

KERALA CEE

Engineering Entrance Exam

Solved Paper 2019

Physics

1. An electron, placed in an electric field, experiences a force F of 1 N. What are the magnitude and direction of the electric field E at the point where the electron is located ($e = 1.6 \times 10^{-19}$ C)?

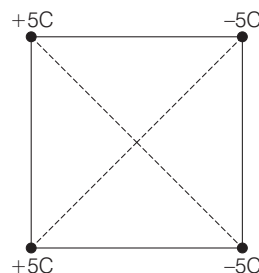
- (a) $\frac{1}{e}$ N/C, F and E are along the same direction
 (b) $\frac{1}{e}$ N/C, F and E are against each other
 (c) $\frac{1}{e}$ N/C, F and E are perpendicular
 (d) $\frac{1}{e}$ N/C, F and E are against each other
 (e) e N/C, F and E are perpendicular

2. The distance between two charges $q_1 = +2\mu\text{C}$ and $q_2 = +8\mu\text{C}$ is 15 cm. Calculate the distance from the charge q_1 to the points on the line segment joining the two charges where the electric field is zero.

- (a) 1 cm (b) 2 cm (c) 3 cm (d) 4 cm
 (e) 5 cm

3. Four point charge (with equal magnitude of charge of 5 C; but with different signs) are placed at four corners of a square of side 10 m. Assuming that the square is centered at the origin and the configuration of the charges are as given in the figure, the potential and the magnitude of electric field at the origin, respectively are

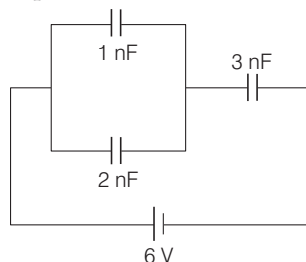
[Note $k = \frac{1}{4\pi\epsilon_0}$]



- (a) 0 V and 0 V/m
 (b) 0 V and $\frac{\sqrt{2}}{5}k$ V/m
 (c) $\frac{\sqrt{2}}{5}k$ V and $\frac{\sqrt{2}}{5}k$ V/m
 (d) 0 V and 5 V/m
 (e) $\frac{\sqrt{2}}{5}k$ V and 0 V/m
4. A point dipole with dipole moment, $\mathbf{p} = p_0\hat{\mathbf{k}}$, is kept at the origin. An external electric field given by $\mathbf{E} = E_0(2\hat{\mathbf{i}} - 3\hat{\mathbf{j}} + 4\hat{\mathbf{k}})$, is applied on it. Which one of the following statement is true?
- (a) The force on the dipole is zero while torque rotates the dipole on the xy -plane.
 (b) The force on the dipole moves it along the direction of electric field.
 (c) The interaction energy between the dipole and electric field is zero.
 (d) The potential due to the dipole alone on the xy -plane with $z = 0$ depends on the value of p_0 .
 (e) The application of the electric field orients the dipole along the $-\hat{\mathbf{k}}$ direction.

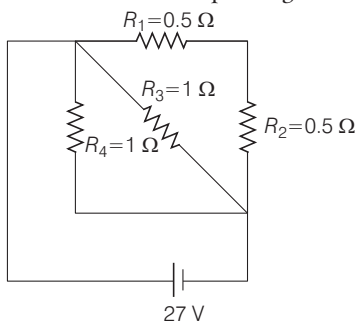
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5. Find the total capacitance and total charge on the capacitors



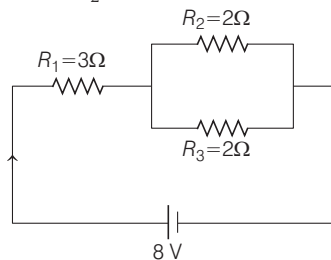
- (a) 1.5 nF, 9 nC (b) 3.0 nF, 18 nC
 (c) 1.5 nF, 4.5 nC (d) 3.0 nF, 9 nC
 (e) 3.0 nF, 4.5 nC

6. A circuit is made using R_1, R_2, R_3, R_4 and a battery as shown in the following figure. Find the equivalent resistance of the given circuit and the current passing through R_3



- (a) $3\Omega, \frac{1}{3}A$ (b) $\frac{1}{3}\Omega, 27A$
 (c) $\frac{2}{3}\Omega, \frac{21}{2}A$ (d) $\frac{1}{3}\Omega, \frac{21}{2}A$
 (e) $\frac{2}{3}\Omega, \frac{21}{3}A$

7. Find the voltage and current passing through the resistor R_2 shown in the following circuit



- (a) 3 V, 3 A (b) 1 V, 1 A
 (c) 3 V, 1 A (d) 1 V, 2 A
 (e) 2 V, 1 A

8. The resistor $R_1 = 3\Omega$ and $R_2 = 1\Omega$ are connected in parallel to a 20 V battery. Find the heat developed in the resistor R_1 in one minute

- (a) 600 J (b) 800 J (c) 6000 J (d) 8000 J
 (e) 7000 J

9. The velocity and acceleration of a particle performing simple harmonic motion have a steady phase relationship. The acceleration shows a phase lead over the velocity in radians of

- (a) $+\pi$ (b) 0 (c) $+\frac{\pi}{2}$ (d) $-\frac{\pi}{2}$
 (e) $-\pi$

10. Consider a driven damped mechanical oscillator is in resonance. Which of the following statements is true?

- (a) Driving frequency is twice the natural frequency of the oscillator.
 (b) Power transfer from the driving source to system is minimum.
 (c) Driving frequency is the same as the natural frequency of the oscillator.
 (d) The force damping the oscillations are at a minimum value.
 (e) The driving force is in phase with the displacement.

11. A body undergoing simple harmonic motion has a maximum acceleration of 8 m/s^2 and maximum speed of 1.6 m/s. What is the time period T ?

- (a) 0.1 sec (b) 0.2 sec (c) 1.93 sec (d) 1.25 sec
 (e) 0.5 sec

12. A bat emits an ultrasonic sound wave at 33.0 kHz and receives an echo 0.1 s later. What is the distance of the bat from the object-producing echo? (Speed of sound in air is 330 m/s)

- (a) 10.0 m (b) 20.0 m (c) 33.0 m (d) 66.0 m
 (e) 16.5 m

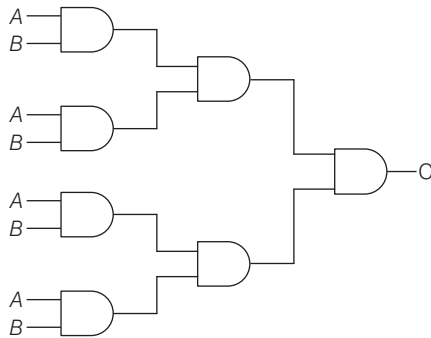
13. A wave along a string has the following equation $y = 0.05 \sin(28t - 1.78x)$ m (where, t is in seconds and x is in meters). What are the amplitude (A), frequency (f) and wavelength (λ) of the wave?

- (a) $A = 0.05 \text{ m}, f = 4.456 \text{ Hz}$ and $\lambda = 3.529 \text{ m}$
 (b) $A = 0.05 \text{ m}, f = 28 \text{ Hz}$ and $\lambda = 2.0 \text{ m}$
 (c) $A = 5.0 \text{ m}, f = 4.456 \text{ Hz}$ and $\lambda = 3.529 \text{ m}$
 (d) $A = 0.05 \text{ m}, f = 2.0 \text{ Hz}$ and $\lambda = 28 \text{ m}$
 (e) $A = 0.05 \text{ m}, f = 3.456 \text{ Hz}$ and $\lambda = 4.529 \text{ m}$

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- 14.** A train sounds its whistle as it approaches an observer standing at a point near the track. The observer measures a frequency of 216 Hz as the train approaches and a frequency of 184 Hz as the train leaves. What is the frequency of its whistle?
 (a) 210 Hz (b) 190 Hz (c) 205 Hz (d) 202 Hz
 (e) 200 Hz

- 15.** The following figure is the combination of logic gates, The inputs are A and B . The output is C . Which one of the following choices gives the correct matching?



(a)

A	B	C
0	0	1
0	1	1
1	0	1
1	1	1

(b)

A	B	C
0	0	1
0	1	0
1	0	1
1	1	0

(c)

A	B	C
0	0	0
0	1	1
1	0	0
1	1	1

(d)

A	B	C
0	0	1
0	1	1
1	0	0
1	1	0

(e)

A	B	C
0	0	0
0	1	0
1	0	0
1	1	0

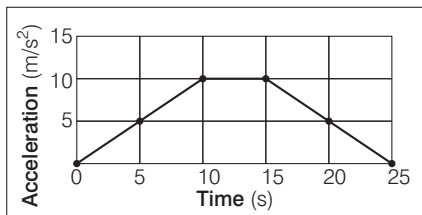
- 16.** A particle of mass m and charge q with an initial velocity v is subjected to a uniform magnetic field \mathbf{B} along the vertical direction. The particle will
 (a) follow a circular path if v is along the vertical direction
 (b) make helical motion if v is along the horizontal direction
 (c) make helical motion if v is neither parallel nor orthogonal to \mathbf{B}
 (d) always make circular motion
 (e) always make helical motion

- 17.** Consider a circular loop of radius R on the xy -plane carrying a steady current anticlockwise. The magnetic field at the center of the loop is given by
 (a) $\frac{\mu_0}{2R} j \hat{x}$ (b) $\frac{\mu_0}{2R} j \hat{y}$ (c) $\frac{\mu_0}{2R} j \hat{z}$ (d) $\frac{\mu_0}{R} j \hat{x}$
 (e) $\frac{\mu_0}{R} j \hat{y}$

- 18.** Consider two parallel current carrying conductors separated by a distance. Which one of the following statements is true?
 (a) Currents flowing in same direction will lead to repulsion.
 (b) Currents flowing in opposite directions will lead to attraction.
 (c) The conductors will always attract each other.
 (d) The conductors will always repel each other.
 (e) Currents flowing in same direction will lead to attraction and opposite directions will lead to repulsion

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- 19.** The energy gap is much more in silicon than in germanium because
- it has less number of electrons
 - it has high atomic mass number
 - its crystal has much stronger bonds called ionic bonds
 - its valence electrons are more tightly bound to their parent nuclei
 - its valence electrons are more loosely bound to their parent nuclei
- 20.** The dimensions for pressure is
- $[MLT^{-2}]$
 - $[ML^{-1}T^{-2}]$
 - $[M^{-1}L^{-1}T^{-2}]$
 - $[ML^{-1}T^{-1}]$
 - $[MLT]$
- 21.** The magnitude of deceleration required for a body, moving at a speed of 10 m/s to come to a complete halt at a distance of 100 m is
- 20 m/s^2
 - 10 m/s^2
 - 2 m/s^2
 - 0.5 m/s^2
 - 1 m/s^2
- 22.** An accurate measurement implies that
- the spread of the readings are broad around the mean value
 - the spread of the readings are narrow around the mean value
 - the mean value of the readings is always lower than the true value
 - the mean value of the readings is always higher than the true value
 - the closeness of the mean of the readings to the true value
- 23.** The following plot gives the variation of acceleration (m/s^2) with time (s) for an object that started from rest at time $t = 0$ s. The velocity at time $t = 15$ s (v_{15}) and at 25 s (v_{25}), respectively are



- $v_{15} = 50 \text{ m/s}$ and $v_{25} = 0 \text{ m/s}$
- $v_{15} = 100 \text{ m/s}$ and $v_{25} = 150 \text{ m/s}$
- $v_{15} = 50 \text{ m/s}$ and $v_{25} = 25 \text{ m/s}$
- $v_{15} = 100 \text{ m/s}$ and $v_{25} = 25 \text{ m/s}$
- $v_{15} = 75 \text{ m/s}$ and $v_{25} = 50 \text{ m/s}$

- 24.** An object, moving with velocity 5 m/s, undergoes an acceleration of 1 m/s^2 at time $t = 0$. If the object has a mass of 1 kg, the kinetic energy (KE) of the object at time $t = 5$ s is

- KE = 12.5 J
- KE = 20 J
- KE = 30 J
- KE = 50 J
- KE = 0 J

- 25.** The variation of speed (in m/s) of an object with time (in seconds) is given by the expression $V(t) = V_0 - 5t + 5t^2$

- at time $t = 0$ s, the instantaneous acceleration is zero
- at time $t = 0$ s, there is a deceleration of the object
- at time $t = 1$ s, the object is at rest
- at time $t = 1$ s, the instantaneous acceleration is zero
- The distance travelled by the object at time $t = 1$ s is V_0 m

- 26.** A boat is moving from the east bank to the west bank on a south flowing river. If the speed of the boat is 4 km/h and that of the river is 3 km/h. If the width of the river is 2 km, the distance travelled by the boat is

- 5 km
- 4 km
- 3 km
- 2.5 km
- 2 km

- 27.** A bead is tied on one end of a stiff rope of length 1 m. With the other end of the rope as the center, the rope is rotated in such a way that the bead completes 10 revolutions per second. The centripetal acceleration of the bead is

- 4000 m/s^2
- 2000 m/s^2
- 400 m/s^2
- 200 m/s^2
- 100 m/s^2

- 28.** The electric field of an electromagnetic wave in free space is given by $\mathbf{E} = 5 \sin\left(\frac{2\pi}{3}z - \omega t\right) \hat{\mathbf{y}}$

V/m. Which of the following statements is correct?

- The wave propagates along $\hat{\mathbf{y}}$
- The wave vector is given $\mathbf{k} = \frac{2\pi}{3} \hat{\mathbf{z}}$
- The wavelength of the electromagnetic wave is $\frac{1}{3}$ m
- The corresponding magnetic field is $\mathbf{B} = \frac{5}{c} \cos\left(\frac{2\pi}{3}z - \omega t\right) \hat{\mathbf{x}}$ T
- The frequency of the wave is approximately 10^6 Hz

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- 29.** The radiation produced by a 100 W bulb has the following property
- The radiation is in the form of an electromagnetic wave which carries energy but not momentum.
 - The radiation is in the form of an electromagnetic wave which carries momentum but not energy.
 - The radiation is in the form of an electromagnetic wave which carries both energy and momentum.
 - The radiation neither carries energy nor momentum.
 - The intensity of radiation is independent of the distance from source.
- 30.** A parallel plate capacitor (of capacitance C) with circular plates of radius r_0 located at position $\pm \alpha$, is connected in series with a resistor R and is charged by a battery of voltage V . Consider a circular loop L of radius $\frac{r_0}{2}$ parallel to the capacitor plates is located at the center. Which of the following statements is correct?
- The charge on the capacitor at time t is $q(t) = CR(1 - e^{-t/(CV)})$.
 - The charge on the capacitor at time t is $q(t) = CV(1 - e^{-t/(CV)})$.
 - The flux through the loop L is independent of the area enclosed by it.
 - The magnetic field is directed orthogonal to the loop L .
 - The magnetic field is directed along the loop L .
- 31.** A monochromatic light of frequency $\nu = \frac{1}{6.63} \times 10^{16}$ Hz is produced by a laser. The power emitted is $P = 10^2$ W. The average number of photos per second emitted by the source is
- $\frac{1}{(6.63)^2} \times 10^{16}$
 - $(6.63)^2 \times 10^{20}$
 - $(6.63)^2 \times 10^{16}$
 - 10^{20}
 - 10^{16}
- 32.** The work function of three photosensitive materials used to build photoelectric devices are given as : Sodium (2.75eV), copper (4.65 eV) and gold (5.1 eV). Which of the following statements is correct. (The frequency of visible light lies in the range 4×10^{14} Hz to 8×10^{14} Hz)?
- Devices built by copper and gold can operate with visible light
 - Devices built using sodium can operate with ultraviolet light
 - All the devices can operate with infrared light
 - All the devices can operate with visible light
 - No device can operate with visible light
- 33.** An object is placed at 9cm in front of a concave mirror of radius of curvature 12 cm. The following statement is true
- The image is formed 36 cm behind the mirror.
 - The image is 36 cm in front of the mirror.
 - The image is magnified, virtual and erect.
 - The image is magnified, real and erect
 - The image is magnified, real and inverted.
- 34.** An optician prescribes a lens of power + 2.5 D. The focal length of the lens in water is (Refractive indices of the lens and water are respectively 1.5 and 1.3)
- 40 cm
 - $\frac{2660}{17}$ cm
 - $\frac{17}{2660}$ cm
 - $\frac{3000}{17}$ cm
 - $\frac{17}{3000}$ cm
- 35.** In a single slit diffraction (of width α) by a monochromatic source of wavelength λ the first minimum of the intensity distribution occurs at an angle
- $\frac{\lambda}{\alpha}$
 - $\frac{\lambda}{2\alpha}$
 - $\frac{\alpha}{\lambda}$
 - $\frac{\alpha}{2\lambda}$
 - $\frac{\pi}{4}$
- 36.** A monochromatic source of wavelength 60 nm was used in Young's double slit experiment to produce interference pattern. I_1 is the intensity of light at a point on the screen where the path difference is 150 nm. The intensity of light at a point where the path difference is 200 nm is given by
- $\frac{1}{2}I_1$
 - $\frac{3}{2}I_1$
 - $\frac{2}{3}I_1$
 - $\frac{3}{4}I_1$
 - $\frac{4}{3}I_1$
- 37.** The Brewster's angle for air to water interface is
- $\tan^{-1}(1.33)$
 - $\sin^{-1}(1.33)$
 - $\cos^{-1}(1.33)$
 - $\tan^{-1}\left(\frac{1}{1.33}\right)$
 - $\sin^{-1}\left(\frac{1}{1.33}\right)$

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- 38.** A TV transmitting antenna is 81 m tall. It has a half-power, beam-width of 10 degrees, If the receiving antenna is at the ground level, the service area covered by the transmitter is determined by
- the half-power beam width, the height of the transmitter and the radius of the earth.
 - the height of the transmitter and the radius of the earth.
 - the half-power beam width and the radius of the earth.
 - the height of the transmitter and the half-power beam width.
 - the height of the transmitter.
- 39.** In the amplitude modulation mode of transmission, the normal speed signal is with a maximum frequency of 5 kHz. If the carrier frequency is 200 kHz, the modulated signal will have the frequencies varying between
- 190 kHz to 210 kHz
 - 195 kHz to 205 kHz
 - 195 kHz to 200 kHz
 - 200 kHz to 205 kHz
 - 199.5 kHz to 200.5 kHz
- 40.** For signal transmission, modulation is necessary
- to reduce distortion of the signal
 - to modify the frequency content of the signal
 - to mask the signal information from enemy
 - to radiate the signal to a large distance using antennas
 - to make it easy to amplify the signal
- 41.** A light emitting diode is
- a n - p - n type semiconductor with a forward bias
 - a p - n - p semiconductor with a reverse bias
 - a p - n - p semiconductor with a forward bias
 - a p - n semiconductor with a reverse bias
 - a p - n semiconductor with a forward bias
- 42.** In the context of p - n junction, select the correct statement from the following
- The barrier potential remains constant under forward bias
 - The width of the depletion region depends on the doping level in the p -type and n -type regions
 - Under forward bias condition, the p - n junction behaves like a pure resistor irrespective of bias voltage
 - Under reverse bias condition, the p - n junction behaves like a pure resistor irrespective of bias voltage
 - The barrier potential decreases under reverse bias
- 43.** The radius of gyration about an axis through the center of a hollow sphere with external radius a and internal radius b is
- $\sqrt{\frac{2(a^3 - b^3)}{5(a^5 - b^5)}}$
 - $\sqrt{\frac{1(a^4 - b^4)}{4(a^2 - b^2)}}$
 - $\sqrt{\frac{1(a^5 - b^5)}{2(a^3 - b^3)}}$
 - $\sqrt{\frac{2(a^5 - b^5)}{5(a^3 - b^3)}}$
 - $\sqrt{\frac{5(a^4 - b^4)}{2(a^2 - b^2)}}$
- 44.** A ball of mass 1 kg and radius 0.5 m, starting from rest rolls down on a 30° inclined plane. The torque acting on the ball at the distance of the 7 m from the starting point is close to (take acceleration due to gravity as 10 m/s^2)
- 0.25 N-m
 - 0.7 N-m
 - 0.5 N-m
 - 0.4 N-m
 - 1.4 N-m
- 45.** If the radius of the earth suddenly decreases by half of its present value. Then the time duration of one day will be
- 6 h
 - 8 h
 - 12 h
 - 24 h
 - 48 h
- 46.** A hollow sphere and a solid sphere, of equal mass and equal radii roll down without slipping on an inclined plane, If the torque experienced by the hollow sphere and solid sphere are τ_H and τ_S respectively, then
- $\tau_H < \tau_S$
 - $\tau_H > \tau_S$
 - $\tau_H = \tau_S$
 - $\tau_H = 0$
 - $\tau_S = 0$
- 47.** A brick of mass 2 kg slides down an incline of height 5 m and angle 30° . If the coefficient of friction of the incline is $\frac{1}{2\sqrt{3}}$, the velocity of the block at the bottom of the incline is (Assume the acceleration due to gravity is 10 m/s^2)
- 5 m/s
 - 50 m/s
 - 7 m/s
 - 0
 - 10 m/s
- 48.** A spherically uniform planet of mass 8×10^{24} kg and or radius 6×10^6 m is orbiting around the Sun. The escape velocity for the planet is close to (Take, $G = 6 \times 10^{-11} \text{ N-m}^2/\text{kg}^2$)
- 11.2 km/s
 - 16 km/s
 - 4 km/s
 - 12.6 km/s
 - 1.6 km/s

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- 49.** Suppose to planets A and B revolved around a Sun in the galaxy, The semi major axis of A and B are 1 and 5 AU (astronomical unit) respectively. If the period of revolution of A is 1 yr, the period of revolution of B is
 (a) 1 yr (b) 5 yr (c) 11 yr (d) 25 yr
 (e) 125 yr
- 50.** The half-life of ${}_{43}\text{Tc}^{99}$ is 6 h. If 12 mg of ${}_{43}\text{Tc}^{99}$ is injected to a patient, after 24 h how much Tc will be left in the patients body?
 (a) 0 mg (b) 0.75 mg
 (c) 3 mg (d) 6 mg
 (e) 12 mg
- 51.** For atoms, which of the following statement is correct?
 (a) Heavier nuclei have more neutrons than protons.
 (b) Heavier nuclei have equal number of protons and neutrons.
 (c) Lighter nuclei have more neutrons than protons.
 (d) Lighter nuclei have less number of neutrons than protons.
 (e) For heavier nuclei, atomic mass varies as square of atomic number.
- 52.** Which of the following statements is not a property of nuclear force?
 (a) It is an attractive force
 (b) It is independent of interacting nucleons
 (c) It is a long range force
 (d) It is non-central force
 (e) It is a short range force
- 53.** Which of the following elements you need to remove to form an isotone family?
 (a) ${}_{8}\text{O}^{16}$ (b) ${}_{7}\text{N}^{15}$ (c) ${}_{6}\text{C}^{14}$ (d) ${}_{13}\text{Al}^{27}$
 (e) ${}_{9}\text{F}^{17}$
- 54.** A magnetic field of 1 T applied at an angle $\frac{\pi}{3}$ to the vertical direction is decreased to zero at a steady rate in one second. The magnitude of induced emf in a horizontally placed circular loop of radius 5 cm is given by
 (a) $125\sqrt{3}\pi$ mV
 (b) $125\sqrt{3}\pi$ V
 (c) 1.25π mV
 (d) 125π V
 (e) 25π V
- 55.** The dimension of mutual inductance is (Denote dimension of current as A)
 (a) $[M L^2 T^2 A^{-2}]$ (b) $[M L^2 T^{-2} A^{-2}]$
 (c) $[M L^{-2} T^2 A^{-2}]$ (d) $[M L^2 T^{-3} A^{-1}]$
 (e) $[M L^2 T^{-3} A^{-3}]$
- 56.** A pure inductor of inductance 0.1 H is connected to an AC source (of rms voltage) 220V angular frequency of 300 Hz. The rms current is
 (a) $\frac{3}{22}$ A (b) $\frac{22}{3}$ A (c) $\frac{11}{150}$ A (d) $\frac{150}{11}$ A
 (e) $\frac{11}{3\pi}$ A
- 57.** In an LCR series circuit (of inductance L , capacitance C and resistance R), the impedance is minimum when the angular frequency of the source is given by
 (a) \sqrt{LC} (b) $\frac{1}{\sqrt{LC}}$ (c) $\sqrt{\frac{L}{C}}$ (d) $\sqrt{\frac{C}{L}}$
 (e) \sqrt{LCR}
- 58.** A Carnot engine is operating between a hot body and cold body maintained at temperature T_1 and T_2 respectively. Consider the following three cases
Case I : The temperature of the hot body is changed to $T_1 + \Delta T$ and cold body is at T_2
Case II : The temperature of the hot body is at T_1 and cold body is changed to $T_2 + \Delta T$
Case III : The temperature of the hot body is at T_1 and cold body is changed to $T_2 - \Delta T$
 (a) The efficiency of the Carnot cycle is highest for case-I
 (b) The efficiency of the Carnot cycle is highest for case-II
 (c) The efficiency of the Carnot cycle is highest for case-III
 (d) The efficiency of case - II is higher than case - III
 (e) The efficiency of the Carnot cycle is same for all three cases
- 59.** Some smoke is trapped in a small glass container and is viewed through a microscope. A number of very small smoke particles are seen in continuous random motion as a result of their bombardment by air molecules. If the mass of the smoke

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particle is about 10^{12} times higher than that of an air molecule the average speed of a smoke particle is

- (a) 10^6 times the average speed of an air molecule
- (b) 10^{-12} times the average speed of an air molecule
- (c) 10^{12} times the average speed of an air molecule
- (d) 10^{-6} times the average speed of an air molecule
- (e) 10^{-10} times the average speed of an air molecule

60. The standard of length is maintained by a 1 m long bar made up of a material having coefficient of linear expansion $\alpha = 0.00001^\circ \text{C}^{-1}$. If the length of the bar were to be preserved to an accuracy of 1 part per million, what would be maximum allowed temperature variation?

- (a) $\pm 0.01^\circ\text{C}$
- (b) $\pm 0.1^\circ\text{C}$
- (c) $\pm 0.001^\circ\text{C}$
- (d) $\pm 0.0001^\circ\text{C}$
- (e) $\pm 1.0^\circ\text{C}$

61. Inside the engine of an automobile, the cylinder compresses the air from approximately standard temperature and pressure to one-twentieth of the original volume and a pressure of 50 atm. What is the temperature of the compressed air?

- (a) 500 K
- (b) 682 K
- (c) 550 K
- (d) 1000 K
- (e) 200 K

62. A spring of natural length l and spring constant 50 N/m is kept on a horizontal frictionless table with one end attached to a rigid support. First the spring was compressed by 10 cm and then released to hit a ball of mass 20 g kept at a distance l from the rigid support, if after hitting the ball, the natural length of the spring is restored, what is the speed with which the ball moved?

(Ignore the air resistance)

- (a) 5 m/s
- (b) 7 m/s
- (c) 25 m/s
- (d) 50 m/s
- (e) 2500 m/s

63. In a water container, an aluminium piece of volume 0.5 m^3 is lowered through an external force, until it is completely submerged. In another identical water container, a lead piece of same volume was similarly submerged using the same amount of external force. The mass density of lead is 4 times larger than the mass density of the aluminium. If F_A and F_L are the buoyancy

forces acting on aluminum and lead respectively, then which of the following statement is correct?

- (a) $F_A > 4F_L$
- (b) $F_L > 4F_A$
- (c) $F_A > 2F_L$
- (d) $F_L > 2F_A$
- (e) $F_L = F_A$

64. A boy formed a bubble and a liquid drop form the same soapy water. The pressure difference between inside and outside of the soap bubble is measured to be 100 N/m^2 . If the radius of the droplet is half of the radius of the bubble, then the pressure difference between the inside and outside of the droplet is

- (a) 0
- (b) 50 N/m^2
- (c) 100 N/m^2
- (d) 200 N/m^2
- (e) 400 N/m^2

65. A mass m , suspended vertically by a massless ideal spring with spring constant k , is at rest. The mass is displaced upward by a height h . When released, the kinetic energy of the mass will be proportional to (Neglecting air resistance)

- (a) only h
- (b) only h^2
- (c) m
- (d) a linear combination of terms involving h and h^2
- (e) k

66. Instantaneous power delivered to a damped harmonic oscillator (natural frequency is ω_0), by an external periodic force (driving frequency ω) under steady state conditions is

- (a) positive always
- (b) negative always
- (c) positive and negative with power integrated over a period being zero
- (d) positive and negative with power integrated over a period being positive
- (e) positive and negative with power integrated over a period being negative

67. The Q factor for a damped oscillator is given by the

- (a) ratio of energy stored per cycle to the initial energy
- (b) ratio of energy dissipated per cycle to the initial energy
- (c) ratio of energy stored per cycle to the energy dissipated per cycle
- (d) ratio of energy dissipated per cycle to the energy stored per cycle
- (e) ratio of the damping coefficient to the natural frequency

68. A ball of mass m is projected upward with a speed v_0 . The speed at a height h is (Neglecting air resistance)

- independent of angle and direction of projection
- independent of mass, angle and the direction of projection
- dependent on the direction of projection
- dependent on the shape, size and mass of the ball and angle of projection
- dependent on mass of the ball but independent of the angle and direction of projection

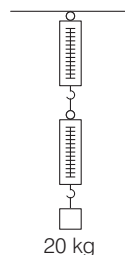
69. An object having a velocity 5 m/s is accelerated at the rate 2 m/s^2 for 6 s. Find the distance travelled during the period of acceleration

- 60 m
- 25 m
- 36 m
- 66 m
- 45 m

70. A vehicle moving at 36 km/h is to be stopped by applying brakes in the next 5 m. If the vehicle weight 2000 kg, determine the average force that must be applied on it

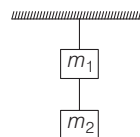
- 10^4 N
- $2 \times 10^4 \text{ N}$
- $3 \times 10^4 \text{ N}$
- $5 \times 10^3 \text{ N}$
- 10^3 N

71. A block of mass 20 kg is suspended through two spring balances with negligible mass as shown in figure. What will be the readings in the upper and lower balance respectively?



- 0 kg, 20 kg
- 10 kg, 20 kg
- 20 kg, 10 kg
- 10 kg, 10 kg
- 20 kg, 20 kg

72. Two masses connected in series with two massless strings are hanging from a support as shown in the figure. Find the tension in the upper string



- m_1g
- $(m_1 - m_2)g$
- m_2g
- $(m_1 + m_2)g$
- $(m_1 \times m_2)g$

Chemistry

73. Propylene on treatment with $\text{HBr} / \text{H}_2\text{O}_2$ provides

- 1-bromopropane
- 2-bromopropane
- 1, 2-dibromopropane
- 1-bromopropane-2-ol
- 2-bromopropane-1-ol

74. is a potent vasodilator.

- Histamine
- Serotonin
- Codeine
- Cimetidine
- Aspirin

75. An invert sugar is

- isorotatory
- levorotatory
- dextrorotatory
- optically inactive
- mutarotatory

76. The strongest base among the following is

- NH_2^-
- OH^-
- $\text{CH} = \text{C}^-$
- CH_3CH_2^-
- OEt^-

77. The neopentyl halide in ethanol yields alkenes by E1 mechanism due to

- low concentration of solvent
- absence of base
- it is a primary halide
- steric factor which prevents E2 mechanism
- solvation effect

78. Arylbromides are not good candidates for

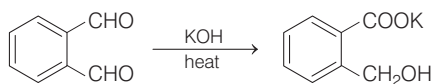
- Wurtz-Fitting reaction
- Fitting reaction
- Friedel-Crafts reaction
- Grignard reaction
- Gabriel-phthalimide synthesis

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79. Sulfonation of benzene with excess sulfuric acid provides

- (a) benzenesulfonic acid
 (b) *p*-benzenedisulfonic acid
 (c) *o*-benzenedisulfonic acid
 (d) *m*-benzenedisulfonic acid
 (e) decomposition of benzene

80. The following reaction is named as



- (a) Reimer-Tiemann (b) Kolbe-Schmitt
 (c) Cannizzaro (d) Gattermann
 (e) Aldol

81. Which of the following is obtained when 4-methylbenzene sulphonic acid is hydrolysed with excess of sodium acetate?

- (a) Cc1ccc(cc1)C(=O)[O-].[Na+]
 (b) Cc1ccc(cc1)S(=O)(=O)
 (c) Cc1ccc(cc1)S(=O)(=O)[Na].CC(=O)O
 (d) Cc1ccc(cc1)S(=O)(=O)C(=O)C.[Na]
 (e) Cc1ccc(cc1)C(=O)Cl

82. The compound which does not lead to benzoic acid by oxidation with KMnO_4 is

- (a) Toluene (b) benzyl alcohol
 (c) *n*-butylbenzene (d) *t*-butylbenzene
 (e) styrene

83. In the Hofmann rearrangement of primary amides having optically active group with *S*-configuration, the product amine has

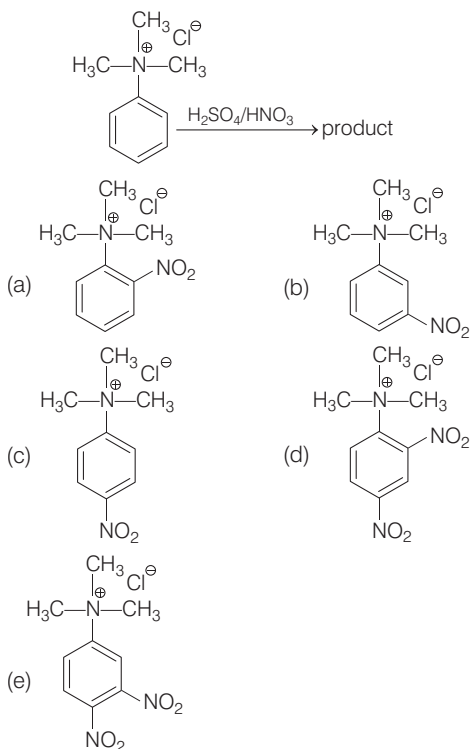
- (a) *r*-configuration (b) *S*-configuration
 (c) racemic mixture (d) meso form
 (e) achiral nature

84. Benzonitrile can be prepared from benzaldehyde on treatment with

- (a) NH_3
 (b) NH_3 followed by hydrogenation with Ni
 (c) NH_2OH

- (d) NH_2OH followed by dehydration with acetic anhydride
 (e) hydrogen cyanide

85. The product formed in the below reaction is



86. NO^+ has bond order

- (a) 2 (b) 2.5 (c) 3 (d) 3.5
 (e) 4

87. Which hydride amongst the following has the least boiling point?

- (a) NH_3 (b) PH_3 (c) AsH_3 (d) BF_3 , PF_5
 (e) BiH_3

88. Which of the following sets has Lewis acid behaviour for all the components?

- (a) BH_3 (b) BF_3 , SiF_4 , PF_5 (c) SiF_4 , PF_5
 (d) BH_3 , PF_5 (e) (a) and (b)

89. The carbon atoms in calcium carbide are held by

- (a) ionic bonds (b) two sigma bonds
 (c) two sigma and one coordinate bond
 (d) one sigma and two π bonds
 (e) one sigma and one π bond

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- 90.** According to the VSEPR theory, the shape of ClO_3^- would be
 (a) linear (b) triangular planar
 (c) pyramidal (d) square planar
 (e) angular
- 91.** Acetic acid in liquid ammonia behaves as
 (a) weaker acid than that in water
 (b) stronger acid than that in water
 (c) base acid
 (d) neutral acid
 (e) (c) and (d)
- 92.** The compound(s) that does(do) not exist is (are)
 (a) BiF_5 (b) PF_5 (c) AsF_5 (d) SbF_5
 (e) All the compounds exist
- 93.** Rare gases are sparingly soluble in water because of
 (a) hydrogen bonding
 (b) dipole-dipole interaction
 (c) induced dipole-induced dipole interaction
 (d) dipole-induced dipole interaction
 (e) (a) and (d)
- 94.** An example of a non-stoichiometric oxide when heated is
 (a) BeO (b) ZnO (c) MgO (d) CaO
 (e) Li_2O
- 95.** The donor atom in EDTA are
 (a) two N and two O (b) two N and four O
 (c) four N and two O (d) three N and three O
 (e) two N and three O
- 96.** Hard acids prefer to combine with
 (a) soft bases (b) soft acids
 (c) hard acids (d) hard bases
 (e) salts
- 97.** Among the following, which species represents a pseudohalide?
 (a) CN^- (b) CaO (c) I_2 (d) K_2Khl_4
 (e) BiOCl
- 98.** PCl_3 is stored in a well stoppered bottle since
 (a) it decomposes in the presence of moisture.
 (b) it is decomposed by light
 (c) it is highly volatile
 (d) it reacts with air to form POCl_3
 (e) (a) and (c)
- 99.** An orange solid *A* on heating gives a green residue *B*, a colourless gas *C* and water vapours. The dry gas *C* upon passing over heated Mg gave a white solid *D* which upon subsequent reaction with water gave a gas *E* that gave dense white fumes with HCl.
 Identify *D*
 (a) $\text{Fe}(\text{NH}_3)\text{Cl}_2$ (b) CuN_2
 (c) Mg_3N_2 (d) NH_4Cl
 (e) FeCl_2
- 100.** On passing silent electric discharge through oxygen in an ozoniser, 5.5 mol% of oxygen is converted to ozone. How many moles of O_2 and O_3 result when 35 moles of O_2 is originally present?
 (a) 33.0 (b) 34.4 (c) 35.0 (d) 31.8
 (e) 31.0
- 101.** Carnallite is a mineral containing
 (a) K (b) Na (c) Mg (d) Fe
 (e) (a) and (c)
- 102.** Maximum number of photons emitted by a bulb capable of producing monochromatic light of wavelength 550 nm is, if 100 V and 1 A is supplied for one hour
 (a) 1×10^{24} (b) 5×10^{24}
 (c) 2×10^{24} (d) 5×10^{23}
 (e) 2×10^{23}
- 103.** Which of the following is the correct unit of angular momentum of an electron in an orbital of an atom?
 (a) J-s (b) J/s
 (c) W/s^2 (d) W-s
 (e) Js^2
- 104.** Experimentally it was found that a metal oxide has formula $\text{M}_{0.98}\text{O}$. Metal M is present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be :
 (a) 4.08% (b) 6.05% (c) 5.08% (d) 7.01%
 (e) 8.08%
- 105.** The edge length of a solid possessing cubic unit cell is $2\sqrt{2}r$ (structure I), based on hard sphere model, which upon subjecting to a phase transition, a new cubic structure (structure II) having an edge length of $\frac{4r}{\sqrt{3}}$ is

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obtained, where r is the radius of the hard sphere. Which of the following statements is true?

- (a) Density of the structure II is lower than structure I
 (b) Density of structure II is higher than structure I
 (c) The pore volume in structure I is 1.2 times higher than that of structure II
 (d) The pore volume of both the structures are equal
 (e) The octahedral voids in structure I is transformed into tetrahedral voids in structure II

106. At 100°C and 1 atm, if the density of the liquid water is 1.0 g cm^{-3} and that of water vapour is 0.0006 g cm^{-3} , then the volume occupied by water molecules in 1L of steam at this temperature is

- (a) 6cc (b) 60cc (c) 0.6cc (d) 0.06cc
 (e) 0.006cc

107. The rms velocity of hydrogen is $\sqrt{7}$ times the rms velocity of nitrogen. If T is the temperature of the gas, then

- (a) $T_{H_2} = T_{N_2}$ (b) $T_{H_2} > T_{N_2}$ (c) $T_{H_2} < T_{N_2}$
 (d) $T_{H_2} = \sqrt{7}T_{N_2}$ (e) $T_{H_2} = \sqrt{7}T_{N_2}$

108. A solution of methanol in water is 20% by volume. If the solution and pure methanol have densities of 0.964 kg L^{-1} and 0.793 kg L^{-1} , respectively, find the percent of methanol by weight?

- (a) 15.8 (b) 16.45 (c) 20 (d) 14.8
 (e) 17.6

109. The Henry's law constant for O_2 dissolved in water is $4.34 \times 10^4 \text{ atm}$ at certain temperature. If the partial pressure of O_2 in a gas mixture that is in equilibrium with water is 0.434 atm, what is the mole fraction of O_2 in the solution?

- (a) 1×10^{-5} (b) 1×10^{-4} (c) 2×10^{-5} (d) 1×10^{-6}
 (e) 2×10^{-6}

110. The standard heat of formation of CH_4 , CO_2 and $\text{H}_2\text{O} (l)$ are -76.2 , -394.8 and $-285.82 \text{ kJ mol}^{-1}$, respectively. Heat of vaporisation of water is 44 kJ mol^{-1} .

Calculate the amount of heat evolved when 22.4 L of CH_4 , kept under normal conditions, is oxidized into its gaseous products.

- (a) 802 kJ (b) 878.4 kJ (c) 702 kJ (d) 788.4 kJ
 (e) 500 kJ

111. Acetic acid dimerises when dissolved in benzene. As a result boiling point of the solution rises by 0.36°C , when 100 g of benzene is mixed with X g of acetic acid. In this solution, if experimentally measured molecular weight of acetic acid is 117.8 and molar elevation constant of benzene is $2.57 \text{ K kg mol}^{-1}$, what is the weight % and degree of dissociation (in %) of acetic acid in benzene?

- (a) 1.62 and 98.3 (b) 0.81 and 98.3
 (c) 0.5 and 86 (d) 1 and 98.3
 (e) 1.4 and 99

112. At a certain temperature, 2 moles of CO and 4 moles of Cl_2 gases were reacted to form COCl_2 in a 10 L vessel. At equilibrium if one mole of CO is present then equilibrium constant for the reaction is

- (a) 4 (b) 3.3 (c) 1 (d) 2.5
 (e) 4.5

113. The equilibrium constant for the reaction, $\text{N}_2(g) + 3\text{H}_2 \longrightarrow 2\text{NH}_3(g)$ and $2\text{N}_2(g) + 6\text{H}_2 \longrightarrow 4\text{NH}_3(g)$ are K_1 and K_2 , respectively.

The relations between K_1 and K_2 is

- (a) $K_2 = K_1^2$ (b) $K_2 = K_1^{-2}$
 (c) $K_1 = K_2^2$ (d) $K_2 = \sqrt{K_1}$
 (e) $K_1 = \sqrt{K_2}$

114. For a first order reaction, $A(g) \rightarrow B(g)$ at 35°C , the volume of A left in reaction vessel at various times are given below.
 [Given data : $\log(5/4) = 0.096$.

t/minutes	0	10	20	30	40
V/mL	25	20	15.7	12.5	9.6

What is the value of rate constant?

- (a) 0.02231 min^{-1} (b) 0.04231 min^{-1}
 (c) 0.06231 min^{-1} (d) 0.08231 min^{-1}
 (e) 0.1231 min^{-1}

115. E_{cell} of the following cell is $\text{Pt}(s) | \text{H}_2(g), 1 \text{ bar} | \text{H}^+ (1 \text{ M}) || \text{H}^+ (0.1 \text{ M}) | \text{H}_2(g), 1 \text{ bar} | \text{Pt}(s)$

- (a) $\frac{-2.303 RT}{F}$ (b) $\frac{2.303 RT}{F}$
 (c) $\frac{-2.303 RT}{2F}$ (d) $\frac{2.303 RT}{2F}$
 (e) $\frac{RT}{2F}$

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- 116.** In a lead-acid battery, if 1 A current is passed to charge the battery for 1 h, ν is the amount of $PbSO_4$ converted to PbO_2 ? (Given data : $1 F = 96500 C mol^{-1}$)
- (a) 0.0373 moles (b) 0.0186 moles
(c) 0.0093 moles (d) 0.0268 moles
(e) 0.0400 moles
- 117.** Which of the statement is incorrect if electrolysis of CH_3COONa (aq.) is made using Pt electrodes?
- (a) Ph of solution increases
(b) Molar ratio of gases at anode and cathode is 3 : 1
(c) CH_3COO^- in solution decreases
(d) The molar ratio of gases at anode and cathode is 2 : 1.
(e) Ph of solution decreases
- 118.** The chemical name of anisole is
- (a) ethanoic acid (b) methoxybenzene
(c) propanone (d) acetone
(e) propanol
- 119.** Cyclohexylamine and aniline can be distinguished.
- (a) Hinsberg's test (b) Carbylamibne test
(c) Bromine test (d) Beilstein's test
(e) Lassaigne's test
- 120.** The compounds pyridine and planar cyclooctatetraene are respectively.
- (a) aromatic and non-aromatic
(b) aromatic and anti-aromatic
(c) aromatic and aromatic
(d) anti-aromatic and non-aromatic
(e) anti-aromatic and anti-aromatic

Mathematics

- 1.** If $\mathbf{r} = 3\mathbf{i} + 2\mathbf{j} - 5\mathbf{k}$, $\mathbf{a} = 2\mathbf{i} - \mathbf{j} + \mathbf{k}$, $\mathbf{b} = \mathbf{i} + 3\mathbf{j} - 2\mathbf{k}$ and $\mathbf{c} = -2\mathbf{i} + \mathbf{j} - 3\mathbf{k}$ such that $\mathbf{r} = \lambda\mathbf{a} + \mu\mathbf{b} + \gamma\mathbf{c}$ then
- (a) μ, γ, λ are in GP (b) λ, μ, γ are in HP
(c) λ, μ, γ are in AP (d) $\mu, \frac{\lambda}{2}, \gamma$ are in AP
(e) None of these
- 2.** If $|\mathbf{a}| = |\mathbf{b}| = |\mathbf{a} - \mathbf{b}| = 1$. Then angle between \mathbf{a} and \mathbf{b} is
- (a) $\frac{\pi}{6}$ (b) $\frac{\pi}{4}$ (c) $\frac{\pi}{3}$ (d) $\frac{\pi}{2}$
(e) $\frac{\pi}{8}$
- 3.** If $x = \sin t \cos 2t$ and $y = \cos t \sin 2t$, then at $t = \frac{\pi}{4}$, value of $\frac{dy}{dx}$ is equal to
- (a) $\frac{1}{2}$ (b) 0 (c) -1 (d) $-\frac{1}{2}$
(e) 1
- 4.** If $f(x) = \sin \log x$, then value of $f(xy) + f\left(\frac{x}{y}\right) - 2f(x)\cos \log y$ is equal to
- (a) 0 (b) $\frac{\cos \log x}{x}$ (c) 1 (d) $\frac{1}{2}$
(e) None of these
- 5.** If $AB = A$ and $BA = B$, then A^2, B^2 is equal to
- (a) $-A, -B$ (b) $2A, B$
(c) $\frac{A}{2}, B$ (d) $-A, B$
(e) A, B
- 6.** If $\begin{vmatrix} 1 & a & a^2 \\ 1 & x & x^2 \\ b^2 & ab & a^2 \end{vmatrix} = 0$ then, $x =$
- (a) a (b) b (c) $\frac{a}{b}, a$ (d) $\frac{b}{a}, a$
(e) 0
- 7.** The coefficient of x^3 in the expansion of $(1 - x + x^2)^5$ is
- (a) 30 (b) -30
(c) 20 (d) -25
(e) 10
- 8.** $P(A) = \frac{4}{5}$, $P(B) = \frac{2}{5}$ and $P(A \cap B) = \frac{1}{2}$, then $P(A \cap B')$ equals.
- (a) $\frac{2}{7}$ (b) $\frac{1}{5}$
(c) $\frac{3}{10}$ (d) $\frac{1}{10}$
(e) $\frac{2}{5}$

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9. Two dice are thrown together. If both numbers appearing are different, then what is the probability that their sum is 5?
- (a) $\frac{1}{6}$ (b) $\frac{1}{9}$ (c) $\frac{1}{12}$ (d) $\frac{1}{5}$
(e) $\frac{2}{15}$
10. If the points with position vectors $30\hat{i} + 3\hat{j}$, $20\hat{i} + 6\hat{j}$ and $5\hat{i} + b\hat{j}$ are collinear, then b equal
- (a) 30 (b) 10 (c) -20 (d) -30
(e) None of these
11. $\int \cos \left\{ 2 \tan^{-1} \sqrt{\frac{1-x}{1+x}} \right\} dx$ is equal to
- (a) $\frac{1}{2}x^2 + k$ (b) $\frac{1}{2}x + k$
(c) $\frac{1}{4}(x^2 + 1) + k$ (d) $x^2 + k$
(e) None of these
12. If $12\cot^2 \theta - 31 \operatorname{cosec} \theta + 32 = 0$, then which of the following can be the value of $\sin \theta$?
- (a) $\frac{3}{5}$ (b) $\frac{1}{2}$
(c) $-\frac{1}{2}$ (d) $\frac{4}{5}$
(e) 0
13. $\lim_{x \rightarrow 4} \left[\frac{x^{3/2} - 8}{x - 4} \right]$ equals
- (a) 3 (b) 1 (c) 2 (d) $\frac{2}{3}$
(e) $\frac{3}{2}$
14. The third term in the expansion of $\left(\frac{1}{x} + x^{\log_{10} x} \right)^5$, $x > 1$ is 1000, then x equals.
- (a) 1 (b) 10
(c) 100 (d) $\sqrt{10}$
(e) $\frac{1}{\sqrt{10}}$
15. If each vertex of a triangle is an integer, then triangle will not be.
- (a) Scalene (b) Isosceles
(c) Right angled (d) Equilateral
(e) None of these
16. The length of the Latus rectum of the parabola $x = ay^2 + by + c$ is
- (a) $\frac{4a}{3}$ (b) $\frac{3}{4}a$ (c) $\frac{1}{2a}$ (d) $\frac{1}{a}$
(e) $\frac{a}{3}$
17. The values of λ for which the line $y = x + \lambda$ touches the ellipse $9x^2 + 16y^2 = 144$, are
- (a) ± 3 (b) ± 4 (c) ± 5 (d) ± 9
(e) ± 11
18. Remainder when $x = 1! + 2! + 3! + 4! + \dots + 100!$ is divided by 240, is
- (a) 151 (b) 71 (c) 153 (d) 37
(e) 31
19. $f(x) = (x+1)^2 - 1$, $x \geq -1$ then the set $\{x : f(x) = f^{-1}(x)\}$ is equal to
- (a) $\{0\}$ (b) $\{0, 1\}$ (c) $\{0, -1\}$ (d) $\{-1, 1\}$
(e) ϕ
20. $(1+i)^8 + (1-i)^8 =$
- (a) 2^3 (b) 2^5 (c) $2^5 \cos \frac{\pi}{4}$ (d) 2^8
(e) 2^8
21. The product of all values of $(\cos \alpha + i \sin \alpha)^{3/5}$ is
- (a) $\cos 5\alpha + i \sin 5\alpha$ (b) $\cos 3\alpha + i \sin 3\alpha$
(c) $\cos 2\alpha + i \sin 2\alpha$ (d) 1
(e) None of these
22. The solution of the equation $3^{\log_a x} + 3x^{\log_a 3} = 2$ is given by
- (a) $2^{\log_2 a}$ (b) $3^{\log_3 a}$ (c) $3^{-\log_2 a}$ (d) $2^{-\log_3 a}$
(e) 0
23. If $\sin x + \cos x = \frac{1}{5}$, then $\tan 2x$ is
- (a) $\frac{23}{7}$ (b) $\frac{7}{25}$ (c) $\frac{24}{7}$ (d) $\frac{3}{25}$
(e) $\frac{19}{7}$
24. The average weight of a class of 14 students is 42 kg. On including the teacher the average increases by 400 g, then weight of teacher is
- (a) 42 (b) 48 (c) 54 (d) 50
(e) 46

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- 25.** The sum of 10 items is 12 and the sum of their squares is 18, then standard deviation will be
 (a) $\frac{3}{5}$ (b) $\frac{-3}{5}$ (c) $\frac{2}{5}$ (d) $\frac{4}{5}$
 (e) $\frac{1}{5}$
- 26.** The line of intersection of the planes $r(2\hat{i} - \hat{j} + \hat{k}) = 2$ and $r(\hat{i} + 3\hat{j} - \hat{k}) = 2$ is parallel to
 (a) $-2\hat{i} + 3\hat{j} + 7\hat{k}$ (b) $2\hat{i} - 3\hat{j} + 7\hat{k}$
 (c) $-2\hat{i} + 5\hat{j} + 3\hat{k}$ (d) $2\hat{i} + 3\hat{j} + 7\hat{k}$
 (e) None of these
- 27.** $\int \frac{1}{\log a} (a^x \cos a^x) dx =$
 (a) $\frac{1}{(\log a)^2} \sin a^x + C$ (b) $(\log a)^2 \sin a^x + C$
 (c) $\frac{1}{\log a} \sin a^x + C$ (d) $\sin a^x + C$
 (e) $a^x \sin a^x + C$
- 28.** The total number of 4 digit numbers in which the digits are in ascending order is
 (a) ${}^{10}C_4$ (b) $\frac{10!}{4!}$ (c) $\frac{{}^{10}C_4}{4!}$ (d) ${}^{10}C_4 \times 4!$
 (e) $10! \times 4!$
- 29.** If **a** and **b** are unit vectors and θ is the angle between them, then $\left| \frac{\mathbf{a} - \mathbf{b}}{2} \right|$ is
 (a) $\sin 2\theta$ (b) $\sin \theta$ (c) $\sin \frac{\theta}{2}$ (d) $2 \sin 2\theta$
 (e) 0
- 30.** The differential equation of all circles passing through origin and having their centres on the X-axis is
 (a) $x^2 = y^2 - 2xy \frac{dy}{dx}$ (b) $y^2 = x^2 - 2xy \frac{dy}{dx}$
 (c) $x^2 = y^2 + 2xy \frac{dy}{dx}$ (d) $y^2 = x^2 + 2xy \frac{dy}{dx}$
 (e) None of these
- 31.** The area between the curve $y = 2x^4 - x^2$, the X-axis and the ordinates of two minima of the curve is
 (a) $\frac{5}{120}$ (b) $\frac{11}{120}$ (c) $\frac{13}{120}$ (d) $\frac{7}{120}$
 (e) $\frac{9}{120}$
- 32.** If ${}^nC_{r-1} = 10$, ${}^nC_r = 45$ and ${}^nC_{r+1} = 120$, then r equals
 (a) 1 (b) 2 (c) 3 (d) 5
 (e) 4
- 33.** A determinant of second order is made up of elements 0 and 1. The number of determinants with non-negative values is
 (a) 9 (b) 7 (c) 5 (d) 3
 (e) 13
- 34.** If $3^{49} (x + iy) = \left(\frac{3}{2} + \frac{\sqrt{3}i}{2} \right)^{100}$ and $x = ky$, then k is
 (a) $-\sqrt{3}$ (b) $\frac{-1}{\sqrt{3}}$ (c) $\frac{-1}{3}$ (d) 3
 (e) $\sqrt{3}$
- 35.** In a pack of playing cards, 4 are missing. The probability that the missing cards are one from each suit is
 (a) $\frac{256}{270725}$ (b) $\frac{4!}{13!}$ (c) $\frac{2197}{20825}$ (d) $\frac{1}{13}$
 (e) None of these
- 36.** If $\int_1^2 e^{x^2} dx = a$ the value of $\int_e^{e^4} \sqrt{\ln(x)} dx$ is
 (a) $e^4 + a$ (b) $e^4 + e$ (c) $2e^4$ (d) $2e^4 - e$
 (e) $2e^4 - e - a$
- 37.** The value of $\sqrt{7 + \sqrt{7 - \sqrt{7 + \sqrt{7 - \dots \infty}}}}$ is
 (a) 2 (b) 5 (c) 3 (d) 1
 (e) 6
- 38.** The equation of the plane passing through the points (3, 2, -1) (3, 4, 2) and (7, 0, 6) is $5x + 3y - 2z = \lambda$, where λ is :
 (a) 21 (b) 19 (c) 11 (d) 17
 (e) 23
- 39.** The projections of a line on the axes are 3, 4, 5. The length of the line is
 (a) 7 (b) 50 (c) 49 (d) 16
 (e) $\sqrt{50}$
- 40.** If the circle $x^2 + y^2 + 4x + 22y + c = 0$ bisects the circumference of the circle $x^2 + y^2 - 2x + 8y - d = 0$ then $c + d$ is equal to
 (a) 30 (b) 45
 (c) 60 (d) 35
 (e) 50

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- 41.** The equation of the curve that passes through the point (1, 2) and satisfies $\frac{dy}{dx} = \frac{-2xy}{x^2 + 1}$ is
 (a) $y(x^2 + 1) + 2 = 0$ (b) $y(x^2 + 1) + 1 = 0$
 (c) $y(x^2 + 1) = 4$ (d) $y(x^2 + 1) = 2$
 (e) $y(x^2 - 1) = 2$
- 42.** Range of the function $f(x) = {}^{7-x}P_{x-3}$, is
 (a) {1, 2, 3, 4, 5} (b) {1, 2, 3}
 (c) {1, 2} (d) {1, 2, 3, 4}
 (e) {1}
- 43.** The Length of the axes of the conic $9x^2 + 4y^2 - 6x + 4y + 1 = 0$ are
 (a) $\frac{2}{3}, 1$ (b) 2, 1 (c) $\frac{2}{5}, 3$ (d) $\frac{5}{6}, 2$
 (e) 4, 3
- 44.** The eccentricity of the ellipse, if the distance between foci is equal to the latusrectum is :
 (a) $\frac{\sqrt{5} + 1}{2}$ (b) $\frac{\sqrt{5} - 1}{2}$ (c) $\frac{\sqrt{5} - 1}{4}$ (d) $\frac{\sqrt{5}}{2}$
 (e) None of these
- 45.** The value of $\int_0^4 \{\sqrt{x}\} dx$, where $\{\cdot\}$ denotes the fractional part function, is
 (a) $\frac{7}{3}$ (b) $\frac{5}{3}$ (c) $\frac{1}{3}$ (d) 1
 (e) 0
- 46.** Let $\{a_n\}$ be a GP such that $\frac{a_4}{a_6} = \frac{1}{9}$ and $a_2 + a_5 = 1$ then 1st term is
 (a) 2 (b) 3 (c) 5 (d) 8
 (e) 10
- 47.** Let $f : R \rightarrow R$ be a differentiable function and $f(1) = 4$, then $\lim_{x \rightarrow 1} \int_4^{f(x)} \frac{2t}{x-1} dt = ?$
 (a) $8f'(1)$ (b) $4f'(1)$ (c) $3f'(1)$ (d) $2f'(1)$
 (e) $\frac{f'(1)}{2}$
- 48.** The value of $\lim_{x \rightarrow 0} \frac{(1+x)^{1/x} - e + \frac{1}{2}ex}{x^2}$ is
 (a) $\frac{-11e}{24}$ (b) $\frac{e}{11}$ (c) $\frac{e}{24}$ (d) $\frac{11e}{24}$
 (e) None of these
- 49.** $(7 - 4\sqrt{3})^{x^2 - 4x + 3} + (7 + 4\sqrt{3})^{x^2 - 4x + 3} = 14$, then $x = ?$
 (a) 3, $3 \pm \sqrt{3}$ (b) $3 \pm \sqrt{2}$, 3
 (c) $2 \pm \sqrt{3}$, 2 (d) 2, 1
 (e) 2, $2 \pm \sqrt{2}$
- 50.** If z is a normal root of $\sqrt[3]{-1}$ then $z^{85} + z^{142} + z^{191}$ is
 (a) 0 (b) z (c) -1 (d) 2
 (e) None of these
- 51.** If $z_1 = 5y^2 - 3 - 8ix$, $z_2 = 4y^2 - 16i$ and $z_1 = \bar{z}_2$, then $z = x + iy$ is equal to
 (a) $2 \pm \sqrt{3}$ (b) $-2 \pm \sqrt{3}$ (c) $1 \pm \sqrt{3}$ (d) $-1 + \sqrt{3}$
 (e) None of these
- 52.** The equation $\sin(e^x) = 5^x + 5^{-x}$ has exactly how many solutions?
 (a) 1 (b) 2 (c) 0 (d) 3
 (e) infinite
- 53.** Ram and Shyam throw a dice. The probability that Ram's throw is not greater than shyam's is
 (a) $\frac{1}{3}$ (b) $\frac{1}{6}$ (c) $\frac{7}{12}$ (d) $\frac{2}{3}$
 (e) None of these
- 54.** If $f(x) = [\tan^2 x]$ (where $[\cdot]$ denotes the greatest integer function), then
 (a) $f(x)$ is differentiable at $x = 0$
 (b) $f(0) = 1$
 (c) $f(x)$ is not continuous at $x = 0$
 (d) $\lim_{x \rightarrow 0} f(x)$ does not exist
 (e) None of the above
- 55.** In a group of 6 girls, two are sisters. In how many ways can they sit if the sisters do not sit with each other
 (a) 30240 (b) $\frac{6!}{2!}$
 (c) 4830 (d) $6!$
 (e) 2830
- 56.** Number of ways of dividing 7 men and 7 women into 7 couples, with a man and woman each is
 (a) 7! (b) 140
 (c) 70 (d) 175
 (e) None of these

- 57.** The coordinates of a point on the line $\frac{x+1}{2} = \frac{y-1}{3} = \frac{z-1}{1}$ at a distance of $\sqrt{56}$ units from the point $(1, 2, 0)$ are
 (a) $(5, -5, 1)$ (b) $(3, 7, 3)$
 (c) $(-5, 5, 1)$ (d) $(5, 5, 1)$
 (e) $(-3, -7, -3)$
- 58.** Let $f(x+y) = f(x)f(y)$ for all x and y . If $f(4) = 3$ and $f'(0) = 1$, then $f'(4)$ equals.
 (a) 3 (b) 1 (c) $\frac{1}{3}$ (d) 0
 (e) None of these
- 59.** If $I = \int_0^{1.5} [x^2] dx$, then I is equal to
 (a) $2 + \sqrt{2}$ (b) $\sqrt{2} - 1$ (c) 2 (d) 0
 (e) $2 - \sqrt{2}$
- 60.** $\lim_{x \rightarrow \frac{\pi}{4}} (2 - \cot x)^{\log \cot x}$ is equal to
 (a) 1 (b) 0 (c) e^2 (d) e^{-1}
 (e) 2
- 61.** If $n(A) = 61$, $n(B) = 95$, $n(A - B) = 25$, then $(A \cup B)$ is equal to
 (a) 85 (b) 105 (c) 120 (d) 125
 (e) 131
- 62.** If the roots of $x^3 - 12x^2 + 39x - 28 = 0$ are in AP, then their common difference is
 (a) ± 2 (b) ± 3
 (c) 0 (d) ± 1
 (e) ± 6
- 63.** The remainder when 2^{2003} is divided by 17 is
 (a) 7 (b) 8
 (c) 2 (d) 1
 (e) 0
- 64.** The coefficient of x^{13} in the expansion of $(1-x)^5 (1+x+x^2+x^3)^4$ is
 (a) 0 (b) 2
 (c) 4 (d) -4
 (e) None of these
- 65.** Number of values of a in the interval $[-\pi, 0]$ which satisfy $\sin a + \int_a^{2a} \cos 2x dx = 0$ are
 (a) 0 (b) 1
 (c) 2 (d) 3
 (e) infinite
- 66.** A man speaks truth 3 out of 4 times. He throws a dice and reports that it is 3. Probability that it is actually 3 is
 (a) $\frac{5}{8}$ (b) $\frac{3}{8}$ (c) $\frac{1}{3}$ (d) $\frac{1}{2}$
 (e) None of these
- 67.** The length of the latusrectum of an ellipse is $\frac{1}{2}$ of the major axis. Its eccentricity would be
 (a) $\sqrt{2}$ (b) $\frac{1}{\sqrt{2}}$ (c) 2 (d) 1
 (e) None of these
- 68.** The value of $(1+i)^5 \times (1-i)^5$ is
 (a) 2^3 (b) 2^0 (c) 2^4 (d) 2^5
 (e) 0
- 69.** The number of 6 digit telephone numbers having atleast one of their digits repeated is
 (a) $10^6 - {}^{10}P_5$ (b) $10^6 - {}^{10}P_6$
 (c) $10^6 - {}^{10}P_8$ (d) 10^6
 (e) None of these.
- 70.** If $z = \frac{\sqrt{3} + i}{2}$, then the value of z^{69} is
 (a) 1 (b) -1 (c) 0 (d) i
 (e) $-i$
- 71.** Distance between the lines $4x + 3y = 6$ and $4x + 3y = 11$ is
 (a) 1 unit (b) 2 unit (c) 0 unit (d) 4 unit
 (e) Can't be determined
- 72.** The number of solutions of $\sum_{r=1}^4 \cos rx = 4$ in the interval $[0, 2\pi]$ is
 (a) 1 (b) 0 (c) 4 (d) 3
 (e) Infinite solutions
- 73.** If $x \in [0, 2\pi]$, $y \in [0, 2\pi]$ and $\sin x + \sin y = 2$ then the value of $x + y$ is
 (a) π (b) $\frac{\pi}{3}$ (c) 3π (d) π
 (e) None of these
- 74.** If $\sin x + \sin^2 x = 1$, then the value of $\cos^{12} x + 3\cos^{10} x + 3\cos^8 x + \cos^6 x - 1$ is equal to
 (a) 0 (b) -1 (c) 1 (d) 2
 (e) 3

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- 75.** If $x = 3^{100}$, then x has
 (a) unit's digit as 0 (b) unit's digit as 1
 (c) unit's digit as 2 (d) unit's digit as 5
 (e) unit's digit as 3
- 76.** The probability that a ball will hit a target is $\frac{1}{5}$. Then the probability that the target is hit at least once in 10 shots is
 (a) $\frac{1}{5^{10}}$ (b) $1 - \left(\frac{1}{5^{10}}\right)$
 (c) $\left(\frac{3}{5}\right)^{10}$ (d) $1 - \left(\frac{3}{5}\right)^{10}$
 (e) $1 - \left(\frac{4}{5}\right)^{10}$
- 77.** A class consists of 80 students, 25 of them are girls and 55 are boys. If 10 of them are rich and rest poor and also 20 are intelligent, probability of choosing poor not intelligent boy is
 (a) $\frac{231}{512}$ (b) $\frac{221}{512}$
 (c) $\frac{81}{512}$ (d) $\frac{63}{512}$
 (e) None of these
- 78.** If $m_1, m_2, m_3, \dots, m_{20}$ are AMs between 13 and 67, then $\max m_1, m_2, m_3, \dots, m_{20}$ is
 (a) $(20)^{40}$ (b) $(40)^{20}$
 (c) $(30)^{20}$ (d) $(40)^{40}$
 (e) $(20)^{20}$
- 79.** If an AP, $a_7 = 9$ if $a_1 a_2 a_7$ is least, the common difference is
 (a) $\frac{23}{20}$ (b) $\frac{11}{20}$
 (c) $\frac{33}{20}$ (d) $\frac{41}{20}$
 (e) $\frac{13}{20}$
- 80.** An integer is chosen at random from the numbers 1, 225. The probability that it is divisible by 3 or 4 is
 (a) $\frac{11}{25}$ (b) $\frac{14}{25}$
 (c) $\frac{2}{25}$ (d) $\frac{12}{25}$
 (e) $\frac{9}{25}$
- 81.** If ω is a complex cube root of unity and $(1 + \omega)^7 = A + B\omega$, then A and B are equal to
 (a) 1, 1 (b) 1, 0
 (c) 0, 1 (d) -1, 1
 (e) 1, 2
- 82.** The equation $ax^2 + 4xy + y^2 + ax + 3y + 2 = 0$ represents a parabola if a is
 (a) 0 (b) 4 (c) -4 (d) 8
 (e) None of these
- 83.** The condition that the straight line $lx + my + n = 0$ touches the parabola $x^2 = 4ay$ is
 (a) $bn = am^2$ (b) $am = ln^2$
 (c) $al^2 - mn = 0$ (d) $ln = am^2$
 (e) None of these
- 84.** The line $\frac{x}{2} = \frac{-y}{3} = \frac{z}{1}$ is vertical. The direction cosines of the line of greatest slope in the plane $3x - 2y + z = 5$ are proportional to
 (a) (11, 16, -1) (b) (-11, 16, 1)
 (c) (16, 11, -1) (d) (16, 11, 1)
 (e) (11, 16, 1)
- 85.** The lines $\frac{x+1}{1} = \frac{y-1}{2} = \frac{z-2}{-1}$, $\frac{x-1}{2} = \frac{y}{1} = \frac{z+1}{4}$ are
 (a) parallel
 (b) perpendicular
 (c) perpendicular skew lines
 (d) intersecting
 (e) None of the above
- 86.** The line $\frac{x-2}{3} = \frac{y+1}{2} = \frac{z-1}{-1}$, intersects the curve $xy = c^2, z = 0$ if c is equal to
 (a) $\pm \frac{1}{3}$ (b) $\pm \sqrt{5}$
 (c) ± 1 (d) ± 2
 (e) None of these
- 87.** The number of values of a for which $(a^2 - 3a + 2)x^2 + (a^2 - 5a + 6)x + a^2 - 4 = 0$ is an identity in x is
 (a) 0 (b) 1
 (c) 2 (d) 3
 (e) 4

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88. The value of $\cos \frac{2\pi}{7} + \cos \frac{4\pi}{7} + \cos \frac{6\pi}{7}$ is equal to
 (a) -1 (b) 1
 (c) $-\frac{1}{2}$ (d) $\frac{1}{2}$
 (e) 0
89. The points $(k, 2 - 2k)$, $(-k + 1, 2k)$ and $(-4 - k, 6 - 2k)$ are collinear for
 (a) all values of k (b) $k = -1$
 (c) $k = -\frac{1}{2}$ (d) $k = 0$
 (e) No values of k
90. ABC is an isosceles triangle. If the coordinates of the base are $B(1, 3)$, $C(-2, 7)$, the coordinates of A are
 (a) $(6, 1)$ (b) $\left(\frac{5}{6}, 6\right)$
 (c) $\left(-\frac{1}{2}, 5\right)$ (d) $(1, 6)$
 (e) $(0, 0)$
91. If a and b are positive integers such that $a^2 - b^2$ is a prime number, then $a^2 - b^2$ is equal to :
 (a) $a^2 + b^2$ (b) $a + b$
 (c) $a - b$ (d) ab
 (e) $\frac{a}{b}$
92. The sum of all proper divisor of 9900 is
 (a) 29351 (b) 23951 (c) 33851 (d) 5263
 (e) None of these
93. If $y = \frac{1}{4}u^4$ and $u = \frac{2}{3}x^3 + 5$, then $\frac{dy}{dx}$ is equal to
 (a) x^2 (b) $2x^3 + 15$
 (c) $x^2 + 10$ (d) $\frac{2}{27}x^2(2x^3 + 15)^3$
 (e) None of these
94. The interval in which the function $f(x) = x^{1/x}$ is increasing is
 (a) $(-\infty, e)$ (b) (e, ∞)
 (c) $(-\infty, \infty)$ (d) $\left(-\infty, \frac{1}{e}\right)$
 (e) $\left(\frac{1}{e}, e\right)$
95. If $f(x) = \frac{3x + 2}{5x - 3}$, then
 (a) $f^{-1}(x) = f(x)$ (b) $f^{-1}(x) = -f(x)$
 (c) $(f \circ f)(x) = -x$ (d) $f^{-1}(x) = -\frac{f(x)}{19}$
 (e) $(f \circ f)(x) = \frac{1}{x}$
96. $\lim_{x \rightarrow 0} \frac{\sin(\pi \cos^2 x)}{x^2}$ is equal to
 (a) $-\pi$ (b) π
 (c) $\frac{\pi}{2}$ (d) 1
 (e) $\frac{1}{\pi}$
97. If $\int f(x) dx = f(x) + C$, then $\int \{f(x)\}^2 dx$ is
 (a) $\{f(x)\}^2 + k$ (b) $\frac{1}{3}\{f(x)\}^3 + k$
 (c) $\frac{1}{2}\{f(x)\}^2 + k$ (d) $f(x) + k$
 (e) $\frac{f(x)}{2} + C$
98. $\int_0^{4\pi} |\sin x| dx$ is equal to
 (a) 0 (b) 2 (c) 4 (d) 8
 (e) 7
99. The area of the region bounded by the curve $xy - 3x - 2y - 10 = 0$, X -axis and the lines $x = 3$, $x = 4$ is
 (a) 3 sq. unit (b) $x + 16\log 2$ sq. units
 (c) $16\log 2$ sq. units (d) $3 + 16\log 2$ sq. units
 (e) None of these
100. If A be a square matrix of order n and if $|A| = D$ and $|\text{adj } A| = D'$ then.
 (a) $DD' = D^2$ (b) $DD' = D^{-1}$
 (c) $DD' = D^n$ (d) $DD' = D^3$
 (e) $DD' = D^{2n}$
101. If α, β and γ are the roots of the equation $x^3 + px + q = 0$, then the value of the determinant $\begin{vmatrix} \alpha & \beta & \gamma \\ \beta & \gamma & \alpha \\ \gamma & \alpha & \beta \end{vmatrix}$ is
 (a) 0 (b) -2
 (c) 3 (d) 2
 (e) 4

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102. The mean of the values of $1, 2, 3, \dots, n$ with respectively frequencies $x, 2x, 3x, \dots, nx$ is

- (a) $\frac{n}{2}$ (b) $\frac{1}{3}(2n+1)$
 (c) $\frac{1}{6}(2n+1)$ (d) $\frac{n}{4}$
 (e) $\frac{2n}{3}$

103. $\int_{-2}^2 |x \cos \pi x| dx$ is equal to

- (a) $\frac{8}{\pi}$ (b) $\frac{4}{\pi}$
 (c) $\frac{2}{\pi}$ (d) $\frac{1}{\pi}$
 (e) $\frac{5}{\pi}$

104. The area included between the curves

$$y = \frac{1}{x^2 + 1} \text{ and } X\text{-axis is}$$

- (a) $\frac{\pi}{2}$ sq units (b) π sq units
 (c) 2π sq units (d) $\frac{\pi}{3}$ sq units
 (e) 3π sq units

105. $\lim_{x \rightarrow 0} (\cos x)^{1/x^4}$

- (a) 0 (b) 1
 (c) e (d) 2
 (e) e^2

106. Let $f(x) = x^2 - x + 1, x \geq \frac{1}{2}$, then the solution

of the equation $f(x) = f^{-1}(x)$ is

- (a) $x = 1$ (b) $x = 2$
 (c) $x = \frac{1}{2}$ (d) $x = \frac{1}{3}$
 (e) 4

107. The value of $[\mathbf{a} - \mathbf{b}, \mathbf{b} - \mathbf{c}, \mathbf{c} - \mathbf{a}]$ is equal to

- (a) 0 (b) 1
 (c) 2 (d) 3
 (e) 4

108. In a ΔABC , if $a = 2x, b = 2y$ and $\angle C = 120^\circ$, then the area of the triangle is

- (a) xy sq unit (b) $xy\sqrt{3}$ sq unit
 (c) $3xy$ sq unit (d) $2xy$ sq unit
 (e) $xy\sqrt{5}$ sq unit

109. If $\mathbf{a} \cdot \hat{\mathbf{i}} = \mathbf{a} \cdot (\hat{\mathbf{i}} + \hat{\mathbf{j}}) = \mathbf{a} \cdot (\hat{\mathbf{i}} + \hat{\mathbf{j}} + \hat{\mathbf{k}})$, then \mathbf{a} is equal to

- (a) $\hat{\mathbf{i}}$ (b) $\hat{\mathbf{k}}$
 (c) $\hat{\mathbf{j}}$ (d) $\hat{\mathbf{i}} + \hat{\mathbf{j}} + \hat{\mathbf{k}}$
 (e) $\hat{\mathbf{j}}$

110. The variance of 20 observations is 5. If each observation is multiplied by 2, then what is the new variance of the resulting observation ?

- (a) 5 (b) 10
 (c) 20 (d) 40
 (e) 60

111. If A is an invertible matrix of order n and k is any positive real number, then the value of $[\det(kA)]^{-1} \det(A)$ is

- (a) k^{-n} (b) k^{-1}
 (c) k^n (d) nk
 (e) $5k$

112. What is the value of k for which the following function $f(x)$ is continuous for all x ?

$$f(x) = \begin{cases} x^3 - 3x + 2 & \text{for } x \neq 1 \\ k & \text{for } x = 1 \end{cases}$$

- (a) 0 (b) 2
 (c) 1 (d) 3
 (e) 4

113. Let f be a function with domain $[-3, 5]$ and let $g(x) = |3x + 4|$, then the domain of $f \circ g(x)$ is

- (a) $\left(-3, \frac{1}{3}\right)$
 (b) $\left[-3, \frac{1}{3}\right]$
 (c) $\left[-3, \frac{1}{3}\right)$
 (d) $\left(-3, \frac{1}{3}\right]$
 (e) None of the above

114. If θ is the angle between the vectors $4(\hat{\mathbf{i}} - \hat{\mathbf{k}})$ and $(\hat{\mathbf{i}} + \hat{\mathbf{j}} + \hat{\mathbf{k}})$, then what is $(\sin \theta + \cos \theta)$ equal to ?

- (a) 0 (b) 1
 (c) 4 (d) 2
 (e) 3

115. $\lim_{\theta \rightarrow \frac{\pi}{4}} \frac{\sqrt{2} - \cos \theta - \sin \theta}{(4\theta - \pi)^2}$ is equal to

- (a) $\frac{1}{16}$ (b) $\frac{1}{16\sqrt{2}}$
 (c) $\frac{1}{8}$ (d) $\frac{1}{8\sqrt{2}}$
 (e) $\frac{1}{10}$

116. The mean and variance of n values of a variable x are 0 and σ^2 , respectively. If the variable $y = x^2$, then mean of y is

- (a) σ (b) σ^2
 (c) 1 (d) 3
 (e) $\frac{1}{\sigma}$

117. $\lim_{n \rightarrow \infty} \left\{ \frac{1}{1-n^2} + \frac{2}{1-n^2} + \dots + \frac{n}{1-n^2} \right\}$ is equal to

- (a) 0 (b) $\frac{-1}{2}$
 (c) $\frac{1}{2}$ (d) 1
 (e) 3

118. If \mathbf{a} and \mathbf{b} are unit vectors, then the greatest value of $|\mathbf{a} + \mathbf{b}| + |\mathbf{a} - \mathbf{b}|$ is

- (a) $\sqrt{3}$
 (b) $\sqrt{2}$
 (c) $2\sqrt{2}$
 (d) 4
 (e) $3\sqrt{3}$

119. If a variable takes the discrete values

$$\alpha + 4, \alpha - \frac{7}{2}, \alpha - \frac{5}{2}, \alpha - 3, \alpha - 2, \alpha + \frac{1}{2}, \alpha - \frac{1}{2},$$

$\alpha + 5$ ($\alpha > 0$), then the median is

- (a) $\alpha - \frac{5}{4}$ (b) $\alpha - \frac{1}{2}$
 (c) $\alpha - 2$ (d) $\alpha + \frac{5}{4}$
 (e) $\alpha + \frac{1}{2}$

120. In a triangle $\left(1 - \frac{r_1}{r_2}\right) \left(1 - \frac{r_1}{r_2}\right) = 2$, then the

triangle is

- (a) right angled (b) equilateral
 (c) isosceles (d) scalene
 (e) isosceles right angle triangle

Answers

Physics & Chemistry

1.	(b)	2.	(e)	3.	(b)	4.	(a)	5.	(a)	6.	(b)	7.	(e)	8.	(d)	9.	(c)	10.	(c)
11.	(d)	12.	(e)	13.	(a)	14.	(e)	15.	(*)	16.	(c)	17.	(c)	18.	(e)	19.	(d)	20.	(b)
21.	(d)	22.	(e)	23.	(b)	24.	(d)	25.	(b)	26.	(d)	27.	(a)	28.	(b)	29.	(c)	30.	(e)
31.	(e)	32.	(b)	33.	(e)	34.	(b)	35.	(a)	36.	(*)	37.	(a)	38.	(b)	39.	(b)	40.	(d)
41.	(e)	42.	(b)	43.	(d)	44.	(b)	45.	(a)	46.	(b)	47.	(c)	48.	(d)	49.	(c)	50.	(b)
51.	(a)	52.	(c)	53.	(d)	54.	(c)	55.	(b)	56.	(e)	57.	(b)	58.	(c)	59.	(d)	60.	(b)
61.	(b)	62.	(a)	63.	(e)	64.	(c)	65.	(d)	66.	(a)	67.	(c)	68.	(c)	69.	(d)	70.	(b)
71.	(e)	72.	(d)	73.	(a)	74.	(a)	75.	(b)	76.	(a)	77.	(d)	78.	(e)	79.	(d)	80.	(c)
81.	(c)	82.	(d)	83.	(b)	84.	(d)	85.	(b)	86.	(c)	87.	(b)	88.	(b)	89.	(d)	90.	(c)
91.	(b)	92.	(e)	93.	(d)	94.	(b)	95.	(b)	96.	(d)	97.	(a)	98.	(a)	99.	(c)	100.	(b)
101.	(e)	102.	(a)	103.	(a)	104.	(a)	105.	(a)	106.	(c)	107.	(c)	108.	(b)	109.	(a)	110.	(a)
111.	(a)	112.	(b)	113.	(e)	114.	(a)	115.	(a)	116.	(b)	117.	(d)	118.	(b)	119.	(c)	120.	(b)

Mathematics

1.	(d)	2.	(c)	3.	(a)	4.	(a)	5.	(e)	6.	(c)	7.	(b)	8.	(c)	9.	(e)	10.	(e)
11.	(a)	12.	(d)	13.	(a)	14.	(c)	15.	(d)	16.	(d)	17.	(c)	18.	(c)	19.	(c)	20.	(b)
21.	(b)	22.	(d)	23.	(c)	24.	(b)	25.	(a)	26.	(a)	27.	(a)	28.	(a)	29.	(c)	30.	(d)
31.	(d)	32.	(b)	33.	(e)	34.	(b)	35.	(c)	36.	(e)	37.	(c)	38.	(e)	39.	(e)	40.	(e)
41.	(c)	42.	(b)	43.	(a)	44.	(b)	45.	(a)	46.	(a)	47.	(a)	48.	(d)	49.	(e)	50.	(b)
51.	(b)	52.	(c)	53.	(c)	54.	(a)	55.	(a)	56.	(b)	57.	(b)	58.	(a)	59.	(e)	60.	(a)
61.	(c)	62.	(b)	63.	(b)	64.	(c)	65.	(d)	66.	(b)	67.	(b)	68.	(d)	69.	(b)	70.	(e)
71.	(a)	72.	(a)	73.	(a)	74.	(a)	75.	(b)	76.	(e)	77.	(a)	78.	(b)	79.	(c)	80.	(d)
81.	(a)	82.	(b)	83.	(c)	84.	(a)	85.	(b)	86.	(b)	87.	(c)	88.	(c)	89.	(b)	90.	(b)
91.	(b)	92.	(b)	93.	(d)	94.	(a)	95.	(a)	96.	(b)	97.	(c)	98.	(d)	99.	(d)	100.	(c)
101.	(a)	102.	(b)	103.	(a)	104.	(b)	105.	(a)	106.	(a)	107.	(a)	108.	(b)	109.	(a)	110.	(c)
111.	(a)	112.	(d)	113.	(b)	114.	(b)	115.	(b)	116.	(b)	117.	(b)	118.	(c)	119.	(a)	120.	(a)

Note (*) None of the option is correct.

Answer with Explanations

Physics

1. (b) Magnitude of electric field is given as,

$$E = \frac{F}{q}$$

where, F is the magnitude of the electrostatic force and q is the charge

Here, $F = 1 \text{ N}$

and $q = e = 1.6 \times 10^{-19} \text{ C}$

$$\Rightarrow E = \frac{1}{e} \text{ N/C}$$

Force experienced by a negative charge is in the opposite direction to the electric field. As, for a negatively charged particle, its electric field vector at each point is directed radially inwards.

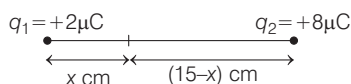
Thus, the magnitude and direction of E is $\frac{1}{e} \text{ N/C}$ and

E and F are against each other.

2. (e) Given, charge $q_1 = +2\mu\text{C}$, charge $q_2 = +8\mu\text{C}$ and distance between the charges $d = 15 \text{ cm}$.

As, the electric field is zero at point p only if the field due to charge $+2\mu\text{C}$ balances the field due to charge $+8\mu\text{C}$.

Let x be the distance from charge q_1 at which the electric field is zero as shown in the figure below.



$$\therefore \frac{kq_1}{x^2} = \frac{kq_2}{(15-x)^2}$$

$$\Rightarrow \frac{1}{4\pi\epsilon_0} \cdot \frac{2 \times 10^{-6}}{x^2} = \frac{1}{4\pi\epsilon_0} \frac{8 \times 10^{-6}}{(15-x)^2}$$

$$\Rightarrow \frac{1}{x^2} = \frac{4}{(15-x)^2}$$

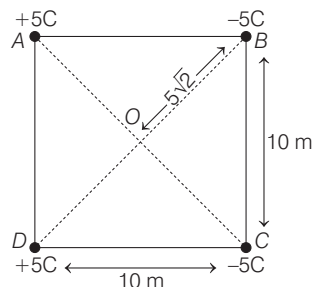
$$\therefore \frac{1}{x} = \frac{2}{15-x}$$

$$\Rightarrow 2x = 15 - x$$

$$\Rightarrow x = 5 \text{ cm}$$

Thus, the required point is at a distance of 5 cm from $2\mu\text{C}$.

3. (b) Four point charges are placed at four corners of a square of side 10 m, is given in figure below as



Now, the potential at point O

$$\begin{aligned} V_O &= V_{-5C} + V_{-5C} + V_{+5C} + V_{+5C} \\ &= 2V_{-5C} + 2V_{+5C} \\ &= \frac{2}{4\pi\epsilon_0} \frac{(-5)}{5\sqrt{2}} + \frac{2}{4\pi\epsilon_0} \frac{(+5)}{5\sqrt{2}} \\ &= 0 \text{ V (zero)} \end{aligned}$$

and now electric field at origin

$$\begin{aligned} E_{OB} &= \frac{1}{4\pi\epsilon_0} \frac{5}{(5\sqrt{2})^2} \\ &= k \frac{1}{10} \text{ (towards O)} \end{aligned}$$

$$\text{Similarly, } E_{OC} = k \frac{5}{(5\sqrt{2})^2} = k \frac{1}{10} \text{ (towards O)}$$

$$E_{OA} = k \frac{1}{10} \text{ (away from O)}$$

$$E_{OD} = k \frac{1}{10} \text{ (away from O)}$$

Now, the vector sum of all the fields

$$\begin{aligned} E^2 &= (2E_{OA})^2 + (2E_{OB})^2 \\ &= \frac{2}{25} k^2 \end{aligned}$$

$$\Rightarrow E = \frac{\sqrt{2}}{5} k \text{ V/m}$$

4. (a) The given electric field is uniform in nature. Thus, the net force acting on it will be zero. However, couple of forces will act on either charges of the

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dipole in opposite direction that would constitute torque. Due to this torque the dipole would rotate.

As, torque on the dipole is given as $\tau = \mathbf{p} \times \mathbf{E}$

Given, $p_0 = P_0 \cdot \hat{\mathbf{k}}$

and $\mathbf{E} = E_0 (2\hat{\mathbf{i}} - 3\hat{\mathbf{j}} + 4\hat{\mathbf{k}})$, then

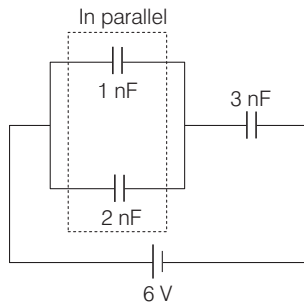
$$\begin{aligned} \tau &= (P_0 \cdot \hat{\mathbf{k}}) \times E_0 (2\hat{\mathbf{i}} - 3\hat{\mathbf{j}} + 4\hat{\mathbf{k}}) \\ &= E_0 [2P_0(\hat{\mathbf{k}} \times \hat{\mathbf{i}}) - 3P_0(\hat{\mathbf{k}} \times \hat{\mathbf{j}})] \quad [\because \hat{\mathbf{k}} \times \hat{\mathbf{k}} = 0] \\ &= E_0 [2P_0\hat{\mathbf{j}} - 3P_0(-\hat{\mathbf{i}})] \end{aligned}$$

$[\because \hat{\mathbf{k}} \times \hat{\mathbf{j}} = \hat{\mathbf{j}}$ and $\hat{\mathbf{k}} \times \hat{\mathbf{i}} = -\hat{\mathbf{i}}] = P_0 E_0 (3\hat{\mathbf{i}} + 2\hat{\mathbf{j}})$

So, it implies that torque is acting on the dipole rotating it on x-y plane. However, the interaction energy between the dipole and electric field

$$E = \mathbf{PE} = p_0 \hat{\mathbf{k}} \cdot E_0 (2\hat{\mathbf{i}} - 3\hat{\mathbf{j}} + 4\hat{\mathbf{k}}) = P_0 E_0 4 \neq 0$$

5. (a) 3 capacitors connected with a 6V battery as shown in the figure below



\therefore Equivalent capacitance of 1 nF and 2 nF connected in parallel is given as, $C' = (1 + 2) \text{ nF}$

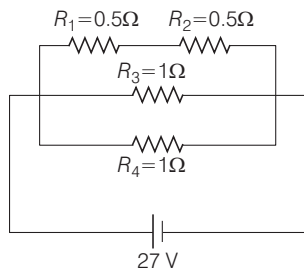
This equivalent C' is connected in series with 3 nF. So, the equivalent capacitance of the given circuit is

$$C_{eq} = \frac{(1 \times 2) \times 3}{(1 + 2) + 3} = 1.5 \text{ nF}$$

Total charge on the capacitors = $V \times C_{eq}$

$$= 6 \times (1.5 \text{ nF}) = 9 \text{ nC}$$

6. (b) The circuit can be redrawn as shown in the figure below,



So, the equivalent resistance of the three parallel branches is given as,

$$R_{eq} = \frac{1}{\frac{1}{0.5 + 0.5} + \frac{1}{1} + \frac{1}{1}} = \frac{1}{\frac{2}{1} + \frac{1}{1} + \frac{1}{1}} = \frac{1}{3} \Omega$$

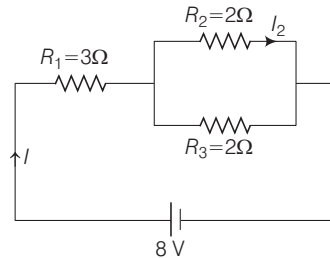
Now, from Ohm's law

$$I = \frac{V}{R} = \frac{27}{1/3} = 27 \times 3 = 18 \text{ A}$$

Here in the figure, 3 branches are of equal resistance, so current will divide equally in each branch, So, current in R_3 ,

$$I_{R_3} = \frac{27 \times 3}{3} = \frac{81}{3} = 27 \text{ A}$$

7. (e) The given circuit can be drawn as shown below



Equivalent resistance of circuit,

$$R_{eq} = R_1 + \frac{R_2 R_3}{R_3 + R_2} = 3 + \frac{2 \times 2}{2 + 2} = 4 \Omega$$

Net current drawn from battery

$$I = \frac{V}{R} = \frac{8}{4} = 2 \text{ A}$$

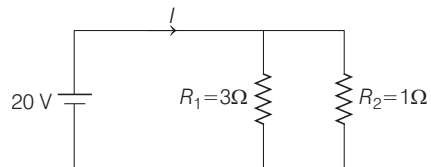
Now the current I_2

$$I_2 = \frac{I R_3}{R_2 + R_3} = \frac{2 \times 2}{2 + 2} = 1 \text{ A}$$

and potential drop across R_2

$$V_{R_2} = I_2 R_2 = 1 \times 2 = 2 \text{ V}$$

8. (d) A circuit with two resistances 3Ω and 1Ω are connected with 20 V battery is as shown in figure below



Since resistors are connected in parallel, so each branch of the circuit has potential drop of 20V.

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$$\therefore \text{Current in } R_1 \text{ resistor, } I = \frac{V}{R_1} = \frac{20}{3} \text{ A}$$

$$\therefore \text{Heat developed in } R_1 \text{ is given by } H = I^2 R_1 t$$

$$\text{where, } t = 1 \text{ min} = 60 \text{ s}$$

$$\Rightarrow H = \frac{20}{3} \times \frac{20}{3} \times 3 \times 60 = 8000 \text{ J}$$

9. (c) Let displacement equation of a particle executing SHM is given as

$$x = a \sin \omega t$$

$$\text{then velocity } (v) = \frac{dx}{dt} = a\omega \cos \omega t \quad \dots (i)$$

$$\text{and acceleration } (a) = \frac{d^2x}{dt^2} = \frac{dv}{dt} = -a\omega^2 \sin \omega t$$

$$a = a\omega^2 \cos \left(\omega t + \frac{\pi}{2} \right) \quad \dots (ii)$$

$$\left(\because \cos \left(\theta + \frac{\pi}{2} \right) = -\sin \theta \right)$$

Now, comparing Eqs (i) and (ii), we can conclude that the acceleration lead the velocity by a phase of $+\frac{\pi}{2}$ radians.

10. (c) Under the condition for resonance for a damped harmonic oscillator, the body oscillates with its own natural frequency f_0 with the help of an external periodic force whose frequency f_d (driving frequency) which is equal to the natural frequency of the body,

$$\text{This means } f_0 = f_d$$

Thus, statement given in option (c) is correct.

11. (d) In the given simple harmonic motion, maximum acceleration $a_{\max} = 8 \text{ m/s}^2$ and maximum speed $v_{\max} = 1.6 \text{ m/s}$.

As, we know that for simple harmonic motion

$$a_{\max} = \omega^2 A$$

$$\text{and } v_{\max} = \omega A$$

where, $A =$ amplitude of SHM,

$$\Rightarrow a_{\max} = v_{\max} \omega \quad \dots (i)$$

So, from Eq.(i), we get

$$\omega = \frac{a_{\max}}{v_{\max}} = \frac{8}{1.6} = 5 \Rightarrow \omega = 5 \quad \left(\because \omega = \frac{2\pi}{T} \right)$$

\therefore Time period,

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{5} = 1.25 \text{ s}$$

12. (e) Given, time in which an echo is received = 0.1s and speed of sound in air = 330 m/s

Since, the echo received by bat travelled a distance double to the distance between bat and object.

$$\therefore 2D = v \times (\text{time})$$

where, $D =$ distance between bat and object and $v =$ speed of sound.

$$\Rightarrow D = \frac{v \times \text{time}}{2} = \frac{330 \times 0.1}{2} = 16.5 \text{ m}$$

13. (a) Given the equation of wave along string

$$y = 0.05 \sin(28t - 1.78x) \quad \dots (i)$$

The general equation of a wave is given as

$$y = A \sin(\omega t - kx) \quad \dots (ii)$$

Now, comparing Eqs. (i) and (ii), we get

$$\text{Amplitude, } A = 0.05 \text{ m, } k = 1.78$$

$$\text{and } \omega = 28$$

$$\Rightarrow \text{Frequency, } f = \frac{\omega}{2\pi} = \frac{28}{2\pi} = 4.456 \text{ Hz}$$

$$\text{and wavelength, } \lambda = \frac{2\pi}{k} = \frac{2\pi}{1.78} = 3.529 \text{ m}$$

14. (e) **Case I** When train is moving towards a stationary observer.

According to Doppler's effect of sound,

$$\text{apparent frequency heard, } n' = \frac{nv}{v - v_s}$$

where, $n =$ frequency of source, $v =$ speed of sound and $v_s =$ speed of source.

$$\Rightarrow v_s = v \left[1 - \frac{n}{n'} \right] \quad \dots (i)$$

Case II When train is leaving the standing observer.

Again, according to the Doppler's effect of sound,

Apparent frequency heard,

$$n' = \frac{nv}{v + v_s} \Rightarrow v_s = v \left[\frac{n}{n'} - 1 \right] \quad \dots (ii)$$

From Eqs. (i) and (ii), we get

$$\frac{n}{n'} + \frac{n}{n'} = 2$$

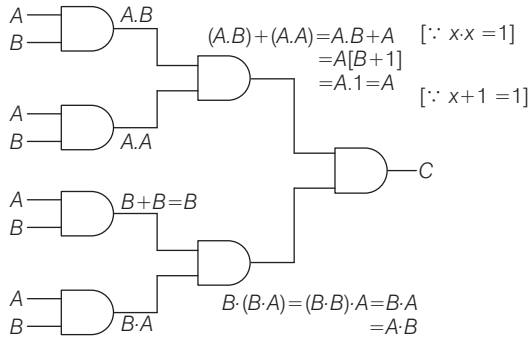
Given, $n' = 216 \text{ Hz}$ and $n = 184 \text{ Hz}$

Substituting these values in the above equation, we get

$$n = \frac{2 \times 216 \times 184}{(216 + 184)} \approx 200 \text{ Hz}$$

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15. (*) The given circuit diagram with the respective boolean expression is as shown below,



∴ The resultant $C = A \cdot (A \cdot B) = (A \cdot A) \cdot B = A \cdot B$

This expression is equivalent to the boolean expression for a AND gate. Thus, its truth table will be

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

∴ (*) No options given is correct.

16. (c) When a charged particle q move with velocity v inside a uniform magnetic field \mathbf{B} , then force acting on it.

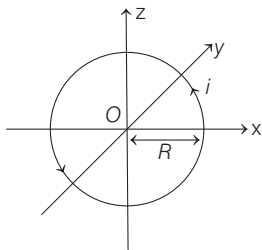
$$\mathbf{F} = q(\mathbf{v} \times \mathbf{B}) = 2q vB \sin \theta$$

Since we know that, if v and B are neither orthogonal nor parallel i.e., $\theta \neq 0, 90^\circ$ and 180° then particle will describe a helical motion.

However, if v and B are perpendicular to each other, then particle will describe a circle.

So, statement given in option (c) is correct.

17. (c) A circular loop of radius R and current I is shown in the figure below



From Biot-savart law, the magnetic field at some point in space at distance R is given as,

$$dB = \frac{\mu_0}{4\pi} i \frac{d\mathbf{l} \times \mathbf{P}}{R^3}$$

Since, the loop is circular in shape so,

$$= 2\pi R$$

Now integrating the field in whole length of wire loop

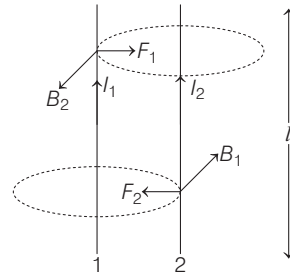
$$\Rightarrow \int_0^B dB = \frac{\mu_0}{4\pi} \frac{iR}{R^3} \int_0^{2\pi R} dl$$

$$\Rightarrow B = \frac{\mu_0}{4\pi} \frac{i}{R^2} 2\pi R = \frac{\mu_0 i}{2R}$$

Also, with help of right hand thumb rule, we can conclude, that the magnetic field is in $+z$ direction.

$$\Rightarrow \mathbf{B} = \frac{\mu_0 i}{2R} \hat{z}$$

18. (e) Two parallel conductors 1 and 2 carrying current I_1 and I_2 , respectively of length l is shown in the figure given below,



Force on wire 2 due to B_1 is given by

$$F_2 = I_2 l B_1$$

Using right hand screw rule, direction of F_2 would be towards wire 1.

Similarly, force on wire due to B_2 (field of wire 2)

$$F_1 = I_1 l B_2$$

Again, by using right hand screw rule, direction of F_1 would be towards 2.

If two parallel conductors carry (equal or unequal) current in same direction, they will exert force towards each other i.e., they will attract.

However, if these parallel conductors have current in the opposite direction then they will exert force away from each other such that they would repel.

19. (d) The energy gap in silicon is more than germanium because in an silicon atom, electrons are more tightly bound to the nucleus than the germanium atom electrons. This happens due to the smaller size of the silicon atom.

20. (b) As we know

$$[\text{Pressure}] = \frac{[\text{Force}]}{[\text{Area}]} = \frac{[\text{MLT}^{-2}]}{[\text{M}^0\text{L}^2\text{T}^0]} = [\text{ML}^{-1}\text{T}^{-2}]$$

So, the correct option is (b).

21. (d) Given speed of body (u) = 10 m/s
and distance travelled (s) = + 100 m

From the equation of motion

$$v^2 - u^2 = 2as$$

Given, $v = 0, a = ?$

$$- (10)^2 = 2a(100\text{m})$$

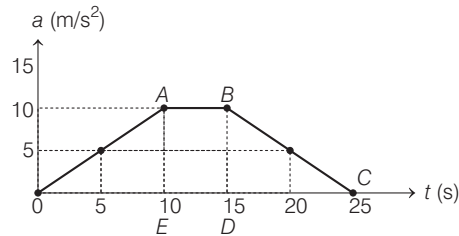
$$\Rightarrow a = -\frac{100}{2 \times 100} = -0.5\text{m/s}^2$$

So acceleration is negative with magnitude of 0.5 m/s^2

22. (e) As we know, accuracy refers to the closeness of a measured value to a standard or true value.

So, a accurate measurement is the closeness of measured value (mean of measured values) to true value.

23. (b) As, we know that, area of acceleration-time ($a-t$) graph gives the velocity. A plot of variation of acceleration with time is given below



The velocity at time $t = 15 \text{ s}$

$$v_{15} = \text{Area of } (\Delta OAE + ABDE) = \frac{1}{2} \times 10 \times 10 + 10 \times (15 - 10) = 100 \text{ m/s}$$

Similarly, velocity at time $t = 25 \text{ s}$

$$v_{25} = \text{Area of } (\Delta OAE + ABDE + \Delta BCD) = \frac{1}{2} \times 10 \times 10 + 10 \times (15 - 10) + \frac{1}{2} \times 10 \times (25 - 15) = 150 \text{ m/s}$$

24. (d) Given, $u = 5 \text{ m/s}, a = 1 \text{ m/s}^2$
and mass = 1 kg.

So, velocity after 5 s is given as

$$v = u + at \text{ (Equation of motion)}$$

$$v = 5 + 1 \times 5$$

$$\Rightarrow v = 10 \text{ m/s}$$

Kinetic energy of object

$$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 1 \times (10)^2 = 50 \text{ J}$$

25. (b) The velocity of a object is given by equation

$$v(t) = v_0 - 5t + 5t^2$$

Acceleration

$$a = \frac{dv}{dt} = \frac{d}{dt}(v_0 - 5t + 5t^2) = -5 + 10t$$

at $t = 0$ the acceleration of object

$$a = -5 + 10(0) = -5 \text{ ms}^{-2}$$

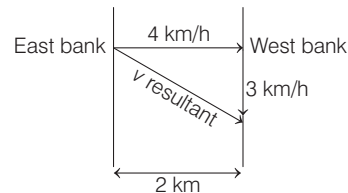
So, at time $t = 0$, there is deceleration of object.

at $t = 1 \text{ s}, v = v_0 - 5 + 5 = v_0 \text{ ms}^{-1}$

and $a = -5 + 10 = +5 \text{ ms}^{-2}$

So, at $t = 0$, there is non zero and positive value of velocity and acceleration.

26. (d) In figure, speed of boat $v_0 = 4 \text{ km/h}$, speed of river $v_r = 3 \text{ km/h}$ and width of river = 2 km.



The magnitude of the resultant velocity is

$$v_{\text{res}} = \sqrt{v_b^2 + v_r^2} = \sqrt{3^2 + 4^2}$$

$$\Rightarrow v_{\text{res}} = 5 \text{ km/h}$$

Since, horizontal component (speed of boat) remain constant, so time taken in travelling 2 km distance is

$$t = \frac{2}{4} = 0.5 \text{ h}$$

In 0.5 h, distance travelled by object with resultant velocity

$$D = v_{\text{res}} \times t = 5 \times 0.5 = 2.5 \text{ km}$$

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27. (a) Given, rope length = 1 m and frequency = 10 revolution/second
Here, rope length work as radius of this circular motion.

$$\therefore \text{Centripetal acceleration } (a_c) = \frac{v^2}{r}$$

$$\because v = \omega r$$

$$\Rightarrow a_c = \frac{\omega^2 r^2}{r} = \omega^2 r$$

Now putting the values

$$a_c = (2\pi \cdot 10)^2 \times 1 \quad (\because \omega = 2\pi f)$$

$$\Rightarrow a_c = 3947 \approx 4000 \text{ m/s}^2$$

28. (b) Given, the electric part of electromagnetic wave

$$\mathbf{E} = 5 \sin\left(\frac{2\pi}{3} Z - \omega t\right) \hat{\mathbf{y}} \text{ V/m}$$

from given equation signifies that the EM wave is moving in Z-axis, ($\hat{\mathbf{z}}$)

General equation of electric field

$$\mathbf{E} = E_0 \sin(kz - \omega t),$$

we get, $k = \frac{2\pi}{3}$

$$\therefore \text{Wave vector} = \hat{\mathbf{k}} = \frac{2\pi}{3} \mathbf{z}$$

Wavelength of EM wave

$$\because k = \frac{2\pi}{\lambda} = \frac{2\pi}{3} \Rightarrow \lambda = 3\text{m}$$

Frequency of EM wave

$$f = \frac{2\pi}{\omega} \text{ Hz}$$

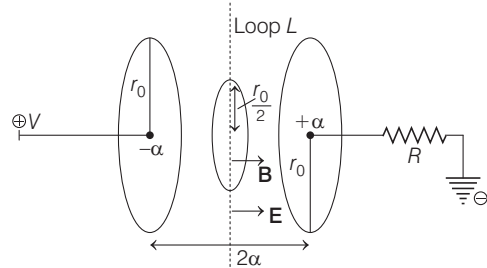
Expression of magnetic field part

$$= B_0 \sin(kz - \omega t) \hat{\mathbf{x}} t$$

$$\Rightarrow \mathbf{B} = \frac{C}{5} \sin\left(\frac{2\pi}{3} Z - \omega t\right) \hat{\mathbf{x}} t \quad (\because B_0 E_0 = C)$$

29. (c) A 100 W electric bulb is a device which produces EM radiations waves in visible region. These radiations carries energy and momentum. Also, the intensity of these radiations is dependent on the distance from the source.
So, option (c) is correct.

30. (e) A parallel plate capacitor of plate radius r_0 located at position $\pm a$ is shown in figure below



As we know the charge on capacitor at time t

$$q(t) = CV (1 - e^{-t/RC})$$

Flux through the circular loop L

$$\phi = EA$$

$$= \frac{V'}{2\alpha} \left(\pi \frac{r_0^2}{4} \right) = \frac{\pi r_0^2 V'}{8 \alpha}$$

So, the flux depend the area of circular loop. Both \mathbf{B} and \mathbf{E} are in same direction, where magnetic field is directed along the loop L .

31. (e) Given, frequency of EM wave, $\nu = \frac{1}{6.63} \times 10^{16} \text{ Hz}$

and power emitted $P = 10^{-2} \text{ W}$.

Energy of a photon $E = h\nu$

$$E = 6.63 \times 10^{-34} \times \frac{10^{16}}{6.63} = 10^{-18} \text{ J}$$

So, number of photons per second = $\frac{\text{Power}}{E}$

$$= \frac{10^{-2}}{10^{-18}} = 10^{16}$$

32. (b) Given, work function are as,

$$W_{Na} = 2.75\text{eV},$$

$$W_{Cu} = 4.65\text{eV}$$

and

$$W_{Au} = 5.1 \text{ eV}$$

The frequency range of visible light $4 \times 10^{14} \text{ Hz}$ to $8 \times 10^{14} \text{ Hz}$, so the maximum energy of photon and minimum energy of photon in visible light.

$$E_{\text{max}} = \frac{6.63 \times 10^{-34} \times 8 \times 10^{14}}{1.6 \times 10^{-19}} \quad (\because E = h\nu)$$

$$= 3.31 \text{ eV}$$

$$\text{Similarly, } E_{\min} = \frac{6.63 \times 10^{-34} \times 4 \times 10^{14}}{1.6 \times 10^{-19}}$$

$$= 1.65 \text{ eV}$$

Now, comparing the work function of above mentioned metal with E_{\max} . We get only sodium device can give photoelectron.

Further sodium device can also work with photons of higher energy than 2.75 eV like x -rays, UV rays etc.

- 33. (e)** Given, object distance $u = -9$ cm, radius of curvature, $R = -12$ cm

As we know mirror formula

$$\frac{1}{v} + \frac{1}{u} = \frac{2}{R} \Rightarrow \frac{1}{v} - \frac{1}{9} = \frac{2}{-12}$$

$$\Rightarrow v = -18 \text{ cm}$$

Now, lateral magnification

$$m = -\frac{v}{u} = -\frac{(-18)}{(-9)} = -2$$

So, image is magnified, real and inverted.

- 34. (b)** Given, power of lens = + 2.5 D, $\mu_{\text{water}} = 1.3$ and $\mu_{\text{lens}} = 1.5$

Lens maker's formula for equiconvex lens

$$\frac{1}{f} = (\mu_{\text{rel}} - 1) \frac{2}{R}$$

Since, power of lens, $P = \frac{1}{f}$

So, for air, lens medium

$$25 = \left(\frac{1.5}{1} - 1 \right) \frac{2}{R} \quad (\because \mu_{\text{air}} = 1)$$

$$\Rightarrow 25 = \frac{0.5 \times 2}{R}$$

$$\Rightarrow R = \frac{1}{25} \text{ m}$$

(where, R = radius of curvature)

New focal length, when lens in water

$$\frac{1}{f'} = \left(\frac{\mu_{\text{lens}}}{\mu_{\text{water}}} - 1 \right) \frac{2}{R}$$

$$\Rightarrow \frac{1}{f'} = \left(\frac{1.5}{1.3} - 1 \right) 2 \times 25$$

$$\Rightarrow f' = \frac{1}{0.15 \times 2 \times 25} = 1.333 \text{ m} = 1333 \text{ cm}$$

So, near by option is (b).

- 35. (a) Key idea** Angular position of n th minima in single slit diffraction by a monochromatic source is given by

$$\alpha \sin \theta_n = n\lambda$$

$$(n = 1, 2, 3, \dots)$$

Where, λ = wavelength and α = slit width

$$\text{As we know, } \sin \theta_n = \frac{n\lambda}{\alpha}$$

So, for first minima i.e., $n = 1$

$$\Rightarrow \sin \theta = \frac{\lambda}{\alpha}$$

- 36. (*)** Given, $\lambda = 60$ nm, $\Delta x_1 = 150$ nm and $\Delta x_2 = 200$

If the path difference is 150 nm then intensity

$$I_1 = 4 I_0 \cos^2 \frac{\phi}{2}$$

$$\text{where, } \phi = \frac{\Delta x}{\lambda} 2\pi = \frac{150}{60} \times 2\pi = 5\pi$$

$$\Rightarrow I_1 = 4 I_0 \cos^2 \left(\frac{5\pi}{2} \right)$$

$$= 4 I_0 \cos^2 \left(2\pi + \frac{\pi}{2} \right)$$

$$\Rightarrow I_1 = 0$$

Similarly, if path difference is 200 nm then intensity.

$$I_2 = 4 I_0 \cos^2 \frac{\phi}{2}$$

$$\text{where, } \phi = \frac{200}{60} \times 2\pi = \frac{20}{3} \pi$$

$$I_2 = 4 I_0 \cos^2 \left(\frac{20}{3} \pi \right) = I_0$$

So, $I_1 = 0$ and $I_2 = I_0$

\therefore No option given is correct

- 37. (a)** As we know, when partially reflected and refracted rays makes 90° angle then both get polarised, i.e.

$$i_p = \tan^{-1}(\mu) \quad (\text{Brewster's law})$$

$$\Rightarrow i_p = \tan^{-1} \left(\frac{\mu_{\text{water}}}{\mu_{\text{air}}} \right)$$

where, i_p = Brewster's angle.

$$\Rightarrow i_p = \tan^{-1} \left(\frac{1.33}{1} \right)$$

$$i_p = \tan^{-1}(1.33)$$

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- 38. (b)** The relation of the distance covered by a transmitting antenna is given by

$$D = \sqrt{2hR}$$

where, h = height of antenna
and R = radius of earth.

Since, the area covered is circular in shape which has antenna located at centre.

\therefore Total surface area covered by the transmitter

$$\text{Area} = \pi D^2 = 2\pi hR$$

So, the service area covered by antenna is depend on the height of antenna and radius of earth.

- 39. (b)** Given, carrier wave frequency $f_c = 200$ kHz and message signal frequency $f_m = 5$ kHz.
In amplitude modulation the lower and upper side frequencies are given as,

$$f_{\max} = f_c + f_m$$

and $f_{\min} = f_c - f_m$

So, by putting the values, we get

$$f_{\max} = 200 + 5 = 205 \text{ kHz}$$

and $f_{\min} = 200 - 5 = 195 \text{ kHz}$

- 40. (d)** Whenever a message signal is transmitted over a large distance, then it has the tendency to lose some of the information. However, in order to prevent this, carrier signals are being added to the message signal using antennas which is known as modulation.

Thus, this process of modulation is necessary to radiate the signal to a large distance using antennas.

- 41. (e)** Light emitting diode (LED) is a heavily doped p - n junction diode.

It emits spontaneous radiation, under forward bias.

- 42. (b)** In the context of p - n junction

- (i) The barrier potential decreases under forward bias, since both potentials are in opposite direction.
- (ii) A ideal p - n diode work as zero resistance conductor under forward bias
- (iii) The barrier potential increase in reverse bias, due to the same polarity of potentials of barrier potential and biasing battery.
- (iv) Width of depletion region depends on the doping level in p -type and n -type.

- 43. (d)** As we know moment of inertia of a hollow sphere with external radius a and internal radius b is

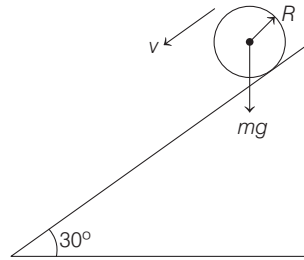
$$I = \frac{2}{5} M \left(\frac{a^5 - b^5}{a^3 - b^3} \right)$$

Radius of gyration, $K = \sqrt{\frac{I}{M}}$

where, M = mass of sphere.

so, $K = \frac{\sqrt{\frac{2}{5} M \left(\frac{a^5 - b^5}{a^3 - b^3} \right)}}{M} \Rightarrow K = \sqrt{\frac{2}{5} \left(\frac{a^5 - b^5}{a^3 - b^3} \right)}$

- 44. (b)** Given, ball of mass $M = 1$ kg,
radius of ball $R = 0.5$ m, angle of inclination $\theta = 30^\circ$
A ball placed on a inclined plane is given in figure.



Acceleration of ball

$$a = \frac{g \sin \theta}{1 + \frac{I}{MR^2}}$$

where, I = moment of inertia of ball

$$\Rightarrow a = \frac{10 \times \sin 30^\circ}{1 + \frac{2 MR^2}{5 MR^2}} = \frac{5 \times 5}{7}$$

Torque on the ball $\tau = I \alpha = I \frac{a}{R}$

$$\begin{aligned} \Rightarrow \tau &= \frac{2}{5} MR^2 \left[\frac{5 \times 5}{7} \right] \frac{1}{R} \\ &= \frac{2}{5} \times 1 \times 0.5 \times \frac{5 \times 5}{7} \\ &= \frac{5}{7} = 0.71 \text{ N-m} \end{aligned}$$

- 45. (a)** As we know in the absence of external torque, angular momentum is constant so,

$$\mathbf{L}_{\text{initial}} = \mathbf{L}_{\text{final}}$$

$$m_1 (\mathbf{r}_1 \times \mathbf{v}_1) = m_2 (\mathbf{r}_2 \times \mathbf{v}_2)$$

since, $v = r\omega$

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$$\Rightarrow m_1 \omega_1 r_1^2 = m_2 \omega_2 r_2^2$$

For earth mass remain constant (i.e., $m_1 = m_2$)

$$\Rightarrow \omega_1 r_1^2 = \omega_2 r_2^2 \quad \left(\because \omega = \frac{2\pi}{T} \right)$$

$$\Rightarrow \frac{r_1^2}{T_1} = \frac{r_2^2}{T_2}$$

Given, $T_1 = 24 \text{ h}, r_1 = R_1$

and $r_2 = \frac{R_1}{2} \Rightarrow \frac{T_2}{24} = \frac{R_1^2}{R_1^2 \cdot 4} \Rightarrow T_2 = 6 \text{ h}$

- 46. (b)** As we know, moment of inertia of hollow sphere $I_H = \frac{2}{3}MR^2$ and moment of inertia of solid sphere $I_S = \frac{2}{5}MR^2$

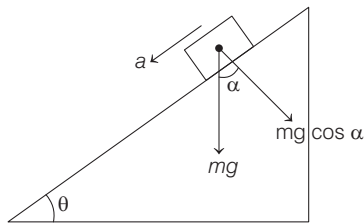
$$\therefore I_H > I_S$$

Since, torque = $I\alpha$

$$\Rightarrow \text{Torque } (\tau_H) > \text{Torque } (\tau_S)$$

- 47. (c) Key idea** Acceleration of block sliding down a rough inclined plane as shown in the figure, is given by

$$a = g(\sin \theta - \mu \cos \theta)$$



Given, mass of brick $m = 2 \text{ kg}$,
height of plane $H = 5 \text{ m}$, $\theta = 30^\circ$ and
coefficient of friction $\mu = \frac{1}{2\sqrt{3}}$.

$$\therefore a = g(\sin 30^\circ - \frac{1}{2\sqrt{3}} \cos 30^\circ)$$

$$\Rightarrow a = 10 \left[\frac{1}{2} - \frac{1}{4} \right] = 2.5 \text{ m/s}^2$$

Length of inclined plane

$$x = H \sin \theta = 5 \times \sin 30^\circ = 10 \text{ m}$$

From 3rd equation of motion

$$v^2 - u^2 = 2as$$

$$\Rightarrow v = \sqrt{2as}$$

$$\Rightarrow v = \sqrt{2 \times 2.5 \times 10} = \sqrt{50} = 7.07$$

So, nearby correct option is (c).

- 48. (d) Key idea** Escape velocity is calculated by using the law of conservation of energy

$$KE_s + U_s = KE_\infty + U_\infty$$

As, we know escape velocity of a planet of mass M and radius R is

$$v_e = \sqrt{\frac{2GM}{R}}$$

Given, $M = 8 \times 10^{24} \text{ kg}, R = 6 \times 10^6 \text{ m}$

and $G = 6 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$

$$v_e = \sqrt{\frac{2 \times 6 \times 10^{-11} \times 8 \times 10^{24}}{6 \times 10^6}} = \sqrt{160} \text{ km/s} = 12.6 \text{ km/s}$$

- 49. (c) Key Idea** Kepler's law of periods states that the square of time period of revolution of a planet is proportional to cube of the semi-major axis of the ellipse traced out by the planet i.e.

$$T^2 \propto R^3$$

Given, semi-major axis of planets, $R_A = 1 \text{ AU}$ and $R_B = 5 \text{ AU}$, and period of revolution of planet A ,

$$T_A = 1 \text{ yr.}$$

$$\text{As, } \left(\frac{T_A}{T_B} \right)^2 = \left(\frac{R_A}{R_B} \right)^3 \Rightarrow \left(\frac{1}{T_B} \right)^2 = \left(\frac{1}{5} \right)^3$$

$$\Rightarrow T_B = \sqrt{125} = 11.18 \text{ yr.}$$

So, the near by option is (c).

- 50. (b)** Given, half life of ${}_{43}\text{Tc}^{99}$, $T_{1/2} = 6 \text{ h}$ and initial mass of element $m_0 = 12 \text{ mg}$.

The remaining mass of radioactive element after

$$24 \text{ h is } m = m_0 \frac{1}{2^{\left(\frac{T}{T_{1/2}}\right)}} = 12 \times \frac{1}{2^{\left(\frac{24}{6}\right)}} = \frac{12}{2^4} = \frac{12}{16}$$

$$\Rightarrow m = 0.75 \text{ mg}$$

- 51. (a)** For atoms, heavy nuclei are the one that usually has more number of neutrons than protons.

However, light nuclei are the one that has equal number of protons and neutrons.

- 52. (c)** Nuclear force is a short range force which is of the order of 10^{-15} m .

These are the forces that holds the nucleons together inside the nucleus of an atom. It is charge independent, non-central and attractive in nature.

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53. (d) Two or more nuclides are isotones, if they have the same neutron number. Hence,

(a) ${}_8\text{O}^{16} = 8 \text{ protons} + 8 \text{ neutrons}$

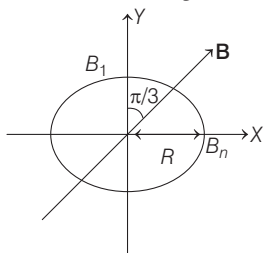
(b) ${}_7\text{N}^{15} = 7 \text{ protons} + 8 \text{ neutrons}$

(c) ${}_6\text{C}^{14} = 6 \text{ protons} + 8 \text{ neutrons}$

(d) ${}_{13}\text{Al}^{27} = 13 \text{ protons} + 14 \text{ neutrons}$

(e) ${}_9\text{F}^{17} = 9 \text{ protons} + 8 \text{ neutrons}$

54. (c) A magnetic field of 1 T applied $\frac{\pi}{3}$ to the vertical direction is shown in figure below. Induced Emf in circular ring.



$$\varepsilon = \frac{\Delta \phi}{\Delta t} = \frac{BA \cos \theta}{t}$$

$$\Rightarrow \varepsilon = \frac{1 \times \pi (5 \times 10^{-2})^2 \times \cos \frac{\pi}{3}}{1}$$

$$\Rightarrow \varepsilon = 1.25 \pi \text{ mV}$$

55. (b) As we know, induced Emf $= L \times \frac{\Delta I}{\Delta t}$

$$\Rightarrow [L] = \frac{[\text{Voltage}] [\text{T}]}{[\text{Current}]} = \frac{[\text{ML}^2\text{T}^{-3}\text{A}^{-1}] [\text{T}]}{[\text{A}]}$$

$$= [\text{M L}^2 \text{T}^{-2} \text{A}^{-2}]$$

\therefore Dimension of mutual inductance is

$$[\text{M L}^2 \text{T}^{-2} \text{A}^{-2}]$$

56. (e) Given, pure inductor of inductance $L = 0.1 \text{ H}$
AC source voltage $V = 220 \text{ V}$ and angular frequency,
 $f = 300 \text{ Hz}$.

As, impedance, $Z = \omega L$

$$= 2\pi \times 300 \times 0.1 = 30\Omega \quad (\because \omega = 2\pi f)$$

So, the rms current $I_{\text{rms}} = \frac{V_{\text{rms}}}{Z}$

$$= \frac{220}{30 \times 2\pi} = \frac{11}{3\pi} \text{ A}$$

57. (b) **Key Idea** In a series LCR circuit, the impedance is minimum at resonance and it is given as

$$Z = R$$

where, $R =$ resistance in circuit.

As at resonance capacitive reactance is equal to inductive reactance,

$$\text{So,} \quad \omega L = \frac{1}{\omega C}$$

$$\Rightarrow \omega^2 = \frac{1}{LC} \Rightarrow \omega = \frac{1}{\sqrt{LC}}$$

Where, $\omega =$ angular frequency of the source.

58. (c) We know that efficiency of Carnot engine is given by relation

$$\eta = \frac{T_1 - T_2}{T_1}$$

Hence in

$$\begin{aligned} \text{Case I} \quad \eta_{\text{I}} &= \frac{(T_1 + \Delta T) - T_2}{T_1 + \Delta T} \\ &= \frac{(T_1 - T_2) + \Delta T}{T_1 + \Delta T} \end{aligned}$$

$$\text{Case II} \quad \eta_{\text{II}} = \frac{T_1 - (T_2 + \Delta T)}{T_1}$$

$$\begin{aligned} \text{Case III} \quad \eta_{\text{III}} &= \frac{T_1 - (T_2 - \Delta T)}{T_1} \\ &= \frac{(T_1 - T_2) + \Delta T}{T_1} \end{aligned}$$

So, from above efficiencies we can conclude the order as

$$\eta_{\text{III}} > \eta_{\text{II}} > \eta_{\text{I}}$$

59. (d) Let there is elastic collision and both act like two ideal gases then.

$$v_{\text{avg}} = \sqrt{\frac{8kT}{\pi m}}$$

where temperature is constant, so $v \propto \sqrt{\frac{1}{m}}$

$$\text{Hence the ratio} \quad \frac{v_{\text{smoke}}}{v_{\text{air}}} = \sqrt{\frac{m_{\text{air}}}{m_{\text{smoke}}}}$$

Given, $m_{\text{smoke}} = 10^{12} m_{\text{air}}$

$$\Rightarrow \frac{v_{\text{smoke}}}{v_{\text{air}}} = \sqrt{\frac{m_{\text{air}}}{10^{12} m_{\text{air}}}} = 10^{-6}$$

So, v_{smoke} is 10^{-6} times the average speed of an air molecule.

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60. (b) Given, length of bar = 1 m and coefficient of linear expansion $\alpha = 0.00001^\circ\text{C}^{-1}$

So, expansion of 1 m length

$$\Delta L = l \alpha = 1 \times 0.00001^\circ\text{C}^{-1}$$

$$\Delta L = 10^{-5}^\circ\text{C}^{-1}$$

Since, the accuracy = 1 ppm = $\pm 10^{-6}$

Hence, the maximum allowed temperature variation

$$\pm \Delta T = \frac{10^{-6}}{10^{-5}^\circ\text{C}^{-1}} = \pm 0.1^\circ\text{C}$$

61. (b) As, we know the standard temperature and pressure are 273 K and 1 atm, respectively.

So, from ideal gas equation

$$pV = nRT$$

$$\text{Ratio } \frac{p_1 V_1}{p_2 V_2} = \frac{T_1}{T_2}$$

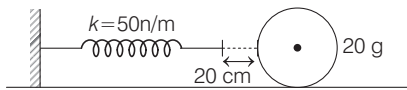
Given, $p_1 = 1 \text{ atm}$, $p_2 = 50 \text{ atm}$, $V_1 = V$

$$V_2 = \frac{V}{50} \text{ and } T_1 = 273 \text{ K}$$

$$\Rightarrow \frac{1 \times V}{50 \times \frac{V}{20}} = \frac{273}{T_2}$$

$$\Rightarrow T_2 = 682 \text{ K}$$

62. (a) A spring of spring constant 50 N/m is attached to a rigid wall. A 20 g ball is placed on the horizontal table as shown in figure



If spring is compressed then potential energy

$$U = \frac{1}{2} kx^2$$

When spring hit the ball, it transfer all its potential energy to kinetic energy of ball

$$\frac{1}{2} kx^2 = \text{KE}_{\text{ball}}$$

$$\Rightarrow \frac{1}{2} kx^2 = \frac{1}{2} mv^2$$

$$\Rightarrow v = \sqrt{\frac{kx^2}{m}}$$

Given, $x = 20 \text{ cm}$, $m = 20 \text{ g}$ and $v = 50 \text{ N/m}$

$$\Rightarrow v = \sqrt{\frac{50 \times (20 \times 10^{-2})^2}{20 \times 10^{-3}}} = \sqrt{25} = 5 \text{ m/s}$$

63. (e) Buoyancy force on a body is given as

$$F_b = \rho Vg$$

where, ρ = fluid density, V = Volume of liquid, which displaced by body.

$$\therefore g = 9.806 \text{ m/s}^2$$

So, for aluminium piece

$$F_A = \rho_{\text{liq}} (0.5 \text{ m}^3) 9.8 \quad \dots(\text{i})$$

Similarly, for lead

$$F_L = \rho_{\text{liq}} (0.5 \text{ m}^3) 9.8 \quad \dots(\text{ii})$$

Hence, from Eqs. (i) and (ii), we get

$$F_A = F_L$$

64. (c) The excess pressure inside a spherical drop

$$p_b - p_{bo} = \Delta p_b = \frac{2T}{r_b} \quad \dots(\text{i})$$

Similarly, the excess pressure inside a spherical soap bubble.

$$(p_s - p_{so}) = \Delta p_s = \frac{4T}{r_s} \quad \dots(\text{ii})$$

From Eqs. (i) and (ii) we get

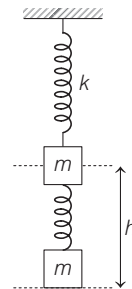
$$\frac{\Delta p_b}{\Delta p_s} = \frac{r_s}{2r_b}$$

Given, $\Delta p_s = 100 \text{ N/m}^2$

$$\text{and } r_b = \frac{r_s}{2}$$

$$\text{So, } \Delta p_b = \frac{100}{2} \times \frac{r_s}{\frac{r_s}{2}} = 100 \text{ N/m}^2$$

65. (d) A mass suspended by a massless spring is given in figure.



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Mass m is displaced by height h , then potential energy of spring and change in gravitational potential energy due to height

$$U_{\text{spring}} = \frac{1}{2}kx^2 = \frac{1}{2}kh^2$$

and $U_{\text{gravitation}} = mgh$

If the system is released, then both the energies converted into kinetic energy.

$$\text{Hence, KE} = \frac{1}{2}kh^2 + mgh$$

So, kinetic energy of mass is a linear combination of terms $\left(\frac{1}{2}kh^2 \text{ and } mgh\right)$ involving h and h^2 .

66. (a) As we know in damped harmonic oscillation the amplitude of oscillation dies away with time. Hence for steady state, continuous external periodic force (driving frequency) is required or in other word a continuous supply of positive power is required.

67. (c) Quality factor It is defined as the 2π times the ratio of the energy stored in the system to the energy lost per period

$$\text{i.e., } Q = 2\pi \frac{\text{energy stored in system}}{\text{energy loss per period}}$$

68. (c) If a ball of mass m and speed v_0 is thrown upward, then speed at height h is

$$v = v_0 \sin \theta - 2gh$$

So, the speed depends on the direction of projection i.e. $\sin \theta$, if v_0 , g and h are constant.

69. (d) Given, $u = 5 \text{ m/s}$, $a = + 2 \text{ ms}^{-2}$ and $t = 6 \text{ s}$

Equation of motion

$$S = ut + \frac{1}{2}at^2$$

So, by putting the values, we get

$$\begin{aligned} S &= 5 \times 6 + \frac{1}{2} \times 2 \times 6^2 \\ &= 30 + 36 = 66 \text{ m} \end{aligned}$$

70. (b) Given, initial velocity of vehicle $u = 36 \text{ km/h}$

$$= 10 \text{ m/s}$$

Stopping distance of vehicle $s = 5 \text{ m}$ and

mass of vehicle $m = 2000 \text{ kg}$

So, from equation of motion

$$v^2 - u^2 = 2as$$

since, final velocity of vehicle $v = 0$ and acceleration of vehicle $= -a$ (acceleration)

$$\Rightarrow -u^2 = -2as$$

$$\Rightarrow a = \frac{u^2}{2s}$$

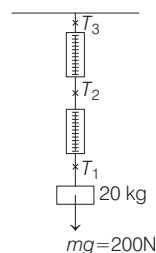
$$= \frac{10 \times 10}{2 \times 5} = 10 \text{ m/s}^2$$

The average force for braking

$$F = ma = 2000 \times 10 = 2 \times 10^4 \text{ N}$$

71. (e) A block of mass 20 kg is suspended through two spring balance as shown in figure.

Since, it is given that, spring balances has negligible mass.



So, $T_1 = 200 \text{ N}$

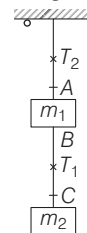
$$T_2 = 200 \text{ N}$$

and $T_3 = 200 \text{ N}$

i.e., tension in both suspended balances is same.

So each has reading of 20 kg .

72. (d) Two masses, m_1 and m_2 are hanging from a support as shown in figure.



The tension in string BC

$$T_1 = (\text{total mass hanging on string})g = m_2g$$

Similarly, the tension in string OA

$$T_2 = (\text{total mass hanging on string OA})g$$

$$T_2 = (m_1 + m_2)g$$

Hence, the tension in the upper, string is

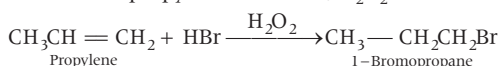
$$T = (m_1 + m_2)g$$

Chemistry

73. (a) Addition of HBr to unsymmetrical alkenes takes place contrary to the markovnikov's rule in presence of peroxide.

Propylene on treatment with HBr / H₂O₂ provides 1-bromopropane. In the presence of peroxide (H₂O₂), addition of HBr to unsymmetrical alkenes like propylene takes place contrary to the Markovnikov's rule. This happens only with HBr but not with HCl and HI.

Reaction of propylene with HBr / H₂O₂ is as follows



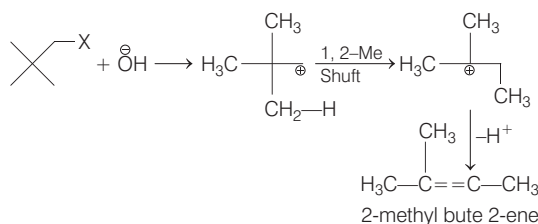
74. (a) Histamine is a potent vasodilator. It means that this chemical has a very powerful effect on vasodilation i.e., widening of blood vessels. It contracts the smooth muscles in the bronchi and guts and relaxes other muscles such as those in the walls of fine blood vessels.

75. (b) An invert sugar is laevorotatory. Sucrose is known as 'invert sugar'. After hydrolysis it gives dextrarotatory glucose and laevorotatory fructose. Since the laevorotation of fructose (− 92.4°) is more than dextrarotation of glucose (+ 52.5°), the mixture obtained is laevorotatory.

76. (a) The strongest base is NH₂[⊖]. It is a conjugate base of NH₃. OH[⊖] is a conjugate base of H₂O and OEt[⊖] is a conjugate base of EtOH. Both H₂O and EtOH are stronger acid than NH₂. So OH[⊖] and OEt[⊖] are weaker bases than NH₂[⊖].

77. (d) E1 mechanism readily occur in 3° carbocation. Presence of higher alkyl groups in alkyl halide also favours E1 mechanism.

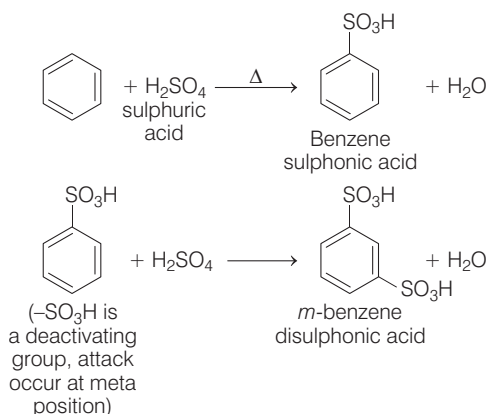
The neopentyl halide in ethanol yields alkenes by E1 mechanism due to steric factor which prevents E2 mechanism. In E1 mechanism, Heterolytic dissociation of alkyl halide followed by abstraction of proton by base from a C adjacent to the positively charged C atom (β-C atom), takes place as follows:



78. (e) Arylbromides are not good candidates for Gabriel. Phthalimide synthesis because arylbromides do not undergo nucleophilic substitution reaction with the anion formed by phthalimide.

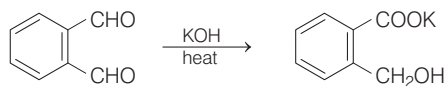
Nucleophilic substitution reactions in aryl halides occur only under drastic conditions. These conditions are not provided in Gabriel-phthalimide synthesis.

79. (d) Sulfonation of benzene with excess sulfuric acid provides *m*-benzenedisulfonic acid. Initially, the replacement of a hydrogen atom from benzene ring by a sulphonic acid group occur, that results in the formation of benzenesulphonic acid. As excess of sulphonic acid is present in mixture, the reaction continues and form *m*-benzene disulfonic acid.



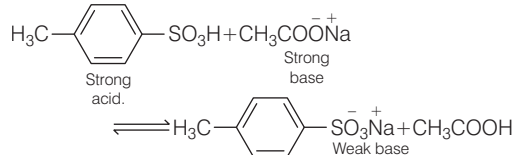
80. (c) **Key Idea** Cannizzaro reaction takes place in those aldehydes that do not have an α-hydrogen. It proceed via disproportionation reaction.

The given reaction is named as Cannizzaro reaction. In this reaction, aldehydes that do not have an α-hydrogen atom undergoes self oxidation and reduction (disproportionation) reaction on heating with concentrated alkali. In this reaction, one —CHO group of the aldehyde is reduced to alcohol while another is oxidised to carboxylic acid salt.



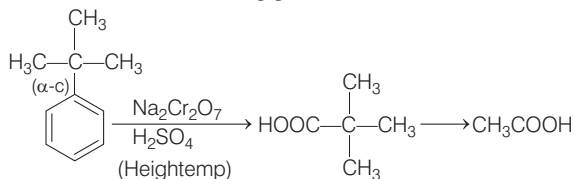
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81. (c) A spontaneous neutralisation will occur between strong acid and strong base as



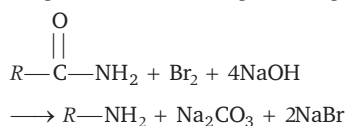
82. (d) The compound which does not lead to benzoic acid by oxidation with KMnO_4 is *t*-butylbenzene.

In this compound, the side chain has no C—H bond at α -carbon (with respect to benzene nucleus) Hence, benzene ring get cleaved.



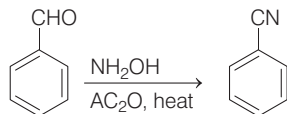
Toluene, benzyl alcohol, *n*-butyl benzene and styrene all contain one benzylic C—H bond and on oxidation forms benzoic acid.

83. (b) In Hofmann rearrangement of primary amides having optically active group with *S*-configuration, the product amine has *S*-configuration. If the reactant '*R*' is chiral (asymmetric), then it migrates with unchanged configuration.

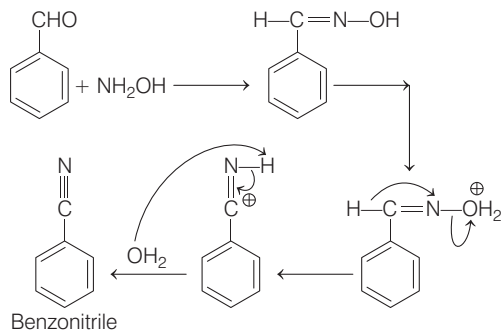


Note Here, C-atom is optically optive group with *S*-configuration.

84. (d) Benzonitrile can be prepared from benzaldehyde on treatment with NH_2OH followed by dehydration with acetic anhydride. This reaction occur *via* Beckmann rearrangement.

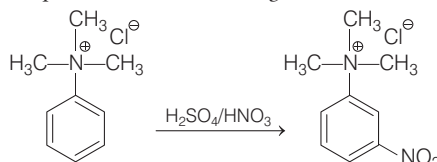


For benzonitrile formation, the key step is a hydride shift followed by deprotonation of nitrogen that ultimately gives benzonitrile



85. (b) **Key Idea :** Deactivating groups attached on benzene ring are meta-directing groups.

The product formed in the given reaction is



In the above reaction, '*N*' bears a positive charge that decreases the electron density due to its strong $-I$ effect and hence is called a deactivating group. The overall electron density on the benzene ring decreases (inspite of three $-\text{CH}_3$ groups) thus, the electrophilic substitution becomes difficult. The electron density on *o*- and *p*-position is comparatively lesser than that at *m*-position. So, electrophile attacks at *m*-position i.e. substitution occur at *m*-position.

86. (c) **Key Idea :** Bond order of NO^+ can be calculated by following formula.

$$\text{Bond order} = \frac{N_b - N_a}{2}$$

The increasing order of energies of various molecular orbitals for NO^+ is given below

$$\text{NO}^+ (14) = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, (\pi 2p_x + \pi 2p_y)$$

$$\sigma 2p_z^2, (\pi^* 2p_x^0 = \pi^* 2p_y^0), \sigma^* 2p_z^0.$$

The bond order can be calculated as

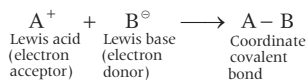
$$\begin{aligned} \text{Bond order} &= \frac{N_b - N_a}{2} \\ &= \frac{10 - 4}{2} = \frac{6}{2} = 3 \end{aligned}$$

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87. (b) Key Idea : Boiling point increases with the increase in attractive forces between the molecules in liquid state.

- (a) NH_3 → In spite of small size of N-atoms. It has strong H-bonds due to high electronegativity of nitrogen. Thus has high boiling point.
- (b) PH_3 → Due to the small size of P-atoms, it has least van der Waals force and will not form intermolecular H-bonds.
- (c) AsH_3 → It has larger As-atoms which provides more van der Waals force.
- (d) $\text{BF}_3 \cdot \text{PF}_3$ → It has also larger molecular size than that of PH_3 and AsH_3 , thus has more van der Waals force.
- (e) BiH_3 → It has larger size than that of PH_3 , thus offers more van der Waals force.
Thus PH_3 has least boiling point.

88. (b) BF_3 , SiF_4 and PF_5 shows Lewis acid behaviour as these species readily accept electron pair. In Lewis concept, many acids do not have proton. These species are electron deficient that readily react with base by accepting its lone-pair of electron

General reaction

89. (d) The carbon atoms in calcium carbide are held together by one sigma and two π -bonds.

The structural representation of CaC_2 is

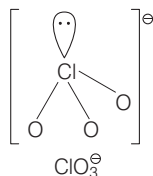


This can be produced industrially from a mixture of lime and coke in an electric arc furnace at $2,200^\circ\text{C}$.

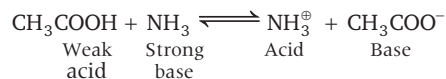
90. (c) According to VSEPR theory, the shape of a molecule depends upon the number of valence shell electron pairs around the central atom. Pairs of electrons in the valence shell repel each other. The order of their repulsions is

$$lp - lp > lp - bp > bp - bp.$$

The geometry of ClO_3^- is tetrahedron but due to the presence of $lp - bp$ repulsion, the structure changes to pyramidal shape.



91. (b) Acetic acid in liquid ammonia behaves as stronger acid than that in water, ammonia acts as strong base than H_2O i.e. it has strong tendency to take up protons. Hence, even weak acids ionize to a considerable extent and behave as strong acids. For e.g.

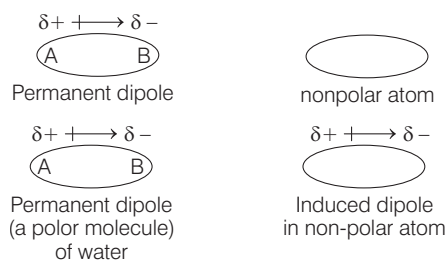


92. (e) Key Idea N does not have d-orbitals but other group 15 elements have d-orbitals.

All the given compounds i.e., BiF_5 , PF_5 , AsF_5 and SbF_5 exist. Only nitrogen is not able to form pentahalides because the second shell contains a maximum of eight electrons i.e., four bonds. The subsequent elements have suitable d-orbitals and form s-pentahalides.

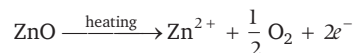
93. (d) Rare gases are sparingly soluble in water because of dipole-induced dipole interaction. Water (a polar molecule) has permanent dipole that induces a dipole on the electrically neutral atom by deforming its electron cloud.

Thus, an induced dipole is developed in other atom.



94. (b) An example of a non-stoichiometric oxide when heated is ZnO . Zinc oxide is white in colour at room temperature.

On heating, it loses oxygen and turns yellow.



Now, there is excess of zinc in the crystal and its formula becomes Zn_{1+x}O . The excess Zn^{2+} ions move to interstitial sites and the electron to the neighbouring interstitial sites.

95. (b) The donor atoms in EDTA are two nitrogen (N) and four oxygen (O). It is a hexadentate ligand. It can bind through two nitrogen and four oxygen atoms to a central metal ion.

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104. (a) Metal oxide = $M_{0.98}O$

If x ions of M are in +3 state then,

$$3x + (0.98 - x) \times 2 = 2$$

$$x = 0.04$$

So, the percentage of metal in +3 state would be

$$\frac{0.04}{0.98} \times 100 = 4.08\%$$

105. (a) Density of a unit cell $\propto \frac{1}{a^3}$ ($\because z = 1$)

$$\text{for structure I, } d_1 \propto \frac{1}{(2\sqrt{2}r)^3} \quad \dots \text{ (i)}$$

$$\text{for structure II } d_2 \propto \frac{1}{\left(\frac{4r}{\sqrt{3}}\right)^3} \quad \dots \text{ (ii)}$$

Dividing Eqs. (i) and (ii)

$$\begin{aligned} \frac{d_1}{d_2} &= \frac{\frac{1}{(2\sqrt{2})^3 r^3}}{\frac{1}{\left(\frac{4}{\sqrt{3}}\right)^3 \times r^3}} \Rightarrow \frac{d_1}{d_2} = \frac{1}{16(\sqrt{2})} \times \frac{\sqrt{3} \times \sqrt{3} \times \sqrt{3}}{4} \\ &= \frac{3\sqrt{3}}{64\sqrt{2}} \\ \frac{d_1}{d_2} &\Rightarrow \frac{519}{90.5} \end{aligned}$$

$$d_1 = d_2 \times \frac{519}{90.5} \Rightarrow d_1 = 0.056 \times d_2$$

Final result concludes that density of structure I is higher than structure II.

Hence, statement I is correct.

106. (c) For water vapours, $d = 0.0006 \text{ g cc}^{-1}$

$$0.0006 = \frac{\text{Mass}}{\text{Volume}} = \frac{\text{Mass}}{1000}$$

$$\text{Mass} = 1000 \times 0.0006 = 0.6 \text{ g}$$

$$\text{Density of liquid water} = 1 \text{ g cc}^{-1}$$

Volume occupied by water

$$= \frac{\text{Mass}}{\text{density}} = \frac{0.6}{1} = 0.6 \text{ cc}$$

107. (c) rms velocity of H_2 and N_2 are related to each other as

$$\left[\sqrt{\frac{3RT}{M}} \right]_{(H_2)} = \sqrt{7} \left[\sqrt{\frac{3RT}{M}} \right]_{(N_2)}$$

$$\frac{T}{2}(H_2) = \frac{7T}{28}(N_2)$$

$$(\because M \text{ for } H_2 = 2 \text{ and } M \text{ for } N_2 = 28)$$

$$\text{or, } 28T(H_2) = 14T(N_2)$$

$$\text{or, } 2T(H) = T(N_2)$$

$$\therefore T_{(N_2)} > T_{(H_2)}$$

108. (b) Given, methanol = 20 mL

Water = 80 mL

density of methanol = 0.793 kg L^{-1} or 0.793 gmL^{-1}

density of solution = 0.964 kg L^{-1} or 0.964 gmL^{-1}

$$\text{As, density} = \frac{\text{mass}}{\text{volume}}$$

\therefore mass/weight of methanol

$$= 0.793 \text{ g mL}^{-1} \times 20 \text{ mL} = 15.86 \text{ g}$$

Similarly weight of solution

$$= 0.964 \text{ g mL}^{-1} \times 80 \text{ mL} = 96.4 \text{ g}$$

We know that,

$$\% \text{ by weight} = \frac{\text{weight of solute}}{\text{weight of solution}} \times 100$$

$$= \frac{15.86 \text{ g}}{96.4 \text{ g}} \times 100 = 16.45$$

109. (a) Given, K_H for O_2 dissolved in water

$$= 4.34 \times 10^4 \text{ atm}$$

$$P_{O_2} = 0.434 \text{ atm}$$

x (mole fraction of O_2 in solution) = ?

According to Henry's law,

$$P = K_H \times x$$

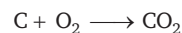
$$\frac{0.434}{4.34 \times 10^4} = x_{O_2}$$

$$1 \times 10^{-5} = x_{O_2}$$

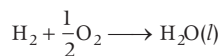
\therefore Mole fraction of O_2 in water = 1×10^{-5} .

110. (a) Given : $C + 2H_2 \longrightarrow CH_4$

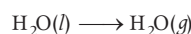
$$\Delta_f H^\circ = -76.2 \text{ kJ mol}^{-1} \quad \dots \text{ (i)}$$



$$\Delta_f H^\circ = -349.8 \text{ kJ mol}^{-1} \quad \dots \text{ (ii)}$$



$$\Delta_f H^\circ = -285.82 \text{ kJ mol}^{-1} \quad \dots \text{ (iii)}$$



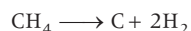
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$$\Delta_v H^\circ = 44 \text{ kJ mol}^{-1} \quad \dots \text{(iv)}$$

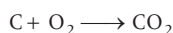
Oxidation of CH_4 into its gaseous products is given as



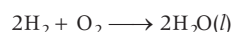
To get the required equation, rewrite the above equation.



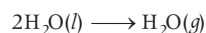
$$\Delta_f H^\circ = + 76.2 \text{ kJ mol}^{-1} \quad \dots \text{(i)}$$



$$\Delta_f H^\circ = - 394.8 \text{ kJ mol}^{-1} \quad \dots \text{(ii)}$$



$$\Delta_f H^\circ = 2 \times - 285.82 \text{ kJ mol}^{-1} \quad \dots \text{(iii)}$$



$$\Delta_v H^\circ = 2 \times 44 \text{ kJ mol}^{-1} \quad \dots \text{(iv)}$$

give $\text{CH}_4(g) + 2\text{O}_2(g) \longrightarrow \text{CO}_2 + 2\text{H}_2\text{O}(g)$

$$\Delta H^\circ = 76.2 - 394.8 - 2 \times 285.82 + 88$$

$$\Delta H = - 802.24$$

Thus, heat evolved when 22.4L (or 1 mole of CH_4) is oxidised into its gaseous products is 802.64 kJ.

111. (a) Given : $\Delta T_b = 0.36^\circ\text{C}$

$$M_A \text{ (weight of solvent)} = 100 \text{ g}$$

$$K_b = 257 \text{ k kg mol}^{-1}$$

Experimental molecular weight of acetic acid

$$= 117.8$$

$$\text{As, } i = \frac{\text{normal molar mass}}{\text{abnormal molar mass}}$$

$$\therefore i = \frac{60}{117.8} = 0.51$$

$$\text{Now, } \Delta T_b = iK_b \times m$$

$$0.36 = 0.51 \times 257 \times \frac{x / 60 \times 1000}{100 \times}$$

$$x = 1.65 \text{ g}$$

Weight % of acetic acid

$$= \frac{\text{weight of acetic acid}}{\text{weight of solution}} \times 100$$

$$= \frac{1.65}{101.65} \times 100 = 1.62$$

Also, dimerisation of acetic acid is given as,



$$\alpha \text{ (degree of association)} = \frac{i - 1}{\frac{1}{n} - 1} = \frac{0.51 - 1}{\frac{1}{2} - 1} = .98 \text{ or } 98\%$$

Thus, weight % and degree of association of acetic acid is 1.62 and 98% respectively.

112. (b) $\text{CO} + \text{Cl}_2 \rightleftharpoons \text{COCl}_2$

$$\text{Initial moles} \quad 2 \quad 4 \quad 0$$

$$\text{At equilibrium} \quad 2 - x \quad 4 - x \quad x$$

At equilibrium one mole of CO is present

Therefore, $2 - x = 1$ (given)

$$x = 1$$

On substituting the value of x , we get

$$1 \text{ mole of CO} = \frac{1}{10}; \text{ conc. of 1 mole of Cl}_2 = \frac{3}{10}$$

$$\text{conc. of 1 mole of COCl}_2 = \frac{1}{10}$$

Using these value, in equilibrium constant reaction.

$$K_c = \frac{[\text{COCl}_2]}{[\text{CO}][\text{Cl}_2]} = \frac{[1/10]}{\left[\frac{1}{10}\right]\left[\frac{3}{10}\right]} = \frac{10 \times 10}{10 \times 3} = 33$$

113. (e) The equilibrium constants for the reaction are



Equilibrium constant for (i) reaction is

$$K_1 = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} \quad \dots \text{(iii)}$$

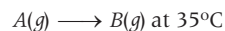
Equilibrium constant for (ii) reaction is

$$K_2 = \frac{[\text{NH}_3]^4}{[\text{N}_2]^2[\text{H}_2]^6} \quad \dots \text{(iv)}$$

Comparing (iii) and (v)

$$K_2 = K_1^2 \text{ or } K_1 = \sqrt{K_2}$$

114. (a) For a first order reaction,



The rate constant k is expressed as

$$K = \frac{2303}{t} \log \frac{C_0}{C} = \frac{2303}{10} \log \frac{25}{20}$$

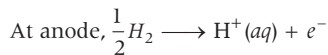
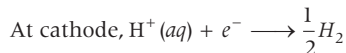
$$= \frac{2303}{10} \log \frac{5}{4} = \frac{2303}{10} \times 0.096$$

$$= 0.0221 \text{ min}^{-1} \approx 0.02231 \text{ min}^{-1}.$$

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115. (a) $\text{Pt}(s) | \text{H}_2(g), 1 \text{ bar} | \text{H}^+ (1 \text{ M}) || \text{H}^+ (0.1 \text{ M}) | \text{H}_2(g), 1 \text{ bar} | \text{Pt}(s)$

Half cell corresponding to the reaction are



Nernst equation, $E_{\text{cell}} = E_{\text{cell}}^\circ - \frac{2303 RT}{nF} \log \left[\frac{1}{[\text{H}^+]} \right]$

$$E_{\text{cell}} = 0 - \frac{2303 RT}{F} \log \left[\frac{1}{0.1} \right]$$

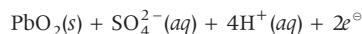
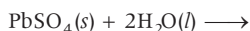
$$= - \frac{2303 RT}{F} \log 10$$

$$E_{\text{cell}} = - \frac{2303 RT}{F}$$

116. (b) Number of faradays = $\frac{I \times T}{96500 C}$

$$= \frac{1 \times 60 \times 60 \text{ s}}{96500 \text{ C mol}^{-1}} = 0.037 \text{ F}$$

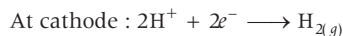
Reaction involved in conversion of PbO_2 from PbSO_4



$2e^-$ moles of electron = $2F \equiv 1 \text{ mol}$ of PbO_2

$$0.037 \text{ F} = \frac{1 \times 0.037}{2} = 0.0185 \text{ moles. (approx.)}$$

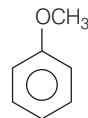
117. (d) At anode :



$\therefore \text{CO}_2 : \text{H}_2 = 2 : 1$

Thus, statement (d) is incorrect. Rest of the statements are correct.

118. (b) The structure of anisole can be represented as

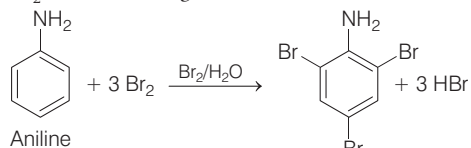


Common name : Anisole

IUPAC name : methoxybenzene

It is an ether. The name of ether is given as alkoxy alkane. So, its name is methoxybenzene.

119. (c) Cyclohexylamine and aniline can be distinguished by bromine test. Aniline react with Br_2 and water to give 2, 4, 6-tri bromo aniline.



2, 4, 6-tribromo
aniline
(white ppts)

Cyclohexylamine does not react with it.

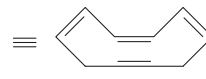
120. (b) The compounds pyridine and planar cyclooctatetraene are aromatic and anti-aromatic respectively. For a compound to be aromatic, it must be cyclic, planar. It must contain $(4n + 2) \pi$ electrons, where n is any whole number. Antiaromatic compounds are cyclic compounds with a π electron system that has higher energy due to the presence of $4n$ delocalised electrons in it.



Pyridine
(planar follows
Huckel's rule)



cyclo octatetraene
(not planar)



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Mathematics

1. (d) As, $3\mathbf{i} + 2\mathbf{j} - 5\mathbf{k} = \lambda(2\mathbf{i} - \mathbf{j} + \mathbf{k}) + \mu(\mathbf{i} + 3\mathbf{j} - 2\mathbf{k})$
 $\qquad\qquad\qquad + \gamma(-2\mathbf{i} + \mathbf{j} - 3\mathbf{k})$

$$\Rightarrow 3 = 2\lambda + \mu - 2\gamma, \quad 2 = -\lambda + 3\mu + \gamma,$$

$$\qquad\qquad\qquad -5 = \lambda - 2\mu - 3\gamma$$

On solving we get, $\mu = 1, \gamma = 2, \lambda = 3$

$\therefore \mu, \frac{\lambda}{2}, \gamma$ i.e. $1, \frac{3}{2}, 2$ are in AP.

2. (c) We know that

$$|\mathbf{a} - \mathbf{b}|^2 = (\mathbf{a} - \mathbf{b}) \cdot (\mathbf{a} - \mathbf{b})$$

$$\Rightarrow (l)^2 = |\mathbf{a}|^2 + |\mathbf{b}|^2 - 2\mathbf{a} \cdot \mathbf{b} \qquad [\because |\mathbf{a}| = |\mathbf{b}| = 1]$$

$$\Rightarrow 1 = 1 + 1 - 2|\mathbf{a}||\mathbf{b}|\cos\theta$$

[$\because |\mathbf{a}| = |\mathbf{b}| = 1$ and θ is angle between \mathbf{a} and \mathbf{b}]

$$\Rightarrow 1 = 2 - 2\cos\theta$$

$$\Rightarrow \cos\theta = \frac{1}{2}$$

$$\Rightarrow \theta = \frac{\pi}{3} \qquad \left[\because \cos\frac{\pi}{3} = \frac{1}{2} \right]$$

3. (a) We have, $x = \sin t \cos 2t$ and $y = \cos t \sin 2t$

Differentiating both, we get,

$$\frac{dx}{dt} = \cos t \cos 2t - 2\sin t \sin 2t$$

$$\frac{dy}{dt} = 2\cos t \cos 2t - \sin t \sin 2t$$

Dividing both, we get.

$$\frac{dy}{dx} = \frac{2\cos t \cos 2t - \sin t \sin 2t}{\cos t \cos 2t - 2\sin t \sin 2t}$$

$$\therefore \left(\frac{dy}{dx} \right)_{\text{at } t = \frac{\pi}{4}} = \frac{2\cos\frac{\pi}{4}\cos\frac{\pi}{2} - \sin\frac{\pi}{4}\sin\frac{\pi}{2}}{\cos\frac{\pi}{4}\cos\frac{\pi}{2} - 2\sin\frac{\pi}{4}\sin\frac{\pi}{2}}$$

$$= \frac{0 - \frac{1}{\sqrt{2}}}{0 - 2 \times \frac{1}{\sqrt{2}}}$$

$$\Rightarrow \left(\frac{dy}{dx} \right)_{\text{at } t = \frac{\pi}{4}} = \frac{1}{2}$$

4. (a) $f(xy) = \sin \log xy = \sin(\log x + \log y) \dots$ (i)

$$f\left(\frac{x}{y}\right) = \sin \log\left(\frac{x}{y}\right) = \sin(\log x - \log y) \dots$$
 (ii)

On adding Eqs. (i) and (ii)

$$f(xy) + f(x/y) = 2\sin \log x \cos \log y$$

$$\therefore f(xy) + f\left(\frac{x}{y}\right) = 2f(x) \cos \log y$$

$$\Rightarrow f(xy) + f(x/y) - 2f(x) \cos \log y = 0$$

5. (e) Given, $AB = A$ and $BA = B$, So,

$$ABA = A^2$$

$$A(BA) = A^2$$

$$A.B = A^2 \text{ or } A = A^2$$

Also, $BA = B$

$$BAB = B^2$$

$$BA = B^2 \text{ or } B = B^2$$

6. (c) We have,
$$\begin{vmatrix} 1 & a & a^2 \\ 1 & x & x^2 \\ b^2 & ab & a^2 \end{vmatrix}$$

Applying, $R_3 \rightarrow R_3 - R_1$ and $R_2 \rightarrow R_2 - R_1$ we get,

$$(x-a)(b-1) \begin{vmatrix} 1 & a & a^2 \\ 0 & 1 & x+a \\ b+1 & a & 0 \end{vmatrix} = 0$$

Which gives $x = \frac{a}{b}, a$

7. (b) $(1 - x + x^2)^5 = \{1 + x(x-1)\}^5$

$$= {}^5C_0 + {}^5C_1 x(x-1) + {}^5C_2 x^2(x-1)^2 + {}^5C_3 x^3(x-1)^3 + \dots$$

The coefficient of $x^3 = -2 \cdot {}^5C_2 - {}^5C_3 = -30$

8. (c) $P(B) = 1 - P(B') = 1 - \frac{2}{5} = \frac{3}{5}$

$$\therefore P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

$$= \frac{4}{5} + \frac{3}{5} - \frac{1}{2} = \frac{9}{10}$$

$$\therefore P(A \cap B') = P(A \cup B) - P(B)$$

$$= \frac{9}{10} - \frac{3}{5} = \frac{3}{10}$$

9. (e) Favourable outcomes : (1, 4), (2, 3), (3, 2), (4, 1)

$$P(\text{sum} = 5) = \frac{4}{6 \times 5} = \frac{2}{15}$$

10. (e) Let $\mathbf{P} (30\hat{i} + 3\hat{j})$, $\mathbf{Q} (20\hat{i} + 6\hat{j})$ and $\mathbf{R} (5\hat{i} + b\hat{j})$ be the collinear points.

So, $\mathbf{PQ} = \lambda \mathbf{QR}$ for some scalar λ .

$$\Rightarrow -10\hat{i} + 3\hat{j} = \lambda[-15\hat{i} + (b-6)\hat{j}]$$

$$\Rightarrow -10 = -15\lambda \text{ and } 3 = \lambda(b-6)$$

$$\Rightarrow \lambda = \frac{2}{3}, b = 10.5$$

11. (a) Let $I = \int \cos \left\{ 2 \tan^{-1} \sqrt{\frac{1-x}{1+x}} \right\} dx$

Put, $x = \cos 2\theta$

$$I = \int \cos \{ 2 \tan^{-1} \tan \theta \} (-2 \sin 2\theta) d\theta = - \int \sin 4\theta d\theta$$

$$= \frac{1}{4} \cos 4\theta + C = \frac{1}{4} (2x^2 - 1) + C = \frac{1}{2} x^2 + k$$

12. (d) Given, $12 \cot^2 \theta - 31 \operatorname{cosec} \theta + 32 = 0$

$$\Rightarrow 12 \cos^2 \theta - 31 \sin \theta + 32 \sin^2 \theta = 0$$

$$\Rightarrow 20 \sin^2 \theta - 31 \sin \theta + 12 = 0$$

$$\therefore \sin \theta = \frac{31 \pm \sqrt{31^2 - 4 \times 20 \times 12}}{2 \times 20} = \frac{4}{5}, \frac{3}{4}$$

13. (a) $y = \lim_{x \rightarrow 4} \left[\frac{x^{3/2} - 8}{x - 4} \right] = \lim_{x \rightarrow 4} \left[\frac{(x^{1/2})^3 - (2)^3}{(\sqrt{x} - 2)(\sqrt{x} + 2)} \right]$

$$y = \lim_{x \rightarrow 4} \left[\frac{(x^{1/2} - 2)(x + 4 + 2\sqrt{x})}{(\sqrt{x} - 2)(\sqrt{x} + 2)} \right]$$

$$y = \lim_{x \rightarrow 4} \frac{(x + 4 + 2\sqrt{x})}{(\sqrt{x} + 2)} = \frac{12}{4} = 3$$

14. (c) Given, $T_3 = 1000$

$$\Rightarrow {}^5C_2 \left(\frac{1}{x} \right)^{5-2} (x^{\log_{10} x})^2 = 1000$$

$$\Rightarrow x^{2 \log_{10}(x-3)} = 100 \Rightarrow 2 \log_{10} x - 3 = \log_x 10^2$$

$$\Rightarrow 2y - 3 = \frac{2}{y}, \text{ (where } y = \log_{10} x \text{)}$$

$$\Rightarrow y = \frac{-1}{2}, 2$$

When $y = 2, x = 100$

and when $y = \frac{-1}{2}, x = 10^{-1/2}$

As, $x > 1$, So, $x = 100$

15. (d) Let all points on the vertices be integers

Then, Δ = a rational number

But if the triangle is equilateral, then

$$\Delta = \frac{\sqrt{3}}{4} (\text{side})^2 = \frac{\sqrt{3}}{4} \times$$

an integer = an irrational number

Hence, the triangle cannot be equilateral.

16. (d) Given, $x = ay^2 + by + c$

$$\Rightarrow \left(y + \frac{b}{2a} \right)^2 = \frac{1}{a} \left(x + \frac{b^2 - 4ac}{4a} \right)$$

Latus rectum = $\frac{1}{a}$

17. (c) Given, the equation of the line is $y = x + \lambda$

Comparing with the standard equation of the line, we get,

$$m = 1, c = \lambda$$

and ellipse is

$$\frac{x^2}{16} + \frac{y^2}{9} = 1$$

Comparing with the standard equation of ellipse.

we get,

$$a = \pm 4, b = \pm 3$$

If the line touches the ellipse, then

$$c^2 = a^2 m^2 + b^2$$

$$\lambda^2 = 16 + 9 \quad \text{or} \quad \lambda = \pm 5$$

18. (c) For only $r \geq 6$, $r!$ is divisible by 240 as $5! < 240$.

Thus, when x is divided by 240, Remainder is factorials preceding 6.

Or $1! + 2! + 3! + 4! + 5! = 153$

19. (c) Let $y = (x + 1)^2 - 1, x \geq -1$

$$\Rightarrow (x + 1)^2 = y + 1$$

$$\Rightarrow x + 1 + \sqrt{y + 1} \text{ as, } x \geq -1$$

$$\Rightarrow x = -1 + \sqrt{y + 1}, y \geq -1$$

Thus, $f^{-1}(x) = -1 + \sqrt{x + 1}$

So, $f(x) = f^{-1}(x)$

$$\Rightarrow (x + 1)^2 - 1 = -1 + \sqrt{x + 1}$$

$$\Rightarrow \sqrt{x + 1} = 0 \text{ or } (x + 1)^{3/2} = 1$$

$$x = \{-1, 0\}$$

20. (b) $1 + i = \sqrt{2} \left(\cos \frac{\pi}{4} + i \sin \frac{\pi}{4} \right)$

and $1 - i = \sqrt{2} \left(\cos \frac{\pi}{4} - i \sin \frac{\pi}{4} \right)$

$$\therefore (1 + i)^8 + (1 - i)^8 = 2^4 \left(\cos \frac{\pi}{4} + i \sin \frac{\pi}{4} \right)^8$$

$$+ 2^4 \left(\cos \frac{\pi}{4} - i \sin \frac{\pi}{4} \right)^8$$

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$$= 2^4 (\cos 2\pi + i \sin 2\pi) + 2^4 (\cos 2\pi - i \sin 2\pi)$$

$$[\because (\cos \theta + i \sin \theta)^n = \cos n\theta + i \sin n\theta]$$

$$= 2^4 (2 \cos 2\pi) = 2^5$$

$$= \frac{18}{10} - \left(\frac{12}{10}\right)^2 = \frac{9}{5} - \frac{36}{25} = \frac{9}{25}$$

$$\sigma = \frac{3}{5}$$

21. (b) Let, $(\cos \alpha + i \sin \alpha)^{3/5} = z$

$$\Rightarrow z^5 = (\cos \alpha + i \sin \alpha)^3$$

$$\Rightarrow z^5 = \cos 3\alpha + i \sin 3\alpha$$

$$\Rightarrow z^5 - (\cos 3\alpha + i \sin 3\alpha)$$

\(\therefore\) Product of all values of

$$z = \frac{-[-(\cos 3\alpha + i \sin 3\alpha)]}{1}$$

$$= \cos 3\alpha + i \sin 3\alpha = 0$$

22. (d) $3^{\log_a x} + 3x^{\log_a 3} = 2$

$$\Rightarrow 3^{\log_a x} + 3 \cdot 3^{\log_a x} = 2 \quad [\because a^{\log_c b} = b^{\log_c a}]$$

$$\Rightarrow 4 \cdot 3^{\log_a x} = 2$$

$$\Rightarrow 3^{\log_a x} = \frac{1}{2}$$

$$\Rightarrow \log_a x = -\log_3 2$$

$$\therefore x = a^{-\log_3 2} = a^{\log_3 (1/2)} = \left(\frac{1}{2}\right)^{\log_3 a} = 2^{-\log_3 a}$$

23. (e) Squaring, $(\sin x + \cos x)^2 = \frac{1}{25}$

$$\Rightarrow \sin^2 x + \cos^2 x + 2 \sin x \cos x = \frac{1}{25}$$

$$\Rightarrow \sin 2x = \frac{1}{25} - 1 = \frac{-24}{25}$$

$$\Rightarrow \cos 2x = \pm \sqrt{1 - \sin^2 2x} = \pm \frac{\sqrt{49}}{25} = \pm \frac{7}{25}$$

So, $\tan 2x = \frac{\sin 2x}{\cos 2x} = \frac{-24}{25} \times \pm \left(\frac{25}{7}\right) = \frac{\pm 24}{7}$

24. (b) Given, $\frac{\Sigma x}{14} = 42 \Rightarrow \Sigma x = 42 \times 14 = 588$

and $\frac{\Sigma x + w}{15} = 42.4$

$$588 + w = 636$$

$$w = 48 \text{ kg.}$$

25. (a) Given, $x_1 + x_2 + \dots + x_{10} = 12$

and $x_1^2 + x_2^2 + \dots + x_{10}^2 = 18$

$$\sigma^2 = \frac{1}{n} \Sigma x^2 - \left(\frac{1}{n} \Sigma x\right)^2$$

26. (a) The line of intersection of the planes

$$r(2\hat{i} - \hat{j} + \hat{k}) = 1$$

and $r(\hat{i} + 3\hat{j} - \hat{k}) = 2$ is perpendicular to each of the normal vectors

$$r_1 = 2\hat{i} - \hat{j} + \hat{k} \text{ and } r_2 = \hat{i} + 3\hat{j} - \hat{k}$$

\(\therefore\) It is parallel to the vector

$$r_1 \times r_2 = (2\hat{i} - \hat{j} + \hat{k}) \times (\hat{i} + 3\hat{j} - \hat{k})$$

$$= -2\hat{i} + 3\hat{j} + 7\hat{k}$$

27. (a) Put $a^x = v \Rightarrow a^x dx = \frac{dv}{\log a}$, then it reduces to

$$\int \frac{1}{(\log a)^2} \cos v dv = \frac{1}{(\log a)^2} \sin v + C$$

$$= \frac{1}{(\log a)^2} \sin a^x + C$$

28. (a) The total number of arrangements of 10 digits 0, 1, 2, 3, 4, ..., 9 by taking 4 at a time

$$= {}^{10}C_4 \times 4!$$

In every arrangement of 4 selected digits there is just one arrangement in which digits are in ascending order. Hence, Total = $\frac{{}^{10}C_4 \times 4!}{4!} = {}^{10}C_4$

29. (c) $\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}| |\mathbf{b}| \cos \theta = 1 \cdot \cos \theta = \cos \theta$

$$\left| \frac{\mathbf{a} - \mathbf{b}}{2} \right|^2 = \frac{(\mathbf{a} - \mathbf{b}) \cdot (\mathbf{a} - \mathbf{b})}{4}$$

$$= \frac{|\mathbf{a}|^2 + |\mathbf{b}|^2 - 2\mathbf{a} \cdot \mathbf{b}}{4}$$

$$= \frac{1 + 1 - 2\mathbf{a} \cdot \mathbf{b}}{4}$$

$$= \frac{2 - 2|\mathbf{a}| |\mathbf{b}| \cos \theta}{4}$$

$$= \frac{1 - \cos \theta}{2} = \sin^2 \left(\frac{\theta}{2}\right)$$

$$\therefore \left| \frac{\mathbf{a} - \mathbf{b}}{2} \right| = \sin \left(\frac{\theta}{2}\right)$$

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30. (d) Equation of any circle passing through origin and having their centres on the X-axis is

$$x^2 + y^2 + 2gx = 0$$

Differentiating,

$$x + y \frac{dy}{dx} + g = 0$$

$$g = -y \frac{dy}{dx} - x = -\left(x + y \frac{dy}{dx}\right)$$

Putting g in the equation.

$$x^2 + y^2 - 2x \left(x + y \frac{dy}{dx}\right) = 0$$

Solving we get,

$$y^2 = x^2 + 2xy \frac{dy}{dx}$$

31. (d) $y = 2x^4 - x^2$

Differentiating w.r.t x.

$$\frac{dy}{dx} = 8x^3 - 2x$$

For maxima or minima $\frac{dy}{dx} = 0$

$$x = -\frac{1}{2}, 0, \frac{1}{2}$$

$$\frac{d^2y}{dx^2} = 24x^2 - 2$$

$$\left(\frac{d^2y}{dx^2}\right)_{at\ x=-\frac{1}{2}} > 0, \left(\frac{d^2y}{dx^2}\right)_{x=0} < 0,$$

$$\left(\frac{d^2y}{dx^2}\right)_{x=\frac{1}{2}} > 0$$

∴ Required area = $\left| \int_{-1/2}^{1/2} (2x^4 - x^2) dx \right| = \frac{7}{120}$ sq unit

32. (b) Using $\frac{{}^n C_r}{{}^n C_{r-1}} = \frac{n-r+1}{r}$

$$\frac{{}^n C_r}{{}^n C_{r-1}} = \frac{45}{10} \text{ and } \frac{{}^n C_{r+1}}{{}^n C_r} = \frac{120}{45}$$

$$\Rightarrow \frac{n-r+1}{r} = \frac{9}{2} \text{ and } \frac{n-r}{r+1} = \frac{8}{3}$$

$$\Rightarrow \frac{8}{3}(r+1) + 1 = \frac{9}{2}r$$

$$\Rightarrow 16r + 16 + 6 = 27r$$

$$r = 2$$

33. (e) There are only three determinants of second order with negative value,

$$\begin{vmatrix} 0 & 1 \\ 1 & 0 \end{vmatrix}, \begin{vmatrix} 0 & 1 \\ 1 & 1 \end{vmatrix}, \begin{vmatrix} 1 & 1 \\ 1 & 0 \end{vmatrix}$$

Number of possible determinants with elements 0 and 1 are $2^4 = 16$.

Hence, number of determinants with non-negative value is 13.

34. (b) $3^{49}(x + iy) = \left(\frac{3}{2} + \frac{\sqrt{3}i}{2}\right)^{100}$

$$= \left[i\sqrt{3} \left(\frac{1 - i\sqrt{3}}{2} \right) \right]^{100}$$

$$\Rightarrow 3^{49}(x + iy) = i^{100} \cdot 3^{50} \cdot (-\omega)^{100}$$

$$\Rightarrow 3^{49}(x + iy) = 3^{50} \cdot \omega = 3^{50} \left(\frac{-1}{2} + \frac{i\sqrt{3}}{2} \right)$$

$$\therefore x + iy = -\frac{3}{2} + \frac{3\sqrt{3}i}{2} \Rightarrow x = -\frac{1}{\sqrt{3}}y$$

$$\therefore k = -\frac{1}{\sqrt{3}}$$

35. (c) Selection of 4 cards from a pack of 52 cards is ${}^{52}C_4$.

Ways of selecting one card from each

$$\text{suit} = ({}^{13}C_1)^4$$

$$\text{Probability} = \frac{({}^{13}C_1)^4}{{}^{52}C_4} = \frac{2197}{20825}$$

36. (e) Let $I = \int_e^{e^4} \sqrt{\ln(x)} dx$

Putting $\ln(x) = t^2$

$$\Rightarrow \frac{1}{x} dx = 2t dt$$

$$\text{So, } I = \int_1^2 e^{t^2} \cdot 2t^2 dt = (te^{t^2})_1^2 - \int_1^2 e^{t^2} dt$$

$$= 2e^4 - e - a$$

37. (c) Assuming, $y = \sqrt{7 + \sqrt{7-y}}$

$$(y^2 - 7)^2 = 7 - y$$

$$y^4 - 14y^2 + y + 42 = 0$$

$$(y - 3)(y^3 + 3y^2 - 5y + 14) = 0$$

$$\therefore y = 3$$

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38. (e) Equation of plane through (7, 0, 6) is

$$a(x - 7) + b(y - 0) + c(z - 6) = 0$$

Also, (3, 2, -1) and (3, 4, 2) lie on this.

Then, $-4a + 2b - 7c = 0$

and $-4a + 4b - 4c = 0$

Eliminating a, b, c we get,

$$\begin{vmatrix} x-7 & y & z-6 \\ -4 & 2 & -7 \\ -4 & 4 & -4 \end{vmatrix} = 0$$

We get, $20x - 12y - 8z = 92$

or $5x - 3y - 2z = 23$

$\therefore \lambda = 23$

39. (e) Given, $r \cos \alpha = 3, r \cos \beta = 4$ and $r \cos \gamma = 5$

$$\therefore r^2(\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma) = 9 + 16 + 25$$

$$r = \sqrt{50}$$

40. (e) The common chord will be a diameter of the second circle.

Common chord is $S_1 - S_2 = 0$

or $6x + 14y + (c + d) = 0$

The centre of the second circle is (1, -4) lies on it.

$$6(1) + 14(-4) + c + d = 0$$

$\therefore c + d = 50$

41. (c) $\frac{dy}{dx} = \frac{-2xy}{x^2 + 1} \Rightarrow \frac{dy}{y} = \frac{-2x}{x^2 + 1} dx$

Integrating, we get, $\log y = -\log(1 + x^2) + C$

$$\Rightarrow y(1 + x^2) = C$$

Since (1, 2) is on the curve

$$\therefore 2(1 + 1) = C \Rightarrow C = 4$$

Hence, solution is $y(x^2 + 1) = 4$.

42. (b) As $f(x) = {}^{7-x}P_{x-3}$ is defined only for positive integer values of x satisfying

$$7 - x > 0, x - 3 \geq 0 \text{ and } x - 3 \leq 7 - x \text{ or } x = 3, 4, 5$$

$$\text{Range } (f) = \{f(3), f(4), f(5)\}$$

$$= \{{}^4P_0, {}^3P_1, {}^2P_2\} = \{1, 2, 3\}$$

43. (a) $\{(3x)^2 - 6x + 1\} + \{(2y)^2 + 4y + 1\} = 1$

$$\Rightarrow (3x - 1)^2 + (2y + 1)^2 = 1$$

$$\Rightarrow \frac{(x - 1/3)^2}{\left(\frac{1}{3}\right)^2} + \frac{(y + 1/2)^2}{\left(\frac{1}{2}\right)^2} = 1$$

Hence, Minor axis = $2 \times \frac{1}{3} = \frac{2}{3}$

Major axis = $2 \times \frac{1}{2} = 1$

44. (b) As, $2ae = \frac{2b^2}{a} \Rightarrow a^2e = b^2$

$$\Rightarrow a^2e = a^2(1 - e^2)$$

$$\Rightarrow e^2 + e - 1 = 0 \Rightarrow e = \frac{\sqrt{5} - 1}{2}$$

45. (a) $\int_0^4 \{\sqrt{x}\} dx = \int_0^4 (\sqrt{x} - [\sqrt{x}]) dx$

$$\int_0^4 \sqrt{x} dx - \int_0^4 [\sqrt{x}] dx$$

$$= \frac{2}{3} \{x^{3/2}\}_0^4 - \left(\int_0^1 [\sqrt{x}] dx + \int_1^2 \{ \sqrt{x} \} dx \right)$$

$$= \frac{2}{3} \cdot 8 - [0 + 1 \cdot (2^2 - 1^2)] = \frac{16}{3} - 3 = \frac{7}{3}$$

46. (a) Given, $\frac{a_4}{a_6} = \frac{1}{9} \Rightarrow \frac{a_1 r^3}{a_1 r^5} = \frac{1}{9}$

$$\Rightarrow r = \pm 3$$

and $a_2 + a_5 = 168$

$$a_1 r + a_1 r^4 = 168$$

$$a_1 (r + r^4) = 168$$

For $r = 3$

$$a_1 = 2$$

and for $r = -3$

$$a = \frac{28}{13}$$

Hence, (a) is the correct option.

47. (a) $\lim_{x \rightarrow 1} \frac{[x^2]_4^{f(x)}}{x - 1} = \lim_{x \rightarrow 1} \frac{\{f(x)\}^2 - 16}{(x - 1)}$

$$= \lim_{x \rightarrow 1} \frac{2f(x) f'(x) - 0}{1}$$

$$= 2f(1) f'(1) = 2 \times 4 \times f'(1) = 8f'(1)$$

$$(1 + x)^{1/x} - e + \frac{1}{2} ex$$

48. (d) $\lim_{x \rightarrow 0} \frac{(1 + x)^{1/x} - e + \frac{1}{2} ex}{x^2}$

$$\lim_{x \rightarrow 0} \frac{e \left(1 - \frac{x}{2} + \frac{11}{24} x^2 + \dots \right) - e + \frac{1}{2} ex}{x^2}$$

$$= \frac{\frac{11}{24} ex^2 + \dots}{x^2} = \frac{11}{24} e$$

49. (e) As, $(7 + 4\sqrt{3})(7 - 4\sqrt{3}) = 1$

Hence, the equation becomes

$$y + \frac{1}{y} = 14$$

$$y = (7 - 4\sqrt{3})x^2 - 4x + 3$$

$$\Rightarrow y^2 - 14y + 1 = 0$$

$$\Rightarrow y = 7 \pm 4\sqrt{3}$$

So, $y = 7 + 4\sqrt{3}$

$$\Rightarrow x^2 - 4x + 3 = -1 \Rightarrow x = 2, 2$$

and $y = 7 - 4\sqrt{3}$

$$\Rightarrow x^2 - 4x + 3 = 1 \Rightarrow x = 2 \pm \sqrt{2}$$

50. (b) Given, $z^7 = -1$

Hence, $z^{85} + z^{142} + z^{191}$

$$= (z^7)^{12}z^1 + (z^7)^{20}z^2 + (z^7)^{27}z^2$$

$$= (-1)^{12}z^1 + (-1)^{20}z^2 + (-1)^{27}z^2$$

$$= z + z^2 - z^2 = z$$

51. (b) Given, $z_1 = \bar{z}_2$

$$5y^2 - 3 - 8ix = 4y^2 - 16i$$

$$(y^2 - 3) - 8i(x + 2) = 0$$

Since, complex number is zero.

$$\Rightarrow y^2 - 3 = 0 \text{ and } x + 2 = 0$$

$$\Rightarrow y = \pm\sqrt{3} \text{ and } x = -2$$

Thus, $z = x + iy = -2 \pm \sqrt{3}i$

52. (c) Given, $\sin(e^x) = 5^x + 5^{-x}$

put $5^x = y$

Then, $\sin(e^x) = y + \frac{1}{y} = \left(\sqrt{y} - \frac{1}{\sqrt{y}}\right)^2 + 2$ [$\because 5^x > 0$]

$$\sin(e^x) \geq 2$$

The given equation has no solution.

53. (c) According to the question,

If B throws 1, then A is allowed to throw only 1,

if B throws 2, then A can throw 1 and 2 and soon.

Hence, required probability.

$$\frac{1}{6} \cdot \frac{1}{6} + \frac{1}{6} \cdot \frac{2}{6} + \frac{1}{6} \cdot \frac{3}{6} + \frac{1}{6} \cdot \frac{4}{6} + \frac{1}{6} \cdot \frac{5}{6} + \frac{1}{6} \cdot \frac{6}{6}$$

$$= \frac{1}{6 \times 6} (1 + 2 + 3 + 4 + 5 + 6)$$

$$= \frac{6 \times 7}{6 \times 6 \times 2} = \frac{7}{12}$$

54. (a) $f(x) = [\tan^2 x] = 0$ if $x \in \left(-\frac{\pi}{4}, \frac{\pi}{4}\right)$

Hence, the function is differentiable and continuous at $x = 0$.

55. (a) 6 Girls can sit in 6! ways

For the sisters to not sit with each other,

They can sit in any the given empty places

$${}^0G_1 {}^0G_2 {}^0G_3 {}^0G_4 {}^0G_5 {}^0G_6$$

Hence, total number of ways

$$= 6! \times {}^7C_2 \times 2! = 30240$$

56. (b) Number of ways of choosing first couple is

$$({}^7C_1) ({}^7C_1) = 7^2$$

Similarly, choosing the second couple

$$= ({}^6C_1) ({}^6C_1) = 6^2 \text{ and so on.}$$

Hence, total number of ways is

$$7^2 + 6^2 + 5^2 + 4^2 + 3^2 + 2^2 + 1^2$$

$$= 49 + 36 + 25 + 16 + 9 + 4 + 1$$

$$= 140$$

57. (b) The coordinates of any point on the given line are :

$$(2r - 1, 3r + 1, r + 1)$$

The distance of this point from $(1, 2, 0)$ is $\sqrt{56}$

$$\Rightarrow (2r)^2 + (3r)^2 + (r)^2 = (\sqrt{56})^2$$

$$\Rightarrow 14r^2 = 56$$

$$\Rightarrow r = \pm 2$$

Hence, coordinates of the required point is :

$$(3, 7, 3) \text{ or } (-5, -5, -1)$$

58. (a) $f'(4) = \lim_{h \rightarrow 0} \frac{f(4+h) - f(4)}{h}$

$$= \lim_{h \rightarrow 0} \frac{f(4)f(h) - f(4)f(0)}{h}$$

$$= f(4) \lim_{h \rightarrow 0} \frac{f(h) - f(0)}{h}$$

$$= f(4)f'(0)$$

$$= 3 \times 1 = 3$$

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59. (e) Let $x^2 = t$

$$dx = \frac{1}{2\sqrt{t}} dt$$

$$\begin{aligned} I &= \int_0^{2.25} \frac{[t]}{2\sqrt{t}} dt \\ &= \int_0^1 \frac{[t]}{2\sqrt{t}} dt + \int_1^2 \frac{[t]}{2\sqrt{t}} dt + \int_2^{2.25} \frac{[t]}{2\sqrt{t}} dt \\ &= 0 + \int_1^2 \frac{1}{2\sqrt{t}} dt + \int_2^{2.25} \frac{2}{2\sqrt{t}} dt \\ &= [\sqrt{t}]_1^2 + [2\sqrt{t}]_2^{2.25} \\ &= (\sqrt{2} - 1) + 2(1.5 - \sqrt{2}) = 2 - \sqrt{2} \end{aligned}$$

60. (a) $\lim_{x \rightarrow \frac{\pi}{4}} (2 - \cot x)^{\log \cot x} = (2 - 1)^{\log 1} = 1^0 = 1$

61. (c) $n(A) = n(A - B) + n(A \cap B)$

$$61 = 25 + n(A \cap B)$$

$$\therefore n(A \cap B) = 36$$

$$\begin{aligned} n(A \cup B) &= n(A) + n(B) - n(A \cap B) \\ &= 61 + 95 - 36 = 120 \end{aligned}$$

62. (b) If the roots are $\alpha - d, \alpha, \alpha + d$ with their common difference d , then,

$$\begin{aligned} \alpha - d + \alpha + \alpha + d &= 12 \\ \alpha &= 4 \end{aligned}$$

$$\text{and } (\alpha - d)\alpha(\alpha + d) = 28$$

$$\Rightarrow (4^2 - d^2)4 = 28 \Rightarrow d = \pm 3$$

63. (b) We have,

$$\begin{aligned} 2^{2000} &= (2^4)^{500} = (17 - 1)^{500} \\ &= {}^{500}C_0 17^{500} - {}^{500}C_1 17^{499} + \dots - {}^{500}C_{499} 17 + (-1)^{500} \\ &= 17m + 1, \text{ where } m \text{ is some positive integer} \\ &= 2^{2003} = (8)(2^{2000}) = 8(17m + 1) \\ &= 17(8m) + 8 \end{aligned}$$

Hence, the remainder will be 8.

64. (c) $(1 - x)^5 \cdot (1 + x)^4 \cdot (1 + x^2)^4 =$

$$(1 - x)(1 - x^2)^4(1 + x^2)^4 = (1 - x)(1 - x^4)^4$$

$$\therefore \text{The coefficient of } x^{13} = {}^{-4}C_3(-1)^3 = 4$$

65. (d) $\sin a + \left[\frac{\sin 2x}{2} \right]_a^{2a} = 0$

$$\sin a + \frac{\sin 4a - \sin 2a}{2} = 0$$

$$\Rightarrow 2\sin a + \sin 4a - \sin 2a = 0$$

$$\Rightarrow 2\sin a + 2\cos 3a \sin a = 0$$

$$\Rightarrow 2\sin a(1 + \cos 3a) = 0$$

$$\Rightarrow \sin a(1 + \cos 3a) = 0$$

$$\Rightarrow \sin a = 0, \cos 3a = -1$$

$$\therefore a = 0 \text{ or } 3a = -\pi, -3\pi$$

$$a = \frac{-\pi}{3}, -\pi, 0$$

66. (b) Let T be the event that 3 occurs and A be the event that the man reports it to be a 3.

$$\text{Then probability } P(T/A) = \frac{P(T \cap A)}{P(A)}$$

$$\text{Now, } P(T \cap A) = \frac{1}{6} \times \frac{3}{4} = \frac{3}{24}$$

$$P(A) = P(T \cap A) + P(\bar{T} \cap A)$$

$$= \frac{1}{6} \times \frac{3}{4} + \frac{5}{6} \times \frac{1}{4} = \frac{8}{24}$$

$$P(A/B) = \frac{3/24}{8/24} = \frac{3}{8}$$

67. (b) Given, $\frac{2b^2}{a} = \frac{1}{2}(2a) \Rightarrow 2b^2 = a^2$

$$\Rightarrow 2a^2(1 - e^2) = a^2 \Rightarrow 2(1 - e^2) = 1$$

$$\Rightarrow 2 - 2e^2 = 1 \Rightarrow e = \frac{1}{\sqrt{2}}$$

68. (d) $(1 + i)^5(1 - i)^5 = (1 - i^2)^5 = 2^5$

69. (b) The number of 6 digit telephone numbers. Using digits 0, 1.....9 is 10^6 .

The number of 6-digit telephone numbers. Which have none of their digits repeated is ${}^{10}P_6$.

$$\text{Required ways} = 10^6 - {}^{10}P_6$$

70. (e) Given, $z = \frac{\sqrt{3}}{2} + \frac{i}{2}$

$$iz = \frac{-1}{2} + i \frac{\sqrt{3}}{2} = \omega$$

$$\text{And } z^{69} = z^{4(17)}z = (iz)^{4(17)}z = (\omega)^{68}z \quad (\because i^{4n} = 1)$$

$$= \frac{\omega^{69}}{i} = \frac{(\omega^3)^{23}}{i} = -i$$

71. (a) Given lines, $4x + 3y - 6 = 0$ and $4x + 3y - 11 = 0$

since these lines are parallel

\therefore Distance between these lines

$$= \frac{|-11 - (-6)|}{\sqrt{4^2 + 3^2}} = \frac{5}{5} = 1$$

72. (a) $\sum_{r=1}^4 \cos rx = 4$

$\cos x + \cos 2x + \cos 3x + \cos 4x = 4$

Which is possible only iff,

$\cos x = \cos 2x = \cos 3x = \cos 4x = \cos 5x = 1$

and it satisfied by $x = 0$ only

\therefore Number of solutions is 1.

73. (a) Since, $x \in [0, 2\pi]$ and $y \in [0, 2\pi]$ and

$\sin x + \sin y = 2$

It is possible only when

$\sin x = 1$ and $\sin y = 1$

$\therefore x = \frac{\pi}{2}$ and $y = \frac{\pi}{2}$

$x + y = \pi$

74. (a) From $\sin x + \sin^2 x = 1$

we get, $\sin x = \cos^2 x$

The given expression is simplified as

$\cos^6 x (\cos^6 x + 3\cos^4 x + 3\cos^2 x + 1) - 1$

$= \cos^6 x (\cos^2 x + 1)^3 - 1$

$= \sin^3 x (\sin x + 1)^3 - 1$

$= (\sin^2 x + \sin x)^3 - 1 = 0$

75. (b) As, $3^2 = 10 - 1$

$3^{100} = (10 - 1)^{50}$

$100m - {}^{50}C_{49}(10) + 1$

where, $m = {}^{50}C_0 10^{48} - {}^{50}C_1 10^{47} + \dots + {}^{50}C_{48}$

So, $3^{100} = 100m - 500 + 1$

$= 100(m - 5) + 1$

Hence, the last digit is 1.

76. (e) The probability of hitting a target is $\frac{1}{5}$.

The probability of not hitting a target is $\frac{4}{5}$.

\therefore Required number of probability

$= 1 - {}^{10}C_0 \left(\frac{1}{5}\right)^0 \left(\frac{4}{5}\right)^{10} = 1 - \left(\frac{4}{5}\right)^{10}$.

77. (a) Total students = 80

Total boys = 55 and total girls = 25

Hence, Required probability

$= \frac{7}{8} \times \frac{3}{4} \times \frac{55}{80} = \frac{231}{512}$

78. (b) As, 13, $m_1, m_2, \dots, m_{20}, 67$ are in AP

$\therefore m_1 + m_2 + \dots + m_{20} = 20 \left(\frac{13 + 67}{2} \right) = 800$

As, AM \geq GM

$\frac{m_1 + m_2 + \dots + m_{20}}{20} \geq (m_1 m_2 m_3 \dots m_{20})^{1/20}$

$\Rightarrow \left(\frac{800}{20} \right) \geq (m_1 m_2 m_3 \dots m_{20})^{1/20}$

or $m_1 m_2 \dots m_{20} \leq (40)^{20}$

Max value of $m_1 m_2 m_3 \dots m_{20}$ is $(40)^{20}$.

79. (c) Let d be the common difference

$\therefore a_7 = 9$

$\therefore a_1 + 6d = 9$

Let $D = a_1 a_2 a_7 = (9 - 6d)(9 - 5d) 9$

$= 270 \left\{ \left(d - \frac{33}{20} \right)^2 - \frac{9}{400} \right\}$

For least value of D, $d - \frac{33}{20} = 0$

$\therefore d = \frac{33}{20}$

80. (d) Numbers divisible by 3

are 3, 6, 9, 12, 15, 18, 21, 24

Numbers divisible by 4 are : 4, 8, 12, 16, 20, 24

Numbers divisible by both 3 and 4 i.e.

divisible by 12

$(3 \times 4 = 12)$ are 12, 24

\therefore Probability = $\frac{{}^8C_1}{{}^{25}C_1} + \frac{{}^6C_1}{{}^{25}C_1} - \frac{{}^2C_1}{{}^{25}C_1} = \frac{12}{25}$

81. (a) $1 + \omega + \omega^2 = 0$

$1 + \omega = -\omega^2$

$\therefore (1 + \omega)^7 = -\omega^{14} = -\omega^2 = A + B\omega$

$\Rightarrow 1 + \omega = A + B\omega$

$\therefore A = 1, B = 1$

82. (b) $H^2 = AB$ and $\Delta \neq 0$

$\therefore 4 = a.1 \Rightarrow a = 4$

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$$83. (c) \quad y = \frac{-(lx + n)}{m}$$

Parabola $x^2 = 4ay$

$$\therefore x^2 = 4a \left\{ \frac{-(lx + n)}{m} \right\}$$

$$mx^2 + 4alx + 4an = 0$$

For touching $B^2 = 4AC$

$$\Rightarrow 16a^2l^2 = 4m(4an)$$

$$al^2 = mn \Rightarrow al^2 - mn = 0$$

84. (a) Equation of horizontal plane through origin

$$2x - 3y + z = 0$$

The direction ratios of the line of intersection of the planes $2x - 3y + z = 0$ and $3x - 2y + z = 5$ are given by

$$2a - 3b + c = 0$$

and $3a - 2b + c = 0$

$$\therefore \frac{a}{-1} = \frac{b}{1} = \frac{c}{5}$$

Let l, m, n be the DC's of the line of greatest slope, because the line of greatest slope is perpendicular to the line of intersection of the given plane with the horizontal plane.

$$-l + m + 5n = 0$$

and $3l - 2m + n = 0$

$$\text{So, } \frac{l}{11} = \frac{m}{16} = \frac{n}{-1}$$

\therefore DC's are proportional to $(11, 16, -1)$

85. (b) $(l) (2) + 2(l) + (-1) (4) = 0$

Hence, the lines are perpendicular

86. (b) As $z = 0$ for the point where the line intersects the curve

$$\therefore \frac{x-2}{3} = \frac{y+1}{2} = \frac{0-1}{-1}$$

$$\Rightarrow \frac{x-2}{3} = 1 \text{ and } \frac{y+1}{2} = 1 \Rightarrow x = 5, y = 1$$

Putting values we get,

$$xy = c^2$$

$$5 = c^2$$

$$c = \pm \sqrt{5}$$

87. (c) $(a^2 - 3a + 2)x^2 + (a^2 - 5a + 6)x + a^2 - 4 = 0$ for identity $a^2 - 3a + 2 = 0, a = 1, 2$

$$a^2 - 5a + 6 = 0$$

$$\Rightarrow a = 2, 3 \Rightarrow a^2 - 4 = 0$$

$$\Rightarrow a = \pm 2$$

$$\text{and } a^2 - 3a + 2 = a^2 - 5a + 6 = a^2 - 4$$

$$\therefore a = 2$$

$$88. (c) \cos\left(\frac{2\pi}{7}\right) + \cos\left(\frac{4\pi}{7}\right) + \cos\left(\frac{6\pi}{7}\right)$$

$$= \operatorname{Re} \left\{ e^{\frac{2\pi i}{7}} + e^{\frac{4\pi i}{7}} + e^{\frac{6\pi i}{7}} \right\}$$

$$[e^{2\pi i/7} + e^{4\pi i/7} + e^{6\pi i/7} + e^{-2\pi i/7}$$

$$+ e^{-4\pi i/7} + e^{-6\pi i/7}]$$

$$= \frac{[-1 + (1 + e^{2\pi i/7} + e^{4\pi i/7} + e^{6\pi i/7} + e^{-2\pi i/7} + e^{-4\pi i/7} + e^{-6\pi i/7})]}{2}$$

$$= \frac{-1 + (\text{sum of seven roots of unity})}{2}$$

$$= -\frac{1+0}{2} = -\frac{1}{2}$$

89. (b) The given points are collinear if

$$\begin{vmatrix} k & 2-2k & 1 \\ -k+1 & 2k & 1 \\ -4-k & 6-2k & 1 \end{vmatrix} = 0$$

$$\begin{vmatrix} k & 2-2k & 1 \\ -2k+1 & 4k-2 & 0 \\ -4-2k & 4 & 0 \end{vmatrix} = 0$$

$$[R_2 \rightarrow R_2 - R_1, R_3 \rightarrow R_3 - R_1]$$

$$= 4(-2k+1) - (-4-2k)(4k-2) = 0$$

$$\Rightarrow k = \frac{1}{2}, = -1$$

90. (b) The vertex A (x, y) is equidistant from B and C.

$$(x-1)^2 + (y-3)^2 = (x+2)^2 + (y-7)^2$$

$$\Rightarrow 6x - 8y + 43 = 0$$

Any point satisfying this can be vertex A, except midpoint $\left(-\frac{1}{2}, 5\right)$. Hence, coordinates are $\left(\frac{5}{6}, 6\right)$

91. (b) $a^2 - b^2 = (a+b)(a-b)$ is a prime number

$\therefore (a+b)(a-b)$ is divisible by either 1 or by the number itself. Since, $a-b < a+b$

$$\therefore a-b = 1 \Rightarrow a^2 - b^2 = a+b$$

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92. (b) $9900 = 3^2 \times 2^2 \times 5^2 \times 11$

∴ Sum of all divisors

$$\frac{(3^0 + 3^1 + 3^2)(2^0 + 2^1 + 2^2)(5^0 + 5^1 + 5^2)}{(11^0 + 11^1)}$$

∴ Sum of all proper divisors.

$$= 13 \times 7 \times 31 \times 12 - 1 - 9900 = 23951$$

93. (d) We have, $y = \frac{1}{4}u^4$

$$\therefore \frac{dy}{du} = \frac{1}{4}4u^3 = u^3$$

also $u = \frac{2}{3}x^3 + 5$

$$\therefore \frac{du}{dx} = \frac{2}{3} \cdot 3x^2 = 2x^2$$

$$\begin{aligned} \therefore \frac{dy}{dx} &= \frac{dy}{du} \times \frac{du}{dx} = u^3 \times 2x^2 = \left(\frac{2}{3}x^3 + 5\right)^3 (2x^2) \\ &= \frac{2}{27}x^2 (2x^3 + 15)^3 \end{aligned}$$

94. (a) Given, $f(x) = x^{1/x}$; $f(x) = \frac{1}{x^2} (1 - \log x)x^{1/x}$

$$f'(x) > 0, \text{ if } 1 - \log x > 0$$

$$\Rightarrow \log x < 1 \Rightarrow x < e$$

∴ $f(x)$ is increasing in the interval $(-\infty, e)$

95. (a) Since, $y = \frac{3x + 2}{5x - 3}$

$$x = \frac{3y + 2}{5y - 3} = f^{-1}(y)$$

$$f^{-1}(x) = \frac{3x + 2}{5x - 3} = f(x)$$

96. (b) $\lim_{x \rightarrow 0} \frac{\sin(\pi \cos^2 x)}{x^2}$

$$= \lim_{x \rightarrow 0} \left\{ \frac{\cos(\pi \cos^2 x) \cdot \pi \cdot 2 \cos x (-\sin x)}{2x} \right\}$$

(using L'Hopitals, Rule)

$$= \lim_{x \rightarrow 0} \pi \cos(\pi \cos^2 x) \cdot \cos x \cdot \left(\frac{-\sin x}{x}\right)$$

$$= \pi(-1) \cdot 1 \cdot (-1) = \pi$$

97. (c) Given, $\int f(x) dx = f(x) + C$

$$f(x) = f'(x)$$

$$\therefore \int \{f(x)\}^2 dx = \int \{f(x)\} \cdot f'(x) dx = \frac{1}{2} \int \{f(x)\}^2 + C$$

98. (d) We know that, $|\sin x|$ is a periodic function of π . Hence.

$$\int_0^{4\pi} |\sin x| dx = 4 \int_0^{\pi} \sin x dx = 4(-\cos x)_0^{\pi} = 8$$

99. (d) The equation of the curve is

$$xy - 3x - 2y - 10 = 0$$

$$y = \frac{3x + 10}{x - 2}$$

$$\therefore \text{Required area} = \int_3^4 \frac{3x + 10}{x - 2} dx$$

$$= \int_3^4 \left\{ 3 + \frac{16}{x-2} \right\} dx$$

$$= [3x + 16 \log(x - 2)]_3^4$$

$$= 12 + 16 \log 2 - 9 - \log 1$$

$$= 3 + 16 \log 2 \text{ sq. units.}$$

100. (c) $|A| \text{ adj } A = |A|^n$ for order n

$$\Rightarrow DD' = D^n$$

101. (a) Since, $\alpha + \beta + \gamma = 0$

Applying $C_1 \rightarrow C_1 + C_2 + C_3$ in the given determinant.

$$A = \begin{vmatrix} \alpha + \beta + \gamma & \beta & \gamma \\ \alpha + \beta + \gamma & \gamma & \alpha \\ \alpha + \beta + \gamma & \alpha & \beta \end{vmatrix} = \begin{vmatrix} 0 & \beta & \gamma \\ 0 & \gamma & \alpha \\ 0 & \alpha & \beta \end{vmatrix} = 0$$

102. (b) Mean = $\frac{1 \times x + 2 \times 2x + 3 \times 3x + \dots + n \times nx}{x + 2x + 3x + \dots + nx}$

$$= \frac{x(1^2 + 2^2 + 3^2 + \dots + n^2)}{x(1 + 2 + 3 + \dots + n)}$$

$$\begin{aligned} &= \frac{n(n+1)(2n+1)}{2} = \frac{2n+1}{3} \\ &= \frac{6}{n(n+1)} = \frac{2n+1}{3} \end{aligned}$$

103. (a) Let, $I = \int_{-2}^2 |x \cos \pi x| dx$

$$= 2 \int_0^2 |x \cos \pi x| dx$$

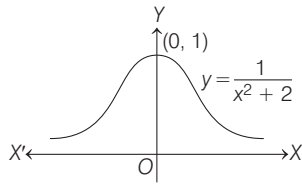
$$= 2 \left[\int_0^{1/2} |x \cos \pi x| dx + \int_{1/2}^2 |x \cos \pi x| dx \right]$$

$$+ \int_{3/2}^2 |x \cos \pi x| dx$$

$$= \frac{8}{\pi}$$

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104. (b) Required area = $\int_{-\infty}^{\infty} \frac{1}{1+x^2} dx$



= $2[\tan^{-1} x]_0^{\infty} = \pi$ sq. units.

105. (a) $\lim_{x \rightarrow 0} (\cos x)^{1/x^4}$

$\lim_{x \rightarrow 0} \left(\frac{\cos x - 1}{x^4} \right) = e^{\lim_{x \rightarrow 0} \frac{\sin x}{4x^3}} = e^{\lim_{x \rightarrow 0} \frac{-\sin x}{x} \cdot \frac{1}{4x^2}} = e^{-\infty} = 0$

106. (a) Let $y = x^2 - x + 1$

$\Rightarrow x = \frac{1 \pm \sqrt{1 - 4(1 - y)}}{2}$

$\therefore x > \frac{1}{2}$

$x = \frac{1}{2} + \sqrt{y - \frac{3}{4}} \Rightarrow f^{-1}(x) = \frac{1}{2} + \sqrt{x - \frac{3}{4}}$

Now, $x^2 - x + 1 = \frac{1}{2} + \sqrt{x - \frac{3}{4}}$

$\Rightarrow x = 1$ (by checking the given possibilities)

107. (a) $[\mathbf{a} - \mathbf{b}, \mathbf{b} - \mathbf{c}, \mathbf{c} - \mathbf{a}]$

= $\{(\mathbf{a} - \mathbf{b}) \times (\mathbf{b} - \mathbf{c})\} \cdot (\mathbf{c} - \mathbf{a})$
 = $\{(\mathbf{a} \times \mathbf{b} - \mathbf{a} \times \mathbf{c} - \mathbf{b} \times \mathbf{b} + \mathbf{b} \times \mathbf{c})\} \cdot (\mathbf{c} - \mathbf{a})$
 = $\{(\mathbf{a} \times \mathbf{b} + \mathbf{c} \times \mathbf{a} + \mathbf{b} \times \mathbf{c})\} \cdot (\mathbf{c} - \mathbf{a})$
 = $\{(\mathbf{a} \times \mathbf{b}) \cdot \mathbf{c} - (\mathbf{b} \times \mathbf{c}) \cdot \mathbf{a}\}$
 = $[\mathbf{a} \ \mathbf{b} \ \mathbf{c}] - [\mathbf{a} \ \mathbf{b} \ \mathbf{c}]$
 = 0

108. (b) we have $a = 2x$, $b = 2y$ and $\angle C = 120^\circ$,

Area of triangle $A = \frac{1}{2} ab \sin C$
 = $\frac{1}{2} \times 2x \times 2y \times \sin 120^\circ$
 = $xy\sqrt{3}$ sq. units.

109. (a) Let $\mathbf{a} = x\hat{i} + y\hat{j} + z\hat{k}$

$\mathbf{a} \cdot \hat{i} = (x\hat{i} + y\hat{j} + z\hat{k}) \cdot \hat{i} = x$

$\mathbf{a} \cdot (\hat{i} + \hat{j}) = (x\hat{i} + y\hat{j} + z\hat{k}) \cdot (\hat{i} + \hat{j})$
 = $x + y$

and $\mathbf{a} \cdot (\hat{i} + \hat{j} + \hat{k}) = (x\hat{i} + y\hat{j} + z\hat{k}) \cdot (\hat{i} + \hat{j} + \hat{k})$

= $x + y + z$

It is given that, $\mathbf{a} \cdot \hat{i} = \mathbf{a} \cdot (\hat{i} + \hat{j}) = \mathbf{a} \cdot (\hat{i} + \hat{j} + \hat{k})$

$\Rightarrow x = x + y = x + y + z$

Taking, $x = x + y \Rightarrow y = 0$

$x + y = x + y + z \Rightarrow z = 0$

x has any real values.

Now, take $x = 1$

$\therefore \mathbf{a} = \hat{i}$

110. (c) Let x_1, x_2, \dots, x_{20} be the given observations

We have, $\frac{1}{20} \sum_{i=1}^{20} (xi - \bar{x})^2 = 5$

To find variance of $2x_1, 2x_2, 2x_3, \dots, 2x_{20}$

Let \bar{y} denotes the mean of new observations.

Clearly, $\bar{X} = \frac{\sum_{i=1}^{20} 2x_i}{20} = \frac{2 \sum_{i=1}^{20} 2x_i}{20} = 2\bar{x}$

Now, variance of new observation

= $\frac{1}{20} \sum_{i=1}^{20} (2x_i - 2\bar{x})^2 = \frac{1}{20} \sum_{i=1}^{20} 4(x_i - \bar{x})^2$
 = $4 \left(\frac{1}{20} \sum_{i=1}^{20} (x_i - \bar{x})^2 \right) = 4 \times 5 = 20$

111. (a) $[\det(kA)]^{-1} \det(A) = \frac{1}{\det(kA)} \times \det(A)$

= $\frac{1}{k^n \det(A)} \times \det(A) = \frac{1}{k^n} = k^{-n}$

112. (d) We have, $f(x) = \begin{cases} x^3 - 3x + 2, & \text{for } x \neq 1 \\ k, & \text{for } x = 1 \end{cases}$

Since, the function is continuous

$\therefore \lim_{x \rightarrow 1} f(x) = f(1)$
 $\Rightarrow k = \lim_{x \rightarrow 1} \frac{x^3 - 3x + 2}{(x - 1)^2}$
 $\Rightarrow \lim_{x \rightarrow 1} \frac{(x - 1)^2 (x + 2)}{(x - 1)^2}$
 $\Rightarrow k = 1 + 2 = 3$

113. (b) $f \circ g(x) = f[g(x)] = f(3x + 4)$

Since, the domain of f is $[-3, 5]$.

$\therefore -3 \leq 3x + 4 \leq 5$
 $\Rightarrow |3x + 4| \leq 5$

$$\begin{aligned} \Rightarrow -5 &\leq 3x + 4 \leq 5 \\ \Rightarrow -9 &\leq 3x \leq 1 \\ \Rightarrow -3 &\leq x \leq \frac{1}{3} \end{aligned}$$

\therefore Domain of fog is $\left[-3, \frac{1}{3}\right]$.

114. (b) Let $\mathbf{a} = 4\hat{i} - 4\hat{k}$

and $\mathbf{b} = \hat{i} + \hat{j} + \hat{k}$ let θ be the angle between \mathbf{a} and \mathbf{b}

$$\begin{aligned} \therefore \cos \theta &= \frac{\mathbf{a} \cdot \mathbf{b}}{|\mathbf{a}||\mathbf{b}|} = \frac{(4\hat{i} - 4\hat{k}) \cdot (\hat{i} + \hat{j} + \hat{k})}{|\mathbf{a}||\mathbf{b}|} \\ &= \frac{4 + 0 - 4}{|\mathbf{a}||\mathbf{b}|} = 0 \end{aligned}$$

$$\Rightarrow \theta = 90^\circ$$

$$\begin{aligned} \sin \theta + \cos \theta &= \sin 90^\circ + \cos 90^\circ \\ &= 1 \end{aligned}$$

$$\begin{aligned} \mathbf{115. (b)} \lim_{\theta \rightarrow \frac{\pi}{4}} \frac{\sqrt{2} - \sqrt{2} \cos\left(\theta - \frac{\pi}{4}\right)}{16\left(\theta - \frac{\pi}{4}\right)^2} \\ = \lim_{y \rightarrow 0} \frac{\sqrt{2}(1 - \cos y)}{16y^2} \end{aligned}$$

$$\text{Where, } y = \theta - \frac{\pi}{4} \rightarrow 0 \text{ as } \theta = \frac{\pi}{4}$$

$$\begin{aligned} &= \frac{1}{8\sqrt{2}} \lim_{y \rightarrow 0} \frac{2\sin^2\left(\frac{y}{2}\right)}{y^2} \\ &= \frac{1}{8\sqrt{2}} \cdot \frac{1}{2} = \frac{1}{16\sqrt{2}} \end{aligned}$$

116. (b) Given that, mean = 0 and variance = σ^2

$$\text{Therefore, variance} = \sigma^2 = \frac{\sum X^2}{n} - \left(\frac{\sum X}{n}\right)^2$$

$$\Rightarrow \sigma^2 = \frac{\sum X^2}{n} - 0$$

$$\Rightarrow \sigma^2 = \frac{\sum X^2}{n}$$

$$\text{Now, } y = x^2$$

$$\Rightarrow \Sigma y = \Sigma x^2$$

$$\therefore \bar{y} = \frac{\Sigma X^2}{n} = \sigma^2$$

$$\begin{aligned} \mathbf{117. (b)} \lim_{n \rightarrow \infty} \left\{ \frac{1}{1-n^2} + \frac{2}{1-n^2} + \dots + \frac{n}{1-n^2} \right\} \\ = \lim_{n \rightarrow \infty} \frac{1+2+3+\dots+n}{1-n^2} \\ = \lim_{n \rightarrow \infty} \frac{\Sigma n}{1-n^2} = \lim_{n \rightarrow \infty} \frac{n(n+1)}{2(1-n^2)} \\ = \lim_{n \rightarrow \infty} \frac{1+\frac{1}{n}}{2\left[\frac{1}{n^2}-1\right]} = -\frac{1}{2} \end{aligned}$$

118. (c) Let θ be an angle between unit vectors \mathbf{a} and \mathbf{b} .

Then, $\mathbf{a} \cdot \mathbf{b} = \cos \theta$

$$\text{Now, } |\mathbf{a} + \mathbf{b}|^2 = |\mathbf{a}|^2 + |\mathbf{b}|^2 + 2\mathbf{a} \cdot \mathbf{b}$$

$$= 2 + 2\cos \theta = 4\cos^2 \frac{\theta}{2}$$

$$|\mathbf{a} - \mathbf{b}|^2 = |\mathbf{a}|^2 + |\mathbf{b}|^2 - 2\mathbf{a} \cdot \mathbf{b}$$

$$= 2 - 2\cos \theta = 4\sin^2 \frac{\theta}{2}$$

$$\therefore |\mathbf{a} + \mathbf{b}| = 2\cos \frac{\theta}{2}, |\mathbf{a} - \mathbf{b}| = 2\sin \frac{\theta}{2}$$

$$\therefore |\mathbf{a} + \mathbf{b}| + |\mathbf{a} - \mathbf{b}| = 2\left(\cos \frac{\theta}{2} + \sin \frac{\theta}{2}\right) \leq 2\sqrt{2}$$

119. (a) Since, $\alpha > 0$ (given) arrange the data in ascending order,

$$\alpha - \frac{7}{2}, \alpha - 3, \alpha - \frac{5}{2}, \alpha - 2, \alpha - \frac{1}{2}, \alpha + \frac{1}{2},$$

$$\alpha + 4, \alpha + 5$$

$$\text{Median} = \frac{\alpha - 2 + \alpha - \frac{1}{2}}{2} = \frac{2\alpha - \frac{5}{2}}{2} = \alpha - \frac{5}{4}$$

$$\mathbf{120. (a)} \text{ Since, } \left(1 - \frac{r_1}{r_2}\right) \left(1 - \frac{r_1}{r_3}\right) = 2$$

$$\Rightarrow \left(1 - \frac{s-b}{s-a}\right) \left(1 - \frac{s-c}{s-a}\right) = 2$$

$$\Rightarrow \frac{(b-a)(c-a)}{(s-a)^2} = 2$$

$$\begin{aligned} \Rightarrow 2bc - 2ab - 2ac + 2a^2 \\ = b^2 + c^2 + a^2 + 2bc \end{aligned}$$

$$- 2ab - 2ac$$

$$\Rightarrow a^2 = b^2 + c^2$$

So, triangle is right angled.

t.me/keampyq