

JEE MAIN 2016

Date: 09/04/2016

Time: 3 Hours.

Max. Marks: 360

Important Instructions :

1. The question paper consists of '90' objective type questions. There are '30' questions each in **Physics, Chemistry and Mathematics** respectively. **Please fill the OMR answer Sheet accordingly and carefully.**
2. Each question has four choices (1), (2), (3) and (4) out of which **ONLY ONE** is correct.
3. You will be **awarded 4 marks** for each question, if you have darkened only the bubble corresponding to the correct answer and zero mark if no bubble are darkened. In all other cases, **minus one (-1) mark** will be awarded.
4. There is only one correct response for each question. Filling up more than one response in each question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instruction 3 above.
5. Use **Black or Blue Ball Point Pen** only for filling particulars.
6. Use of **Calculator, Log Table, Slide Rule and Mobile** is not allowed.
7. Rough work is to be done on the space provided at the bottom and in end of the booklet for this purpose in the Test Booklet only.
8. On completion of the test, the candidate must hand over the Answer Sheet to the Invigilator. However, the candidates are allowed to take away this Test Booklet with them.
9. Do not fold or make any stray marks on the Answer Sheet.

महत्वपूर्ण निर्देश :

1. इस प्रश्न पत्र में 90 विकल्पात्मक प्रकार के प्रश्न हैं **भौतिक, रसायन** तथा **गणित** प्रत्येक में क्रमशः 30 प्रश्न हैं। कृपया **OMR** उत्तर पुस्तिका को सही प्रकार तथा सावधानीपूर्वक भरें।
2. प्रत्येक प्रश्न के चार विकल्प (1), (2), (3) तथा (4) हैं जिनमें से केवल एक सही है।
3. यदि आपने सही उत्तर से सम्बन्धित गोले को काला किया है, तो आपको **4 अंक** प्रदान किये जायेंगे तथा यदि कोई भी गोला काला नहीं किया गया है तो शून्य अंक दिये जायेंगे। अन्य सभी स्थितियों में **-1 अंक** दिये जायेंगे।
4. प्रत्येक प्रश्न के लिए केवल एक सही उत्तर है। एक से अधिक विकल्प एक प्रश्न में भरने पर इन्हें गलत विकल्प माना जायेगा तथा निर्देश 3 के अनुसार गलत विकल्प मानते हुए अंक काट लिये जायेंगे।
5. गोले को भरने के लिये केवल **काला या नीला बॉल प्वाइंट पेन** का प्रयोग करें।
6. संगणक, लघुगणक सारणी, नामांकित पैमाना तथा मोबाइल का प्रयोग वर्जित है।
7. रफ कार्य करने के लिए केवल पृष्ठ के नीचे दिये गये स्थान तथा पुस्तिका के अन्त में छोड़े गये स्थान का ही प्रयोग करें।
8. परीक्षा की समाप्ति पर, विद्यार्थी अपनी उत्तर पुस्तिका वीक्षक को सौंपें। यद्यपि प्रश्न पुस्तिका विद्यार्थी अपने साथ ले जा सकते हैं।
9. उत्तर पुस्तिका को मोड़े नहीं या उस पर किसी तरह का चिन्ह अंकित ना करें।

नोट:- यदि प्रश्न पत्र के हिन्दी अनुवाद में विद्यार्थी किसी भी प्रकार की त्रुटि पाता है तो वह अंग्रेजी माध्यम के प्रश्न को ही सही मानकर हल करें।

Name of the Candidate (in Capitals) :

परीक्षार्थी का नाम (बड़े अक्षरों में) :

Roll Number : in figures

अनुक्रमांक : अंकों में

: in words

: शब्दों में

Centre of Examination (in Capitals) :

परीक्षा केन्द्र (बड़े अक्षरों में) :

Candidate's Signature :

परीक्षार्थी के हस्ताक्षर :

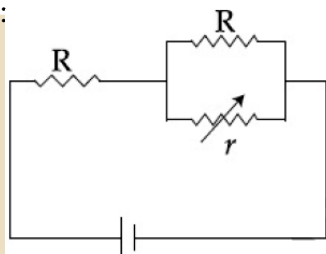
Fascimile signature stamp of Centre Superintendent :

PART A - PHYSICS

ALL THE GRAPHS GIVEN ARE SCHEMATIC AND NOT DRAWN TO SCALE.

1. Three capacitors each of $4\mu\text{F}$ are to be connected in such a way that the effective capacitance is $6\mu\text{F}$. This can be done by connecting them:
- (1) all in series (2) all in parallel
 (3) two in parallel and one in series (4*) two in series and one in parallel

2. In the circuit shown, the resistance r is a variable resistance. If for $r = fR$, the heat generation in r is maximum then the value of f is :



- (1*) $\frac{1}{2}$ (2) 1 (3) $\frac{1}{4}$ (4) $\frac{3}{4}$

3. The ratio of work done by an ideal monoatomic gas to the heat supplied to it in an isobaric process is:

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

4. A rocket is fired vertically from the earth with an acceleration of $2g$, where g is the gravitational acceleration. On an inclined plane inside the rocket, making an angle θ with the horizontal, a point object of mass m is kept. The minimum coefficient of friction μ_{min} between the mass and the inclined surface such that the mass does not move is:

- (1) $\tan 2\theta$ (2*) $\tan \theta$ (3) $3 \tan \theta$ (4) $2 \tan \theta$

5. In Young's double slit experiment, the distance between slits and the screen is 1.0 m and monochromatic light of 600 nm is being used. A person standing near the slits is looking at the fringe pattern. When the separation between the slits is varied, the interference pattern disappears for a particular distance

d_0 between the slits. If the angular resolution of the eye is $\frac{1^\circ}{60}$ the value of d_0 is close to :

- (1) 1 mm (2*) 3 mm (3) 2 mm (4) 4 mm

6. A car of weight W is on an inclined road that rises by 100 m over a distance of 1 km and applies a constant frictional force $\frac{W}{20}$ on the car. While moving uphill on the road at a speed of 10 ms^{-1} , the car

needs power P . If it needs power $\frac{P}{2}$ while moving downhill at speed v then value of v is :

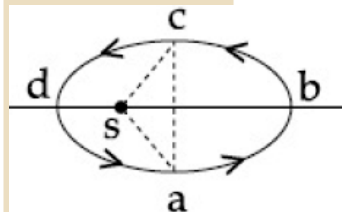
- (1) 20 ms^{-1} (2) 5 ms^{-1} (3*) 15 ms^{-1} (4) 10 ms^{-1}

7. Two particles are performing simple harmonic motion in a straight line about the same equilibrium point. The amplitude and time period for both particles are same and equal to A and T , respectively.

At time $t = 0$ one particle has displacements while the other one has displacement $-\frac{A}{2}$ and they are moving towards each other. If they cross each other at time t , then t is

- (1) $\frac{5T}{6}$ (2) $\frac{T}{3}$ (3) $\frac{T}{4}$ (4*) $\frac{T}{6}$

8. Figure shows elliptical path $abcd$ of a planet around the sun S such that the area of triangle csa is $\frac{1}{4}$ the area of the ellipse. (See figure) With db as the semimajor axis, and ca as the semiminor axis. If t_1 is the time taken for planet to go over path abc and t_2 for path taken over cda then :



- (1) $t_1 = 4t_2$ (2) $t_2 = 2t_1$ (3*) $t_1 = 3t_2$ (4) $t_1 = t_2$

9. An unknown transistor needs to be identified as a npn or pnp type. A multimeter, with +ve and -ve terminals, is used to measure resistance between different terminals of transistor. If terminal 2 is the base of the transistor then which of the following is correct transistor ?

- (1) +ve terminal 2, -ve terminal 3, resistance low
 (2) +ve terminal 2, -ve terminal 1, resistance high
 (3*) +ve terminal 1, -ve terminal 2, resistance high
 (4) +ve terminal 3, -ve terminal 2, resistance high

10. An experiment is performed to determine the I-V characteristics of a Zener diode, which has a protective resistance of $R = 100 \Omega$, and a maximum power of dissipation rating of 1 W. The minimum voltage range of the DC. source in the circuit is :

- (1) 0 – 5V (2) 0 – 24 V (3) 0 – 12 V (4*) 0 – 8 V

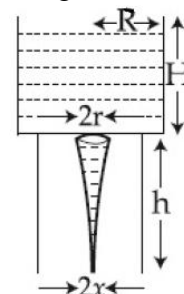
11. A uniformly tapering conical wire is made from a material of Young's modulus Y and has a normal, unextended length L . The radii, at the upper and lower ends of this conical wire, have values R and $3R$, respectively. The upper end of the wire is fixed to a rigid support and a mass M is suspended from its lower end. The equilibrium extended length, of this wire, would equal;

- (1) $L \left(1 + \frac{2}{9} \frac{Mg}{\pi Y R^2} \right)$ (2) $L \left(1 + \frac{1}{9} \frac{Mg}{\pi Y R^2} \right)$
 (3*) $L \left(1 + \frac{1}{3} \frac{Mg}{\pi Y R^2} \right)$ (4) $L \left(1 + \frac{2}{3} \frac{Mg}{\pi Y R^2} \right)$

12. In the following 'I' refers to current and other symbols have their usual meaning. Choose the option that corresponds to the dimensions of electrical conductivity :

- (1) $M^{-1} L^{-3} T^3 I$ (2*) $M^{-1} L^{-3} T^3 I^2$
 (3) $M^{-1} L^3 T^3 I$ (4) $M L^{-3} T^3 I^2$

13. Consider a water jar of radius R that has water filled up to height H and is kept on a stand of height h (see figure). Through a hole of radius r ($r \ll R$) at its bottom, the water leaks out and the stream of water coming down towards the ground has a shape like a funnel as shown in the figure. If the radius of the cross-section of water stream when it hits the ground is x . Then :



(1*) $x = r \left(\frac{H}{H+h} \right)^{1/4}$ (2) $x = r \left(\frac{H}{H+h} \right)$
 (3) $x = r \left(\frac{H}{H+h} \right)^2$ (4) $x = r \left(\frac{H}{H+h} \right)^{1/2}$

14. Two engines pass each other moving in opposite directions with uniform speed of 30m/s. One of them is blowing a whistle of frequency 540 Hz. Calculate the frequency heard by driver of second engine before they pass each other. Speed of sound is 330 m/sec.

(1) 450 Hz (2) 540 Hz (3) 270 Hz (4*) 648 Hz

15. An audio signal consists of two distinct sounds : one a human speech signal in the frequency band of 200 Hz to 2700 Hz, while the other is a high frequency music signal in the frequency band of 10200 Hz to 15200 Hz. The ratio of the AM signal bandwidth required to send both the signals together to the AM signal bandwidth required to send just the human speech is :

(1) 2 (2*) 5 (3) 6 (4) 3

16. To know the resistance G of a galvanometer by half deflection method, a battery of emf V_E and resistance R is used to deflect the galvanometer by angle θ . If a shunt of resistance S is needed to get half deflection then G , R and S are related by the equation :

(1*) $S\{R + G\} = RG$ (2) $2S\{R + G\} = RG$ (3) $2G = S$ (4) $2S = G$

17. A hydrogen atom makes a transition from $n = 2$ to $n = 1$ and emits a photon. This photon strikes doubly ionized lithium atom ($z = 3$) in excited state and completely removes the orbiting electron. The least quantum number for the excited state of the ion for the process is :

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

18. 200 g water is heated from 40°C to 60°C . Ignoring the slight expansion of water, the change in its internal energy is close to (Given specific heat of water = 4184 J/ kg/ K) :

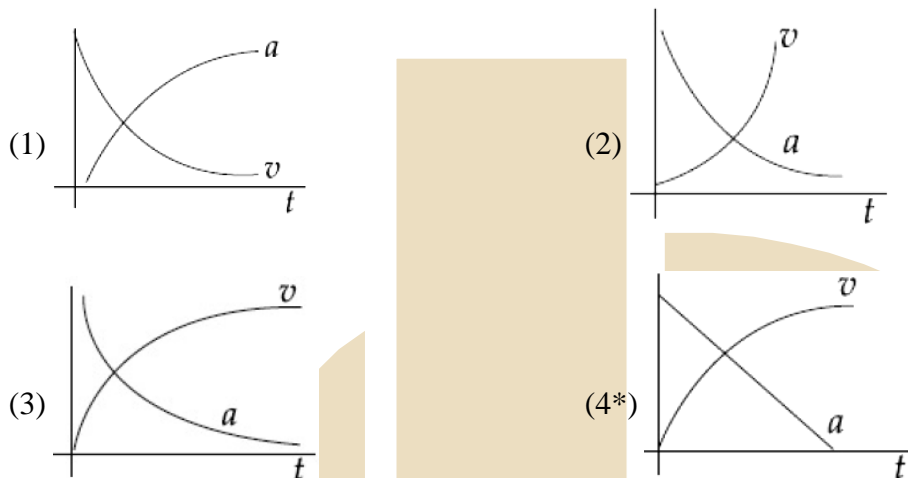
(1) 167.4 kJ (2) 8.4 kJ (3) 4.2 kJ (4*) 16.7 kJ

19. When photons of wavelength λ_1 are incident on an isolated sphere, the corresponding stopping potential is found to be V . When photons of wavelength λ_2 are used, the corresponding stopping potential was thrice that of the above value. If light of wavelength λ_3 , is used then find the stopping potential for this case:

(1) $\frac{hc}{e} \left[\frac{1}{\lambda_3} + \frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right]$ (2) $\frac{hc}{e} \left[\frac{1}{\lambda_3} + \frac{1}{2\lambda_2} - \frac{1}{\lambda_1} \right]$
 (3) $\frac{hc}{e} \left[\frac{1}{\lambda_3} - \frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right]$ (4*) $\frac{hc}{e} \left[\frac{1}{\lambda_3} + \frac{1}{2\lambda_2} - \frac{3}{2\lambda_1} \right]$

20. A magnetic dipole is acted upon by two magnetic fields which are inclined to each other at an angle of 75° . One of the fields has a magnitude of 15 mT. The dipole attains stable equilibrium at an angle of 30° with this field. The magnitude of the other field (in mT) is close to :
- (1) 1 (2*) 11 (3) 36 (4) 1060

21. Which of the following option correctly describes the variation of the speed v and acceleration 'a' of a point mass falling vertically in a viscous medium that applies a force $F = -kv$, where 'k' is a constant on the body ? (Graphs are schematic and not drawn to scale)



22. The truth table given in fig. represents :

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

- (1*) OR-Gate (2) NAND - Gate (3) AND-Gate (4) NOR - Gate

23. The potential (in volts) of a charge distribution is given by
 $V(z) = 30 - 5z^2$ for $|z| \leq 1$ m
 $V(z) = 35 - 10|z|$ for $|z| \geq 1$ m.
 $V(z)$ does not depend on x and y . If this potential is generated by a constant charge per unit volume ρ_0 (in units of ϵ_0) which is spread over a certain region, then choose the correct statement.
- (1) $\rho_0 = 20\epsilon_0$ in the entire region
 (2*) $\rho_0 = 10\epsilon_0$ for $|z| \leq 1$ m and $\rho_0 = 0$ elsewhere
 (3) $\rho_0 = 20\epsilon_0$ for $|z| \leq 1$ m and $\rho_0 = 0$ elsewhere
 (4) $\rho_0 = 40\epsilon_0$ in the entire region.

24. Microwave oven acts on the principle of:
- (1) giving rotational energy to water molecules
 (2) giving translational energy to water molecules
 (3) giving vibrational energy to water molecules
 (4*) transferring electrons from lower to higher energy level in water molecule

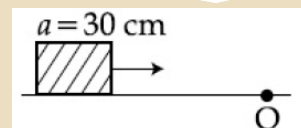
25. To find the focal length of a convex mirror, a student records the following data :

Object Pin	Convex Lens	Convex Mirror	Image Pin
22.2 cm	32.2 cm	45.8 cm	71.2 cm

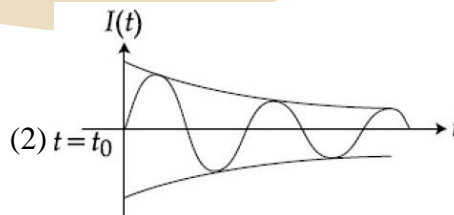
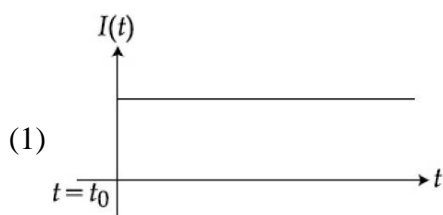
The focal length of the convex lens is f_1 and that of mirror is f_2 . Then taking index correction to be negligibly small, f_1 and f_2 are close to:

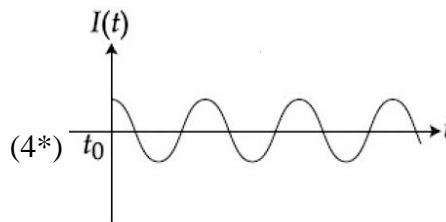
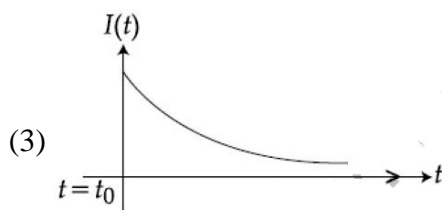
- (1*) $f_1=7.8\text{cm}$ $f_2=12.7\text{cm}$ (2) $f_1=12.7\text{cm}$ $f_2=7.8\text{cm}$
 (3) $f_1=15.6\text{cm}$ $f_2=25.4\text{cm}$ (4) $f_1=7.8\text{cm}$ $f_2=25.4\text{cm}$
26. A 50Ω resistance is connected to a battery of 5V . A galvanometer of resistance 100Ω is to be used as an ammeter to measure current through the resistance, for this a resistance r_s is connected to the galvanometer. Which of the following connections should be employed if the measured current is within 1% of the current without the ammeter in the circuit ?
- (1) $r_s = 0.5\Omega$ in series with the galvanometer
 (2) $r_s = 0.5\Omega$ in series with the galvanometer
 (3) $r_s = 1\Omega$ in parallel with galvanometer
 (4*) $r_s = 1\Omega$ in parallel with galvanometer
27. A simple pendulum made of a bob of mass m and a metallic wire of negligible mass has time period 2 s at $T=0^\circ\text{C}$. If the temperature of the wire is increased and the corresponding change in its time period is plotted against its temperature, the resulting graph is a line of slope S . A coefficient of linear expansion of metal is α then the value of S is :
- (1) $\frac{\alpha}{2}$ (2) 2α (3*) α (4) $\frac{1}{\alpha}$

28. A cubical block of side 30 cm is moving with velocity 2 ms^{-1} on a smooth horizontal surface. The surface has a bump at a point O as shown in figure. The angular velocity (in rad/s) of the block immediately after it hits the bump, is :

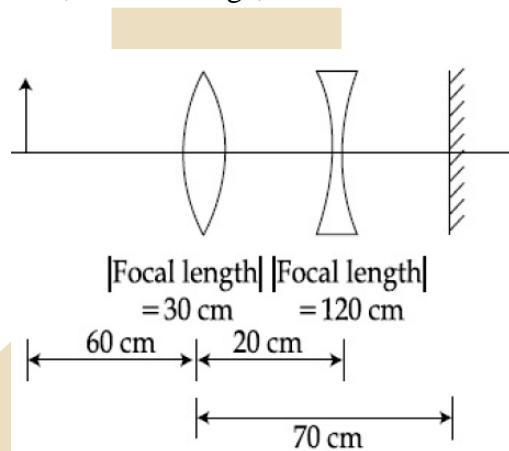


- (1) 13.3 (2*) 5.0 (3) 9.4 (4) 6.7
29. A series LR circuit is connected to a voltage source with $V(f)=V_0 \sin\Omega t$. After very large time, current $I(t)$ behaves as $\left(t_0 \gg \frac{L}{R}\right)$:





30. A convex lens, of focal length 30 cm, a concave lens of focal length 120 cm, and a plane mirror are arranged as shown. For an object kept at a distance of 60 cm from the convex lens, the final image, formed by the combination, is a real image, at a distance of :



- (1*) 60 cm from the convex lens
 (2) 60 cm from the concave lens
 (3) 70 cm from the convex lens
 (4) 70 cm from the concave lens

PART A: MATHEMATICS

1. The shortest distance between the lines

$$\frac{x}{2} = \frac{y}{2} = \frac{z}{1} \text{ and } \frac{x+2}{-1} = \frac{y-4}{8} = \frac{z-5}{4}$$

lies in the interval

- (1) (3, 4] (2*) (2, 3] (3) [1, 2) (4) [0, 1)

2. If m and M are the minimum and the maximum values of

$$4 + \frac{1}{2} \sin^2 2x - 2 \cos^4 x, x \in \mathbb{R}, \text{ then}$$

M – m is equal to :

- (1*) $\frac{9}{4}$ (2) $\frac{15}{4}$ (3) $\frac{7}{4}$ (4) $\frac{1}{4}$

3. If the equations $x^2 + bx - 1 = 0$ and $x^2 + x + b = 0$ have a common root different from -1, then |b| is equal to :

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

4. A circle passes through (-2,4) and touches the y-axis at (0, 2). Which one of the following equations can represent a diameter of this circle ?

- (1*) $2x - 3y + 10 = 0$ (2) $3x + 4y - 3 = 0$
 (2) $4x + 5y - 6 = 0$ (4) $5x + 2y + 4 = 0$

5. If a variable line drawn through the intersection of the lines $\frac{x}{3} + \frac{y}{4} = 1$ and $\frac{x}{4} + \frac{y}{3} = 1$, meets the coordinate axes at A and B, (A ≠ B), then the locus of the midpoint of AB is :

- (1*) $7xy = 6(x + y)$ (2) $4(x + y)^2 - 28(x + y) + 49 = 0$
 (3) $6xy = 7(x + y)$ (4) $14(x + y)^2 - 97(x + y) + 168 = 0$

6. If $2 \int_0^1 \tan^{-1} x dx = \int_0^1 \cot^{-1}(1 - x + x^2) dx$, then $\int_0^1 \tan^{-1}(1 - x + x^2) dx$ is equal to:

- (1) $\frac{\pi}{2} + \log 2$ (2*) $\log 2$ (3) $\frac{\pi}{2} - \log 4$ (4) $\log 4$

7. The number of $x \in [0, 2\pi]$ for which $|\sqrt{2 \sin^4 x + 18 \cos^2 x} - \sqrt{2 \cos^4 x + 18 \sin^2 x}| = 1$ is:

- (1) 2 (2) 6 (3) 4 (4*) 8

8. The distance of the point (1, -2, 4) from the plane passing through the point (1, 2, 2) and perpendicular to the planes $x - y + 2z = 3$ and $2x - 2y + z + 12 = 0$, is :

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

9. If the tangent at a point on the ellipse $\frac{x^2}{27} + \frac{y^2}{3} = 1$ meets the coordinate axes at A and B, and O is the origin, then the minimum area (in sq. units) of the triangle OAB is
- (1) $3\sqrt{3}$ (2) $\frac{9}{2}$ (3*) 9 (4) $9\sqrt{3}$
10. If $f(x)$ is a differentiable function in the interval $(0, \infty)$ such that $f(1) = 1$ and $\lim_{t \rightarrow x} \frac{t^2 f(x) - x^2 f(t)}{t - x} = 1$, for each $x > 0$, then $f(3/2)$ is equal to:
- (1) $\frac{23}{18}$ (2) $\frac{13}{6}$ (3*) $\frac{25}{9}$ (4) $\frac{31}{18}$
11. If the mean deviation of the numbers $1, 1+d, \dots, 1+100d$ from their mean is 255, then a value of d is :
- (1*) 10.1 (2) 5.05 (3) 20.2 (4) 10
12. If A and B are any two events such that $P(A) = 2/5$ and $P(A \cap B) = 3/20$, then the conditional probability, $P(A/(A' \cup B'))$, where A' denotes the complement of A, is equal to:
- (1) 11/20 (2*) 5/17 (3) 8/17 (4) 1/4
13. The value of $\sum_{r=1}^{15} r^2 \left(\frac{{}^{15}C_r}{{}^{15}C_{r-1}} \right)$ is equal to:
- (1) 1240 (2) 560 (3) 1085 (4*) 680
14. The point (2, 1) is translated parallel to the line $L : x - y = 4$ by $2\sqrt{3}$ units. If the new point Q lies in the third quadrant, then the equation of the line passing through Q and perpendicular to L is
- (1) $x + y = 2 - \sqrt{6}$ (2) $2x + 2y = 1 - \sqrt{6}$ (3) $x + y = 3 - 3\sqrt{6}$ (4*) $x + y = 3 - 2\sqrt{6}$
15. The minimum distance of a point on the curve $y = x^2 - 4$ from the origin is :
- (1*) $\frac{\sqrt{15}}{2}$ (2) $\sqrt{\frac{19}{2}}$ (3) $\sqrt{\frac{15}{2}}$ (4) $\frac{\sqrt{19}}{2}$
16. The area (in sq. units) of the region described by $A = \{(x, y) | y \geq x^2 - 5x + 4, x + y \geq 1, y \leq 0\}$ is :
- (1*) $\frac{19}{6}$ (2) $\frac{17}{6}$ (3) $\frac{7}{2}$ (4) $\frac{13}{6}$
17. In a triangle ABC, right angled at the vertex A, if the position vectors of A, B and C are respectively $3\hat{i} + \hat{j} - \hat{k}$, $-\hat{i} + 3\hat{j} + p\hat{k}$ and $5\hat{i} + q\hat{j} - 4\hat{k}$, then the point (p, q) lies on a line:
- (1) making an obtuse angle with the positive direction of x-axis
 (2) parallel to x-axis.
 (3) parallel to y-axis.
 (4*) making an acute angle with the positive direction of x-axis.

18. If $\int \frac{dx}{\cos^3 x \sqrt{2 \sin 2x}} = (\tan x)^A + C(\tan x)^B + k,$

where k is a constant of integration, then A + B + C equals :

- (1*) $\frac{16}{5}$ (2) $\frac{27}{10}$ (3) $\frac{7}{10}$ (4) $\frac{21}{5}$

19. Consider the following two statements :

P: If 7 is an odd number, then 7 is divisible by 2.

Q: If 7 is a prime number, then 7 is an odd number.

If V_1 is the truth value of the contrapositive of P and V_2 is the truth value of contrapositive of Q, then the ordered pair (V_1/V_2) equals :

- (1) (F, F) (2*) (F, T) (3) (T, F) (4) (T, T)

20. The point represented by $2 + i$ in the Argand plane moves 1 unit eastwards, then 2 units northwards and finally from there $2\sqrt{2}$ units in the south-westwards direction. Then its new position in the Argand plane is at the point represented

- (1*) $1 + i$ (2) $2 + 2i$ (3) $-2 - 2i$ (4) $-1 - i$

21. For $x \in \mathbb{R}, x \neq 0, x \neq 1$, let $f_0(x) = \frac{1}{1-x}$ and $f_{n+1}(x) = f_0(f_n(x)), n = 0, 1, 2, \dots$ Then the value

of $f_{100}(3) + f_1\left(\frac{2}{3}\right) + f_2\left(\frac{3}{2}\right)$ is equal to

- (1) $\frac{8}{3}$ (2) $\frac{4}{3}$ (3*) $\frac{5}{3}$ (4) $\frac{1}{3}$

22. If the function $f(x) = \begin{cases} -x, & x < 1 \\ a + \cos^{-1}(x+b), & 1 \leq x \leq 2 \end{cases}$ is differentiable at $x = 1$, then $\frac{a}{b}$ is equal to:

- (1*) $\frac{\pi+2}{2}$ (2) $\frac{\pi-2}{2}$ (3) $\frac{-\pi-2}{2}$ (4) $-1 - \cos^{-1}(2)$

23. If $\lim_{x \rightarrow \infty} \left(1 + \frac{a}{x} - \frac{4}{x^2}\right)^{2x} = e^3$, then 'a' is equal to:

- (1) 2 (2*) $\frac{3}{2}$ (3) $\frac{1}{2}$ (4) $\frac{2}{3}$

24. Let x, y, z be positive real numbers such that $x + y + z = 12$ and $x^3y^4z^5 = (0.1) (600)^3$. Then $x^3 + y^3 + z^3$ is equal to

- (1) 342 (2*) 216 (3) 258 (4) 270

25. The number of distinct real roots of the equation,

$$\begin{vmatrix} \cos x & \sin x & \sin x \\ \sin x & \cos x & \sin x \\ \sin x & \sin x & \cos x \end{vmatrix} = 0 \text{ in the interval } \left[-\frac{\pi}{4}, \frac{\pi}{4}\right] \text{ is:}$$

- (1) 1 (2) 4 (3*) 2 (4) 3

26. Let a and b respectively be the semi-transverse and semi-conjugate axes of a hyperbola whose eccentricity satisfies the equation $9e^2 - 18e + 5 = 0$. If S(5,0) is a focus and $5x = 9$ is the corresponding directrix of this hyperbola, then $a^2 - b^2$ is equal to :

- (1*) -7 (2) -5 (3) 5 (4) 7

27. If $P = \begin{bmatrix} \frac{\sqrt{3}}{2} & \frac{1}{2} \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \end{bmatrix}$, $A = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$ and $Q = PAP^T$, the $P^T Q^{2015} P$ is

- (1) $\begin{bmatrix} 2015 & 0 \\ 0 & 0 \end{bmatrix}$ (2) $\begin{bmatrix} 2015 & 0 \\ 1 & 2015 \end{bmatrix}$ (3*) $\begin{bmatrix} 1 & 2015 \\ 0 & 1 \end{bmatrix}$ (4) $\begin{bmatrix} 2015 & 1 \\ 0 & 2015 \end{bmatrix}$

28. For $x \in \mathbb{R}$, $x \neq -1$ if $(1+x)^{2016} + x(1+x)^{2015} + x^2(1+x)^{2014} + \dots + x^{2016} = \sum_{i=0}^{2016} a_i x^i$, then a_{17} is equal to

- (1*) $\frac{2017!}{17! 2000!}$ (2) $\frac{2016!}{17! 1999!}$ (3) $\frac{2016!}{16!}$ (4) $\frac{2017!}{2000!}$

29. If the four letter words (need not be meaningful) are to be formed using the letters from the word "MEDITERRANEAN" such that the first letter is R and the fourth letter is E, then the total number of all such words is :

- (1) 110 (2*) 59 (3) $\frac{11!}{(2!)^3}$ (4) 56

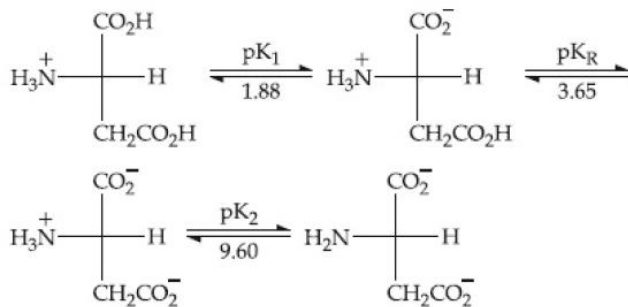
30. If the tangent at a point P, with parameter t, on the curve $x = 4t^2 + 3$, $y = 8t^3 - 1$, $t \in \mathbb{R}$, meets the curve again at a point Q, then the coordinates of Q are :

- (1) $(16t^2 + 3, -64t^3 - 1)$ (2) $(4t^2 + 3, -8t^3 - 1)$
 (3) $(t^2 + 3, t^3 - 1)$ (4*) $(t^2 + 3, -t^3 - 1)$

PART C: CHEMISTRY

31. The gas evolved on heating CH_3MgBr in methanol is :
 (1*) Methane (2) Ethane (3) Propane (4) HBr
32. The total number of orbitals associated with the principal quantum number 5 is :
 (1) 20 (2*) 25 (3) 10 (4) 5
33. BOD stands for:
 (1) Biochemical Oxidation Demand (2) Biological Oxygen Demand
 (3*) Biochemical Oxygen Demand (4) Bacterial Oxidation Demand
34. Identify the incorrect statement regarding heavy water :
 (1) It reacts with SO_3 , to form deuterated sulphuric acid (D_2SO_4)
 (2*) It is used as a coolant in nuclear reactors
 (3) It reacts with CaC_2 to produce C_2D_2 and $\text{Ca}(\text{OD})_2$
 (4) It reacts with Al_4C_3 to produce CD_4 and $\text{Al}(\text{OD})_3$
35. Which one of the following complexes will consume more equivalents of aqueous solution of $\text{Ag}(\text{NO}_3)$?
 (1) $\text{Na}_2[\text{CrCl}_5(\text{H}_2\text{O})]$ (2) $\text{Na}_3[\text{CrCl}_6]$ (3) $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2$ (4*) $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$
36. A particular adsorption process has the following characteristics :
 (i) It arises due to van der Waals forces and (ii) it is reversible.
 Identify the correct statement that describes the above adsorption process:
 (1) Adsorption is monolayer.
 (2) Adsorption increases with increase in temperature.
 (3) Enthalpy of adsorption is greater than 100 kJmol^{-1}
 (4*) Energy of activation is low.
37. Bouveault-Blanc reduction reaction involves :
 (1) Reduction of an acyl halide with H_2/Pd .
 (2) Reduction of an anhydride with LiAlH_4 .
 (3*) Reduction of an ester with $\text{Na}/\text{C}_2\text{H}_5\text{OH}$.
 (4) Reduction of a carbonyl compound with Na/Hg and HCl .
38. At very high pressures, the compressibility factor of one mole of a gas is given by :
 (1*) $1 + \frac{pb}{RT}$ (2) $\frac{pb}{RT}$ (3) $1 - \frac{pb}{RT}$ (4) $1 - \frac{b}{\text{VRT}}$
39. The non-metal that does not exhibit positive oxidation state is :
 (1) Chlorine (2) Iodine (3*) Fluorine (4) Oxygen
40. 5 L of an alkane requires 25 L of oxygen for its complete combustion. If all volumes are measured at constant temperature and pressure, the alkane is :
 (1) Isobutane (2) Ethane (3) Butane (4*) Propane
41. The correct order of the solubility of alkaline-earth metal sulphates in water is :
 (1*) $\text{Mg} > \text{Ca} > \text{Sr} > \text{Ba}$ (2) $\text{Mg} > \text{Sr} > \text{Ca} > \text{Ba}$
 (3) $\text{Mg} < \text{Ca} < \text{Sr} < \text{Ba}$ (4) $\text{Mg} < \text{Sr} < \text{Ca} < \text{Ba}$

42. The group of molecules having identical shape is:
 (1) $\text{PCl}_5, \text{IF}_5, \text{XeO}_2\text{F}_2$ (2) $\text{BF}_3, \text{PCl}_3, \text{XeO}_3$ (3) $\text{SF}_4, \text{XeF}_4, \text{CCl}_4$ (4*) $\text{ClF}_3, \text{XeOF}_2, \text{XeF}_3^+$
43. Consider the following sequence for aspartic acid:



The pI (isoelectric point) of aspartic acid is

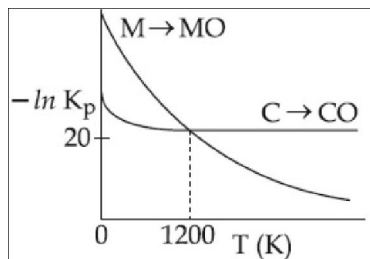
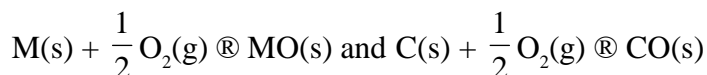
- (1) 3.65 (2*) 2.77 (3) 5.74 (4) 1.88

44. What will occur if a block of copper metal is dropped into a beaker containing a solution of 1M ZnSO_4 ?
 (1) The copper metal will dissolve with evolution of oxygen gas.
 (2) The copper metal will dissolve with evolution of hydrogen gas.
 (3*) No reaction will occur.
 (4) The copper metal will dissolve and zinc metal will be deposited.
45. Which intermolecular force is most responsible in allowing xenon gas to liquefy ?
 (1*) Instantaneous dipole - induced dipole (2) Ion - dipole
 (3) Ionic (4) Dipole - dipole
46. **Assertion :** Rayon is a semi synthetic polymer whose properties are better than natural cotton.
Reason : Mechanical and aesthetic properties of cellulose can be improved by acetylation.
 (1*) Both assertion and reason are correct, but the reason is not the correct explanation for the assertion.
 (2) Both assertion and reason are correct and the reason is the correct explanation for the assertion.
 (3) Assertion is incorrect statement but the reason is correct.
 (4) Both assertion and reason are incorrect.
47. Match the items in Column I with i use listed in Column II :

Column I	Column II
(A) Silica gel	(i) Transistor
(B) Silicon	(ii) Ion-exchanger
(C) Silicone	(iii) Drying agent
(D) Silicate	(iv) Sealant

- (1*) (A)-(iii), (B)-(i), (C)-(iv), (D)-(ii) (2) (A)-(iv), (B)-(i), (C)-(ii), (D)-(iii)
 (3) (A)-(ii), (B)-(i), (C)-(iv), (D)-(iii) (4) (A)-(ii), (B)-(iv), (C)-(i), (D)-(iii)

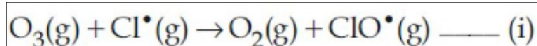
48. The hydrocarbon with seven carbon atoms containing a neopentyl and a vinyl group is :
 (1) 2, 2-dimethyl-4-pentene (2*) 4, 4-dimethylpentene
 (3) Isopropyl-2-butene (4) 2, 2-dimethyl-3-pentene
49. The plot shows the variation of $-\ln K_p$ versus temperature for the two reactions.



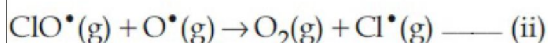
Identify the correct statement:

- (1) At $T < 1200$ K, oxidation of carbon is unfavourable.
 (2) Oxidation of carbon is favourable at all temperatures.
 (3) At $T < 1200$ K, the reaction $MO(s) + C(s) \rightleftharpoons M(s) + CO(g)$ spontaneous.
 (4*) At $T > 1200$ K, carbon will reduce $MO(s)$ to $M(s)$.
50. An organic compound contains C, H and S. The minimum molecular weight of the compound containing 8% sulphur is : (atomic weight of S = 32 amu)
 (1) 600 g mol^{-1} (2) 2200 g mol^{-1} (3*) 400 g mol^{-1} (4) 300 g mol^{-1}
51. The most appropriate method of making egg-albumin sol is:
 (1) Break an egg carefully and transfer the transparent part of the content to 100 mL of 5% w/V saline solution and stir well.
 (2) Keep the egg in boiling water for 10 minutes. After removing the shell, transfer the yellow part of the content to 100 mL of 5% w/V saline solution and homogenize with a mechanical shaker.
 (3*) Keep the egg in boiling water for 10 minutes. After removing the shell, transfer the white part of the content to 100 mL of 5% w/V saline solution and homogenize with a mechanical shaker.
 Break an egg carefully and transfer
 (4) Only the yellow part of the content to 100 mL of 5% w/V saline solution and stir well.
52. The amount of arsenic pentasulphidic that can be obtained when 35.5 g arsenic acid is treated with excess H_2S in the presence of conc. HCl (assuming 100% conversion) is :
 (1) 0.25 mol (2) 0.50 mol (3) 0.333 mol (4*) 0.125 mol

53. The reaction of ozone with oxygen atoms in the presence of chlorine atoms can occur by a two step process shown below :



$$k_{\text{i}} = 5.2 \times 10^9 \text{ L mol}^{-1} \text{ s}^{-1}$$



$$k_{\text{ii}} = 2.6 \times 10^{10} \text{ L mol}^{-1} \text{ s}^{-1}$$

The closest rate constant for the overall reaction $\text{O}_3(\text{g}) + \text{O}^\bullet(\text{g}) \rightarrow 2 \text{O}_2(\text{g})$ is:

(1*) $1.4 \times 10^{20} \text{ L mol}^{-1} \text{ s}^{-1}$

(2) $3.1 \times 10^{10} \text{ L mol}^{-1} \text{ s}^{-1}$

(3) $5.2 \times 10^9 \text{ L mol}^{-1} \text{ s}^{-1}$

(4) $2.6 \times 10^{10} \text{ L mol}^{-1} \text{ s}^{-1}$

54. The artificial sweetener that has the highest sweetness value in comparison to cane sugar is:
 (1) Sucralose (2) Aspartane (3) Saccharin (4*) Alitame
55. Which one of the following species is stable in aqueous solution ?
 (1) Cr^{2+} (2*) MnO_4^{2-} (3) MnO_4^{3-} (4) Cu^+
56. The test to distinguish primary, and tertiary amines is :
 (1) Sandmeyer's reaction (2) Carbylamine reaction
 (3*) Mustard oil test (4*) $\text{C}_6\text{H}_5\text{SO}_2\text{Cl}$
57. The solubility of N_2 in water at 300 K and 500 torr partial pressure is 0.01 g L^{-1} . The solubility (in g L^{-2}) at 750 torr partial pressure is :
 (1) 0.0075 (2) 0.005 (3) 0.02 (4*) 0.015
58. For the reaction,
 $\text{A}(\text{g}) + \text{B}(\text{g}) \rightleftharpoons \text{C}(\text{g}) + \text{D}(\text{g})$, ΔH° and ΔS° are, respectively, $-29.8 \text{ kJ mol}^{-1}$ and $-0.100 \text{ kJ K}^{-1} \text{ mol}^{-1}$ at 298 K. The equilibrium constant for the reaction at 298 K is:
 (1) 1.0×10^{-10} (2) 10 (3*) 1 (4) 1.0×10^{10}
59. A reaction at 1 bar is non-spontaneous at low temperature but becomes spontaneous at high temperature. Identify the correct statement about the reaction among the following :
 (1) ΔH is negative while ΔS is positive.
 (2) Both ΔH and ΔS are negative.
 (3) ΔH is positive while ΔS is negative.
 (4*) Both ΔH and ΔS are positive.
60. Identify the correct trend given below : (Atomic No. = Ti: 22, Cr : 24 and Mo : 42)
 (1) Δ_o of $[\text{Cr}(\text{H}_2\text{O})_6]^{2+} > [\text{Mo}(\text{H}_2\text{O})_6]^{2+}$ and Δ_o of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+} > [\text{Ti}(\text{H}_2\text{O})_6]^{2+}$
 (2) Δ_o of $[\text{Cr}(\text{H}_2\text{O})_6]^{2+} > [\text{Mo}(\text{H}_2\text{O})_6]^{2+}$ and Δ_o of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+} < [\text{Ti}(\text{H}_2\text{O})_6]^{2+}$
 (3*) Δ_o of $[\text{Cr}(\text{H}_2\text{O})_6]^{2+} < [\text{Mo}(\text{H}_2\text{O})_6]^{2+}$ and Δ_o of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+} > [\text{Ti}(\text{H}_2\text{O})_6]^{2+}$
 (4) Δ_o of $[\text{Cr}(\text{H}_2\text{O})_6]^{2+} < [\text{Mo}(\text{H}_2\text{O})_6]^{2+}$ and Δ_o of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+} < [\text{Ti}(\text{H}_2\text{O})_6]^{2+}$