx\}$ and $y < 2^x$ where $\frac{1}{2} < x < 1$:

(1) $\frac{2+\sqrt{2}}{\ell n2}$ (2) $\frac{2-\sqrt{2}}{\ell n2}$ (3) $\frac{1-\sqrt{2}}{\ell n2}$ (4) $\frac{1+\sqrt{2}}{\ell n2}$

Ans. (2)

Sol.



$\int_{\frac{1}{2}}^{1} \quad \left(\ell n2\right)_{\frac{1}{2}}^{1} \quad \ell n2$

21. If $f(x) = \begin{vmatrix} \sin^2 x & -2+\cos^2 x & \cos 2x \\ 2+\sin^2 x & \cos^2 x & \cos 2x \\ \sin^2 x & \cos^2 x & 1+\cos 2x \end{vmatrix}$, $x \in (0, \pi]$. Then the maximum value of $f(x)$ is ?

Ans. 06.00

Sol. $R_1 \to R_1 - R_2$

$R_2 \to R_2 - R_3$

$$= \begin{vmatrix} -2 & -2 & 0 \\ 2 & 0 & -1 \\ \sin^2 x & \cos^2 x & 1+\cos 2x \end{vmatrix}$$

$= -2(\cos^2 x) + 2(2+2\cos 2x + \sin^2 x)$

$= -2(\cos^2 x - \sin^2 x) + 4\cos 2x + 4$

$= 4 + 2\cos 2x = 2(2 + \cos 2x)$, maximum value of $f(x) = 6$

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