

# FIITJEE

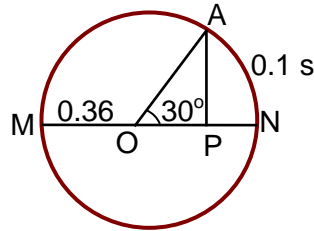
## Solutions to JEE (Main)-2021

JEE–Main–2021 –Feb–25–Second–Shift  
PHYSICS, CHEMISTRY & MATHEMATICS

### (PHYSICS)

#### SECTION – A

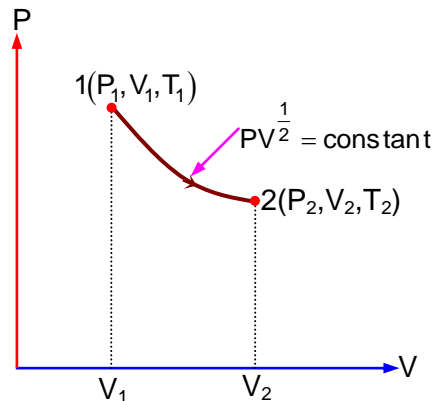
- Q1.** The point A moves with a uniform speed along the circumference of a circle of radius 0.36 m and covers  $30^\circ$  in 0.1 s. The perpendicular projection 'P' from 'A' on the diameter MN represents the simple harmonic motion of 'P'. The restoration force per unit mass when P touches M will be:



- (A) 100 N  
(C) 9.87 N

- (B) 50 N  
(D) 0.49 N

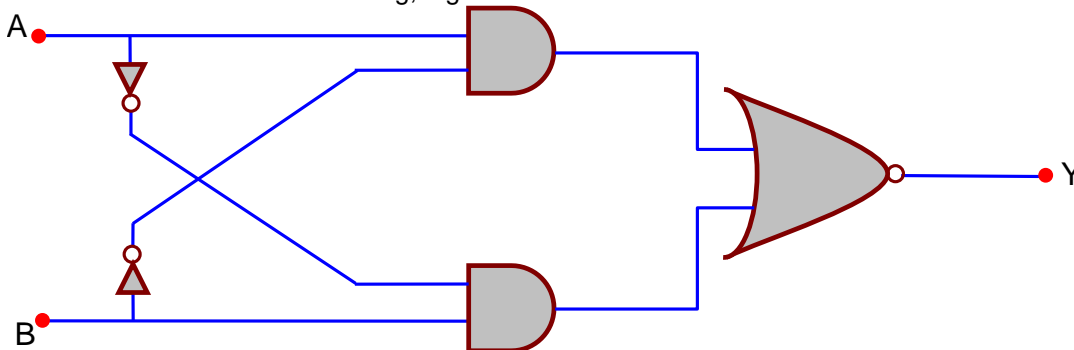
- Q2.** Thermodynamic process is shown below on a P-V diagram for one mole of an ideal gas. If  $V_2 = 2V_1$  then the ratio of temperature  $T_2/T_1$  is :



- (A) 2  
(C)  $\sqrt{2}$

- (B)  $\frac{1}{\sqrt{2}}$   
(D)  $\frac{1}{2}$

- Q3.** The truth table for the following, logic circuit is :



(A)

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

(B)

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

(C)

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

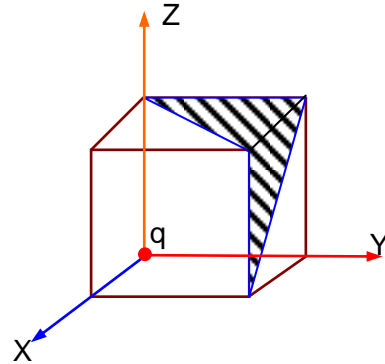
(D)

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

- Q4.** The stopping potential for electrons emitted from a photosensitive surface illuminated by light of wavelength 491 nm is 0.710 V. When the incident wavelength is changed to a new value, the stopping potential is 1.43 V. The new wavelength is :
- (A) 382 nm (B) 309 nm  
(C) 329 nm (D) 400 nm
- Q5.** For extrinsic semiconductors; when doping level is increased;
- (A) Fermi-level of p and n-type semiconductors will not be affected.  
(B) Fermi-level of p-type semiconductor will go upward and Fermi-level of n-type semiconductors will go downward.  
(C) Fermi-level of p-type semiconductors will go downward and Fermi-level of n-type semiconductor will go upward  
(D) Fermi-level of both p-type and n-type semiconductors will go upward for  $T > T_F$  K and downward for  $T < T_F$  K, where  $T_F$  is Fermi temperature.
- Q6.** If  $e$  is the electronic charge,  $c$  is the speed of light in free space and  $h$  is Planck's constant, the quantity  $\frac{1}{4\pi\epsilon_0} \frac{|e|^2}{hc}$  has dimensions of :
- (A)  $[MLT^0]$  (B)  $[MLT^{-1}]$   
(C)  $[M^0L^0T^0]$  (D)  $[LC^{-1}]$
- Q7.** An LCR circuit contains resistance of  $110 \Omega$  and a supply of 220 V at 300 rad/s angular frequency. If only capacitance is removed from the circuit, current lags behind the voltage by  $45^\circ$ . If on the other hand, only inductor is removed the current leads by  $45^\circ$  with the applied voltage. The rms current flowing in the circuit will be:
- (A) 1 A (B) 2 A  
(C) 1.5 A (D) 2.5 A
- Q8.** A stone is dropped from the top of a building. When it crosses a point 5 m below the top, another stone starts to fall from a point 25 m below the top. Both stones reach the bottom of building simultaneously. The height of the building is :
- (A) 35 m (B) 45 m  
(C) 50 m (D) 25 m

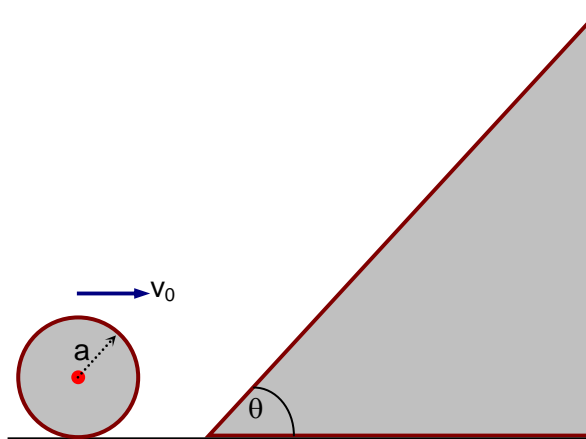
- Q9.** Given below are two statements :  
 Statement I : In a diatomic molecule, the rotational energy at a given temperature obeys Maxwell's distribution.  
 Statement II : In a diatomic molecule, the rotational energy at a given temperature equals the translational kinetic energy for each molecule.  
 In the light of the above statements, choose the correct answer from the options given below :  
 (A) Statement I is false but Statement II is true.  
 (B) Both Statement I and Statement II are true.  
 (C) Statement I is true but Statement II is false.  
 (D) Both Statement I and Statement II are false.

- Q10.** A charge 'q' is placed at one corner of a cube as shown in figure. The flux of electrostatic field  $\vec{E}$  through the shaded area is :



- (A)  $\frac{q}{8\epsilon_0}$  (B)  $\frac{q}{4\epsilon_0}$   
 (C)  $\frac{q}{24\epsilon_0}$  (D)  $\frac{q}{48\epsilon_0}$
- Q11.** If a message signal of frequency ' $f_m$ ' is amplitude modulated with a carrier signal of frequency ' $f_c$ ' and radiated through an antenna, the wavelength of the corresponding signal in air is :  
 (A)  $\frac{c}{f_c + f_m}$  (B)  $\frac{c}{f_c}$   
 (C)  $\frac{c}{f_c - f_m}$  (D)  $\frac{c}{f_m}$
- Q12.** Consider the diffraction pattern obtained from the sunlight incident on a pinhole of diameter  $0.1\mu\text{m}$ . If the diameter of the pinhole is slightly increased, it will affect the diffraction pattern such that :  
 (A) its size increases, but intensity decreases  
 (B) its size increases, and intensity increases  
 (C) its size decreases, but intensity increases  
 (D) its size decreases, and intensity decreases
- Q13.** An electron of mass  $m_e$  and a proton of mass  $m_p = 1836 m_e$  are moving with the same speed. The ratio of their de Broglie wavelength  $\frac{\lambda_{\text{electron}}}{\lambda_{\text{proton}}}$  will be:  
 (A) 1 (B) 918  
 (C)  $\frac{1}{1836}$  (D) 1836

- Q14.** A sphere of radius 'a' and mass 'm' rolls along a horizontal plane with constant speed  $v_0$ . It encounters an inclined plane at angle  $\theta$  and climbs upward. Assuming that it rolls without slipping, how far up the sphere will travel?



- (A)  $\frac{2}{5} \frac{v_0^2}{g \sin \theta}$  (B)  $\frac{v_0^2}{5g \sin \theta}$   
 (C)  $\frac{v_0^2}{2g \sin \theta}$  (D)  $\frac{10v_0^2}{7g \sin \theta}$

- Q15.** The wavelength of the photon emitted by a hydrogen atom when an electron makes a transition from  $n = 2$  to  $n = 1$  state is :

- (A) 121.8 nm (B) 194.8 nm  
 (C) 490.7 nm (D) 913.3 nm

- Q16.** In a ferromagnetic material, below the curie temperature, a domain is defined as :

- (A) a macroscopic region with zero magnetization.  
 (B) a macroscopic region with saturation magnetization.  
 (C) a macroscopic region with randomly oriented magnetic dipoles.  
 (D) a macroscopic region with consecutive magnetic dipoles oriented in opposite direction.

- Q17.** An electron with kinetic energy  $K_1$  enters between parallel plates of a capacitor at an angle ' $\alpha$ ' with the plates. It leaves the plates at angle ' $\beta$ ' with kinetic energy  $K_2$ . Then the ratio of kinetic energies  $K_1 : K_2$  will be :

- (A)  $\frac{\sin^2 \beta}{\cos^2 \alpha}$  (B)  $\frac{\cos \beta}{\cos \alpha}$   
 (C)  $\frac{\cos \beta}{\sin \alpha}$  (D)  $\frac{\cos^2 \beta}{\cos^2 \alpha}$

- Q18.**  $Y = A \sin(\omega t + \phi_0)$  is the time-displacement equation of a SHM. At  $t = 0$  the displacement of the particle is  $Y = \frac{A}{2}$  and it is moving along negative x-direction. Then the initial phase angle  $\phi_0$  will be :

- (A)  $\frac{5\pi}{6}$  (B)  $\frac{\pi}{6}$   
 (C)  $\frac{\pi}{3}$  (D)  $\frac{2\pi}{3}$

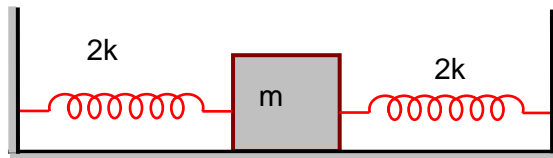
- Q19.** Match List I with List II.

- | List I          | List II   |
|-----------------|---|
| (a) Rectifier   | (i) Used either for stepping up or stepping down the a.c. voltage                         |
| (b) Stabilizer  | (ii) Used to convert a.c. voltage into d.c. voltage                                       |
| (c) Transformer | (iii) Used to remove any ripple in the rectified output voltage                           |
| (d) Filter      | (iv) Used for constant output voltage even when the input voltage or load current change. |

Choose the correct answer from the options given below :

- (A) (a)  $\rightarrow$  (ii), (b)  $\rightarrow$  (iv), (c)  $\rightarrow$  (i), (d)  $\rightarrow$  (iii)  
 (B) (a)  $\rightarrow$  (iii), (b)  $\rightarrow$  (iv), (c)  $\rightarrow$  (i), (d)  $\rightarrow$  (ii)  
 (C) (a)  $\rightarrow$  (ii), (b)  $\rightarrow$  (i), (c)  $\rightarrow$  (iv), (d)  $\rightarrow$  (iii)  
 (D) (a)  $\rightarrow$  (ii), (b)  $\rightarrow$  (i), (c)  $\rightarrow$  (iii), (d)  $\rightarrow$  (iv)

- Q20.** Two identical springs of spring constant '2k' are attached to a block of mass m and to fixed support (see figure). When the mass is displaced from equilibrium position on either side, it executes simple harmonic motion. The time period of oscillations of this system is :



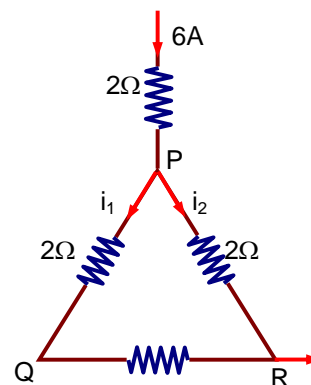
- (A)  $\pi\sqrt{\frac{m}{k}}$  (B)  $\pi\sqrt{\frac{m}{2k}}$   
 (C)  $2\pi\sqrt{\frac{m}{k}}$  (D)  $2\pi\sqrt{\frac{m}{2k}}$

**SECTION – B**

- Q1.** Two small spheres each of mass 10 mg are suspended from a point by threads 0.5 m long. They are equally charged and repel each other to a distance of 0.20 m. The charge on each of the sphere is  $\frac{a}{21} \times 10^{-8}$  C. The value of 'a' will be.....  
 [ Given  $g = 10 \text{ ms}^{-2}$  ]

- Q2.** Two particles having masses 4 g and 16 g respectively are moving with equal kinetic energies. The ratio of the magnitudes of their linear momentum is n : 2. The value of n will be .....
- Q3.** A reversible heat engine converts one-fourth of the heat input into work. When the temperature of the sink is reduced by 52 K, its efficiency is doubled. The temperature in Kelvin of the source will be.....

- Q4.** A current of 6 A enters one corner P of an equilateral triangle PQR having 3 wires of resistance  $2\Omega$  each and leaves by the corner R. The currents  $i_1$  in ampere is.....



- Q5.** The percentage increase in the speed of transverse waves produced in a stretched string if the tension is increased by 4%, will be.....%.
- Q6.** The wavelength of an X-ray beam is  $10 \text{ \AA}$ . The mass of a fictitious particle having the same energy as that of the X-ray photons is  $\frac{x}{3}h$  kg. The value of x is.....  
 (h = Planck's constant)
- Q7.** The initial velocity  $v_i$  required to project a body vertically upward from the surface of the earth to reach a height of  $10R$ , where R is the radius of the earth, may be described in terms of escape velocity  $v_e$  such that  $v_i = \sqrt{\frac{x}{y}} \times v_e$ . The value of x will be.....
- Q8.** If  $\vec{P} \times \vec{Q} = \vec{Q} \times \vec{P}$ , the angle between  $\vec{P}$  and  $\vec{Q}$  is  $\theta (0^\circ < \theta < 360^\circ)$ . The value of 'θ' will be .....

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- Q9.** Two identical conducting spheres with negligible volume have 2.1 nC and -0.1 nC charges, respectively. They are brought into contact and then separated by a distance of 0.5 m. The electrostatic force acting between the spheres is .....  $\times 10^{-9}$  N.

[Given :  $4\pi\epsilon_0 = \frac{1}{9 \times 10^9}$  SI unit]

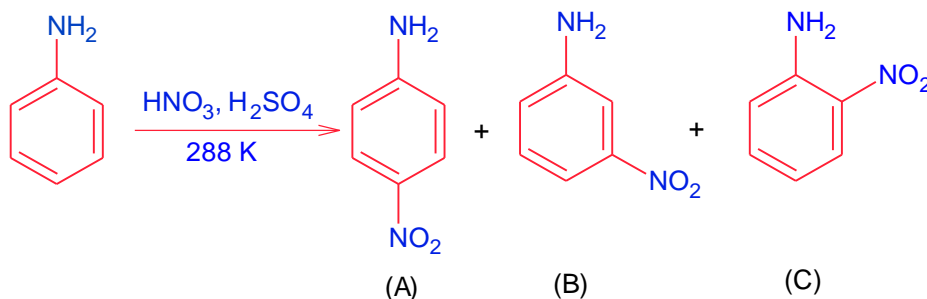
- Q10.** The peak electric field produced by the radiation coming from the 8 W bulb at a distance of 10 m is  $\frac{x}{10} \sqrt{\frac{\mu_0 c}{\pi}} \frac{V}{m}$ . The efficiency of the bulb is 10% and it is a point source. The value of x is.....

# PART – B (CHEMISTRY)

## SECTION – A

- Q1.** Given below are two statements:  
Statement I :  
 $\alpha$  and  $\beta$  forms of sulphur can change reversibly between themselves with slow heating or slow cooling.  
Statement II :  
At room temperature the stable crystalline form of sulphur is monoclinic sulphur.  
In the light of the above statements, choose the correct answer from the options given below :  
(A) Both Statement I and Statement II are false.  
(B) Statement I is true but Statement II is false.  
(C) Both Statement I and Statement II are true.  
(D) Statement I is false but Statement II is true.
- Q2.** Which one of the following statements is FALSE for hydrophilic sols?  
(A) They do not require electrolytes for stability.  
(B) These sols are reversible in nature.  
(C) The sols cannot be easily coagulated.  
(D) Their viscosity is of the order of that  $H_2O$ .
- Q3.** Which among the following species has unequal bond lengths?  
(A)  $SiF_4$  (B)  $BF_4^-$   
(C)  $SF_4$  (D)  $XeF_4$
- Q4.** The correct sequence of reagents used in the preparation of 4-bromo-2-nitroethyl benzene from benzene is :  
(A)  $HNO_3 / H_2SO_4, Br_2 / AlCl_3, CH_3COCl / AlCl_3, Zn - Hg / HCl$   
(B)  $CH_3COCl / AlCl_3, Br_2 / AlBr_3, HNO_3 / H_2SO_4, Zn / HCl$   
(C)  $Br_2 / AlBr_3, CH_3COCl / AlCl_3, HNO_3 / H_2SO_4, Zn / HCl$   
(D)  $CH_3COCl / AlCl_3, Zn - Hg / HCl, Br_2 / AlBr_3, HNO_3 / H_2SO_4$
- Q5.** The solubility of  $Ca(OH)_2$  in water is :  
[Given : The solubility product of  $Ca(OH)_2$  in water =  $5.5 \times 10^{-6}$ ]  
(A)  $1.77 \times 10^{-2}$  (B)  $1.77 \times 10^{-6}$   
(C)  $1.11 \times 10^{-2}$  (D)  $1.11 \times 10^{-6}$

**Q6.**



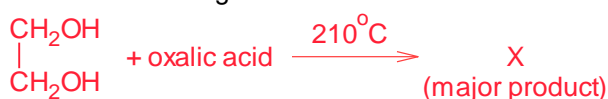
Correct statement about the given chemical reaction is :

- (A)  $-\ddot{N}H_2$  group is ortho and para directive, so product (B) is not possible.  
(B) The reaction will form sulphonated product instead of nitration.  
(C) Reaction is possible and compound (A) will be major product.  
(D) Reaction is possible and compound (B) will be the major product.
- Q7.** The method used for the purification of Indium is :  
(A) van Arkel method (B) liquation  
(C) vapour phase refining (D) zone refining

**Q8.** In which of the following order the given complex ions are arranged correctly with respect to their decreasing spin only magnetic moment?

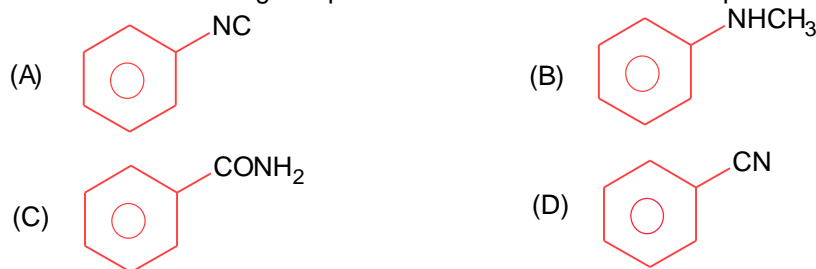
- (i)  $[\text{FeF}_6]^{3-}$ , (ii)  $[\text{Co}(\text{NH}_3)_6]^{3+}$ , (iii)  $[\text{NiCl}_4]^{2-}$ , (iv)  $[\text{Cu}(\text{NH}_3)_4]^{2+}$   
 (A) (ii) > (i) > (iii) > (iv) (B) (i) > (iii) > (iv) > (ii)  
 (C) (ii) > (iii) > (i) > (iv) (D) (iii) > (iv) > (ii) > (i)

**Q9.** What is 'X' in the given reaction?



- (A)  $\begin{array}{c} \text{CH}-\text{OH} \\ || \\ \text{CH}_2 \end{array}$  (B)  $\begin{array}{c} \text{CHO} \\ | \\ \text{CHO} \end{array}$   
 (C)  $\begin{array}{c} \text{CH}_2 \\ || \\ \text{CH}_2 \end{array}$  (D)  $\begin{array}{c} \text{CH}_2\text{OH} \\ | \\ \text{CHO} \end{array}$

**Q10.** Carbylamine test is used to detect the presence of primary amino group in an organic compound. Which of the following compound is formed when this test is performed with aniline?



**Q11.** The correct order of bond dissociation enthalpy of halogens is :

- (A)  $\text{Cl}_2 > \text{Br}_2 > \text{F}_2 > \text{I}_2$  (B)  $\text{Cl}_2 > \text{F}_2 > \text{Br}_2 > \text{I}_2$   
 (C)  $\text{I}_2 > \text{Br}_2 > \text{Cl}_2 > \text{F}_2$  (D)  $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$

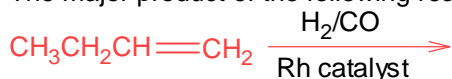
**Q12.** Which of the following compound is added to the sodium extract before addition of silver nitrate for testing of halogens?

- (A) Sodium hydroxide (B) Hydrochloric acid  
 (C) Nitric acid (D) Ammonia

**Q13.** The major components of German Silver are :

- (A) Cu, Zn and Ag (B) Ge, Cu and Ag  
 (C) Cu, Zn and Ni (D) Zn, Ni and Ag

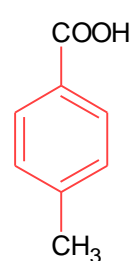
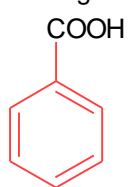
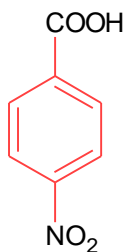
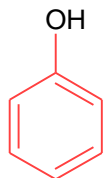
**Q14.** The major product of the following reaction is :



- (A)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$  (B)  $\begin{array}{c} \text{CH}_3\text{CH}_2\text{C}=\text{CH}_2 \\ | \\ \text{CHO} \end{array}$   
 (C)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$  (D)  $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}-\text{CHO}$



Q15. The correct order of acid character of the following compounds is :



- (A) III > II > I > IV  
(C) I > II > III > IV

- (B) II > III > IV > I  
(D) IV > III > II > I

Q16. Given below are two statements :

Statement I :

The pH of rain water is normally ~5.6

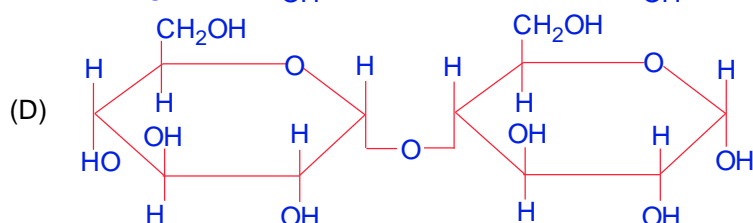
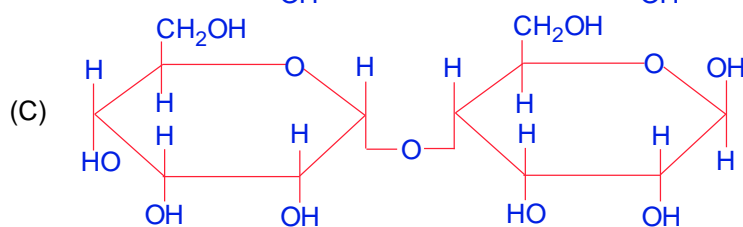
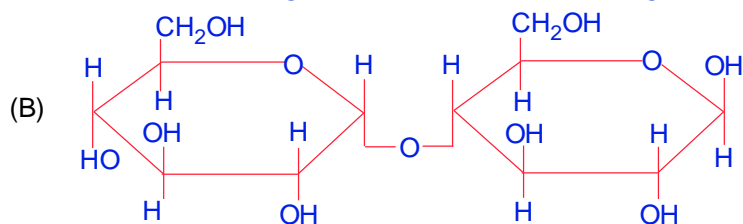
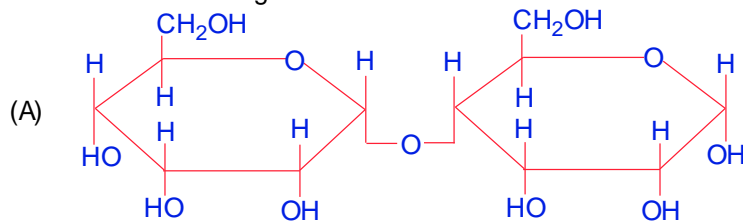
Statement II :

If the pH of rain water drops below 5.6, it is called acid rain.

In the light of the above statements, choose the correct answer from the options given below :

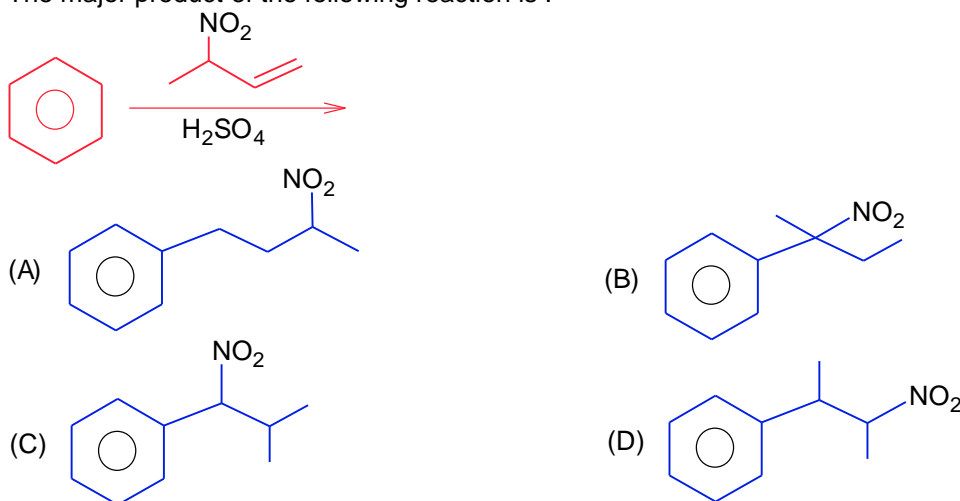
- (A) Statement I is false but Statement II is true.  
(B) Both Statement I and Statement II are true.  
(C) Both Statement I and Statement II are false.  
(D) Statement I is true but Statement II is false.

Q17. Which of the following is correct structure of  $\alpha$ -anomer of maltose?



- Q18.** Given below are two statements :  
 Statement I :  
 The identification of  $\text{Ni}^{2+}$  is carried out by dimethyl glyoxime in the presence of  $\text{NH}_4\text{OH}$ .  
 Statement II :  
 The dimethyl glyoxime is a bidentate neutral ligand.  
 In the light of the above statements, choose the correct answer from the options given below :  
 (A) Both Statement I and Statement II are true.  
 (B) Statement I is false but Statement II is true.  
 (C) Both Statement I and Statement II are false.  
 (D) Statement I is true but Statement II is false.
- Q19.** Water does not produce CO on reacting with :  
 (A)  $\text{C}_3\text{H}_8$  (B)  $\text{CO}_2$   
 (C)  $\text{CH}_4$  (D) C

- Q20.** The major product of the following reaction is :



### SECTION – B

- Q1.** Copper reduces  $\text{NO}_3^-$  into NO and  $\text{NO}_2$  depending upon the concentration of  $\text{HNO}_3$  in solution. (Assuming fixed  $[\text{Cu}^{2+}]$  and  $P_{\text{NO}} = P_{\text{NO}_2}$ ), the  $\text{HNO}_3$  concentration at which the thermodynamic tendency for reduction of  $\text{NO}_3^-$  into NO and  $\text{NO}_2$  by copper is same is  $10^x$  M. The value of  $2x$  is.....(Rounded-off to the nearest integer).  
 [Given,  $E_{\text{Cu}^{2+}/\text{Cu}}^{\circ} = 0.34$  V,  $E_{\text{NO}_3^-/\text{NO}}^{\circ} = 0.96$  V,  $E_{\text{NO}_3^-/\text{NO}_2}^{\circ} = 0.79$  V and at 298 K,  $\frac{RT}{F}(2.303) = 0.059$ ]
- Q2.** The rate constant of a reaction increases by five times on increase in temperature from  $27^\circ\text{C}$  to  $52^\circ\text{C}$ . The value of activation energy in  $\text{kJ mol}^{-1}$  is ..... (Rounded-off to the nearest integer).  
 [  $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$  ]
- Q3.** The unit cell of copper corresponds to a face centered cube of edge length  $3.596 \text{ \AA}$  with one copper atom at each lattice point. The calculated density of copper in  $\text{kg/m}^3$  is.....  
 [Molar mass of Cu = 63.54 g : Avogadro Number =  $6.022 \times 10^{23}$ ]
- Q4.** Five moles of an ideal gas at 293 K is expanded isothermally from an initial pressure of 2.1 MPa to 1.3 MPa against at constant external pressure 4.3 MPa. The heat transferred in this process is.....  $\text{kJ mol}^{-1}$ . (Rounded-off to the nearest integer).  
 [Use  $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ ]
- Q5.** If a compound AB dissociates to the extent of 75% in an aqueous solution, the molality of the solution which shows a 2.5 K rise in the boiling point of the solution is.....molal. (Rounded-off to the nearest integer).  
 [ $K_b = 0.52 \text{ K kg mol}^{-1}$ ]

- Q6.** Consider titration of NaOH solution versus 1.25 M oxalic acid solution. At the end point following burette readings were obtained.
- (i) 4.5 mL (ii) 4.5 mL (iii) 4.4 mL  
(iv) 4.4 mL (v) 4.4 mL
- If the volume of oxalic acid taken was 10.0 mL then the molarity of the NaOH solution is.....M. (Rounded-off to the nearest integer).
- Q7.** The number of compound/s given below which contain/s – COOH group is.....  
(Integer answer)
- (A) Sulphanilic acid (B) Picric acid  
(C) Aspirin (D) Ascorbic acid
- Q8.** Electromagnetic radiation of wavelength 663 nm is just sufficient to ionise the atom of metal A. The ionization energy of metal A in  $\text{kJ mol}^{-1}$  is.....(Rounded-off to the nearest integer)  
 $[h = 6.63 \times 10^{-34} \text{ Js}, c = 3.00 \times 10^8 \text{ ms}^{-1}, N_A = 6.02 \times 10^{23} \text{ mol}^{-1}]$
- Q9.** Among the following, number of metal/s which can be used as electrodes in the photoelectric cell is.....  
(Integer answer)
- (A) Li (B) Na  
(C) Rb (D) Cs
- Q10.** The spin only magnetic moment of a divalent ion in aqueous solution (atomic number 29) is.....BM.

# PART-C (MATHEMATICS)

## SECTION – A

- Q1.** Let  $\alpha$  and  $\beta$  be the roots of  $x^2 - 6x - 2 = 0$ . If  $a_n = \alpha^n - \beta^n$  for  $n \geq 1$ , then the value of  $\frac{a_{10} - 2a_8}{3a_9}$  is:
- (A) 2 (B) 1  
(C) 4 (D) 3
- Q2.** The following system of linear equations
- $$2x + 3y + 2z = 9$$
- $$3x + 2y + 2z = 9$$
- $$x - y + 4z = 8$$
- (A) has a unique solution  
(B) has a solution  $(\alpha, \beta, \gamma)$  satisfying  $\alpha + \beta^2 + \gamma^3 = 12$   
(C) has infinitely many solutions  
(D) does not have any solution
- Q3.** If  $I_n = \int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \cot^n x \, dx$ , then :
- (A)  $\frac{1}{I_2 + I_4}, \frac{1}{I_3 + I_5}, \frac{1}{I_4 + I_6}$  are in G.P. (B)  $\frac{1}{I_2 + I_4}, \frac{1}{I_3 + I_5}, \frac{1}{I_4 + I_6}$  are in A.P.  
(C)  $I_2 + I_4, I_3 + I_5, I_4 + I_6$  are in A.P. (D)  $I_2 + I_4, (I_3 + I_5)^2, I_4 + I_6$  are in G.P.
- Q4.** If the curve  $x^2 + 2y^2 = 2$  intersects the line  $x + y = 1$  at two points P and Q, then the angle subtended by the line segment PQ at the origin is :
- (A)  $\frac{\pi}{2} - \tan^{-1}\left(\frac{1}{4}\right)$  (B)  $\frac{\pi}{2} + \tan^{-1}\left(\frac{1}{4}\right)$   
(C)  $\frac{\pi}{2} - \tan^{-1}\left(\frac{1}{3}\right)$  (D)  $\frac{\pi}{2} + \tan^{-1}\left(\frac{1}{3}\right)$
- Q5.** If  $\alpha, \beta \in \mathbb{R}$  are such that  $1 - 2i$  (here  $i^2 = -1$ ) is a root of  $z^2 + \alpha z + \beta = 0$ , then  $(\alpha - \beta)$  is equal to :
- (A) -3 (B) 3  
(C) 7 (D) -7
- Q6.** If  $0 < x, y < \pi$  and  $\cos x + \cos y - \cos(x + y) = \frac{3}{2}$ , then  $\sin x + \cos y$  is equal to :
- (A)  $\frac{\sqrt{3}}{2}$  (B)  $\frac{1 - \sqrt{3}}{2}$   
(C)  $\frac{1 + \sqrt{3}}{2}$  (D)  $\frac{1}{2}$

- Q7.** A hyperbola passes through the foci of the ellipse  $\frac{x^2}{25} + \frac{y^2}{16} = 1$  and its transverse and conjugate axes coincide with major and minor axes of the ellipse, respectively. If the product of their eccentricities is one, then the equation of the hyperbola is :
- (A)  $x^2 - y^2 = 9$  (B)  $\frac{x^2}{9} - \frac{y^2}{16} = 1$   
 (C)  $\frac{x^2}{9} - \frac{y^2}{25} = 1$  (D)  $\frac{x^2}{9} - \frac{y^2}{4} = 1$
- Q8.** The contrapositive of the statement "If you will work, you will earn money" is :
- (A) If you will earn money, you will work  
 (B) To earn money, you need to work  
 (C) You will earn money, if you will not work  
 (D) If you will not earn money, you will not work
- Q9.** Let  $x$  denote the total number of one-one functions from a set  $A$  with 3 elements to a set  $B$  with 5 elements and  $y$  denote the total number of one-one functions from the set  $A$  to the set  $A \times B$ . Then :
- (A)  $2y = 273x$  (B)  $2y = 91x$   
 (C)  $y = 91x$  (D)  $y = 273x$
- Q10.**  $\operatorname{cosec}\left[2\cot^{-1}(5) + \cos^{-1}\left(\frac{4}{5}\right)\right]$  is equal to
- (A)  $\frac{65}{33}$  (B)  $\frac{56}{33}$   
 (C)  $\frac{65}{56}$  (D)  $\frac{75}{56}$
- Q11.** The integral  $\int \frac{e^{3\log_e 2x} + 5e^{2\log_e 2x}}{e^{4\log_e x} + 5e^{3\log_e x} - 7e^{2\log_e x}} dx, x > 0$  is equal to :
- (where  $c$  is a constant of integration)
- (A)  $\frac{1}{4} \log_e |x^2 + 5x - 7| + c$  (B)  $4 \log_e |x^2 + 5x - 7| + c$   
 (C)  $\log_e \sqrt{x^2 + 5x - 7} + c$  (D)  $\log_e |x^2 + 5x - 7| + c$
- Q12.** A plane passes through the points  $A(1,2,3)$ ,  $B(2,3,1)$  and  $C(2,4,2)$ . If  $O$  is the origin and  $P$  is  $(2, -1, 1)$ , then the projection of  $\overline{OP}$  on this plane is of length :
- (A)  $\sqrt{\frac{2}{5}}$  (B)  $\sqrt{\frac{2}{3}}$   
 (C)  $\sqrt{\frac{2}{7}}$  (D)  $\sqrt{\frac{2}{11}}$
- Q13.** In a group of 400 people, 160 are smokers and non-vegetarian; 100 are smokers and vegetarian and the remaining 140 are non-smokers and vegetarian. Their chances of getting a particular chest disorder are 35%, 20% and 10% respectively. A person is chosen from the group at random and is found to be suffering from the chest disorder. The probability that the selected person is a smoker and non-vegetarian is:
- (A)  $\frac{56}{85}$  (B)  $\frac{66}{85}$   
 (C)  $\frac{46}{85}$  (D)  $\frac{58}{85}$

- Q14.** The minimum value of  $f(x) = a^{ax} + a^{1-ax}$ , where  $a, x \in \mathbb{R}$  and  $a > 0$ , is equal to :
- (A)  $2a$  (B)  $a + 1$   
 (C)  $2\sqrt{a}$  (D)  $a + \frac{1}{a}$
- Q15.** Let  $A$  be a  $3 \times 3$  matrix with  $\det(A) = 4$ . Let  $R_i$  denote the  $i^{\text{th}}$  row of  $A$ . If a matrix  $B$  is obtained by performing the operation  $R_2 \rightarrow 2R_2 + 5R_3$  on  $2A$ , then  $\det(B)$  is equal to :
- (A) 64 (B) 16  
 (C) 128 (D) 80
- Q16.**  $\lim_{n \rightarrow \infty} \left[ \frac{1}{n} + \frac{n}{(n+1)^2} + \frac{n}{(n+2)^2} + \dots + \frac{n}{(2n-1)^2} \right]$  is equal to :
- (A)  $\frac{1}{3}$  (B)  $\frac{1}{4}$   
 (C) 1 (D)  $\frac{1}{2}$
- Q17.** Let  $A$  be a set of all 4-digit natural numbers whose exactly one digit is 7. Then the probability that a randomly chosen element of  $A$  leaves remainder 2 when divided by 5 is :
- (A)  $\frac{2}{9}$  (B)  $\frac{97}{297}$   
 (C)  $\frac{122}{297}$  (D)  $\frac{1}{5}$
- Q18.** The shortest distance between the line  $x - y = 1$  and the curve  $x^2 = 2y$  is :
- (A) 0 (B)  $\frac{1}{\sqrt{2}}$   
 (C)  $\frac{1}{2}$  (D)  $\frac{1}{2\sqrt{2}}$
- Q19.** If for the matrix,  $A = \begin{bmatrix} 1 & -\alpha \\ \alpha & \beta \end{bmatrix}$ ,  $AA^T = I_2$ , then the value of  $\alpha^4 + \beta^4$  is :
- (A) 3 (B) 4  
 (C) 2 (D) 1
- Q20.** A function  $f(x)$  is given by  $f(x) = \frac{5^x}{5^x + 5}$ , then the sum of the series  $f\left(\frac{1}{20}\right) + f\left(\frac{2}{20}\right) + f\left(\frac{3}{20}\right) + \dots + f\left(\frac{39}{20}\right)$  is equal to :
- (A)  $\frac{39}{2}$  (B)  $\frac{19}{2}$   
 (C)  $\frac{29}{2}$  (D)  $\frac{49}{2}$

**SECTION – B**

- Q1.** A line ' $l$ ' passing through origin is perpendicular to the lines
- $$l_1 : \vec{r} = (3+t)\hat{i} + (-1+2t)\hat{j} + (4+2t)\hat{k}$$
- $$l_2 : \vec{r} = (3+2s)\hat{i} + (3+2s)\hat{j} + (2+s)\hat{k}$$
- If the co-ordinates of the point in the first octant on ' $l_2$ ' at a distance of  $\sqrt{17}$  from the point of intersection of ' $l$ ' and ' $l_1$ ' are  $(a,b,c)$ , then  $18(a + b + c)$  is equal to.....

- Q2.** If  $\lim_{x \rightarrow 0} \frac{ax - (e^{4x} - 1)}{ax(e^{4x} - 1)}$  exists and is equal to  $b$ , then the value of  $a - 2b$  is.....
- Q3.** The total number of two digit numbers 'n', such that  $3^n + 7^n$  is a multiple of 10, is.....
- Q4.** A line is a common tangent to the circle  $(x - 3)^2 + y^2 = 9$  and the parabola  $y^2 = 4x$ . If the two points of contact  $(a, b)$  and  $(c, d)$  are distinct and lie in the first quadrant, then  $2(a + c)$  is equal to.....
- Q5.** If the curve,  $y = y(x)$  represented by the solution of the differential equation  $(2xy^2 - y)dx + xdy = 0$ , passes through the intersection of the lines,  $2x - 3y = 1$  and  $3x + 2y = 8$ , then  $|y(1)|$  is equal to.....
- Q6.** If the remainder when  $x$  is divided by 4 is 3, then the remainder when  $(2020 + x)^{2022}$  is divided by 8 is....
- Q7.** The value of  $\int_{-2}^2 |3x^2 - 3x - 6| dx$  is.....
- Q8.** A function  $f$  is defined on  $[-3, 3]$  as
- $$f(x) = \begin{cases} \min\{|x|, 2 - x^2\}, & -2 \leq x \leq 2 \\ \lceil |x| \rceil, & 2 < |x| \leq 3 \end{cases}$$
- where  $\lceil x \rceil$  denotes the greatest integer  $\leq x$ . The number of points, where  $f$  is not differentiable in  $(-3, 3)$  is.....
- Q9.** If the curves  $x = y^4$  and  $xy = k$  cut at right angles, then  $(4k)^6$  is equal to.....
- Q10.** Let  $\vec{a} = \hat{i} + \alpha\hat{j} + 3\hat{k}$  and  $\vec{b} = 3\hat{i} - \alpha\hat{j} + \hat{k}$ . If the area of the parallelogram whose adjacent sides are represented by the vectors  $\vec{a}$  and  $\vec{b}$  is  $8\sqrt{3}$  square units, then  $\vec{a} \cdot \vec{b}$  is equal to.....