JEE (Main) PHYSICS SOLVED PAPER

2023

12th April Shift 1

Section A

Q. 1. The ratio of escape velocity of a planet to the escape velocity of earth will be:
Given: Mass of the planet is 16 times mass of earth and radius of the planet is 4 times the radius of earth.
(1) 1 : 4 **(2)** 4 : 1 **(3)** 2 : 1 **(4)** $1:\sqrt{2}$

Q. 2. An engine operating between the boiling and freezing points of water will have
A. efficiency more than 27%
B. efficiency less than the efficiency of a Carnot engine operating between the same two temperatures.
C. efficiency equal to 27%
D. efficiency less than 27%
Choose the correct answer from the options given below:
(1) B and C only **(2)** B and D only
(3) B, C and D only **(4)** A and B only

Q. 3. A wire of resistance 160 Ω is melted and drawn in a wire of one-fourth of its length. The new resistance of the wire will be:
(1) 640 Ω **(2)** 40 Ω **(3)** 10 Ω **(4)** 16 Ω

Q. 4. Three forces $F_1 = 10$ N, $F_2 = 8$ N, $F_3 = 6$ N are acting on a particle of mass 5 kg. The forces F_2 and F_3 are applied perpendicularly so that particle remains at rest. If the force F_1 is removed, then the acceleration of the particle is :
(1) 4.8 m s^{-2} **(2)** 0.5 m s^{-2}
(3) 7 m s^{-2} **(4)** 2 m s^{-2}

Q. 5. Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.
Assertion A: EM waves used for optical communication have longer wavelengths than that of microwave, employed in Radar technology.
Reason R: Infrared EM waves are more energetic than microwaves, (used in Radar)
In the light of given statements, choose the correct answer from the options given below:
(1) A is true but R is false
(2) Both A and R are true and R is the correct explanation of A
(3) A is false but R is true
(4) Both A and R are true but R is NOT the correct explanation of A

Q. 6. If the r.m.s speed of chlorine molecule is 490 m s^{-1} at 27°C, the r.m.s. speed of argon molecules at the same temperature will be (Atomic mass of argon = 39.9 u, molecular mass of chlorine = 70.9 u)
(1) 651.7 m s^{-1} **(2)** 451.7 m s^{-1}
(3) 551.7 m s^{-1} **(4)** 751.7 m s^{-1}

Q. 7. Two satellites A and B move round the earth in the same orbit. The mass of A is twice the mass of B. The quantity which is same for the two satellites will be:
(1) Kinetic energy **(2)** Speed
(3) Total energy **(4)** Potential energy

Q. 8. Given below are two statements:
Statement I: When the frequency of an A.C. source in a series LCR circuit increases, the current in the circuit first increases, attains a maximum value and then decreases.
Statement II: In a series LCR circuit, the value of power factor at resonance is one.
In the light of given statements, choose the most appropriate answer from the options given below:
(1) Statement I is correct but Statement II is false.
(2) Both Statement I and Statement II are true.
(3) Statement I is incorrect but Statement II is true.
(4) Both Statement I and Statement II are false.

Q. 9. A particle is executing simple harmonic motion (SHM). The ratio of potential energy and kinetic energy of the particle when its displacement is half of its amplitude will be:
(1) 1 : 1 **(2)** 1 : 3
(3) 1 : 4 **(4)** 2 : 1

Q. 10. Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.
Assertion A : If an electric dipole of dipole moment 30×10^{-5} C m is enclosed by a closed surface, the net flux coming out of the surface will be zero.
Reason R : Electric dipole consists of two equal and opposite charges.
In the light of above statements, choose the correct answer from the options given below:
(1) Both A and R are true but R is NOT the correct explanation of A
(2) A is false but R is true
(3) Both A and R are true and R is the correct explanation of A
(4) A is true but R is false

Q. 11. Given below are two statements:
Statement I: The diamagnetic property depends on temperature.
Statement II: The induced magnetic dipole moment in a diamagnetic sample is always opposite to the magnetizing field.
In the light of given statements, choose the correct answer from the options given below.

(1) Both Statement I and Statement II are true.
(2) Both Statement I and Statement II are False.
(3) Statement I is correct but Statement II is false.
(4) Statement I is incorrect but Statement II is true.

Q. 12. Match List I with List II:

List I		List II	
A.	Spring constant	I.	$[T^{-1}]$
B.	Angular speed	II.	$[M\,T^{-2}]$
C.	Angular momentum	III.	$[M\,L^2]$
D.	Moment of Inertia	IV.	$[M\,L^2\,T^{-1}]$

Choose the correct answer from the options given below:
(1) A-II, B-III, C-I, D-IV
(2) A-IV, B-I, C-III, D-II
(3) A-I, B-III, C-II, D-IV
(4) A-II, B-I, C-IV, D-III

Q. 13. An ice cube has a bubble inside. When viewed from one side the apparent distance of the bubble is 12 cm. When viewed from the opposite side, the apparent distance of the bubble is observed as 4 cm. If the side of the ice cube is 24 cm, the refractive index of the ice cube is:
(1) $\frac{4}{3}$ **(2)** $\frac{3}{2}$ **(3)** $\frac{2}{3}$ **(4)** $\frac{6}{5}$

Q. 14. The amplitude of 15sin (100πt) is modulated by 10sin (4πt) signal. The amplitude modulated signal contains frequencies of:
A. 500 Hz B. 2 Hz
C. 250 Hz D. 498 Hz
E. 502 Hz
Choose the correct answer from the options given below:
(1) A and B only **(2)** A and D only
(3) A and C only **(4)** A, D and E only

Q. 15. A 12.5 e V electron beam is used to bombard gaseous hydrogen at room temperature. The number of spectral lines emitted will be:
(1) 2 **(2)** 3 **(3)** 4 **(4)** 1

Q. 16. A ball is thrown vertically upward with an initial velocity of 150 m s^{-1}. The ratio of velocity after 3 s and 5 s is $\frac{x+1}{x}$. The value of x is:
(take, $g = 10$ m s^2)
(1) 6 **(2)** 5 **(3)** –5 **(4)** 10

Q. 17. In an *n-p-n* common emitter (CE) transistor the collector current changes from 5 mA to 16 mA for the change in base current from 100 µA and 200 µA respectively. The current gain of transistor is:
(1) 110 **(2)** 9 **(3)** 0.9 **(4)** 210

Q. 18. A body cools from 80°C to 60°C in 5 minutes. The temperature of the surrounding is 20°C. The time it takes to cool from 60°C to 40°C is:
(1) 450 s **(2)** 500 s **(3)** 420 s **(4)** $\frac{25}{3}$ s

Q. 19. A proton and an α -particle are accelerated from rest by 2 V and 4 V potentials, respectively. The ratio of their de-Broglie wavelength is:
(1) 2 : 1 **(2)** 4 : 1 **(3)** 8 : 1 **(4)** 16 : 1

Q. 20. Given below are two statements:
Statement I: A truck and a car moving with same kinetic energy are brought to rest by applying breaks which provide equal retarding forces. Both come to rest in equal distance.
Statement II: A car moving towards east takes a turn and moves towards north, the speed remains unchanged.
The acceleration of the car is zero.
In the light of given statements, choose the most appropriate answer from the options given below:
(1) Statement I is correct but Statement II is incorrect.
(2) Statement I is incorrect but Statement II is correct.
(3) Both Statement I and Statement II are correct.
(4) Both Statement I and Statement II are incorrect

Section B

Q. 21. To maintain a speed of 80 km/h by a bus of mass 500 kg on a plane rough road for 4 km distance, the work done by the engine of the bus will be _____ kJ. (The coefficient of friction between tyre of bus and road is 0.04.)

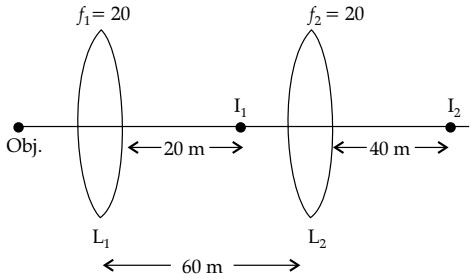
Q. 22. A conducting circular loop is placed in a uniform magnetic field of 0.4 T with its plane perpendicular to the field. Somehow, the radius of the loop starts expanding at a constant rate of 1 mm s^{-1}. The magnitude of induced emf in the loop at an instant when the radius of the loop is 2 cm will be _____ µV.

Q. 23. A common example of alpha decay is:
$^{238}_{92}U \rightarrow ^{234}_{90}Th + {}_2He^4 + Q$
Given :
$^{238}_{92}U = 238.05060\ u$
$^{234}_{90}Th = 234.04360\ u$
$^{4}_{2}He = 4.00260\ u$ and
$1u = 931.5\ MeVC^{-2}$
The energy released (Q) during the alpha decay of $^{238}_{92}U$ is _____ M e V.

Q. 24. 64 identical drops each charged upto potential of 10 mV are combined to form a bigger drop. The potential of the bigger drop will be _____ mV.

Q. 25. For a rolling spherical shell, the ratio of rotational kinetic energy and total kinetic energy is $\frac{x}{5}$. The value of x is _____.

Q. 26. Two convex lenses of focal length 20 cm each are placed coaxially with a separation of 60 cm between them.
The image of the distant object formed by the combination is at _____ cm from the first lens.



Q. 27. A compass needle oscillates 20 times per minute at a place where the dip is 30^o and 30 times per minute where the dip is 60^o. The ratio of total magnetic field due to the earth at two places respectively is $\frac{4}{\sqrt{x}}$. The value of x is.

Q. 28. For a certain organ pipe, the first three resonance frequencies are in the ratio of 1 : 3 : 5 respectively. If the frequency of fifth harmonic is 405 Hz and the speed of sound in air is 324 ms^{-1} the length of the organ pipe is _____m.

Q. 29. Glycerin of density 1.25×10^3 kg m^{-3} is flowing through the conical section of pipe. The area of cross-section of the pipe at its ends are 10 cm^2 and 5 cm^2 and pressure drop across its length is 3 N m^{-2}. The rate of flow of glycerin through the pipe is $x \times 10^{-5}$ m^3 s^{-1}. The value of x is _____.

Q. 30. The current flowing through a conductor connected across a source is 2 A and 1.2 A at 0°C and 100°C respectively. The current flowing through the conductor at 50°C will be _____ $\times 10^2$ mA.

Answer Key

Q. No.	Answer	Topic name	Chapter name
1	(3)	Escape velocity	Gravitation
2	(2)	Carnot engine	Thermodynamics
3	(3)	Resistivity	Current electricity
4	(4)	Force	Laws of motion
5	(3)	Applications of EMW	Electromagnetic waves
6	(1)	Speed of Gases	Kinetic theory of gases
7	(2)	Satellite system	Gravitation
8	(2)	Power factor	Alternating current
9	(2)	Energy in SHM	Oscillations
10	(3)	Electric flux	Electric charges and fields
11	(4)	Magnetic materials	Magnetism and matter
12	(4)	Dimensions	Units and dimesnions
13	(2)	Refraction	Ray optics
14	(4)	Modulation	Communication systems
15	(2)	Atomic spectrum	Atoms
16	(2)	Equations of motion	Motion in a straight line
17	(1)	Current gain	Semiconductor electronics
18	(4)	Newton's law of cooling	Thermal properties of matter
19	(3)	de-Broglie wavelength	Dual nature of radiation and matter
20	(1)	Kinetic energy	Work, energy and power
21	[8000]	Work	Work, energy and power
22	[50]	Induced EMF	Electromagnetic induction
23	[4.25]	Radioactive decay	Nuclei
24	[0.16]	Electric potenttial	Electrostatic potential and capacitance
25	[2]	Rotational kinetic energy	System of particles and rotational motion
26	[100]	Combination of lens	Ray optics
27	[243]	Dip	Magnetism and matter
28	[1]	Stationary waves in organ pipes	Waves
29	[4]	Equation of continuity, Bernoulli's equation	Mechanical properties of fluids
30	[15]	Resistivity	Current electricity

SOLUTIONS

Section A

1. Option (3) is correct.

Given, $M_e = M$, $R_E = R$

$M_p = 16M$, $R_P = 4R$

Escape velocity is given by, $V_e = \sqrt{\frac{2GM}{R}}$

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

On planet $v'_e = \sqrt{\frac{2GM \times 16}{4 \times R}} = \sqrt{4 \times \frac{2GM}{R}} = 2v_e$

Now, $\frac{v'_e}{v_e} = 2:1$

2. Option (2) is correct.

Given, $T_1 = 100°C = 100 + 273 = 373$ K

$T_2 = 0°C = 0 + 273 = 273$ K

Efficiency of Carnot Engine,

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\Rightarrow \quad \eta = 1 - \frac{273}{373} = \frac{100}{373} = 0.268$$

$$\Rightarrow \quad \%\eta = 0.268 \times 100 = 26.8\%$$

Clearly we can see efficiency is less than 27%.

3. Option (3) is correct.

Given, $R = \rho\frac{1}{A} = 160\ \Omega$

Now length $l' = \frac{l}{4}$, since volume remains same so $A' = 4A$

New resistance $R' = \rho\frac{l'}{A'}$

$$\Rightarrow \quad \rho\frac{\frac{l}{4}}{4A} = \frac{1}{16}\rho\frac{l}{A}$$

$$\Rightarrow \quad R' = \frac{1}{16} \times 160 = 10\Omega$$

4. Option (4) is correct.

Since F_1 is removed, So net force will be in between F_2 and F_3.

Net force, $F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos 90}$

$$\Rightarrow \quad F = \sqrt{8^2 + 6^2 + 0} = 10\ \text{N}$$

Acceleration, $a = \frac{F}{m} = \frac{10}{5} = 2\ \text{m s}^{-2}$

5. Option (3) is correct.

In optical communication, we use infrared wave so that attenuation is less, infrared waves has higher frequency and lower wavelength as compared to microwaves. So, assertion is incorrect.

6. Option (1) is correct.

Given, m_{Cl}=70.9 u m_{Ar}=39.9 u

r.m.s. speed of gases is given by, $v_{rms} = \sqrt{\frac{3RT}{m}}$

Clearly, $v_{rms} \propto \frac{1}{\sqrt{m}}$

$$\frac{v_{rms}(Ar)}{v_{rms}(Cl)} = \sqrt{\frac{m_{Cl}}{m_{Ar}}}$$

$$\Rightarrow \quad v_{rms}(Ar) = 490\sqrt{\frac{70.9}{39.9}} = 653.33\ \text{m s}^{-1}$$

$$\approx 651.7$$

7. Option (2) is correct.

Speed of satellite moving in an orbit of radius r,

$$v = \sqrt{\frac{GM}{r}}$$

Here, M is mass of earth. Since radius of orbit is same and mass of satellite does have no impact on their speed, hence speed will be same.

8. Option (2) is correct.

Impedance, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$$= \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)} = \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$$

As we increase f, Z decrease as and When $X_L = X_C$, impedance is minimum, again it will start increasing. So current first increases, but then current will reduce. At resonance, $X_L = X_C$, hence impedance becomes purely resistive, i.e. $R = Z$

Power factor, $\cos\phi = \frac{R}{Z} = 1$

Hence, both statements are correct.

9. Option (2) is correct.

Given, $x = \frac{A}{2}$

In SHM, $\text{KE} = \frac{1}{2}m\omega^2[A^2 - x^2]$

$$\text{KE} = \frac{1}{2}m\omega^2\left[A^2 - \frac{A^2}{4}\right] = \frac{1}{2}m\omega^2\left[3\frac{A^2}{4}\right] \quad ...(i)$$

In SHM, $\text{PE} = \frac{1}{2}m\omega^2x^2$

$$\text{PE} = \frac{1}{2}m\omega^2\frac{A^2}{4} \quad ...(ii)$$

On dividing eq. (ii) by eq. (i), we get

$$\frac{\text{PE}}{\text{KE}} = \frac{1}{3}$$

10. Option (3) is correct.

Dipole is made of equal and opposite charges, so net charge of surface containing dipole is zero.

So, $\phi = \frac{q}{\varepsilon_0} = \frac{0}{\varepsilon_0} = 0$

Hence both statements are correct and R is the correct explanation of Assertion.

11. Option (4) is correct.

Diamagnetic materials are repelled by magnetic field, so induced magnetic dipole moment is in opposite direction. Net magnetic momentum of diamagnetic material is always zero so it does not depend upon temperature. Thus, I is incorrect but II is correct.

12. Option (4) is correct.

(A) Spring constant, $F = kx$

$$k = \frac{F}{x} = \frac{\text{kg m s}^{-2}}{\text{m}} = \text{kg s}^{-2}$$
$$= [M^1 L^0 T^{-2}]$$

(B) Angular speed, $\omega = \frac{2\pi}{\text{T}} = [M^0 L^0 T^{-1}]$

(C) Angular momentum, $L = Mvr$

$$L = \text{kg m s}^{-1}\ \text{m} = [M^1 L^2 T^{-1}]$$

(D) Moment of inertia, $I = MR^2 = \text{kg m}^2 = [M^1 L^2 T^0]$

13. Option (2) is correct.

Given, Refractive index of air, $\mu_2 = 1$

Refractive index of glass, $\mu_1 = ?$

When viewed from one side,

$$\frac{\mu_2}{\mu_1} = \frac{\text{Apperant depth}}{\text{Real depth}} = \frac{12}{d}$$

$$\Rightarrow \quad \frac{1}{\mu_1} = \frac{12}{d} \Rightarrow d = 12\mu_1$$

Similarly from other end

$$\Rightarrow \quad d' = 4\mu_1$$

Given, $d + d' = 24$ m

$$\Rightarrow \quad 12\mu_1 + 4\mu_1 = 24$$

$$\Rightarrow \quad \mu_1 = \frac{24}{16} = \frac{3}{2} \text{ or } 1.5$$

14. Option (4) is correct.

Given, $\omega_C = 1000\pi$, $\omega_m = 2\pi$

$$f_C = \frac{1000\pi}{2\pi} = 500 \text{ Hz}$$

$$f_m = \frac{4\pi}{2\pi} = 2\text{Hz}$$

Range of frequency = (500 – 2), (500), (500 + 2)
= 498 Hz, 500 Hz, 502 Hz

15. Option (2) is correct.

Given, $\Delta E = 12.5\ eV$, $n_1 = 1$ and $n_2 = n$

Energy absorbed by electrons, $\Delta E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$$12.5 = 13.6\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

$$\Rightarrow \quad 0.919 = 1 - \frac{1}{n^2} \Rightarrow \frac{1}{n^2} = 0.081 \Rightarrow n \approx 3.5$$

So, $n^2 = n = 3$

No. of transactions from 3rd level to 1st level is 3. i.e. $(3 \to 2, 3 \to 1, 2 \to 1)$

16. Option (2) is correct.

Given, $u = 150\ \text{m s}^{-1}$, $t_1 = 3$ s, $t_2 = 5$ s

$$v_1 = u + at_1 = 150 - 10 \times 3 = 120$$
$$v_2 = u + at_2 = 150 - 10 \times 5 = 100$$

Now, $\frac{v_1}{v_2} = \frac{120}{100} = \frac{6}{5} = \frac{x+1}{x}$

On comparing we get, $x = 5$

17. Option (1) is correct.

Given, $\Delta I_C = 11$ mA, $\Delta I_B = 100\ \mu A$

Current gain, $\beta = \frac{\Delta I_C}{\Delta I_B}$

$$\beta = \frac{11 \times 10^{-3}}{100 \times 10^{-6}} = 110$$

18. Option (4) is correct.

Given, temperature of surrounding,

$T_0 = 20°C$

As per Newton's law of cooling,

$$\frac{dT}{dt} = -k(T - T_0)$$

$$\frac{80 - 60}{5} = k(70 - 20)$$

$$\& \ \frac{60 - 40}{t} = k(50 - 20)$$

$$\frac{4t}{20} = \frac{50}{30} \Rightarrow t = \frac{25}{3} \text{ sec}$$

19. Option (3) is correct.

Given, $m_p = m$, $m_\alpha = 4m$

$V = 2$ V, $V' = 4$ V

de-Broglie wavelength, $\lambda = \frac{1}{\sqrt{2mqV}}$

$$\lambda_P = \frac{1}{\sqrt{2mq2V}} \quad \text{...(i)}$$

$$\lambda_\alpha = \frac{1}{\sqrt{2 \times 4m \times 2q \times 4V}} \quad \text{...(ii)}$$

On dividing eq. (i) in eq. (ii), $\frac{\lambda_P}{\lambda_\alpha} = \frac{4}{1}$

$$\lambda_P : \lambda_\alpha = 4 : 1$$

20. Option (1) is correct.

Acceleration depends upon velocity not on speed. As car took turn, its velocity changed due to change in direction hence acceleration can't be zero. Hence, statement II is wrong.

Section B

21. The correct answer is (8000).

Given, speed of bus, $v = 80$ km/h

Mass of bus, $m = 500$ kg

Distance to be covered, $d = 4$ km

Coefficient of friction, $\mu = 0.04$

To keep a bus going, it must overcome friction, hence

$F = \mu mg$

$F = 0.04 \times 5000 = 200$ N

Work done, W = Force × displacement

$W = 200 \times 4000 = 8000$ kJ

22. The correct answer is (50).

Given, B= 0.4 T, $r = 2$ cm

$$\varepsilon = \frac{d\phi}{dt} = \frac{d(B\pi r^2)}{dt} = B2\pi r\frac{dr}{dt}$$

$$\varepsilon = 2\times\frac{22}{7}\times 2\times 10^{-2}\times 0.4\times 1\times 10^{-3}$$

$\varepsilon = 50 \times 10^{-6}$ or 50 μV

23. The correct answer is (4.25).

$Q = \Delta E = \Delta mc^2$

$= [m_u - (m_{Th} + m_{He})]c^2$

$= [238.05060 - 234.04360 - 4.00260]c^2$

$= 0.00456c^2 \times \frac{931}{c^2}$ Me V

$= 4.25$ Me V

24. The correct answer is (0.16).

$V' = Vn^{2/3}$

$\Rightarrow V' = 10 \times 10^{-3} \times 64^{2/3} = 0.16$ volt

25. The correct answer is (2).

For a spherical rolling shell,

$$KE_{translational} = \frac{1}{2}mV^2$$

$$KE_{rotational} = \frac{1}{2}\times\frac{2}{3}mR^2\left(\frac{V}{R}\right)^2$$

$$= \frac{1}{3}mV^2$$

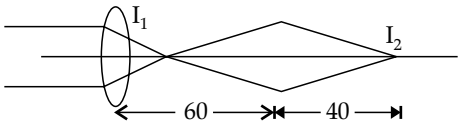
$$KE_{Total} = KE_{rotational} + KE_{translational}$$
$$= \frac{1}{3}mV^2 + \frac{1}{2}mV^2 = \frac{5}{6}mV^2$$

Now, $\frac{KE_{rotational}}{KE_{total}} = \frac{\frac{1}{3}mV^2}{\frac{5}{6}mV^2} = \frac{2}{5}$

Comparing with $\frac{x}{5}$, we get $x = 2$

26. The correct answer is (100).

Given, $f_1 = f_2 = 20$ cm



For 1st lens, $\frac{1}{v} - \frac{1}{\infty} = \frac{1}{20}$

$\Rightarrow v = 20$ cm

For 2nd lens, $\frac{1}{v'} - \frac{1}{-40} = \frac{1}{20}$

$\Rightarrow v' = 40$ cm

Therefore the distance between first lens and I_2 is

$= 60 + 40 = 100$ cm

27. The correct answer is (243).

Period of oscillations, $T \propto \frac{1}{\sqrt{B_H}}$

$$\frac{T_1}{T_2} = \sqrt{\frac{B_2\cos\theta_2}{B_1\cos\theta_1}} \Rightarrow \frac{30}{20} = \sqrt{\frac{B_2\cos 60°}{B_1\cos 30°}}$$

On squaring both sides,

$$\Rightarrow \frac{9}{4} = \frac{B_2\times\frac{1}{2}}{B_1\frac{\sqrt{3}}{2}} \Rightarrow \frac{B_1}{B_2} = \frac{4}{9\sqrt{3}} = \frac{4}{\sqrt{243}} = \frac{4}{\sqrt{x}}$$

$\Rightarrow x = 243$

28. The correct answer is (1).

Resonance frequency in closed organ pipe is given by $f = (2n+1)\frac{v}{4l}$

For 5th harmonic, $405 = 5\times\frac{324}{4l}$

$$l = \frac{324\times 5}{405\times 4} = 1 \text{ m}$$

29. The correct answer is (4).

Given, $\rho = 1.25 \times 10^3$ kg m^{-3}

$A_1 = 10$ cm^2, $A_2 = 5$ cm^2

Pressure drop, $\Delta P = 3$ Nm^{-2}

As per Bernoulli's theorem,

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho gh = P_2 + \frac{1}{2}\rho V_2^2 + \rho gh$$

$$\Rightarrow P_1 - P_2 = \frac{1}{2}\rho(V_2^2 - V_1^2) \quad ...(i)$$

According to equation of continuity, $A_1V_1 = A_2V_2$

$$\Rightarrow V_1 = \frac{A_2V_2}{A_1}$$

Substituting value of V_1 in eq (i),

$$P_1 - P_2 = \frac{1}{2}\rho\left[1 - \left(\frac{A_2}{A_1}\right)^2\right]V_2^2$$

$$3 = \frac{1}{2}\times 1.25\times 10^3\left(1 - \left[\frac{5}{10}\right]^2\right)V_2^2$$

$\Rightarrow V_2 = 8 \times 10^{-2}$ m s^{-1}

Discharge rate, $A_2V_2 = 5 \times 10^{-4} \times 8 \times 10^{-2}$

$= 4 \times 10^{-5}$ m^3 s^{-1}

Comparing with $x \times 10^{-5}$, we get $x = 4$

30. The correct answer is (15).

Since votlage is same,

so $V_0 = V_{100}$

$\Rightarrow i_0R_0 = i_{100}R_{100}$

$\Rightarrow 2R_0 = 1.2R_0(1 + \alpha\Delta T)$

$\Rightarrow 1 = 0.6\,(1 + \alpha(100 - 0))$

$\Rightarrow \alpha = \frac{1}{150}$

Now, $R_{50} = R_0(1 + \alpha\Delta T)$

$$= R_0\left(1 + \frac{1}{150}(50 - 0)\right) = \frac{4}{3}R_0$$

Similarly, $V_0 = V_{50}$

$$\Rightarrow 2R_0 = i_{50}\times\frac{4}{3}R_0$$

$$i_{50} = \frac{6}{4} = 1.5 \text{ A or } 15\times 10^2 \text{ mA}$$

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