QB365

Model Question Paper 3

11th Standard CBSE

Physics

Reg.No. :

Time : 02:00:00 Hrs

Total Marks : 100

Section-A

1) If 4 : 9 is ratio of densities of two gases at the given temperature.Find out the ratio of their rms speeds? **1**

2) Name an experimental evidence in support of random motion of gas molecules. **1**

3) What is mean free path of a gas? **1**

4) What would be the effect on the time period if the amplitude of a simple pendulum increases? **1**

5) Write the relation between time period T, displacement x and acceleration a of a particle in SHM. **1**

6) If the body is given a small displacement from the mean position, a force comes in to play which tends to bring the body back to the mean point, this give rise to vibration. Define phase of a vibrating particle. **1**

7) The velocity of sound in a tube conatining air at 27^{0}C and a pressure of 76 cm of mercury is 330 m / s. What will it be when pressure is increased to 100 cm. of mercury and the temperature is kept constant? **1**

8) In case of a stationary wave, where will a man hear maximum sound, at the node or at the antinode? **1**

9) Two tuning forks of frequencies 250 Hz and 252 Hz are being vibrated simultaneously. Ff a loud sound is produced just now, after what time would the sound be agin equally loud? **1**

10) Does a vibrating source always produce sound? **1**

Section-B

11) If value of most probable speed for an ideal gas is 500 m/s. Find the value of root mean square speed for this gas. **2**

12) Find the temperature at which rms speed of a gas is half of its value of 0^{0}C, pressure remaining constant. **2**

13) Estimate the total number of air molecules (inclusive of oxygen, nitrogen, water vapour and other constituents) in a room of capacity 25.0 m^3 at a temperature of 2^{0}C and 1 atm pressure .(k_B = 1.38 x 10^{-23} JK^{-1}) **2**

14) Calculate the number of degrees of freedom in 15 cm^3 of nitrogen at NTP. **2**

15) A diatomic gas is heated in a vessel to a temperature of 10000K.If each molecules possess an average energy E_1. After sometime, a few molecule escape into the atmosphere at 300K. Due to which, their energy changes to E_2. Calculate the ratio of $\frac{E_1}{E_2}$. **2**

16) A simple harmonic motion given by $x = 6.0 \quad cos\left(100t + \frac{\pi}{4}\right)$ where x is in cm and t in second. What is the (i) displacement amplitude, (ii) frequency? **2**

17) A simple harmonic motion given by $x = 6.0 \quad cos\left(100t + \frac{\pi}{4}\right)$ where x is in cm and t in second. What is the displacement amplitude **2**

18) Justofy the following statements. **2**
The time period of a simple pendulumwill get doubled if its length is increased four times.

19) A body of mass 12 kg is suspended by coil spring of natural length 50 cm and force constant 2.0x10^{3}Nm^{-1}. What is the streched length of the spring?If the bosy is pulled down further streching the spring to a length of 5.9 cm and then released,then what is the frequencyof oscillation of the suspended mass? **2**

20) A particle excutes SHM of period 8 s. After what time of its passing through the mean position will be energy be half kinetic and half potential? **2**

21) Which of the following examples represent periodic motion? **2**
An arrow released from a bow.

22) Which of the following examples represent (nearly) simple harmonic motion and which represent periodic but not simple harmonic motion? **2**
Motion of a ball bearing inside a smooth curved bowl, when released from a point slightly above the lowermost point.

23) A narrow sound pulse (e.g. a short pip by a whistle) is sent across a medium. **2**
If the pulse rate is 1 after every 20 s, (that is the whistle is blow for a split of second after every 20 s), is the frequency of the note produced by the whistle equal to 1/20 or 0.05 Hz?

24) Equation of a plane progressive wave is given by y=0.6 $\sin 2\pi\left(t - \frac{x}{2}\right)$ **2**
On reflection from a denser medium, its amplitude becomes 2/3 of the amplitude of incident wave. What will be equation of reflected wave?

25) You have learnt that a travelling wave in one dimension is represented by a function y=f(x,t) where, x and t must appear in the combination x-vt or x+vt, i.e. y=f(x ± vt). Is the converse true? Examine if the following functions for Y can possibly represent a travelling wave **2**
$(x-vt)^2$

26) Three moles of a diamotic gas is mixed with two moles of monoatomic gas.What will be the molecular specific heat of the mixture at constant volume? [given,R=8.31 J mol^{-1}K^{-1}] **2**

27) A bodyoscillates with SHM according to the equation x(t) $= 5cos\left(2\pi t + \frac{\pi}{4}\right)$, where x is in metres and t is in seconds. **2**

Calculate the following

angular freuency

28) When the mass is displaced a little to one side, one spring gets compressed and another is elongated.Due to which the combination of sp[rings. Here, effective spring factor k will be given by $k = k_1 + k_2 = 600 + 600 = 1200Nm^{-1}$ **2**

29) Answer the following question **2**

A man with a wristwatch on his hand falls from the top of a tower.Does the watch give correct time during the free fall?

30) Answer the following question **2**

What is thefrequency of oscillation of a simple pendulum mounted in a cabin that is freely falling under gravity?

Section-C

31) A vessel contains two non-reacting gases, i.e. neon (monoatonic) and oxygen (diatomic). The ratio of their partial pressures is 3:2. Estimate the ration of number of molecules **5**

32) A vessel contains two non-reacting gases, i.e. neon (monoatonic) and oxygen (diatomic). The ratio of their partial pressures is 3:2. Estimate the ration of **5**

33) The average speed of air molecules is 485 m/s.At STP the number density is $2.7 \times 10^{25}/m^3$ and diameter of the air molecule is $2 \times 10^{-10}m$ .Find the value if mean free path (λ) for the air molecule and average time (τ) between successive collisions. **5**

34) The vertical motion of a huge piston in machine is simple harmonic with a frequency of 0.50 s^{-1}. A block of 10 kg is placed on the piston. What is the maximum amplitude of the piston's SHM for the block and the piston to remain together? **5**

35) A box of 1.00 m^3 is filled with nitrogen at 1.5 atm at 300 K. The box has a hole of an area 0.010 mm^2 . How much time is required for the pressure to reduce by 0.10 atm, if the pressure outside is 1 atm. **5**

36) An electric bulb of volume 250 cm^3 was sealed off during manufacture at a pressure of 10^{-3} mm of mercury at 27^0C. Compute the number of air molecule contained in the bulb.Given that, molecules contained in the bulb. Given that, R=8.31 J/mol/K N_A=$6.02 \times 10^{23} mol^{-1}$. **5**

37) A gas in equilibrium has uniform density and pressure throughout its volume.This is strictly true only if there are no external influences.A gas column under gravity,e.g. does not have uniform density(and pressure).As you might except, its density decreases with height.The precise dependence is given by the so called law of atmosphere. **5**

n_2=n_1 exp[-mg(h_2-h_1)/k_BT]

Where, n_2 and n_1 refer to number density at heights h_2 and h_1, respectively. Use this relation to derive the equation for sedimentation equilibrium of a suspension in a liquid column.

$$n_2 = n_1 \quad exp\left[-mg \quad N_A(\rho - \rho^{'})(h_2 - h_1)/(\rho RT)\right]$$

Where, ρ is the density of the suspended particle and $\rho^{'}$, that of surrounding medium.

[∵ N_A is Avogadro's number and R is the universal gas constant.]

38) A train, standing in station-yard blows a whistle of frequency 400 Hz in still air. The wind starts blowing in the direction from the yard to the station with a speed of $10ms^{-1}$. What are the frequency, wavelength and speed of sound for an observer standing on the station's platform? Is the situation exactly identical to the case when the air is still and the observer runs towards the yard at a speed of $10ms^{-1}$? The speed of sound in still air can be taken as 340ms^{-1} **5**

39) Use the formula, $v = \sqrt{\frac{Yp}{\rho}}$ to explain, why the speed of sound in air **5**

(i) is independent on pressure

(ii) increases with temperature

(iii) increases with humidity

40) In the given progressive wave, **5**

Where, y and x are in m,t is in seconds. What is the wave velocity?

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Section-A

1) 3:2 **1**

2) Brownian motion and diffusion of gases provide experimental evidence in support of random motion of gas molecules. **1**

3) The average distance travelled by molecules between two successive collisions is known as mean free path of the molecule. **1**

4) . **1**

5) . **1**

6) The phase of a vibrating particle at any instant of time is the state of particle as regards to its position and state of motion. **1**

7) will remain same **1**

8) . **1**

9) . **1**

10) A vibrating source produced when it vibrates in a medium and frequency of vibration lies within the audible range (20 Hz to 20 KHz). **1**

Section-B

11) 390 m/s **2**

12) 68.25 K **2**

13) Given V = 25.0 m^3, T = 273 + 27 = 300 K **2**

$k_B = 1.38 \times 10^{-23}\ JK^{-1}$

Now, pV = μRT

$\Rightarrow$ pV = μ ($N_A k_B$) T

$\Rightarrow$ pV = $\mu N' k_B T$

[N' is total number of molecules]

$\therefore \quad N' = \frac{pV}{K_B T}$

$= \frac{(1.01 \times 10^5) \times 25}{(1.38 \times 10^{-23}) \times 300}$

$= 6.10 \times 10^{26}$

14) Number of nitrogen molecules in 22400 cm^3 of gas at NTP=6.023x10^{23} **2**

$\therefore$ Number of nitrogen molecules in 15cm^3 of gas at NTP

$= \frac{6.023 \times 10^{23} \times 15}{22400} = 4.03 \times 10^{20}$

Number of degrees of freedom of nitrogen (diatomic) molecule at 273K=5

$\therefore$ Total degrees of freedom of 15cm^3 of gas

=4.03x10^{20}x5=2.015x10^{21}

15) Number of degrees of freedom of diatomic gas at 10000K=7. **2**

Number of degrees of freedom of diatomic gas at 300K=5

$\therefore \frac{E_1}{E_2} = \frac{(\frac{7}{2}) k_B T_1}{(\frac{5}{2}) k_B T_2} = \frac{7}{5} \times \frac{T_1}{T_2} = \frac{7}{5} \times \frac{10000}{300} = \frac{140}{3}$

16) (i) -6.0cm **2**

(ii) 16 Hz

17) 16 Hz **2**

18) Time period of simple pendulum, **2**

$T = 2\pi\sqrt{\frac{l}{g}}$ i.e., $T\alpha\sqrt{l}$

Clearly, if the length is increased four times, the time period gets doubles.

19) Given m=12Kg, original length l=50cm **2**

K =2.0x10^3 Nm^{-1}

F =ky

$y = \frac{F}{k} = \frac{mg}{k} = \frac{12 \times 9.8}{2 \times 10^3} = 5.9 \times 10^{-2} m = 5.9 \quad cm$

Stretched length of the spring = l + y = 50+55.9 cm

=105.9cm

Frequency of oscillations, $\nu = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$= \frac{1}{2 \times 3.14}\sqrt{\frac{2 \times 10^3}{12}} = 2.06 s^{-1}$

20) Given PE=KE **2**

i.e $\frac{1}{2} m\omega^2 x^2 = \frac{1}{2} m\omega^2 (A^2 - x^2)$

$x^2 = A^2 - x^2 \Rightarrow x = \frac{A}{\sqrt{2}} Now \quad x = A \quad sin \quad \omega t = A \quad sin\left(\frac{2\pi}{T}\right) tSo, \quad \frac{A}{\sqrt{2}} = A \quad sin 2\pi\frac{t}{8} or \quad sin\frac{\pi t}{4} = \frac{A}{\sqrt{2}} = sin\frac{\pi}{4} or \quad \frac{\pi t}{4} = \frac{\pi}{4} \quad or \quad t = 1s$cbse-11-phy-aio-c14-546-

21) There is no repetition, hence not periodic. **2**

22) A periodic motion, oscillatory in nature about lower most point as mean position following SHM force law, hence, it is SHM. **2**

23) 0.05 Hz will be the frequency of repetition of the short pip. **2**

24) On reflection from the denser medium, there will be a phase change of 180^0 **2**

Net amplitude = $\frac{2}{3} \times 0.6 = 0.4$

Hence, equation of reflected wave will be

y=0.4sin $2\pi\left[t + \frac{x}{2} + \pi\right] = 0.4 sin 2\pi(t + x/2)$

25) **2**

Conceptual question based on fundamentals of characteristics of travelling wave.

The converse is not true means if the function can be represented in the form y=f(x $\pm$ vt), it does not necessarily express a travelling wave. As the essential condition for a travelling wave is that the vibrating particle must have finite displacement value for all x and t.

For x = 0,

If t $\rightarrow$ 0, then $(x-vt)^2 \rightarrow 0$ which is finite, hence, it is a wave as it passes the two tests.

26) 2

$For \quad a \quad monoatomic \quad gas, \quad i.e. \gamma = \frac{5}{3} C_{V_\gamma} = \frac{R}{\gamma - 1} = \frac{R}{\frac{5}{3} - 1} = \frac{3}{2} R For \quad a \quad diamotic \quad gas, \quad i.e. \quad \gamma = \frac{7}{5} C_V = \frac{R}{\frac{7}{5} - 1} = \frac{5}{2} R By \quad conservation \quad of \quad energy, C_{V_{mixture}} = \frac{\mu_1 C_{V_1} + \mu_2 C_{V_2}}{\mu_1 + \mu_2}$

27) 6.28 s^{-1} 2

28) $T = 0.314 \quad s, \quad v_{max} = 1 ms^{-1}, \quad E = 1.5 \quad J$ 2

29) Yes, sice the motion of hands of a wristwatch to indicate time depends on action of the spring and has nothing to do with acceleration due to gravity. 2

30) In a free fall the effective g=0,i.e. gravity disappears 2

Time period $T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{l}{0}} = \infty$

Frequency, $v = \frac{1}{T} = 0$

i.e. frequency of oscillation is zero.

Section-C

31) As V and T are same for the two gases, we can write 5

$_{\rho Nc}V = {}_{\mu Nc}RTand \quad \rho_{O_2}V = {}_{\mu O_2}RTor \qquad \frac{p_{Ne}}{p_{O_2}} = \frac{\mu_{Ne}}{\mu_{O_2}} \therefore \qquad \frac{p_{Ne}}{p_{O_2}} = \frac{2}{3} \Rightarrow \frac{\mu_{Ne}}{\mu_{O_2}} = \frac{3}{2}$

In N_{Ne} and N_{O_2} are the number of molecules of the two gases and N_A is Avogadro's number, then

$\frac{\mu_{Ne}}{\mu_{O_2}} = \frac{N_{Ne}/N_A}{N_{O_2}/N_A} = \frac{3}{2} \Rightarrow \frac{N_{Ne}}{N_{O_2}} = 1.5$

32) Now, $\mu_{O_2} = \frac{m_{O_2}}{M_{O_2}} \quad and \quad \mu_{Ne} = \frac{m_{Ne}}{M_{Ne}}$ 5

$\therefore \frac{\rho_{Ne}}{\rho_{O_2}} = \frac{m_{Ne}/V}{m_{O_2}/V} = \frac{m_{Ne}}{m_{O_2}} = \frac{\mu_{Ne}M_{Ne}}{\mu_{O_2}M_{O_2}} \qquad = \frac{3}{2} \times \frac{20.2}{32} = 0.947$

33) To find the mean free path, we need the values of d and n. Just put these values in the formula of mean free path. 5

$\lambda = \frac{1}{\sqrt{2}n\pi d^2} = \frac{1}{\sqrt{2}\pi \times 2.7 \times 10^{25}(2 \times 10^{-10})^2} \quad = 2.9 \times 10^{-7} m The \quad value \quad of \quad \tau = \frac{l}{v} Now, \quad put \quad the \quad values \quad and \quad get \quad value \quad of \quad \tau. \tau = \frac{2.9 \times 10^{-7}}{485} = 5.9 \times 10^{-10} s.$

34) As, $v = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ 5

$k = 4\pi^2 m v^2$

For maximum displacement $y_{max} = A$

Maximum restoring force,

F=-kA=-mg

or $A = \frac{mg}{k} = \frac{mg}{4\pi^2 m v^2} = \frac{g}{4\pi^2 v^2} = \frac{9.8}{4 \times (3.14)^2 \times (0.50)^2} = 0.99 m$

35) **Ans.** $1.38 \times 10^5 s$ 5

36) **Ans.** 8×10^{15} 5

37) According to the law of atmospheres. 5

$n_2 = n_1 \quad exp. \left[-\frac{mg}{K_B T}\left(h_2 - h_1\right) \right] - - \quad (i)$

where, n_2 and n_1 refer to number density of particles at heights h_2 and h_1, respectively.

If we consider the sedimentation equilibrium of suspended particles in a liquid, then in place of mg, we will have to take effective weight of the suspended particles.

Let, V=average volume of a suspended particle,

ρ= density of suspended particle, ρ' =density of liquid, m=mass of one suspended particle, m' =mass of equal volume of liquid displaced.

According to Archimedes' priciple, effective weight of one suspended particle

=Actual weight-weight of liquid displaced = mg-m'g

$= mg - V\rho' g = mg - \left(\frac{m}{\rho}\right)\rho' g = mg\left(1 - \frac{\rho'}{\rho}\right) Also, \quad Boltzmann \quad constant, K_B = \frac{R}{N_A}$

where, R is gas constant and N_A is Avogadro's number.

$putting, \quad mg\left(1 - \frac{\rho'}{\rho}\right) in \quad place \quad of \quad mg \quad and \quad value \quad of \quad K_B \quad in Eq. (i) \quad we \quad get n_2 = n_1 exp\left[-\frac{mgN_A}{RT}\left(1 - \frac{\rho'}{\rho}\right)\left(h_2 - h_1\right) \right], \quad which \quad id \quad required \quad relation.$

38) Here, given v=400Hz 5

$v_w = 10m/s$=speed of wind

speed of sound in still air = 340 m/s

As the wind is blowing in the same direction as wave hence, effective speed of sound

$= v + v_w = 340 + 10 = 350m/s$ On the platform as both source and observer are at rest, hence, frequency remains unchanged v=400 Hz.

Wavelength, $\lambda = \frac{v+v_w}{v}\frac{350}{400} = 0.875 \quad m$

When air is still $v_w = 0$ observer's speed = v_0=10ms^{-1};$v_s = 0$As observer moves towards the source

$$v' = \frac{v+v_0}{v} \times v \Rightarrow v'\left(\frac{340+10}{340}\right) \times 400 = \left(\frac{350}{340}\right) \times 400 = \left(\frac{35}{34}\right)(400) = 411.76 \quad Hz$$

As source is at rest wavelength dos not change,

Speed of sound will remain same=340m/s

It is obvious that both the cases are different.

39) (i) Effect of pressure 5

$$v \quad speed \quad of \quad sound \quad in \quad a \quad gas = \sqrt{\frac{Yp}{\rho}} p = pressure, \quad \rho = density, \frac{M}{V} \Rightarrow V = \sqrt{\frac{YpV}{M}}$$

When T is constant, pV = constant ⇒ v = constant

Hence, velocity of sound is independent of the change in pressure of the gas provided temperature remains constant

(ii) Formula for Velocity, $v = \sqrt{\frac{Yp}{\rho}}$

According to standard gas equation,

$$pV = RT \Rightarrow \rho = \frac{RT}{V} \Rightarrow v = \sqrt{\frac{Y \times RT}{pV}} = \sqrt{\frac{YRT}{M}}$$

Where M = pV = molecule weight of the gas

$\Rightarrow v \propto \sqrt{T}$

Hence, v increases with temperature.

(iii) Due to pressure of water vapours in air density changes. Hence, velocity of sound changes with humidity.

Let ρ_m=density of moist ρ_d=density of dry air

v_m=velocity of sound in moist air

v_d =velocity of sound in dry air

$$v_m = \sqrt{\frac{Yp}{\rho_m}}. v_d = \sqrt{\frac{Yp}{\rho_d}} \frac{v_m}{v_d} = \sqrt{\frac{\rho_d}{\rho_m}} as \rho_d > p_m \Rightarrow v_m > v_d$$

40) Wave velocity, v=$v\lambda$=50X5=250m/s 5