PRACTICE SET -4

1. In Young's double slit experiment the light emitted from source has $\lambda = 6.5 \times 10^{-7}$ m and the distance between the two slits is 1 mm. Distance between the screen and slit is 1 metre. Distance between third dark and fifth birth fringe will be:
   a. 3.2 mm b. 1.63 mm
   c. 0.585 mm d. 2.31 mm

2. A radar operates at wavelength 50.0 cm. If the beat frequency between the transmitted signal and the signal reflected from aircraft (Δv) is 1 kHz, then velocity of the aircraft will be:
   a. 800 km/hr b. 900 km/hr
   c. 1000 km/hr d. 1032 km/hr

3. Find the values of magnetic field between plates of capacitor at distance 1 m from centre where electric field varies by 10^{10} volt / m/s.
   a. 5.56×10^{-8}T b. 5.56×10^{-3}T
   c. 5.56μT d. 5.56 T

4. In the question no.18, the energy density at a distance 4 m from the source will be (in joules /m^3):
   a. 1.33×10^{-6} b. 1.33×10^{-7} c. 1.33×10^{-8} d. 1.33×10^{-9}

5. The momentum of the photon of wavelength 5000 Å will be:
   a. 1.3×10^{-27} kg- m/sec b. 1.3×10^{-28} kg- m/sec
   c. 4×10^{29} kg- m/sec d. 4×10^{-18} kg- m/sec

6. Five elements A, B, C, D and E have work functions 1.2 eV, 2.4 eV, 3.6 eV, 4.8 eV and 6 eV respectively. If light of wavelength 4000 Å is allowed to fall on these elements, then photoelectrons are emitted by:
   a. A, B and C b. A, B, C, D and E
   c. A and B d. Only E

7. The specific charge of proton is 9.6×10^{7} coul/kg. That for α-particle will be:
   a. 2.4×10^7 coul/kg b. 4.8×10^7 coul/kg
   c. 19.2×10^7 coul/kg d. 38.4×10^7 coul/kg

8. A beam of α-particles moving with velocity 10^5 m/s enters a region of electric and magnetic fields. All the three vectors $\vec{\upsilon}, \vec{E}$ and $\vec{B}$ are mutually perpendicular and the strength of electric field is 2×10^4 V/m. If the beam passes undeflected, then the strength of magnetic field must be
   a. 2 Tesla b. 0.2 Tesla
   c. 5 Tesla d. 2×10^9 Tesla

9. The nucleus $^{115}_{48}Cd$ after two successive β^- decays will give:
   a. $^{115}_{46}$Pa b. $^{114}_{49}$In
   c. $^{113}_{50}$Sn d. $^{115}_{50}$Sn

10. Which sample contains greater number of nuclei: a 5.00 -μCi sample of ^{240}Pu (half-life 6560 y) or a 4.45 -μCi sample of ^{243}Am (half-life 7370 y):
    a. ^{240}Pu b. ^{243}Am
    c. Equal in both d. None of these

11. An optical fibre communication system works on a wavelength of 1.3 μm. The number of subscribers it can feed if a channel requires 20 kHz are:
    a. 2.3×10^{10} b. 1.15×10^{10}
    c. 1×10^5 d. None of these

12. A telephone link operating at a central frequency of 10 GHz is established. If 1% of this is available then how many telephone channel can be simultaneously given when each telephone covering a band width of 5 kHz.
    a. 2×10^4 b. 2×10^6
    c. 5×10^4 d. 5×10^6

13. Oersted is a unit of
    a. Dip b. Magnetic intensity
    c. Magnetic moment d. Pole strength

14. Position of a particle in a rectangular coordinate system is (3, 2, 5). Then, its position vector will be:
    a. $3\hat{i} + 5\hat{j} + 2\hat{k}$ b. $3\hat{i} + 2\hat{j} + 5\hat{k}$
    c. $5\hat{i} + 3\hat{j} + 2\hat{k}$ d. None of these

15. A particle moves in the xy-plane as $\upsilon = a\hat{i} + bx\hat{j}$ where, $\hat{i}$ and $\hat{j}$ are the unit vector along x and y -axis. The particle tarts form origin at t = 0. Find the radius of curvature of the particle as a function of x:
    a. $\frac{a^2 + b^2x^2}{ba}$ b. $\frac{a}{b}\left[1 + \left(\frac{bx}{a}\right)^2\right]^{3/2}$
    c. $\frac{b}{a}\left[1 + \left(\frac{ax}{b}\right)^2\right]^{3/2}$ d. None of these

16. Rain water is falling vertically downwards with a velocity υ. When the velocity of the wind is zero, water is collected at a rate R. When the wind starts blowing horizontally at a speed υ, the rate of collection of water in the same vessel is:

a. $\sqrt{u^2+\upsilon^2}R$ **b.** $\frac{\upsilon}{u}R$ **c.** $\frac{uR}{\upsilon}$ **d.** R

17. *A* particle of mass 0.3 *kg* is subjected to a force $F=-kx$ with $k=15N/m$. What will be its initial acceleration if it is released from a point 20 *cm* away from the origin?

a. 5 m/s^2 **b.** 10 m/s^2
c. 3 m/s^2 **d.** 15 m/s^2

18. *A* lift accelerated downward with acceleration '*a*'. A man in the lift throws a ball upward with acceleration $a_0(a_0 < a)$. Then acceleration of ball observed by observer, which is on earth, is:

a. $(a+a_0)$ upward **b.** $(a-a_0)$ upward
c. $(a+a_0)$ downward **d.** $(a-a_0)$ downward

19. If a long spring is stretched by 0.02 *m*, its potential energy is *U*. If the spring is stretched by 0.1 *m*, then its potential energy will be:

a. $\frac{U}{5}$ **b.** U
c. $5U$ **d.** $25U$

20. Two bodies of masses *m* and 2*m* have same momentum. Their respective kinetic energies E_1 and E_2 are in the ratio:

a. 1 : 2 **b.** 2 : 1
c. $1:\sqrt{2}$ **d.** 1 : 4

21. *A* particle undergoes uniform circular motion. About which point on the plane of the circle, will the angular momentum of the particle remain conserved?

a. Centre of circle
b. On the circumference of the circle
c. Inside the circle
d. Outside the circle

22. This question has statement I and statement II. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement I: *A* point particle of mass *m* moving with speed *v* collides with stationary point particle of mass *M*. If the maximum energy loss possible is given as: $f\left(\frac{1}{2}mv^2\right)$, then $f=\left(\frac{m}{M+n}\right)$.

Statement II: Maximum energy loss occurs when the particles get stuck together as a result of the collision.

a. Statement I is true, Statement II is true, and Statement II is the correct explanation of Statement I
b. Statement I is true, Statement II is true, but Statement II is not the correct explanation of Statement I
c. Statement I is true, Statement II is false
d. Statement I is false, Statement II is true.

23. Two particles are executing S.H.M. The equations of their motion are $y_1 = 10\sin\left(\omega t+\frac{\pi T}{4}\right)$, $y_2 = 25\sin\left(\omega t+\frac{\sqrt{3}\pi T}{4}\right)$ .What is the ratio of their amplitude?

a. 1 : 1 **b.** 2 : 5
c. 1 : 2 **d.** None of these

24. *A* body is executing Simple Harmonic Motion. At a displacement *x* its potential energy is E_1 and at a displacement *y* its potential energy is E_2. The potential energy *E* at displacement $(x+y)$ is:

a. $\sqrt{E}=\sqrt{E_1}-\sqrt{E_2}$ **b.** $\sqrt{E}=\sqrt{E_1}+\sqrt{E_2}$
c. $E=E_1+E_2$ **d.** $E=E_1+E_2$

25. *R* and *r* are the radii of the earth and moon respectively. ρ_e and ρ_m are the densities of earth and moon respectively. The ratio of the accelerations due to gravity on the surfaces of earth and moon is:

a. $\frac{R}{r}\frac{\rho_e}{\rho_m}$ **b.** $\frac{r}{R}\frac{\rho_e}{\rho_m}$ **c.** $\frac{r}{R}\frac{\rho_m}{\rho_e}$ **d.** $\frac{R}{r}\frac{\rho_e}{\rho_m}$

26. The acceleration of a body due to the attraction of the earth (radius *R*) at a distance 2 *R* from the surface of the earth is: (*g* = acceleration due to gravity at the surface of the earth)

a. $\frac{g}{9}$ **b.** $\frac{g}{3}$ **c.** $\frac{g}{4}$ **d.** g

27. *A* cylinder is filled with a liquid of density *d* up to a height *h*. If the cylinder is placed in a lift moving downwards with acceleration '*a*' then pressure at the bottom is:

a. 0 **b.** hdg **c.** $hd(g-a)$ **d.** $hd(g+a)$

28. Two stretched membranes of areas 2 m^2 and 3 m^2 are placed in a liquid at the same depth. The ratio of the pressure on them is:

a. 1 : 1 **b.** 2 : 3 **c.** $\sqrt{2}:\sqrt{3}$ **d.** $2^2:3^2$

29. The Young's modulus of a rubber string 8 *cm* long and density $1.5\,kg/m^3$ is $5\times10^8\,N/m^2$, is suspended on the ceiling in a room. The increase in length due to its own weight will be:

a. $9.6\times10^{-5}\,m$ **b.** $9.6\times10^{-11}\,m$
c. $9.6\times10^{-3}\,m$ **d.** 9.6 *m*

30. Two wires '*A*' and '*B*' of the same material have radii in the ratio 2 : 1 and lengths in the ratio 4 : 1. The ratio of the normal forces required to produce the same change in the lengths of these two wires is:

a. 1 : 1 **b.** 2 : 1 **c.** 1 : 4 **d.** 1 : 2

31. *A* tube, closed at one end and containing air, produces, when excited, the fundamental note of frequency 512 Hz. If the tube is opened at both ends the fundamental frequency that can be excited is (in Hz)

a. 1024 **b.** 512 **c.** 256 **d.** 128

32. *A* train moves towards a stationary observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17 m/s, the frequency registered is f_2. If the speed of sound is 340 m/s then the ratio f_1/f_2 is:

a. 18/19 **b.** 1 / 2 **c.** 2 **d.** 19/18

33. *A* tuning fork of 512 Hz is used to produce resonance in a resonance tube experiment. The level of water at first resonance is 30.7 cm and at second resonance is 63.2 cm. The error in calculating velocity of second is:

a. 204.1 cm/s **b.** 110 cm/s **c.** 58 cm/s **d.** 280 cm/s

34. One quality of a thermometer is that its heat capacity should be small. If *P* is a mercury thermometer, *Q* is a resistance thermometer and *R* thermocouple type then

a. *P* is best, *R* worst **b.** *R* is best, *P* worst
c. *R* is best, *Q* worst **d.** *P* is best, *Q* worst

35. *A* gas in an airtight container is heated from 25° *C* to 90° *C*. The density of the gas will

a. increase slightly **b.** increase considerably
c. remain the same **d.** decrease slightly

36. How much heat energy is gained when 5 *kg* of water at $20°C$ is brought to its boiling point? (Specific heat of water = 4.2 $kJ\,kg^{-1}c^{-1}$)

a. 1680 *kJ* **b.** 1700 *kJ*
c. 1720 *kJ* **d.** 1740 *kJ*

37. A gas is enclosed in a closed pot. On keeping this pot in a train moving with high speed, the temperature of the gas:

a. Will increase
b. Will decrease
c. Will remain the same
d. Will change according to the nature of the gas

38. The energy of a *gas/litre* is 300 joules, then, its pressure will be:

a. $3\times10^5\ N/m^2$ **b.** $6\times10^5\ N/m^2$
c. $10^5\ N/m^2$ **d.** $2\times10^5\ N/m^2$

39. Air is filled at $60°C$ in a vessel of open mouth. The vessel is heated to a temperature *T* so that 1/4th part of air escapes. Assuming the volume of the vessel remaining constant, the value of *T* is:

a. $80°C$ **b.** $444°C$ **c.** $333°C$ **d.** $171°C$

40. At room temperature, the rms speed of the molecules of a certain diatomic gas is found to be 1930 m/s. The gas is:

a. H_2 **b.** F_2 **c.** O_2 **d.** CI_2

41. Two rods, one of aluminium and the other made of steel, having initial length l_1 and l_2 are connected together to form a single rod of length l_1+l_2. The coefficients of linear expansion for aluminium and steel are α_a and α_s respectively. If the length of each rod increases by the same amount when their temperature are raised by $t°C$, then find the ratio $\frac{l_1}{l_1+l_2}$

a. $\frac{\alpha_s}{\alpha_a}$ **b.** $\frac{\alpha_a}{\alpha_s}$
c. $\frac{\alpha_s}{(\alpha_a+\alpha_s)}$ **d.** $\frac{\alpha_a}{(\alpha_a+\alpha_s)}$

42. When an ideal diatomic gas is heated at constant pressure, the fraction of the heat energy supplied which increases the internal energy of the gas, is:

a. $\frac{2}{5}$ **b.** $\frac{3}{5}$ **c.** $\frac{3}{7}$ **d.** $\frac{5}{7}$

43. The coefficients of thermal conductivity of copper, mercury and glass are respectively K_c, K_m and K_g such that $K_c > K_m > K_g$. If the same quantity of heat is to flow per second per unit area of each and corresponding temperature gradients are X_c, X_m and X_g, then

a. $X_c = X_m = X_g$ **b.** $X_c > X_m > X_g$
c. $X_c < X_m < X_g$ **d.** $X_m < X_c < X_g$

44. Three equal charges are placed on the three corners of a square. If the force between q_1 and q_2 is F_{12} and that between q_1 and q_3 is F_{13}, the ratio of magnitudes $\frac{F_{12}}{F_{13}}$ is:

a. $1/2$ **b.** 2 **c.** $1/\sqrt{2}$ **d.** $\sqrt{2}$

45. Two point charges $3\times10^{-6}C$ and $8\times10^{-6}C$ repel each other by a force of $6\times10^{-6}N$. If each of them is given an additional charge $-6\times10^{6}N$, the force between them will be:

a. $2.4\times10^{-3}N$ (attractive) **b.** $2.4\times10^{-9}N$ (attractive)

c. $1.5\times10^{-3}N$ (repulsive) **d.** $1.5\times10^{-3}N$ (attractive)

46. Two moles of oxygen is mixed with eight moles of helium. The effective specific heat of the mixture at constant volume is

a. 1.3R **b.** 1.4R

c. 1.7R **d.** 1.9R

47. One mole of an ideal monatomic gas at temperature T_0 expands slowly according to the law $\frac{P}{V}$ = constant. If the final temperature is $2T_0$, heat supplied to the gas is

a. $2RT_0$ **b.** RT_0

c. $\frac{3}{2}RT_0$ d. $\frac{1}{2}RT_0$

48. The amount of heat supplied to 4 × 10_{-2} nitrogen at room temperature to rise its temerature by 50°C at constant pressure is (Molecular mass of nitrogen is 28 and R = 8.3J mol^{-1} K^{-1})

a. 2.08 kJ **b.** 3.08 kJ

c. 4.08 kJ **d.** 5.08 kJ

49. A sample of ideal gas (y = 1.4) is heated at pressure. If 100 J of heat is supplied to the work done by the gas is

a. 28.57 J b. 56.54 J

c. 38.92 J **d.** 65.38 J

50. What amount of heat must be supplied to 35 g of oxygen at room temperature to raise its temperature by 80°C at constant volume (molecular mass of oxygen is 32 and R = 8.3 J mol^{-1} K^{-1})

a. 1.52 kJ **b.** 3.23 kJ

c. 1.81 kJ d. 1.62 kJ

Answers and Solutions

1. **(b)** $x5 = n\frac{\lambda D}{d} = \frac{5\times6.5\times10^{-7}\times1}{10^{-3}} = 32.5\times10^{-4}\text{m}$

$x3 = (2n-1)\frac{\lambda}{2}\frac{D}{d} = \frac{5\times6.3\times10^{-7}x1}{2\times10^{-3}} = 16.25\times10^{-4}\text{m}$

$x5 - x3 \approx$ 1.63 mm.

2. **(b)** When source is fixed and observer is moving towards it: $\upsilon' = \frac{c+a}{c}.\upsilon$

When source is moving towards observer at rest:

$$\upsilon'' = \frac{c}{c-a}\upsilon' = \frac{c+a}{c-a}.\upsilon = c\left[\frac{1+\frac{a}{c}}{1-\frac{a}{c}}\right]\upsilon$$

$$= c\left[1+\frac{a}{c}\right]\left[1-\frac{a}{c}\right]^{-1}\upsilon \approx \left[1+\frac{2a}{c}\right]\upsilon$$

$\therefore \quad \Delta\upsilon = \upsilon' - \upsilon = \frac{2a\upsilon}{c} = \frac{2a}{\lambda}$

$\therefore \quad a = \lambda\frac{\Delta\upsilon}{2} = \frac{0.5\times1000}{2} = 250\ ms^{-1}$ = 900 km/hr

3. **(a)** $B = \frac{\mu_0 \in_0 r}{2}\frac{dE}{dt} = \frac{1}{9\times10^{16}\times2}\times10^{10}$

5.56×10^{-8}T .

4. **(c)** Energy density, $u = \frac{1}{2}\in_0 E_0^2$

$= \frac{1}{2}$ 8.85 10 12 $(54.77)^2$ = 1.33 × 10^{-8} J/m^3.

5. **(a)** $p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}}{(5000\times10^{-10})} = 1.3\times10^{-27}\ kg\text{-}m/s$

6. **(c)** $E = \frac{12375}{4000} = 3.09\,eV$

Photoelectrons emits if energy of incident light > work function.

7. **(b)** $(e/m)_\alpha = \frac{(e/m)_{proton}}{2} = \frac{9\cdot6\times10^7}{2} = 4\cdot8\times10^7$ coul/kg.

8. **(b)** For the beam to pass undeflected, $eE = evB$

$\Rightarrow \quad B = \frac{E}{v} = \frac{2\times10^4}{10^5} = 0.2\,\text{Tesla}$

9. **(d)** ${}_{48}Cd^{115} \xrightarrow{2(-1\beta^o)} {}_{50}Sn^{115}$

10. **(b)** Number of half-lives $n = \frac{19}{3.8} = 5$; Now $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$\Rightarrow \quad \frac{N}{10.38} = \left(\frac{1}{2}\right)^5 \Rightarrow N = 10.38\times\left(\frac{1}{2}\right)^5 = 0.32\,gm$

11. **(b)** Optical source frequency

$f = \frac{c}{\lambda} = \frac{3\times10^8}{1.3\times10^{-6}} = 2.3\times10^{14}\,Hz$

$\therefore$ Number of channels or subscribers $= \frac{2.3\times10^{14}}{20\times10^3}$

$= 1.15 \times 10^{10}$

12. **(a)** 1% of 10 GHz = $10\times10^9\times\frac{1}{100}=10^8\,Hz$

Number of channels $=\frac{10^8}{5\times10^3}=2\times10^4$

13. **(b)** 1 Oersted $=1$ Gauss $=10^{-4}$ Tesla

14. **(b)** If a point have coordinate (x, y, z) then its position vector $= x\hat{i}+y\hat{j}+z\hat{k}$.

15. **(b)** $\frac{dx}{dt}=a$ or $x=at$

$\frac{dy}{dt}=bx=bat$

Or $y=\frac{bat^2}{2}=\frac{ba}{2}\left(\frac{x}{a}\right)^2=\frac{bx^2}{2a}$

$\therefore$ $\frac{dy}{dx}=\frac{b}{a}x$ and $\frac{d^2y}{dx^2}=\frac{b}{a}$

$$\therefore\quad R=\frac{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{3/2}}{\left(\frac{d^2y}{dx^2}\right)}=\frac{\left[1+\left(\frac{b}{a}x\right)^2\right]^{3/2}}{\frac{b}{a}}=\frac{a}{b}\left[1+\left(\frac{b}{a}x\right)^2\right]^{3/2}$$

16. **(d)** In general R (Rate of collection) $=\upsilon A\cos\theta$

Where, θ is the angle between the velocity of the rain and the normal to the cross-section A of the vessel.

$R=\upsilon A\cos0°=\upsilon A$

When the wind blows, $R'=\upsilon' A\cos\theta$

Where, υ' is the new velocity of rain.

Now $\upsilon'=\sqrt{u^2+\upsilon^2}$ and $\cos\theta=\frac{\upsilon}{\sqrt{u^2+\upsilon^2}}$

$\therefore$ $R'=\upsilon' A\cos\theta=\upsilon A=R$

17. **(b)** Force on particle at 20 cm away $F=kx$

$F = 15\times0.2 = 3\,N$ $[\text{As } k=15\,N/m]$

$\therefore$ Acceleration = $\frac{\text{Force}}{\text{Mass}}=\frac{3}{0.3}=10m/s^2$

18. **(d)** The effective acceleration of ball observed by observer on earth $=(a-a_0)$

As $a_0<a$, hence net acceleration is in downward direction.

19. **(d)** $U\propto x^2\Rightarrow\frac{U_2}{U_1}=\left(\frac{x_2}{x_1}\right)^2=\left(\frac{0.1}{0.02}\right)^2=25$

$\therefore$ $U_2=25U$

20. **(b)** $E=\frac{P^2}{2m}$. If momentum are same then $E\propto\frac{1}{m}$

$\therefore$ $\frac{E_1}{E_2}=\frac{m_2}{m_1}=\frac{2m}{m}=\frac{2}{1}$

21. **(a)** In uniform circular motion the only force acting on the particle is centripetal (towards centre). Torque of this force about the centre is zero. Hence, angular momentum about centre remains conserved.

22. **(d)** Maximum energy loss $=\frac{p^2}{2m}-\frac{p^2}{2(m+M)}$

$\left(\because \text{KE}=\frac{p^2}{2m}\right)$

Before collision the mass m and after collision the mass is $m+M$

$=\frac{p^2}{2m}\left[\frac{M}{(m+M)}\right]=\frac{1}{2}mv^2\left\{\frac{M}{m+M}\right\}\left(f=\frac{M}{m+M}\right)$

23. **(b)** $\frac{a_1}{a_2}=\frac{10}{25}=\frac{2}{5}$

24. **(b)** $E_1=\frac{1}{2}Kx^2\Rightarrow x=\sqrt{\frac{2E_1}{K}}$,

$E_2=\frac{1}{2}Ky^2\Rightarrow y=\sqrt{\frac{2E_2}{K}}$

and $E=\frac{1}{2}K(x+y)^2\Rightarrow x+y=\sqrt{\frac{2E}{K}}$

$\Rightarrow$ $\sqrt{\frac{2E_1}{K}}+\sqrt{\frac{2E_2}{K}}=\sqrt{\frac{2E}{K}}$

$\Rightarrow$ $\sqrt{E_1}+\sqrt{E_2}=\sqrt{E}$

25. **(a)** $g=\frac{4}{3}\pi\rho GR$ $\therefore g\propto r\rho$ $\therefore\frac{g_e}{g_m}=\frac{R}{r}\times\frac{\rho_e}{\rho_m}$

26. **(a)** $g'=g\left(\frac{R}{R+h}\right)^2=g\left(\frac{R}{R+2R}\right)^2=\frac{g}{9}$

27. **(c)** If lift moves downwards with acceleration a, then effective value of g is reduced from g to: $g'=(g-a)$

$\therefore$ Pressure at bottom $=hdg'=hd(g-a)$

28. **(a)** Pressure $= hdg$ is independent of area.

29. **(b)** $l = \frac{L^2 dg}{2Y} = \frac{(8\times10^{-2})^2\times1.5\times9.8}{2\times5\times10^8} = 9.6\times10^{-11} m$

30. **(a)** $F = Y\times A\times\frac{l}{L} \Rightarrow F \propto \frac{r^2}{L}$ (Y and l are constant)

$\therefore \quad \frac{F_1}{F_2} = \left(\frac{r_1}{r_2}\right)^2\left(\frac{L_2}{L_1}\right) = \left(\frac{2}{1}\right)^2\left(\frac{1}{4}\right) = 1$

$\Rightarrow \quad \frac{F_1}{F_2} = 1:1$

31. **(a)** $f_C = \frac{v}{4l} = 512Hz$, $f_C = \frac{v}{2l} = 2f_C 1024Hz$

32. **(d)** $f_1 = f\left(\frac{v}{v-v_z}\right)$

$f_1 = f\left(\frac{340}{340-34}\right) = f\left(\frac{340}{306}\right)$

and $f_2 = f\left(\frac{340}{340-17}\right) = f\left(\frac{340}{323}\right)$

$\therefore \quad \frac{f_1}{f_2} = \frac{323}{306} = \frac{19}{18}$

33. **(d)** The question is incomplete, as speed of sound is not given. Let us assume speed of sound as 330 m/s. Then, method will be as under.

$\frac{\lambda}{2} = (63.2-30.7)\text{cm or } \lambda = 0.65\text{m}$

$\therefore$ speed of sound observed,

$v_0 = f\lambda = 512\times0.65 = 332.8\ m/s$

$\therefore$ Error in calculating velocity of sound = 2.8 m/s = 280 m/s

34. **(c)** Thermoelectric thermometer is used for finding rapidly varying temperature.

35. **(c)** Mass and volume of the gas will remain same, so density will also remain same.

36. **(a)** $Q = m.c.\Delta\theta = 5\times(1000\times4.2)\times(100-20)$

$= 1680\times10^3 J = 1680 kJ$

37. **(a)** $v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow \frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{(273+90)}{(273+30)}} = 1.1$

% increase $= \left(\frac{v_2}{v_1}-1\right)\times100 = 0.1\times100 = 10\%$

38. **(d)** Energy $= 300J/litre = 300\times10^3 J/m^3$

$P = \frac{2}{3}E = \frac{2\times300\times10^3}{3} = 2\times10^5 N/m^2$

39. **(d)** For open mouth vessel, pressure is constant. Volume is also given constant.

Hence from $PV = \mu RT = \left(\frac{m}{M}\right)RT$

$\Rightarrow \quad T \propto \frac{1}{m} \Rightarrow \frac{T_1}{T_2} = \frac{m_2}{m_1}$

$\because \quad \frac{1}{4}th$ part escapes, so remaining mass in the vessel

$m_2 = \frac{3}{4}m_1$

$\Rightarrow \quad \frac{(273+60)}{T} = \frac{3/4 m_1}{m_1} \Rightarrow T = 444K = 171°C$

40. **(a)** $v_{rms} = \sqrt{\frac{3RT}{M}}$ **;** Room temperature $T \approx 300K$

$\therefore \quad 1930 = \sqrt{\frac{3\times8.31\times10^3\times300}{M}}$

$\therefore \quad M$ = 2.0 g /mol or the gas is H_2.

41. Given $\Delta l_1 = \Delta l_2$ or $l_1\alpha_a t = l_2\alpha_s t$

$\therefore \quad \frac{l_1}{l_2} = \frac{\alpha_s}{\alpha_a}$

or $\quad \frac{l_1}{l_1+l_2} = \frac{\alpha_s}{\alpha_a+\alpha_s}$

42. **(d)** Fraction of supplied energy which increases the internal energy is given by:

$f = \frac{\Delta U}{(\Delta Q)_P} = \frac{(\Delta Q)_V}{(\Delta Q)_P} = \frac{\mu C_V\Delta T}{\mu C_P\Delta T} = \frac{1}{\gamma}$

For diatomic gas $\gamma = \frac{7}{5} \Rightarrow f = \frac{5}{7}$

43. **(c)** $\frac{Q}{At} = K\frac{\Delta\theta}{l} \Rightarrow K\frac{\Delta\theta}{l} = \text{constant} \Rightarrow \frac{\Delta\theta}{l} \propto \frac{1}{K}$

Hence, If $K_c > K_m > K_g$, then

$\left(\frac{\Delta\theta}{l}\right)_c < \left(\frac{\Delta\theta}{l}\right)_m < \left(\frac{\Delta\theta}{l}\right)_g \Rightarrow X_c < X_m < X_g$

Because, higher K implies lower value of the temperature gradient.

44. **(b)** $F_{12} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{a^2}$ and $F_{13} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{(a\sqrt{2})^2}$

$$\Rightarrow \quad \frac{F_{12}}{F_{13}} = 2$$

45. **(d)** $F \propto Q_1Q_2 \Rightarrow \frac{F_1}{F_2} = \frac{Q_1Q_2}{Q_1'Q_2'}$

$$= \frac{3\times10^{-6}\times8\times10^{-6}}{(3\times10^{-6}-6\times10^{-6})(8\times10^{-6}-6\times10^{-6})} = \frac{3\times8}{-3\times2}$$

$$= \frac{3\times8}{-3\times2} = -\frac{4}{1}$$

$$\Rightarrow \quad F_2 = -\frac{F_1}{4} = -\frac{6\times10^{-3}}{4} = -1.5\times10^{-3}\,N \text{ (Attractive)}$$

46. **(c)** Molar specific heat of mixture at constant volume is

$$(C_V)_{mixture} = \frac{n_1C_{V_1}+n_2C_{V_2}}{n_1+n_2} = \frac{2\times\frac{5R}{2}+8\times\frac{3R}{2}}{2+8} = 1.7\text{ R}$$

47. **(a)** In a process PV^x = constant, molar heat capacity is given by $C = \frac{R}{\gamma-1}+\frac{R}{1-x}$

As the process is $\frac{P}{V}$ = constant,

i.e., PV^{-1} = constant, therefore, x = –1.

For an ideal monatomic gas, $\gamma = \frac{5}{3}$

$$\therefore C = \frac{R}{\frac{5}{3}-1}+\frac{R}{1-(-1)} = \frac{3}{2}R+\frac{R}{2} = 2R$$

$$\Delta Q = nC(\Delta T) = 1(2R)(2T_0-T_0) = 2RT_0$$

48. **(a)** Given, m = 4 × 10^{-2} kg = 40 g, ΔT = 50 °C

Number of moles, $n = \frac{m}{M} = \frac{40}{28} = 1.43$

As nitrogen is a diatomic gas, molar specific heat at constant pressure is

$C_p = \frac{7}{2}R = \frac{7}{2}$ × 8.3 J mol^{-1} K^{-1} = 29.05 J mol^{-1} K^{-1}

As $\Delta Q = nC_P\Delta T$

∴ ΔQ = 1.43 × 29.05 × 50 = 2.08 × 10^3 J = 2.08 kJ

49. **(a)** $dQ = nC_P\,dT$

$dU = nCVdT$

$dW = dQ - dU = n(C_P - C_V)dt$

$$\frac{dW}{dQ} = \frac{n(C_p-C_V)dT}{nC_pdT} = \frac{C_P}{C_P}-\frac{C_V}{C_P}$$

$$\frac{dW}{dQ} = 1-\frac{C_V}{C_P} = 1-\frac{1}{1.4} = \frac{0.4}{1.4} = \frac{4}{14} = \frac{2}{7}$$

$$dW = 100\times\frac{2}{7} = 28.57\text{ J}$$

50. **(c)** Here mass of oxygen (m) = 35 g

molar mass of O_2 (M) = 32 g mol^{-1}

rise in temperature, ΔT = 80 °C

∴ number of moles $n = \frac{m}{M} = \frac{35}{32} = 1.09$ mol

As oxygen is a diatomic gas, then molar specific heat at constant volume is $C_v = \frac{5}{2}R$

and amount of heat supplied to gas

$$\Delta Q = nC_V\Delta T = 1.09\times\frac{5}{2}R\times80$$

$$= 1.09\times\frac{5}{2}\times8.3\times80$$

= 1809.4 J = 1.8094 kJ = 1.81 kJ

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