

# JEE MAIN 2016

Date: 10/04/2016

Time: 3 Hours.

Max. Marks: 360

**Important Instructions :**

- 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.**
- Each question has four choices (1), (2), (3) and (4) out of which **ONLY ONE** is correct.
- 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.
- 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.
- Use **Black or Blue Ball Point Pen** only for filling particulars.
- Use of **Calculator, Log Table, Slide Rule and Mobile** is not allowed.
- 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.
- 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.
- Do not fold or make any stray marks on the Answer Sheet.

**महत्वपूर्ण निर्देश :**

- 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।
- प्रत्येक प्रश्न के चार विकल्प (1), (2), (3) तथा (4) हैं जिनमें से केवल एक सही है।
- 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।
- 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।
- गोले को भरने के लिये केवल **काला या नीला बॉल प्वाइंट पेन** का प्रयोग करें।
- संगणक, लघुगणक सारणी, नामांकित पैमाना तथा मोबाइल का प्रयोग वर्जित है।
- रफ कार्य करने के लिए केवल पृष्ठ के नीचे दिये गये स्थान तथा पुस्तिका के अन्त में छोड़े गये स्थान का ही प्रयोग करें।
- परीक्षा की समाप्ति पर, विद्यार्थी अपनी उत्तर पुस्तिका वीक्षक को सौंपें। यद्यपि प्रश्न पुस्तिका विद्यार्थी अपने साथ ले जा सकते हैं।
- 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. A conducting metal circular-wire-loop of radius  $r$  is placed perpendicular to a magnetic field which varies with time as  $B = B_0 e^{-t/\tau}$ , where  $B_0$  and  $\tau$  are constants, at time  $t = 0$ . If the resistance of the loop is  $R$  then the heat generated in the loop after a long time ( $t \rightarrow \infty$ ) is :

(1)  $\frac{\pi^2 r^4 B_0^4}{2\tau R}$       (2\*)  $\frac{\pi^2 r^4 B_0^2}{2\tau R}$       (3)  $\frac{\pi^2 r^4 B_0^2 R}{\tau}$       (4)  $\frac{\pi^2 r^4 B_0^2}{\tau R}$

2. Within a spherical charge distribution of charge density  $\rho(r)$ ,  $N$  equipotential surfaces of potential  $V_0, V_0 + \Delta V, V_0 + 2\Delta V, \dots, V_0 + N\Delta V$  ( $\Delta V > 0$ ), are drawn and have increasing radii  $r_0, r_1, r_2, \dots, r_N$ , respectively. If the difference in the radii of the surfaces is constant for all values of  $V_0$  and  $\Delta V$  then :

(1)  $\rho(r) = \text{constant}$       (2)  $\rho(r) \propto \frac{1}{r^2}$   
 (3\*)  $\rho(r) \propto \frac{1}{r}$       (4)  $\rho(r) \propto r$

3. A thin 1 m long rod has a radius of 5 mm. A force of  $50 \pi \text{ kN}$  is applied at one end to determine its Young's modulus. Assume that the force is exactly known. If the least count in the measurement of all lengths is 0.01 mm which of the following statements is false ?

(1\*) The maximum value of  $Y$  that can be determined is  $10^{14} \text{ N/m}^2$

(2)  $\frac{\Delta Y}{Y}$  gets minimum contribution from the uncertainty in the length.

(3)  $\frac{\Delta Y}{Y}$  gets its maximum contribution from the uncertainty in strain.

(4) The figure of merit is the largest for the length of the rod.

4. Concrete mixture is made by mixing cement, stone and sand in a rotating cylindrical drum. If the drum rotates too fast, the ingredients remain stuck to the wall of the drum and proper mixing of ingredients does not take place. The maximum rotational speed of the drum in revolutions per minute (rpm) to ensure proper mixing is close to :

(Take the radius of the drum to be 1.25 m and its axle to be horizontal):

(1\*) 27.0      (2) 0.4      (3) 1.3      (4) 8.0

5. The ratio ( $R$ ) of output resistance  $r_o$ , and the input resistance  $r_i$  in measurements of input and output characteristics of a transistor is typically in the range :

(1\*)  $R \sim 10^2 - 10^3$       (2)  $R \sim 1 - 10$       (3)  $R \sim 0.1 - 1.0$       (4)  $R \sim 0.1 - 0.01$

6. Consider an electromagnetic wave propagating in vacuum. Choose the correct statement:

(1) For an electromagnetic wave propagating in +y direction the electric field is  $\vec{E} = \frac{1}{\sqrt{2}} E_{yz}(x, t)\hat{z}$

and the magnetic field is  $\vec{B} = \frac{1}{\sqrt{2}} B_z(x, t)\hat{y}$ .

(2) For an electromagnetic wave propagating in +y direction the electric field is  $\vec{E} = \frac{1}{\sqrt{2}} E_{yz}(x, t)\hat{y}$

and the magnetic field is  $\vec{B} = \frac{1}{\sqrt{2}} B_{yz}(x, t)\hat{z}$ .

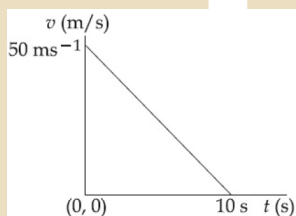
(3) For an electromagnetic wave propagating in +x direction the electric field is

$\vec{E} = \frac{1}{\sqrt{2}} E_{yz}(y, z, t)(\hat{y} + \hat{z})$  and the magnetic field is  $\vec{B} = \frac{1}{\sqrt{2}} B_{yz}(y, z, t)(\hat{y} + \hat{z})$ .

(4\*) For an electromagnetic wave propagating in +x direction the electric field is

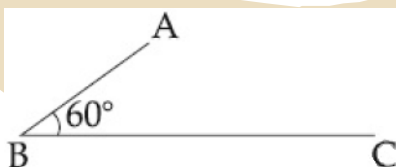
$\vec{E} = \frac{1}{\sqrt{2}} E_{yz}(x, t)(\hat{y} - \hat{z})$  and the magnetic field is  $\vec{B} = \frac{1}{\sqrt{2}} B_{yz}(x, t)(\hat{y} + \hat{z})$ .

7. Velocity-time graph for a body of mass 10 kg is shown in figure. Work-done on the body in first two seconds of the motion is :



- (1) -9300J                      (2) 12000 J                      (3\*) -4500 J                      (4) -12000 J

8. In the figure shown ABC is a uniform wire. If centre of mass of wire lies vertically below point A, then  $\frac{BC}{AB}$  is close to :

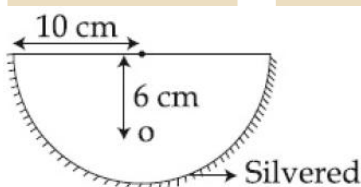


- (1) 1.85                      (2) 1.5                      (3\*) 1.37                      (4) 3

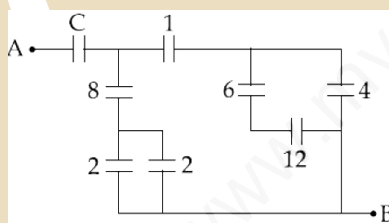
9. A particle of mass m is acted upon by a force F given by the empirical law  $F = \frac{R}{t^2} v(t)$ . If this law is to be tested experimentally by observing the motion starting from rest the best way is to plot:

- (1\*)  $\log v(t)$  against  $\frac{1}{t}$                       (2)  $v(t)$  against  $t^2$   
 (3)  $\log v(t)$  against  $\frac{1}{t^2}$                       (4)  $4 \log v(t)$  against  $t$

10. To determine refractive index of glass slab using a travelling microscope, minimum number of readings required are :  
 (1) Two (2) Four (3\*) Three (4) Five
11. A fighter plane of length 20 m, wing span (distance from tip of one wing to the tip of the other wing) of 15 m and height 5 m is flying towards east over Delhi. Its speed is  $240 \text{ ms}^{-1}$ . The earth's magnetic field over Delhi is  $5 \times 10^{-5} \text{ T}$  with the declination angle  $\sim 0^\circ$  and dip of  $\theta$  such that  $\sin \theta = \frac{2}{3}$ . If the voltage developed is  $V_B$  between the lower and upper side of the plane and  $V_w$  between the tips of the wings then  $V_B$  and  $V_w$  are close to :  
 (1)  $V_B = 40 \text{ mV}$ ;  $V_w = 135 \text{ mV}$  with left side of pilot at higher voltage  
 (2)  $V_B = 45 \text{ mV}$ ;  $V_w = 120 \text{ mV}$  with right side of pilot at higher voltage  
 (3)  $V_B = 40 \text{ mV}$ ;  $V_w = 135 \text{ mV}$  with right side of pilot at high voltage  
 (4\*)  $V_B = 45 \text{ mV}$ ;  $V_w = 120 \text{ mV}$  with left side of pilot at higher voltage
12. A hemispherical glass body of radius 10 cm and refractive index 1.5 is silvered on its curved surface. A small air bubble is 6 cm below the flat surface inside it along the axis. The position of the image of the air bubble made by the mirror is seen:



- (1) 14 cm below flat surface (2\*) 20 cm below flat surface  
 (3) 16 cm below flat surface (4) 30 cm below flat surface
13. Figure shows a network of capacitors where the numbers indicates capacitances in micro Farad. The value of capacitance C if the equivalent capacitance between point A and B is to be  $1 \mu\text{T}$  is :



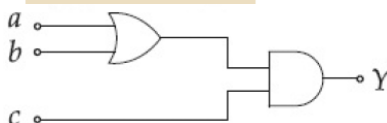
- (1\*)  $\frac{32}{23} \mu\text{F}$  (2)  $\frac{31}{23} \mu\text{F}$  (3)  $\frac{33}{23} \mu\text{F}$  (4)  $\frac{34}{23} \mu\text{F}$
14. A particle of mass M is moving in a circle of fixed radius R in such a way that its centripetal acceleration at time t is given by  $n^2 R t^2$  where n is a constant. The power delivered to the particle by the force acting on it, is :  
 (1)  $\frac{1}{2} M n^2 R^2 t^2$  (2\*)  $M n^2 R^2 t$  (3)  $M n R^2 t^2$  (4)  $M n R^2 t$
15. A, B, C and D are four different physical quantities having different dimensions. None of them is dimensionless. But we know that the equation  $AD = C \ln(BD)$  holds true. Then which of the combination is not a meaningful quantity ?

- (1)  $\frac{C}{BD} - \frac{AD^2}{C}$  (2)  $A^2 - B^2 C^2$  (3)  $\frac{A}{B} - C$  (4\*)  $\frac{(A-C)}{D}$

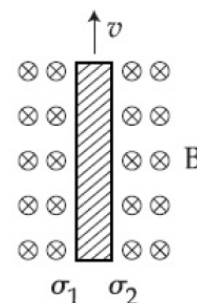
16. A modulated signal  $C_m(f)$  has the form  $C_m(t) = 30 \sin 300\pi t + 10 (\cos 200\pi t - \cos 400\pi t)$ . The carrier frequency  $f_c$ , the modulating frequency (message frequency)  $f_m$ , and the modulation index  $\mu$  are respectively given by :
- (1)  $f_c = 200$  Hz,  $f_m = 50$  Hz;  $\mu = 1/2$                       (2\*)  $f_c = 150$  Hz,  $f_m = 50$  Hz;  $\mu = 2/3$   
 (3)  $f_c = 150$  Hz,  $f_m = 30$  Hz;  $\mu = 1/3$                       (4)  $f_c = 200$  Hz,  $f_m = 30$  Hz;  $\mu = 1/2$

17. In an engine the piston undergoes vertical simple harmonic motion with amplitude 7 cm. A washer rests on top of the piston and moves with it. The motor speed is slowly increased. The frequency of the piston at which the washer no longer stays in contact with the piston, is close to :
- (1) 0.7 Hz                      (2\*) 1.9 Hz                      (3) 1.2 Hz                      (4) 0.1 Hz

18. To get an output of 1 from the circuit shown in figure the input must be:

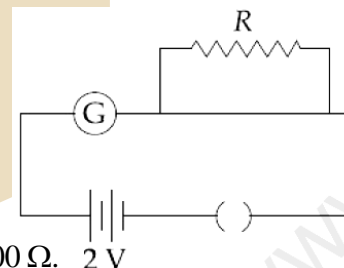


- (1)  $a = 0, b = 0, c = 1$                       (2)  $a = 1, b = 0, c = 0$   
 (3\*)  $a = 1, b = 0, c = 1$                       (4)  $a = 0, b = 1, c = 0$
19. Consider a thin metallic sheet perpendicular to the plane of the paper moving with speed 'v' in a uniform magnetic field B going into the plane of the paper (See figure). If charge densities  $\rho_1$  and  $\rho_2$  are induced on the left and right surfaces respectively, of the sheet then (ignore fringe effects) :

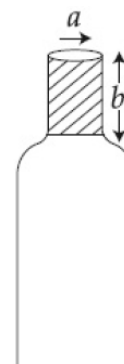


- (1)  $\rho_1 = \frac{-\epsilon_0 vB}{2}, \rho_2 = \frac{\epsilon_0 vB}{2}$                       (2\*)  $\rho_1 = \epsilon_0 vB, \rho_2 = -\epsilon_0 vB$   
 (3)  $\rho_1 = \frac{\epsilon_0 vB}{2}, \rho_2 = \frac{-\epsilon_0 vB}{2}$                       (4)  $\rho_1 = \rho_2 = \epsilon_0 vB$
20. A Carnot freezer takes heat from water at  $0^\circ\text{C}$  inside it and rejects it to the room at a temperature of  $27^\circ\text{C}$ . The latent heat of ice is  $336 \times 10^3 \text{ J kg}^{-1}$ . If 5 kg of water at  $0^\circ\text{C}$  is converted into ice at  $0^\circ\text{C}$  by the freezer, then the energy consumed by the freezer is close to:
- (1)  $1.51 \times 10^5 \text{ J}$                       (2)  $1.68 \times 10^6 \text{ J}$                       (3)  $1.71 \times 10^7 \text{ J}$                       (4\*)  $1.67 \times 10^5 \text{ J}$

21. A galvanometer has a 50 division scale. Battery has no internal resistance. It is found that there is deflection of 40 divisions when  $R = 2400 \Omega$ . Deflection becomes 20 divisions when resistance taken from resistance box is  $4900 \Omega$ . Then we can conclude:
- (1) Current sensitivity of galvanometer is  $20 \mu\text{A/division}$ .  
 (2) Resistance of galvanometer is  $200 \Omega$ .  
 (3) Resistance required on R.B. for a deflection of 10 divisions is  $9800 \Omega$ .  
 (4) Full scale deflection current is  $2\text{mA}$ .



22. A bottle has an opening of radius  $a$  and length  $b$ . A cork of length  $b$  and radius  $(a + \Delta a)$  where  $(\Delta a \ll a)$  is compressed to fit into the opening completely (See figure). If the bulk modulus of cork is  $B$  and frictional coefficient between the bottle and cork is  $\mu$  then the force needed to push the cork into the bottle is :

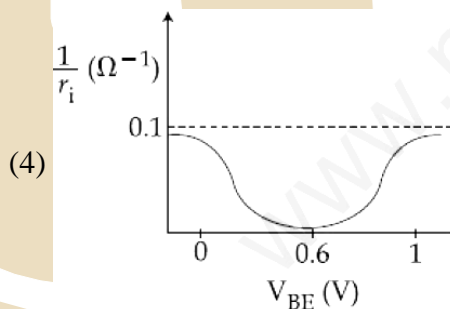
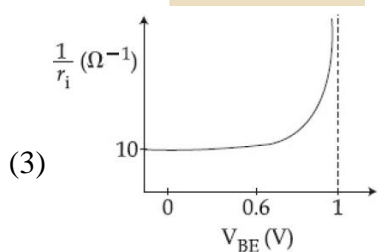
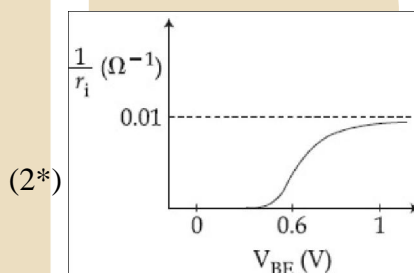
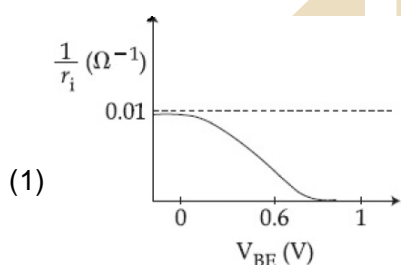


- (1)  $(\pi\mu B b)a$   
 (2)  $(2\pi\mu B b)\Delta a$   
 (3)  $(\pi\mu B b)\Delta a$   
 (4\*)  $(4\pi\mu B b)\Delta a$

23. A toy-car, blowing its horn, is moving with a steady speed of 5 m/s, away from a wall. An observer, towards whom the toy car is moving, is able to hear 5 beats per second. If the velocity of sound in air is 340 m/s, the frequency of the horn of the toy car is close to:

- (1) 680 Hz                      (2) 510 Hz                      (3) 340 Hz                      (4\*) 170 Hz

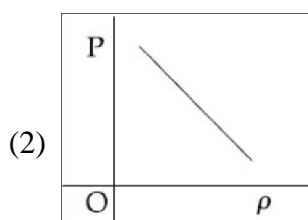
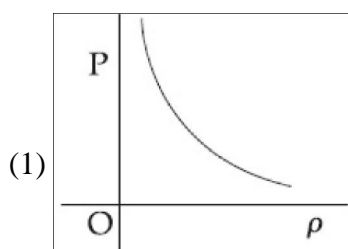
24. A realistic graph depicting the variation of the reciprocal of input resistance in an input characteristics measurement in a common-emitter transistor configuration is :

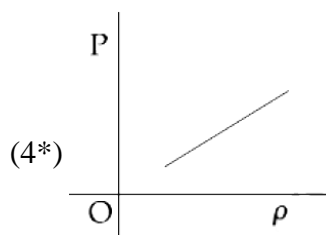
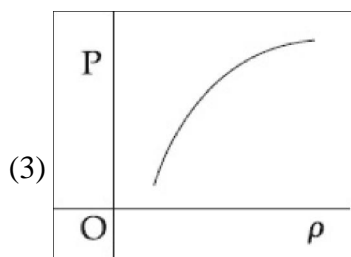


25. A neutron moving with a speed 'v' makes a head on collision with a stationary hydrogen atom in ground state. The minimum kinetic energy of the neutron for which inelastic collision will take place is :

- (1\*) 20.4 eV                      (2) 10.2 eV                      (3) 12.1 eV                      (4) 16.8 eV

26. Which of the following shows the correct relationship between the pressure 'P' and density  $\rho$  of an ideal gas at constant temperature ?





27. The resistance of an electrical toaster has a temperature dependence given by  $R(T) = R_0 [1 + \alpha(T - T_0)]$  in its range of operation. At  $T_0 = 300$  K,  $R = 100 \Omega$  and at  $T = 500$  K,  $R = 120 \Omega$ . The toaster is connected to a voltage source at 200 V and its temperature is raised at a constant rate from 300 to 500 K in 30 s. The total work done in raising the temperature is :

(1)  $400 \ln \frac{5}{6}$  J      (2)  $200 \ln \frac{2}{3}$  J      (3) 300 J      (4)  $400 \ln \frac{1.5}{1.3}$  J

28. Two stars are 10 light years away from the earth. They are seen through a telescope of objective diameter 30 cm. The wavelength of light is 600 nm. To see the stars just resolved by the telescope, the minimum distance between them should be (1 light year =  $9.46 \times 10^{15}$  m) of the order of:

(1\*)  $10^8$  km      (2)  $10^{10}$  km      (3)  $10^{11}$  km      (4)  $10^6$  km

29. An astronaut of mass  $m$  is working on a satellite orbiting the earth at a distance  $h$  from the earth's surface. The radius of the earth is  $R$ , while its mass is  $M$ . The gravitational pull  $F_G$  on the astronaut is :

(1) Zero since astronaut feels weightless

(2)  $\frac{GMm}{(R+h)^2} < F_G < \frac{GMm}{R^2}$

(3\*)  $F_G = \frac{GMm}{(R+h)^2}$

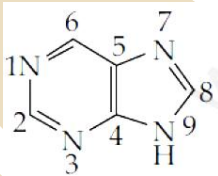
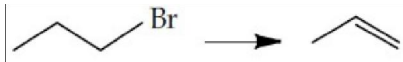
(4)  $0 < F_G < \frac{GMm}{R^2}$

30. A photoelectric surface is illuminated successively by monochromatic light of wavelengths  $\lambda$  and  $\frac{\lambda}{2}$ . If the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function of the surface is :

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



## PART B: CHEMISTRY

31. Which of the following polymers is synthesized using a free radical polymerization technique ?  
 (1) Terylene (2) Melamine polymer  
 (3) Nylon 6,6 (4\*) Teflon
32. The volume of 0.1N dibasic acid sufficient to neutralize 1 g of a base that furnishes 0.04 mole of OH<sup>-</sup> in aqueous solution is :  
 (1\*) 400 mL (2) 600 mL (3) 200 mL (4) 800 mL
33. Aqueous solution of which salt will not contain ions with the electronic configuration  $1s^2 2s^2 2p^6 3s^2 3p^6$ ?  
 (1\*) NaF (2) KBr (3) NaCl (4) CaI<sub>2</sub>
34. Fluorination of an aromatic ring is easily accomplished by treating a diazonium salt with HBF<sub>4</sub>. Which of the following conditions is correct about this reaction ?  
 (1) NaF/Cu (2) Cu<sub>2</sub>O/H<sub>2</sub>O (3\*) Only heat (4) NaNO<sub>2</sub>/Cu
35. Gold numbers of some colloids are : Gelatin : 0.005 - 0.01, Gum Arabic : 0.15 - 0.25; Oleate : 0.04 - 1.0; Starch : 15 - 25. Which among these is a better protective colloid ?  
 (1\*) Gelatin (2) Starch (3) Oleate (4) Gum Arabic
36. Sodium extract is heated with concentrated HNO<sub>3</sub> before testing for halogens because :  
 (1) Ag<sub>2</sub>S and AgCN are soluble in acidic medium.  
 (2) Silver halides are totally insoluble in nitric acid.  
 (3\*) S<sup>2-</sup> and CN<sup>-</sup> decomposed by conc. HNO<sub>3</sub> and hence do not interfere in the test.  
 (4) Ag reacts faster with halides in medium.
37. The "N" which does not contribute to the basicity for the compound is :  
  
 (1\*) N 6 (2) N 3 (3) N 1 (4) N 7
38. The commercial name for calcium oxide is :  
 (1\*) Quick lime (2) Milk of lime (3) Slaked lime (4) Limestone
39. Which one of the following reagents is not suitable for the elimination reaction ?  
  
 (1\*) NaI (2) NaOEt/EtOH (3) NaOH/H<sub>2</sub>O (4) NaOH/H<sub>2</sub>O-EtOH
40. Which one of the following substances used in dry cleaning is a better strategy to control environmental pollution ?  
 (1) Sulphur dioxide (2) Carbon dioxide (3) Nitrogen dioxide (4\*) Tetrachloroethylene



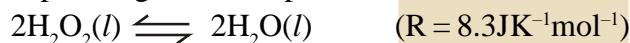
41. The transition metal ions responsible for color in ruby and emerald are respectively:  
 (1)  $\text{Co}^{3+}$  and  $\text{Cr}^{3+}$       (2)  $\text{Co}^{3+}$  and  $\text{Co}^{3+}$       (3\*)  $\text{Cr}^{3+}$  and  $\text{Cr}^{3+}$       (4)  $\text{Cr}^{3+}$  and  $\text{Co}^{3+}$
42. The bond angle  $\text{H-X-H}$  is the greatest in the compound :  
 (1)  $\text{PH}_3$       (2\*)  $\text{CH}_4$       (3)  $\text{NH}_3$       (4)  $\text{H}_2\text{O}$
43. An aqueous solution of a salt  $\text{MX}_2$  at certain temperature has a van't Hoff factor of 2. The degree of dissociation for this solution of the salt is :  
 (1\*) 0.50      (2) 0.33      (3) 0.67      (4) 0.80
44. Oxidation of succinate ion produces ethylene and carbon dioxide gases. On passing 0.2 Faraday electricity through an aqueous solution of potassium succinate, the total volume of gases (at both cathode and anode) at STP (1 atm and 273 K) is :  
 (1\*) 8.96 L      (2) 4.48 L      (3) 6.72 L      (4) 2.24 L
45. Observation of "Rhumann's purple" is a confirmatory test for the presence of :  
 (1) Starch      (2) Reducing sugar      (3\*) Protein      (4) Cupric ion
46. The correct statement about the synthesis of erythritol ( $\text{C}(\text{CH}_2\text{OH})_4$ ) used in the preparation of PETN is :  
 (1\*) The synthesis requires three aldol condensations and one Cannizzaro reaction.  
 (2) Alpha hydrogens ethanol and methanol are involved in this reaction.  
 (3) The synthesis requires two aldol condensations and two Cannizzaro reactions.  
 (4) The synthesis requires four aldol condensations between methanol and ethanol.
47. Which of the following is a bactericidal antibiotic ?  
 (1\*) Ofloxacin      (2) Tetracycline      (3) Chloramphenicol      (4) Erythromycin
48. Identify the incorrect statement:  
 (1\*) The S-S-S bond angles in the  $\text{S}_8$  and  $\text{S}_6$  rings are the same.  
 (2) Rhombic and monoclinic sulphur have  $\text{S}_8$  molecules.  
 (3)  $\text{S}_2$  is paramagnetic like oxygen.  
 (4)  $\text{S}_8$  ring has a crown shape.
49. Extraction of copper by smelting uses silica as an additive to remove :  
 (1)  $\text{Cu}_2\text{O}$       (2)  $\text{FeS}$       (3\*)  $\text{FeO}$       (4)  $\text{Cu}_2\text{S}$
50. Identify the reaction which does not liberate hydrogen :  
 (1\*) Reaction of lithium hydride with  $\text{B}_2\text{H}_6$   
 (2) Electrolysis of acidified water using Pt electrodes.  
 (3) Reaction of zinc with aqueous alkali.  
 (4) Allowing a solution of sodium in liquid ammonia to stand.
51. The rate law for the reaction below is given by the expression  $k[\text{A}][\text{B}]$   
 $\text{A} + \text{B} \rightarrow \text{Product}$   
 If the concentration of B is increased from 0.1 to 0.3 mole, keeping the value of A at 0.1 mole, the rate constant will be :  
 (1) 3k      (2) 9k      (3\*) k/3      (4) k

52. The following statements concern elements in the periodic table. Which of the following is true ?  
 (1) For Group 15 elements, the stability of +5 oxidation state increases down the group.  
 (2\*) Elements of Group 16 have lower ionization enthalpy values compared to those of Group 15 in the corresponding periods.  
 (3) The Group 13 elements are all metals.  
 (4) All the elements in Group 17 are gases.

53. A solid XY kept in an evacuated sealed container undergoes decomposition to form a mixture of gases X and Y at temperature T, The equilibrium pressure is 10 bar in this vessel. K for this reaction is :

(1) 25                                      (2\*) 100                                      (3) 10                                      (4) 5

54. If 100 mole of  $\text{H}_2\text{O}_2$  decompose at 1 bar and 300 K, the work done (kJ) by one mole of  $\text{O}_2(\text{g})$  as it expands against 1 bar pressure is

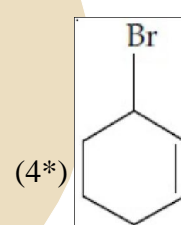
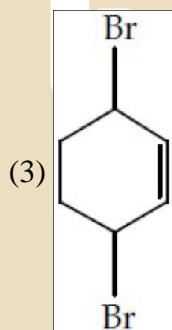
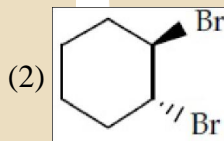
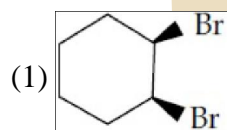
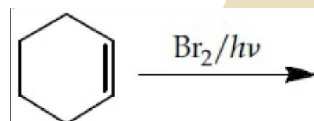


(1) 124.50                                      (2\*) 249.00                                      (3) 498.00                                      (4) 62.25

55. Which of the following is an example of homoleptic complex ?

(1\*)  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$       (2)  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$       (3)  $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]$       (4)  $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$

56. Bromination of cyclohexene under conditions given below yields :

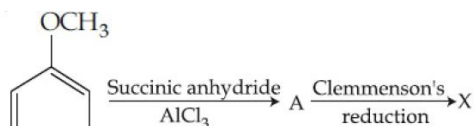


57. **Assertion:** Among the carbon allotropes, diamond is an insulator, whereas, graphite is a good conductor of electricity.

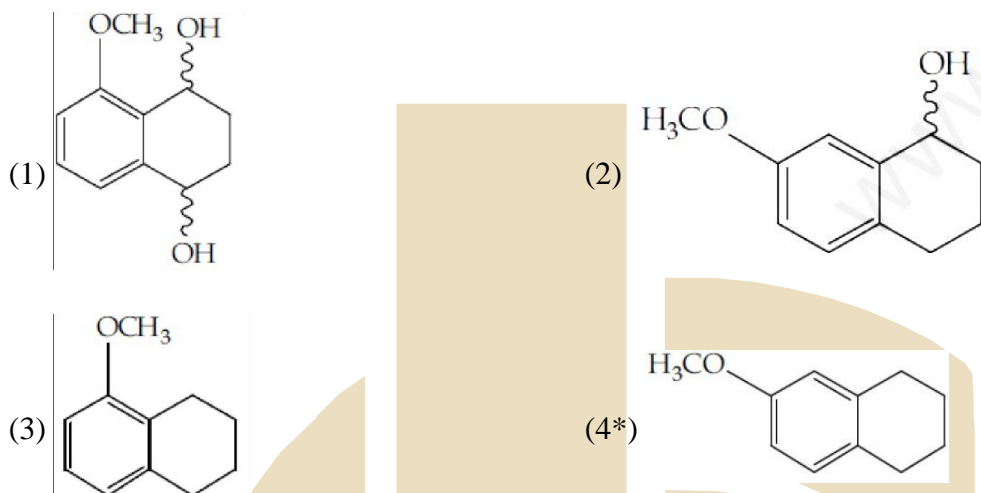
**Reason :** Hybridization of carbon in diamond and graphite are  $sp^3$  and  $sp^2$ , respectively.

- (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, but the reason is the correct explanation for the assertion.  
 (3) Both assertion and reason are incorrect.  
 (4) Assertion is incorrect statement, but the reason is correct.

Q.58 Consider the reaction sequence below :



X is :



29. Initially, the root mean square (rms) velocity of  $N_2$  molecules at certain temperature is  $u$ . If this temperature is doubled and all the nitrogen molecules dissociate into nitrogen atoms, then the new rms velocity will be :

- (1\*)  $2u$                       (2)  $14u$                       (3)  $4u$                       (4)  $u/2$

30. Identify the correct statement:

- (1) Corrosion of iron can be minimized by forming a contact with another metal with a higher reduction potential.  
 (2) Iron corrodes in oxygen-free water.  
 (3\*) Corrosion of iron can be minimized by forming an impermeable barrier at its surface.  
 (4) Iron corrodes more rapidly in salt water because its electrochemii potential is higher.

**PART A: Mathematics**

1. For  $x \in \mathbb{R}$ ,  $x \neq 0$ , if  $y(x)$  is a differentiable function such that

$$x \int_1^x y(t) dt = (x + 1) \int_1^x ty(t) dt, \text{ then } y(x) \text{ equals :}$$

(where  $C$  is a constant.)

- (1)  $Cx^3 e^{1/x}$                       (2)  $\frac{C}{x^2} e^{-1/x}$                       (3)  $\frac{C}{x} e^{-1/x}$                       (4\*)  $\frac{C}{x^3} e^{-1/x}$

2. The sum  $\sum_{r=1}^{10} (r^2 + 1) \times (r!)$  is equal to:

- (1)  $11 \times (11!)$                       (2\*)  $10 \times (11!)$                       (3)  $(11!)$                       (4)  $101 \times (10!)$

3. Let  $a, b \in \mathbb{R}$ , ( $a \neq 0$ ). If the function  $f$  defined as

$$f(x) = \begin{cases} \frac{2x^2}{a}, & 0 \leq x < 1 \\ a, & 1 \leq x < \sqrt{2} \\ \frac{2b^2 - 4b}{x^3}, & \sqrt{2} \leq x < \infty \end{cases}$$

is continuous in the interval  $[0, \infty)$ , then ordered pair  $(a, b)$  is :

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

4. The angle of elevation of the top of a vertical tower from a point A, due east of it is  $45^\circ$ . The angle of elevation of the top of the same tower from a point B, due south of A is  $30^\circ$ . If the distance between A and B is  $54\sqrt{2}$  m, then the height of the tower (in metres), is :

- (1) 108                      (2)  $36\sqrt{3}$                       (3)  $54\sqrt{3}$                       (4\*) 54

5. P and Q are two distinct points on the parabola,  $y^2 = 4x$  with parameters  $t$  and  $t_1$  respectively. If the normal at P passes through Q, then the minimum value of  $t_1^2$  is

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

6. ABC is a triangle in a plane with vertices  $A(2, 3, 5)$ ,  $B(-1, 3, 2)$  and  $C(1, 5, m)$ . If the median through A is equally inclined to the coordinate axes, then the value of  $(l^3 + m^3 + 5)$  is :

- (1) 1130                      (2\*) 1348                      (3) 1077                      (4) 676

7. The solution of the differential equation  $\frac{dy}{dx} + \frac{y}{2} \sec x = \frac{\tan x}{2y}$ , where  $0 \leq x < \frac{\pi}{2}$ , and  $y(0) = 1$ , is given by

- (1)  $y^2 = 1 + \frac{x}{\sec x + \tan x}$                       (2)  $y = 1 + \frac{x}{\sec x + \tan x}$   
 (3)  $y = 1 - \frac{x}{\sec x + \tan x}$                       (4\*)  $y^2 = 1 - \frac{x}{\sec x + \tan x}$

8. The value of the integral

$$\int_4^{10} \frac{[x^2] dx}{[x^2 - 28x + 196] + [x^2]}, \text{ where } [x] \text{ denotes the greatest integer less than or equal to } x, \text{ is}$$

- (1)  $\frac{1}{3}$                       (2) 6                      (3) 7                      (4\*) 3

9. Let A be a  $3 \times 3$  matrix such that  $A^2 - 5A + 7I = O$ .

**Statement - 1:**  $A^{-1} = \frac{1}{7} (5I - A)$ .

**Statement - 2:** The polynomial  $A^3 - 2A^2 - 3A + I$  can be reduced to  $5(A - 4I)$ .

Then:

- (1\*) Both the statements are true.  
 (2) Both the statements are false.  
 (3) Statement-I is true, but Statement-II is false.  
 (4) Statement-I is false but Statement-II is true.

10. Let  $a_1, a_2, a_3, \dots, a_n, \dots$  be in A.P. If  $a_3 + a_7 + a_{11} + a_{15} = 72$ , then the sum of its first 17 terms is equal to:

- (1\*) 306                      (2) 204                      (3) 153                      (4) 612

Q.11 If  $A = \begin{bmatrix} -4 & -1 \\ 3 & 1 \end{bmatrix}$ , then the determinant of the matrix  $(A^{2016} - 2A^{2015} - A^{2014})$  is:

- (1) -175                      (2) 2014                      (3) 2016                      (4\*) -25

Q.12 Let ABC be a triangle whose circumcentre is at P. If the position vectors of A, B, C and P are  $\vec{a}, \vec{b}, \vec{c}$

and  $\frac{\vec{a} + \vec{b} + \vec{c}}{4}$  respectively, then the position vector of the orthocentre of this triangle, is:

- (1)  $-\left(\frac{\vec{a} + \vec{b} + \vec{c}}{2}\right)$                       (2)  $\vec{a} + \vec{b} + \vec{c}$                       (3\*)  $\left(\frac{\vec{a} + \vec{b} + \vec{c}}{2}\right)$                       (4)  $\vec{0}$

Q.13 Let  $z = 1 + ai$  be a complex number,  $a > 0$ , such that  $z^3$  is a real number. Then the sum  $1 + z + z^2 + \dots + z^{11}$  is equal to:

- (1)  $1365\sqrt{3} i$                       (2\*)  $-1365\sqrt{3} i$                       (3)  $-1250\sqrt{3} i$                       (4)  $1250\sqrt{3} i$

Q.14 Equation of the tangent to the circle, at the point  $(1, -1)$ , whose centre is the point of intersection of the straight lines  $x - y = 1$  and  $2x + y = 3$  is:

- (1\*)  $x + 4y + 3 = 0$                       (2)  $3a - y - 4 = 0$                       (3)  $x - 3y - 4 = 0$                       (4)  $4x + y - 3 = 0$

Q.15 A straight line through origin O meets the lines  $3y = 10 - 4x$  and  $8x + 6y + 5 = 0$  at points A and B respectively. Then O divides the segment AB in the ratio:

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

Q.16 The integral  $\int \frac{dx}{(1+\sqrt{x})\sqrt{x-x^2}}$  is equal to :

(where C is a constant of integration.)

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

Q.17 If  $A > 0, B > 0$  and  $A + B = \frac{\pi}{6}$ , then the minimum value of  $\tan A + \tan B$  is :

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

Q.18 A ray of light is incident along a line which meets another line,  $7x - y + 1 = 0$ , at the point  $(0, 1)$ . The ray is then reflected from this point along the line,  $y + 2x = 1$ . Then the equation of the line of incidence of the 'ray of light' is :

- (1)  $41x - 25y + 25 = 0$  (2)  $41x + 25y - 25 = 0$   
 (3\*)  $41x - 38y + 38 = 0$  (4)  $41x + 38y - 38 = 0$

Q.19 A hyperbola whose transverse axis is along the major axis of the conic,  $\frac{x^2}{3} + \frac{y^2}{4} = 4$  and has the vertices at the foci of this conic. If the eccentricity of the hyperbola is  $\frac{3}{2}$ , then which of the following points does NOT lie on it ?

- (1)  $(\sqrt{5}, 2\sqrt{2})$  (2)  $(0, 2)$  (3\*)  $(5, 2\sqrt{3})$  (4)  $(\sqrt{10}, 2\sqrt{3})$

Q.20 An experiment succeeds twice as often as it fails. The probability of at least 5 successes in the six trials of this experiment is :

- (1)  $\frac{496}{729}$  (2)  $\frac{192}{729}$  (3)  $\frac{240}{729}$  (4\*)  $\frac{256}{729}$

Q.21 The contrapositive of the following statement, "If the side of a square doubles, then its area increases four times", is :

- (1) If the area of a square increases four times, then its side is not doubled.  
 (2) If the area of a square increases four times, then its side is doubled.  
 (3\*) If the area of a square does not increase four times, then its side is not doubled.  
 (4) If the side of a square is not doubled, then its area does not increase four times.

Q.22 Let  $P = \{q : \sin q - \cos q = \sqrt{2} \cos q\}$  and  $Q = \{q : \sin q + \cos q = \sqrt{2} \sin q\}$  be two sets. Then:

- (1)  $P \subset Q$  and  $Q - P \neq \phi$   
 (2)  $Q \not\subset P$   
 (3\*)  $P = Q$   
 (4)  $P \not\subset Q$

Q.23 If  $\frac{{}^{n+2}C_6}{{}^{n-2}P_2} = 11$ , then  $n$  satisfies the equation:

- (1)  $n^2 + n - 110 = 0$  (2)  $n^2 + 2n - 80 = 0$   
 (3\*)  $n^2 + 3n - 108 = 0$  (4)  $n^2 + 5n - 84 = 0$

Q.24 If  $x$  is a solution of the equation,  $\sqrt{2x+1} - \sqrt{2x-1} = 1$ ,  $\left(x \geq \frac{1}{2}\right)$ , then  $\sqrt{4x^2 - 1}$  is equal to :

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

Q.25 Let  $C$  be a curve given by  $y(x) = 1 + \sqrt{4x-3}$ ,  $x > \frac{3}{4}$ . If  $P$  is a point on  $C$ , such that the tangent at  $P$  has slope  $\frac{2}{3}$ , then a point through which the normal at  $P$  passes, is :

- (1\*) (1, 7) (2) (3, -4) (3) (4, -3) (4) (2, 3)

Q.26 The number of distinct real values of  $\lambda$  for which the lines  $\frac{x-1}{1} = \frac{y-2}{2} = \frac{z+3}{\lambda^2}$  and  $\frac{x-3}{1} = \frac{y-2}{\lambda^2} = \frac{z-1}{2}$  are coplanar is:

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

Q.27 The mean of 5 observations is 5 and their variance is 124. If three of the observations are 1, 2 and 6; then the mean deviation from the mean of the data is :

- (1) 2.5 (2\*) 2.6 (3) 2.8 (4) 2.4

Q.28 Let  $f(x) = \sin^4 x + \cos^4 x$ . Then  $f$  is an increasing function in the interval

- (1)  $\left[\frac{5\pi}{8}, \frac{3\pi}{4}\right]$  (2)  $\left[\frac{\pi}{2}, \frac{5\pi}{8}\right]$  (3\*)  $\left[\frac{\pi}{4}, \frac{\pi}{2}\right]$  (4)  $\left]0, \frac{\pi}{4}\right[$

Q.29  $\lim_{x \rightarrow 0} \frac{(1 - \cos 2x)^2}{2x \tan x - x \tan 2x}$  is:

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

Q.30 If the coefficients of  $x^{-2}$  and  $x^{-4}$  in the expansion of  $\left(x^{1/3} + \frac{1}{2x^{1/3}}\right)^{18}$ , ( $x > 0$ ) are  $m$  and  $n$  respectively,

then  $\frac{m}{n}$  is equal to :

- (1) 27 (2\*) 182 (3)  $\frac{5}{4}$  (4)  $\frac{4}{5}$