Subject Part – 1: Physics
SECTION 1 (32 Marks)

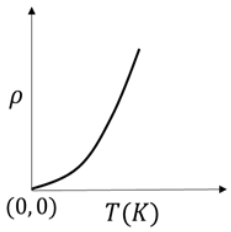
- This section contains **EIGHT (8)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, darken the bubble on the OMR sheet corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

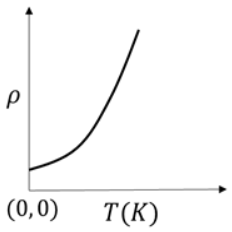
Full Marks : $+4$ If **ONLY** the correct option is chosen;
Zero Marks : 0 If none of the options is chosen (i.e., the question is unanswered).
Negative Marks : -1 In all other cases

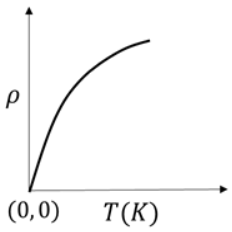
Q.1 Which of the following is **NOT** an electromagnetic wave?

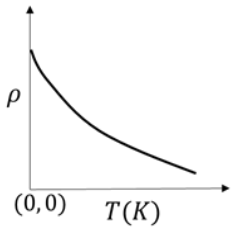
(A) Radio wave (B) Visible light (C) Sound wave (D) X-ray

Q.2 Which of the following plots represents the correct qualitative variation of the resistivity, ρ of a metal with absolute temperature T(K)?

(A)


(B)


(C)


(D)


Q.3 Which one of the following statements is correct for the photoelectric effect?

(A) Photoelectric current increases linearly with frequency of the incident light.
(B) Photoelectric current increases linearly with intensity of the incident light.
(C) Stopping potential does not depend on the frequency of the incident light.
(D) Stopping potential increases linearly with the intensity of the incident light.

Q.4 The magnitude of angular momentum for an electron in the n-th energy level of a Hydrogen atom is 6.31×10^{-34} J sec. Considering Bohr's model, the value of n is (rounded off to the nearest integer) [Take value of the Planck constant as 6.6×10^{-34} J sec and π as 3.14]

(A) 8 (B) 7 (C) 9 (D) 6

Q.5 The moment of inertia of a uniform circular plate of radius R about an axis perpendicular to the plane of the plate passing at a distance $\frac{R}{2}$ away from the center of the plate, is given as $48\ \text{kg m}^2$. If the mass of the circular plate is 1 kg, the value of R, in m, is

(A) 8 (B) 4 (C) 6 (D) 2

Q.6 The unit of the coefficient of volume expansion (thermal) of a substance is

(A) m^{-3} (B) $m^3 K^{-1}$ (C) K^{-1} (D) K

Q.7 Which of the following statement is true for ideal gas?

(A) Free expansion of a gas is an isobaric process
(B) In an isothermal expansion, work is done by the gas
(C) In an adiabatic process, work is always done by the gas
(D) In an isochoric process, no work is done on the gas or by the gas

Q.8 A solid sphere of radius 0.3 m and mass 4π kg is floating in a liquid of density $1000\ kg\ m^{-3}$. The volume of the sphere outside the liquid is _____ $\pi \times 10^{-3}\ m^3$.

(A) 24 (B) 16 (C) 32 (D) 18

Subject Part – 1: Physics
SECTION 2 (24 Marks)

- This section contains **SIX (6)** questions.
- The answer to each question is a **SINGLE DIGIT NON-NEGATIVE INTEGER** ranging from 0 to 9, both inclusive.
- For each question, darken the correct digit on your **OMR sheet**. **Do not** write the answer on the question paper.
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  Zero Marks : 0 In all other cases.

Q.9 A 500 W light bulb is connected to an AC voltage source of r.m.s. value 250 V. The r.m.s. value of the current flowing through the bulb, in amperes, is ____.

Q.10 A solid spherical ball of diameter D falls under the gravity through a viscous liquid with a terminal velocity U. Another ball of the same material having a diameter 2D falls under the gravity through the same liquid with a terminal velocity nU. The value of n is _____.

Q.11 A projectile is thrown in such a way that it covers the maximum horizontal range. If the range is 5 m, the time of flight of the projectile, in sec, is _____.
[Neglect air resistance. Take acceleration due to gravity g as 10 m sec^{-2}]

Q.12 An object is placed in front of a thin converging lens of focal length fat a distance of qf from the lens. If the size of the real image formed is the same as the size of the object, the value of q is _____.

Q.13 The wavelength of the n-th line in the Paschen series for the hydrogen atom is λ_p. The wavelength of the first line in the Lyman series for the hydrogen atom is λ_l. If $\lambda_p = 9\,\lambda_l$, the value of n is _____.

Q.14 An unstable nucleus $^{223}_{88}\text{Ra}$ decays in two ways

$^{223}_{88}\text{Ra} \rightarrow {}^{209}_{82}\text{Pb} + {}^{14}_{6}\text{C}$ and

$^{223}_{88}\text{Ra} \rightarrow {}^{219}_{86}\text{Rn} + {}^{4}_{2}\text{He}$.

The nucleus $^{219}_{86}\text{Rn}$ has "n" more neutrons than $^{209}_{82}\text{Pb}$. The value of n is _____.

Subject Part – 1: Physics
SECTION 3 (24 Marks)

- This section contains **THREE (3)** paragraphs.
- Based on each paragraph, there are **TWO (2)** questions.
- The questions are of multiple-choice type, based on the given paragraph.
- If the answer is numerical, the final answer is obtainable by truncation/round-off of the value to TWO decimal places.
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- For each question, darken the bubble on the OMR sheet corresponding to the correct answer.
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Negative Marks : -1 In all other cases

PARAGRAPH I

The period of a simple pendulum is given by $T = 2\pi\sqrt{\frac{L}{g}}$ where L is the length of the pendulum string and g is the acceleration due to gravity
[Take the value of g as $10\ \text{m sec}^{-2}$ and π^2 as 10]

Q.15 For a time period of 1 sec, the value of L, in meters, is.

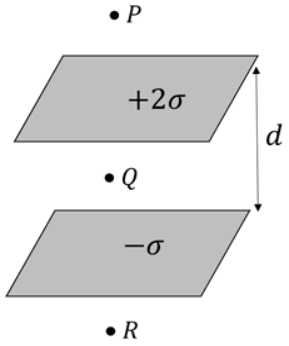
(A) 1 (B) $\frac{1}{2}$ (C) $\frac{1}{4}$ (D) $\frac{1}{8}$

Q.16 If $L = 1$ m, the number of oscillations (periods) executed by the pendulum in 1 minute is

(A) 60 (B) 30 (C) 15 (D) 12

PARAGRAPH II

Two infinite parallel plane sheets, having surface charge densities $+2\sigma$ and $-\sigma$, respectively, are separated by a distance d, as shown below.
[Take permittivity of the free space as ϵ_0]



Q.17 The magnitude of the total electric field at point P is

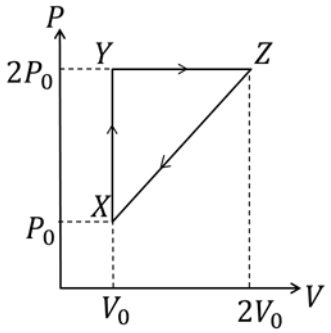
(A) $\frac{\sigma}{\epsilon_0}$ (B) $\frac{\sigma}{2\epsilon_0}$ (C) $\frac{2\sigma}{\epsilon_0}$ (D) $\frac{3\sigma}{2\epsilon_0}$

Q.18 The magnitudes of the total electric field at points Q and R are related as

(A) $E_Q = E_R$ (B) $E_Q = 2E_R$ (C) $E_Q = 3E_R$ (D) $E_Q = \frac{E_R}{2}$

PARAGRAPH III

A monoatomic ideal gas undergoes a cyclic process X → Y → Z → X, depicted on the pressure P versus volume V diagram, as shown below.



Q.19 The amount of work done by the gas is

(A) $\frac{P_0V_0}{2}$ (B) P_0V_0 (C) $2P_0V_0$ (D) $-P_0V_0$

Q.20 The amount of heat absorbed by the gas is

(A) less than the work done by the gas (B) more than the work done by the gas
(C) equal to the work done by the gas (D) zero

END OF SUBJECT PART - PHYSICS

Subject Part – 2: Chemistry
SECTION 1 (32 Marks)

- This section contains **EIGHT (8)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, darken the bubble on the OMR sheet corresponding to the correct answer.
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Negative Marks : −1 In all other cases

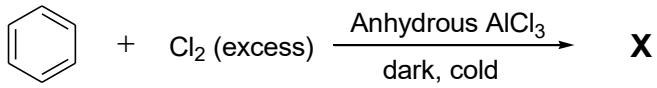
Q.21 Among the following, the metal that reacts most violently with water, is

(A) Ca (B) Na (C) Al (D) Zn

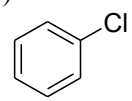
Q.22 Among the following, the molecule with the highest dipole moment is

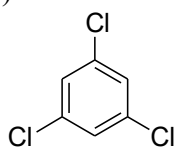
(A) CO_2 (B) BeF_2 (C) BF_3 (D) NH_3

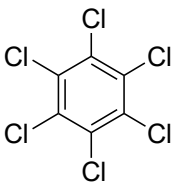
Q.23 Consider the following reaction:

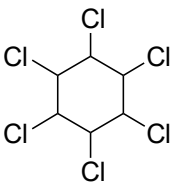


The major organic product **X** formed in the given reaction is

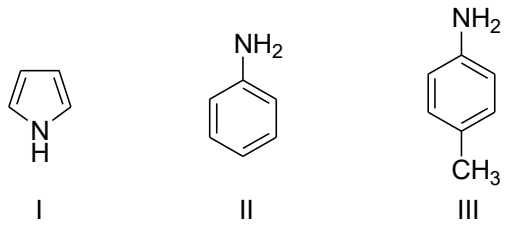
(A) 

(B) 

(C) 

(D) 

Q.24 The increasing order of basicity for the following compounds is



I II III

(A) I < II < III (B) I < III < II (C) II < III < I (D) II < I < III

Q.25 What should you do if you accidentally inhale fumes in a laboratory?

(A) Immediately inhale fresh air and seek medical assistance, if needed.
(B) Wash your face with soap water
(C) Report to your supervisor and continue working.
(D) Ignore it and continue working.

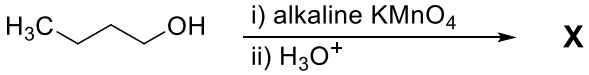
Q.26 The CORRECT statement amongst the following is:

(A) The energy of an isolated system is constant
(B) The energy of an open system is constant
(C) The energy of a closed system is constant
(D) Matter can be exchanged in closed systems

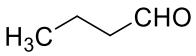
Q.27 The CORRECT statement regarding the manner in which a catalyst impacts the rate of a chemical reaction at a constant temperature is

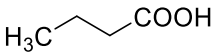
(A) rate increases due to increase in the activation energy.
(B) rate remains constant due to increase in the activation energy.
(C) rate remains constant due to decrease in the activation energy.
(D) rate increases due to decrease in the activation energy.

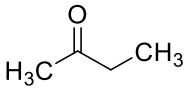
Q.28 Consider the reaction given below:

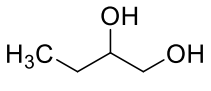


The major product '**X**' formed in the given reaction is

(A)


(B)


(C)


(D)


Subject Part – 2: Chemistry
SECTION 2 (24 Marks)

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Q.29 The maximum number of structural isomers possible for a cyclic hydrocarbon having the molecular formula C_4H_6 is _____.

Q.30 When 15 moles of acetylene are passed through a red hot iron tube at 873 K, it forms a product. The number of moles of the product assuming complete conversion is _____.

Q.31 The total number of unpaired electrons present in the ground state electronic configuration of phosphorous atom (atomic number 15) is _____.

Q.32 The standard EMF for the cell reaction, $X + 2Y^{+}(aq) \rightarrow X^{2+}(aq) + 2Y$, in Volts is _____. $[E^{0}(X^{2+}/X) = 0.5\ V \text{ and } E^{0}(Y^{+}/Y) = 1.5\ V]$

Q.33 'n' moles of an ideal gas expand reversibly and isothermally from 4 m^3 to 20 m^3 at 500 K. If the heat absorbed in the process is 26.766 kJ, the value of $'n'$, rounded off to the nearest integer, is _____.[Use $R = 8.314\ JK^{-1}mol^{-1}$]

Q.34 For a pseudo first order reaction, $A + B \rightarrow P$, the reactant B is taken in excess. The rate of the reaction increases m-fold when the concentration of A is increased four folds. The value of $'m'$ is _____.

Subject Part – 2: Chemistry
SECTION 3 (24 Marks)

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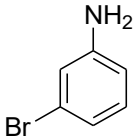
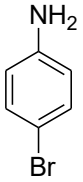
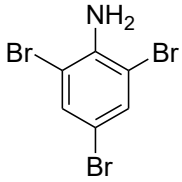
PARAGRAPH IV

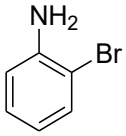
The reaction of aniline with bromine water at room temperature yields compound '**X**', which on reaction with $NaNO_2$ and HCl produces compound '**Y**'. The reaction of **Y** with CuBr forms compound '**Z**'.

Q.35 The structure of **X** is

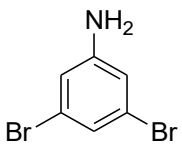
(A) 

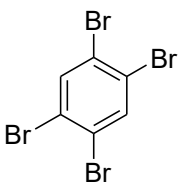
(B) 

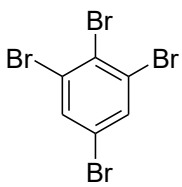
(C) 

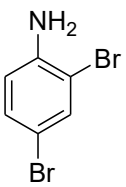
(D) 

Q.36 The structure of **Z** is

(A) 

(B) 

(C) 

(D) 

PARAGRAPH V

When silver is exposed to air, it often gets a black coating.

Q.37 The formula of the compound present in the black coating is

(A) Ag_2CO_3 (B) AgCl (C) AgO (D) Ag_2S

Q.38 The formation of the black coating is an example of

(A) oxidation (B) reduction (C) electrolysis (D) disproportionation

PARAGRAPH VI

When excited H-atoms emit from an excited state, n_2, to the state $n_1 = 1$, the series of lines is called 'Lyman series'.

Q.39 In the electromagnetic spectrum, Lyman series lies in the

(A) X-ray region (B) Ultraviolet region (C) Visible region (D) Infrared region

Q.40 In the Lyman series, emission of light of $\bar{\nu} = 105289.92\ cm^{-1}$ implies the atoms relax from $n_2 =$ [Use Rydberg constant $= 109{,}677\ cm^{-1}$]

(A) 2 (B) 3 (C) 4 (D) 5

END OF SUBJECT PART – CHEMISTRY

Subject Part – 3: Mathematics
SECTION 1 (32 Marks)

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Zero Marks : 0 If none of the options is chosen (i.e., the question is unanswered).
Negative Marks : -1 In all other cases

Q.41 The value of the integral

$$\int_{-3}^{1} |x^3 - x\,|dx$$

is equal to

(A) 16 (B) $\frac{31}{2}$ (C) $\frac{29}{2}$ (D) $)\frac{33}{2}$

Q.42 For the functions

$$f(x) = \frac{x|x|}{4+x^2} \quad and \quad g(x) = x\,e^{-x^2}$$

consider the following statements.

I) f is decreasing in $(-\infty, 0)$ and increasing in $(0, \infty)$
II) g is decreasing in $(-\infty, 0)$ and increasing in $(0, \infty)$

Then which one of the following statements is TRUE?

(A) I) only (B) II) only (C) Both I) and II) (D) Neither I) nor II)

Q.43 Suppose PQR is a right angled triangle where $\angle Q = 90^o$, and S is a point on the side PQ such that SR bisects $\angle R$. If PSR is an isosceles triangle, then $\frac{PR}{PQ-QR}$ is equal to

(A) $\sqrt{3}+1$ (B) $\sqrt{3}-1$ (C) $\sqrt{3}+2$ (D) $\sqrt{3}$

Q.44 The number of values of $x \in [-\frac{\pi}{4}, \frac{\pi}{4}]$ for which the determinant of the matrix

$$\begin{pmatrix} \sin x & \cos x & \cos x \\ \cos x & \sin x & \cos x \\ \cos x & \cos x & \sin x \end{pmatrix}$$

is zero, is equal to

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

Q.45 Suppose $M(\theta) = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}$, where $\theta \in [0,2\pi]$.

Which one of the following statements is TRUE for all $\theta, \phi \in [0,2\pi]$?

(A) $M(\theta)M(\phi) = M(\phi)M(\theta)$
(B) $M(\theta) + M(\phi) = M(\theta)M(\phi)$
(C) $M(\theta)^2 = M(\phi)^2$
(D) $M(\theta)^2 + M(\phi)^2 = 2\,M(\theta)M(\phi)$

Q.46 Two persons P and Q each toss independently three unbiased coins. Let X and Y represent the number of heads obtained by person P and Q, respectively. Then, the probability of the event that $X \neq Y$ is equal to

(A) $\frac{5}{16}$ (B) $\frac{11}{16}$ (C) $\frac{13}{16}$ (D) $\frac{7}{16}$

Q.47 A particular medicine is given to rats in a sequence of independent trials to test the efficiency of the medicine. The probability of the medicine given to a rat to be successful is $\frac{1}{3}$. Then, the probability of the second success on the fourth or later trial, is

(A) $\frac{7}{27}$ (B) $\frac{17}{27}$ (C) $\frac{20}{27}$ (D) $\frac{10}{27}$

Q.48 Suppose a random group of students are surveyed about their use of calculator in a particular mathematics course. The data of the survey are summarized in the following table.

	Use a Calculator	Do not use a Calculator	Total
Boy	25	15	40
Girl	45	15	60
Total	70	30	100

What proportion of students who are boys use a calculator?

(A) 0.45 (B) 0.2 (C) 0.25 (D) 0.15

Subject Part – 3: Mathematics
SECTION 2 (24 Marks)

- This section contains **SIX (6)** questions.
- The answer to each question is a **SINGLE DIGIT NON-NEGATIVE INTEGER** ranging from 0 to 9, both inclusive.
- For each question, darken the correct digit on your **OMR sheet**. **Do not** write the answer on the question paper.
- Answer to each question will be evaluated according to the following marking scheme:
  Full Marks : $+4$ If **ONLY** the correct digit is darkened;
  Zero Marks : 0 In all other cases.

Q.49 Suppose $g(x)$ is the inverse of the function

$$f(x) = 27\frac{x^2+1}{x^2+2x+1}, \qquad x > 1.$$

Then $4g'(15)$ is equal to _____

Q.50 If $0 < \theta < 2\pi$, the number of solutions of

$$2(\sin^4\theta - \cos^4\theta) = 1$$

is equal to _____

Q.51 In a shoe cupboard, there are five different pairs of shoes. Suppose, two shoes are picked at random. Let p be the probability that no pair is selected. Then, the value of $9p$ is equal to _____

Q.52 Consider rectangles with one of their sides on the x-axis and a pair of vertices on the circle $x^2 + y^2 = r^2$. If the maximum area of such a rectangle is 16, then the value of r is equal to _____

Q.53 The sides of a triangle are in arithmetic progression with common difference 1. If the largest angle of this triangle is twice of it smallest angle, then the length of the smallest side is _____

Q.54 The line L intersects $x + 2y = 9$ at an angle 45^o, and α is the angle between L and $3x + y = 7$. If $10^o \leq \alpha \leq 90^o$, then $\frac{\alpha}{10}$ is equal to _____

Subject Part – 3: Mathematics
SECTION 3 (24 Marks)

- This section contains **THREE (3)** paragraphs.
- Based on each paragraph, there are **TWO (2)** questions.
- The questions are of multiple-choice type, based on the given paragraph.
- If the answer is numerical, the final answer is obtainable by truncation/round-off of the value to TWO decimal places.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, darken the bubble on the OMR sheet corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : $+4$ If **ONLY** the correct option is chosen;
Zero Marks : 0 If none of the options is chosen (i.e., the question is unanswered).
Negative Marks : -1 In all other cases

PARAGRAPH VII

For $p > 0$, the function f is defined by

$$f(x) = \int_0^x \frac{p(t+1)}{t^3 + t^2 + p^2 t + p^2}\, dt, \quad x > 0.$$

Q.55 If $f(2) = \frac{\pi}{4}$, then the value of p is equal to

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

Q.56 If $f(5) = \frac{\pi}{3}$, then the value of p is equal to

(A) $\sqrt{3}$ (B) $\frac{\sqrt{3}}{2}$ (C) $\frac{5}{\sqrt{3}}$ (D) $5\sqrt{3}$

PARAGRAPH VIII

Suppose C is the circle given by $x^2 + y^2 - 6x + 1 = 0$ and P is the parabola given by $y^2 = 4x$.

Q.57 The area of the triangle obtained by joining the origin and the points of contacts of C and P is

(A) 8 (B) 4 (C) 6 (D) 2

Q.58 The equation of the tangent at the point of the contact of C and P in the first quadrant is

(A) $x - y + 1 = 0$ (B) $x + y + 1 = 0$
(C) $x - y - 1 = 0$ (D) $x + y - 1 = 0$

PARAGRAPH IX

Suppose the sum of the first n terms of an Arithmetic Progression (A.P.) is $6n - n^2$.

Q.59 The sum of the absolute values of the first 5 terms is equal to

(A) 13 (B) 12 (C) 11 (D) 17

Q.60 If the product of the first n terms is -15, then the value of n is equal to

(A) 7 (B) 6 (C) 5 (D) 4

END OF THE QUESTION PAPER

Rough Work:

Rough Work:

Rough work:

Rough Work

Rough Work

Rough Work