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Memory Based
Answers & Solutions

Time : 3 hrs.   *for*   M.M. : 300

JEE (Main)-2022 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1)   The test is of **3 hours** duration.

(2)   The Test Booklet consists of 90 questions. The maximum marks are 300.

(3)   There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.

(i)   **Section-A:** This section contains 20 multiple choice questions which have only one correct answer. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer.

(ii)   **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10.** The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.
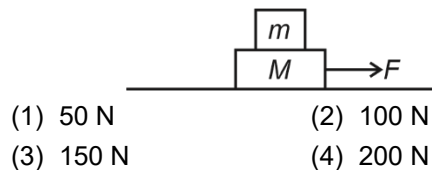
PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.
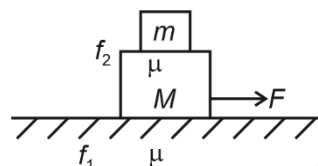
Choose the correct answer:

1. Referring to the diagram friction is present everywhere. Friction coefficient $\mu = 0.5$, $m = 2$ kg and $M = 8$ kg. The maximum value of F for which both of the block move together

   (1) 50 N   (2) 100 N
   (3) 150 N   (4) 200 N

Answer (2)

Sol.

   $m = 2$ kg
   $M = 8$ kg
   m = 0.5
   $(f_1)_{max} = 0.5 \times (10) \times 10 = 50$ N
   $(f_2)_{max} = 0.5 \times 2 \times 10 = 10$ N
   $a_{max} = mg = 0.5 \times 10 = 5$ m/s^2
   $\therefore$ $F_{req} - 50 = (10) \times 5$
   $F_{req} = 100$ N

2. Two columns are given below. Column 1 gives a range of electromagnetic spectrum while column 2 gives possible uses. Match column 1 with column 2.

	Column 1		Column 2
(P)	UV	(A)	Study crystal structure
(Q)	Microwaves	(B)	Greenhouse effect
(R)	Infra-red	(C)	Sterilizing surgical instruments
(S)	X-rays	(D)	Radio signals

   (1) P(C), Q(D), R(B), S(A)
   (2) P(A), Q(B), R(C), S(D)
   (3) P(D), Q(B), R(C), S(A)
   (4) P(C), Q(D), R(A), S(B)

Answer (1)

Sol. Theory based

   X-rays $\rightarrow$ study crystal structure
   Infra-red $\rightarrow$ greenhouse effect
   Microwave $\rightarrow$ communication
   UV $\rightarrow$ for sterilization

3. Measurement of a wire yields the following results:

   Mass = 0.6 ± 0.006 g
   Radius = 0.5 ± 0.005 mm
   Length = 4 ± 0.04 cm

   Find the maximum % error in density of the wire.

   (1) 2%   (2) 3%
   (3) 4%   (4) 5%

Answer (3)

Sol. $\because$ $\rho = \dfrac{m}{\pi r^2 l}$

   $\Rightarrow \dfrac{\Delta \rho}{\rho} = \dfrac{\Delta m}{m} + 2\dfrac{\Delta r}{r} + \dfrac{\Delta l}{l}$

   $= \dfrac{0.006}{0.6} + 2 \times \dfrac{0.005}{0.5} + \dfrac{0.04}{4}$
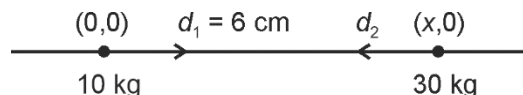
   $= 0.01 + 0.02 + 0.01$

   $= 0.04$

   $\therefore$ % error in ρ = 4%

4. Two blocks 10 kg and 30 kg lies on x-axis at (0,0) and (x, 0) respectively. The block 10 kg is moved on the same line, 6 cm towards the other block. What distance should the other block move to keep the centre of mass of system unchanged?

   (1) 4 cm away from 10 kg block
   (2) 4 cm towards 10 kg block
   (3) 2 cm away from 10 kg block
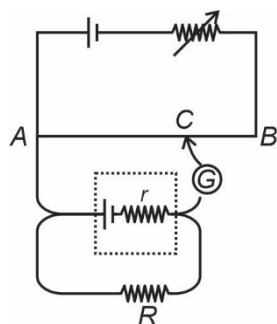   (4) 2 cm towards 10 kg block

Answer (4)

Sol.

   For centre of mass to be at same position,
   $m_1 d_1 = m_2 d_2$
   $\Rightarrow$ $10 \times 6 = 30 \times d_2$
   $\Rightarrow$ $d_2 = 2$ cm towards 10 kg block

5. In an experiment of potentiometer if $R = 8\ \Omega$ then null point AC is equal to 3 m and when $R = 4\ \Omega$ then $AC = 2$ m then value of internal resistance r is.

(1) $3\ \Omega$
(2) $4\ \Omega$
(3) $6\ \Omega$
(4) $8\ \Omega$

Answer (2)

Sol. From potentiometer theory:

$$\frac{3}{(8+r)} = \frac{2}{(4+r)}$$
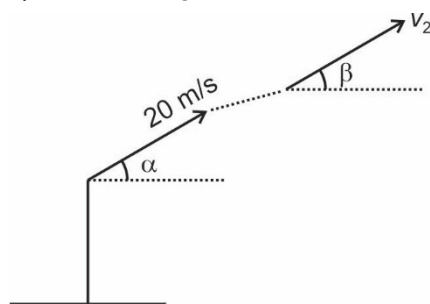
$\Rightarrow\ 12 + 3r = 16 + 2r$

$\Rightarrow\ r = 4\ \Omega$

6. A projectile is projected (from the top of a tower) with velocity 20 m/s at an angle α with the horizontal. After 10 s, the inclination of velocity with the horizontal becomes β. Then the value of $\tan\alpha - \tan\beta$ is (use $g = 10$ m/s^2)

(1) $5\cos\alpha$
(2) $5\sec\alpha$
(3) $6\sin\alpha$
(4) $4\cot\alpha$

Answer (2)

Sol. $v_x = 20\cos\alpha = v_2\cos\beta$

$v_y = 20\sin\alpha - g \times 10$

$\Rightarrow\ \tan\beta = \dfrac{20\sin\alpha - 100}{20\cos\alpha}$

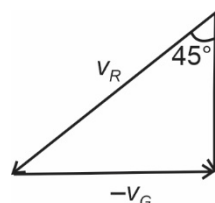$\Rightarrow\ \tan\beta = \tan\alpha - \dfrac{5}{\cos\alpha}$

$\Rightarrow\ \tan\alpha - \tan\beta = \dfrac{5}{\cos\alpha}$

$= 5\sec\alpha$

7. A girl holds an umbrella at an angle of 45° against the rain. Suddenly she starts running at a speed of 25 m/s, now rain is falling vertically towards the girl. Then find the velocity of rain.

(1) 30 m/s
(2) $25\sqrt{2}$ m/s
(3) 50 m/s
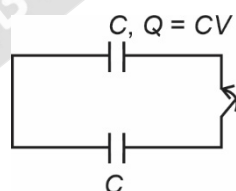(4) $\dfrac{25}{\sqrt{2}}$ m/s

Answer (2)

Sol. $v_G = 25$ m/s

$\Rightarrow\ v_R = v_G \times \sqrt{2}$

$= 25\sqrt{2}$ m/s

8. A capacitor of capacitance C is connected to a source of voltage V. After long time it is disconnected and then connected to a capacitor of same capacitance. The loss of energy in the process after connecting with the capacitor is

(1) $\dfrac{1}{2}CV^2$
(2) $\dfrac{1}{8}CV^2$
(3) $\dfrac{1}{4}CV^2$
(4) CV^2

Answer (3)

Sol.

$\Delta H = U_i - U_f$

$$= \frac{1}{2}CV^2 - \frac{1}{2}(2C)\times\left(\frac{V}{2}\right)^2$$

$$= \frac{1}{2}CV^2 - \frac{1}{4}CV^2$$

$$= \frac{1}{4}CV^2$$

9. An α particle and C^{12} atom has same kinetic energy. Find the ratio of de-Broglie wavelength of α-particle to that of C^{12} atom.

(1) $\sqrt{2}$
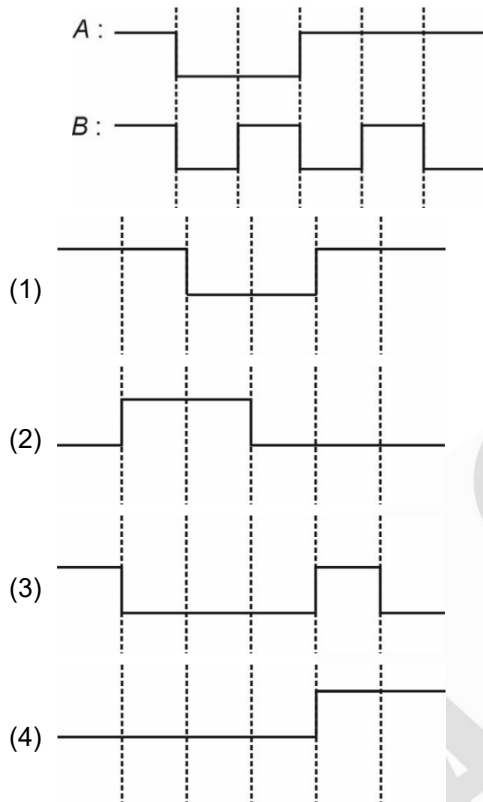(2) $\sqrt{3}$
(3) $\sqrt{5}$
(4) $\sqrt{6}$

Answer (2)

Sol. $\because$ $\lambda = \dfrac{h}{mv} = \dfrac{h}{\sqrt{2m(KE)}}$

$\Rightarrow$ $\dfrac{\lambda_1}{\lambda_2} = \sqrt{\dfrac{m_2}{m_1}}$

$= \sqrt{\dfrac{12}{4}} = \sqrt{3}$

10. Two given inputs (*A* and *B*) are applied to an AND gate. Then choose the correct output waveform.

Answer (3)

Sol. For AND gate, correct output wave form is option (3).

11. A bob is suspended by the means of thread of length 2 m. A bullet of mass 75 gm moving with velocity *v* penetrates through bob. After collision speed of bullet is $\dfrac{v}{3}$ and bob is just able to complete vertical circle. If mass of bob is 50 gm then the value of *v* is
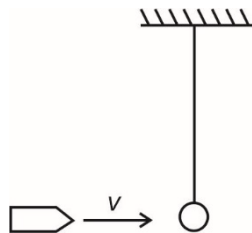
(1) 7.5 m/sec (2) 10 m/sec
(3) 15 m/sec (4) 100 m/sec

Answer (2)

Sol. For the block to complete the vertical circle

$= \sqrt{5gr}$

$= \sqrt{5 \times 10 \times 2}$

$= 10$ m/s

By COLM:

$75 \times V = 50 \times 10 + 75 \times \dfrac{V}{3}$

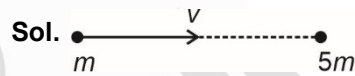$\Rightarrow$ $75 \times \dfrac{2V}{3} = 50 \times 10$

$\Rightarrow$ $V = 10$ m/s

12. A ball of mass *m* moving with speed *v* collides head-on and elastically with another ball of mass 5*m*. Find the absolute % change in kinetic energy of the lighter ball.

(1) 22.22% (2) 44.44%
(3) 66.66% (4) 55.56%

Answer (4)

Sol.

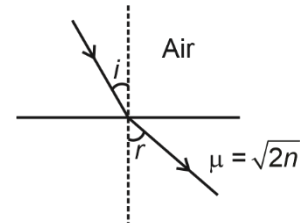Velocity of lighter ball after collision

$= \dfrac{5m - m}{5m + m} \times v$

$= \dfrac{4}{6} \times v = \dfrac{2v}{3}$

$\therefore$ % change in KE $= \dfrac{\dfrac{1}{2}mv^2 - \dfrac{1}{2}m\left(\dfrac{2v}{3}\right)^2}{\dfrac{1}{2}mv^2}$

$= \left(1 - \dfrac{4}{9}\right) \times 100$

$= 55.56\%$

13. For the refraction shown *i* = 2*r* then the value of angle of incidence is

(1) $\cos^{-1}\sqrt{\dfrac{n}{2}}$ (2) $\cos^{-1}\left(\sqrt{2n}\right)$
(3) $2\cos^{-1}\sqrt{\dfrac{n}{2}}$ (4) $2\cos^{-1}\left(\sqrt{2n}\right)$

Answer (3)

Sol. $\sin i = \sqrt{2n} \sin r$

and $i = 2r$

$\Rightarrow \quad \sin i = \sqrt{2n} \times \sin\left(\dfrac{i}{2}\right)$

$\Rightarrow \quad 2\sin\left(\dfrac{i}{2}\right)\cos\left(\dfrac{i}{2}\right) = \sqrt{2n}\,\sin\left(\dfrac{i}{2}\right)$

$\Rightarrow \quad \cos\left(\dfrac{i}{2}\right) = \sqrt{\dfrac{n}{2}}$

$\Rightarrow \quad i = 2\cos^{-1}\sqrt{\dfrac{n}{2}}$

14. **Statement 1:** Law of gravitation is applicable for all bodies in the universe.

    Statement 2: Weight of body at earth's centre is zero.

    Choose the correct option regarding the above two statements.

    (1) Both statements are true

    (2) Statement 1 is true and statement 2 is false

    (3) Statement 1 is false and statement 2 is true

    (4) Both statements are false

Answer (1)

Sol. Both the statements are true. Law of gravitation is universal law.

Now, $E_{\text{centre}} = 0$ for earth.

15. Find the dimensional formula of self inductance.

    (1) $[ML^2TA^{-1}]$

    (2) $[M^2LTA^{-2}]$

    (3) $[ML^2T^{-2}A^{-2}]$

    (4) $[M^2L^2TA^{-3}]$

Answer (3)

Sol. $\because \quad U = \dfrac{1}{2}Li^2$

$\Rightarrow \quad [L] = \dfrac{[U]}{[i^2]}$
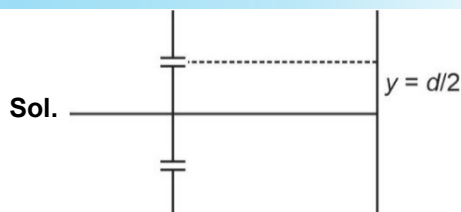
$\quad\quad = \dfrac{ML^2T^{-2}}{A^2}$

$\quad\quad = [ML^2T^{-2}A^{-2}]$

16. In a Young's double-slit setup, first minima is formed opposite to slit. Find the wavelength used if $d = 0.6$ mm and $D = 80$ cm.

    (1) 450 nm

    (2) 350 nm

    (3) 500 nm

    (4) 650 nm

Answer (1)

Sol.

$\Delta x = y \times \dfrac{d}{D} = \text{odd} \times \left(\dfrac{\lambda}{2}\right)$

$\Rightarrow \quad \dfrac{d}{2} \times \left(\dfrac{d}{D}\right) = (\text{odd}) \times \left(\dfrac{\lambda}{2}\right)$

$\Rightarrow \quad \lambda = \dfrac{d^2}{(\text{odd}) \times D} = \dfrac{(0.6 \times 10^{-3})^2}{0.8 \times (\text{odd})}$

$\quad\quad = \dfrac{4.5 \times 10^{-7}}{1} = 450$ nm

17. A particle performs SHM with amplitude A. It is found that it is at mean position at $t = 0$ and at half the amplitude at $t = 3$ s. Find the time period of the SHM.

    (1) 30 s

    (2) 42 s

    (3) 24 s

    (4) 36 s

Answer (4)

Sol. According to the given information,

$A\sin\omega t = \dfrac{A}{2}$

$\Rightarrow \quad \sin\omega t = \dfrac{1}{2}$

$\Rightarrow \quad \left(\dfrac{2\pi}{T}\cdot t\right) = \dfrac{\pi}{6}$

$\Rightarrow \quad T = 12 \times 3\text{ s} = 36\text{ s}$

18. An observer is moving towards a stationary light source with the speed of $\dfrac{c}{5}$. What is the percentage change in the frequency?

    (1) 22.5%

    (2) 15.4%

    (3) 20%

    (4) 18.5%

Answer (1)

Sol. $\nu' = \sqrt{\dfrac{1 + \dfrac{v}{c}}{1 - \dfrac{v}{c}}} \times \nu$

$\quad = \sqrt{\dfrac{1 + \dfrac{1}{5}}{1 - \dfrac{1}{5}}} \times \nu = \sqrt{\dfrac{6}{4}} \times \nu$

$\quad = 1.225\,\nu$

% change in $\nu = 22.5\%$

19. The susceptibility of a material is 99. Then find the relative permeability of the material.

   (1) 98

   (2) 100

   (3) 199

   (4) 50

Answer (2)

Sol. $\mu_r = 1 + x$

   $= 1 + 99$

   $= 100$

20. A Carnot cycle is operating between 527°C and 200 K. If work done in a cycle is $W = 12$ kJ, then heat absorbed in the cycle is

   (1) 8 kJ

   (2) 16 kJ

   (3) 9 kJ

   (4) 6 kJ

Answer (2)

Sol. $\eta = 1 - \dfrac{T_2}{T_1}$

   $= 1 - \dfrac{200}{800}$

   $= \dfrac{3}{4}$

   $\Rightarrow \dfrac{W}{Q_1} = \eta = \dfrac{3}{4}$

   $\Rightarrow Q_1 = 12 \times 10^3 \times \dfrac{4}{3}$

   $= 16$ kJ

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, −00.33, −00.30, 30.27, −27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. 25 V, 5 W
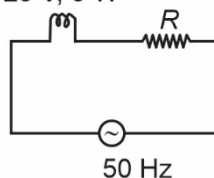
   Find R when the bulb is the brightest.

Answer (125)

Sol. For bulb to be brightest,
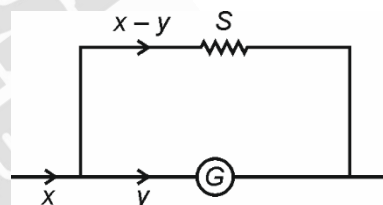
   $r_b = R$

   $\Rightarrow \dfrac{(25)^2}{5} = R$

   $\Rightarrow 125 = R$

   $R = 125\ \Omega$

22. A galvanometer of resistance 72 Ω is shunted by a resistance of 8 Ω. Then find the percentage of total current which passes through the galvanometer.

Answer (10)

Sol. The circuit diagram is as shown

   $R_G = 72\ \Omega, \quad R_S = 8\ \Omega$

   $y \times 72 = (x - y)8$

   $\Rightarrow y = \dfrac{x}{10}$

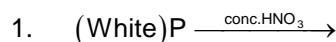 $\Rightarrow$ Current in galvanometer is 10% of the total current.

23.

24.

25.

26.

27.

28.

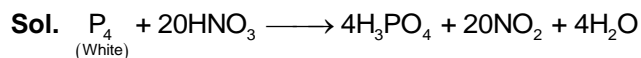29.

30.

CHEMISTRY

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. $(White)P \xrightarrow{conc.HNO_3}$

   (1) $H_3PO_3 + N_2$ (2) $NO_2 + PH_3$

   (3) $H_3PO_4 + NO_2$ (4) $H_3PO_3 + NO_2$

Answer (3)

Sol. $\underset{(White)}{P_4} + 20HNO_3 \longrightarrow 4H_3PO_4 + 20NO_2 + 4H_2O$

2. Match the molecules given in column I with their corresponding shapes in Column II

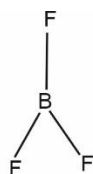 | Column I | | Column II | |
   |---|---|---|---|
   | (i) | SF_4 | (P) | T shaped |
   | (ii) | BF_3 | (Q) | See-saw |
   | (iii) | XeF_4 | (R) | Trigonal planar |
   | (iv) | ClF_3 | (S) | Square planar |

   (1) (i)-Q, (ii)-R, (iii)-S, (iv)-P

   (2) (i)-P, (ii)-Q, (iii)-R, (iv)-S

   (3) (i)-R, (ii)-P, (iii)-Q, (iv)-S
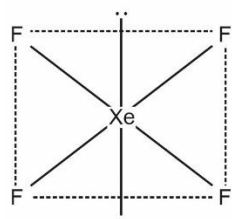
   (4) (i)-Q, (ii)-S, (iii)-P, (iv)-R
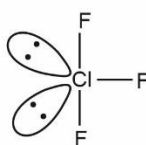
Answer (1)

Sol. The shapes of the molecules are,
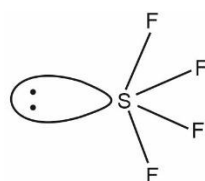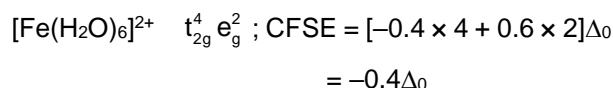

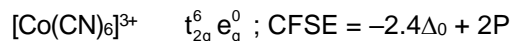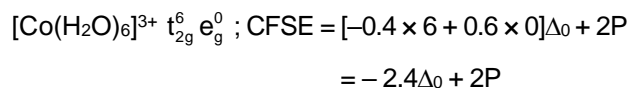Sec-saw   Trigonal planar

Square planar   T-shaped

3. Which of the following has maximum CFSE value?

   (1) $[Fe(H_2O)_6]^{3+}$ (2) $[Co(H_2O)_6]^{3+}$

   (3) $[Co(CN)_6]^{3-}$ (4) $[Fe(H_2O)_6]^{2+}$

Answer (3)

Sol. $[Fe(H_2O)_6]^{3+}$ $t_{2g}^3 e_g^2$; CFSE = 0

$[Co(H_2O)_6]^{3+}$ $t_{2g}^6 e_g^0$; CFSE = $[-0.4 \times 6 + 0.6 \times 0]\Delta_0 + 2P$

$$= -2.4\Delta_0 + 2P$$

$[Co(CN)_6]^{3+}$ $t_{2g}^6 e_g^0$; CFSE = $-2.4\Delta_0 + 2P$

$[Fe(H_2O)_6]^{2+}$ $t_{2g}^4 e_g^2$; CFSE = $[-0.4 \times 4 + 0.6 \times 2]\Delta_0$

$$= -0.4\Delta_0$$
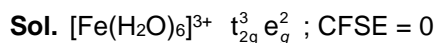
Since CN^- ion is a strong field ligand, Δ_0 of this complex will be higher than that of $[Co(H_2O)_6]^{3+}$

4. $BeCl_2 + LiAlH_4 \longrightarrow$ Products

   (1) $Be, LiAlCl_4, HCl$ (2) $BeH_2, LiCl, AlCl_3$

   (3) AlH_3, BeH_2, HCl (4) $Be, AlCl_3, LiCl$

Answer (2)

Sol. $2BeCl_2 + LiAlH_4 \longrightarrow 2BeH_2 + LiCl + AlCl_3$

This is method of preparation of BeH_2.

5. **Statement I:** Classical smog is formed in cold and humid climate.

   Statement II: Photochemical smog contains O_3 and PAN.

   The correct statements are

   (1) Both I and II   (2) Only I

   (3) Only II   (4) Neither I nor II

Answer (1)

Sol. Classical smog occurs in cold and humid climate. It is a mixture of smoke, fog and SO_2.

Photochemical smog occurs in warm, dry and sunny climate. The common components of photochemical smog are O_3, nitric oxide, PAN (peroxyacetyl nitrate)

6. **Statement-1:** O^{2-} and Mg^{2+} have same ionic size.

   Statement-2: They are isoelectronic species.

   (1) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1

   (2) Statement-1 is true, statement-2 is true; statement-2 is not a correct explanation for statement-1

   (3) Statement-1 is true, statement-2 is false

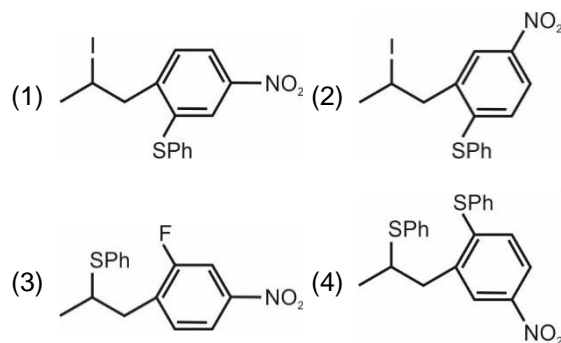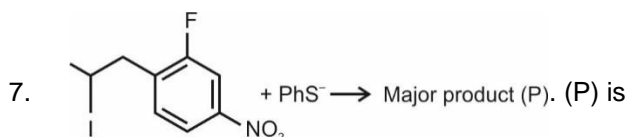   (4) Statement-1 is false, statement-2 is true

Answer (4)

Sol. In case of isoelectronic species, more the number of protons less the size of the species.
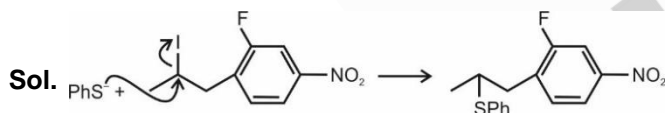
Mg^{2+} has 10 electrons and O^{2-} also have 10 electrons. Hence, they are isoelectronic species.

Order of size $O^{2-} > Mg^{2+}$

Hence, statement-1 is false and statement-2 is true.

7. + PhS⁻ ⟶ Major product (P). (P) is

(1) (2)

(3) (4)

Answer (3)

Sol.

8. Match the column-I having processes and elements with their corresponding ores/reagents or processes used in extraction.

	Column-I		Column-II
(i)	Blister copper	P.	Sulphide ore
(ii)	Froth floatation	Q.	Electrolytic refining
(iii)	Gold extraction	R.	$[Au(CN)_2]^-$

(1) (i) → P; (ii) → Q, P; (iii) → R, P

(2) (i) → Q, P (ii) → P; (iii) → Q, R

(3) (i) → R, P; (ii) → Q; (iii) → P

(4) (i) → Q, P; (ii) → R, Q; (iii) → Q, P

Answer (2)

Sol.

- Blister copper is obtained from a sulphide ore, copper pyrite ($CuFeS_2$). It is further refined using electrolytic refining.

- Froth floatation process is used for concentration of sulphide ores.

- In gold extraction, NaCN is used as a reagent for leaching of gold further followed by displacement of the cyanide complex with zinc. It is then refined using electrolytic refining.

9. What is the product formed when barium peroxide is treated with sulphuric acid?
   (1) BaO and H_2O_2
   (2) BaS and H_2O_2
   (3) $BaSO_4$ and H_2O_2
   (4) $BaSO_4$ and H_2O

Answer (3)

Sol. $BaO_2 \cdot 8H_2O(s) + H_2SO_4(aq) \longrightarrow BaSO_4(S) + H_2O_2(aq)$

$$+ 8H_2O(l)$$
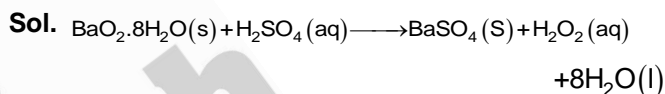
Hence option (3) is correct

10. Correct match of column I with column II is

	Column I		Column II
(i)	Emulsion	(a)	Protective colloid
(ii)	Positively charged colloid	(b)	$FeCl_3$ + NaOH
(iii)	Negatively charged colloid	(c)	$FeCl_3$ + hot water
(iv)	Lyophillic colloid	(d)	Liquid-liquid sol.

(1) (i) - d, (ii) - c, (iii) - b, (iv) - a
(2) (i) - a, (ii) - b, (iii) - c, (iv) - d
(3) (i) - c, (ii) - a, (iii) - d, (iv) - b
(4) (i) - a, (ii) - d, (iii) - c, (iv) - b

Answer (1)

Sol. If $FeCl_3$ is added to excess of hot water, a positively charged sol of hydrated Ferric oxide is formed

$Fe_2O_3 . x H_2O/Fe^{+3}$ = positively charged sol
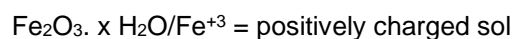
And when $FeCl_3$ is added to NaOH a negatively charged sol is obtained

$Fe_2O_3 . x H_2O/ OH^-$ = Negatively charged sol.

Emulsion is a liquid in liquid type sol and Lyophillic colloid can act as protective colloid

11. Match the following

| 1. | Polystyrene | (i) | Electrical switches |
2.	Polyvinyl chloride	(ii)	Paints and lacquers
3.	Glyptal	(iii)	Wrapping material
4.	Bakelite	(iv)	Pipes

Choose the correct option

(1) 1-(iii), 2-(iv), 3-(ii), 4-(i)
(2) 1-(iv), 2-(iii), 3-(i), 4-(ii)
(3) 1-(iii), 2-(i), 3-(iv), 4-(ii)
(4) 1-(iv), 2-(i), 3-(ii), 4-(iii)

Answer (1)

Sol.

1.	Polystyrene	(i)	Wrapping material, manufacture of toys and radio cabinets.
2.	Polyvinyl chloride (PVC)	(ii)	Rain coats, water pipes
3.	Glyptal	(iii)	Manufacture of paints and lacquers
4.	Bakelite	(iv)	Electrical switches

12. Which of the following is separating funnel

(1)
(2)
(3)
(4)
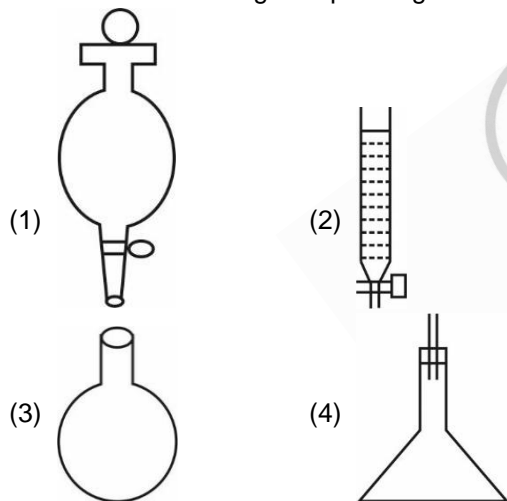
Answer (1)

Sol. Separating funnel is,

Before extraction   After extraction
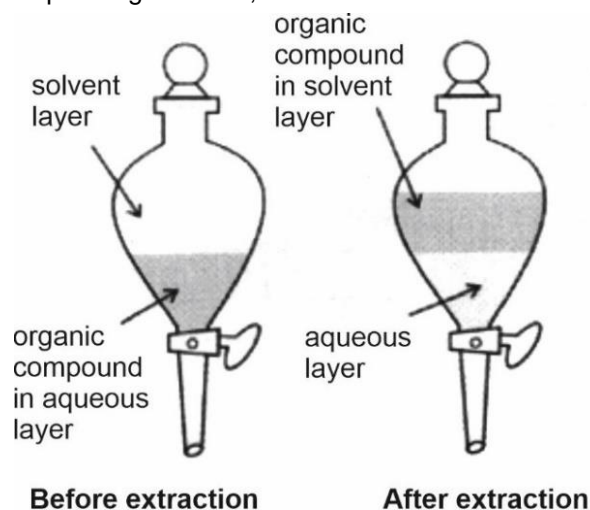
13. Compound A $\xrightarrow[\text{Zn/H}_2\text{O}]{\text{O}_3}$ glyoxal + butane-1, 4-dial

Compound B $\xrightarrow[\text{Zn/H}_2\text{O}]{\text{O}_3}$ 5-oxohexanal

Then compound A and B are respectively

(1)
(A)   (B)

(2)
(A)   (B)

(3)
(A)   (B)

(4)
(A)   (B)
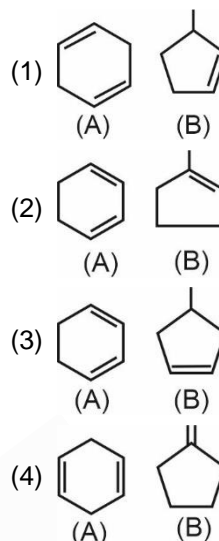
Answer (2)

Sol. Compound (A) is likely to be 1,3-Cyclohexadiene
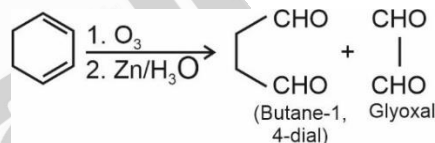
Compound (B) is likely to be 1-methyl cyclopentene
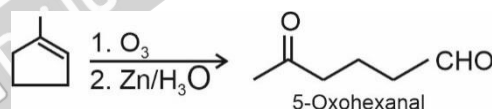
14. A compound X having four carbon atoms can react with 3 moles of CH_3COO^- ion during acetylation reaction. The compound X also gives positive tollen's reagent test. It reacts with bromine water to form an optically active compound, but reacts with conc. HNO_3 to form an optically inactive compound. Compound X is

(1)
CHO
H——OH
HO——H
CH₂OH

(2)
CHO
H——OH
H——OH
CH₂OH

(3)
CHO
H——OH
H——OH
COOH

(4) None of these
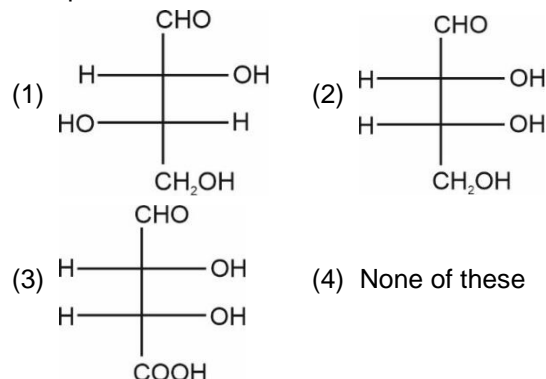
Answer (2)
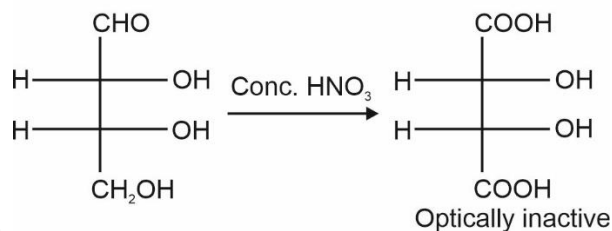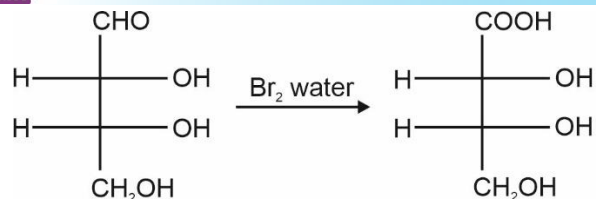
Sol.

15. Consider the following statements regarding Hoffmann Bromamide Degradation Reaction

   Statement I: One alkyl (R) group migrates from carbonyl carbon to N-atom.

   Statement II: Migration of alkyl group takes place towards electron deficient N atom.

   The correct statements are,

   (1) Both (I) and (II) (2) Only (I)

   (3) Only (II) (4) Neither (I) nor (II)

Answer (1)

Sol. Both the statements are correct.

16. Match the following

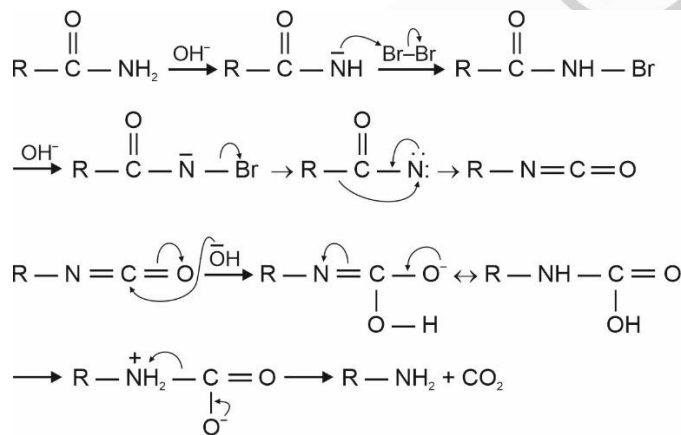|	Column I		Column II
(a)	Laundry soaps filler	(i)	Cetyltrimethyl ammonium Bromide
(b)	Hair conditioner	(ii)	Non-ionic detergent
(c)	Liquid dishwasher	(iii)	Sodium dode-cylbenzene-sulphonate
(d)	House-hold detergent	(iv)	Na_2CO_3, sodium rosinate

Choose the correct option

(1) (a) - (iv), (b) - (i), (c) - (ii), (d) - (iii)

(2) (a) - (iii), (b) - (iv), (c) - (i), (d) - (ii)

(3) (a) - (ii), (b) - (iii), (c) - (iv), (d) - (i)

(4) (a) - (ii), (b) - (i), (c) - (iv), (d) - (iii)

Answer (1)

Sol. Laundry soaps contains filler like sodium rosinate, sodium silicate, borax and sodium carbonate
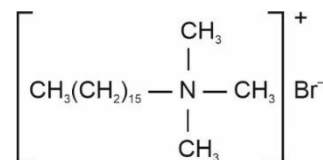
Cetyltrimethyl ammonium bromide is a popular cationic detergent and is used in hair conditioners.

Non-ionic detergents do not contain any ion in their constitution, these are used in liquid dishwasher.

Anionic detergent are mostly used for household work. Anionic detergents are also used in toothpastes.

17. The change in angular momentum during transition of an electron from the ground state of H-atom. It is given that the electron absorbs 10.2 eV energy during the transition from ground state to an excited state

   (1) $\dfrac{h}{\pi}$ (2) $\dfrac{h}{2\pi}$

   (3) $\dfrac{3h}{2\pi}$ (4) $\dfrac{2h}{\pi}$

Answer (2)

Sol. Energy of ground state of H-atom is equal to -13.6 eV

Energy of the first excited state = -3.4 eV

Therefore, change in angular momentum

$= \dfrac{2h}{2\pi} - \dfrac{h}{2\pi}$

$= \dfrac{h}{2\pi}$

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, −00.33, −00.30, 30.27, −27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. $Fe_{0.93}O$ has metal deficiency defect. Calculate the percentage of Fe^{+2} ins $Fe_{0.93}O$ compound.

    [Round off to nearest integer]

Answer (85)

Sol. Since,

Total cationic charge = Total anionic charge

Let,

Number of Fe^{2+} ion → x

Number of Fe^{3+} ion → 93 − x

2x + 9 (93 − x) = 2 × 100

2x + 3 × 93 − 3x = 200

x = 79

% of Fe^{2+} = $\dfrac{79}{93} \times 100$
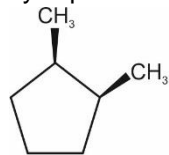
$\simeq$ 85%

22. Find out the number of stereoisomers formed by
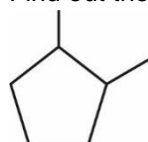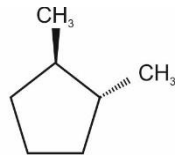

Answer (3)

Sol. There are 3 stereoisomers of 1, 2- dimethyl-cyclopentane.
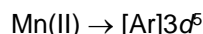

cis/meso   trans (±)

23. Find the spin only magnetic moment (in B.M) of Mn containing species which is formed by $KMnO_4$ in acidic medium. [Round off to the nearest integer]

Answer (6)

Sol. In acidic medium, Mn^{+7} gets reduced to Mn^{2+}

$Mn(II) \rightarrow [Ar]3d^5$

Number of unpaired electrons in Mn^{2+} = 5

$\mu = \sqrt{5(5+2)}$

$\mu \simeq 6$ B.M

24. What is the molar conductivity of AgI at zero concentration if the $\wedge_0$ value of NaI, $AgNO_3$ and $NaNO_3$ are respectively 12 Ω^{-1} cm^2 mol^{-1}, 16 Ω^{-1} cm^2 mol^{-1} and 10 Ω^{-1} cm^2 mol^{-1}.

Answer (18)

Sol. $\wedge_m^{\circ}(NaI) = \lambda_{Na^+}^{\circ} + \lambda_{I^-}^{\circ} = 12\ \Omega^{-1}\ cm^2\ mol^{-1}$

$\wedge_m^{\circ}(AgNO_3) = \lambda_{Ag^+}^{\circ} + \lambda_{NO_3^-}^{\circ} = 16\ \Omega^{-1}\ cm^2\ mol^{-1}$

$\wedge_m^{\circ}(NaNO_3) = \lambda_{Na^+}^{\circ} + \lambda_{NO_3^-}^{\circ} = 10\ \Omega^{-1}\ cm^2\ mol^{-1}$

$\wedge_m^{\circ}(AgI) = \lambda_{Ag^+}^{\circ} + \lambda_{I^-}^{\circ} = 12 + 16 - 10$

$= 18\ \Omega^{-1}\ cm^2\ mol^{-1}$

25. Consider the following equilibrium,

    $2NOCl\,(g) \rightleftharpoons 2NO\,(g) + Cl_2\,(g)$
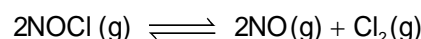
    If reaction has started with 2 moles NaCl in 1 litre closed container and allowed to attain equilibrium. At equilibrium, the moles of NO was found to be 0.4. The equilibrium constant (K_C) for the reaction is x × 10^{-3}. Then the value of x is

Answer (12.5)

Sol.

$$2NOCl\,(g) \rightleftharpoons 2NO\,(g) + Cl_2\,(g)$$

t = 0   2   –   –
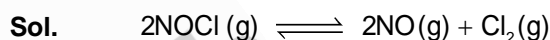
t = t_{eq} 2 − 2x   2x   x

Since 2x = 0.4 $\Rightarrow$ x = 0.2

$K_C = \dfrac{[NO]^2[Cl_2]}{[NOCl]^2} = \dfrac{(0.4)^2(0.2)}{(1.6)^2}$

$K_C = 12.5 \times 10^{-3}$

26. Calculate the wavelength (in Å) of the radiation absorbed during of an electron from ground state of Li^{2+} to the second excited state of Li^{2+}. [Round off to the nearest integer]

Answer (114)

Sol. (114)

In Li^{2+}, for transition 3 → 1

$\Delta E = \dfrac{hc}{\lambda}$

$\Delta E = 13.6 \times 9\left(\dfrac{1}{1^2} - \dfrac{1}{3^2}\right)eV = \dfrac{9 \times 13.6 \times 8}{9} \times 1.6 \times 10^{-19}J$

Hence,

$13.6 \times 8 \times 1.6 \times 10^{-19}$

$= \dfrac{6.626 \times 10^{-34} \times 3 \times 10^8}{\lambda}$

$\lambda \simeq 114 \times 10^{-10}$ m

27.

28.

29.

30.

MATHEMATICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. The value of $\int_{-2}^{2} \frac{|x^3 + x|}{1 + e^{x|x|}} dx$ is

   (1) 4　　　　　　　(2) 6

   (3) $5e^2 - 3$　　　(4) $4e^2 - 2$

Answer (2)

Sol. Let $I = \int_{-2}^{2} \frac{|x^3 + x|}{1 + e^{x|x|}} dx$　　…(i)

Using $\int_{a}^{b} f(x) dx = \int_{a}^{b} f(a + b - x) dx$ we get

$I = \int_{-2}^{2} \frac{|x^3 + x|}{1 + e^{-x|x|}} dx = \int_{-2}^{2} \frac{e^{x|x|}|x^3 + x|}{1 + e^{x|x|}} dx$　…(ii)

Adding (i) and (ii) we get

$2I = \int_{-2}^{2} |x^3 + x| dx$

$\Rightarrow I = \int_{0}^{2} (x^3 + x) dx$

$\Rightarrow I = \frac{x^4}{4} + \frac{x^2}{2} \Big|_{0}^{2} = 4 + 2 = 6$

2. Find the value of $\cos \frac{2\pi}{7} \cos \frac{4\pi}{7} \cos \frac{6\pi}{7}$

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

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

Answer (4)

Sol. $\cos \frac{2\pi}{7} \cdot \cos \frac{4\pi}{7} \cdot \cos \frac{6\pi}{7}$　$\left\{ \because \cos \frac{6\pi}{7} = \cos \frac{8\pi}{7} \right\}$

$= \frac{2^3 \sin \frac{2\pi}{7} \cdot \cos \frac{2\pi}{7} \cdot \cos \frac{4\pi}{7} \cdot \left(\cos \frac{8\pi}{7} \right)}{2^3 \sin \frac{2\pi}{7}}$

$= \frac{\sin \frac{16\pi}{7}}{8 \cdot \sin \frac{2\pi}{7}} = \frac{1}{8}$

3. If $\vec{a} = \hat{i} + \hat{j} - \hat{k}$ & $\vec{c} = 2\hat{i} + \hat{j} - 3\hat{k}, \vec{b} \times \vec{c} = \vec{a};$

   $|\vec{b}| \in \{1, 2, 3, ... 10\},$ then number of possible values of $\vec{b}$ is

   (1) 0　　　　　　(2) 1

   (3) 2　　　　　　(4) 3

Answer (1)

Sol. $\because$　$\vec{a} = \hat{i} + \hat{j} - \hat{k}, \vec{c} = 2\hat{i} + \hat{j} - 3\hat{k}$

$\therefore$　$\vec{a} \cdot \vec{c} = 2 + 1 + 3 = 6 \neq 0.$

But $\vec{b} \times \vec{c} = \vec{a}$ hence $\vec{a}$ is perpendicular to $\vec{c}$

Hence data is inconsistent

$\therefore$　No such $\vec{b}$ is possible.

4. Find number of real roots of the equation $x^4 - 4x + 1 = 0$.

   (1) 0　　　　　　(2) 1

   (3) 2　　　　　　(4) 4

Answer (3)

Sol. $x^4 - 4x + 1 = 0$

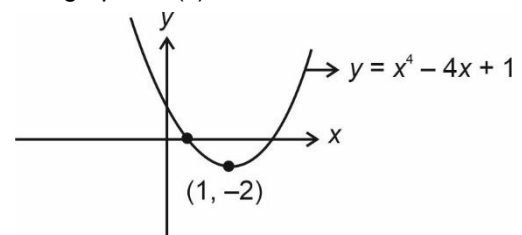Let $f(x) = x^4 - 4x + 1$

$f'(x) = 4x^3 - 4$　　　　　and $f'(x) = 0$

$\Rightarrow x = 1$

$f''(x) = 12x^2$　　　　$\therefore f''(1) > 0$

and at $x = 1, f(1) = -2 < 0$

So, graph of $f(x)$ will be

$\therefore$　No. of real roots of $f(x) = 0$ equals to 2.

5. In a binomial distribution, $n = 7$ and $p(x = 3) = 5p(x = 4)$. Find the value of sum of mean and variance.

(1) $\dfrac{14}{36}$ (2) $\dfrac{77}{36}$

(3) $\dfrac{31}{36}$ (4) $\dfrac{35}{36}$

Answer (2)

Sol. Let probability of success is p and not success is q.

Here $n = 7$,

$\because$ $p(x = 3) = 5p(x = 4)$

$\Rightarrow$ $^7C_3\, p^3 \cdot q^4 = 5 \cdot {}^7C_4 \cdot p^4 \cdot q^3$

$\Rightarrow$ $q = 5p$ …(i)

$\because$ $p + q = 1 \Rightarrow 6p = 1$

$\therefore$ $p = \dfrac{1}{6}$ and $q = \dfrac{5}{6}$

$\therefore$ Mean $= np = 7 \cdot \dfrac{1}{6} = \dfrac{7}{6}$

And variance $= npq = 7 \cdot \dfrac{1}{6} \cdot \dfrac{5}{6} = \dfrac{35}{36}$

$\therefore$ Sum of mean and variance $= \dfrac{7}{6} + \dfrac{35}{36}$

$= \dfrac{77}{36}$

6. If $X = \displaystyle\sum_{n=0}^{\infty} a^n, Y = \displaystyle\sum_{n=0}^{\infty} b^n$ and $Z = \displaystyle\sum_{n=0}^{\infty} c^n$; where a, b, c, $\in (0, 1)$ and a, b, c are in $A.P.$ Then

(1) X, Y, Z are in $A.P$ (2) X, Y, Z are in $G.P$

(3) $\dfrac{1}{X}, \dfrac{1}{Y}, \dfrac{1}{Z}$ are in $A.P$ (4) $\dfrac{1}{X}, \dfrac{1}{Y}, \dfrac{1}{Z}$ are in H.P

Answer (3)

Sol. $\because$ a, b, c, $\in (0, 1)$

$\therefore$ $X = \displaystyle\sum_{n=0}^{\infty} a^n = \dfrac{1}{1 - a}$

$Y = \displaystyle\sum_{n=0}^{\infty} b^n = \dfrac{1}{1 - b}$

$Z = \displaystyle\sum_{n=0}^{\infty} c^n = \dfrac{1}{1 - c}$

$\because$ a, b, c are A.P.

$\Rightarrow$ $1 - a$, $1 - b$, $1 - c$ are also in A.P

$\Rightarrow$ $\dfrac{1}{1 - a}, \dfrac{1}{1 - b}, \dfrac{1}{1 - c}$ are in H.P

Hence X, Y, Z are in H.P.

and $\dfrac{1}{X}, \dfrac{1}{Y}, \dfrac{1}{Z}$ are in A.P

7. If x_1, x_2, x_3, x_4, x_5 are numbers between 1 & 18 (both inclusive) & $x_1 < x_2 < x_3 < x_4 < x_5$. Find the probability that $x_2 = 7$ and $x_4 = 11$.

(1) $\dfrac{3}{68}$ (2) $\dfrac{1}{68}$

(3) $\dfrac{7}{68}$ (4) $\dfrac{5}{68}$

Answer (2)

Sol. Total ways $= {}^{18}C_5$

Favourable ways

$= \underset{\text{Selection of } x_1}{{}^6C_1} \cdot \underset{\text{Selection of } x_3}{{}^3C_1} \cdot \underset{\text{Selection of } x_5}{{}^7C_1}$

Required probability $= \dfrac{6.3.7}{{}^{18}C_5}$

$= \dfrac{1}{68}$

8. In an isosceles triangle $\triangle ABC$, $A(6, 1)$ base of triangle BC is represented by $2x + y = 4$, point B lies on $x + 3y = 7$. If centroid of the triangle is (α, β). Find the value of $15(\alpha + \beta)$.

(1) 51   (2) 39

(3) 41   (4) None of these

Answer (1)

Sol. Given,
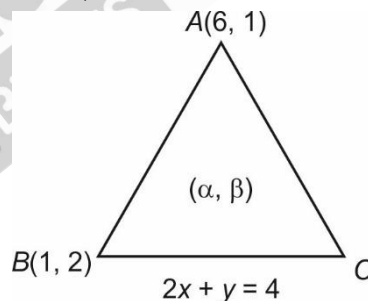
B is intersection point of $2x + y = 4$ and $x + 3y = 7$

i.e $B \equiv (1, 2)$

Also, $AB = AC$ as $\triangle ABC$ is isosceles

Let $C \equiv (h, 4 - 2h)$

Using $AB = AC$ we get $C \equiv \left(\dfrac{19}{5}, \dfrac{-18}{5}\right)$

$\Rightarrow$ $\alpha = \dfrac{6 + 1 + \dfrac{19}{5}}{3} = \dfrac{54}{15}$

and $\beta = \dfrac{1 + 2 - \dfrac{18}{5}}{3} = \dfrac{-3}{15}$

$\Rightarrow$ $15(\alpha + \beta) = 15\left(\dfrac{51}{15}\right) = 51$

9. If $\lim\limits_{x \to 7} \dfrac{18 - [1-x]}{[x-3a]}$ exists, where $[\cdot]$ represents greatest integer function, then the value of a is (where $a \in I$)

(1) -2 (2) -3

(3) -6 (4) -7

Answer (3)

Sol. If $\lim\limits_{x \to 7} \dfrac{18 - [1-x]}{[x-3a]}$ exist $(a \in I)$

$\Rightarrow \lim\limits_{h \to 0} \dfrac{24}{[7-h-3a]} = \lim\limits_{h \to 0} \dfrac{25}{[7+h-3a]}$

$\Rightarrow \lim\limits_{h \to 0} \dfrac{24}{(7-3a)+[-h]} = \lim\limits_{h \to 0} \dfrac{25}{(7-3a)+[h]}$

$\Rightarrow \dfrac{24}{6-3a} = \dfrac{25}{7-3a}$

$\Rightarrow \boxed{a = -6}$

10. In a differential equation,

$\dfrac{dy}{dx} + \dfrac{2^{x-y}\left(2^y - 1\right)}{2^x - 1} = 0,\ y(1) = 1$, find the value of $y(2)$.

(1) $2\log2$ (2) $\log_2\left(\dfrac{4}{3}\right)$

(3) $2\log3$ (4) $\log_2\left(\dfrac{3}{4}\right)$

Answer (2)

Sol. $\dfrac{dy}{dx} + \dfrac{2^{x-y}\left(2^y - 1\right)}{2^x - 1} = 0$

$\Rightarrow \dfrac{2^y}{2^y - 1} dy + \dfrac{2^x}{2^x - 1} dx = 0$

On integrating we get:

$\dfrac{\ln\left|2^y - 1\right|}{\ln 2} + \dfrac{\ln\left|2^x - 1\right|}{\ln 2} = c_1$

$\therefore \left|\left(2^y - 1\right)\left(2^x - 1\right)\right| = c.$ ...(i)

$\because y(1) = 1 \Rightarrow c = 1$

$\therefore \left|\left(2^y - 1\right)\left(2^x - 1\right)\right| = 1$

$\therefore y(2) = \log_2\left(\dfrac{4}{3}\right)$

11. $\bar{z} = iz^2$, area of the polygon formed by non-real roots of the equation.

(1) $\dfrac{3}{4}$ (2) $\dfrac{3\sqrt{3}}{4}$

(3) $\dfrac{\sqrt{3}}{4}$ (4) $\dfrac{2\sqrt{3}}{3}$

Answer (2)

Sol. $\because \bar{z} = iz^2$

$\Rightarrow |\bar{z}| = |z|^2 \Rightarrow |z| = 0$ or $|z| = 1$

Also if $\arg(z) = \theta$ then $2n\pi - \theta = \dfrac{\pi}{2} + 2\theta$

$\Rightarrow \theta = \dfrac{(4n-1)\pi}{6};\ n \in Z$

$\Rightarrow \theta = -\dfrac{\pi}{6}, \dfrac{\pi}{2}$ and $\dfrac{7\pi}{6}$

So, $z = 0,\ e^{-\frac{\pi}{6}},\ e^{\frac{\pi}{2}}$ and $e^{\frac{7\pi}{6}}$ are the solutions.

Non-real roots of z form an equilateral triangle inscribed in a unit circle. Its area will be equal to $\dfrac{\sqrt{3}}{4}\left(\sqrt{3}\right)^2 = \dfrac{3\sqrt{3}}{4}$ sq. unit

12. The eccentricity of $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} = 1,\ a > b$ is $\dfrac{1}{4}$ passes through the point $\left(-4\sqrt{\dfrac{3}{5}}, 3\right)$, then value of $a^2 + b^2$ is equal to

(1) $\dfrac{183}{5}$ (2) $\dfrac{186}{5}$

(3) $\dfrac{190}{7}$ (4) $\dfrac{193}{7}$

Answer (2)

Sol. $\because b^2 = a^2(1 - e^2) \Rightarrow b^2 = \dfrac{15a^2}{16}$

Also, $\dfrac{48}{5a^2} + \dfrac{9}{b^2} = 1$

$\Rightarrow \dfrac{48}{5a^2} + \dfrac{48}{5a^2} = 1$

$\Rightarrow a^2 = \dfrac{96}{5}$

Now, $b^2 = \dfrac{90}{5}$

So, $a^2 + b^2 = \dfrac{186}{5}$

13.
14.
15.
16.
17.
18.
19.
20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. $\dfrac{1}{5} + \dfrac{2}{65} + \dfrac{3}{325} + \dfrac{4}{1025} + \ldots$ is of the form $\dfrac{m}{n}$ where m and n are co-prime, then $m + n$ is equal to____.

Answer (0.25)

Sol. $\dfrac{1}{5} + \dfrac{2}{65} + \dfrac{3}{325} + \dfrac{4}{1025} + \ldots$

r^{th} term of the series $T_r = \dfrac{r}{\left(2r^2\right)^2 + 1}$

$\therefore \quad T_r = \dfrac{r}{\left(2r^2 + 1\right)^2 - \left(2r\right)^2}$

$\qquad = \dfrac{r}{\left(2r^2 - 2r + 1\right)\left(2r^2 + 2r + 1\right)}$

$\qquad = \dfrac{1}{4}\left[\dfrac{1}{\left(2r^2 - 2r + 1\right)} - \dfrac{1}{\left(2r^2 + 2r + 1\right)}\right]$

$\therefore \quad S_n = \dfrac{1}{4}\left[\left(1 - \dfrac{1}{5}\right) + \left(\dfrac{1}{5} - \dfrac{1}{13}\right) + \ldots\right.$

$\qquad \left. + \left(\dfrac{1}{2n^2 - 2n + 1} - \dfrac{1}{2(n+1)^2 + (2n+1) + 1}\right)\right]$

$\therefore \quad S_n = \dfrac{1}{4}\left[1 - \dfrac{1}{2(n+1)^2 + 2(n+1) + 1}\right]$

$\therefore \quad n \to \infty$

$\qquad S_\infty = \dfrac{1}{4}$

22. If $e^{2x} - 11e^x - 45e^{-x} + \dfrac{81}{2} = 0$, then sum of all roots of equation is $\ln p$. Find p.

Answer (45)

Sol. Let $e^n = t$, the equation reduces to

$t^2 - 11t - \dfrac{45}{t} + \dfrac{81}{2} = 0$

$\Rightarrow \quad 2t^3 - 22t^2 + 81t - 45 = 0 \quad \ldots(i)$

Let α, β, γ be roots of $e^{2x} - 11e^x - 45e^{-x} + \dfrac{81}{2} = 0$

$\therefore \quad e^{\alpha_1}, e^{\alpha_2}, e^{\alpha_3}$ will be roots of (i)

Using product of roots

$e^{\alpha_1} \cdot e^{\alpha_2} \cdot e^{\alpha_3} = 45$

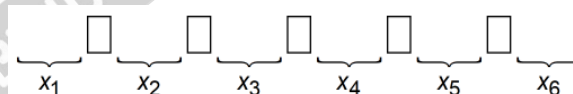$\Rightarrow \quad e^{\alpha_1 + \alpha_2 + \alpha_3} = 45$

$\Rightarrow \quad \alpha_1 + \alpha_2 + \alpha_3 = \ln(45) = \ln p$

$\qquad\qquad \Rightarrow \quad p = 45$

23. In total of 16 cubes, 11 are red and 5 are blue, then no. of arrangement in which there must be at least 2 red cubes between any two blue cubes.

Answer (56)

Sol. First we arrange 5 blue cubes in a row and assume x_1, x_2, x_3, x_4, x_5 and x_6 number of red cubes between them

Here, $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 = 11$

and $x_2, x_3, x_4, x_5 \geq 2$

So $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 = 3$

No. of solutions = $^8C_5 = 56$

24. If $\displaystyle\int e^x\left(\dfrac{x^2 + 1}{(x+1)^2}\right) = e^x f(x) + c$, then the value of $f'''(1)$ is

Answer (0.75)

Sol. $\displaystyle\int e^x\left(\dfrac{x^2 + 1}{(x+1)^2}\right)dx$

$= \displaystyle\int e^x\left(\dfrac{(x+1)^2 - 2(x+1) + 2}{(x+1)^2}\right)dx$

$= \displaystyle\int e^x\, dx + \int e^x\left(\dfrac{-2}{x+1} + \dfrac{2}{(x+1)^2}\right)dx$

$$\because \int e^x (f(x) + f'(x)) \, dx = e^x f(x) + c$$

$$= e^x - e^x \left(\frac{2}{x+1} \right) + c$$

$$= e^x \left(\frac{x-1}{x+1} \right) + c$$

So, $f(x) = \dfrac{x-1}{x+1} = 1 - \dfrac{2}{x+1} \Rightarrow f'(x) = \dfrac{2}{(x+1)^2}$

$$\Rightarrow f''(x) = \frac{-4}{(x+1)^3}$$

$$\Rightarrow f'''(x) = \frac{12}{(x+1)^4} \Rightarrow \text{hence } f'''(1) = \frac{3}{4}$$

25. Let the direction ratios of two lines are roots of the equation $l + m - n = 0$ and $3l^2 + m^2 + nlc = 0$. If lines are parallel then find positive value of c.

Answer (6)

Sol. $\because \quad m = n - l$

and $3l^2 + (n - l)^2 + nlc = 0$

$\Rightarrow \quad 4l^2 + n^2 + (c - 2)nl = 0$

$\Rightarrow \quad 4\left(\dfrac{l}{n} \right)^2 + (c - 2)\dfrac{l}{n} + 1 = 0$

Here, we will get only one value of $\dfrac{l}{n}$ because lines are parallel. So, $D = 0$

$\Rightarrow \quad (c - 2)^2 = 16$

$\Rightarrow \quad c = 6$ (–ve value of c is neglected here)

26.

27.

28.

29.

30.

❑ ❑ ❑