

## PART I : CHEMISTRY

### SECTION – I (Total Marks : 21)

(Single Correct Answer Type)

This section contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

1. Extra pure  $N_2$  can be obtained by heating

- |                       |                 |
|-----------------------|-----------------|
| (A) $NH_3$ with $CuO$ | (B) $NH_4NO_3$  |
| (C) $(NH_4)_2Cr_2O_7$ | (D) $Ba(N_3)_2$ |

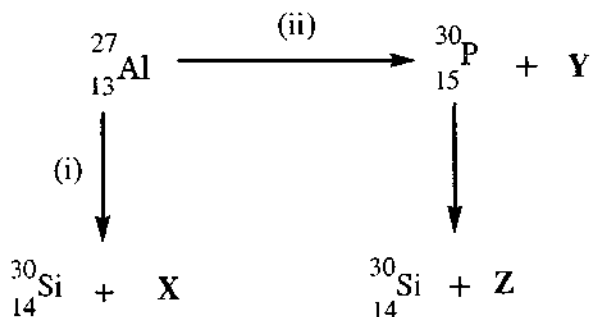
**ANSWER: D**

2. Geometrical shapes of the complexes formed by the reaction of  $Ni^{2+}$  with  $Cl^-$ ,  $CN^-$  and  $H_2O$ , respectively, are

- (A) octahedral, tetrahedral and square planar  
 (B) tetrahedral, square planar and octahedral  
 (C) square planar, tetrahedral and octahedral  
 (D) octahedral, square planar and octahedral

**ANSWER: B**

3. Bombardment of aluminum by  $\alpha$ -particle leads to its artificial disintegration in two ways, (i) and (ii) as shown. Products **X**, **Y** and **Z** respectively are,



- |                               |                               |
|-------------------------------|-------------------------------|
| (A) proton, neutron, positron | (B) neutron, positron, proton |
| (C) proton, positron, neutron | (D) positron, proton, neutron |

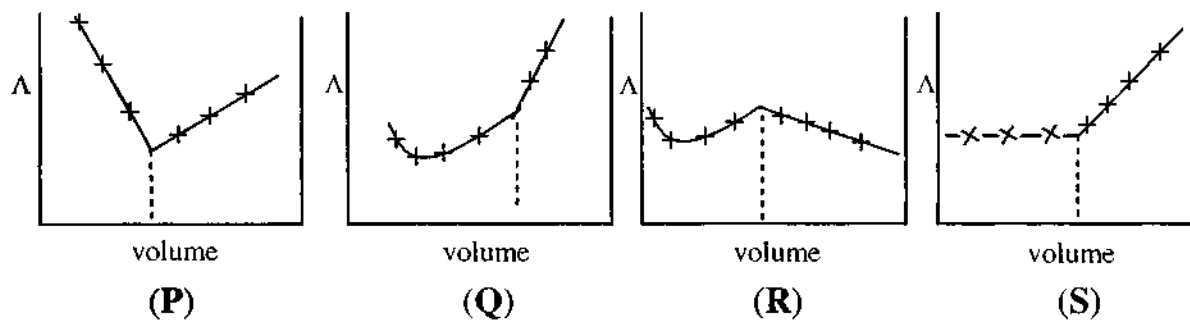
**ANSWER: A**

## CHEMISTRY

4. Dissolving 120 g of urea (mol. wt. 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is
- (A) 1.78 M      (B) 2.00 M      (C) 2.05 M      (D) 2.22 M

**ANSWER: C**

5.  $\text{AgNO}_3$  (aq.) was added to an aqueous  $\text{KCl}$  solution gradually and the conductivity of the solution was measured. The plot of conductance ( $\Lambda$ ) versus the volume of  $\text{AgNO}_3$  is



- (A) (P)      (B) (Q)      (C) (R)      (D) (S)

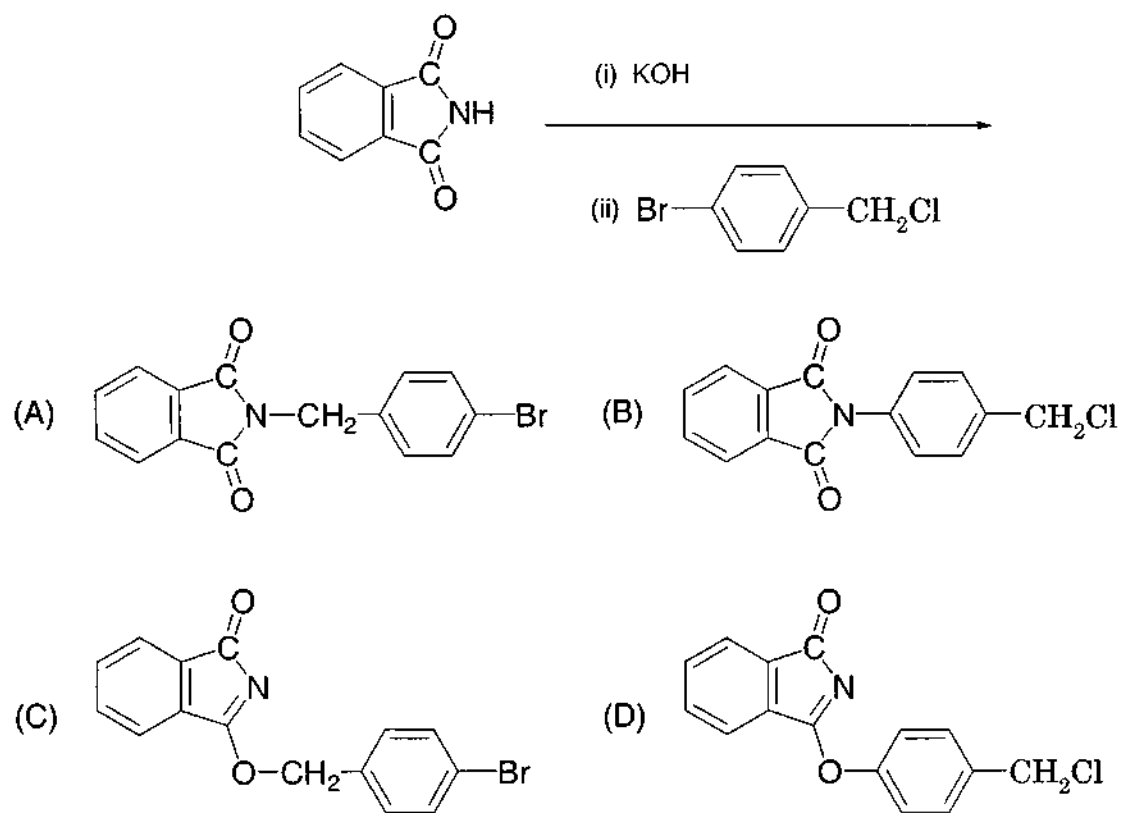
**ANSWER: D**

6. Among the following compounds, the most acidic is

- (A) *p*-nitrophenol      (B) *p*-hydroxybenzoic acid  
 (C) *o*-hydroxybenzoic acid      (D) *p*-toluic acid

**ANSWER: C**

7. The major product of the following reaction is



**ANSWER: A**

**SECTION – II (Total Marks : 16)****(Multiple Correct Answers Type)**

This section contains **4 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE** may be correct.

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8. Extraction of metal from the ore **cassiterite** involves
- (A) carbon reduction of an oxide ore      (B) self-reduction of a sulphide ore  
(C) removal of copper impurity              (D) removal of iron impurity

**ANSWER : AD**

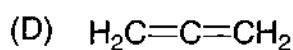
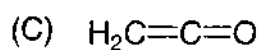
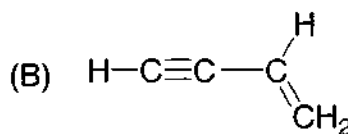
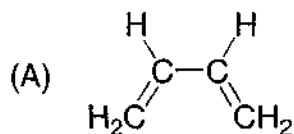
9. The correct statement(s) pertaining to the adsorption of a gas on a solid surface is (are)
- (A) Adsorption is always exothermic.  
(B) Physisorption may transform into chemisorption at high temperature.  
(C) Physisorption increases with increasing temperature but chemisorption decreases with increasing temperature.  
(D) Chemisorption is more exothermic than physisorption, however it is very slow due to higher energy of activation.

**ANSWER : ABD**

10. According to kinetic theory of gases
- (A) collisions are always elastic.
  - (B) heavier molecules transfer more momentum to the wall of the container.
  - (C) only a small number of molecules have very high velocity.
  - (D) between collisions, the molecules move in straight lines with constant velocities.

**ANSWER: ACD**

11. Amongst the given options, the compound(s) in which all the atoms are in one plane in all the possible conformations (if any), is (are)



**ANSWER: BC**

**SECTION – III (Total Marks : 15)****(Paragraph Type)**

This section contains **2 paragraphs**. Based upon one of the paragraphs **3 multiple choice questions** and based on the other paragraph **2 multiple choice questions** have to be answered. Each of these questions has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

**Paragraph for Question Nos. 12 to 14**

When a metal rod **M** is dipped into an aqueous colourless concentrated solution of compound **N**, the solution turns light blue. Addition of aqueous NaCl to the blue solution gives a white precipitate **O**. Addition of aqueous NH<sub>3</sub> dissolves **O** and gives an intense blue solution.

12. The metal rod **M** is

- (A) Fe                      (B) Cu                      (C) Ni                      (D) Co

**ANSWER: B**

13. The compound **N** is

- (A) AgNO<sub>3</sub>                      (B) Zn(NO<sub>3</sub>)<sub>2</sub>  
(C) Al(NO<sub>3</sub>)<sub>3</sub>                      (D) Pb(NO<sub>3</sub>)<sub>2</sub>

**ANSWER: A**

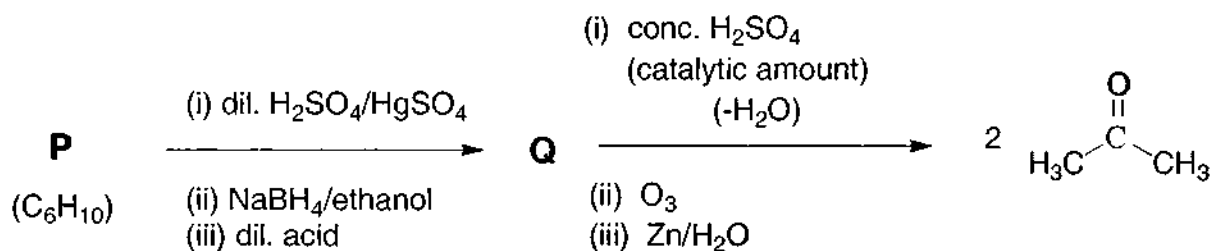
14. The final solution contains

- (A) [Pb(NH<sub>3</sub>)<sub>4</sub>]<sup>2+</sup> and [CoCl<sub>4</sub>]<sup>2-</sup>                      (B) [Al(NH<sub>3</sub>)<sub>4</sub>]<sup>3+</sup> and [Cu(NH<sub>3</sub>)<sub>4</sub>]<sup>2+</sup>  
(C) [Ag(NH<sub>3</sub>)<sub>2</sub>]<sup>+</sup> and [Cu(NH<sub>3</sub>)<sub>4</sub>]<sup>2+</sup>                      (D) [Ag(NH<sub>3</sub>)<sub>2</sub>]<sup>+</sup> and [Ni(NH<sub>3</sub>)<sub>6</sub>]<sup>2+</sup>

**ANSWER: C**

## Paragraph for Question Nos. 15 and 16

An acyclic hydrocarbon **P**, having molecular formula  $C_6H_{10}$ , gave acetone as the only organic product through the following sequence of reactions, in which **Q** is an intermediate organic compound.



15. The structure of compound **P** is



**ANSWER : D**

16. The structure of the compound **Q** is



**ANSWER : B**

**SECTION – IV (Total Marks : 28)****(Integer Answer Type)**

This section contains **7 questions**. The answer to each of the questions is a **single-digit integer**, ranging from 0 to 9. The bubble corresponding to the correct answer is to be darkened in the ORS.

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17. The difference in the oxidation numbers of the two types of sulphur atoms in  $\text{Na}_2\text{S}_4\text{O}_6$  is

**ANSWER: 5**

18. Reaction of  $\text{Br}_2$  with  $\text{Na}_2\text{CO}_3$  in aqueous solution gives sodium bromide and sodium bromate with evolution of  $\text{CO}_2$  gas. The number of sodium bromide molecules involved in the balanced chemical equation is

**ANSWER: 5**

19. The maximum number of electrons that can have principal quantum number,  $n = 3$ , and spin quantum number,  $m_s = -1/2$ , is

**ANSWER: 9**



20. The work function ( $\phi$ ) of some metals is listed below. The number of metals which will show photoelectric effect when light of 300 nm wavelength falls on the metal is

Metal	Li	Na	K	Mg	Cu	Ag	Fe	Pt	W
$\phi$ (eV)	2.4	2.3	2.2	3.7	4.8	4.3	4.7	6.3	4.75

**ANSWER: 4**

21. To an evacuated vessel with movable piston under external pressure of 1 atm., 0.1 mol of He and 1.0 mol of an unknown compound (vapour pressure 0.68 atm. at 0 °C) are introduced. Considering the ideal gas behaviour, the total volume (in litre) of the gases at 0 °C is close to

**ANSWER: 7**

22. The total number of alkenes possible by dehydrobromination of 3-bromo-3-cyclopentylhexane using alcoholic KOH is

**ANSWER: 5**

23. A decapeptide (Mol. Wt. 796) on complete hydrolysis gives glycine (Mol. Wt. 75), alanine and phenylalanine. Glycine contributes 47.0 % to the total weight of the hydrolysed products. The number of glycine units present in the decapeptide is

**ANSWER: 6**

## PART II : PHYSICS

### SECTION – I (Total Marks : 21)

(Single Correct Answer Type)

This section contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

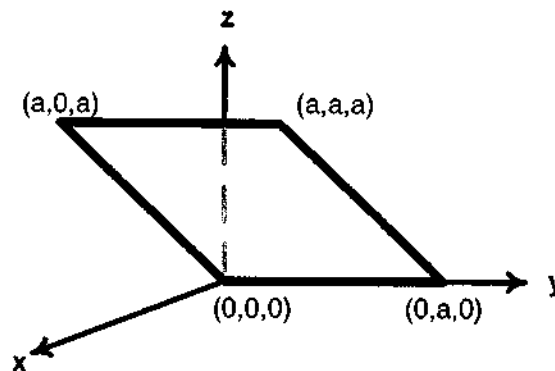
24. A police car with a siren of frequency 8 kHz is moving with uniform velocity 36 km/hr towards a tall building which reflects the sound waves. The speed of sound in air is 320 m/s. The frequency of the siren heard by the car driver is
- (A) 8.50 kHz      (B) 8.25 kHz      (C) 7.75 kHz      (D) 7.50 kHz

**ANSWER: A**

25. 5.6 liter of helium gas at STP is adiabatically compressed to 0.7 liter. Taking the initial temperature to be  $T_1$ , the work done in the process is
- (A)  $\frac{9}{8} R T_1$       (B)  $\frac{3}{2} R T_1$       (C)  $\frac{15}{8} R T_1$       (D)  $\frac{9}{2} R T_1$

**ANSWER: A**

26. Consider an electric field  $\vec{E} = E_0 \hat{x}$ , where  $E_0$  is a constant. The flux through the shaded area (as shown in the figure) due to this field is



- (A)  $2E_0a^2$       (B)  $\sqrt{2}E_0a^2$       (C)  $E_0a^2$       (D)  $\frac{E_0a^2}{\sqrt{2}}$

**ANSWER: C**

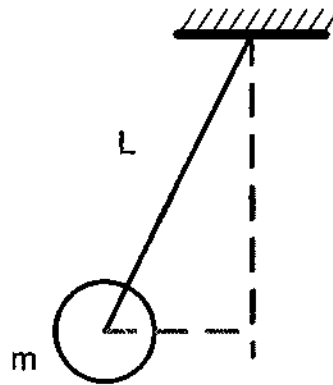
**PHYSICS**

27. The wavelength of the first spectral line in the Balmer series of hydrogen atom is  $6561 \text{ \AA}$ . The wavelength of the second spectral line in the Balmer series of singly-ionized helium atom is

(A)  $1215 \text{ \AA}$       (B)  $1640 \text{ \AA}$       (C)  $2430 \text{ \AA}$       (D)  $4687 \text{ \AA}$

**ANSWER: A**

28. A ball of mass ( $m$ )  $0.5 \text{ kg}$  is attached to the end of a string having length ( $L$ )  $0.5 \text{ m}$ . The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is  $324 \text{ N}$ . The maximum possible value of angular velocity of ball (in radian/s) is

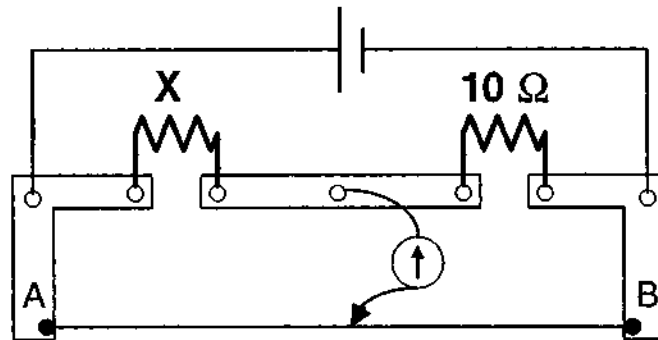


(A) 9      (B) 18      (C) 27      (D) 36

**ANSWER: D**

**PHYSICS**

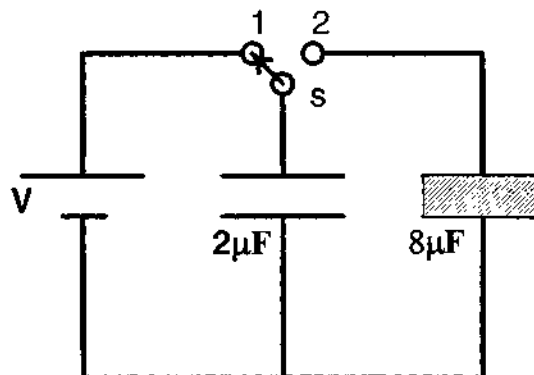
29. A meter bridge is set-up as shown, to determine an unknown resistance 'X' using a standard 10 ohm resistor. The galvanometer shows null point when tapping-key is at 52 cm mark. The end-corrections are 1 cm and 2 cm respectively for the ends A and B. The determined value of 'X' is



- (A) 10.2 ohm      (B) 10.6 ohm      (C) 10.8 ohm      (D) 11.1 ohm

**ANSWER: B**

30. A  $2 \mu\text{F}$  capacitor is charged as shown in figure. The percentage of its stored energy dissipated after the switch S is turned to position 2 is



- (A) 0%      (B) 20%      (C) 75%      (D) 80%

**ANSWER: D**

**SECTION – II (Total Marks : 16)****(Multiple Correct Answers Type)**

This section contains **4 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE** may be correct.

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31. A spherical metal shell A of radius  $R_A$  and a solid metal sphere B of radius  $R_B (< R_A)$  are kept far apart and each is given charge '+Q'. Now they are connected by a thin metal wire. Then

(A)  $E_A^{inside} = 0$

(B)  $Q_A > Q_B$

(C)  $\frac{\sigma_A}{\sigma_B} = \frac{R_B}{R_A}$

(D)  $E_A^{on\ surface} < E_B^{on\ surface}$

**ANSWER: ABCD**

32. An electron and a proton are moving on straight parallel paths with same velocity. They enter a semi-infinite region of uniform magnetic field perpendicular to the velocity. Which of the following statement(s) is/are true?

(A) They will never come out of the magnetic field region.

(B) They will come out travelling along parallel paths.

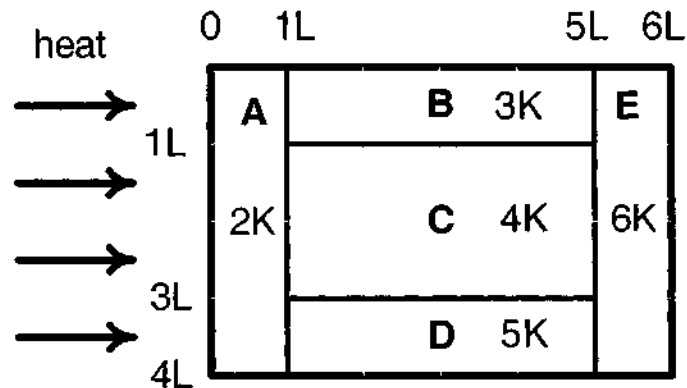
(C) They will come out at the same time.

(D) They will come out at different times.

**ANSWER: BC, BD, BCD**

## PHYSICS

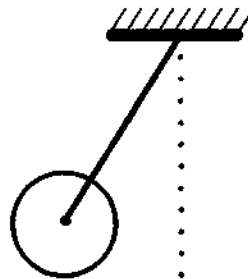
33. A composite block is made of slabs A, B, C, D and E of different thermal conductivities (given in terms of a constant  $K$ ) and sizes (given in terms of length,  $L$ ) as shown in the figure. All slabs are of same width. Heat ' $Q$ ' flows only from left to right through the blocks. Then in steady state



- (A) heat flow through A and E slabs are same.  
 (B) heat flow through slab E is maximum.  
 (C) temperature difference across slab E is smallest.  
 (D) heat flow through C = heat flow through B + heat flow through D.

**ANSWER : ACD**

34. A metal rod of length ' $L$ ' and mass ' $m$ ' is pivoted at one end. A thin disk of mass ' $M$ ' and radius ' $R$ ' ( $< L$ ) is attached at its center to the free end of the rod. Consider two ways the disc is attached: (case A) The disc is not free to rotate about its center and (case B) the disc is free to rotate about its center. The rod-disk system performs SHM in vertical plane after being released from the same displaced position. Which of the following statement(s) is (are) true?



- (A) Restoring torque in case A = Restoring torque in case B  
 (B) Restoring torque in case A < Restoring torque in case B  
 (C) Angular frequency for case A > Angular frequency for case B.  
 (D) Angular frequency for case A < Angular frequency for case B.

**ANSWER : AD**

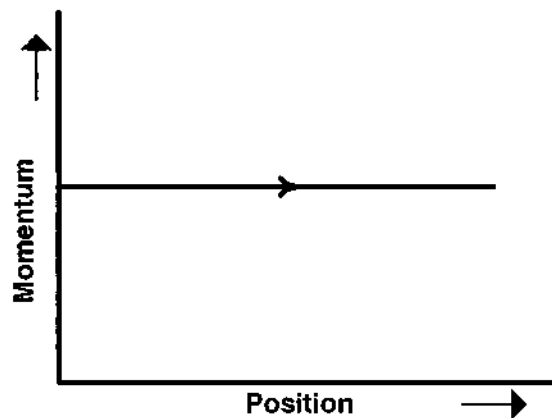
**SECTION – III (Total Marks : 15)**  
**(Paragraph Type)**

This section contains **2 paragraphs**. Based upon one of the paragraphs **3 multiple choice questions** and based on the other paragraph **2 multiple choice questions** have to be answered. Each of these questions has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

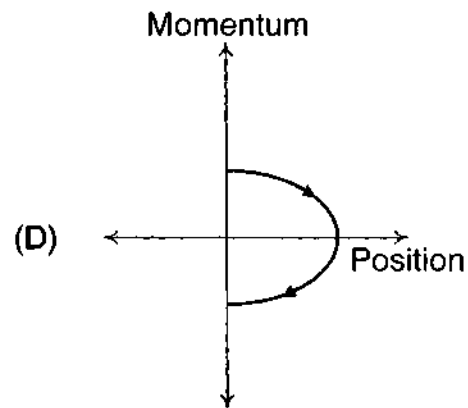
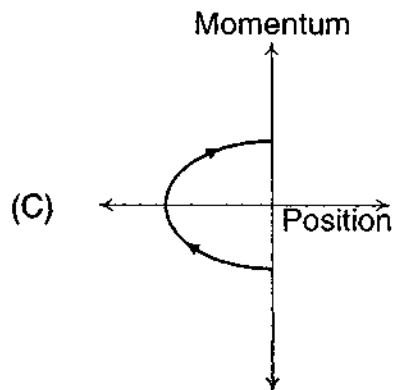
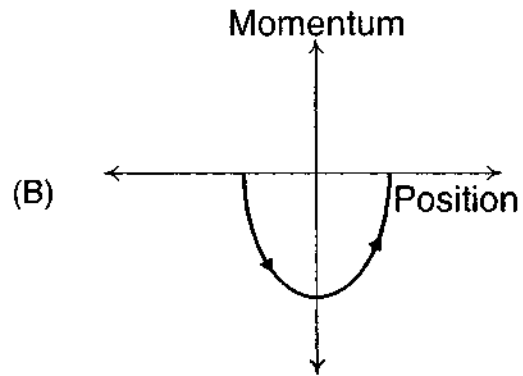
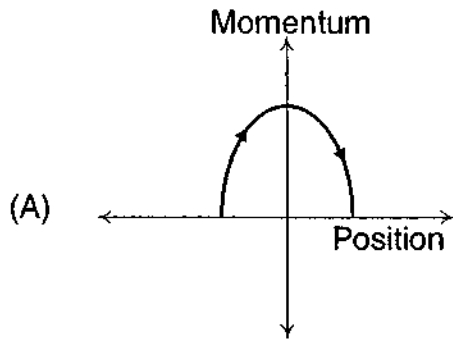
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**Paragraph for Question Nos. 35 to 37**

Phase space diagrams are useful tools in analyzing all kinds of dynamical problems. They are especially useful in studying the changes in motion as initial position and momentum are changed. Here we consider some simple dynamical systems in one-dimension. For such systems, phase space is a plane in which position is plotted along horizontal axis and momentum is plotted along vertical axis. The phase space diagram is  $x(t)$  vs.  $p(t)$  curve in this plane. The arrow on the curve indicates the time flow. For example, the phase space diagram for a particle moving with constant velocity is a straight line as shown in the figure. We use the sign convention in which position or momentum upwards (or to right) is positive and downwards (or to left) is negative.



35. The phase space diagram for a ball thrown vertically up from ground is

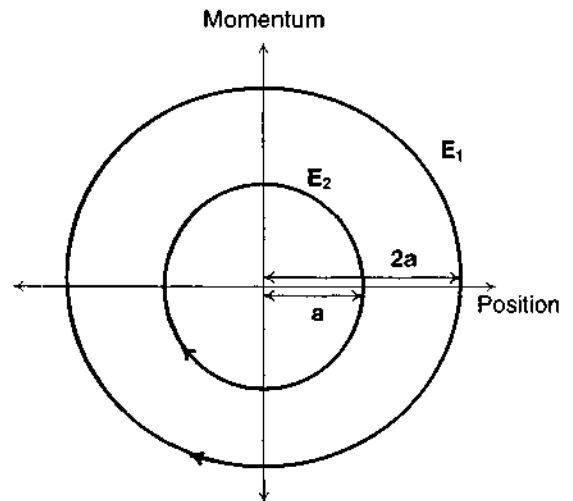


**ANSWER: D**



**PHYSICS**

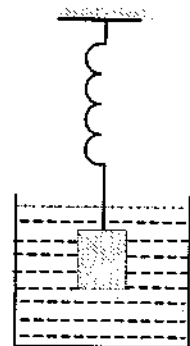
36. The phase space diagram for simple harmonic motion is a circle centered at the origin. In the figure, the two circles represent the same oscillator but for different initial conditions, and  $E_1$  and  $E_2$  are the total mechanical energies respectively. Then



- (A)  $E_1 = \sqrt{2} E_2$       (B)  $E_1 = 2 E_2$   
 (C)  $E_1 = 4 E_2$       (D)  $E_1 = 16 E_2$

**ANSWER: C**

37. Consider the spring-mass system, with the mass submerged in water, as shown in the figure. The phase space diagram for one cycle of this system is



- (A) (B)
- (C) (D)

**ANSWER: B**

## Paragraph for Question Nos. 38 and 39

A dense collection of equal number of electrons and positive ions is called neutral plasma. Certain solids containing fixed positive ions surrounded by free electrons can be treated as neutral plasma. Let 'N' be the number density of free electrons, each of mass 'm'. When the electrons are subjected to an electric field, they are displaced relatively away from the heavy positive ions. If the electric field becomes zero, the electrons begin to oscillate about the positive ions with a natural angular frequency ' $\omega_p$ ', which is called the plasma frequency. To sustain the oscillations, a time varying electric field needs to be applied that has an angular frequency  $\omega$ , where a part of the energy is absorbed and a part of it is reflected. As  $\omega$  approaches  $\omega_p$ , all the free electrons are set to resonance together and all the energy is reflected. This is the explanation of high reflectivity of metals.

38. Taking the electronic charge as ' $e$ ' and the permittivity as ' $\epsilon_0$ ', use dimensional analysis to determine the correct expression for  $\omega_p$ .

(A)  $\sqrt{\frac{Ne}{m\epsilon_0}}$       (B)  $\sqrt{\frac{m\epsilon_0}{Ne}}$       (C)  $\sqrt{\frac{Ne^2}{m\epsilon_0}}$       (D)  $\sqrt{\frac{m\epsilon_0}{Ne^2}}$

**ANSWER: C**

39. Estimate the wavelength at which plasma reflection will occur for a metal having the density of electrons  $N \approx 4 \times 10^{27} \text{ m}^{-3}$ . Take  $\epsilon_0 \approx 10^{-11}$  and  $m \approx 10^{-30}$ , where these quantities are in proper SI units.

(A) 800 nm      (B) 600 nm      (C) 300 nm      (D) 200 nm

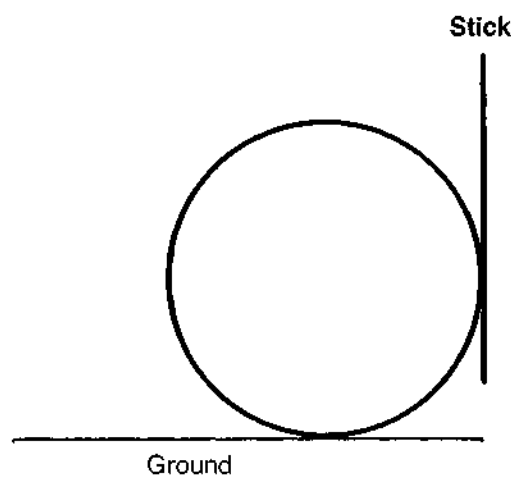
**ANSWER: B**

**SECTION – IV (Total Marks : 28)****(Integer Answer Type)**

This section contains **7 questions**. The answer to each of the questions is a **single-digit integer**, ranging from 0 to 9. The bubble corresponding to the correct answer is to be darkened in the ORS.

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40. A boy is pushing a ring of mass 2 kg and radius 0.5 m with a stick as shown in the figure. The stick applies a force of 2 N on the ring and rolls it without slipping with an acceleration of  $0.3 \text{ m/s}^2$ . The coefficient of friction between the ground and the ring is large enough that rolling always occurs and the coefficient of friction between the stick and the ring is  $(P/10)$ . The value of P is

**ANSWER: 4**

41. A block is moving on an inclined plane making an angle  $45^\circ$  with the horizontal and the coefficient of friction is  $\mu$ . The force required to just push it up the inclined plane is 3 times the force required to just prevent it from sliding down. If we define  $N = 10 \mu$ , then N is

**ANSWER: 5**

42. Four point charges, each of  $+q$ , are rigidly fixed at the four corners of a square planar soap film of side ' $a$ '. The surface tension of the soap film is  $\gamma$ . The system of charges and planar film are in equilibrium, and  $a = k \left[ \frac{q^2}{\gamma} \right]^{1/N}$ , where ' $k$ ' is a constant. Then  $N$  is

**ANSWER: 3**

43. Steel wire of length ' $L$ ' at  $40^\circ\text{C}$  is suspended from the ceiling and then a mass ' $m$ ' is hung from its free end. The wire is cooled down from  $40^\circ\text{C}$  to  $30^\circ\text{C}$  to regain its original length ' $L$ '. The coefficient of linear thermal expansion of the steel is  $10^{-5} / ^\circ\text{C}$ , Young's modulus of steel is  $10^{11} \text{ N/m}^2$  and radius of the wire is 1 mm. Assume that  $L \gg$  diameter of the wire. Then the value of ' $m$ ' in kg is nearly

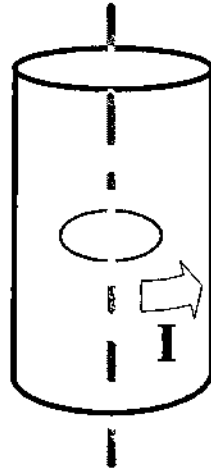
**ANSWER: 3**

44. The activity of a freshly prepared radioactive sample is  $10^{10}$  disintegrations per second, whose mean life is  $10^9$  s. The mass of an atom of this radioisotope is  $10^{-25}$  kg. The mass (in mg) of the radioactive sample is

**ANSWER: 1**

<b>PHYSICS</b>
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45. A long circular tube of length 10 m and radius 0.3 m carries a current  $I$  along its curved surface as shown. A wire-loop of resistance 0.005 ohm and of radius 0.1 m is placed inside the tube with its axis coinciding with the axis of the tube. The current varies as  $I = I_0 \cos(300t)$  where  $I_0$  is constant. If the magnetic moment of the loop is  $N \mu_0 I_0 \sin(300t)$ , then 'N' is



**ANSWER: 6**

46. Four solid spheres each of diameter  $\sqrt{5}$  cm and mass 0.5 kg are placed with their centers at the corners of a square of side 4 cm. The moment of inertia of the system about the diagonal of the square is  $N \times 10^{-4} \text{ kg-m}^2$ , then N is

**ANSWER: 9**

## PART III : MATHEMATICS

### SECTION – I (Total Marks : 21)

(Single Correct Answer Type)

This section contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

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47. Let  $(x_0, y_0)$  be the solution of the following equations

$$\begin{aligned}(2x)^{\ln 2} &= (3y)^{\ln 3} \\ 3^{\ln x} &= 2^{\ln y}.\end{aligned}$$

Then  $x_0$  is

- (A)  $\frac{1}{6}$                       (B)  $\frac{1}{3}$                       (C)  $\frac{1}{2}$                       (D) 6

**ANSWER : C**

48. The value of  $\int_{\sqrt{\ln 2}}^{\sqrt{\ln 3}} \frac{x \sin x^2}{\sin x^2 + \sin(\ln 6 - x^2)} dx$  is

- (A)  $\frac{1}{4} \ln \frac{3}{2}$                       (B)  $\frac{1}{2} \ln \frac{3}{2}$   
(C)  $\ln \frac{3}{2}$                       (D)  $\frac{1}{6} \ln \frac{3}{2}$

**ANSWER : A**

49. Let  $\vec{a} = \hat{i} + \hat{j} + \hat{k}$ ,  $\vec{b} = \hat{i} - \hat{j} + \hat{k}$  and  $\vec{c} = \hat{i} - \hat{j} - \hat{k}$  be three vectors. A vector  $\vec{v}$  in the plane of  $\vec{a}$  and  $\vec{b}$ , whose projection on  $\vec{c}$  is  $\frac{1}{\sqrt{3}}$ , is given by

- (A)  $\hat{i} - 3\hat{j} + 3\hat{k}$  (B)  $-3\hat{i} - 3\hat{j} - \hat{k}$   
 (C)  $3\hat{i} - \hat{j} + 3\hat{k}$  (D)  $\hat{i} + 3\hat{j} - 3\hat{k}$

**ANSWER: C**

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

- (A)  $P \subset Q$  and  $Q - P \neq \emptyset$  (B)  $Q \not\subset P$   
 (C)  $P \not\subset Q$  (D)  $P = Q$

**ANSWER: D**

51. Let the straight line  $x = b$  divide the area enclosed by  $y = (1 - x)^2$ ,  $y = 0$ , and  $x = 0$  into two parts  $R_1$  ( $0 \leq x \leq b$ ) and  $R_2$  ( $b \leq x \leq 1$ ) such that  $R_1 - R_2 = \frac{1}{4}$ . Then  $b$  equals

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

**ANSWER: B**

52. Let  $\alpha$  and  $\beta$  be the roots of  $x^2 - 6x - 2 = 0$ , with  $\alpha > \beta$ . If  $a_n = \alpha^n - \beta^n$  for  $n \geq 1$ , then the value of  $\frac{a_{10} - 2a_8}{2a_9}$  is

- (A) 1                      (B) 2                      (C) 3                      (D) 4

**ANSWER: C**

53. A straight line  $L$  through the point  $(3, -2)$  is inclined at an angle  $60^\circ$  to the line  $\sqrt{3}x + y = 1$ . If  $L$  also intersects the  $x$ -axis, then the equation of  $L$  is

- (A)  $y + \sqrt{3}x + 2 - 3\sqrt{3} = 0$                       (B)  $y - \sqrt{3}x + 2 + 3\sqrt{3} = 0$   
(C)  $\sqrt{3}y - x + 3 + 2\sqrt{3} = 0$                       (D)  $\sqrt{3}y + x - 3 + 2\sqrt{3} = 0$

**ANSWER: B**



## SECTION – II (Total Marks : 16)

(Multiple Correct Answers Type)

This section contains **4 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE** may be correct.

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54. The vector(s) which is/are coplanar with vectors  $\hat{i} + \hat{j} + 2\hat{k}$  and  $\hat{i} + 2\hat{j} + \hat{k}$ , and perpendicular to the vector  $\hat{i} + \hat{j} + \hat{k}$  is/are

- (A)  $\hat{j} - \hat{k}$       (B)  $-\hat{i} + \hat{j}$       (C)  $\hat{i} - \hat{j}$       (D)  $-\hat{j} + \hat{k}$

**ANSWER: AD**

55. Let  $M$  and  $N$  be two  $3 \times 3$  non-singular skew-symmetric matrices such that  $MN = NM$ . If  $P^T$  denotes the transpose of  $P$ , then  $M^2 N^2 (M^T N)^{-1} (MN^{-1})^T$  is equal to

- (A)  $M^2$       (B)  $-N^2$       (C)  $-M^2$       (D)  $MN$

**ANSWER: MARKS TO ALL**

56. Let the eccentricity of the hyperbola  $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$  be reciprocal to that of the ellipse  $x^2 + 4y^2 = 4$ . If the hyperbola passes through a focus of the ellipse, then

- (A) the equation of the hyperbola is  $\frac{x^2}{3} - \frac{y^2}{2} = 1$   
 (B) a focus of the hyperbola is  $(2, 0)$   
 (C) the eccentricity of the hyperbola is  $\sqrt{\frac{5}{3}}$   
 (D) the equation of the hyperbola is  $x^2 - 3y^2 = 3$

**ANSWER: BD**

57. Let  $f: \mathbb{R} \rightarrow \mathbb{R}$  be a function such that

$$f(x+y) = f(x) + f(y), \quad \forall x, y \in \mathbb{R}.$$

If  $f(x)$  is differentiable at  $x=0$ , then

- (A)  $f(x)$  is differentiable only in a finite interval containing zero
- (B)  $f(x)$  is continuous  $\forall x \in \mathbb{R}$
- (C)  $f'(x)$  is constant  $\forall x \in \mathbb{R}$
- (D)  $f(x)$  is differentiable except at finitely many points

**ANSWER: BC, BCD**

### SECTION – III (Total Marks : 15)

#### (Paragraph Type)

This section contains **2 paragraphs**. Based upon one of the paragraphs **3 multiple choice questions** and based on the other paragraph **2 multiple choice questions** have to be answered. Each of these questions has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

#### Paragraph for Question Nos. 58 to 60

Let  $a$ ,  $b$  and  $c$  be three real numbers satisfying

$$[a \ b \ c] \begin{bmatrix} 1 & 9 & 7 \\ 8 & 2 & 7 \\ 7 & 3 & 7 \end{bmatrix} = [0 \ 0 \ 0] \quad \dots\dots\dots(E)$$

58. If the point  $P(a, b, c)$ , with reference to (E), lies on the plane  $2x + y + z = 1$ , then the value of  $7a + b + c$  is

(A) 0                      (B) 12                      (C) 7                      (D) 6

**ANSWER: D**

59. Let  $\omega$  be a solution of  $x^3 - 1 = 0$  with  $\text{Im}(\omega) > 0$ . If  $a = 2$  with  $b$  and  $c$  satisfying (E), then the value of

$$\frac{3}{\omega^a} + \frac{1}{\omega^b} + \frac{3}{\omega^c}$$

is equal to

(A) -2                      (B) 2                      (C) 3                      (D) -3

**ANSWER: A**

60. Let  $b = 6$ , with  $a$  and  $c$  satisfying (E). If  $\alpha$  and  $\beta$  are the roots of the quadratic equation  $ax^2 + bx + c = 0$ , then

$$\sum_{n=0}^{\infty} \left( \frac{1}{\alpha} + \frac{1}{\beta} \right)^n$$

is

(A) 6                      (B) 7                      (C)  $\frac{6}{7}$                       (D)  $\infty$

**ANSWER: B**

**Paragraph for Question Nos. 61 and 62**

Let  $U_1$  and  $U_2$  be two urns such that  $U_1$  contains 3 white and 2 red balls, and  $U_2$  contains only 1 white ball. A fair coin is tossed. If head appears then 1 ball is drawn at random from  $U_1$  and put into  $U_2$ . However, if tail appears then 2 balls are drawn at random from  $U_1$  and put into  $U_2$ . Now 1 ball is drawn at random from  $U_2$ .

61. The probability of the drawn ball from  $U_2$  being white is

- (A)  $\frac{13}{30}$                       (B)  $\frac{23}{30}$                       (C)  $\frac{19}{30}$                       (D)  $\frac{11}{30}$

**ANSWER: B**

62. Given that the drawn ball from  $U_2$  is white, the probability that head appeared on the coin is

- (A)  $\frac{17}{23}$                       (B)  $\frac{11}{23}$                       (C)  $\frac{15}{23}$                       (D)  $\frac{12}{23}$

**ANSWER: D**

### SECTION – IV (Total Marks : 28)

(Integer Answer Type)

This section contains **7 questions**. The answer to each of the questions is a **single-digit integer**, ranging from 0 to 9. The bubble corresponding to the correct answer is to be darkened in the ORS.

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63. Consider the parabola  $y^2 = 8x$ . Let  $\Delta_1$  be the area of the triangle formed by the end points of its latus rectum and the point  $P\left(\frac{1}{2}, 2\right)$  on the parabola, and  $\Delta_2$  be the area of the triangle formed by drawing tangents at  $P$  and at the end points of the latus rectum. Then  $\frac{\Delta_1}{\Delta_2}$  is

**ANSWER : 2**

64. Let  $a_1, a_2, a_3, \dots, a_{100}$  be an arithmetic progression with  $a_1 = 3$  and  $S_p = \sum_{i=1}^p a_i, 1 \leq p \leq 100$ . For any integer  $n$  with  $1 \leq n \leq 20$ , let  $m = 5n$ . If  $\frac{S_m}{S_n}$  does not depend on  $n$ , then  $a_2$  is

**ANSWER : 3, 9, 3 & 9 BOTH**

65. The positive integer value of  $n > 3$  satisfying the equation

$$\frac{1}{\sin\left(\frac{\pi}{n}\right)} = \frac{1}{\sin\left(\frac{2\pi}{n}\right)} + \frac{1}{\sin\left(\frac{3\pi}{n}\right)}$$

is

**ANSWER : 7**

66. Let  $f : [1, \infty) \rightarrow [2, \infty)$  be a differentiable function such that  $f(1) = 2$ . If

$$6 \int_1^x f(t) dt = 3x f(x) - x^3$$

for all  $x \geq 1$ , then the value of  $f(2)$  is

**ANSWER : MARKS TO ALL**

67. If  $z$  is any complex number satisfying  $|z - 3 - 2i| \leq 2$ , then the minimum value of  $|2z - 6 + 5i|$  is

**ANSWER : 5**

68. The minimum value of the sum of real numbers  $a^{-5}$ ,  $a^{-4}$ ,  $3a^{-3}$ ,  $1$ ,  $a^8$  and  $a^{10}$  with  $a > 0$  is

**ANSWER : 8**

69. Let  $f(\theta) = \sin \left( \tan^{-1} \left( \frac{\sin \theta}{\sqrt{\cos 2\theta}} \right) \right)$ , where  $-\frac{\pi}{4} < \theta < \frac{\pi}{4}$ . Then the value of

$$\frac{d}{d(\tan \theta)} (f(\theta))$$

is

**ANSWER : 1**