MENIIT

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# JEE MAIN-2022

## COMPUTER BASED TEST (CBT)

DATE : 24-06-2022 (MORNING SHIFT) | TIME : (9.00 AM to 12.00 PM)

Duration 3 Hours | Max. Marks : 300

# QUESTIONS & SOLUTIONS

# PART A : PHYSICS

## Single Choice Type

This section contains **20 Single choice questions**. Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

**1.** The bulk modulus of a liquid is $3 \times 10^{10}$ $Nm^{-2}$. The pressure required to reduce the volume of liquid by 2% is ;

(A) $3 \times 10^{8}$ $Nm^{-2}$ (B) $9 \times 10^{8}$ $Nm^{-2}$ (C) $6 \times 10^{8}$ $Nm^{-2}$ (D) $12 \times 10^{8}$ $Nm^{-2}$

**Ans.** **C**

**Sol.** $$B = -\frac{\Delta p}{\frac{\Delta V}{V}}$$

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

$$= 3 \times 10^{10} \times \left(2 \times \frac{1}{100}\right) = 6 \times 10^{8}$$

**2.** Given below are two statement : One is labelled as **Assertion (A)** and the other is labelled as **Reason (R).**

**Assertion (A)** : In an uniform magnetic field, speed and energy remains the same for a moving charged particle.

**Reason (R)** : Moving charged particle experience magnetic force perpendicular to its direction of motion.

(A) Both **(A)** and **(R)** are→ true and **(R)** is the correct explanation of (A).

(B) Both **(A) and (R)** and true but **(R)** is NOT the correct explanation of (A).

(C) **(A)** is true but **(R)** is false.

(D) **(A)** is false but **(R)** is true.

**Ans.** **A**

**Sol.** A → Ture

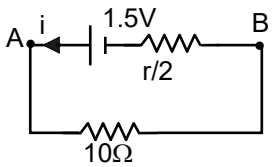
B → True

**3.** Two identical cells each of emf 1.5 V are connected in parallel across a parallel combination of two resistors each of resistance 20 Ω. A voltmeter connected in the circuit measures 1.2 V. The internal resistance of each cell is ;

(A) 2.5 Ω (B) 4 Ω (C) 5 Ω (D) 10 Ω

**Ans.** **C**

**Sol.**



$$i = \frac{15}{10 + \frac{r}{2}}$$

$$V_{AB} = i \times 10 = \frac{15}{10 + \frac{r}{2}} = 1.2$$

$$\frac{150}{12} = 10 + \frac{r}{2}; 12.5 = 10 + \frac{r}{2}$$

2.5 = r/2

R = 5

**4.** Identify the pair of physical quantities which have different dimensions ;

(A) Wave numbers and Rydberg's constant

(B) Stress and Coefficient of elasticity

(C) Coercivity and Magnetisation

(D) Specific heat capacity and Latent heat

**Ans.** D

**Sol.** $\Delta Q = ms\Delta\theta$

$$S = \frac{J}{ky°C}$$

$\Delta Q = mL$

$$L = \frac{\Delta Q}{m}$$

$$L = \frac{J}{kg}$$

S & L are different unit.

**5.** A projectile is projected with velocity of 25 m/s at an angle $\theta$ with the horizontal. After t seconds its inclination with horizontal becomes zero. If R represents horizontal range of the projectile, the value of $\theta$ will be ;

[use $g = 10m/s^2$]

(A) $\frac{1}{2}\sin^{-1}\left(\frac{5t^2}{4R}\right)$ (B) $\frac{1}{2}\sin^{-1}\left(\frac{4R}{5t^2}\right)$ (C) $\tan^{-1}\left(\frac{4t^2}{5R}\right)$ (D) $\cot^{-1}\left(\frac{R}{20t^2}\right)$

**Ans.** D

**Sol.** $$t = \frac{u\sin\theta}{g}$$

$R = u\cos\theta\,(2t)$

$$\frac{t}{R} = \frac{\tan\theta}{g(2t)}$$

$$\boxed{\tan\theta = \frac{2gt^2}{R}}; \theta = \tan^{-1}\left(\frac{2gt^2}{R}\right)$$

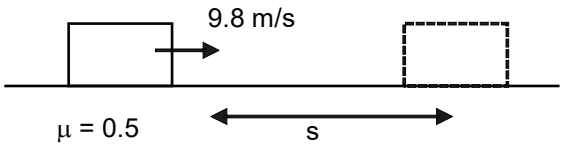
**6.** A block of mass 10 kg starts sliding on a surface with an velocity of $9.8ms^{-1}$. The coefficient of friction between the surface and block is 0.5. The distance covered by the block before coming to rest is ;

[use $g = 9.8ms^{-2}$]

(A) 4.9 m (B) 9.8 m (C) 12.5 m (D) 19.6 m

**Ans.** **B**

**Sol.**




$v^2 = u^2 + 2as$

$0 = (9.8)^2 - 2 \times 0.5 \times 9.8 \times s$

$s = 9.8$ m

**7.** A boy ties a stone of mass 100 g to the end of a 2 m long string and whirls it around in a horizontal plane. The string can withstand the maximum tension of 80 N. If the maximum speed with which the stone can revolve is $\frac{K}{\pi}$ rev./min. The value of K is :

(Assume the string is massless and unstretchable)

(A) 400 (B) 300 (C) 600 (D) 800

**Ans.** C

**Sol.** $T = m\omega^2 r$

$$\omega = \sqrt{\frac{T}{mr}} = \sqrt{\frac{80}{0.1 \times 2}} = 20 rad/sec.$$

$$= \frac{20 \times 60}{2\pi} = \frac{600}{\pi} rev/minutes$$

**8.** A vertical electric field of magnitude $4.9 \times 10^5$ N/C just prevents a water droplet of a mass 0.1 g from falling. The value of charge on the droplet will be :

(Given $g = 9.8\ m/s^2$)

(A) $1.6 \times 10^{-9}$ C (B) $2.0 \times 10^{-9}$ C (C) $3.2 \times 10^{-9}$ C (D) $0.5 \times 10^{-9}$ C

**Ans.** **B**

**Sol.** m = 0.1 gm

q = ?

qE = mg.z

$$q = \frac{0.1 \times 10^{-3} \times 9.8}{4.9 \times 10^5}$$

$q = 2 \times 10^{-9}$

**9.** A particle experiences a variable force $\vec{F} = \left(4x\hat{i} + 3y^2\hat{j}\right)$ in a horizontal x-y plane. Assume distance in meters and force is newton. If the particle moves from point (1, 2) to point (2, 3) in the x-y plane, then Kinetic Energy changes by :

(A) 50.0 J (B) 12.5 J (C) 25.0 J (D) 0 J

**Ans.** **C**

**Sol.** Using work energy theorem

$W_f = K_F - K_i$

$$\int_1^2 4xdx + \int_2^3 3y^2dy = K_f - 0$$

$$4.\left[\frac{x^2}{2}\right]_1^2 + 3\left[\frac{y^3}{3}\right]_2^3 = K_f - 0$$

$$\Rightarrow K_f = 4.\left[\frac{x^2}{2}\right]_1^2 + 3\left[\frac{y^3}{3}\right]_2^3$$

= 2(4 – 1) + (27 – 8) = 6 + 19 = 25 Joule

**10.** The approximate height from the surface of earth at which the weight of the body becomes $\frac{1}{3}$ of its weight on the surface of earth is :

[Radius of earth R = 6400 km and $\sqrt{3} = 1.732$]

(A) 3840 km (B) 4685 km (C) 2133 km (D) 4267 km

**Ans.** **B**

**Sol.** h = ?

$g_{eff} = g/3$

$$g = \frac{g_0}{\left(1+\frac{n}{R}\right)^2}$$

$$\frac{1}{3} = \frac{1}{\left(1+\frac{n}{R}\right)^2}$$

$$1+\frac{n}{R} = \sqrt{3}$$

$$n = R\left(\sqrt{3}-1\right)$$

= 6400 × 0.732 = 4654.8 = 4685 km

**11.** A resistance of 40 Ω is connected to a source of alternating current 220 V, 50 Hz. Find the time taken by the current to change from its maximum value to the rms value :

(A) 2.5 ms (B) 1.25 ms (C) 2.5 s (D) 0.25 s

**Ans.** **A**

**Sol.** $i_0$ to $i_{rms} = \frac{i_0}{\sqrt{2}}$

$$t = \frac{T}{8}$$

$= \frac{1}{f \times 8}$

$= \frac{1}{50 \times 8} = \frac{1}{400}\text{sec} = \frac{1000}{400}\text{ms} = 2.5$

**12.** The equations of two waves are given by ;

$y_1 = 5 \sin 2\pi(x - vt)$ cm

$y_2 = 3 \sin 2\pi(x - vt + 1.5)$ cm

These waves are simultaneously passing through a string. The amplitude of the resulting wave is :

(A) 2 cm (B) 4 cm (C) 5.8 cm (D) 8 cm

**Ans.** **A**

$A_1 = 5$

$A_2 = 3$

$\phi = 2\pi \times 1.5 = 3\pi$

$A_{min.} = A_1 - A_2$

$= 5 - 3 = 2$ cm

**13.** A plane electromagnetic wave travels in a medium of relative permeability 1.61 relative permittivity 6.44. If magnitude of magnetic intensity is $4.5 \times 10^{-2}$ $Am^{-1}$ at a point, what will be the approximate magnitude of electric field intensity at that point ?

(Given : Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ $Na^{-2}$, speed of light in vacuum $c = 3 \times 10^8$ $ms^{-1}$)

(A) 16.96 $Vm^{-1}$ (B) $2.25 \times 10^{-2}$ $Vm^{-1}$ (C) 8.48 $Vm^{-1}$ (D) $6.75 \times 10^6$ $V,m^{-1}$

**Ans.** **C**

**Sol.** $B = \mu_0\mu_r H$

$V = \frac{C}{\sqrt{\varepsilon_r u_r}}$

$E = AB$

$= \frac{C}{\sqrt{\varepsilon_r u_r}} \times \mu_0\mu_r H$

$C\mu_0\sqrt{\frac{\mu_r}{\varepsilon_r}}H$

$= 3 \times 10^8 \times 4p \times 10^{-7}\sqrt{\frac{1.61}{6.44}} \times 4.5 \times 10^{-2}$

$= 30 \times 4\pi \times \frac{1}{2} \times 4.5 \times 10^{-2}$

$= 0.60\pi \times 9/2 \times 10^{-1}$

$= 30\pi \times 9 \times 10^{-2}$

$= 8.47$

**14.** Choose the correct option from the following options given below :

(A) In the ground state of Rutherford's model electrons are in stable equilibrium. While in Thomson's model electrons always experience always experience a net-force.

(B) An atom has a nearly continuous mass distribution in a Rutherford's model but has a highly non-uniform mass distribution in Thomson's model

(C) A classical atom based on Rutherford's model is doomed to collapse.

(D) The positively charged part of the atom possesses most of the mass in Rutherford's model but not in Thomson's model.

**Ans.** **C**

**Sol.** In Rutherford model electron finallymerge in nucleus.

**15.** Nucleus A is having mass number 220 and its binding energy per nucleon is 5.6 MeV. It spilt in two fragments 'B' and 'C' of mass numbers 105 and 115. The binding energy of nucleons in 'B' and 'C' is 6.4 MeV per nucleon. The energy Q released per fission will be :

(A) 0.8 MeV (B) 275 MeV (C) 220 MeV (D) 176 MeV

**Ans.** **D**

**Sol.** $A^{220} \longrightarrow B^{105} + C^{115}$

$\downarrow \quad \downarrow \quad \downarrow$

5.6 6.4 6.4

$Q = 6.4 \times (105 + 115) - 220 \times 5.6 = 176$ MeV

**16.** A baseband signal of 3.5 MHz frequency is modulated with a carrier signal of 3.5 GHz frequency using amplitude modulation method. What should be the minimum size of antenna required to transmit the modulated signal ?

(A) 42.8 m (B) 42.8 mm (C) 21.4 mm (D) 21.4 m

**Ans.** **C**

**Sol.** $\lambda = \frac{c}{f_c} = \frac{3 \times 10^8}{3.5 \times 10^9}$

$h \approx \frac{\lambda}{4} = \frac{3 \times 10^8}{3.5 \times 10^9} \times \frac{1}{4} m = \frac{3000}{35 \times 4} = 21.4mm$

**17.** A Carnot engine whose heat sinks at 27°C, has an efficiency of 25%. By how many degrees should the temperature of the source be changed to increase the efficiency by 100% of the original efficiency ?

(A) Increase by 18°C (B) Increase by 200°C (C) Increase by 120°C (D) Increase by 73°C

**Ans.** **B**

**Sol.** $n = 1 - T_2/T_1$

$0.25 = 1 - \frac{T_2}{T_1}$ $T_2$ = 300 K (sink)

$\frac{1}{4} = 1 - \frac{300}{T_1}$

$T_1 = 400K$

Efficiency increased by 100%, so new efficiency $\eta$ = 50%

$$0.5 = 1 - \frac{300}{T_1'}$$

$$\frac{300}{T_1'} = 0.5$$

$T_1' = 600$

So change in temperature = 600 – 400 = 200K

**18.** A parallel plate capacitor is formed by two plates each of area $30\pi$ cm$^2$ separated by 1mm.

A material of dielectric strength $3.6 \times 10^7$ Vm$^{-1}$ is filled between the plates. If the maximum charge that can be stored on the capacitor without causing any dielectric breakdown is $7 \times 10^{-6}$ C, the value of dielectric constant of the material is :

$$\left[\text{Use } \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{Nm}^2\text{C}^{-2}\right]$$

(A) 1.66 (B) 1.75 (C) 2.25 (D) 2.33

**Ans.** **D**

**Sol.** A, d, E = Given

K = ?

q = CV

$$q = \frac{KA\varepsilon_0}{d} \times E \times d.$$

$$K = \frac{q \times d}{A\varepsilon_0 E \times d}$$

$$= \frac{7 \times 10^{-6} \times 10^3}{30\pi \times 10^{-4} \times 3.6 \times 10^7 \times 8.85 \times 10^{-12}}$$

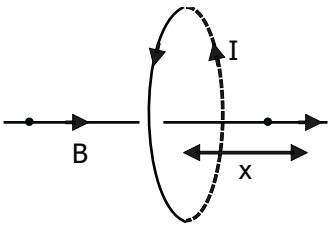
$$= \frac{10^3 \times 7}{30\pi \times 3.6 \times 8.85} = 2.33$$

**19.** The magnetic field at the centre of a circular coil of radius r, due to current I flowing through it, is B. The magnetic field at a point along the axis at a distance $\frac{r}{2}$ from the centre is :

(A) B/2 (B) 2B (C) $\left(\frac{2}{\sqrt{5}}\right)^3$ B (D) $\left(\frac{2}{\sqrt{3}}\right)^3$ B

**Ans.** **C**

**Sol.**




Magnetic field on the axis of the loop : $B = \frac{\mu_0 NIR^2}{2\left(R^2 + x^2\right)^{3/2}}$

x = R/2

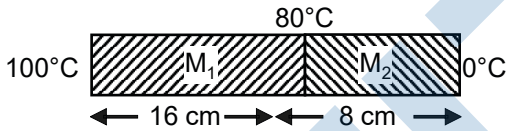
$$B = \frac{\mu_0}{2}\frac{IR^2}{\left(\frac{R^2}{4}+R^2\right)^{3/2}}$$

$$B = \frac{\mu_0 IR^2}{2\left(\frac{5}{4}R^2\right)^{3/2}} = \frac{\mu_0 IR^2}{2R^3\left(\frac{5}{4}\right)^{3/2}}$$

$$B = \frac{\mu_0 IR^2}{2R\left(\frac{5}{4}R^2\right)^{3/2}} = \frac{B_0}{\left(\frac{5}{4}\right)^{3/2}} = \frac{8B_0}{5\sqrt{5}}$$

**20.** Two metallic blocks $M_1$ and $M_2$ of same area of cross-section are connected to each other (as shown in figure). If the thermal conductivity of $M_2$ is K then the thermal conductivity of $M_1$ will be :

[Assume steady state heat conduction]




(A) 10 K (B) 8 K (C) 12.5 K (D) 2 K

**Ans.** **B**

**Sol.** $H_1 = H_2 = KA\frac{AO}{\pi}$

$K_1 \propto \frac{20}{16} = K \times \frac{80}{8}$

$K_1 = 8K$

## Numeric Value Type

This Section contains **10 Numeric Value Type question**, out of 10 only 5 have to be done.

**21.** 0.056 kg of Nitrogen is enclosed in a vessel at a temperature of 127°C. The amount of heat required to double the speed of its molecules is _____ k cal.

(Take R = 2 cal mole$^{-1}$ K$^{-1}$)

**Ans.** **12**

**Sol.** M

$N_2 = 28$

V = C

$T_2 = 4T_1$

$\Delta Q = ?$

$\Delta Q = nC_v\Delta T$

$= \frac{56}{28} \times \frac{5}{2} \times R \times 3T_1$

= 5 × 2 × 3 × 400

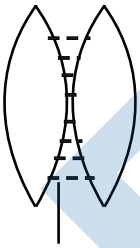
= 12000 cal

= 12 kcal

**22.** Two identical thin biconvex lenses of focal length 15 cm and refractive index 1.5 are in contact with each other. The space between the lenses is filled with a liquid refractive index 1.25. The focal length of the combination is _____ cm.

**Ans.** **10**

**Sol.** f = 15 cm



$\mu = 1.25$

$\mu = 1.5; \frac{1}{15} = (1.5-1) \times \frac{2}{R}$

R = 15 cm

$\frac{1}{f_2} = (1.25-1) \times \frac{2}{15} = \frac{1}{4} \times \frac{-2}{15} = -\frac{1}{30}$

$f_2 = -30$

$\frac{1}{F} = \times \frac{1}{15} \times 2 + \frac{-1}{30} = \frac{4-1}{30}$

F = 10

**23.** A transistor is used in common-emitter mode in an amplifier circuit. When a signal of 10 mV is added to the base-emitter voltage, the base current changes by 10 μA and the collector current changes by 1.5 mA. The load resistance in 5 kΩ. The voltage gain of the transistor will be _____.

**Ans.** **750**

**Sol.** $V_1 = 10$ mV

$\Delta I_B = 10\mu A$

$\Delta Ic = 1.5$ mA

$R_2 = 15\ k\Omega$

VG = ?

$V_1 = I_B \times R_1$

$$R_1 = \frac{10 \times 10^{-3}}{10 \times 10^{-6}}$$

$R_1 = 1k\Omega$

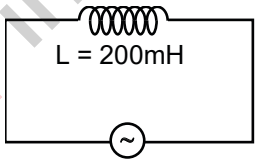
$$VG = \frac{R_2}{R_1} \times \beta$$

$$= \frac{5}{1} \times \frac{1.5 \times 10^{-3}}{10 \times 10^{-6}}$$

$$= \frac{1.5}{2} \times 1000 = 1.5 \times 500$$

$$= \frac{3}{2} \times 500 = 750.$$

**24.** As shown in the figure an inductor of inductance 200 mH is connected to an AC source of emf 220 V and frequency 50 Hz. The instantaneous voltage of the source is 0 V when the peak value of current is $\frac{\sqrt{a}}{\pi}$ A . The value of a is _____.




**Ans.** 242

**Sol.** L = 200 mH

220V, 50 Hz

$V_D$ = OV, a = ?

$$i_0 = \frac{\sqrt{a}}{\pi} A$$

V = i × L

220 – i × wL

$$i = \frac{220}{2\pi \times 50 \times 200 \times 10^{-3}} = \frac{220 \times 10^3 \times 10^{-4}}{\pi \times 2} = \frac{11}{\pi}$$

$I_{peak} = \sqrt{2}i = \sqrt{2} \times \frac{11}{\pi} = \frac{\sqrt{242}}{\pi}$

$i_0 = i\sqrt{2}$

$= \frac{11}{\pi}\sqrt{2} = \frac{\sqrt{242}}{\pi}$

a = 242

**25.** Sodium light of wavelengths 650 nm and 655 nm is used to study diffraction at a single slit of aperture 0.5 mm. The distance between the slit and the screen is 2.0m. The separation between the position of the first maxima of diffraction pattern obtained in the two cases is _____ × $10^{-5}$ m.

**Ans.** 03.00

**Sol.** a = 0.5 mm

D = 2 m

$b\sin\theta = (2n+1)\frac{\lambda}{2}$

$n = 1 \Rightarrow B_1$

$\sin\theta = \frac{3\lambda}{2b} = \frac{Y}{D}$

$Y = \frac{3\lambda D}{2b}$

$d = \frac{3D}{2b}(\lambda_2 - \lambda_1)$

$= \frac{3 \times 2}{2 \times 0.5 \times 10^{-3}} \times 5 \times 10^{-3} \times 10^{-6} = 30 \times 10^{-6} m = 3 \times 10^{-5} m$

**26.** When light of frequency twice the threshold frequency is incident on the metal plate, the maximum velocity of emitted electron is $v_1$. When the frequency of incident radiation is increased to five times the threshold value, the maximum velocity of emitted electron becomes $v_2$. If $v_2 = x\, v_1$, the value of x will be _____.

**Ans.** **02.00**

**Sol.** $\frac{1}{2}mv_1^2 = h(2\nu_{th}) - h(\nu_{th})$.....(1) $\frac{1}{2}mv_2^2 = h(5\nu_{th}) - h(\nu_{th})$.....(2)

From (2) / (1)

$\left(\frac{V_2}{V_1}\right)^2 = \frac{4}{1}$

$\left(\frac{V_2}{V_1}\right) = 2$

**27.** From the top of a tower, a ball is thrown vertically upward which reaches the ground in 6 s. A second ball thrown vertically downward from the same position with the same speed reaches the ground in 1.5 s. A third ball released, from the rest from the same location, will reach the ground in _____ s.

**Ans.** **3.00**

**Sol.** $+h = -u \times 6 + \frac{1}{2} + g \times 6^2$ .....(1)

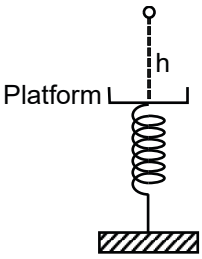
$+h = u \times 1.5 + \frac{1}{2} g(1.5)^2$ .....(2)

$+h = \frac{1}{2} g \times t^2$ .....(3)

After solving $t = \sqrt{t_1 t_2} = 3\,\text{sec}.$

**28.** A ball of mass 100 g is dropped from a hight h = 10 cm on a platform fixed at the top of a vertical spring (as shown in figure). The ball stays on the platform and the platform is depressed by a distance $\frac{h}{2}$. The spring constant is _____ $Nm^{-1}$.

(Use g = 10 $ms^{-2}$)




**Ans.** **120**

**Sol.** $mg\left(n + \frac{h}{2}\right) = \frac{1}{2} kx^2$

$mg \times \frac{3h}{2} = \frac{1}{2} kx^2$

$x = \frac{h}{2} = \frac{0.1}{2}$

$K = \frac{3mgh}{x^2}$

$= \frac{3 \times 0.1 \times 10 \times 0.1 \times 4}{(0.1)^2} = 120$

**29.** In a potentiometer arrangement, a cell gives a balancing point at 75 cm length of wire. This cell is now replaced by another cell of unknown emf. If the ratio of the emf's of two cells respectively is 3 : 2, the difference in the balancing length of the potentiometer wire in above two cases will be _____ cm.

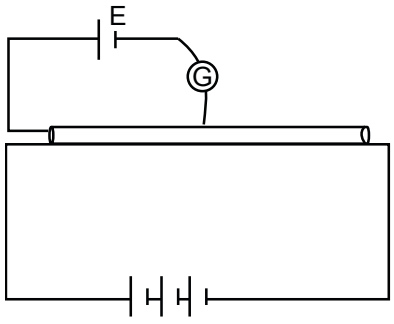
**Ans.** **25.00**

**Sol.** $E_1 = K \times 75$

$E_1 = K \times x$

$\frac{E_1}{E_2} = \frac{3}{2} = \frac{75}{x} \Rightarrow x = 50\text{cm}$

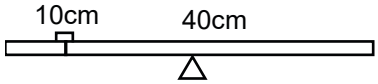
Difference = 75 – 50 = 25 cm



**30.** A metre scale is balanced on a knife edge at its centre. When two coins, each of mass 10 g are put one on the top of the other at the 10.0 cm mark the scale is found to be balanced at 40.0 cm mark. The mass of the metre scale is found to be $x \times 10^{-2}$ kg. The value of x is _____.

**Ans.** **06.00**

**Sol.** m = 10 gm




$2 \times 10 \times 30 = m_1 + 10$

$M_1 = 60$ gm

$= 60 \times 10^{-3}$ kg $= 6 \times 10^{-2}$ kg

= 6 Ans

# PART B : CHEMISTRY

## Single Choice Type

This section contains **20 Single choice questions**. Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

**1.** If a rocket runs on a fuel ($C_{15}H_{30}$) and liquid oxygen, the weight of oxygen required and $CO_2$ released for every litre of fuel respectively are :

(A) 1188 g and 1296 g (B) 2376 g and 2592 g

(C) 2592 g and 2376 g (D) 3429 g and 3142 g

**Ans.** **C**

**Sol.** $\text{density} = \frac{\text{mass}}{\text{volume}}$

mass of $C_{15}H_{30} = d \times V = 0.756 \times 1000 = 756$ gram

$$C_{15}H_{30}(\ell) + \frac{45}{2}O_2(g) \longrightarrow 15CO_2(g) + 15H_2O$$

$$\frac{756}{210} \quad \frac{45}{2}\left[\frac{756}{210}\right] \text{mole} \quad 15\left[\frac{756}{210}\right]$$

$$W_{O_2} = \frac{45}{2}\left[\frac{756}{210}\right]32 = 2592\text{gram}$$

$$W_{CO_2} = 2376\text{gram}$$

**2.** Consider the following pairs of electrons

(A) (a) $n = 3, 1 = 1, m_1 = 1, m_s = +\frac{1}{2}$

(b) $n = 3, 1 = 2, m_1 = 1, m_s = +\frac{1}{2}$

(B) (a) $n = 3, 1 = 2, m_1 = -2, m_s = -\frac{1}{2}$

(b) $n = 3, 1 = 2, m_1 = -1, m_s = -\frac{1}{2}$

(C) (a) $n = 4, 1 = 2, m_1 = 2, m_s = +\frac{1}{2}$

(b) $n = 3, 1 = 2, m_1 = 2, m_s = +\frac{1}{2}$

The pairs of electrons present in degenerate orbitals is/are :

(A) Only (A) (B) Only (B) (C) Only (C) (D) (B) and (C)

**Ans.** **B**

**Sol.** The orbitals with similar values of n & $\ell$ but with different value of m are degenerate.

(Orbitals with same values of n + $\ell$ are degenerate orbitals)

**3.** Match **List – I** with List – **II** –

| List – I | List – II |
|---|---|
| (A) $[PtCl_4]^{2-}$ | (I) $sp^3d$ |
| (B) $BrF_5$ | (II) $d^2sp^3$ |
| (C) $PCl_5$ | (III) $dsp^2$ |
| (D) $[Co(NH_3)_6]^{3+}$ | (IV) $sp^3d^2$ |

Choose the **most appropriate** answer from the options given below :

(A) (A)- (II), (B)-(IV), (C)-(I), (D)-(III)

(B) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)

(C) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)

(D) (A)-(II), (B)-(I), (C)-(IV), (D)-(II)

**Ans.** **B**

**Sol.**

| | Compound | | Hybridisation |
|---|---|---|---|
| (A) | $[Pt(Cl)_4]^{2-}$ | (III) | $dsp^2$ |
| (B) | $BrF_5$ | (IV) | $sp^3d^2$ |
| (C) | $PC\ell_5$ | (I) | $sp^3d$ |
| (D) | $[Co(NH_3)_6]^{3+}$ | (II) | $d^2sp^3$ |

**4.** For a reaction at equilibrium

$$A(g) \rightleftharpoons B(g) + \frac{1}{2}C(g)$$

the relation between dissociation constant (K), degree of dissociation ($\alpha$) and equilibrium pressure (p) is given by :

(A) $K = \dfrac{\alpha^{\frac{1}{2}}p^{\frac{3}{2}}}{\left(1+\frac{3}{2}\alpha\right)^{\frac{1}{2}}(1-\alpha)}$

(B) $K = \dfrac{\alpha^{\frac{3}{2}}p^{\frac{1}{2}}}{(2+\alpha)^{\frac{1}{2}}(1-\alpha)}$

(C) $K = \dfrac{(\alpha p)^{\frac{3}{2}}}{\left(1+\frac{3}{2}\alpha\right)^{\frac{1}{2}}(1-\alpha)}$

(D) $K = \dfrac{(\alpha p)^{\frac{3}{2}}}{(1+\alpha)(1-\alpha)^{\frac{1}{2}}}$

**Ans.** **B**

**Sol.**

$$\begin{array}{lccc} & A & \rightleftharpoons B & + \dfrac{1}{2}C \\ \text{Initially} & 1 & 0 & 0 \\ & (1-\alpha) & \alpha & \dfrac{\alpha}{2} \end{array}$$

$$n_{Total} = \left(1+\frac{\alpha}{2}\right)$$

$$K_p = \frac{\left[\frac{\alpha}{1+\frac{\alpha}{2}}P\right]\left[\frac{\alpha}{\left(1+\frac{\alpha}{2}\right)}P\right]^{\frac{1}{2}}}{\left[\frac{1-\alpha}{1+\frac{\alpha}{2}}P\right]} = \frac{\left[\frac{2\alpha}{(2+\alpha)}P\right]\left[\frac{2\alpha}{2+\alpha}P\right]^{\frac{1}{2}}}{\left[\frac{2(1-\alpha)}{(2+\alpha)}P\right]} = \frac{\alpha}{(1+\alpha)} \times \left(\frac{2\alpha}{(2+\alpha)} \times P\right)^{\frac{1}{2}} = \frac{\sqrt{2}(\alpha)^{\frac{3}{2}}P^{\frac{1}{2}}}{(1-\alpha)(2+\alpha)^{\frac{1}{2}}}$$

**5.** Given below are two statement ;

**Statement I :** Emulsions of oil in water are unstable and sometimes they separate into two layers on standing.

**Statement II :** For stabilisation of an emulsion, excess of electrolyte is added. In the light of the above statement, choose the most appropriate answer from the questions given below :

(A) Both **Statement I** and **Statement II** are correct.

(B) Both **Statement I** and **Statement II** are incorrect.

(C) **Statement I** is correct but **Statement II** is incorrect.

(D) **Statement I** is incorrect but **Statement II** is correct.

**Ans.** **C**

**Sol.** Emulsions of oil in water are unstable and sometimes they separate into two layers on standing. For stabilisation of an emulsion, a third component called emulsifying agent is usually added

**6.** Given below are the oxides :

$Na_2O$, $As_2O_3$, $N_2O$, NO and $Cl_2O_7$

Number of amphoteric oxides is :

(A) 0 (B) 1 (C) 2 (D) 3

**Ans.** **B**

**Sol.** Acidic $\Rightarrow Cl_2O_7$

Basic $\Rightarrow Na_2O$

Amphoteric $\Rightarrow As_2O_3$

Neutral $\Rightarrow NO, N_2O$

**7.** Match **List – I** with **List – II** :

| **List – I** | **List – II** |
|---|---|
| (A) Sphalerite | (I) $FeCO_3$ |
| (B) Calamine | (II) PbS |
| (C) Galena | (III) $ZnCO_3$ |
| (D) Siderite | (IV) ZnS |

Choose the **most appropriate** answer from the options given below :

(A) (A)- (IV), (B)-(III), (C)-(II), (D)-(I)

(B) (A)-(IV), (B)-(I), (C)-(II), (D)-(III)

(C) (A)-(II), (B)-(III), (C)-(I), (D)-(IV)

(D) (A)-(III), (B)-(IV), (D)-(II), (D)-(I)

**Ans.** **A**

**Sol.**

| | |
|---|---|
| Calamine | $ZnCO_3$ |
| Sphalarite | ZnS |
| Galena | PbS |
| Siderite | $FeCO_3$ |

**8.** The highest industrial consumption of molecular hydrogen is to produce compounds element :

(A) Carbon (B) Nitrogen (C) Oxygen (D) Chlorine

**Ans.** **B**

**Sol.** The largest single use of dihydrogen is in the synthesis of ammonia (compound of nitrogen) which is used in the manufacture of nitric acid and nitrogenous fertilizers

**9.** Which of the following statement are **correct** ?

(A) Both LiCl and $MgCl_2$ are soluble in ethanol.

(B) The oxides $Li_2O$ and MgO combine with excess of oxygen to give superoxide.

(C) LiF is less soluble in water than other alkali metal fluorides.

(D) $Li_2O$ is more soluble is water than other alkali metal oxides.

Choose the **most appropriate** answer from the options given below :

(A) (A) and (C) only

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

(C) (B) and (C) only

(D) (A) and (D) only

**Ans.** **A**

**Sol.** (i) Both LiCl & $MgCl_2$ have covalent character so soluble in ethanal.

(ii) Lif have low solubility due to high LaHice energy.

**10.** Identify the correct statement for $B_2H_6$ from those given below.

(A) In $B_2H_6$, all B-H bonds are equivalent.

(B) In $B_2H_6$, there are four 3-centre-2-electron bonds.

(C) $B_2H_6$ is a Lewis acid.

(D) $B_2H_6$ can be synthesized from both $BF_3$ and $NaBH_4$.

(E) $B_2H_6$ is a planer molecular.

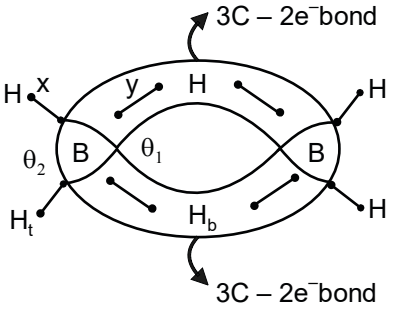
Choose the **most appropriate** answer from the options given below :

(A) (A) and (E) only (B) (B), (C) and (E) only

(C) (C) and (D) only (D) (C) and (E) only

**Ans.** **C**

**Sol.**




$B_2H_6$ have 4 2c-2e bonds and 2 3c-2e bonds. Bridging bonds have larger bond length than terminal bonds. Angle between terminal bonds in more than angle between bridging bonds if all 4 terminal bonds are in one plane then bridging bonds are in perpendicular plane.

$$3NaBH_4 + 4BF_3 \xrightarrow[450K]{\text{ether}} 3NaBF_4 + 2B_2H_6$$

**11.** The most stable trihalide of nitrogen is :

(A) $NF_3$ (B) $NCl_3$ (C) $NBr_3$ (D) $NI_3$

**Ans.** **A**

**Sol.** $NF_3$ is stable while $NCl_3$, $NBr_3$, $NI_3$ are explosive

**12.** Which one of the following elemental forms is **not** present in the enamel of the earth ?

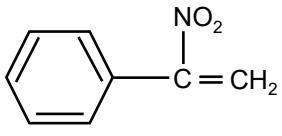
(A) $Ca^{2+}$ (B) $p^{3+}$ (C) $F^-$ (D) $p^{5+}$

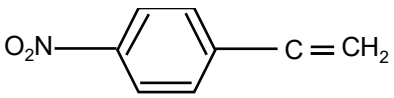
**Ans.** **B**

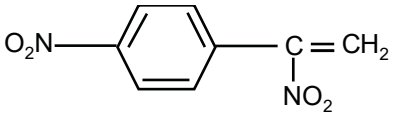
**Sol.** Calcium and phosphate are the major component of hydroxyapatite crystal that from the inorganic portion of the teeth

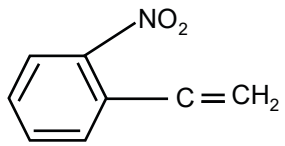
**13.** In the given reaction sequence, the major product 'C' is :

$$C_8H_{10} \xrightarrow[H_2SO_4]{HNO_3} A \xrightarrow[\Delta]{Br_2} B \xrightarrow[KOH]{\text{alcoholic}} C$$

(A) 

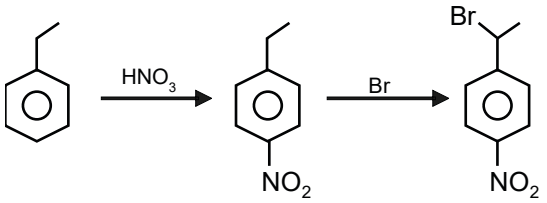

(B) 


(C) 


(D) 

**Ans.** **B**

**Sol.**




**14.** Two statement are given below ;

**Statement I :** The melting point monocarboxylic acid with even number of carbon atoms is higher than that of with odd number of carbon atoms acid immediately below and above it in the seires.

**Statement II :** The solubility of monocarboxylic acids in water decrease with increase in molar mass.

Choose the **most appreciate** option :

(A) Both **Statement I** and **Statement II** are correct.

(B) Both **Statement I** and **Statement II** are incorrect.

(C) **Statement I** is correct but **Statement II** is incorrect.

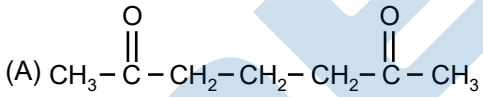
(D) **Statement I** is incorrect but **Statement II** is correct.

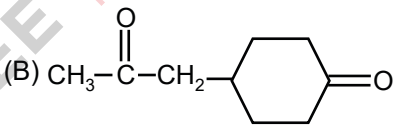
**Ans.** **D**

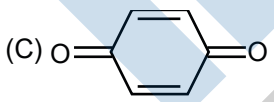
**Sol.** The melting point of carboxylic acid has no trend as we can observe from the following data of melting point.

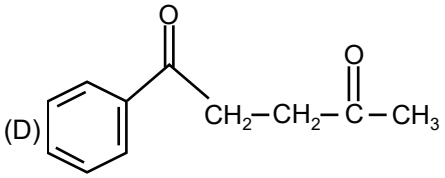
Methanoic acid = 8°C, Ethanoic acid = 17°, Propanoic acid = 2°C, Butanoic acid = 6°C, Pentonoic acid = –35°C, Hexonic acid = –20°C, Heptanoic acid = –8°C, Octanoic acid = 17°C acid. Water solubility of carboxylic acid decreases as we increase the molar mass & hence hydrophobic part of the chain.

**15.** Which of the following is an example of conjugated diketone ?

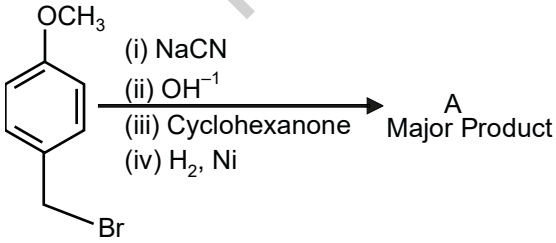
(A) 

(B) 

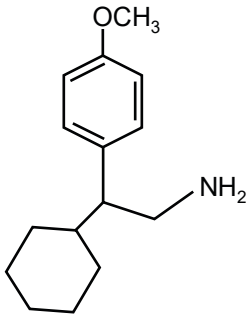
(C) 

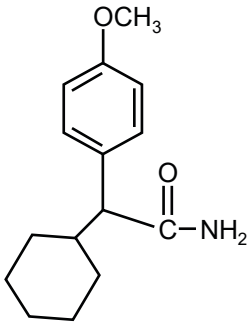
(D) 

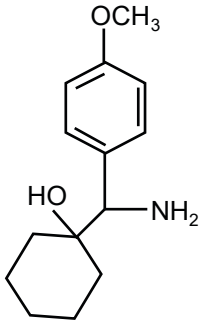
**Ans.** **C**

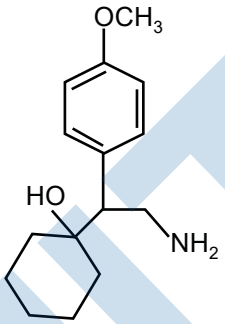
**16.** 


The major product of the above reactions is :

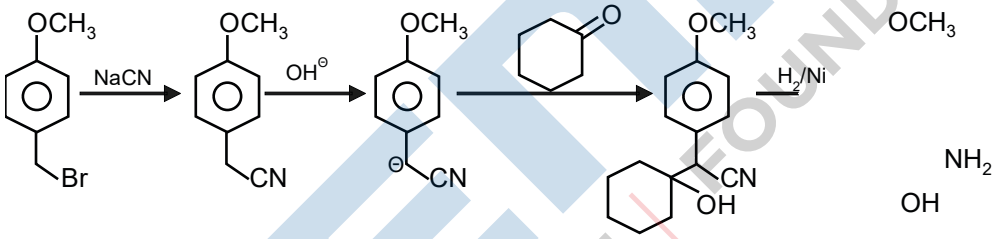
(A) 

(C) 

(B) 

(D) 

**Ans.** **D**

**Sol.** 

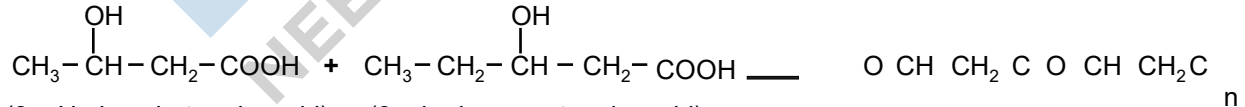
**17.** Which of the following is an example of polyester ?

(A) Butadiene-styrene copolymer (B) Melamine polymer

(C) Neoprene (D) Poly-β-hydroxybutyrate-co-β-hydroxyvalerat

**Ans.** **D**

**Sol.** Poly β-hydroxybutyrate-co-β-hydroxy valerate (PHBV) : **It is obtained by the copolymerisation of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid.**



(3 – Hydroxybutanoic acid) (3 – hydroxypentanoic acid)

PHBV

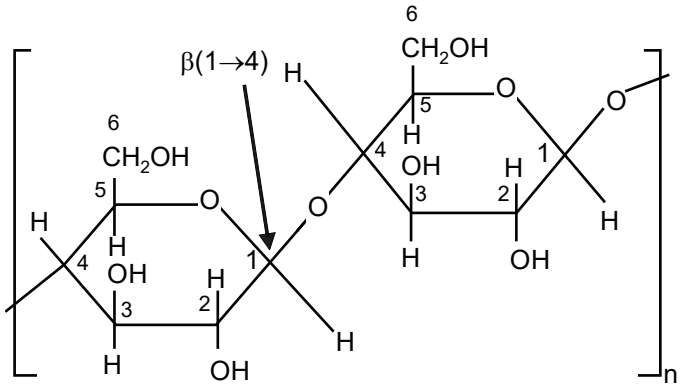
PHBV is used in speciality packaging, orthopaedic devices and in controlled release of drugs. PHBV undergoes bacterial degradation in the environment.

**18.** A polysaccharide 'X' on boiling with dil $H_2SO_4$ at 393 K under 2-3 atm pressure yields 'Y'. 'Y' on treatment with bromine water gives gluconic acid. 'X' contains β-glycosidic linkages only. Compound 'X' is :

(A) starch (B) cellulose (C) amylose (D) amylopectin

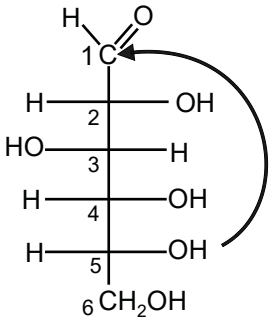
**Ans.** **B**

**Sol.** **Cellulose, $(C_6H_{10}O_5)_n$**




1,4-Glycosidic linkage of β-D-Glucose

Cellulose




**D-Glucose**
**Specific rotation (+52.7°)**

**19.** Which of the following is **not** a board spectrum antibiotic ?

(A) Vancomycin (B) Ampicillin (C) Ofloxacin (D) Penicillin G

**Ans.** **D**

**Sol.** The range of bacteria or other microorganisms that are affected by certain antibiotic is expressed as its spectrum of action. Antibiotics which kill or inhibit a wide range of Gram-positive and Gram-negative bacteria are said to be broad spectrum antibiotics. Those effective mainly against a single organism or disease, they are referred to as limited spectrum antibiotics. Penicillin G has a narrow spectrum. Ampicillin and Amoxycillin are synthetic of penicillins.]

**20.** During the qualitative analysis of salt with cation $y^{2+}$ , addition of a reagent (X) to alkaline solution of the salt gives a bright red precipitate. The reagent (X) and the cation ($y^{2+}$) present respectively are :

(A) Dimethylglyoxime and $Ni^{2+}$ (B) Dimethylglyoxime and $Co^{2+}$

(C) Nessler's reagent and $Hg^{2+}$ (D) Nessler's reagent and $Ni^{2+}$

**Ans.** **A**

**Sol.** $Ni^{2+} + dmg \xrightarrow{\text{Ammonical Solution}} \underset{\text{Redcolour}}{\left[Ni(dmg)_2\right]}\downarrow$

## Numeric Value Type

This Section contains **10 Numeric Value Type question**, out of 10 only 5 have to be done.

**21.** Atoms of element X form hcp lattice and those of element Y occupy $\frac{2}{3}$ of its tetrahedral voids. The percentage of element X in the lattice is _____. (Nearest integer)

**Ans.** **43**

**Sol.** X = 6[HCP unit cell]

$$Y = \frac{2}{3} \times [TV] = \frac{2}{3} \times 12 = 8$$

Formula = $X_6Y_8 \Rightarrow X_3Y_4$

% of × in unit cell $= \frac{3}{7} \times 10 = 42.857 \approx 43$

**22.** $2O_3(g) \rightleftharpoons 3O_2(g)$

At 300 K, ozone is fifty percent dissociated. The standard free energy, change at this temperature and 1 atm pressure is (–) _____ J $mol^{-1}$. (Nearest integer)

[Given : In 1.35 = 0.3 and R = 8.3] j $K^{-1}$ $mol^{-1}$]

**Ans.** **747**

**Sol.** $2O_3(g) \rightleftharpoons 3O_2(g)$

Initially 1 mole 0

(1 – 0.5) $\frac{3}{2} \times 0.5$

0.5 mole $\frac{1.5}{2} = 0.75$ mole

$$K_p = \frac{\left(P_{O_2}\right)^3}{\left(P_{O_2}\right)^2} = \frac{\left(\frac{0.75}{1.25}\right)^3}{\left(\frac{0.5}{1.25}\right)^2} = \frac{\left(\frac{3}{5}\right)^2}{\left(\frac{2}{5}\right)^2}$$

$$= \frac{(0.6)^3}{(0.4)^2} = \frac{(0.216)}{(0.16)} = 1.35$$

$\Delta G° = -RT\ell nK_p$

$= -8.3 \times 300\ \ell n\ 1.35$

$= -8.3 \times 300 \times 0.3$

$= -747$ J/mole

**23.** The osmotic pressure of blood is 7.47 bar at 300K. To inject glucose to a intravenously, it has to be istonic with blood. The concentration of glucose solution in $gL^{-1}$ is _____.

(Molar mass of glucose = 180 g $mol^{-1}$

R = 0.083 L bar $K^{-1}$ $mol^{-1}$) (Nearest integer)

**Ans.** **54**

**Sol.** For isotonic solution

$\pi_{Injection} = \pi_{Blood}$

(CRT) = 7.47

C × 0.082 × 300 = 7.47

C = 0.3 mole/lit

= 0.3 × 180 = 54 gram/lit

**24.** The cell potential for the following cell

Pt $|H_2(g)|H^+(aq)||$ $Cu^{2+}$ (0.01 M)|Cu(s)

Is 0.576 V at 298 K. The pH of the solution is _____. (Nearest integer)

(Given : $E^0_{Cu^{2+}/Cu} = 0.34V$ and $\frac{2.303RT}{F} = 0.6V$ )

**Ans.** **5**

**Sol.** Anode $\Rightarrow H_2(g) \longrightarrow 2H^+(aq) + 2e^-$

Cathode $\Rightarrow \underline{Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)}$

Overall $\Rightarrow \underline{H_2(g) + Cu^{2+}(aq) \longrightarrow 2H^+(aq) + Cu(s)}$

$E^0_{cell} = E^0_{Cu^{2+}|Cu} - E^0_{H^+|H_2} = 0.34V$

$E_{cell} = E^0_{cell} - \frac{0.06}{2}\log\frac{[H^+]^2}{[Cu^{2+}]}$

$0.576 = 0.34 + 0.03\,[-\log[H^+]^2 + \log[Cu^{2+}]$

$0.576 = 0.34 + 0.03\,[2pH + \log[Cu^{2+}]]$

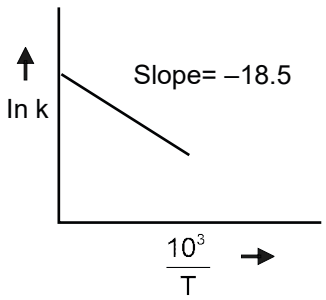
$0.236 = 0.03\,[2pH - 2]$

$7.866 = 2pH - 2$

$pH = 4.93 \approx 5$

**25.** The rate constant for decomposition of acetaldehyde have been measured over the temperature range 700 – 1000 K. The data has been analysed by plotting in k vs $\frac{10^3}{T}$ graph. The value of activation energy for the reaction is _____ kJ $mol^{-1}$. (Nearest integer)

(Given : R = 8.31 J $K^{-1}$ $mol^{-1}$)



**Ans.** **154**

**Sol.** $k = Ae^{\frac{-Ea}{Rt}}$

$$\ell nk = \ell nA - \frac{E_a}{R_T}$$

$$\ell nk = \ell nA + \left[\frac{-E_a}{1000R}\right]\frac{1000}{T}$$

$$\text{Slope} = \frac{-E_a}{1000R} = -18.5$$

$E_a = 18.5 \times 1000 \times 8.31$

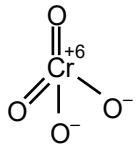
$= 153.735 \times 10^3$ J

$= 154$ KJ

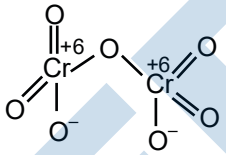
**26.** The difference in oxidation state of chromium in chromate and dichromate salts is _____.

**Ans.** **0**

**Sol.** Chromate $\Rightarrow CrO_4^{2-}$



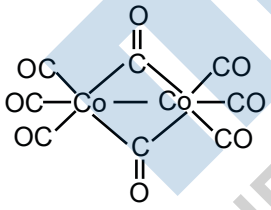
Chromate $\Rightarrow CrO_7^{2-}$



**27.** In the cobalt-carbonyl complex : $[Co_2(CO)_8]$, number of Co-Co bonds is "X" and terminal CO ligands is "Y". X + Y = _____.

**Ans.** **7**

**Sol.** $Co_2(CO)_8$



$[Co_2(CO)_8]$

No. of Co – Co bond = X = 1

No. of terminal ligend = Y = 6

X + Y = 7

**28.** A 0.166 g sample of an organic compound was digested with conc. $H_2SO_4$ and then distilled with NaOH. The ammonia gas evolved was passed through 50.0 mL of 0.5 N $H_2SO_4$. The used acid required 30.0 mL of 0.25 N NaOH for completed neutralization. The mass percentage of nitrogen in the organic compound is _____ .

**Ans.** **63**

**Sol.** Organic Compound (Containing Nitrogen) 0.166 gram + Conc. $H_2SO_4$ $\xrightarrow{NaOH^-}$ $NH_3$ + $CH_3$

Pass through $H_2SO_4$

Remaining Acid + NaOH $\longrightarrow$ Complete neutralization

Mili eq. of $NH_3$ = mili eq. of Used $H_2SO_4$ = mili eq. of NaOH

$= 0.25 \times 30$

$= 75$

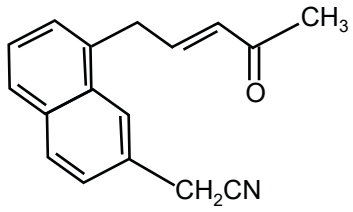
Milimole of Nitrogen = 7.5

$W_{Nitrogen} = 7.5 \times 14 \times 10^{-3}$

$= 0.105$ gram

$$\% \text{ of Nitrogen} = \frac{0.105}{0.166} \times = 63.25 = 63$$

**29.** Number of electrophilic centres in the given compound is _____.




**Ans.** **3**

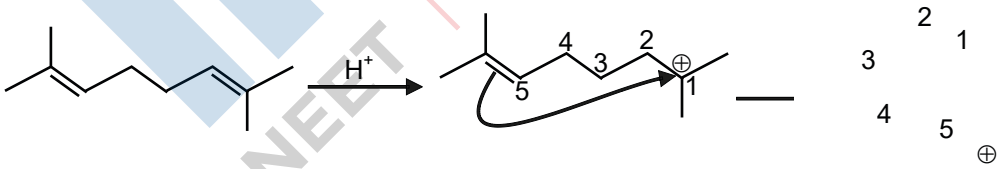
**Sol.** Electric centres are areas low of electron density. Most often they are atoms which contain a full of particle positive charge. In the given structure the –CN group, the Keto group & the double bond in conjugation with Keto group are the 3 electrophilic centres.

**30.** The major product 'A' of the following given reaction has _____ $sp^2$ hybridized carbon atoms.

2,7 – Dimethyl – 2,6 – octadiene $\xrightarrow{H^+}$ A (Major Product)

**Ans.** **2**

**Sol.**



# PART C : MATHEMATICS

## Single Choice Type

This section contains **20 Single choice questions**. Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

**1.** Let $A = \{z \in C : 1 \le |z - (1 + i)| \le 2\}$

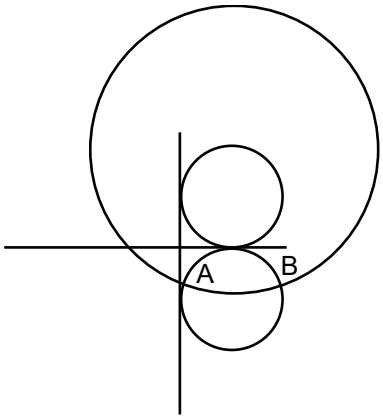
and $B = \{z \in A : |z - (1 + i)| = 1\}$. Then, B :

(A) is an empty set (B) contains exactly two statement

(C) Contains exactly three elements (D) is an infinite set

**Ans.** **D**

**Sol.**




Set A contains all point on minor are AB of circle $|z - (1 - i)| = 1$

**2.** The remainder when $3^{2022}$ is divided by 5 is :

(A) 1 (B) 2 (C) 3 (D) 4

**Ans.** **D**

**Sol.** $9^{1011} = (10 - 1)^{1011} = 10\lambda - 1 = 5\mu - 1$

$\Rightarrow$ remainder = 4

**3.** The surface area of a balloon of spherical shape being inflated, increase at a constant at a constant rate. If initially, the radius of balloon is 3 units and after 5 seconds, it becomes 7 units, then its radius after 9 seconds is :

(A) 9 (B) 10 (C) 11 (D) 12

**Ans.** **A**

**Sol.** $A = 4\pi r^2$

$$\frac{dA}{dt} = 8\pi r = \frac{dr}{dt} = k$$

$4\pi r^2 = kt + C$

at $t = 0$, $r = 3 \Rightarrow 36\pi = C$

at $t = 5$, $r = 7 \Rightarrow 4\pi \times 49 = 5k + 36\pi$

$\Rightarrow 5K = 4\pi(49 - 9)$

$5K = 4\pi \times 40$

$K = 32\pi$

$\Rightarrow 4\pi r^2 = 32\pi t + 36\pi$

$\Rightarrow r^2 = 8t + 9 \Rightarrow r^2 = 81 \Rightarrow r = 9$

**4.** Bag A contains 2 white, 1 black and 3 red balls and bag B contains 3 black, 2 red and n white balls. One bag is chosen at random and 2 balls drawn from it at random, are found to be 1 red and 1 black. If the probability that both balls come from Bag A is $\frac{6}{11}$, then n is equal to _____.

(A) 13 (B) 6 (C) 4 (D) 3

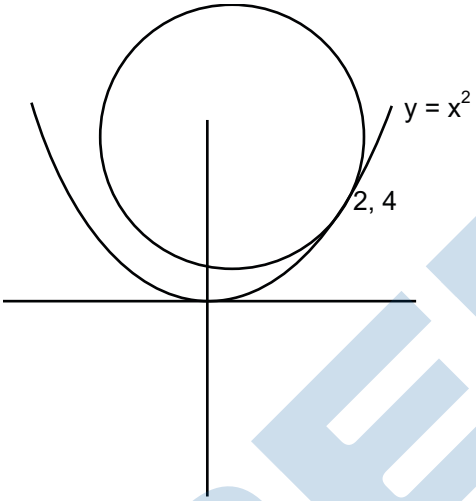
**Ans.** **C**

**5.** Let $x^2 + y^2 + Ax + By + C = 0$ be a circle passing through (0, 6) and touching the parabola $y = x^2$ at (2, 4). Then A + C is equal to _____.

(A) 16 (B) 88/5 (C) 72 (D) –8

**Ans.** **A**

**Sol.**




Equation of tangent to parabola at (2, 4) $y - 4 = m(x - 2)$

$\frac{dy}{dx} = 2x \Rightarrow m = \left.\frac{dy}{dx}\right|_{(2,4)} = 4$

$y - 4 = 4(x - 2) \Rightarrow 4x - y - = 0$

Let equation of circle be $S + \lambda L = 0$

$(x - 2)^2 + (y - 4)^2 + \lambda(4x - y - 4) = 0$

It passes through (0, 6) $\Rightarrow 4 + 4 + \lambda(0 - 6 - 4) = 0$

$\lambda = \frac{8}{10} = \frac{4}{5}$

$(x-2)^2 - (y-4)^2 + \frac{4}{5}(4x - y - 4) = 0$

$x^2 + y^2\left(\frac{16}{5}x - 4x\right) + \left(-8y - \frac{4}{5}y\right) + \left(20 - \frac{16}{5}\right) = 0$

$x^2 + y^2 - \frac{4}{5}x - \frac{44y}{5} + \frac{84}{5} = 0$

$$A=-\frac{4}{5},B=-\frac{44}{5},C=\frac{84}{5}$$

$$A+C=\frac{80}{5}=16$$

**6.** The number of values of $\alpha$ for which the system of equations :

(A) 0 (B) 1 (C) 2 (D) 3

**Ans.** **B**

**7.** If the sum of the squares of the reciprocals of the roots $\alpha$ and $\beta$ of the equation $3x^2 + \lambda - 1 = 0$ is 15, then $6(\alpha^3 + \beta^3)$ is equal to ;

(A) 18 (B) 24 (C) 36 (D) 96

**Ans.** **B**

**Sol.** $3x^2 + \lambda x - 1 = 0$

$$\alpha+\beta=\frac{-\lambda}{3}\alpha\beta=-\frac{1}{3}$$

$$\frac{1}{\alpha^2}+\frac{1}{\beta^2}=15\Rightarrow\alpha^2+\beta^2=15\alpha^2\beta^2$$

$\Rightarrow (\alpha + \beta)^2 - 2\alpha\beta = 15(\alpha\beta)^2$

$$\Rightarrow\frac{\lambda^2}{9}-2\left(-\frac{1}{3}\right)=15\left(-\frac{1}{3}\right)$$

$$\Rightarrow\frac{\lambda^2}{9}+\frac{2}{3}=\frac{5}{3}\Rightarrow\lambda^2=9$$

$6(\alpha^3 + \beta^3)^2 = 6((\alpha + \beta)^3 - 3\alpha\beta(\alpha + \beta))^2$

$$=6\left(-\frac{\lambda^3}{27}+\left(-\frac{\lambda}{3}\right)\right)^2$$

$$=6\frac{\lambda^2}{9}\left(\frac{\lambda^2}{9}+1\right)^2$$

$$=6\frac{9}{9}\times\left(\frac{9}{9}+1\right)^2=6\times4=24$$

**8.** The set of all values of k for which $(\tan^{-1}x)^3 + (\cot^{-1}x)^3 = k\pi^3$, $x \in \mathbf{R}$, is the interval :

(A) $\left[\frac{1}{32},\frac{7}{8}\right)$ (B) $\left(\frac{1}{24},\frac{13}{16}\right)$ (C) $\left[\frac{1}{48},\frac{13}{16}\right]$ (D) $\left[\frac{1}{32},\frac{9}{8}\right)$

**Ans.** **A**

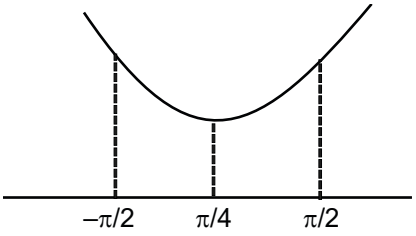
**Sol.** Let $\tan^{-1}x = t, \cot^{-1}x = \frac{\pi}{2} - t$

$$y=t^3+\left(\frac{\pi}{2}-t\right)^3$$

$$y=t^3+\left(\frac{\pi^3}{8}-t^3+\frac{3\pi}{2}t^2-\frac{3\pi^2}{4}t\right)$$

$$y = \frac{3\pi}{2}t^2 - \frac{3\pi^2}{4}t + \frac{\pi^3}{8}, t \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$$

$$t = -\frac{b}{2a} = \frac{\frac{3\pi^2}{4}}{2 \times \frac{3\pi^2}{2}} = \frac{\pi}{4}$$




Range of $y \in \left[F\left(\frac{\pi}{4}\right), F\left(-\frac{\pi}{2}\right)\right]$

$$t = \frac{\pi}{4}, y = \frac{\pi^3}{64} + \frac{\pi^3}{64} = \frac{\pi^3}{32}$$

$$t = -\frac{\pi}{2}, y = -\frac{\pi^3}{8} + \pi^3 = \frac{7}{8}\pi^3$$

$$y \in \left[\frac{\pi^3}{32}, \frac{7\pi^3}{8}\right] \Rightarrow k \in \left[\frac{1}{32}, \frac{7}{8}\right)$$

**9.** **Let** $S = \{\sqrt{n} : 1 \le n \le 50 \text{ and } n \text{ is odd}\}$.

Let $a \in S$ and $A = \begin{bmatrix} 1 & 0 & a \\ -1 & 1 & 0 \\ -a & 0 & 1 \end{bmatrix}$.

If $\sum_{a \in S} \det(\text{adj}A) = 100\lambda$, then $\lambda$ is equal to :

(A) 218 (B) 221 (C) 663 (D) 1717

**Ans.** **B**

**Sol.** $|\text{adj}A| = |A|^{n-1}$ $n \rightarrow$ order of bet

$|\text{adj}A| = |A|^2$

$$|A| = \begin{vmatrix} 1 & 0 & a \\ -1 & 1 & 0 \\ -a & 0 & 1 \end{vmatrix} = 1(1-0) + a(a) = 1 + a^2$$

$|\text{adj}A| = (1 + a^2)^2$

Now $S = \{\sqrt{n} 1 \le n \le 50\}$, n = odd integer

$$\sum \det(\text{adj}A) = \sum (a^2 + 1)^2 = \sum (n+1)^2$$

$= 2^2 + 4^2 + \ldots\ldots + 48^2 + 50^2$

$= 2^2 (1^2 + 2^2 + \ldots\ldots + 25^2)$

$= 2^2 \frac{25 \times 26 \times 51}{6}$

$= 100 \times 221$

$\Rightarrow \lambda = 221$

**10.** For the function

$f(x) = 4\log_e(x-1) - 2x^2 + 4x + 5$, $x > 1$, which one of the following is not correct ?

(A) $f$ is increasing in (1, 2) and decreasing in $(2, \infty)$

(B) $f(x) = -1$ has exactly two solutions

(C) $f'(e) - f''(2) < 0$

(D) $f(x) = 0$ has a root in the interval (e, e +1)

**Ans.** **C**

**11.** If the tangent at the point $(x_1, y_1)$ on the curve $y = x^3 + 3x^2 + 5$ passes through the origin, then $(x_1, y_1)$ does NOT lie on the curve :

(A) $x^2 + \frac{y^2}{81} = 2$ (B) $\frac{y^2}{9} - x^2 = 8$ (C) $y = 4x^2 + 5$ (D) $\frac{x}{3} - y^2 = 2$

**Ans.** **D**

**12.** The sum of absolute maximum and absolute minimum values of the function

$f(x) = |2x^2 + 3x - 2| + \sin x \cos x$ in the interval [0, 1] is :

(A) $3 + \frac{\sin(1)\cos^2(1/2)}{2}$ (B) $3 + \frac{1}{2}(1 + 2\cos(1))\sin(1)$

(C) $5 + \frac{1}{2}(\sin(1) + \sin(2))$ (D) $2 + \sin\left(\frac{1}{2}\right)\cos\left(\frac{1}{2}\right)$

**Ans.** **B**

**Sol.** $f(x) = |2x^2 + 3x - 2| + \sin x \cos x \quad x \in [0, 1]$

$y = 2x^2 + 3x - 2 = (x + 2)(2x - 1)$

$f(x) = |(x + 2)(2x - 1)| + \frac{1}{2}\sin(2x)$

**C-1** when $0 \le x \le \frac{1}{2}$

$f(x) = -(2x^2 + 3x - 2) + \frac{1}{2}\sin(2x)$

$f'(x) = -(4x + 3) + \cos(2x)$

$x \in \left[0, \frac{1}{2}\right) \Rightarrow 4x + 3 \in [3, 5) \Rightarrow -(4x + 3) \in [-5, -3]$

$f'(x) < 0 \forall x \in \left[0, \frac{1}{2}\right) \Rightarrow f(x) \downarrow$

$f(x)_{max} = f(0) = 2, f(x)_{min} = f(1/2) = \frac{\sin 1}{2}$

**C-2** When $x \in \left[\frac{1}{2},1\right]$

$f(x) = \left(2x^2 + 3x - 2\right) + \frac{1}{2}\sin(2x)$

$f'(x) = 4(x + 3) + \cos(2x)$

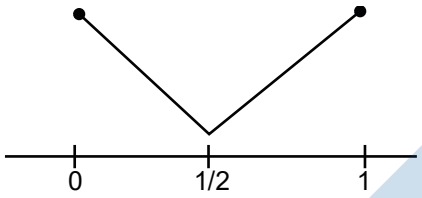
For $x \in \left[\frac{1}{2},1\right] \Rightarrow 4x + 3 \in [5,7]$

$f'(x) > 0 \forall x \in \left[\frac{1}{2},1\right] \Rightarrow f(x) \uparrow$

$f(0 = 2, f\left(\frac{1}{2}\right) \sin(1) = 3 + \frac{1}{2}\sin(2)$

sum of maximum and minimum

$= 3 + \frac{1}{2}(\sin 2 + \sin 1)$




**13.** if $\{a_i\}_{i=1}^{n}$, where n is an even integer, is an arithmetic progression with common difference 1, and $\sum_{i=1}^{n} a_i = 192, \sum_{i=1}^{n/2} a_{2i} = 120$, then n is equal to :

(A) 48 (B) 96 (C) 92 (D) 104

**Ans.** **B**

**Sol.** $a_1 + a_2 + a_3 + a_4 + \ldots\ldots\ldots\ldots + a_n = 192$

$a_2 + a_4 + a_6 + a_8 + \ldots\ldots\ldots\ldots + = 120 \ldots\ldots (i)$

$\Rightarrow a_1 + a_3 + a_5 + \ldots\ldots\ldots\ldots + = 192 - 120 = 72 \ldots\ldots (ii)$

By (i) and (2)

$(a_2 - a_1) + (a_4 - a_3) + \ldots\ldots\ldots = 48$

$1 + 1 + \ldots\ldots\ldots \frac{n}{2} \text{terms} = 48$

$\Rightarrow \frac{n}{2} = 48 \Rightarrow n = 96$

**14.** If x = x(y) is the solution of the differentiable equation $y\frac{dy}{dx} = 2x + y^3\left(y + 1\right)e^y, x(1) = 0$ ; then x(e) is equal to :

(A) $e^3(e^e - 1)$ (B) $e^e(e^3 - 1)$ (C) $e^2(e^e + 1)$ (D) $e^e(e^2 - 1)$

**Ans.** **A**

**15.** Let $\lambda x - 2y = \mu$ be a tangent to the hyperbola $a^2x^2 - y^2 = b^2$. Then $\left(\frac{\lambda}{a}\right)^2 - \left(\frac{\mu}{b}\right)^2$ is equal to :

(A) –2 (B) –4 (C) 2 (D) 4

**Ans.** **D**

**16.** Let $\hat{a}, \hat{b}$ be unit vectors. If $\vec{c}$ be a vectors such that the angle between $\hat{a}$ and $\vec{c}$ is $\frac{\pi}{12}$, and $\hat{b} = \vec{c} + 2\left(\vec{c} \times \hat{a}\right)$, then $\left|6\vec{c}\right|^2$ is equal to :

(A) $6\left(3-\sqrt{3}\right)$ (B) $3+\sqrt{3}$ (C) $6\left(3+\sqrt{3}\right)$ (D) $6\left(\sqrt{3}+1\right)$

**Ans.** **C**

**Sol.** $\left|\vec{b}\right| = \sqrt{c^2 + 4\left(\vec{c} \times \vec{a}\right)^2 + 0}$

$1 = c^2 + 4c^2 \sin^2 \frac{\pi}{12}$

$1 = c^2 + 4c^2 \times \left(\frac{\sqrt{3}-1}{2\sqrt{2}}\right)^2$

$1 = c^2 + c^2 \times \left(\frac{4-2\sqrt{3}}{2}\right) \Rightarrow 1 = c^2 + c^2\left(2-\sqrt{3}\right)$

$1 = c^2\left(3-\sqrt{3}\right) \Rightarrow 3+\sqrt{3} = c^2\left(3-\sqrt{3}\right)\left(3+\sqrt{3}\right)$

$3+\sqrt{3} = 6c^2$

$6\left(3+\sqrt{3}\right) = (6c)^2$

**17.** If a random variable X follows the Binomial distribution B(33, p) such that 3P(X = 0) = P(X) then the value of $\frac{P(X=15)}{P(X=15)} - \frac{P(X=16)}{P(X=17)}$ is equal to :

(A) 1320 (B) 1088 (C) $\frac{120}{1331}$ (D) $\frac{1088}{1089}$

**Ans.** **A**

**18.** The domain of the function $f(x) = \frac{\cos^{-1}\left(\frac{x^2-5X+6}{x^2-9}\right)}{\log_e\left(x^2-3x+2\right)}$ is :

(A) $(-\infty, 1) \cup (2, \infty)$ (B) $(2, \infty)$

(C) $\left[-\frac{1}{2}, 1\right] \cup (2, \infty)$ (D) $\left[-\frac{1}{2}, 1\right] \cup (2, \infty) - \left\{\frac{3+\sqrt{5}}{2}, \frac{3-\sqrt{5}}{2}\right\}$

**Ans.** **D**

**19.** Let $S = \left\{\theta \in [-\pi, \pi] - \left\{\pm\frac{\pi}{2}\right\} : \sin\theta\tan\theta + \tan\theta = \sin 2\theta\right\}$ is equal to :

(A) $7+\sqrt{3}$ (B) 9 (C) $8+\sqrt{3}$ (D) 10

**Ans.** **B**

**Sol.** $\sin\theta \tan\theta + \tan\theta = \sin 2\theta$

$\tan\theta (\sin\theta + 1) - 2\sin\theta\cos\theta = 0$

$$\sin\theta = \left\{\frac{(\sin\theta + 1)}{\cos\theta} - 2\cos\theta\right\} = 0$$

$\sin\theta = 0$ or $\sin\theta + 1 - 2\cos^2\theta = 0$

$\theta = 0, \pi, -\pi$ $\quad\quad$ $\sin\theta + 1 - 2(1 - \sin^2\theta) = 0$

$2\sin^2\theta + \sin\theta - 1 = 0$

$$\sin\theta = -1, \frac{1}{2}$$

$$\theta = -\frac{\pi}{2}, \frac{\pi}{6}, \frac{5\pi}{6}$$

Hence, $S = \left\{0, \frac{\pi}{6}, \frac{5\pi}{6}\right\} \Rightarrow n(S) = 5$

$\Sigma(\theta(2\theta)) = \cos(0) + \cos(\pi/3) + \cos(5\pi/3)) + \cos(-2\pi)$

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

$T + n(S) = 4 + 5 = 9$

**20.** The number of choices of $\Delta \in \{\wedge, \vee, \Rightarrow, \Leftrightarrow\}$, such that $(p \Delta q) \Rightarrow ((p \Delta \sim q) \vee ((\sim p) \Delta q))$ is a tautology, is:

(A) 1 $\quad$ (B) 2 $\quad$ (C) 3 $\quad$ (D) 0

**Ans.** **B**

## Numeric Value Type

This Section contains **10 Numeric Value Type question**, out of 10 only 5 have to be done.

**21.** The number of one-one functions $f$ : {a, b, c, d} $\rightarrow$ {0, 1, 2, …., 10} such that $2f(a) - f(b) + 3f(c) + f(d) = 0$ is _____.

**Ans.** **31**

**22.** In an examination, there are 5 multiple choice questions with 3 choices, out of which exactly one is correct. There are 3 marks for each correct answer, –2 marks for each wrong answer and 0 mark if the questions is not attempted. Then, the number of ways a student appearing in the examination gets 5 marks is _____.

**Ans.** **40**

**23.** Let $A\left(\frac{3}{\sqrt{a}}, \sqrt{a}\right), a > 0$, be a fixed point in the xy-plane. The image of A in y-axis be B and the image of B in x-axis be C. If D(3 cos$\theta$, a sin$\theta$) is a point in the fourth quadrant such that the maximum area of $\Delta$ACD is 12 square, then a is equal to _____.

**Ans.** **8**

**24.** Let a line having direction ratios 1, –4, 2 intersect the lines $\frac{x-7}{3} = \frac{y-1}{-1} = \frac{z+2}{1}$ and $\frac{x}{2} = \frac{y-7}{3} = \frac{z}{1}$ at the points A and B. Then $(AB)^2$ is equal to

**Ans.** **84**

**25.** The number of points where the function

$$f(x) = \begin{cases} |2x^2 - 3x - 7| & \text{if} \quad x \le -1 \\ |4x^2 - 1| & \text{if} \quad -1 < x < 1 \\ |x+1| + |x+2| & \text{if} \quad x \ge 1, \end{cases}$$

[t] denotes the greatest integer $\le$ t, is discontinuous _____.

**Ans.** **7**

**26.** Let $f(\theta) = \sin\theta + \int_{-\pi/2}^{\pi/2} (\sin\theta + t\cos\theta) f(t)\,dt$. Then the value of $\left|\int_0^{\pi/2} f(\theta)\,d\theta\right|$ is _____.

**Ans.** **1**

**27.** Let $\underset{0\le x\le 2}{\text{Max}}\left\{\frac{9-x^2}{5-x}\right\} = \alpha$ and $\underset{0\le x\le 2}{\text{Max}}\left\{\frac{9-x^2}{5-x}\right\} = \beta$.

If $\int_{\beta-\frac{8}{3}}^{2\alpha-1} \text{Max}\left\{\frac{9-x^2}{5-x}\right\} dx = \alpha_1 + \alpha_2 \log_e\left(\frac{8}{15}\right)$ then $\alpha_1 + \alpha_2$ is equal to _____.

**Ans.** **34**

**28.** If two tangents drawn from a point $(\alpha, \beta)$ lying on the ellipse $25x^2 + 4y^2 = 1$ to the parabola $y^2 = 4x$ are such that the slope of one tangent is four times the other, then the value of $(10\alpha + 5)^2 + (16\beta^2 + 50)^2$ equals _____.

**Ans.** **2929**

**29.** Let S be the region bounded by the curves $y = x^3$ and $y^2 = x$. The curve $y = 2|x|$ divides S into two regions of areas $R_1$ and $R_2$.

If max $\{R_1, R_2\} = R_2$, then $\frac{R_2}{R_1}$ is equal to _____.

**Ans.** **19**

**30.** If the shortest distance between the lines $\vec{r} = \left(-\hat{i} + 3\hat{k}\right) + \lambda\left(\hat{i} - a\hat{j}\right)$ and

$\vec{r} = \left(-\hat{j} + 2\hat{k}\right) + \mu\left(\hat{i} - \hat{j} + \hat{k}\right)$ is $\sqrt{\frac{2}{3}}$, then the integral value of a is equal to _____.

**Ans.** **2**