- **Mode:** The exam will be conducted through **online (Remote Proctored Based)** mode.
- **Duration**: Total **2 hours 30 minutes** will be given to solve the exam.
- **Type of Questions:** There will be Multiple Choice Questions **(MCQs)** asked in the exam.
- **Sections:** Total **5 sections** will be there in the paper.
- **Marking Scheme:** For each correct response, **1 mark** will be given.
- **Negative Marking:** There will be **no negative marking** in the exam.
- **Number of Questions:** The exam will be divided according to the following division:

Subject	Number of Questions
Physics	35
Chemistry	35
Mathematics/Biology	40
English	5
Aptitude	10
Total	**125**

PHYSICS

1. The unit of thermal conductivity is:

   A. JmK^{-1}

   B. $Jm^{-1}K^{-1}$

   C. WmK^{-1}

   D. $Wm^{-1}K^{-1}$

   Key: D

   Solution: Heat current $H = -Ka\dfrac{dt}{dx}$

   watt $H = -Ka\dfrac{dt}{dx}$

2. Which of the following combinations of three different physical quantities P, Q, R can never be a meaningful quantity?

   A. $PQ - R$

   B. $\dfrac{PQ}{R}$

   C. $\dfrac{P - Q}{R}$

   D. $\dfrac{PR - Q^2}{QR}$

   Key: C

   Solution: Two physical quantities of different dimensions cannot be added or subtracted

3. P is a point at a distance r from the centre of a spherical shell of mass M and radius R where r < R. The gravitational potential at 'P' is

   A. $\dfrac{-GM}{r}$

   B. $\dfrac{-GM}{R}$

   C. $-GM\dfrac{r}{R^2}$

   D. Zero

   Key: B

   Solution: Inside the shell the potential is equal to that on surface.

4. The altitude at which the weight of a body is only 64% of its weight on the surface of the earth is (radius of the earth is 6400 km)

   A. 1600 m

   B. 16 m

   C. 160 km

   D. 1600 km

   Key: D

   Solution: $\omega_h = 64\%$

   $g_h = 64\%g$

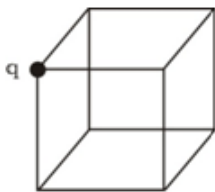$$\frac{64}{100} = \left(\frac{R}{R+h}\right)^2$$

$$h = \frac{R}{4} = 1600 km$$

5. The magnitude of electric field strength E such that an electron placed in it would experience an electrical force equal to its weight is given by :

   A. mge

   B. mg/e

   C. e/mg

   D. $e^2g/2m$

   Key: B

   Solution: Electrical force = eE = mg $\Rightarrow E = \dfrac{mg}{e}$

6. Find the flux through the cube if point charge q is placed at the corner of cube

   A. $\dfrac{q}{8\varepsilon_0}$

   B. $\dfrac{q}{\varepsilon_0}$

   C. $\dfrac{q}{2\varepsilon_0}$

   D. $\dfrac{q}{4\varepsilon_0}$

   Key: A

   Solution: corner charge is shared by 8 such cubes flux through the cube is $\dfrac{1}{8}\left(\dfrac{q}{\varepsilon_0}\right)$

7. A capacitor works in

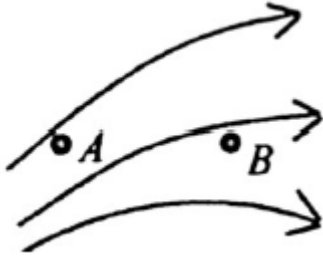   A.C. circuits

   D.C. circuits

Both the circuits

Neither in A.C. (nor) in D.C. circuit

Key: C

Solution: A capacitor will work in both A.C circuit and D.C circuit.

8. The figure shows electric lines of force emerging from a charged body. If the electric fields at A and B are E_A and E_B respectively, then

A. $E_A < E_B$

B. $E_A > E_B$

C. $E_A = E_B$

D. None

Key: B

Solution: Crowded the electric lines stronger the field.

9. The number of electrons that must be removed from an electrically neutral silver dollar to give it a charge of +2.4 C is

A. 2.5×10^{19}

B. 1.5×10^{19}

C. 1.5×10^{10}

D. 2.5×10^{10}

Key: B

Solution: $n = \dfrac{q}{e} = \dfrac{2.4}{1.6 \times 10^{-19}} = 1.5 \times 10^{19}$

10. A galvanometer has a resistance of 20 ohms , a current of 2 mA gives full scale deflection. The necessary resistance in ohms to convert this galvanometer into voltmeter of range 0 – 3 V is

A. 14800

B. 1480

C. 1500

D. 1520

Key: B

Solution: to convert a galvanometer to a volt meter high resistance has to be connected in series where $i_g(R+G)=V$

here $3=2x10^{-3}(R+20)$

$R=1480\,ohms$

11. A hollow cylinder $\left(\rho = 2.2\times10^{-8}\Omega-m\right)$ of length 3 m has inner and outer diameters are 2 mm and 4 mm respectively. The resistance of the cylinder is

$0.35\times10^{-3}\Omega$

$3\times10^{-3}\Omega$

$7\times10^{-3}\Omega$

$3.1\times10^{-3}\Omega$

Key: C

Solution: The resistance of a hollow cylinder can be calculated using the formula:

$R = \dfrac{\rho l}{A}$

where ρ is the resistivity of the material, l is the length of the cylinder, and A is the cross-sectional area of the cylinder.

The cross-sectional area of a hollow cylinder is given by:

$A = \pi\left(r_2^2 - r_1^2\right)$

where r_1 and r_2 are the inner and outer radii of the cylinder, respectively.

Substituting the given values, we get:

$r_1 = 1\,mm = 0.001\ m$

$r_2 = 2\,mm = 0.002\ m$

$l = 3\ m$

$$\rho = 2.2 \times 10^{-8} \ \Omega \, m$$

Therefore, the cross-sectional area is:

$$A = \pi((0.002 \ m)^2 - (0.001 \ m)^2) = 3 \times \pi \times 10^{-6} \ m^2$$

Substituting these values in the formula for resistance, we get:

$$R = \frac{(2.2 \times 10^{-8} \ \Omega \, m) \cdot (3 \ m) \times 7}{3 \times 22 \times 10^{-6} \ m^2} \approx 7 \times 10^{-3} \ \Omega$$

Hence, the correct answer is $7 \times 10^{-3} \Omega$

12. As the temperature increases, the electrical resistance:

  A. decreases for both conductors and semiconductors

  B. increases for conductors but decreases for semiconductors

  C. decreases for conductors but increases for semiconductors

  D. increases for both conductors and semiconductors

  Key: B

  Solution: In case of conductors, **the electrical resistance increases with increase in temperature** because the thermal velocity of free electrons increases with temperature, resulting in more number of collisions between free electrons. Hence, resistance increases.
  But in case of **semiconductors**, with **increase in temperature**, more number of bonds break, resulting in more available charge carriers. This **decreases the resistance.**

13. The terminal potential difference of a cell is greater than its e.m.f. when it is

  A. Being discharged

  B. Being charged

  C. Being either charged or discharged

  D. In open circuit

  Key: B

  Solution: In charging $V > E$

14. A magnetized steel wire of moment M is bent into a semicircle. Its new magnetic moment is

  A. $\dfrac{M}{2}$

  B. $\dfrac{\pi M}{2}$

C. $\dfrac{M}{\pi}$

D. $\dfrac{2M}{\pi}$

Key: D

Solution: after bending the length of the magnet 2l becomes πr

so $r = \dfrac{2l}{\pi}$

distance between the pole is 2r

new moment M'=2r m

$M' = 2\dfrac{2l}{\pi}m = \dfrac{2M}{\pi}$

15. The material suitable for making electromagnets should have

   A. high retentivity and low coercivity

   B. low retentivity and low coercivity

   C. high retentivity and high coercivity

   D. low retentivity and high coercivity

Key: B

Solution: The coercivity of an electromagnet has to be low, if it is high, it will be difficult to handle the electromagnetic field.

The retentivity also has to be low to bring the electromagnet to its original state after removing the electric field.

16. Two electric bulls whose resistance are in the ratio of 1:2 are connected in parallel to a constant voltage source. The powers dissipated in them have the ratio.

   A. 1:2

   B. 1:1

   C. 2:1

   D. 1:4

Key: C

Solution: $P\alpha\dfrac{1}{R}$

$$\frac{P_1}{P_2} = \frac{R_2}{R_1} = \frac{2}{1}$$

17. Resistivity of a conductor depends upon

    A. area of cross – section

    B. material and temperature

    C. Length

    D. all

    Key: B

    Solution: Resistivity of a conductor depends upon the material of the conductor and temperature.

18. A small coil of N turns has area A and a current I flows through it. The magnetic dipole moment of this coil will be

    A. NI/A

    B. NI^2A

    C. N^2AI

    D. NIA

    Key: D

    Solution: Magnetic dipole moment of coil = NIA

19. Energy in a current-carrying coil is stored in :

    A. electric field

    B. magnetic field

    C. dielectric strength

    D. heat

    Key: B

    Solution: Energy in inductor is stored in form of magnetic energy.

20. The equation of an alternating voltage is $V = 100\sin 100\pi t$ volt. Its peak value and frequency are

    A. $100V, 50Hz$

    B. $50V, 100Hz$

    C. $200V, 100Hz$

    D. $100V, 200Hz$

    Key: A

21. Which of the following rays is not an electromagnetic wave?

A. X-rays

B. γ - rays

C. β - rays

D. Heat rays

Key: C

Solution: β -rays are nit electromagnetic waves, β -rays are stream of electrons moving at high speeds.

22. A double convex lens of refractive index 1.5 has radii of 20 cm. Incident rays of light parallel to the axis will come to converge at a distance from the lens is

A. 20 cm

B. 10 cm

C. 40 cm

D. 30 cm

Key: A

Solution: $\dfrac{1}{f} = (\mu - 1).\dfrac{2}{R}$

$f = R = 20 cm$

for parallel rays light will converge at the focus.

23. A concave mirror gives an image three times as large as the object placed at a distance of 20 cm from it. For the image to be real, the focal length should be

A. 10 cm

B. 15 cm

C. 20 cm

D. 30 cm

Key: B

Solution: $m = \dfrac{f}{f-u} \Rightarrow -3 = \dfrac{f}{f-(-20)} \Rightarrow f = -15cm$

24. The maximum number of possible interference minima can be observed on screen for slit separation equal to twice the wavelength in Young's double slit experiment is

   A. Infinite

   B. Five

   C. Three

   D. Four

   Key: D

   Solution: As the distance between the slit is twice the wave length on both the side of the central maxima two maxima will form in between two maxima two minima on either side and total five maxima including central and four minima

25. An electron moving with speed v and a photon moving with speed c, have same de-Broglie wavelength. The ratio of kinetic energy of electron to that of photon is :

   A. $\dfrac{3c}{v}$

   B. $\dfrac{v}{3c}$

   C. $\dfrac{v}{2c}$

   D. $\dfrac{2c}{v}$

   Key: C

   Solution: $\lambda_e = \lambda_{ph}$

   $\dfrac{h}{p_e} = \dfrac{h}{p_{ph}}$

   $\sqrt{2mk_e} = \dfrac{E_{ph}}{c}$

   $mk_e = \dfrac{(E_{ph})^2}{c^2}$

   $\dfrac{k_e}{E_{ph}} = \dfrac{E_{ph}}{c^2}\left(\dfrac{1}{2m}\right)$

$$= \frac{p_{ph}}{c}\left(\frac{1}{2m}\right)$$

$$= \frac{p_e}{c}\left(\frac{1}{2m}\right)$$

$$= \frac{mv}{c}\frac{1}{2m}$$

$$= \frac{v}{2c}$$

26. The de-Broglie wavelength of a proton and alpha particle are equal. The ratio of their velocities is:

   A. 1: 4

   B. 4: 2

   C. 4: 3

   D. 4: 1

   Key: D

   Solution: Given : $\lambda_p = \lambda_a$

   $$\Rightarrow \frac{h}{m_p v_p} = \frac{h}{m_a v_a}$$

   $$\Rightarrow \frac{v_p}{v_a} = \frac{m_a}{m_p} = \frac{4}{1}$$

27. The photoelectric threshold wavelength for silver is λ_0. The energy of the electron rejected from the surface of silver by an incident wavelength $\lambda\left(\lambda < \lambda_0\right)$ will be:

   A. $hc\left(\lambda_0 - \lambda\right)$

   B. $\dfrac{hc}{\lambda_0 - \lambda}$

   C. $\dfrac{h}{c}\left(\dfrac{\lambda_0 - \lambda}{\lambda \lambda_0}\right)$

   D. $hc\left(\dfrac{\lambda_0 - \lambda}{\lambda \lambda_0}\right)$

   Key: D

Solution: $KE = hc\left[\dfrac{1}{\lambda} - \dfrac{1}{\lambda_0}\right]$

28. If the energy of a hydrogen atom in nth orbit is E,, then energy in the nth orbit of a singly ionized helium atom will be

A. 4E

B. $E/4$

C. 2E

D. $E/2$

Key: A

Solution: $E_n \propto z^2 \Rightarrow \dfrac{(E_n)_{He}}{(E_n)_H} = \dfrac{Z_{He}^2}{Z_H^2} = 4 \Rightarrow (E_n)_{He} = 4 \times (E_n)_H = 4E$

29. The radius of the Bohr orbit in the ground state of hydrogen atom is $0.5\ \overset{0}{A}$ The radius of the orbit of the electron in the third excited state of He^+ will be

A. $8\ \overset{0}{A}$

B. $4\ \overset{0}{A}$

C. $0.5\ \overset{0}{A}$

D. $0.25\ \overset{0}{A}$

Key: B

Solution: By using $r_n = r_o \dfrac{n^2}{Z}$; *where* r_o = Radius of the Bohr orbit in the ground state atom . So

for He^+ third excited state n= 4, Z=2, $r_o = 0.5\overset{0}{A} \Rightarrow r_4 = 0.5 \times \dfrac{4^2}{2} = 4\overset{0}{A}$

30. Pick out the incorrect statement from the following

A. In both positive and negative β - decays of the nucleus neutrino is always emitted

B. Nuclear force between two nucleons is spin dependent

C. γ - ray emission makes the nucleus more stable

D. Nuclear force is charge – independent

Key: A

Solution: The emission of electron in β^- decay is accompanied by the emission of an antineutrino $(\bar{v})$; $in\,\beta^+$ decay, instead, a neutrino (v) is generated

31.

   A.

   B. Gravitational contraction

   C. Nucler fusion

   D. Nuclear fission

   Key: C

   Solution: Solar energy is created by nuclear fusion that takes place in the sun. In the sun's core, fusion happens when the protons of colliding hydrogen atoms fuse to form helium atoms. A P-P (proton-proton) chain reaction is what causes this process to produce such a large amount of energy.

32. For a nucleus to be stable, the correct relation between neutron number N and proton number Z for light nuclei is:

   A. $N > Z$

   B. $N = Z$

   C. $N < Z$

   D. $N > Z$

   Key: B

   Solution: $\dfrac{N}{Z}$ should be 1 for lighter nuclei

33. The function of a moderator in a nuclear reactor is to

   A. speed up the slow neutrons

   B. slow down the fast neutrons

   C. absorb the excess neutrons

   D. absorb all the neutrons

   Key: B

   Solution: Decrease the velocity of fast neutrons.

34. Which of the following gate is called universal gate?

   A. NOT gate

   B. OR gate

   C. AND gate

D. NAND gate

Key: D

Solution: NAND gate is called universal gate as any other gate can be constructed with the combination of this gate.

35. A full-wave rectifier is used to convert 'n'Hz a.c into d.c, then the number of pulses per second present in the rectified voltage is

A. n

B. n/2

C. 2n

D. 4n

Key: C

Solution:

- Now, a full-wave rectifier produces one pulse per half cycle.
- We thus receive 2 pulses for each cycle.
- The output pulses for an input of n cycles will be 2n.

Draw a circuit diagram of a full wave rectifier. Explain its working and draw input and output waveforms.

Hence the correct answer is 2n.

Chemistry

36. At room temperature, a dilute solution of urea is prepared by dissolving 0.60 g of urea in 360 g of water. If the vapour pressure of pure water at this temperature is 35 mmHg, lowering of vapour pressure will be: (molar mass of urea $= 60 \text{ g mol}^{-1}$)

A. 0.027 mmHg

B. 0.031 mmHg

C. 0.017 mmHg

D. 0.028 mmHg

Key: C

Solution: Lowering of vapour pressure $= p^0 - p = p^0 \cdot x_{\text{solute}}$

$$\therefore \Delta p = 35 \times \frac{0.6/60}{\frac{0.6}{60} + \frac{360}{18}} = 35 \times \frac{.01}{.01 + 20} = 35 \times \frac{.01}{20.01} = .017 \, mmHg$$

37. The mixture that forms maximum boiling point azeotrope is

   A. Acetone + Carbondisulphide
   B. Heptane + octane
   C. Water + Nitric acid
   D. Ethanol + water

   Key: C

   Solution: Water + Nitric acid forms the maximum boiling point azeotrope as it shows a negative deviation from Raoult's law.

38. Emf of the cell $Al(s)\big|Al^{3+}\left(10^{-3}M\right)\big\|Ag^{+}\left(10^{-1}M\right)\big|Ag$ at 298 K is $\left(E^{0}_{cell} = 2.46V\right)$

   A. 2.46 V
   B. 2.4 V
   C. 2.52 V
   D. 2.37 V

   Key: A

   Solution: $Al \rightarrow Al^{3+} + 3e^{-}$

   $\left[Ag^{+} + e^{-} \rightarrow Ag\right] \times 3$

   over all reaction is :

   $Al + 3Ag^{+} \rightarrow Al^{+3} + 3Ag$

   $$E_{cell} = 2.46 - \frac{0.0591}{3}\log\frac{10^{-3}}{\left(10^{-1}\right)^{3}}$$

   $$E_{cell} = 2.46 - \frac{0.0591}{3}\log\frac{10^{-3}}{\left(10^{-1}\right)^{3}}$$

39. Which of the following is example for buffer solution:

   A. $CH_{3}COOH + CH_{3}COONa$
   B. $HCl + KCl$
   C. $NaOH + NaCl$

D. $H_2SO_4 + Na_2SO_4$
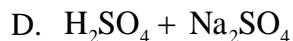
Key: A

Solution: $WA + Salt\ of\ (WA + SB)$

40. The electrochemical equivalent of metal is Y g $coloumb^{-1}$ the equivalent weight of metal is

    A. Y

    B. $Y \times 96500$

    C. $Y / 96500$

    D. $1.6 \times 10^{-19} \times Y$
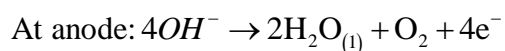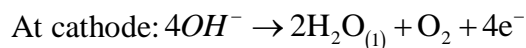
    Key: B

    Solution: $e = \dfrac{E}{F}$

    $\therefore E = Y \times 96500$

41. On electrolysis of dil. Sulphuric acid using platinum (pt) electrode, the product obtained at anode will be

    A. On electrolysis of dil. Sulphuric acid using platinum (pt) electrode, the product obtained at anode will be
    B. hydrogen gasX
    C. oxygen gas
    D. H_2S gas

    Key: B

    Solution: During electrolysis of dil.sulphuric acid,

    $H_2SO_4 \rightarrow 2H^+_{(aq)} + SO_4^{-2}$

    $H_2O \rightarrow H^+_{(aq)} + OH^-_{(aq)}$

    At cathode: $4OH^- \rightarrow 2H_2O_{(1)} + O_2 + 4e^-$

    At anode: $4OH^- \rightarrow 2H_2O_{(1)} + O_2 + 4e^-$

    Note : In case of electrolysis of dilute solution, instead of oxoanions, OH^- ions water oxidize to O_2 gas at anode, and instead of alkali and alkaline earth metals, H+ ions from water are reduced to H2 gas at cathode .

42. For the reaction $2A + B \rightarrow$ products, it is found that doubling the concentration of both reactants increases the rate by a factor of 8. But doubling the concentration of 'B' alone, only doubles the rate. What is the order of reaction wrt 'A' ?

A. 0
B. 2
C. 1
D. 3

Key: B

Solution: $r = K[B]^b$

$2 = K[Z]^b$; $b=1$

$r = K[A]^a[B]^b$

$8 = K[2][2]^1$

$a = 2$

43. The half life period of a 1st order reaction is 60 minutes. What percentage will be left over after 240 minutes ?

A. 6.25%
B. 4.25%
C. 5%
D. 6%

Key: B

Solution: $t_{1/2} = 60\,min$

The no.of half lives = 240 / 60 = 4 (n = 4)

The amount which is left, after four half lives is;

$$\frac{[A]_O}{[A]} = \frac{[A]_O}{16} = 0.0625 \text{ of } A_0 \text{ or } 6.25\%$$

44. The accumulation of molecular species at the surface rather than in the bulk of a solid or liquid is known as

A. Absorption
B. Adsorption
C. Sorption

D. Desorption

Key: B

Solution: Adsorption in surface phenomena.

45. In Langmuir's model of adsorption of a gas on a solid surface

A. the rate of dissociation of adsorbed molecules from the surface does not depend on the surface covered
B. the adsorption at a single site on the surface may involve multiple molecules at the same time
C. the mass of gas striking a given area of surface is proportional to the pressure of the gas
D. the mass of gas striking a given area of surface is independent of the pressure of the gas

Key: C

Solution: Assuming the formation of a monolayer of the adsorbate on the surface of the adsorbent, it was derived by Langmuir that the mass of the gas adsorbed per gram of the adsorbent is related to the equilibrium pressure according to the equation:

$$\frac{x}{m} = \frac{aP}{1+bP}$$

Where x is the mass of the gas adsorbed on m gram of the adsorbent, P is the pressure and a, b are constants.

46. Among halogens, the one which can oxidise water to oxygen most readily is :

A. Chlorine
B. Bromine
C. Fluorine
D. Iodine

Key: C

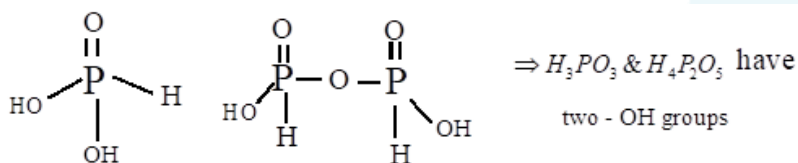Solution: $2F_2 + 2H_2O \rightarrow 4HF + O_2$

F_2 is a stronger oxidizing agent than H_2O. Cl_2 dissolves in water but does not oxidize H_2O

47. The pair that contains two P-OH bonds in each of the oxo acids is

A. H_3PO_2, H_3PO_4
B. $H_3PO_3, H_4P_2O_6$
C. $H_3PO_3, H_4P_2O_5$
D. $H_3PO_4, H_4P_2O_7$

Key: C

Solution:

$\Rightarrow H_3PO_3 \ \& \ H_4P_2O_5$ have two - OH groups

48. Which of the following are d- block elements but not regarded as transition elements.

A. Cu, Ag, Au
B. Zn, Cd, Hg
C. Fe, Co, Ni
D. Ru, Rh, Pd

Key: B

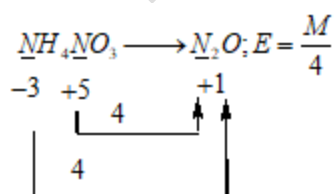Solution: Zn, Cd, Hg have completely filled d- orbital electronic configuration. So not transition element.

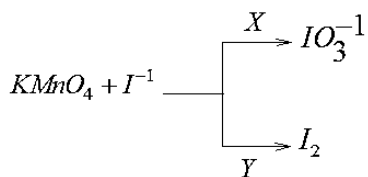49. The equivalent mass of ammonium nitrate from the following reaction is

$$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$$
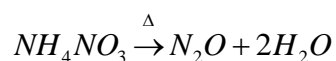
A. $\dfrac{M}{8}$

B. $\dfrac{M}{2}$

C. $\dfrac{M}{4}$

D. $\dfrac{3M}{4}$

Key: C

Solution:

50.

$$KMnO_4 + I^{-1} \xrightarrow{\quad} \begin{array}{c} \xrightarrow{X} IO_3^{-1} \\ \\ \xrightarrow{Y} I_2 \end{array}$$

X and Y are

A. Neutral or strong alkaline solution, Acidic solution respectively
B. Acidic and strong alkaline solution, respectively
C. Acidic and neutral or faintly alkaline solution, respectively
D. Neutral or faintly alkaline solution, Acidic solution respectively

Key: D

Solution: Neutral or faintly alkaline solution, Acidic solution respectively

51. Liquid metal among d-block elements is

A. Hg
B. Zn
C. Nb
D. Cd

Key: A

Solution: Mercury don't have unpaired electron in its outermost shell , which can be used for metallic bond formation. So it's molecules are not attached by metallic binding although it is a metal and the binding is poor.

Hence 'Hg' is a liquid.

52. Which of the following has a square planar geometry?

(Atomic numbers Fe = 26, Co = 27, Ni = 28, Pt = 78)

A. $\left[PtCl_4\right]^{2-}$
B. $\left[CoCl_4\right]^{2-}$
C. $\left[FeCl_4\right]^{2-}$
D. $\left[NiCl_4\right]^{2-}$

Key: A
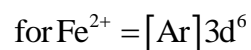
Solution: Conceptual

53. Spin only magnetic moment of an octahedral complex of Fe^{2+} in the presence of a strong field ligand in BM is

A. 4.89

B. 2.82

C. 0

D. 3.46

Key: C

Solution: In presence of strong firld ligand $, \Delta_o > P$

$$\text{for Fe}^{2+} = [Ar]3d^6$$

54. Which of the following complexes gives a white coloured precipitate with $BaCl_2$

A. $[Co(NH_3)_5(SO_4)]Br$

B. $[Co(NH_3)_5Cl]Cl_2$

C. $[Co(NH_3)_5Br]SO_4$

D. $[Cr(H_2O)_6](NO_3)_3$

Key: C

Solution: SO_4^{2-} gives white coloured precipitate of $BaSO_4$ with $BaCl_2$

55. The set which does not have ambidentate ligands is

A. $NO_2^-, C_2O_4^{-2}, EDTA^{-4}$

B. $EDTA^{-4}, NCS^-, C_2O_4^{-2}$

C. $C_2O_4^{-2}$ ethylene dimine, H_2O

D. $C_2O_4^{-2}, NO_2^-, NCS^-$

Key: C

Solution: $C_2O_4^{-2}, Ethylene$ diamine, H_2O
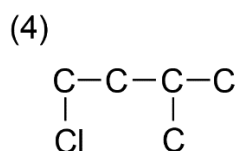$\qquad\qquad\downarrow\qquad\qquad\downarrow$
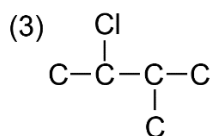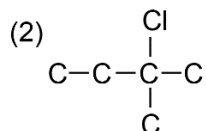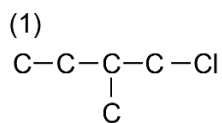$\qquad Bidendate\qquad Bidendate$

NO_2^-, NC^- are ambidendate ligands

56. How many chiral compounds are possible on mono chlorination of $2 - methyl\, butane$
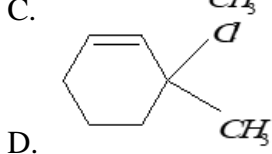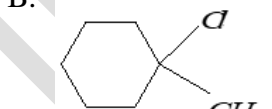
A. 2

B. 4

C. 6

D. 8

E. Solution: Mono chloro derivations

(1)

C—C—C—C—Cl
        |
        C

(2)

        Cl
        |
C—C—C—C
        |
        C

(3)   Cl
      |
C—C—C—C
      |
      C

(4)

C—C—C—C
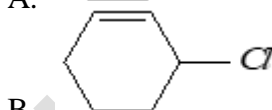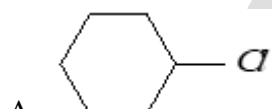| |
Cl   C

In the above four structures 1 and 3 are chiral compounds.

57. Which among the following compounds will be most reactive for SN^1 reaction?

A.

B.

C.

D.

Key: D

Solution: Most stable carbocation is formed, which is allylic and tertiary
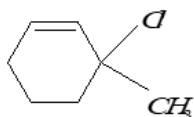
58. Fluorobenzene (C_6H_5F) can be synthesized in the laboratory

A. by heating phenol with HF and KF
B. from aniline by diazotisation followed by heating the diazonium salt with HBF_4
C. by direct fluorination of benzene with F_2 gas
D. by reacting bromobenzene with NaF solution

Key: B

Solution:

59.
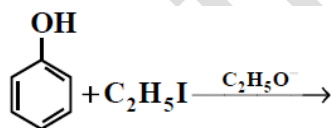
A. $C_6H_5OC_2H_5$
B. $C_2H_5OCH_3$
C. $C_6H_5OC_6H_5$
D. C_6H_5I

Key: A

Solution:

sodium phenoxide → (reaction with ethyl iodide) → phenetole

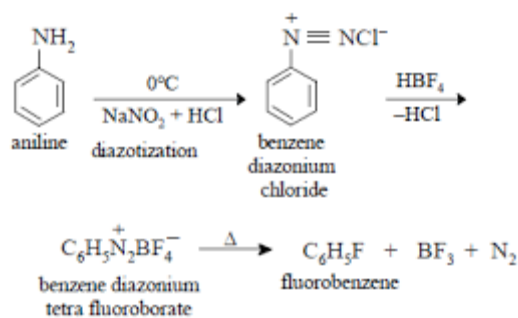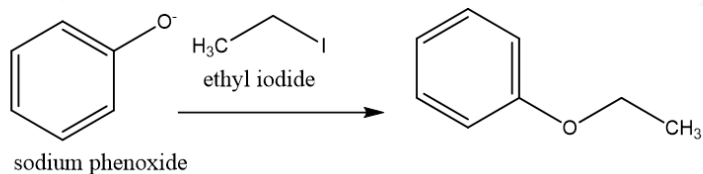60. Chlorobenzene $\xrightarrow{\text{reaction X}}$ Fhenol $\xrightarrow{\text{reaction Y}}$ salicylaldehyde .X and Y reactions are respectively:

A. Fries rearrangement and kolbe – Schmitt
B. Wurtz reaction and Reimer – Tiemann
C. Dow and Reimer – Tiemann
D. Dow and Friedel craft

Key: C

Solution: Dow and Reimer – Tiemann

61. The aromatic product formed from the following reaction is

A.

B.

C.

D.

Solution:

ethoxybenzene → phenol (Y) + iodoethane (Z) [HI, Heat]
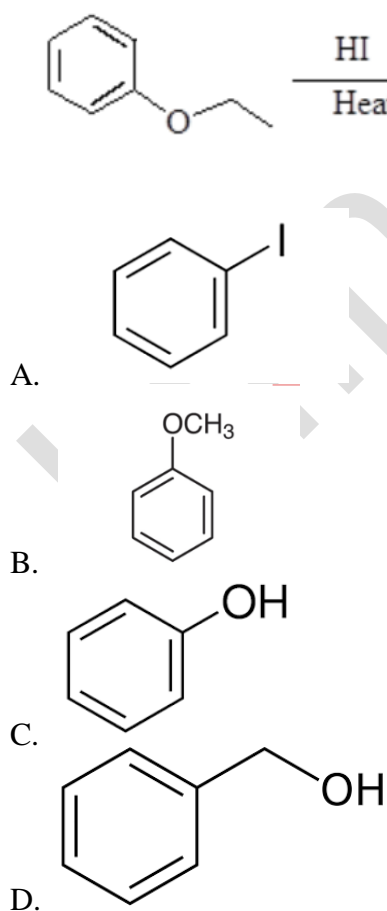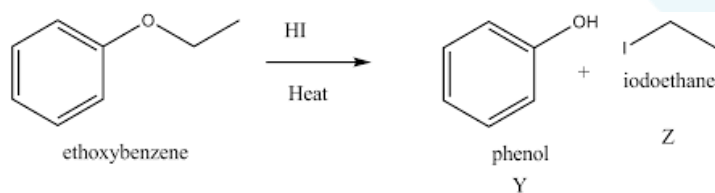
62. Which has the maximum viscosity?

A. Glycol
B. Water
C. Acetone
D. Ethanol

Key: A

Solution: Glycerol has maximum extent of hydrogen bonding

63. Cannizzaro's reaction is not given by _____

A.

B.
C. HCHO
D. CH_3CHO

Key: D

Solution: Aldehydes lacking α – H atom give cannizzaro reaction. The acetaldehyde (CH_3CHO) has α – H atom, so does not give Cannizzaro reaction

64. 2,2-Dichloro propane treated with aqueous KOH followed by heating gives $\underline{X}$. What is X

A. $CH_3C(OH)_2CH_3$
B. $CH_3CH(OH)CH_3$

C.

$$CH_3 - \overset{\overset{O}{\|}}{C} - CH_3$$
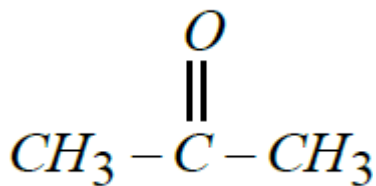
D. $CH_3CH(OH)CH_2HO$

Key: C

Solution:

$$CH_3 - \overset{\overset{Cl}{|}}{\underset{\underset{Cl}{|}}{C}} - CH_3 \xrightarrow[aq]{2KOH}$$

$$CH_3 - \overset{\overset{OH}{|}}{\underset{\underset{OH}{|}}{C}} - CH_3 \xrightarrow[-H_2O]{\Delta} CH_3 - \overset{\overset{O}{\|}}{C} - CH_3$$
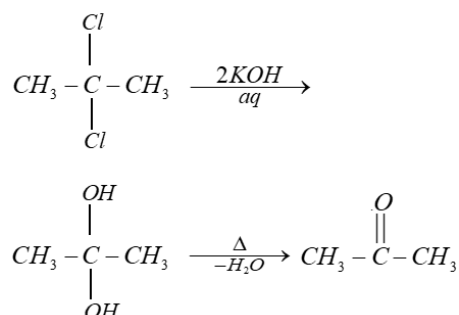
65. Hydrolysis of an ester gives a carboxylic acid which on kolbe's electrolysis yields butane. The ester is

A. Methyl methanoate
B. Methyl ethanoate
C. Ethyl methanoate
D. Methyl propanoate

Key: C

Solution: $CH_3 - CH_2 - \overset{\overset{o}{\|}}{C} - O - CH_3 \overset{H_3O^{\oplus}}{\square} CH_3 - CH_2 - \overset{\overset{o}{\|}}{C} - OH + CH_3OH$

$$2CH_3 - CH_2 - \overset{\overset{o}{\|}}{C} - ONa + H_2O \rightarrow \underset{(bu\tan e)}{C_4H_{10}} + 2CO_2 + 2NaOH + H_2$$
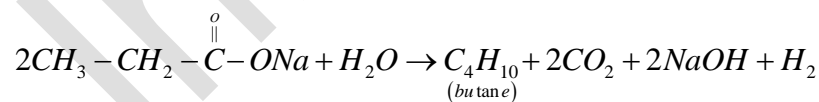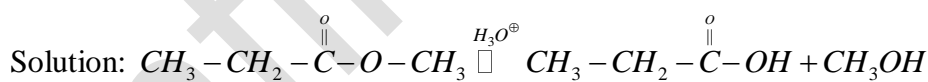
66. Incorrect combination of organic structure and its IUPAC name is

A. $HC \equiv C - CH_2 - CH = CH_2$ Pent-1-en-4-yne

$$OHC - \overset{\underset{\underset{CH_3}{|}}{}}{CH} - CH_2 - CN$$
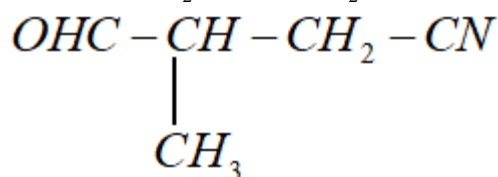
B. ....3-formyl butane nitrile

C.

COOH
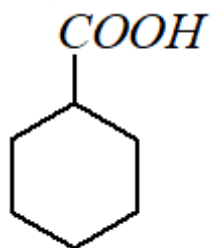
D.   ….Cycloheptanoic acid

$$CH_3 - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} - CH_2 - \underset{\underset{}{|}}{\overset{\overset{OH}{|}}{CH}} - CH_3$$
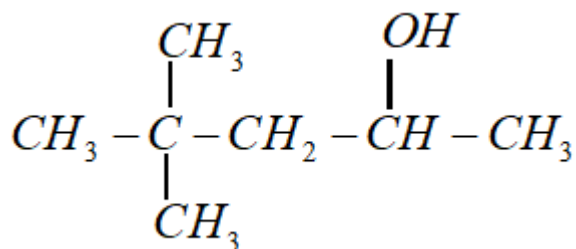
…….4,4-dimethyl pentan-2-ol

Key: C

Solution:
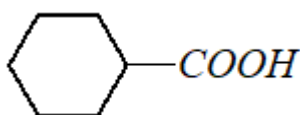
…..Cyclohexane carboxylic acid

67. $PhCONH_2 \xrightarrow[KOBr]{\Delta} B$ Product (B) is

A. $Ph\ NH\ COOMe$
B. $Ph\ NH_2$
C. $Ph\ NH\ COO\ Ph$
D. $C_6H_5 - NO_2$

Key: B

Solution: Hofmann bromide reactions the product $(Ph - N = C = O)$ reacts with $MeOH$ to give urethane

68. Which hybridisation is found in $HClO_4$ and $HClO_3$?

A. SP^3
B. SP^2
C. SP
D. dSP^2

Key: A

Solution: $HClO_3$
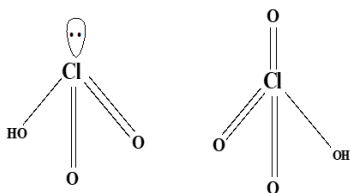
One lone pair

$e^- + 3\sigma$ bonds

SP^3 hybridisation SP^3 hybridisation

69. Transcription is a process when

A. messenger RNA is formed from DNA
B. ribosome RNA is formed from DNA
C. protein is synthesised at the ribosomes
D. none of the above

Key: A

Solution:

- Transcription is the process by which the information in a strand of DNA is copied into a new molecule of messenger RNA (mRNA).
- DNA safely and stably stores genetic material in the nuclei of cells as a reference, or template.

70. Which one of the following is a branched polymer

A. Amylose
B. Natural rubber
C. Neoprene
D. LDPE

Key: D

Solution: LDPE is a branched polymer having low density due to branching

Mathematics

71. For $x \in R$ if $f(x) = \sqrt{\log_{10}\left(\dfrac{3-x}{x}\right)}$, then the domain of f is

A. $\left[0, \dfrac{3}{2}\right]$

B. $\left(0, \dfrac{3}{2}\right]$

C. $[0,1]$

D. $(0,1]$

Key: B

Solution: We have,

$$f(x) = \sqrt{\log_{10}\left(\dfrac{3-x}{x}\right)}$$

Clearly, $f(x)$ is defined, if

$$\log_{10}\left(\dfrac{3-x}{x}\right) \geq 0 \text{ and } \dfrac{3-x}{x} > 0$$

$$\Rightarrow \dfrac{3-x}{x} \geq 10^0 \text{ and } \dfrac{x-3}{x} < 0$$

$$\Rightarrow \dfrac{3-x}{x} \geq 1 \text{ and } \dfrac{x-3}{x} < 0$$

$$\Rightarrow \left(\dfrac{2x-3}{x}\right) \leq 0 \text{ and } \dfrac{x-3}{x} < 0$$

$$\Rightarrow 0 < x \leq \dfrac{3}{2} \Rightarrow x \in \left(0, \dfrac{3}{2}\right]$$

72. Domain of the real valued function $\sqrt{25-9x^2} + \sqrt{x^2+x+1}$ is

A. $\left(-\dfrac{5}{3}, \dfrac{5}{3}\right)$

B. $\left(-\infty, \dfrac{5}{3}\right) \cup \left[\dfrac{5}{3}, \infty\right]$

C. $\left[-\dfrac{5}{3}, \dfrac{5}{3}\right]$

D. $\left(-\infty, -\dfrac{5}{3}\right) \cup \left(\dfrac{5}{3}, \infty\right)$

Key: C

Solution: *Given function is defined if* $25 - 9x^2 \geq 0 \ \& \ x^2 + x + 1 \geq 0$

Here $x^2 + x + 1 \geq 0$ *for all* $x \in R$

and $9x^2 - 25 \leq 0$

$\Rightarrow x^2 \leq \dfrac{25}{9}$

$\Rightarrow x^2 - \left(\dfrac{5}{3}\right)^2 \leq 0$

$\Rightarrow x \in \left[\dfrac{-5}{3}, \dfrac{5}{3}\right]$

73. A = {p, q, r, s, t} and B = {1, 2, 3, 4, 5}, such that, its relation "R" be given by, R = {(p,1), (q,2), (r,3), (s,4), (t,5)} then range of R^{-1} is

A. {p, q, r, s, t}
B. {1, 2, 3, 4, 5}
C. {1, 2, 3, 4}
D. {p, q, r, s}

Key: A

Solution: {p, q, r, s, t}

74. Let $A = \{x \in R : 0 < x < 1\}$ Among the following not an element of A is

A. 1

B. $\dfrac{1}{2}$

C. $\dfrac{1}{3}$

D. $\dfrac{1}{4}$

Key: A

Solution: $1 \in A$ because $A = \{x / x \in R\, and\, 0 < x < 1\}$

$\therefore x \neq 1\, and\, x \neq 0$

x can take only because 0 and 1 R.

75. If the roots of the equation $x^2 - (k+1)x + (k^2 + k - 8) = 0$ are on either side of 2 then the value of k can be

A. 4
B. −4
C. 2
D. −2

Key: C

Solution: $f(2) < 0 \Rightarrow k^2 - k - 6 < 0 \Rightarrow (k-3)(k-2) < 0 \Rightarrow k \in (-2, 3)$

76. Let $\left(1 + x + x^2\right)^n = a_0 + a_1 x + a_2 x^2 + \cdots + a_{2n} x^{2n}$ Then :

A. $a_r = a_{2n-r}$

B. $\displaystyle\sum_{r=0}^{n-1} a_r = \dfrac{1}{2}\left(3^{n-1} - a_n\right)$

C. $\displaystyle\sum_{r=0}^{n-1} a_r = \dfrac{1}{2}\left(3^n - a_n\right)$

D. $(n-r)a_r + (2n-r+1)a_{r-1} = (r+1)a_{r+1}$

Key: A,C ,D

Solution: $\left(1 + x + x^2\right)^n = a_0 + a_1 x + a_2 x^2 + \cdots + a_{2n} x^{2n}$ ....(i)

Replacing x by $\dfrac{1}{x}$,

$\left(1 + x + x^2\right)^n = x^{2n}\left[a_0 + \dfrac{a_1}{x} + \dfrac{a_2}{x^2} + \cdots + \dfrac{a_{2n}}{x^{2n}}\right]$

$= a_{2n} + a_{2n-1}x + a_{2n-2}x^2 + \cdots + a_0 x^{2n}$

Comparing coefficients, $a_r = a_{2n-r}$ ....(ii)

Putting $x = 1$ in (i),

$$[a_0 + a_1 + a_2 + \cdots + a_{n-1}] + a_n + [a_{n+1} + a_{n+2} + \cdots + a_{2n}] = 3^n$$

$$\Rightarrow 2\sum_{r=0}^{n-1} a_r = 3^n - a_n \qquad [\text{Using } a_{2n-r} = a_r]$$

$$\Rightarrow \sum_{r=0}^{n-1} a_r = \frac{1}{2}\left[3^n - a_n\right] \qquad ....(iii)$$

Differentiating eq. (i), we get

$$n(2x+1)(1+x+x^2)^{n-1} = \sum_{r=0}^{2n} r a_r x^{r-1}$$

$$\Rightarrow n(2x+1)(1+x+x^2)^n = (1+x+x^2)\sum_{r=0}^{2n} r \cdot a_r x^{r-1}$$

Equating coefficients of x^r, we get

$$= 2na_{r-1} + {}^n a_r = (r+1)a_{r+1} + {}^r a_r + (r-1)a_{r-1}$$

$$\Rightarrow (r+1)a_{r+1} = (n-r)a_r + (2n-r+1)a_{r-1}.$$

$\therefore$ (a), (c), (d) are correct.

77. If $\sqrt{3\sqrt{3\sqrt{3\sqrt{3\sqrt{3}}}}} = 3^n$ then the value of n is

A. $\dfrac{11}{24}$

B. $\dfrac{15}{16}$

C. $\dfrac{63}{64}$

D. $\dfrac{31}{32}$

Key: D

Solution: $3^{\frac{1}{2}} 3^{\frac{1}{4}} 3^{\frac{1}{8}} 3^{\frac{1}{16}} 3^{\frac{1}{32}} = 3^n$

$$3^{\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\frac{1}{32}} = 3^n$$

$$3^{\frac{16+8+4+2+1}{32}} = 3^n \implies n = \frac{31}{32}$$

78. Value of k, for which $A = \begin{bmatrix} k & 8 \\ 4 & 2k \end{bmatrix}$ is a singular matrix is,

A. 4
B. -4
C. ± 4
D. 0

Key: A,C,D

Solution: Given, that matrix A is singular.
Thus, the determinant of A is 0.
So,

$$|A| = \begin{vmatrix} K & 8 \\ 4 & 2K \end{vmatrix} = 0$$

$$k(2k) - 8(4) = 0$$

$$2k^2 - 32 = 0$$

$$2k^2 = 32$$

$$k^2 = 16$$

$$k = \pm 4$$

79. If the equations $ax^2 + 2bx + c = 0$ and $ax^2 + 2cx + b = 0, b \neq -c$ have a common root,

then $\dfrac{a}{b+c} =$

A. -4
B. 4
C. 5
D. -5

Key: A

Solution: the equations $ax^2 + 2bx + c = 0$ and $ax^2 + 2cx + b = 0$ have a common root

$$\left(ax^2 + 2bx + c\right) - \left(ax^2 + 2cx + b\right) = 0$$

Subtracting we get $2(b-c)x + c - b = 0 \Rightarrow x = \dfrac{1}{2}$

substituting x=1/2

$$\Rightarrow \dfrac{a}{4} + b + c = 0 \Rightarrow \dfrac{a}{b+c} = -4$$

80. If $B = \begin{bmatrix} 8 & 2 \\ 4 & 5 \end{bmatrix}$, then which of the following is correct?

A. $|3B| = 3|B|$
B. $|3B| = 27|B|$
C. $|3B| = 9|B|$
D. $|3B| = |B|$

Key: C

Solution: Given, $B = \begin{bmatrix} 8 & 2 \\ 4 & 5 \end{bmatrix}$

As we know,

The determinant of a 2×2 matrix $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$ ad − bc

Thus,

$$\Rightarrow |B| = (8 \times 5) - (2 \times 4)$$

$$\Rightarrow |B| = 40 - 8$$

$$\Rightarrow |B| = 32 \ ....(i)$$

81. If A and B are two square matrices such that $B = -A^{-1}BA$, Then $(A+B)^2$

A. 0
B. $A^2 + B^2$
C. $A^2 + 2AB + B^2$
D. A+B

Key: B

Solution: $B = -A^{-1}BA$

$AB = -A\left(A^{-1}BA\right) \; AB = -BA$

$\left(A + B\right)^2 = \left(A + B\right)\left(A + B\right) = A^2 + B^2$

82. Let A be a matrix such that $A\begin{bmatrix} 1 & 2 \\ 0 & 3 \end{bmatrix}$ is a scalar matrix and $|3A| = 108$ Then A^2 equals

A. $\begin{bmatrix} 4 & -32 \\ 0 & 36 \end{bmatrix}$

B. $\begin{bmatrix} 4 & 0 \\ -32 & 36 \end{bmatrix}$

C. $\begin{bmatrix} 36 & 0 \\ -32 & 4 \end{bmatrix}$

D. $\begin{bmatrix} 36 & -32 \\ 0 & 4 \end{bmatrix}$

Key: D

Solution: Let $A\begin{bmatrix} 1 & 2 \\ 0 & 3 \end{bmatrix} = \begin{bmatrix} k & 0 \\ 0 & k \end{bmatrix}$

$A \;\; = \begin{bmatrix} k & 0 \\ 0 & k \end{bmatrix}\begin{bmatrix} 1 & 2 \\ 0 & 3 \end{bmatrix}^{-1}$

$= \begin{bmatrix} k & -2k/3 \\ 0 & k/3 \end{bmatrix}$

$|A| \;\; = \;\; \dfrac{k^2}{3}$

$|3A| \;\; = \;\; 108$

$3^2|A| \;\; = \;\; 108$

$9 \times \dfrac{k^2}{3} \;\; = \;\; 108$

$$\therefore A = \begin{bmatrix} 6 & -4 \\ 0 & 2 \end{bmatrix}$$

$$\therefore A^2 = \begin{bmatrix} 36 & -32 \\ 0 & 4 \end{bmatrix}$$

83. The number of ways to arrange the letters of the word CHEESE, are

A. 120
B. 240
C. 720
D. 6

Key: A

Solution: Letters of word "CHEESE" can be arranged in

$\dfrac{6!}{3!} = 120$ ways.

84. In a network of railways, a small island has 15 stations. The number of different types of tickets to be printed for each class, if every station must have tickets for other station, is

A. 230
B. 210
C. 340
D. None of these

Key: B

Solution: For each pair of stations, two different types of tickets are required, Now, the number of selections of 2 stations from 15 stations $= 15 \times 14$

∴ Required number of types of tickets $= 15 \times 14 = 210$

85. There are 12 intermediate stations on a railway line between 2 stations. The number of ways that a train can be made to stop at 4 of these intermediate stations no two of these halting stations being consecutive is

A. 125
B. 126
C. 127
D. 130

Key: B

Solution: *Total no.of railway stations* $= n = 12$

No.of stations to be selected, $r = 3$

No.of ways of selecting r stations

which are non consecutive $= {}^{n-r+1}C_r = {}^9C_4$

$$= \frac{9 \times 8 \times 7 \times 6}{4 \times 3 \times 2} = 126$$

86. If ${}^{12}C_{r+1} = {}^{12}C_{3r-5}$, then $r =$

A. 2 or 3
B. 3 or 4
C. 4 or 5
D. 5 or 6

Key: B

Solution: ${}^{12}C_{r+1} = {}^{12}C_{3r-5}$

$r + 1 = 3r - 5$ *or* $12 = r + 1 + 3r - 5$

$2r = 6$ *or* $16 = 4r$

$r = 3$ *or* $r = 4$

87. $\left(1 + x + x^2\right)^8 = a_0 + a_1 + \ldots + a_{16}x^{16}$ then $a_1 - a_3 + a_5 - a_7 + \ldots - a_{15} =$

A. 1
B. 2
C. 3
D. 0

Key: D

Solution: $\left(1 + x + x^2\right)^8 = a_0 + a_1 x + a_2 x^2 + \ldots + a_{16}x^1$ $-(1)$

Put -x in place of x

$\left(1 - x + x^2\right)^2 = a_0 - a_1 x + a_2 x^2 - a_3 x^3 + \ldots + a_{16}x^{16}$ $-(2)$

$(1) - (2)$

$$\left(1 + x + x^2\right)^8 - \left(1 - x + x^2\right)^8$$

$$= 2x\left[a_1 + a_3 x^2 + \ldots + a_{15} x^{14}\right]$$

$$\frac{\left(1 + x + x^2\right)^8 - \left(1 - x + x^2\right)^8}{2x} = a_1 + a_3 x^2 + \ldots + a_{15} x^{14}$$

Put $x = i$

$$\frac{\left(1 + i + i^2\right)^8 - \left(1 - i + i^2\right)^8}{2i} = a_1 + a_3 i^2 + \ldots + a_{15} i^{14}$$

$$\frac{1 - 1}{2i} = 0 = a_1 - a_3 + a_5 - a_7 + \ldots + a_{13} - a_{15}$$

$$a_1 - a_3 + a_5 - a_7 + \ldots + a_{13} - a_{15} = 0$$

88. Given sum of the first n sympols of an A.P. is $2n + 3n^2$. Another A.P. is formed with the same first term and is double the common difference, the sum of n terms of the new A.P. is

A. $n + 4n^2$
B. $6n^2 - n$
C. $n^2 + 4n$
D. $3n + 2n^2$

Key: B

Solution:

$$\begin{array}{l|l}
& n = 2\, s_2 = 4 + 12 = 16 \\
s_n = 2n + 3n^2 & a_1 + a_2 = 16 \\
n = 1 \Rightarrow s_1 = 5 = a & a_2 = 11
\end{array}$$

$$d = a_2 - a_1 = 11 - 5 = 6$$

$$a = 5 \quad d_1 = 2d = 12$$

$$s_n = \frac{n}{2}\left[10 + (n-1)12\right] = n\left[5 + 6n - 6\right] = n\left[6n - 1\right]$$

89. The domain of the function $f(x) = \sqrt{1 - \sqrt{1 - \sqrt{1 - x^2}}}$ is

A. $[1, -1]$
B. $[-1, 1]$
C. $[-1, -1]$
D. $[1, 1]$

Key: B

Solution: $f(x) = \sqrt{1 - \sqrt{1 - \sqrt{1 - x^2}}}$

$1 - \sqrt{1 - \sqrt{1 - x^2}} \geq 0$

$\sqrt{1 - \sqrt{1 - x^2}} \leq 1$

$1 - \sqrt{1 - x^2} \leq 1$

$\sqrt{1 - x^2} \geq 0$

$1 - x^2 \geq 0$

$x^2 \leq 1$

$x \in [-1, 1]$

90. The function $f(x) = e^{|x|}$ is

A. Continuous everywhere but not differentiable at $x = 0$
B. continuous and differentiable everywhere.
C. not continuous at $x = 0$
D. differentiable everywhere.

Key: A

Solution: $f^1(0^-) = \underset{x \to 0^-}{Lt} \frac{f(x) - f(0)}{x - 0} = \underset{x \to 0^-}{Lt} \frac{e^{-x} - 1}{x} = -1$

$f^1(0^+) = \underset{x \to 0^+}{Lt} \frac{f(x) - f(0)}{x - 0} = \underset{x \to 0^+}{Lt} \frac{e^x - 1}{x} =$

91. If the slope of the tangent drawn to the curve $y = e^{a+bx^2}$ at the point $P(1,1)$ is -2 then the value of $2a - 3b$

A. 5
B. 6
C. 7
D. 8

Key: A

Solution: $y = e^{a+bx^2}$ passing through the point $(1,1)$

$a + b = 0$

Slope of the tangent is

$\therefore \left. \dfrac{dy}{dx} \right|_{P(1,1)} = -2 \cdots (2)$

$\Rightarrow \dfrac{dy}{dx} = \left(e^{a+bx^2} \right)(2bx)$

$\Rightarrow \left. \dfrac{dy}{dx} \right|_{P(1,1)} = \left(e^{a+b} \right)(2b \times 1) = e^{a+b}.2b \cdots (3)$

eq (2) and Eq (3) equal

$\Rightarrow e^{a+b} \times 2b = -2$

a+b=0 then

b=-1

a=1

92. $y = \dfrac{e^x - e^{-x}}{e^x + e^{-x}}$ then $\dfrac{dy}{dx} =$

A. $\dfrac{e^{2x}}{e^{2x} + 1}$

B. $\dfrac{4e^{2x}}{\left(e^{2x} + 1 \right)^2}$

C. $\dfrac{e^x}{\left(e^x + 1 \right)^2}$

D. $\dfrac{e^{2x}}{\left(e^{2x}-1\right)^2}$

Key: B

Solution: $\dfrac{dy}{dx}=\dfrac{e^{-x}\left(e^{2x}-1\right)}{e^{-x}\left(e^{2x}+1\right)}=\dfrac{\left(e^{2x}+1\right)2e^{2x}-\left(e^{2x}-1\right)2e^{2x}}{\left(e^{2x}+1\right)^2}$

$=\dfrac{2e^{2x}\left(e^{2x}+1-e^{2x}+1\right)}{\left(e^{2x}+1\right)^2}=\dfrac{4e^{2x}}{\left(e^{2x}+1\right)^2}$

93. $\displaystyle\int\dfrac{1}{x^2+6x+10}dx$

A. $Tan^{-1}\left(x+2\right)+c$
B. $Tan^{-1}\left(2x+3\right)+c$
C. $Tan^{-1}\left(x+4\right)+c$
D. $Tan^{-1}\left(x+3\right)+c$

Key: D

Solution: $=\displaystyle\int\dfrac{1}{x^2+6x+10}dx$

$=\displaystyle\int\dfrac{1}{\left(x+3\right)^2+1}dx$

$=Tan^{-1}\left(x+3\right)+c$

94. If $\displaystyle\int xsinxdx=k+\sin x+c$ then k=

A. -xsinx
B. -xcosx
C. Xsinx
D. xcosx

Key: B

Solution: $-xcos x+\sin x+c$

95. $\int \dfrac{\sqrt{\cot x}}{\sin 2x} dx$

    A. $\sqrt{\cot x} + c$
    B. $-\sqrt{\cot x} + c$
    C. $\sqrt{Tanx} + c$
    D. $-\sqrt{Tanx} + c$

Key: B

Solution: $\int \dfrac{\sqrt{\cot x}}{\sin 2x} dx = \int \dfrac{\sqrt{\cot x}}{2\sin x \cos x} dx$

$= \int \dfrac{\sqrt{\cot x}}{2\sin^2 x \cot x} dx$

$= \dfrac{1}{2} \int \dfrac{\cos ec^2 x}{\sqrt{\cot x}}$

$= -\sqrt{\cot x} + c$

$\int \dfrac{\sqrt{\cot x}}{\sin 2x} dx = -\sqrt{\cot x} + c$

96. If $\int_0^{\sqrt{e}} x \log x \, dx = k$ then k =

    A. 1
    B. 2
    C. 0
    D. 3

Key: C

Solution: $= \int_0^{\sqrt{e}} x \log x \, dx$

Apply walli's product formula

$= \left(\log x \dfrac{x^2}{2} \right)_0^{\sqrt{e}} - \int_0^{\sqrt{e}} \left(\dfrac{x}{2} \right) dx$

$$= \frac{e}{4} - \left(\frac{x^2}{4}\right)_0^{\sqrt{e}}$$

$$= 0$$

97. Find the equation of a straight line that passes through the point (2, 1) and perpendicular to the straight line x + 4y - 6 = 0.

A. $4x - y - 7 = 0$
B. $9x + 8y - 7 = 0$
C. $x - 2y - 7 = 0$
D. $-2x - 3y - 7 = 0$

Key: A

Solution: Given that the line is perpendicular to the line x + 4y - 6 = 0

This can be written in the form y = mx + c,

$$4y = -x + 6$$

$$y = -\frac{x}{4} + \frac{6}{4}$$

$$y = -\frac{1}{4}x + \frac{3}{2}$$

Here $m_1 = -\frac{1}{4}$ is the slope of the line.

Since the lines are perpendicular,

$$\mathbf{m_1 \times m_2 = -1}$$

$$\Rightarrow \frac{-1}{4} \times m_2 = -1$$

$$\Rightarrow \mathbf{m_2 = 4}$$

Hence, the slope of the second line is 4.

The equation of the line : $y = m_2 x + c$

$$y = 4x + c$$

But given that the line passes through the point (2, 1)

Therefore,

$$\Rightarrow 1 = 4(2) + c$$

$$\Rightarrow c = -7$$

Substitute the value of c.

$$\Rightarrow y = 4x - 7$$

$$\Rightarrow 4x - y - 7 = 0$$

Therefore, the equation of the line is $4x - y - 7 = 0$

98. The medians AD and BE of the triangle with vertices $A(0,b), B(0,0)$ and $C(a,0)$ are mutually perpendicular, if

A. $b = \sqrt{2}a$
B. $a = \pm\sqrt{2}b$
C. $b = -\sqrt{2}a$
D. $a = -2b$

Key: B

Solution: The coordinates of D and E are $(a/2, 0)$ and $(a/2, b/2)$ respectively.

Now, $m_1 =$ Slope of $AD = \dfrac{b-0}{0-a/2} = -\dfrac{2b}{a}$

$m_2 =$ Slope of $BE = \dfrac{b/2-0}{a/2-0} = \dfrac{b}{a}$

Since AD and BE are perpendicular. Therefore,

$$m_1 m_2 = -1 - \frac{2b}{a} \times \frac{b}{a} = -1 \Rightarrow a = \pm\sqrt{2}b$$

99. If the lines $kx + 3y + 5 = 0$ and $3x + 9y - 10 = 0$ are parallel, then the value of $'k'$ is

A. 0
B. 1
C. −1
D. −2

Solution: $m_1 = m_2$

$$\frac{-k}{3} = \frac{-3}{9} \Rightarrow k = -1$$

100.   Consider two lines in space as $L_1 : \vec{r_1} = \hat{j} + 2\hat{k} + \lambda\left(3\hat{i} - \hat{j} - \hat{k}\right)$

and $L_2 : \vec{r_2} = 4\hat{i} + 3\hat{j} + 6\hat{k} + \mu\left(\hat{i} + 2\hat{k}\right)$ If the shortest distance between these lines is $\sqrt{d}$ then d equals:

A. $\frac{9}{2}$

B. $\frac{16}{21}$

C. $\frac{21}{16}$

D. $\frac{15}{16}$

Key: B

Solution: $\vec{a_1} = 0\hat{i} + \hat{J} + 2\hat{k}$ and $\vec{b_1} = 3\hat{i} + \hat{J} + 2\hat{k}$ for L_1.

$\vec{a_2} = 4\hat{i} + 3\hat{J} + 6\hat{k}$ and $\vec{b_2} = \hat{i} + 0\hat{J} + 2\hat{k}$ for L_2

Now,

$$\vec{a_2} - \vec{a_1} = \left(4\hat{i} + 3\hat{J} + 6\hat{k}\right) - \left(0\hat{i} + \hat{J} + 2\hat{k}\right) = 4\hat{i} + 2\hat{J} + 4\hat{k}$$

$$\vec{b_1} \times \vec{b_2} = \begin{vmatrix} \hat{i} & \hat{J} & \hat{k} \\ 3 & 1 & 2 \\ 1 & 0 & 2 \end{vmatrix} = \hat{i}(2-0) - \hat{J}(6-2) + \hat{k}(0-1) = 2\hat{i} - 4\hat{J} - \hat{k}$$

Now magnitude

$$\left|\vec{b_1} \times \vec{b_2}\right| = \sqrt{2^2 + (-4)^2 + (-1)^2} = \sqrt{4 + 16 + 1} = \sqrt{21}$$

$\left(\vec{b_1} \times \vec{b_2}\right) \cdot \left(\vec{a_2} - \vec{a_1}\right) = \left(2\hat{i} - 4\hat{J} - \hat{k}\right) \cdot \left(4\hat{i} + 2\hat{J} + 4\hat{k}\right) = 8 - 8 - 4 = -4$ Therefore, shortest distance

$$= \left| \frac{\left(\vec{b_1} \times \vec{b_2} \right) \cdot \left(\vec{a_2} - \vec{a_1} \right)}{\left| \vec{b_1} \times \vec{b_2} \right|} \right| = \left| \frac{-4}{\sqrt{21}} \right| = \frac{4}{\sqrt{21}}$$

Now, the shortest distance between these lines is $\sqrt{d} = \dfrac{4}{\sqrt{21}} \Rightarrow d = \left(\dfrac{4}{\sqrt{21}} \right)^2 = \dfrac{16}{21}$

Therefore, correct option is (b).

101. If $\vec{a} = 2\hat{i} + 3\hat{j} - 4\hat{k}$, $\vec{b} = \hat{i} + \hat{j} + \hat{k}$, $\vec{c} = 4\hat{i} + 2\hat{j} + 3\hat{k}$ then $\left| \vec{a} \times \left(\vec{b} \times \vec{c} \right) \right| = $ _____

A. $\sqrt{10}$
B. 1
C. 2
D. $\sqrt{5}$

Key: D

Solution: $\left| \vec{a} \times \left(\vec{b} \times \vec{c} \right) \right| = \left| \left(\vec{a}.\vec{c} \right) \vec{b} - \left(\vec{a}.\vec{b} \right) \vec{c} \right|$

$= \sqrt{5}$

102. The unit vector parallel to the resultant vector of $4\vec{i} + 8\vec{j} - 13\vec{k}, \vec{i} + 2\vec{j} + 3\vec{k}$ is

A. $\dfrac{1}{3} \left[\vec{i} + 2\vec{j} - 2\vec{k} \right]$

B. $\dfrac{1}{3} \left[\vec{i} - 2\vec{j} - 2\vec{k} \right]$

C. $\dfrac{1}{3} \left[-\vec{i} + 2\vec{j} + 2\vec{k} \right]$

D. $\dfrac{1}{3} \left[-\vec{i} - 2\vec{j} - 3\vec{k} \right]$

Key: A

Solution: $\vec{r} = 5\vec{i} + 10\vec{j} - 10\vec{k}$ $\vec{e} = $ unit vectors $= \dfrac{5\vec{i} + 10\vec{j} - 10\vec{k}}{\sqrt{25 + 100 + 100}}$

$= \dfrac{1}{15} \left[5\vec{i} + 10\vec{j} - 10\vec{k} \right]$ $= \dfrac{1}{3} \left[\vec{i} + 2\vec{j} - 2\vec{k} \right]$

103. The mean of 5 observations is 4.4 and their variance is 8.24 . If three of those observations are

A. 9,4
B. 9,5
C. 9,2
D. 9,13

Key: A

Solution: Let the other two observations be x and y

$\therefore$ the series is $1, 2, 6, x, y$

Now mean $x = 4.4$

$$4.4 = \frac{1+2+6+x+y}{5}$$

$9 + x + y + = 22$

$x + y = 13 \rightarrow (1)$

Also Variance

$$= 8.24 \frac{1}{n} = (xi - \bar{x})^2$$

$$\Rightarrow 8.24 = \left(\frac{1}{5}\right)\left[(3.4)^2 + (2.4)^2 + (1.6)^2 + x^2 + y^2 - 2x(4.4)x(x+y) + 2x(4.4)^2\right]$$

$$\Rightarrow 41.20 = 11.56 + 5.76 + 2.56 + x^2 + y^2 - 8.8x + 13 + 38.72$$

$x^2 + y^2 = 97 \rightarrow (2)$

But form (1) , we have

$x^2 + y^2 + 2xy = 169 \rightarrow (3)$

Form $(2)\&(3)$

$2xy = 72 \rightarrow (4)$

Subtracting (4)form(2), we get

$$\Rightarrow x^2 + y^2 - 2xy = 97 - 72$$

$$\Rightarrow (x-y)^2 = 25$$

(or)

$$x - y = \pm 5 \rightarrow (5)$$

So form (1)and(5)we get

$$x = 9 \, and \, y = 4$$

When $x - y = 5$

$$x = 4, y = 9$$

104. Find the mean deviation of the first six odd numbers.

A. 3

B. 4

C. 5

D. 2

Key: A

Solution: Given dataset: **1, 3, 5, 7, 9, 11**

We know that **the mean deviation is given by:** $\dfrac{\Sigma |X-\mu|}{N}$; where

μ = Mean of the dataset

N = Total number of data in the set = 6 (Given)

Now,

Mean, $\mu = \dfrac{\textbf{Summation of total values}}{\textbf{No. of values}}$

$$= \frac{1+3+5+7+9+11}{6}$$

$$= \frac{36}{6} = \textbf{6}$$

So, $\mu = \textbf{6}$

Then, mean deviation:

$$= \frac{|1-6|+|3-6|+|5-6|+|7-6|+|9-6|+|11-6|}{6}$$

$$= \frac{5+3+1+1+3+5}{6}$$

$$= \frac{18}{6}$$

$$= \mathbf{3}$$

Hence, **the required mean deviation is** 3.

105. A coin is biased so that the probability of falling head when tossed is $\frac{1}{4}$. If the coin is tossed 5 times, the probability of obtaining 2 heads and 3 tails is

A. $\frac{135}{512}$

B. $\frac{75}{512}$

C. $\frac{1}{512}$

D. $\frac{1}{256}$

Key: A

Solution: $p = \frac{1}{4}, q = \frac{3}{4}$ and $n = 5$

$$P(X = 2) = 5_{C_2} \left(\frac{1}{4}\right)^2 \left(\frac{3}{4}\right)^3$$

$$10.\frac{1}{16}.\frac{27}{4 \times 4 \times 4} = \frac{135}{512}$$

106. A sample of 2 items is selected at random from a bag containing 5 items of which 2 are defective . Then mean of number of defective items is

A. $\frac{4}{5}$

B. $\frac{1}{5}$

C. $\dfrac{2}{5}$

D. $\dfrac{3}{5}$

Key: A

Solution:

X	0	1	2
P(X)	$\dfrac{3}{10}$	$\dfrac{6}{10}$	$\dfrac{1}{10}$

Mean $= \dfrac{4}{5}$

107. If the angle of a triangle are in the ratio 1:1:4 then the ratio of the perimeter of the triangle to its largest side is

A. $\sqrt{2}+2:\sqrt{3}$

B. $3:2$

C. $\sqrt{3}+2:\sqrt{2}$

D. $\sqrt{3}+2:\sqrt{3}$

Key: C

Solution: $A:B:C = 1:1:4$

$A = x, B = x, C = 4x$

$A+B+C = 180$

$6x = 180^0 \Rightarrow x = 30^0$

$A = 30^0, B = 30^0, C = 120^0$

$a = k\sin 30^0, b = k\sin 30^0, c = k\sin 120^0$

$a = \dfrac{k}{2} b = \dfrac{k}{2} c = \dfrac{k\sqrt{3}}{2}$

$a+b+c:c$

$= k+\dfrac{k\sqrt{3}}{2} : \dfrac{\sqrt{3}}{2}k$

$= 2+\sqrt{3} : \sqrt{3}$

108. The range of $f(x) = -3\cos\sqrt{3+x+x^2}$ is

A. $[-1,1]$

B. $[-2,2]$

C. $[-3,3]$

D. $[-4,4]$

Key: C

Solution: *Minimum value of* $f(x) = -3$

Maximum value of $f(x) = 3$

109. If $\sin^{-1}\left(\dfrac{x}{5}\right) + \cos ec^{-1}\left(\dfrac{5}{4}\right) = \dfrac{\pi}{2}$, then the value of 'x' is

A. 1

B. 3

C. 4

D. 5

Key: B

Solution: *Since*, $\sin^{-1}\left(\dfrac{x}{5}\right) + \cos ec^{-1}\left(\dfrac{5}{4}\right) = \dfrac{\pi}{2}$

$\Rightarrow \sin^{-1}\left(\dfrac{x}{5}\right) + \sin^{-1}\left(\dfrac{4}{5}\right) = \dfrac{\pi}{2}$

$\Rightarrow \sin^{-1}\left(\dfrac{x}{5}\right) = \dfrac{x}{2} - \sin^{-1}\left(\dfrac{4}{5}\right)$

$\Rightarrow \sin^{-1}\left(\dfrac{x}{5}\right) = \cos^{-1}\left(\dfrac{4}{5}\right)$

$\Rightarrow \sin^{-1}\left(\dfrac{x}{5}\right) = \sin^{-1}\left(\dfrac{3}{5}\right)$

$\Rightarrow x = 3$

110. The acute angle bisector between the lines $3x - 4y - 5 = 0, 5x + 12y - 26 = 0$ is

A. $7x - 56y + 32 = 0$

B. $9x - 3y + 13 = 0$

C. $14x - 112y + 65 = 0$

D. $7x - 13y + 9 = 0$

Key: C

Solution: $-3x + 4y + 5 = 0, -5x - 12y + 26 = 0$

$c_1 = 5 > 0, c_2 = 26 > 0 \, and \, a_1 a_2 + b_1 b_2 = (-3)(-5) + 4(-12) < 0$

The acute angle bisector is $\dfrac{-3x + 4y + 5}{5} = + \left(\dfrac{-5x - 12y + 26}{13} \right)$

$= 14x - 112y + 65 = 0$

Aptitude

111. How many numbers up to 100 have exactly 3 factors?

A. 30

B. 25

C. 8

D. 4

Key: D

Solution: All the prime numbers, for example, 2, 3, 5, 7... have only 2 factors, that is, 1 and the number itself.
All composite numbers, for example, 4, 6, 8, 9...have more than 3 factors.

So, only the **squares of the prime numbers** are the only numbers which have exactly **three factors**.

Such numbers between 1 and 100 are **4, 9, 25 and 49**.

Hence, the correct answer is: **4**

112. Evaluate $\dfrac{5}{6} \, of \, \dfrac{3}{4} \div \dfrac{7}{8} \times 1\dfrac{1}{2} + \dfrac{5}{6}$.

A. $1\dfrac{19}{21}$

B. $1\dfrac{7}{23}$

C. $1\dfrac{5}{23}$

D. $2\dfrac{3}{21}$

Key: A

Solution: To evaluate the expression, we'll follow the order of operations (BODMAS: Brackets, Orders, Division and Multiplication, Addition and Subtraction from left to right).

$$\dfrac{5}{6} \, of \, \dfrac{3}{4} \div \dfrac{7}{8} \times 1\dfrac{1}{2} + \dfrac{5}{6} = \, ?$$

Step: 1

$$\dfrac{5}{6} \times \dfrac{3}{4} \div \dfrac{7}{8} \times \dfrac{3}{2} + \dfrac{5}{6} = \, ?$$

Step: 2 – Division

$$\dfrac{5}{6} \times \dfrac{6}{7} \times \dfrac{3}{2} + \dfrac{5}{6} = \, ?$$

Step: 3 – Multiplication

$$\dfrac{15}{14} + \dfrac{5}{6} = \, ?$$

Step: 4 – Addition

$$= 1\dfrac{19}{21}$$

113. The following five integers provide the basis for these questions.
834 427 563 649 975
What will happen if the first digit of the second-highest number is divided by the first digit of the lowest number?

A. 5

B. 3

C. 2

D. 4

Key: C

Solution: 2nd highest number's first digit equals 8 3 4.
The lowest number's first digit is 4 2 7.
The result is 8/4 = **2**.

114. The LCM of the prime numbers between 1 to 12 is ___

A. 1010

B. 1000

C. 2310

D. 2020

Key: C

Solution: Prime numbers between 1 to 12 are

2,3,5,7,11

$LCM = 2 \times 3 \times 5 \times 7 \times 11 = 2310$

115. Find the unit digit in the product $(2467)^{153} \times (341)^{72}$

A. 6

B. 7

C. 8

D. 9

Key: B

Solution: Clearly, unit's digit in the given product= unit's digit in $7^{153} \times 1^{72}$

Now, 7^4 gives unit digit 1

$\therefore 7^{153}$ gives unit digit $(1 \times 7) = 7$

Also 1^{72} gives unit digit 1.

Hence, unit's digit in the product $(1 \times 7) = 7$

116. In the given diagram, with O as the circle's center, what is the value of x?

A. $15°$

B. $30°$

C. $45°$

D. $60°$

Key: B

Solution: $\angle AOC = 90° + 30°$

($\because$ exterior angle of a triangle is equal to the sum of the opp. interior angles)

$\angle AOC = 120°$

$$\angle ABC = \frac{1}{2} \times 120^\circ \Rightarrow \angle ABC = 60^\circ$$

$$x = 180^\circ - 60^\circ - 90^\circ = 30^\circ$$

117. Consider the following statements:

   (1) M is the brother of N

   (2) K is the sister of M

   (3) P is the brother of O

   (4) O is the daughter of N

   Who is the uncle of P?

   Which statement in the above question is superfluous?

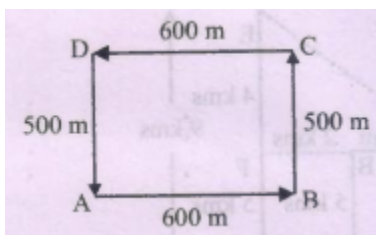   A. 1
   B. 2
   C. 3
   D. 4

   Key: B

   Solution: The answer can be deducted without statement (2), K is the sister of M.

118. Pinky walks a distance of 600 metres towards east, turns left and moves 500 metres, then turns left and walks 600 metres and then turns left again and moves 500 metres and halts. At what distance in metres is she from the starting point?

   A. 0

   B. 2200

   C. 600

   D. 500

   Key: A

   Solution:

119. $x \%$ of $y + y \%$ of $x = ?$

A. 3% of xy

B. 2% of xy

C. 5% of xy

D. None of these

Key: B

Solution: $x\% \, of \, y + y\% \, of \, x = \dfrac{xy}{100} + \dfrac{xy}{100} = \dfrac{xy}{50}$

It implies that 2% of xy

120. A discount of 15 % is offered on an· item that previously cost ₹180/− What is the discounted price?

A. ₹140

B. ₹153

C. ₹160

D. ₹152

Key: B

Solution: M.P. of the article=₹180

Discount percent =15 %

Selling price after discount $= 180 \times \dfrac{85}{100} =$ ₹153

English

Read the passage carefully and answer the questions that follow:

The firearms industry may be the biggest force for evil in America. The evil lies not just in the fact that these manufacturers made the weapons that were used to slaughter 19 school children and two teachers in Uvalde, Texas, last week, 10 shoppers at a Buffalo, NY, grocery store the week before and more than 1,500 other Americans in 270 mass shootings since 2009. No, the firearms merchants have done far more than simply build guns and offer them for sale.

According to evidence revealed by industry whistleblowers and in newly released court documents, the gun makers have, for two decades, helped push the right wing paranoia and conspiratorial fantasies that have fed the fever for assault rifles while using social media, video games and direct marketing to target teenagers as eventual customers. It is no coincidence that the typical mass shooter is a young man brandishing a freshly-purchased weapon of war.

As a result, gun sales have soared since the start of the century and the U.S. now has twice as many guns as it has people. With millions of dollars drawn from this blood money, the gun industry transformed the National Rifle Association, once a respectable, hunting-centred group, into its militant mouthpiece. And, with more millions donated to political campaigns, the industry turned the Republican Party into a legion of pathetic puppets who dutifully block all attempts to pass the sensible gun control legislation that a large majority of Americans support.

The absolutist defence of the Second Amendment presented by the NRA, the GOP and the gun industry is not actually about the right to bear arms. That is a cover story to hide the true motivation behind the gun epidemic that is killing Americans day after day after day: financial profit and political power.

And, with the mourning far from over in Uvalde and Buffalo, that seems especially evil.

121. Which among the following statements is correct?

A. The gun industry is not a 'for profit' organization in America.

B. The gun industry doesn't indulge in political lobbying.

C. The gun industry targets teenagers to push gun sales.

D. The gun manufacturing industry is tightly regulated in the United States of America.

Key: C

Solution:

Option 3 is correct. We can infer so from the second paragraph, which goes thus: "According to evidence revealed by industry whistleblowers and in newly released court documents, the gun makers have, for two decades, helped push the right wing paranoia and conspiratorial fantasies that have fed *the fever for assault rifles while using social media, video games and direct marketing to target teenagers as eventual customers. It is no coincidence that the typical mass shooter is a young man brandishing a freshly-purchased weapon of war*. Advertising works." The rest of the options are not in harmony with the text of the passage. Hence, they are incorrect.

122. Which among the following statements is correct?

A. The Democratic Party is in favour of the National Rifle Association and the gun manufacturers.

B. The gun industry uses social media as an advertising platform to entice teenagers into buying guns.

C. Guns do not threaten public life, as widely feared.

D. The Republican party in the United States of America is at the forefront of the campaign for gun control.

Solution: **Option 2 is correct. The second paragraph talks about the gun industry's use of social media, video games and direct marketing to target teenagers as eventual customers. The other option choices present information that is neither explicitly stated nor implied by the author of the passage. Hence, they are not correct.**

123. Which among the following statements is **incorrect**?

   A. Majority of Americans want tighter gun control laws.

   B. Gun Control legislation is blocked by Republican party lawmakers.

   C. The gun industry, the National Rifle Association and the Grand Old Party (Republican party) defend the right to bear arms.

   D. The Second Amendment abolished citizens' right to bear arms.

   Key: D

   Solution: **Option 4 is correct because it is the only incorrect statement among the four alternatives. Contrary to what is stated, the Second Amendment recognises people's right to keep and bear arms. The rest of the options are in sync with the text of the passage. Therefore, they can't be correct.**

124. Which among the following statements can be inferred from the passage?

   A. The making and selling of guns is a lucrative industry, so the companies behind it are going to promote the benefits of firearms.

   B. The National Rifle Association has been involved in political lobbying since its inception.

   C. Arming teachers and other staff in schools could deter gun attacks.

   D. Gun ownership does more to increase public safety by allowing law-abiding citizens to protect themselves.

   Key: A

   Solution: **Option 1 is correct. We can infer so from the last paragraph, which reads thus: "The absolutist defence of the Second Amendment presented by the NRA, the GOP and the gun industry is not actually about the right to bear arms. *That is a cover story to hide the true motivation behind the gun epidemic that is killing Americans day after day after day: financial profit and political power*." The rest of the options can't be correct because they express views that are neither stated nor implied in the passage.**

125. The antonym of the word 'legion' (third paragraph) is

   A. horde

   B. few

   C. chaos

Key: B

Solution: **The word legion means 'a vast number of people or things; great in number.' Few is its antonym. Therefore, option 2 is correct.**