FIITJEE (JEE-Advanced)

BATCHES – NWCM721O1S, NWCM921X1W, NWCM921A1W & PANINI921-XIIG1

PHYSICS, CHEMISTRY & MATHEMATICS

Pattern - CPT-1 | **QP Code:** | **TEST - 22**

Time Allotted: 3 Hours **Maximum Marks: 198**

- Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.
- You are not allowed to leave the Examination Hall before the end of the test.

INSTRUCTIONS

Caution: Question Paper CODE as given above MUST be correctly marked in the answer OMR sheet before attempting the paper. Wrong CODE or no CODE will give wrong results.

A. General Instructions

1. Attempt ALL the questions. Answers have to be marked on the OMR sheets.
2. This question paper contains **Three Sections**.
3. **Section-I** is Physics, **Section-II** is Chemistry and **Section-III** is Mathematics.
4. Each **Section** is further divided into **Two Parts**: **Part-A & B** in the OMR.
5. Rough spaces are provided for rough work inside the question paper. No additional sheets will be provided for rough work.
6. Blank Papers, clip boards, log tables, slide rule, calculator, cellular phones, pagers and electronic devices, in any form, are not allowed.

B. Filling of OMR Sheet

1. Ensure matching of OMR sheet with the Question paper before you start marking your answers on OMR sheet.
2. On the OMR sheet, darken the appropriate bubble with HB pencil for each character of your Enrolment No. and write in ink your Name, Test Centre and other details at the designated places.
3. OMR sheet contains alphabets, numerals & special characters for marking answers.

C. Marking Scheme For All Two Parts.

(i) **Part-A (01-06) –** Contains six (06) multiple choice questions which have ONLY ONE CORRECT answer Each question carries **+3 marks** for correct answer and **-1 marks** for wrong answer.

(ii) **Part-A (07-12) –** Contains seven (06) multiple choice questions which have **One or More** correct answer.
Full Marks: **+4** If only the bubble(s) corresponding to all the correct options(s) is (are) darkened.
Partial Marks: **+1** For darkening a bubble corresponding **to each correct option,** provided NO incorrect option is darkened.
Zero Marks: **0** If none of the bubbles is darkened.
***Negative Marks*: –2 In all other cases.**
For example, if **(A), (C) and (D)** are all the correct options for a question, darkening all these three will result in **+4 marks**; darkening only **(A) and (D)** will result in **+2 marks**; and darkening **(A) and (B)** will result in **–2** marks, as a wrong option is also darkened.

(ii) **Part-B (01-06)** contains Six (06) Numerical based questions, the answer of which maybe positive or negative numbers or decimals (e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30) and each question carries **+4 marks** for correct answer and **there will be no negative marking.**

Name of the Candidate :_____

Batch :_____ **Date of Examination :**_____

Enrolment Number :_____

SECTION-1 : PHYSICS

PART – A

(Single Correct Choice Type)

This section contains **6 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct.**

1. An electron and a proton are separated by a large distance. The electron starts approaching the proton with energy 2eV. The proton captures the electron and forms a hydrogen atom in first excited state. The resulting photon is incident on a photosensitive metal of threshold wavelength 4600Å. The maximum K.E. of the emitted photoelectron is (Take hc = 12420 eV Å)

(A) 2.4 eV (B) 2.7 eV
(C) 2.9 eV (D) 5.4 eV

1. **B**

2. In an X-ray set up accelerating potential difference is set at V volt and first a target metal having atomic no. Z_1 is used then target metal having Z_2 is used (λ_{α_1} is wavelength of K_α X–ray from Z_1 target and λ_{α_2} is wavelength of K_α, x-ray with Z_2 target)

(A) If $Z_1 > Z_2$ then $\left(\lambda_{\alpha_1} - \lambda_{min}\right) > \left(\lambda_{\alpha_2} - \lambda_{min}\right)$

(B) If $Z_1 < Z_2$ then $\left(\lambda_{\alpha_1} - \lambda_{min}\right) > \left(\lambda_{\alpha_2} - \lambda_{min}\right)$

(C) The difference $\left(\lambda_{\alpha_1} - \lambda_{min}\right)$ and $\left(\lambda_{\alpha_{12}} - \lambda_{min}\right)$ will be same for both the target metals.

(D) If $Z_1 \le Z_2$ then $\left(\lambda_{\alpha_1} - \lambda_{min}\right) \le \left(\lambda_{\alpha_2} - \lambda_{min}\right)$

2. **B**

3. The minimum kinetic energy of proton incident on $^{13}_{6}C$ nuclei at rest that will produce the ^{13}N is (Mass of nitrogen = 13.005738 amu, Mass of neutron = 1.008665 amu, Mass of carbon = 13.005738 amu Mass of proton = 1.007825 amu)

(A) 0.78204 MeV (B) 0.39102 MeV
(C) 0.42132 MeV (D) 0.84264 MeV

3. **D**

4. An electron collides with a fixed hydrogen atom in its ground state. Hydrogen atom gets excited and the colliding electron loses all its kinetic energy. Consequently the hydrogen atom may emit a photon corresponding to the largest wavelength of the Balmer series. The minimum kinetic energy of colliding electron is

(A) 10.2 eV (B) 1.9 eV
(C) 12.1 eV (D) 13.6 eV

4. **C**

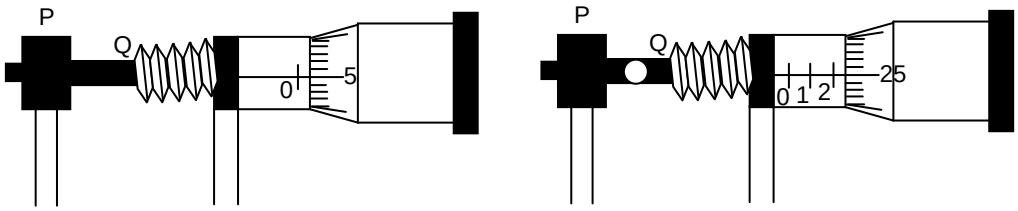
5. Electrons with de-Broglie wavelength λ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-rays is

(A) $\lambda_o = \dfrac{2mc\lambda^2}{h}$ (B) $\lambda_o = \dfrac{2h}{mc}$

(C) $\lambda_o = \dfrac{2m^2c^2\lambda^3}{h^2}$ (D) $\lambda_o = \lambda$

5. **A**

6. Screw gauge shown in the figure has 50 divisions on its circular scale and in one complete rotation of circular scale the main scale moves by 0.5 mm. The diameter of a sphere is measured using this screw gauge. Two positions of screw gauge are shown in the figure. The diameter of sphere is



(A) 1.25 mm (B) 1.20 mm
(C) 2.25 mm (D) 2.20 mm

6. **B**

(Multi Correct Choice Type)

This section contains 6 **multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONE OR MORE** may be correct.

7 A physical quantity *P* is given by $P = \frac{a^3 b^2}{d\sqrt{c}}$. The percentage errors in the measurements of *a,b,c,* and *d* are 1%,3%,4% and 3% respectively.
(A) The maximum percentage error in *P* is 14%
(B) The maximum percentage error in *P* is 10%
(C) The maximum error is contributed by the measurement of *b.*
(D) The maximum error is contributed by the measurement of *c.*

7. **AC**

8. The wavelength of K_α X-rays for lead isotopes Pb^{208}, Pb^{206}, Pb^{204} are λ_1, λ_2 and λ_3 respectively. Then
(A) $\lambda_1 = \lambda_2 = \lambda_3$ (B) $\lambda_1 > \lambda_2 > \lambda_3$
(C) $\lambda_1 < \lambda_2 < \lambda_3$ (D) $\lambda_2 = \sqrt{\lambda_1 \lambda_3}$

8. **AD**

9. If the dimensions of length are expressed as $G^x c^y h^z$; where G, c and h are the universal gravitational constant, speed of light and Planck's constant respectively, then
(A) $x = \frac{1}{2}, y = \frac{1}{2}$ (B) $x = \frac{1}{2}, z = \frac{1}{2}$
(C) $y = \frac{1}{2}, z = \frac{3}{2}$ (D) $y = -\frac{3}{2}, z = \frac{1}{2}$

9. **BD**

10. The pitch of a screw gauge is 1 mm and there are 100 divisions on circular scale. When there is nothing between the two ends (studs) of screw gauge 95^{th} divisions of circular scale is coinciding with screw gauge and in this situation zero of main scale is not visible. When a wire is placed between the studs the linear scale reads 2 division and 20^{th} divisions of circular scale coincides with reference line. For this situation mark the correct statement(s). Each division on the main scale to 1 mm.
(A) LC of the instrument is 0.01 mm.
(B) Zero correction for the instrument is +0.05 mm.
(C) Thickness of wire is 1.20 mm
(D) Thickness of the wire is 2.25 mm.

10. **ABD**

11. In hydrogen atom, if potential energy of electron in ground state is assumed to be zero, then
(A) Total energy of first excited state = 23.8 eV
(B) Potential energy of first excited state = 20.4 eV
(C) Kinetic energy of first excited state = 6.8 eV
(D) Kinetic energy of first excited state = 3.4 eV

11. **ABD**

12. Nucleus A decays to B with decay constant λ_1 and B decays to C with decay constant λ_2. Initially at t = 0, number of nuclei of A and B are $2N_0$ and N_0 respectively. At $t = t_0$, number of nuclei of B stop changing. If at this instant number of nuclei of B are $\frac{3N_0}{2}$.

(A) the value of t_0 is $\frac{1}{\lambda_1}\ln\frac{4}{3}\frac{\lambda_1}{\lambda_2}$ (B) the value of t_0 is $\frac{1}{\lambda_2}\ln\frac{4}{3}\frac{\lambda_1}{\lambda_2}$

(C) the value of N_A at t_0 is $\frac{3N_0}{2}\frac{\lambda_2}{\lambda_1}$ (D) the value of N_A at t_0 is $\frac{2N_0}{3}\frac{\lambda_2}{\lambda_1}$

12. **AC**

PART – B
(Numerical based)

1. Suppose potential energy between electron and proton at separation r is given by U = k ln r, where k is constant. For such hypothetical hydrogen atom, find the ratio of energy difference between energy levels (n = 1 and n = 2) and (n = 2 and n = 4).

1. **1**

2. An electron in hypothetical hydrogen atom is in its 3rd excited state and makes transition from 3rd to 2nd excited, then to 1st excited state and then to ground state. If the amount of time spent by the electron in any state of quantum number n, is proportional to $\left(\frac{1}{n-1}\right)$, then the ratio of no. of revolutions completed by the electron in 1st excited state to that in the 2nd excited state is 'x'. Find the value of 'x'. (Take hc = 12400 eV Å)

2. **6.75**

3. A metallic sphere (work function 4.2 eV) is suspended in a vacuum chamber by an insulating thread. Ultraviolet light of wavelength 0.2 μm strike on the sphere. Find the maximum electric potential (in volt) of the sphere will be

3. **2**

4. A nucleus of ^{60}Ni in an excited state decays to its ground state by emitting a 1.33MeV photon. If the recoil energy of the ^{60}Ni nucleus is a x 10^{-5} MeV, then a =

4. **1.57**

5. The mean lives of a radioactive substance are 1620 years and 405 years for α-emission and
β-emission respectively. If the time during which three fourth of the substance will decay if it is decaying by both α-emission & β-emission simultaneously is = 90n years, then n =

5. **5**

6. An imaginary particle has a charge equal to that of an electron and mass 100 times the mass of the electron. It moves in a circular orbit around a nucleus of charge (+4e). Take the mass of nucleus to be infinite. Assuming that the Bohr's model is applicable to this system. Find the wavelength of the radiation emitted, when the particle jumps from fourth orbit to the second orbit. (In Å)

6. **3**

SECTION-2 : CHEMISTRY

PART – A

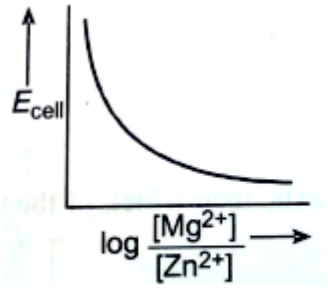
(Single Correct Choice Type)

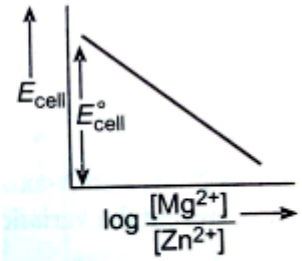
This section contains **6 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct.**

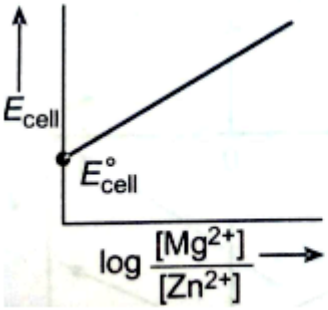
1. Which is the hardest base in the world?
(A) H^- (B) F^-
(C) OH^- (D) NH_2^-

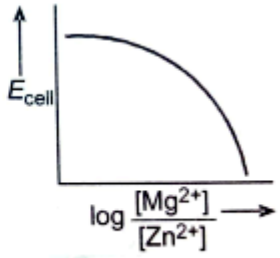
1. B

2. **In the electrochemical cell**
$Mg(s)|Mg^{2+}(aq)||Zn^{2+}(aq)|Zn(s); E^\circ = +3.13V$
The correct plot of E_{cell} versus $\log\frac{[Mg^{2+}]}{[Zn^{2+}]}$ will be represented as:

(A)


(B)


(C)


(D)


2. B

3. Viscosity of sulphur _____ with increase of temperature.
(A) increases (B) decreases
(C) first increases than decreases (D) first decreases than increases

3. C

4. At 300 K, ΔH for the reaction
$Zn(s) + AgCl(s) \longrightarrow ZnCl_2(aq) + 2Ag(s)$ is
-218 kJ/mol while the emf of the cell was 1.015 V, $\left(\frac{dE}{dT}\right)_p$ of the cell is
(A) -4.2×10^{-4} VK^{-1} (B) -3.81×10^{-4} VK^{-1}
(C) 0.11 VK^{-1} (D) 7.62×10^{-4} VK^{-1}

4. B

5. Euchlorine is
(A) $ClO_2 + Cl_2$ (B) $Cl_2 + F_2$
(C) $Cl_2 + OCl_2$ (D) $Cl_2 + ICl$

5. A

6. Which of the following is a thermochromic compound?
(A) S_4N_4 (B) $Na_2S_2O_3$
(C) S_2F_2 (D) Na_2SO_4

6. A

(Multi Correct Choice Type)

This section contains 6 **multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONE OR MORE** may be correct.

7. Match the columns:

	Compound		Properties (O.N of sulphur)
(a)	$H_2S_2O_3$	(p)	0
(b)	$H_2S_2O_5$	(q)	+3
(c)	$H_2S_2O_8$	(r)	+4
(d)	$H_2S_2O_4$	(s)	+5
		(t)	+6

(A) a $\rightarrow$ p, r (B) b $\rightarrow$ q, s
(C) c $\rightarrow$ t (D) d $\rightarrow$ q

7. ABCD

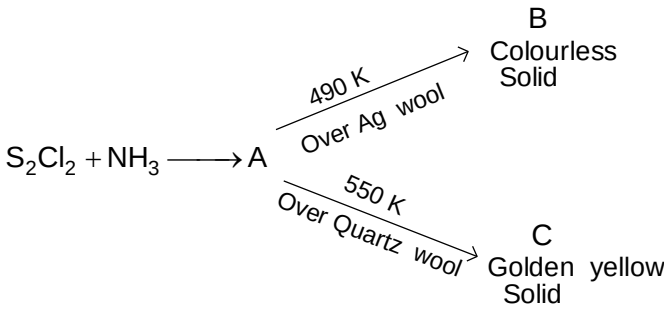
8. BrF_5 on hydrolysis produces
(A) HBr (B) HF
(C) $HBrO_3$ (D) HFO_3

8. AC

9. Spin isomerism is found in
(A) H_2 (B) D_2
(C) N_2 (D) F_2

9. ABCD

10.



Identify the incorrect statements
(A) B is S_4N_4 and C is S_2N_2 (B) B is S_2N_2 and C is S_4N_4
(C) B is polythiazyl$(SN)_x$ and C is S_2N_2 (D) B is S_2N_2 and C is polythiazyl(SN)

10 ABC

11 Which of the following do not form noble gas hydrate?
(A) He (B) Ne
(C) Ar (D) Xe

11 AB

12. Which is/are correct statement/s?
(A) H^+ is the cation and OH^- is the anion having highest molar conductance at infinite dilution
(B) Specific conductance increases with dilution
(C) Molar conductance increase with dilution
(D) Specific conductance is an intensive property

12. ACD

PART – B
(Numerical based)

1. Perxenate ion is a very powerful oxidizing agent, it is XeO_x^{y-}. Here y/x is

1. 1.50

2. $Na_2O_2 \xrightarrow[0^oC]{H_2O} P + Q$
$Na_2O_2 \xrightarrow[25^oC]{H_2O} P + R\uparrow + S$
Calculate the sum of bond order between same bonded atom in Q and R compounds

2. 3

3. The equilibrium constant of the disproportionation reaction is $y \times 10^6$. Calculate the value y from the following given data
$2Cu^+ \longrightarrow Cu^{2+} + Cu$
The standard electrode potentials are:
$E^o_{Cu^+,Cu} = 0.52\,V$ and $E^o_{Cu^{2+},Cu} = 0.34\,V$

3. 1.72

4. How many electrons are present in gerade molecular orbital of O_2^+.

4. 7

5. The solubility product of $Co_2[Fe(CN)_6]$ in water at 25°C is $x \times 10^{-17}$mol per liter. Calculate the value x from the following data. Conductivity of a saturated solution of $Co_2[Fe(CN)_6]$ is $2.06 \times 10^{-6}\ \Omega^{-1}\ cm^{-1}$ and that of water used is $4.1 \times 10^{-7}\ \Omega^{-1}\ cm^{-1}$. The ionic molar conductivity of Co^{2+} and $Fe(CN)_6^{4-}$ are 86.0 $\Omega^{-1}\ cm^2\ mol^{-1}$ and 444.0 $\Omega^{-1}\ cm^2\ mol^{-1}$, respectively

5. 7.68

6. The approximate formula for noble gas hydrate, which is a clathrate compound is
1 gas atom : x H_2O
x is

6. 6

SECTION-3 : MATHEMATICS

PART – A

(Single Correct Choice Type)

This section contains **6 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct.**

1. For a real number α, if the system

$$x + \alpha y + \alpha^2 z = 1$$
$$\alpha x + y + \alpha z = -1$$
$$\alpha^2 x + \alpha y + z = 1$$

of linear equations, has infinitely many solutions, then $1 + \alpha + \alpha^2 =$

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

1. C

2. If A and B are two square matrices of order 3 such that $AB = O$ and $A^2 + B = I$, then $\left|A^2 + B^2\right|$ is equal to:

(A) 0 (B) 1
(C) 9 (D) 3

2. B

3. If A and B are two orthogonal matrices of order n and $\det(A) + \det(B) = 0$; then which of the following is correct.

(A) $\det(A + B) = \det(A) + \det(B)$ (B) $\det(A + B) = 1$
(C) A and B are both singular matrices (D) $A + B = 0$

3. **A**

4. If A and B be two square matrices of order n with real entries and
$ABA - BAB = I$
$A^2B + B^2A = O$

(A) A and B are both singular matrices (B) Either A is singular or B is singular
(C) A and B are both non-singular matrices (D) A+B is singular

4. **C**

5. Let $ab = 1$, $\Delta = \begin{vmatrix} 1 + a^2 - b^2 & 2ab & -2b \\ 2ab & 1 - a^2 + b^2 & 2a \\ 2b & -2a & 1 - a^2 - b^2 \end{vmatrix}$ then the minimum value of Δ is:

(A) 3 (B) 9
(C) 27 (D) 81

5. C

6. Let $\det A = \begin{vmatrix} l & m & n \\ p & q & r \\ 1 & 1 & 1 \end{vmatrix}$ and if

$(l-m)^2+(p-q)^2=9, (m-n)^2+(q-r)^2=16, (n-l)^2+(r-p)^2=25,$ then the value of $(\det.A)^2$ equals:

(A) 36 (B) 100
(C) 144 (D) 169

6. C

(Multi Correct Choice Type)

This section contains 6 **multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONE OR MORE** may be correct.

7. Let $a, \lambda, \mu \in \mathbb{R}$. Consider the system of equations

$$ax + 2y = \lambda$$
$$3x - 2y = \mu$$

Which of the following statement(s) is(are) correct?

(A) If $a = -3$, then the system has infinitely many solutions for all values of λ and μ

(B) If $a \neq -3$, then the system has a unique solution for all values of λ and μ

(C) If $\lambda + \mu = 0$, then the system has infinitely many solutions for $a = -3$

(D) If $\lambda + \mu \neq 0$, then the system has no solution for $a = -3$

7. BCD

8. Let A and B be two square matrices satisfying $A + BA^T = I$ and $B + AB^T = I$, then identify the correct statements:

(A) $A = B^T$ (B) $B = A^T$
(C) $A^4 - 2A^2 + A = 0$ (D) $A^4 - 2A^2 - A = 0$

8. **ABC**

9. Let M be 3×3 matrix satisfying $M^3 = O$. Then which of the following statements are true

(A) $\left|\frac{1}{2}M^2 + M + I\right| \neq 0$ (B) $\left|\frac{1}{2}M^2 - M + I\right| = 0$

(C) $\left|\frac{1}{2}M^2 + M + I\right| = 0$ (D) $\left|\frac{1}{2}M^2 - M + I\right| \neq 0$

9. **AD**

10. If A and B are two non-singular matrices of order 3 such that

$2A + 3BB^T = I$ and $B^{-1} = A^T$, then

(A) $\left|B^T - 2B + 3B^3 + 3BA\right| = 1$ (B) $Tr\left(A^{-1} + I - AB - 3B^3\right) = 6$

(C) $\left|A^{-1} - 3B^3\right| = 27$ (D) $\left|A^{-1} - 3B^3\right| = 8$

10. **ABD**

11. If $\begin{vmatrix} 1+\cos^2\theta & \sin^2\theta & 2\sqrt{3}\tan\theta \\ \cos^2\theta & 1+\sin^2\theta & 2\sqrt{3}\tan\theta \\ \cos^2\theta & \sin^2\theta & 1+2\sqrt{3}\tan\theta \end{vmatrix} = 0$ then θ may be:

(A) $\frac{\pi}{6}$ (B) $\frac{5\pi}{6}$

(C) $\frac{7\pi}{6}$ (D) $\frac{11\pi}{6}$

11. BD

12. Let $D(x) = \begin{vmatrix} x^2+4x-3 & 2x+4 & 13 \\ 2x^2+5x-9 & 4x+5 & 26 \\ 8x^2-6x+1 & 16x-6 & 104 \end{vmatrix} = \alpha x^3 + \beta x^2 + \gamma x + \delta$ then:

(A) $\alpha + \beta = 0$ (B) $\beta + \gamma = 0$

(C) $\alpha + \beta + \gamma + \delta = 0$ (D) $\alpha + \beta + \gamma = 0$

12. ABD

PART – B
(Numerical based)

1. Let $f(x) = \begin{vmatrix} \sin x & \sin(x+h) & \sin(x+2h) \\ \sin(x+2h) & \sin x & \sin(x+h) \\ \sin(x+h) & \sin(x+2h) & \sin x \end{vmatrix}$. If $\lim_{h\to 0} \frac{f(x)}{h^2}$ has the value equal to $k\left(\sin 3x + \sin^3 x\right)$ find $k \in N$.

1. 3

2. Let $A = \left[a_{ij}\right]_{3\times 3}$ be a matrix such that $AA^T = 4I$ and $a_{ij} + 2c_{ij} = 0$ where c_{ij} is the cofactor of a_{ij} and I is the unit matrix of order 3.

If $\begin{vmatrix} a_{11}+4 & a_{12} & a_{13} \\ a_{21} & a_{22}+4 & a_{23} \\ a_{31} & a_{32} & a_{33}+4 \end{vmatrix} + 5\lambda \begin{vmatrix} a_{11}+1 & a_{12} & a_{13} \\ a_{21} & a_{22}+1 & a_{23} \\ a_{31} & a_{32} & a_{33}+1 \end{vmatrix} = 0$ then the value of 10λ is

2. 4

3. If a, b and c are the roots of the cubic $x^3 - 3x^2 + 2 = 0$ then find the value of the determinant $\begin{vmatrix} (b+c)^2 & a^2 & a^2 \\ b^2 & (c+a)^2 & b^2 \\ c^2 & c^2 & (a+b)^2 \end{vmatrix}$

3. –108

4. Let A be a 2×3 and B be a 3×2 matrix. Suppose $BA = \begin{bmatrix} 8 & 2 & -2 \\ 2 & 5 & 4 \\ -2 & 4 & 5 \end{bmatrix}$, then find $\det(AB)$.

4. 81

5. The system of equations
$\alpha x + y + z = \alpha - 1$
$x + \alpha y + z = \alpha - 1$
$x + y + \alpha z = \alpha - 1$
has no solution. Find α.

5. –2

6. For any integer $n \geq 5$, let there be two $n\times n$ invertible matrices with real entries A and B that satisfy the equation
$A^{-1} + B^{-1} = (A+B)^{-1}$.
If $|A| = 3$ then find the value of $|B|$.

6. 3

ANSWERS

SECTION-1 : PHYSICS

PART – A

PART – B

SECTION – 2 : CHEMISTRY

PART – A

PART – B

SECTION – 3 : MATHEMATICS

PART – A

PART – B