Solutions

of

Waves & Thermodynamics

Lesson 14^{th} to 19^{th}

By DC Pandey

14. Wave Motion

Introductory Exercise 14.1

1. A function, f can represent wave equation, if it satisfy

$$\frac{{}^2 f}{t^2} \quad v^2 \quad \frac{{}^2 f}{x^2}$$

For, $\quad y \quad a \sin \quad t,$

$$\frac{{}^2 y}{t^2} \qquad {}^2 a \sin \quad t \qquad {}^2 y$$

but, $\quad \frac{{}^2 y}{x^2} \quad 0$

So, y do not represent wave equation.

2. $y\,(x,\,t) \quad ae^{\,(bx \quad et)^2} \quad ae^{\,(kx \quad t)^2}$

$k \quad b$ and $\quad e \quad v \quad \frac{}{k} \quad \frac{c}{b}$

3. $y\,(x,\,t) \quad \frac{1}{1 \quad (4x \quad t)^2}$ represent the given pulse, where,

$y(x,\,0) \quad \frac{1}{1 \quad k^2 x^2} \quad \frac{1}{1 \quad x^2}$

$k \quad 1$

and $y(x,\,z) \quad \frac{1}{1 \quad (x \quad 2\ )^2} \quad \frac{1}{1 \quad (x \quad 1)^2}$

$\frac{1}{2}$

$v \quad \frac{}{k} \quad \frac{1/2}{1} \quad 0.5\,\text{m/s}$

4. $y \quad \frac{10}{5 \quad (x \quad 2t)^2} \quad \frac{a}{b \quad (kx \quad t)^2}$

Amplitude, $y_{\max} \quad \frac{a}{b} \quad \frac{10}{5} \quad 2\,\text{m}$

and $\quad k \quad 1; \quad 2$

$v \quad \frac{}{k} \quad 2$ m/s and is travelling in (–) x direction.

5. $y \quad \frac{10}{(kx \quad t)^2 \quad 2}$

$y(x,\,0) \quad \frac{10}{k^2 x^2 \quad 2} \quad \frac{10}{x^2 \quad 2} \quad k \quad 1$

$vk \quad 2\,\text{m/s} \quad 1\,\text{m}^{\ 1} \quad 2\,\text{rad/s}$

$y \quad \frac{10}{(x \quad 2t)^2 \quad 2}$

Introductory Exercise 14.2

1. $y(x,\,t) \quad 0.02 \sin \quad \frac{x}{0.05} \quad \frac{t}{0.01} \quad \text{m}$

$A \sin\,(kx \quad t)\,\text{m}$

$A \quad 0.02\,\text{m},\ k \quad \frac{1}{0.05}\,\text{m}^{\ 1}, \quad \frac{1}{0.01}\,\text{s}^{\ 1}$

(a) $v \quad \frac{}{k} \quad \frac{0.05}{0.01}\,\text{m/s} \quad 5\,\text{m/s}$

(b) $v_p \quad \frac{y}{t} \quad A \quad \cos\,(kx \quad t)$

$v_p(0.2,\,0.3) \quad 0.02 \quad \frac{1}{0.01}$

$\cos \quad \frac{0.2}{0.5} \quad \frac{0.3}{0.01}$

$2 \cos\,(4 \quad 30)$

$2 \cos 34$

$2(\quad 0.85)$

1.7 m/s

2. Yes, $(v_p)_{\max} \quad A \quad Ak \quad \frac{}{k} \quad (Ak)v$

3. $\quad 4$ cm, $v \quad 40$ cm/s (given)

(a) $\frac{v}{} \quad \frac{40\,\text{cm/s}}{4\,\text{cm}} \quad 10\,\text{Hz}$

(b) $\frac{2}{\ }\ x$

$\frac{2}{4\text{ cm}}\quad 2.5\text{ cm}\quad \frac{5}{4}\text{ rad}$

(c) $t\quad \frac{T}{2}\quad \frac{1}{2}$

$\frac{1}{2\quad 10}\quad \frac{\ }{3}$

$\frac{1}{60}\text{ s}$

(d) $v_p\quad (v_p)_{\max}$

$A\quad 2\ A$

$2\quad 2\text{ cm}\quad 10\text{ s}^{1}$

$40\ \text{cm/s}$

$1.26\ \text{cm/s}$

$y\quad A\sin(\ t\quad kx)$

$A\sin\ v\ \frac{2}{\ }t\quad \frac{2}{\ }x$

$0.05\sin\ 12\ \frac{2}{0.4}t\quad \frac{2}{0.4}x$

$0.05\sin(60\ t\quad 5\ x)$

(b) $y(0.25, 0.15)$

$0.05\sin(60\quad 0.15\quad 5\quad 0.25)$

$0.05\sin(9\quad 1.25\ )$

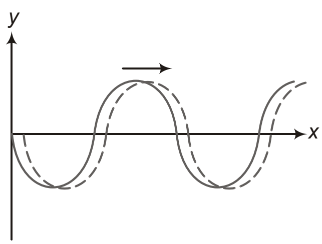
$0.05\sin(7.75\ )\quad 0.05\sin(1.75\ )$

$0.0354\text{ m}\quad 3.54\text{ cm}$

(c) $t\quad \frac{T}{2}\quad \frac{\ }{\ }\quad \frac{0.25}{60}$

$\frac{1}{240}\text{ s}\quad 4.2\text{ ms}$

4. (a)



Introductory Exercise 14.3

1. $v\quad \sqrt{\frac{T}{\ }}\quad \sqrt{\frac{T}{m/l}}\quad \sqrt{\frac{Tl}{m}}$

$\sqrt{\frac{500\quad 2}{0.06}}\quad \frac{100\sqrt{5}}{\sqrt{3}}\quad 129.1\text{ m/s}$

2. $v\quad \sqrt{\frac{T}{\ }}\quad \sqrt{\frac{T}{\ A}}$

$\sqrt{\frac{0.98}{9.8\quad 10^3\quad 10^{\ 6}}}\quad 10\text{ m/s}$

Introductory Exercise 14.4

1. $I\quad \frac{P}{4\ r^2}\quad \frac{1\text{ W}}{4\quad (1\text{ m})^2}\quad \frac{1}{4}\ \text{W/m}^2$

2. For line source, $I\quad \frac{\ }{2\ rl}$

$I\quad \frac{1}{r}$ and as $I\quad A^2$

$A\quad \frac{1}{\sqrt{r}}$

AIEEE Corner

■ Subjective Questions (Level 1)

1. $y(x, t) \quad 6.50\text{ mm}\cos 2 \quad \dfrac{}{28.0\text{ cm}} \quad \dfrac{t}{0.0360\text{s}}$

$A\cos 2 \quad \dfrac{x}{} \quad \dfrac{t}{T}$

$A \quad 6.50\text{ mm}, \qquad 28.0\text{ cm},$

$\dfrac{1}{T} \quad \dfrac{1}{0.036}\text{s}^{\ 1} \quad 27.78\text{ Hz}$

$v \qquad 28.0\text{ cm} \quad 27.78\text{ s}^{\ 1} \quad 778\text{ cm/s}$

7.78 m/s

The wave is travelling along( )ve x-axis.

2. $y \quad 5\sin 30 \quad t \quad \dfrac{x}{240}$

$5\sin \ 30\ t \quad \dfrac{}{8}x \qquad A\sin(\quad t \quad kx)$

(a) $y(2, 0) \quad 5\sin \ 3 \quad 0 \quad \dfrac{}{8} \quad 2$

$5\sin\dfrac{}{4} \qquad \dfrac{5}{\sqrt{2}} \qquad 3.535\text{ cm}$

(b) $\dfrac{2}{k} \quad \dfrac{2}{8} \quad 16\text{ cm}$

(c) $v \quad \dfrac{}{k} \quad \dfrac{30}{/8} \quad 240\text{ cm/s}$

(d) $\dfrac{}{2} \quad \dfrac{30}{2} \quad 15\text{ Hz}$

3. $y \quad 3\text{ cm}\ \sin(3.14\text{ cm}^{\ 1}x \quad 314\text{ s}^{\ 1}t)$

$3\text{ cm}\sin(\quad \text{cm}^{\ 1}x \quad 100 \quad \text{s}^{\ 1}t)$

$A\sin(kx \qquad t)$

(a) $(v_p)_{max} \quad A \qquad 3\text{cm} \quad 100 \quad \text{s}^{\ 1}$

$300 \quad \text{cm/s} \quad 3 \quad \text{m/s} \quad 9.4\text{ m/s}$

(b) $a \qquad ^2y \qquad (100 \quad \text{s}^{\ 1})^2 \quad 3\text{ cm}$

$\sin(6 \qquad 111\ )$

$300 \quad \sin(\ 105\ ) \quad 0$

4. (a) $x \quad \dfrac{}{2} \qquad \dfrac{v/}{2} \qquad \dfrac{350}{500 \quad 2} \quad \dfrac{}{3}$

$\dfrac{7}{60} \quad \dfrac{7}{50}\text{m} \quad 0.166\text{ m}$

(b) $\dfrac{2}{T} \quad t \quad 2 \qquad t \quad 2 \qquad 500 \quad 10^{\ 3}$

180

5. $y(x, t) \quad \dfrac{6}{(kx \qquad t)^2 \quad 3}$

$y(x, 0) \quad \dfrac{6}{k^2x^2 \quad 3} \quad \dfrac{6}{x^2 \quad 3}$

$k \quad 1\text{ m}^{\ 1}$

$vk \quad 4.5\text{ m/s} \quad 1\text{ m}^{\ 1} \quad 4.5\text{ rad/s}$

$y(x, t) \quad \dfrac{6}{(x \quad 4.5t)^2 \quad 3}$

6. $y \quad 1.0\sin \quad \dfrac{x}{2.0} \quad \dfrac{t}{0.01}$

$1.0\sin\ 2 \quad \dfrac{x}{4.0} \quad \dfrac{t}{0.02}$

$A\sin 2 \quad \dfrac{x}{} \quad \dfrac{t}{T}$

(a) $A \quad 1.0\text{ mm}, \qquad 4.0\text{ cm}, T \quad 0.02\text{s}$

(b) $v_p \quad \dfrac{y}{t} \qquad A\cos 2 \quad \dfrac{x}{} \quad \dfrac{t}{T}$

$\dfrac{2\ A}{T}\cos 2 \quad \dfrac{x}{} \quad \dfrac{t}{T}$

$\dfrac{2 \quad 1.0\text{ mm}}{0.02\text{s}}\cos 2 \quad \dfrac{x}{4.0} \quad \dfrac{t}{0.02\text{s}}$

$\dfrac{}{10}\text{m/s}\cos \quad \dfrac{x}{2.0\text{ cm}} \quad \dfrac{t}{0.01\text{s}}$

$v_p(1.0\text{ cm}, 0.01\text{s})$

$\dfrac{}{10}\text{m/s}\cos \quad \dfrac{1}{2} \quad \dfrac{0.01}{0.01}$

$\dfrac{}{10}\text{m/s}\ \cos\dfrac{}{2} \quad 0\text{ m/s}$

(c) $v_p(3.0, 0.01)$

$\dfrac{}{10}\cos \quad \dfrac{3}{2} \quad 1 \quad 0\text{ m/s}$

$v_p\,(5.0\text{ cm}, 0.01\text{s}) \quad \frac{}{10}\text{ms}\cos\quad \frac{5}{2} \quad 1$

0 m/s

$v_p\,(7.0\text{ cm}, 0.01\text{s}) \quad \frac{}{10}\text{m/s}\cos\quad \frac{7}{2} \quad 1$

0 m/s

(d) $v_p\,(1.0\text{ cm}, 0.011\text{s})$

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

$\cos \quad \frac{1}{2} \quad \frac{0.011}{0.01}$

$\frac{}{10}\cos \quad \frac{1}{12} \quad 1.1$

$\frac{}{10}\cos 0.6 \quad \frac{}{10}\cos\frac{3}{5} \quad 9.7\text{ cm/s}$

$v_p\,(1.0\text{ cm}, 0.012\text{s})$

$\frac{}{10}\text{m/s}\cos \quad \frac{1}{2} \quad \frac{0.012}{0.01}$

$\frac{}{10}\cos \quad (0.5 \quad 1.2)$

$\frac{}{10}\cos 0.7 \quad 18.5\text{ cm/s}$

$v_p\,(1.0\text{ cm}, 0.013\text{ s}) \quad \frac{}{10}\text{m/s}$

$\cos \quad \frac{1}{2} \quad \frac{0.013}{0.01} \quad \frac{}{10}\cos 0.8$

25.4 cm/s

7. (a) $k \quad \frac{2}{} \quad \frac{2}{40\text{ cm}} \quad \frac{}{20}\text{cm}^{1}$

0.157 rad/cm

$T \quad \frac{1}{} \quad \frac{1}{8}\text{s} \quad 0.125\text{s}$

$2 \quad 16 \quad \text{rad/s} \quad 50.26\text{ rad/s}$

$v \quad 8\text{s}^{1} \quad 40\text{ cm} \quad 320\text{ cm/s}$

(b) $y\,(x, t) \quad A\cos(kx \quad t)$

$15.0\text{ cm}\cos(0.157x \quad 50.3\,t)$

8. $A \quad 0.06\text{m and } 2.5 \quad 20\text{ cm}$

$\frac{20}{2.5}\text{cm} \quad 8\text{ cm}$

$\frac{v}{} \quad \frac{300\text{ m/s}}{8\text{ cm}} \quad 3750\text{ Hz}$

$y \quad A\sin(kx \quad t) \quad 0.06\text{m}$

$\sin \quad \frac{2}{0.08}x \quad 2 \quad 3750\,t$

$0.06\text{m}\sin(78.5\text{ m}^{1}x \quad 23561.9\text{ s}^{1}t)$

9. (a) $\frac{v}{} \quad \frac{8.00\text{ m/s}}{0.32\text{ m}} \quad 25\text{ Hz}$

$T \quad \frac{1}{} \quad \frac{1}{15}\text{s} \quad 0.043\text{ Hz}$

$k \quad \frac{2}{} \quad \frac{2}{0.32\text{m}} \quad 19.63\text{ rad/m}$

(b) $y \quad A\cos(kx \quad t) \quad A\cos 2 \quad \frac{x}{} \quad \frac{t}{T}$

$0.07\text{m}\cos 2 \quad \frac{x}{0.32\text{m}} \quad \frac{t}{0.04\text{ s}}$

(c) $y \quad 0.07\text{m}\cos 2 \quad \frac{0.36}{0.32} \quad \frac{0.15}{0.04}$

$0.07\text{ m}\cos 2 \quad \frac{9}{8} \quad \frac{30}{8}$

$0.07\text{ m}\cos\frac{39}{4}$

$0.07\text{ m}\cos \quad 10 \quad \frac{}{4}$

$0.07\text{ m}\cos\frac{}{4} \quad 0.0495\text{ m}$

(d) $t \quad \frac{T}{2} \quad \frac{}{2} \quad \frac{/4}{2 \quad 25}$

$\frac{3}{200}\text{s} \quad 0.015\text{s}$

10. $v \quad \sqrt{\frac{T}{}} \quad \sqrt{\frac{T}{A}} \quad \sqrt{\frac{Mg}{A}}$

$\sqrt{\frac{2 \quad 9.8}{8920 \quad 3.14 \quad (1.2 \quad 10^{3})^2}}$

$\sqrt{\frac{2 \quad 9.8 \quad 10^4}{89.2 \quad 3.14 \quad 1.44}} \quad 22\text{ m/s}$

11. $\sqrt{T} \quad \sqrt{M}$

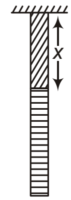
$\frac{2}{1} \quad \sqrt{\frac{M_2}{M_1}}$

$\sqrt{\frac{8}{2}} \quad \sqrt{4} \quad 2.$

$_2 \quad 2 \;_1$

0.12 m.

12. $T(x) \quad (L \quad x)g, v(x) \quad \sqrt{\frac{T(x)}{}}$



$\sqrt{g(L \quad x)}$

$\frac{dx}{\sqrt{g(L \quad x)}} \quad dt\,;$

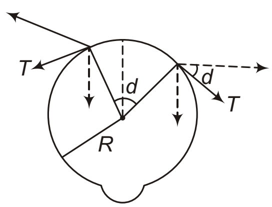
Let, $L \quad x \quad y$

$dx \quad dy$

$_L^0 \frac{dy}{\sqrt{g}\sqrt{y}} \quad t$

$t \quad \frac{1}{\sqrt{g}} \frac{\sqrt{y}}{1/2}\Big|_1^0 \quad 2\sqrt{\frac{L}{g}}$

13. (a) $dm \quad ^2R \quad 2T \sin d$



$R\,2d \quad ^2R \quad 2T\,d$

$^2R^2 \quad \frac{T}{}$

Wave speed, $v \quad \sqrt{\frac{T}{}} \quad \sqrt{\ ^2R^2} \quad R$

(b) Kink remains stationary when rope and kink moves in opposite sence *i.e.*, if rope is rotating anticlockwise then kink has to move clockwise.

14. x is being measured from lover end of the string

$m(x) \quad dm \quad _0^x \;_0\, x\,dx \quad \frac{1}{2} \;_0 x^2$

$v(x) \quad \sqrt{\frac{T(x)}{}} \quad \sqrt{\frac{m(x)g}{}}$

$\sqrt{\frac{\frac{1}{2}\;_0 x^2 g}{_0 x}} \quad \sqrt{\frac{1}{2}gx}$

$_0^l \frac{dx}{\sqrt{\frac{1}{2}gx}} \quad _0^t dt$

$t \quad \sqrt{\frac{2}{g}} \quad 2\sqrt{l_0}$

$t \quad \sqrt{\frac{8l_0}{g}}$

15. $\frac{dm}{dx} \quad kx$

$M \quad dm \quad _0^2 kx\,dx \quad \frac{1}{2}kL^2$

$k \quad \frac{2M}{L^2}$

$v(x) \quad \sqrt{\frac{T}{}} \quad \sqrt{\frac{T}{kx}} \quad \sqrt{\frac{TL^2}{2Mx}} \quad \frac{dx}{dt}$

$t \quad dt \quad _0^L \sqrt{\frac{2Mx}{TL^2}}\,dx \quad \sqrt{\frac{2M}{TL^2}} \; \frac{L^{\frac{1}{2}} \;\, 1}{\frac{1}{2} \quad 1}$

$\frac{2}{3}\sqrt{\frac{2ML^3}{TL^2}} \quad \frac{2}{3}\sqrt{\frac{2ML}{T}}$

16. (a) $v \quad \sqrt{\frac{T}{}} \quad \sqrt{\frac{Mg}{}}$

$\sqrt{\frac{1.5 \quad 9.8}{0.055}} \quad 16.3 \text{ m/s}$

(b) $\frac{v}{} \quad \frac{16.3 \text{ m/s}}{120/\text{s}} \quad 0.136\,\text{m}$

(c) $v \quad \sqrt{T} \quad \sqrt{M}$ *i.e.*, if M is doubled both speed and wavelength increases by a factor of $\sqrt{2}$.

17. $E \quad I\,At \quad 2\;^2\;^2a^2 \quad vAt$

$2\;^2\;^2a^2(\;A)\,(v.t)$

$2\;^2\;^2a^2 \quad .l$

$2\;^2\;^2a^2m$

$2 \quad (3.14)^2 \quad (120)^2 \quad (0.16 \quad 10\;^3)^2$

$80 \quad 10\;^3$

$582 \quad 10\;^6 \text{ J} \quad 582 \quad \text{J} \quad 0.58\,\text{mJ}$

18. $P \quad \frac{E}{t} \quad IA \quad 2\;^2\;^2a^2 \quad A \quad 2\;^2\;^2a^2 \quad v$

$2\;^2\;^2a^2\sqrt{T}$

$2 \quad (3.14)^2 \quad (60)^2$

$(6 \quad 10\;^2)^2\sqrt{80 \quad 5 \quad 10\;^2}$

$4(3.14 \quad 60 \quad 0.06)^2 \quad 511.6 \text{ W}$

19. $P \quad IA \quad 2 \ ^2 \ ^2 a^2 \sqrt{T}$

$2 \quad (3.14)^2 \quad (200)^2$

$10 \ ^6 \sqrt{60 \quad 6 \quad 10 \ ^3}$

$8 \quad (3.14)^2 \quad 10 \ ^2 \quad 6 \quad 10 \ ^1$ W

0.474 W

$E \quad Pt \quad P \ \frac{l}{v}$

$\frac{0.474 \quad 2}{\sqrt{\frac{60}{6 \quad 10 \ ^3}}} \quad \frac{0.474 \quad 2}{100}$ J 9.48 mJ

20. $P \quad 2 \ ^2 v^2 a^2 \ vA \quad 2 \ ^2 v^2 a^2 \ v ; v \quad \sqrt{\frac{T}{}}$

$\frac{T}{v^2}$

$2 \ ^2 \ ^2 a^2 \frac{T}{v^2} \ v \quad 2 \ ^2 \ ^2 a^2 \frac{T}{v}$

$\frac{2 \quad (3.14)^2 \quad (100)^2 (0.5 \quad 10 \ ^3)^2 \quad 100}{100}$

$2 \quad (3.14)^2 \quad 10^4 \quad 0.25 \quad 10 \ ^6$

$4.93 \quad 10 \ ^2$ W 49 mW

Objective Questions (Level 1)

1. $\frac{150 \quad 2}{60} \quad 5$ rad/s, $A \quad 0.04$ m and

$\overline{4}$

$y \quad A \sin(\ t \quad) \quad 0.04 \sin \ 5 \ t \quad \overline{4}$

2. $600 \ , v \quad 300 \quad k \quad \overline{v} \quad 2$

$y \quad A \sin(\ t \quad kx)$

$0.04 \sin (600 \ t \quad 2 \ x)$

$y(0.75, 0.01) \quad 0.04 \sin \ 600 \quad 0.01 \quad 2 \quad \frac{3}{4}$

$0.04 \sin \ 6 \quad \frac{3}{2}$

$0.04 \sin \ 4 \quad \overline{2} \quad 0.04$ m

3. $y(x, t) \quad \frac{1}{2 \quad 3(kx \quad t)^2}$

$y(x, 0) \quad \frac{1}{2 \quad 3k^2 x^2} \quad \frac{1}{2 \quad 3x^2}$

$k \quad 1$

$y(x, 2) \quad \frac{1}{2 \quad 3(x \quad 2 \ )^2} \quad \frac{1}{2 \quad 3(x \quad 2)^2}$

$1 \quad v \quad \overline{k} \quad 1$ m/s

4. $y \quad A \sin(\ t \quad kx) \quad \frac{A}{2}$

$t \quad kx \quad \overline{6}$

$\frac{2}{T} \ \frac{T}{6} \quad \overline{6} \quad kx$

$\overline{6} \ \frac{2}{} \quad 0.04$

$12 \quad 0.04 \quad 0.48$ m.

5. $\overline{v} \quad \frac{300 \text{ m/s}}{25 \text{ Hz}} \quad 12$m

$\overline{2} \quad x \quad \frac{2}{12\text{m}}(16 \quad 10)$m

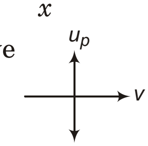
6. $y \quad 0.02 \sin (x \quad 30t) \quad A \sin (kx \quad t)$

$k \quad 1, \quad 30$

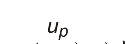
$v \quad \overline{k} \quad 30$ m/s $\sqrt{\frac{T}{}}$

$T \quad v^2 \quad 1.3 \quad 10 \ ^4 \quad 900 \quad 0.117$ N

7. $v_p \quad \frac{y}{t} \quad \frac{y}{x} \ \frac{x}{t} \quad v \frac{y}{x}$ slope v

In transverse wave  they are

perpendicular *i.e.*, $\overline{2}$. In longitudinal

wave , they are either at 0 or

so, 0, $\overline{2}$ and are the possible angles

between v_p and v.

8. $2 \quad 200$ rad/s,

$k \quad \overline{v} \quad \sqrt{\overline{T}} \quad 200 \ \sqrt{\frac{3.5 \quad 10 \ ^3}{35}}$

$2 \quad \text{rad/m}$

$y \quad A\cos(\quad t \quad kx) \quad A\cos(200 \quad t \quad 2 \quad x)$

$\frac{y}{x} \quad 2 \quad A\sin(200 \quad t \quad 2 \quad x)$

When, $y \quad 0$

$\sin(200 \quad t \quad 2 \quad x) \quad 0$

$\sin(200 \quad t \quad 2 \quad x) \quad 1$

$2 \quad A \quad \frac{}{20} \quad A \quad \frac{1}{40} \quad 0.025\,\text{m}$

$y \quad 0.025\cos(200 \quad t \quad 2 \quad x)$

9. $\frac{2}{T} \quad \frac{2}{0.25} \quad 8 \quad \text{rad/s};$

$k \quad \frac{}{v} \quad \frac{8}{48} \quad \frac{}{6}\,\text{rad/cm}$

$y \quad A\sin(\quad t \quad kx)$

$A\sin \quad 8 \quad 1 \quad \frac{}{6} \quad 67$

$A\sin\frac{}{6} \quad A\sin 30 \quad \frac{A}{2} \quad 3\text{ cm}$

$A \quad 6\text{ cm}$

10. $\frac{v_A}{v_B} \quad \sqrt{\frac{T_A}{A_A} \quad \frac{A_B}{T_B}} \quad \sqrt{\frac{T_A}{T_B} \quad \frac{d_B^2}{d_A^2}}$

$\frac{d_B}{d_A}\sqrt{\frac{T_A}{T_B}} \quad \frac{d_B}{d_B/2}\sqrt{\frac{T_B/2}{T_B}}$

$2 \quad \frac{1}{\sqrt{2}} \quad \sqrt{2}$

11. $E \quad A^2 \quad ^2$ for E to constant, A constant

$A_A \quad _A \quad A_B \quad _B \quad A_A 4 \quad _B \quad A_B \quad _B$

$A_B \quad 4A_A$

12. $k \quad 1$ rad/m; $v \quad 4$ m/s

$vk \quad 4\,\text{rad/s}$

$y \quad \frac{6}{(kx \quad t)^2 \quad 3} \quad \frac{6}{(x \quad 4t)^2 \quad 3}$

13. $v_l \quad \sqrt{\frac{Y}{}}$ and $v_t \quad \sqrt{\frac{Y\frac{l}{l}}{}} \quad v_l\sqrt{\frac{l}{l}}$

$\sqrt{\frac{l}{l}} \quad \frac{v_l}{v_t} \quad 10 \quad \frac{l}{l} \quad \frac{1}{100}$

Stress $\quad Y\frac{l}{l} \quad E\frac{l}{l} \quad \frac{E}{100}$

14. $A \quad 4$ m, $\frac{}{5}, k \quad \frac{}{9}, \quad \frac{}{6}$

$v \quad \frac{}{k} \quad \frac{/5}{9} \quad \frac{9}{5}\ \text{m/s}$

$\frac{2}{k} \quad \frac{2}{9} \quad 18\text{ m}$

$\frac{}{2} \quad \frac{/5}{2} \quad \frac{1}{10}\,\text{Hz}$

15. 10 and $k \quad 0.1$

$\frac{2}{k} \quad \frac{2}{0.1} \quad 20\text{ m}$

$\frac{2}{} \quad x \quad \frac{2}{20} \quad 10$

16. $y \quad \frac{2}{(2x \quad 6.2t)^2 \quad 20}$

$A \quad \frac{2}{20} \quad 0.1\text{ m}, k \quad 2\,\text{rad/m}$

and $\quad 6.2$ rad/s

$v \quad \frac{}{k} \quad \frac{6.2}{2} \quad 3.1\text{ m/s}$

$\frac{}{2} \quad \frac{6.2}{2 \quad 3.1} \quad 1\text{ Hz}$

$\frac{2}{k} \quad \frac{2}{2} \quad \text{m}$

17. $I \quad 2 \ ^2 \ ^2 A^2 \ v \quad \frac{1}{2} \ ^2 A^2 \ v$

$u \quad \frac{E}{V} \quad \frac{IST}{V} \quad \frac{2 \ ^2 \ ^2 A^2 \ v\,St}{V}$

$2 \ ^2 \ ^2 A^2 \quad \frac{1}{2} \ ^2 A^2$

$P \quad \frac{E}{t} \quad I.S \quad 2 \ ^2 \ ^2 A^2 \ v \ S$

$\frac{1}{2} \ ^2 A^2 v \ S$

$E \quad Pt \quad P \quad \frac{E}{t} \quad IS \quad I \quad \frac{P}{S}$

18. $y \quad A\sin(\quad x \quad t)$

$y(x, 0) \quad A\sin(\quad x) \quad y \quad 0$ for $x \quad 0$ and 1

$a \quad ^2 y \quad ^2 A\sin(\quad x)$

$a \quad ^2 A$ at $x \quad \frac{1}{2}$ and $\frac{3}{2}$

$v_P \quad A\cos(\quad x) \quad v_p \quad 0$ for $x \quad \frac{1}{2}$ and $\frac{3}{2}$

So all the above options are correct.

19. $y \quad A\sin\frac{2}{a}(x \quad bt) \quad A\sin(kx \quad t)$

$k \quad \frac{2}{a}, \quad \frac{2\ b}{a}$

$v \quad \frac{}{k} \quad \frac{2\ b/a}{2\ /a} \quad b$

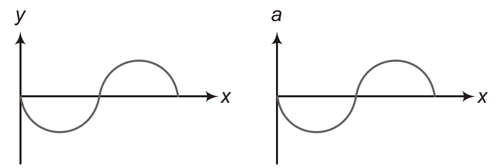
$\frac{2}{k} \quad \frac{2}{2\ /a} \quad a$

20. $y \quad A\sin 2 \quad \frac{x}{a} \quad \frac{t}{b} \quad A\sin 2 \quad \frac{x}{} \quad \frac{t}{T}$

$a, T \quad b$

$v \quad \frac{}{T} \quad \frac{a}{b}$

21.



as $\quad a \quad {}^2y$

JEE Corner

■ Assertion and Reason

1. For propagation of transverse waves medium require tension which is possible due to modulus of rigidity. And in gases there is no such Young's modulus or surface tension. So the reason given is correct explanation.

2. Surface tension of water plays the role of modulus of rigidity and that is why transverse waves can travel on liquid surface.

3. Both the waves are travelling in same direction with a phase difference of . So reason is false.

4. $v \quad f$ is constant for a particular medium so if frequency is doubled wavelength becomes half, and speed remains constant. Thus assertion is false.

5. Sound is mechanical wave which requires material medium for propagation and as on moon there is no atmosphere, sound cannot travel.

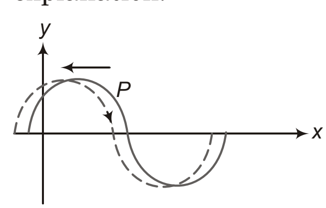
6. Angular wave number, $\quad \frac{2}{}$ while wave number, $k \quad \frac{1}{}$ which is defined as the number of waves per unit length.

7. Electromagnetic wave are non-mechanical, they travel depending upon electric and magnetic properties of medium. They can travel in medium as well as an vacuum. So reason is false.

8. As speed, $v \quad \sqrt{\frac{T}{}} \quad v \quad \frac{1}{\sqrt{}}$ in second string is more (by looking) so v will be less. Thus reason is true explanation of assertion.

9. At point A both v_p and $\quad l$ is zero *ie*, K.E. and P.E. are minimum while at B both v_p and $\quad l$ are maximum *i.e.*, both K.E. and P.E. are maximum. Thus both assertion and reason are true but not correct explanation.

12.



If P is moving downword then it shows that the wave is travelling in ( ) ve x direction. So assertion is false.

11. $A \quad 2a \cos \frac{}{2}$, for $A \quad a$

$$\cos \frac{}{2} \quad \frac{1}{2} \quad \cos \frac{}{3}$$

■ Match the Columns

1. $y \quad a \sin (bt \quad cx) \quad A \sin (\quad t \quad kx)$

(a)	$v \quad \frac{}{k} \quad \frac{b}{c}$	r
(b)	$(v_p)_{max} \quad A \quad ab$	s
(c)	$\frac{}{2} \quad \frac{b}{2}$	p
(d)	$\frac{2}{k} \quad \frac{2}{c}$	s

2. $y \quad 4$ cm $\sin (\quad t \quad 2 \quad x)$

$v_p \quad 4 \quad$ cm/s $\cos (\quad t \quad 2 \quad x)$

$a \quad 4 \quad ^2$ cm/s^2 $\sin (\quad t \quad 2 \quad x)$

(a)	$v_p (0, t) \quad 4 \quad$ cm s $\cos \quad t$ $4 \quad$ for $\cos \quad t \quad 1$ or $t \quad n \quad t \quad n \quad 0, 1, 2, 3,$	q, r
(b)	$a(0, t) \quad 4 \quad ^2$ cm/s^2 $\sin \quad t$ $4 \quad ^2$ for $\sin \quad t \quad 1$ or $t \quad (2n \quad 1) \frac{}{2}$ $t \quad n \quad \frac{1}{2} \quad 0.5, 2.5$	p, s
(c)	$v_p (0.5, t) \quad 4 \quad$ cm/s $\cos (\quad t \quad)$ $4 \quad$ for $\quad t \quad n$ or $t \quad n \quad 1 \quad 0, 1, 2, 3,$	q, r
(d)	$a\,(0.5, t) \quad 4 \quad ^2$ cm/s^2 $4 \quad ^2 \quad t \quad (2n \quad 1) \frac{}{2}$ or $t \quad n \quad \frac{1}{2} \quad 0.5, 1.5, 2.5$	p

3. $y \quad A \sin (\quad t \quad kx)$ at $t \quad 0$

$y \quad A \sin kx$

$v_p \quad A \cos kx$ and $a \quad ^2 y$

(a)	$v_p \quad A \cos kx$	s
(b)	$a_A \quad (\ ) \, v_e$ as y_A is negative	p
(c)	$v_B \quad A$	s
(d)	$a_B \quad 0$ ve $y_0 \quad 0$	r

$$\frac{2}{3} \quad \frac{360}{3} \quad 120$$

Assertion is true but the reason is false.

4. (a) $u \quad \frac{E}{V} \quad \frac{IST}{V} \quad \frac{2 \quad ^2 \quad ^2 A^2 \quad vst}{V}$

$$2 \ ^2 \ ^2 A^2 \quad \frac{1}{2} \quad ^2 A^2$$

$$[u] \quad \frac{[ML^2T^{\ 2}]}{[L^3]} \quad [ML^{\ 1}T^{\ 2}] \quad s$$

(b) $P \quad \frac{E}{t} \quad \frac{ISt}{t} \quad IS \quad 2 \ ^2 \quad ^2 A^2 \ vs$

$$\frac{1}{2} \quad ^2 A^2 \ vs \quad \frac{1}{2} \quad ^2 A^2 s\, v \quad q$$

$$[P] \quad \frac{E}{t} \quad \frac{[ML^2T^{\ 2}]}{[T]} \quad [ML^2T^{\ 3}] \quad p$$

(c) $I \quad \frac{E}{St} \quad \frac{[ML^2T^{\ 2}]}{[L^2T]}$

$$[MT^{\ 3}] \quad [ML^0T^{\ 3}] \quad s$$

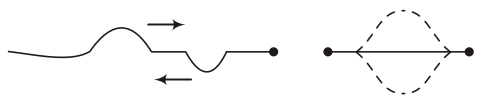
(d) $\frac{1}{} \quad [L^{\ 1}] \quad [M^0L^{\ 1}T^0] \quad s$

5.	(a)	$y \quad A \sin (\quad t \quad kx)$	p
		$v_p \quad A \cos (\quad t \quad kx)$	r
		$a \quad ^2 A \sin (\quad t \quad kx)$	
	(b)	$y \quad A \sin (kx \quad t)$	p
		$v_p \quad A \cos (kx \quad t)$	
		$a \quad ^2 A \sin (kx \quad t)$	
	(c)	$y \quad A \cos (\quad t \quad kx)$	q
		$v_p \quad A \sin (\quad t \quad kx)$	
		$a \quad ^2 A \cos (\quad t \quad kx)$	s
	(d)	$y \quad A \cos (kx \quad t)$	p
		$v_p \quad A \quad \sin (kx \quad t)$	
		$a \quad ^2 A \cos (kx \quad t)$	d s

15. Superposition of Waves

Introductory Exercise 15.1

1.



When displacement of all the particles is momentarily zero, then there is no elastic potential energy stored in the string and as the speed is maximum at mean position, so entire energy is purely kinetic.

2. (a) $v \quad \sqrt{\frac{T}{\ }}$

$\frac{v_2}{v_1} \quad \sqrt{\frac{\ _1}{\ _2}}$

$\sqrt{\frac{\ _1}{0.25 \ _1}} \quad \frac{1}{\sqrt{0.25}}$

$\frac{1}{0.5} \quad 2$

$v_2 \quad 2v_1 \quad 20\ \text{cm/s}$

(b) $a_t \quad \frac{2v_2}{v_1 \quad v_2} a_i$

$\frac{2 \quad 20}{10 \quad 20} a_i \quad \frac{4}{3} a_i$

and $a_r \quad \frac{v_2 \quad v_1}{v_2 \quad v_1} a_i$

$\frac{20 \quad 10}{20 \quad 10} a_i \quad \frac{1}{3} a_i$

3. (a) For fixed end, a phase change of takes place in reflected wave and direction becomes opposite.

as $Y_i \quad 0.3 \cos (2x \quad 40t)$

$Y_r \quad 0.3 \cos (2x \quad 40t \qquad)$

(b) For free end, there is no change in phase for reflected wave and direction becomes opposite.

as $Y_i \quad 0.3 \cos (2x \quad 40t)$

$Y_r \quad 0.3 \cos (2x \quad 40t)$

4. $v_1 \quad \frac{\ }{k_1} \quad \frac{50}{2} \quad 25\ \text{m/s}$ and $v_2 \quad 50\ \text{m/s}$

$a_t \quad \frac{2v_2}{v_1 \quad v_2} a_i \quad \frac{2 \quad 50}{25 \quad 50} a_i$

$\frac{4}{3} \quad 2 \quad 10^{\ 3}\ \text{m} \quad \frac{8}{3}\ \text{mm.}$

$a_r \quad \frac{v_2 \quad v_1}{v_2 \quad v_1} a_i \quad \frac{50 \quad 25}{50 \quad 25} a_i$

$\frac{1}{3} \quad 2 \quad 10^{\ 3}\ \text{m} \quad \frac{2}{3}\ \text{mm.}$

as $v_2 \quad v_1$ the boundary is rearer and there is no phase change.

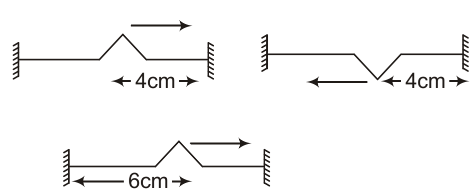
$k_2 \quad \frac{\ }{v_2}$

$\frac{50}{50}$

$y_r \quad \frac{2}{3} \quad 10^{\ 3} \cos \quad (0.2\,x \quad 50t)$

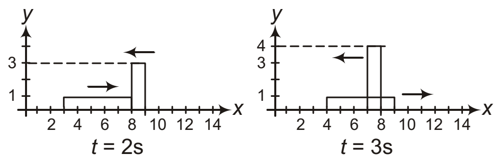
and $y_t \quad \frac{8}{3} \quad 10^{\ 3} \cos \quad (1.0\,x \quad 50t)$

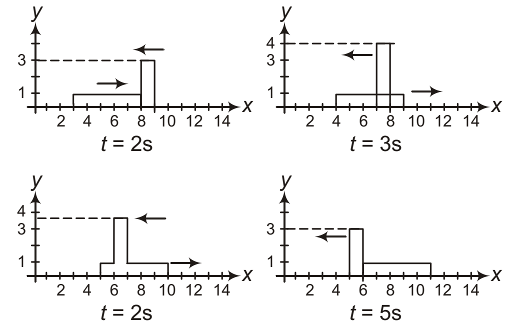
5. $t_1 \quad \frac{2 \quad 40\ \text{cm}}{1\ \text{cm/s}} \quad 8$ s, inverted



$t_2 \quad \frac{4 \quad 10 \quad 6}{1}$

20 s upright

6. 



Introductory Exercise 15.2

1. $y \quad 5 \sin \frac{x}{3} \cos 40 \quad t \quad 2a \sin kx \cos \quad t$

$a \quad \frac{5}{2} \quad 2.5\,\text{cm},\ k \quad \frac{}{3}\ \text{cm}^{\ 1}, \qquad 40 \quad \text{s}^{\ 1}$

$v \quad \frac{}{k} \quad \frac{40}{3} \quad 120\,\text{cm/s}$

$x \quad \frac{}{2} \quad \frac{1}{2}\ \frac{2}{k} \quad \frac{}{k} \quad \frac{}{/9}\ \text{cm} \quad 3\,\text{cm}$

$v_P \quad \frac{dy}{dt} \quad 200 \quad \sin \frac{x}{3} \sin 40 \quad t$

$v_P \quad 1.5, \frac{9}{8} \qquad 200 \quad \sin \quad \frac{}{3}\ \frac{3}{2}$

$\sin \quad 40 \quad \frac{9}{8}$

$200 \quad \sin \quad \frac{}{2} \quad \sin (45 \quad)$

$200 \quad 1 \quad 0$

$0\,\text{cm/s}$

2. Two waves with different amplitudes can produce partial stationary waves with amplitude of antinodes being $a_1 \quad a_2$ and amplitude of nodes being $a_1 \sim a_2$. As here node is not stationary that is why energy is also transported through nodes.

3. (a) $\frac{}{2} \quad 2\,\text{m} \qquad 4\,\text{m},$

$v \quad \sqrt{\frac{T}{}} \quad \sqrt{\frac{100}{4 \quad 10^{\ 2}}} \quad \frac{10^2}{2} \quad 50\,\text{m/s}$

$\frac{v}{} \quad \frac{50}{4} \quad 12.5\,\text{Hz}$

and is fundamental tone or first harmonic.

$y \quad 0.1 \sin \frac{2}{} x \sin 2 \quad t$

$0.1 \sin \frac{2}{4} x \sin 2 \quad 12.5\ t$

$0.1 \sin \frac{}{2} x \sin 25 \quad t$

(b) $3 \frac{}{2} \quad 2\,\text{m} \qquad \frac{4}{3}\ \text{m and } v \quad 50\,\text{m/s}$

$\frac{v}{} \quad \frac{50}{4/3}\ \text{Hz} \quad 37.5\ \text{Hz and is 2nd}$

overtone or 3rd harmonic.

$y \quad 0.04 \sin \frac{2}{4/3} x \sin 2 \quad 37.5\ t$

$0.04 \sin \frac{3}{2} x` \sin 75 \quad t$

4. $v \quad \sqrt{\frac{F}{}} \quad \sqrt{\frac{Fl}{m}} \quad \sqrt{\frac{400 \quad 4}{160 \quad 10^{\ 3}}}$

$\sqrt{\frac{1600}{16 \quad 10^{\ 2}}} \quad 10^2 \quad 100\,\text{m/s}$

(a) $\frac{0}{4} \quad l \qquad {}_0 \quad 4l \quad 16\,\text{m}$

$\frac{3}{4}\,{}_1 \quad l \quad {}_1 \quad \frac{4l}{3} \quad \frac{16}{3}$ m 5.33 m

and $\frac{5}{4}\,{}_2 \quad l \quad {}_2 \quad \frac{4l}{5} \quad \frac{16}{5}$ m 3.2 m

(b) ${}_0 \quad \frac{v}{{}_0} \quad \frac{100}{16}$ 6.25 Hz

${}_1 \quad \frac{v}{{}_1} \quad \frac{100}{16/3}$ 18.75 Hz

${}_3 \quad \frac{v}{{}_3} \quad \frac{100}{16/5}$ 31.25 Hz

5. $l \quad n\frac{}{2} \quad \frac{0.54}{2}\,n \quad 0.27\,n$

and $l \quad (n \quad 1)\frac{}{2} \quad \frac{0.48}{2}(n \quad 1)$

$0.24\,(n \quad 1)$

$0.27\,n \quad 0.24\,n \quad 0.24$

$0.03\,n \quad 0.24 \qquad n \quad 8$

(a) These are 8th and 9th harmonic

(b) $l \quad 0.27\,n \quad 0.27 \quad 8 \quad 2.16$ m

(c) $\frac{{}_0}{2} \quad l \quad {}_0 \quad 2l \quad 4.32$ m

6. $5\,{}_0 \quad 2\,{}_0$ 54 Hz

$3\,{}_0$ 54 Hz ${}_0$ 18 Hz

7. ${}_0 \quad \frac{1}{2l}\sqrt{\frac{F}{}}$

$\frac{{}_2}{{}_1} \quad \sqrt{\frac{F_2}{F_1}}$

$\sqrt{\frac{M \quad 2.2}{2.2}} \quad \frac{260}{220} \quad \frac{13}{11}$

$\frac{M \quad 2.2}{2.2} \quad \frac{169}{121} \quad 1 \quad \frac{48}{121}$

$1 \quad \frac{M}{2.2}$

$M \quad \frac{48 \quad 2.2}{121} \quad \frac{9.6}{11}$ 0.873 kg

8. $n\,{}_0$ 250 Hz and $(n \quad 1)\,{}_0$ 300 Hz

${}_0$ 50 Hz

and n 5 So these are 5th and 6th harmonics.

${}_0 \quad \frac{1}{2l}\sqrt{\frac{F}{}}$

$F \quad 4l^2 v_0^2 \quad 4 \quad 50^2$

$\frac{36 \quad 10^{\;\;3}}{1}$ 360 N

AIEEE Corner

■ Subjective Question (Level 1)

1. $A \quad \sqrt{A_1^2 \quad A_1^2 \quad 2A_1\,A_1 \cos 90}$

$A_1\sqrt{2} \quad 4\sqrt{2}$ cm 5.66 cm

2. $v_2 \quad 2\,v_1$

$A_r \quad \frac{v_2 \quad v_1}{v_2 \quad v_1}A \quad \frac{v_1}{3v_1}A \quad \frac{1}{3}A$

$A_t \quad \frac{2v_2}{v_2 \quad v_1}A \quad \frac{4v_1}{3v_1}A \quad \frac{4}{3}A$

$\frac{I_r}{I_i} \quad \frac{A_r}{A}^{2} \quad \frac{1}{9}$

and $\frac{I_t}{I_i} \quad 1 \quad \frac{1}{9} \quad \frac{8}{9}$

$A \quad \sqrt{10^2 \quad 20^2 \quad 2 \quad 10 \quad 20\cos\frac{}{3}}$

$\sqrt{100 \quad 400 \quad 200} \quad \sqrt{700} \quad 10\sqrt{7}$

26.46 units

$\tan \quad \frac{20\sin\frac{}{3}}{10 \quad 20\cos\frac{}{3}}$

$\sin\frac{}{3} \quad \frac{\sqrt{3}}{2}$

$\tan^{\;1} \frac{\sqrt{3}}{2}$ 0.714 rad

Phase $5x \quad 25t$ 0.714 rad.

4. y_1 1 cm sin (cm ^{1}x 50 s ^{1}t)

$y_2 \quad 1.5\,\text{cm}\sin \quad \frac{}{2}\,\text{cm}^{\;1}x \quad 100 \quad \text{s}^{\;1}t$

$y_1\,(4.5, 5 \quad 10^{\;3}) \quad 1\,\text{cm}\sin \quad 4.5 \qquad \frac{250}{1000}$

$1\sin \frac{9}{2} \qquad \frac{}{4}$

$1\sin \frac{17}{4}$

$1\,\text{cm}\sin \quad 4 \qquad \frac{}{4}$

$1\sin\frac{}{4} \qquad \frac{1}{\sqrt{2}}$ cm and

$y_2\,(4.5, 5 \quad 10^{\;3}) \quad 1.5\,\text{cm}\sin \quad \frac{9}{4} \qquad \frac{500}{1000}$

$1.5\,\text{cm}\sin \quad \frac{9}{4} \qquad \frac{}{2}$

$= 1.5\sin \quad \frac{5}{4}$

$1.5\sin \qquad \frac{}{4}$

$1.5\sin \quad \frac{}{4}$

$\frac{1.5}{\sqrt{2}}$ cm

$y \quad y_1 \quad y_2 \quad \frac{1}{\sqrt{2}} \quad \frac{1.5}{\sqrt{2}}$

$\frac{0.5}{\sqrt{2}} \qquad \frac{1}{2\sqrt{2}}$ cm

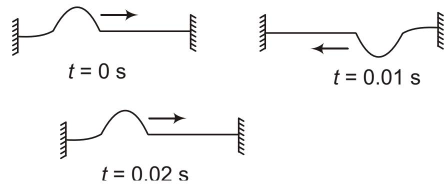
5. $v \quad \sqrt{\frac{T}{}} \quad \sqrt{\frac{16\text{N}}{0.4 \quad 10^{\;3} \quad 10^2\ \text{kg/N}}}$

$\sqrt{\frac{16 \quad 10^2}{4}} \quad 20\,\text{m/s}$

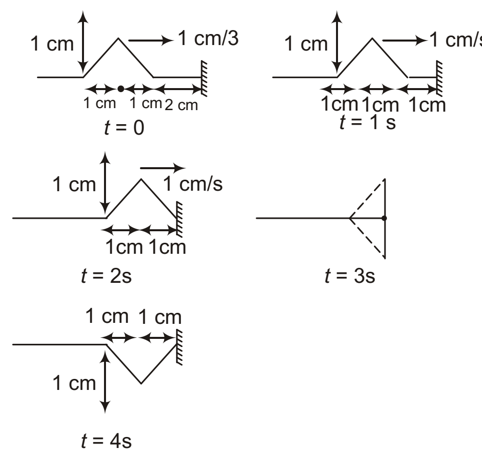
(a) For same shape, time,

$t \quad \frac{2l}{v} \quad \frac{2 \quad 0.2}{20}\,\text{s} \quad 0.02\,\text{s}$

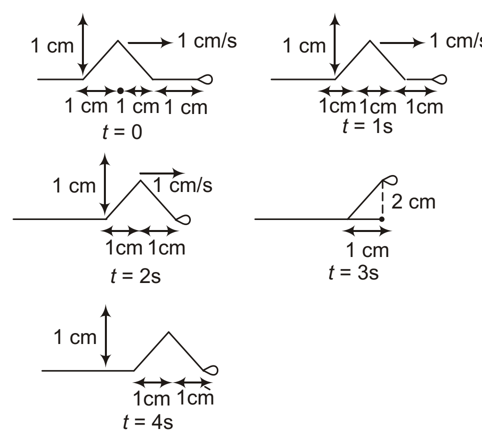
(b)



6. (a)



(b)



7. $y \quad 1.5\sin(0.4\,x)\cos(200t)$

$2A\sin kx\cos \quad t$

$\frac{2}{k} \quad \frac{2}{0.4} \quad 5 \quad \text{m} \quad 15.7\,\text{m}$

$\frac{}{2} \quad \frac{200}{2} \quad \frac{100}{}\,\text{Hz} \quad 31.8\,\text{Hz}$

$v \quad \frac{}{k} \quad \frac{200}{0.4} \quad 500\,\text{m/s}$

8. $y \quad y_1 \quad y_2 \quad 3 \text{ cm} \sin(\; x \quad 0.6 \; t)$

$3 \text{ cm} \sin(\; x \quad 0.6 \; t)$

$6 \text{ cm} \sin \; x \cos 0.6 \; t \quad R \cos 0.6 \; t$

where, $R \quad 6 \text{ cm} \sin \; x$.

(a) $R\,(0.25) \quad 6 \text{ cm} \sin \quad \frac{1}{4}$

$\frac{6}{\sqrt{2}} \quad 3\sqrt{2} \text{ cm} \quad 4.24 \text{ cm}$

(b) $R\,(0.50) \quad 6 \text{ cm} \sin \quad \frac{1}{2} \quad 6 \text{ cm}$

(c) $R\,(1.50) \quad 6 \text{ cm} \sin \frac{3}{2} \quad 6 \text{ cm}$

$|R| \quad 6 \text{ cm}$

(d) For antinodes, $R \quad 6 \text{ cm}$

$\sin \; x \quad 1 \quad x \quad (2n \quad 1)\frac{}{2}$

or $x \quad n \quad \frac{1}{2} \quad 0.5 \text{ cm}, 1.5 \text{ cm}, 2.5 \text{ cm}$

9. $\frac{2}{4} \quad \frac{2}{/2} \quad 4 \text{ cm}$

(a) Distance between successive antinodes $\frac{}{2} \quad 2 \text{ cm}$

(b) $R(x) \quad 2A \sin kx$

$2 \quad \text{cm} \sin \frac{}{2} \quad 0.5$

$2 \sin \frac{}{4}$

$\frac{2}{\sqrt{2}} \quad \sqrt{2} \quad \text{cm}$

10. $_n \quad \frac{n \quad 1}{2l}\sqrt{\frac{T}{}} \quad \frac{n \quad 1}{2 \quad 20}\sqrt{\frac{20}{9 \quad 10 \quad ^3}}$

$\frac{n \quad 1}{60} \quad \frac{100\sqrt{2}}{3} \quad \frac{5\sqrt{2}}{9} \quad \frac{5\sqrt{2}}{9}(n \quad 1)$

$0.786\,(n \quad 1)$

0.786 Hz

$1.57 \text{ Hz}, 2.36 \text{ Hz}, 3.14 \text{ Hz}$

11. (a) $T \quad v^2 \quad ^{2\;2}$

$\frac{1.2 \quad 10 \quad ^3}{0.7} \quad (220)^2 \quad (1.4)^2$

162.6 N

(b) $_2 \quad 3 \; _0 \quad 3 \quad 220 \text{ Hz} \quad 660 \text{ Hz}$

12. $_n \quad \frac{n \quad 1}{2l}\sqrt{\frac{T}{}} \quad \frac{n \quad 1}{2 \quad 0.6}\sqrt{\frac{50}{0.01}}$

$\frac{50\sqrt{2}}{1.2}(n \quad 1) \quad 58.93\,(n \quad 1) \text{ Hz}$

$_n \quad 20{,}000 \text{ Hz} \quad n \quad 338$

$_{338} \quad 339 \quad 58.93 \quad 19975.8 \text{ Hz}$

19.976 kHz

13. $n \; _0 \quad 420 \text{ Hz}$ and $(n \quad 1) \; _0 \quad 490 \text{ Hz}$

$_0 \quad 70 \text{ Hz}$ and $n \quad 6$

$_0 \quad \frac{1}{2l}\sqrt{\frac{T}{}} \quad l \quad \frac{1}{2 \; _0}\sqrt{\frac{T}{}} \quad \sqrt{\frac{\frac{450}{0.005}}{2 \quad 70}}$

$\frac{300}{140} \quad 2.143 \text{ m}$

14. $\frac{v}{} \quad \frac{400 \text{ m/s}}{800 \text{ Hz}} \quad \frac{1}{2} \text{ m},$

$l \quad 4\frac{}{2} \quad 2 \quad 1 \text{ m}$

(a) $4 \; _0 \quad 400 \text{ Hz} \quad _0 \quad 100 \text{ Hz}$

(b) $7 \; _0 \quad 700 \text{ Hz}$

16. $_0 \quad \frac{1}{2l}\sqrt{\frac{T}{}}$

$_0 \quad \frac{1}{l}$

$_1 : \; _2 : \; _3 \quad 1 : 2 : 3$

$\frac{1}{l_1} : \frac{1}{l_2} : \frac{1}{l_3}$

$l_1 : l_2 : l_3 \quad \frac{1}{1} : \frac{1}{2} : \frac{1}{3}$

$6 : 3 : 2 \quad 6x : 3x : 2x$

$6x \quad 3x \quad 2x \quad 1 \text{ m}$

$x \quad \frac{1}{11} \text{ m}$

position of first bridge $6x \quad \frac{6}{11} \text{ m}$

and position of second bridge

$6x \quad 3x \quad 9x \quad \frac{9}{11} \text{ m}$

From the same end or $1 \quad \frac{9}{11} \quad \frac{2}{11}$ m from other end .

17. $_0 \quad \frac{v}{2l}$

$_0 \quad \frac{v}{2l}$

$l \quad \frac{_0}{_0} l \quad \frac{124}{186} \quad 90 \text{ cm} \quad 60 \text{ cm}$

Thus length of the vibrating string has to be 60 cm.

18. $\frac{}{2} \quad 15 \text{ cm} \qquad 30 \text{ cm},$

$R_{max} \quad 2A \quad 0.85 \text{ cm},$

$T \quad 0.075 \text{ s}$

(a) $y \quad 2A \sin kx \sin \quad t$

$0.85 \text{ cm} \sin \frac{2}{0.3 \text{ m}} x \sin \frac{2}{0.075 \text{ s}} t$

(b) $v \quad \frac{}{k} \quad \frac{2 \ /0.075}{2 \ /0.3} \quad \frac{0.3}{0.075} \quad 4 \text{ m/s}$

(c) $\frac{}{4} \quad \frac{30}{4} \quad 7.5 \text{ cm}$

$R\,(7.5 \quad 3) \quad 2A \sin kx$

$0.85 \sin \frac{2}{30} \quad 10.5$

$R(11.5 \text{ cm}) \quad 0.85 \sin \frac{21}{30}$

$0.85 \sin (0.7 \quad)$

$0.85\,(126 \ ) \quad 0.688 \text{ cm}$

19. $_0 \quad \frac{v}{2l} \quad \frac{48}{2 \quad 1.5} \quad 16 \text{ Hz}$

and $\quad _0 \quad 2l \quad 3 \text{ m}$

$_2 \quad 3 \ _0 \quad 48 \text{ Hz and } _2 \quad \frac{v}{_2} \quad \frac{48}{48} \quad 1 \text{ m}$

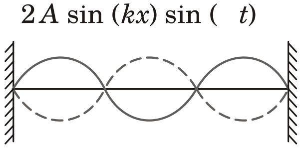
$_3 \quad 4 \ _0 \quad 64 \text{ Hz}$

and $_3 \quad \frac{v}{_3} \quad \frac{48}{64} \quad \frac{3}{4} \quad 0.75 \text{ m}$

20. $y \quad 5.60 \text{ cm} \sin (0.340 \text{ rad/cm } x)$

$\sin (50.0 \text{ rad/s } t)$

$2A \sin (kx) \sin (\quad t)$

(a) 

(b) $2A \quad 5.60 \text{ cm} \qquad A \quad 2.80 \text{ cm}$

(c) $l \quad 3 \frac{}{2} \quad \frac{3}{2} \frac{2}{k} \quad \frac{3}{k}$

$\frac{3}{0.0340} \text{ cm} \quad 277.2 \text{ cm}$

(d) $\frac{2}{k} \quad \frac{2}{0.0340} \text{ cm} \quad 184.8 \text{ cm}$

$\frac{}{2} \quad \frac{50}{2} \quad 7.96 \text{ Hz}$

$T \quad \frac{1}{} \quad \frac{1}{7.96} \text{ s} \quad 0.216 \text{ s}$

$v \qquad 7.96 \text{ Hz} \quad 184.8 \text{ cm}$

1470 cm/s

(e) $(v_p)_{max} \quad R_{max} \quad 2A$

$5.60 \text{ cm} \quad 50 \text{ rad/s}$

280 cm/s

(f) for eight harmonic,

$8 \frac{}{2} \quad l \qquad \frac{l}{4} \quad \frac{277.2}{4} \quad 69.3 \text{ cm}$

$k \quad \frac{2}{} \quad \frac{2 \quad 3.14}{69.3} \quad 0.0907 \text{ rad/cm}$

$v \quad 8\, v_0 \quad \frac{8}{3} \ v \quad \frac{8}{3} \quad 7.96 \text{ Hz}$

21.22 Hz

$2 \qquad 133.4 \text{ rad/s}$

$y \quad 5.60 \text{ cm} \sin (0.0907 \text{ rad/s } x)$

$\sin (133 \text{ rad/s } t)$

21. (a) $v \qquad _0 \ 2l \quad 60 \quad 2 \quad 0.8$

96 m/s

(b) $T \quad v^2 \quad \frac{40 \quad 10^{\ 3}}{80 \quad 10^{\ 2}} \quad (96)^2$

$\frac{96^2}{20} \quad 460.8 \text{ N}$

(c) $(v_p)_{max} \quad R_{max}$

$0.3 \text{ cm} \quad 2$

$60 \text{ rad/s} \quad 113 \text{ cm/s} \quad 1.13 \text{ m/s}$

$a_{max} \quad ^2 R_{max} \quad (120 \ )^2 \quad 0.3 \text{ cm/s}^2$

426.4 m/s^2

■ Objective Questions (Level 1)

1. $\frac{2}{1} \quad \sqrt{\frac{T_2}{T_1}} \quad \frac{3}{2} \quad \sqrt{\frac{T \quad 2.5}{T}}$

$9T \quad 4(T \quad 2.5)$

$5T \quad 10 \quad T \quad 2N$

2. $\frac{n \quad 1}{2l}\sqrt{\frac{T}{}} \quad \frac{n \quad 1}{2l}\sqrt{\frac{T}{r^2}}$

$\frac{n \quad 1}{2lr}\sqrt{\frac{T}{}} \quad \frac{n \quad 1}{ld}\sqrt{\frac{T}{}}$ constant.

$n \quad 1 \quad \frac{ld}{\sqrt{T}}$

$\frac{n_1 \quad 1}{n_2 \quad 1} \quad \frac{l_1}{l_2} \quad \frac{d_1}{d_2}\sqrt{\frac{T_2}{T_1}}$

$\frac{1}{2} \quad \frac{1}{3} \quad \sqrt{2}$

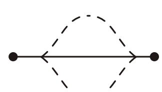
$\frac{1}{3\sqrt{2}} \quad 1:3\sqrt{2}$

or $\frac{n_2 \quad 1}{n_1 \quad 1} \quad 3\sqrt{2}$

3. $f \quad \frac{1}{l}; l \quad l_1 \quad l_2 \quad l_3$

$\frac{1}{f_0} \quad \frac{1}{f_1} \quad \frac{1}{f_2} \quad \frac{1}{f_3}$

4. During overlapping the displacement of particles is zero while velocity is maximum. So the entire energy is purely kinetic.



5. $y(x, y) \quad y_1 \quad y_2 \quad a\cos(kx \quad t) \quad y_2$

$2a \sin kx \sin \quad t$ is necessary for a node at $x \quad 0$. Thus,

$y_2 \quad 2a \sin kx \sin \quad t \quad a\cos(kx \quad t)$

$2a \sin kx \sin \quad t \quad a\cos kx \cos \quad t$

$a \sin kx \sin \quad t$

$a[\cos kx \cos \quad t \quad \sin kx \sin \quad t]$

$a\cos(kx \quad t)$

6. In transverse stationary wave, longitudinal strain is maximum at node. While in longitudinal stationary wave at displacement node pressure and density are maximum. So all are correct.

7. In stationary wave all particles errors the mean position simultaneously and are at their maximum displacement simultaneously at different instant at this time all of them are at rest. So all are correct.

8. Maximum displacement

$y_{max} \quad 3A \quad A \quad 2A \quad 4A$

$\frac{v_t}{v_l} \quad \frac{v_t}{v_l} \quad \frac{\sqrt{\frac{Y \quad l}{l}}}{\sqrt{\frac{Y}{}}} \quad \sqrt{\frac{l}{l}}$

$\sqrt{\frac{\frac{1}{} l}{l}} \quad \frac{1}{\sqrt{}}$

10. $f_n \quad \frac{n \quad 1}{2 \quad 1}\sqrt{\frac{100}{0.01}} \quad 50(n \quad 1)$

50 Hz, 100 Hz, 150 Hz

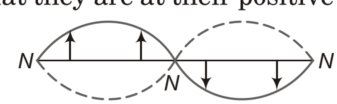
$n_n \quad \frac{2n \quad 1}{4 \quad 1}\sqrt{\frac{100}{0.01}} \quad 25(2m \quad 1)$

25 Hz, 75Hz, 125 Hz

$n_2 \quad 75\text{ Hz} \quad \frac{f_1 \quad f_2}{2}$

$\frac{50\text{ Hz} \quad 100\text{Hz}}{2} \quad 75\text{ Hz}$

11. In stationary waves all particles perform SHM such that they are at their positive and negative extremes one time each in a time period, where they come to rest. Particles between two successive nodes are in phase while beside node are in opposite phase. So all the particles cannot be at positive extreme simultaneously.



12. The question is wrong, string has to be fix at one end and free at other. Then

$(2n \quad 1)\ _0 \quad 90\text{ Hz}, (2n \quad 3)\ _0 \quad 50\text{ Hz}$

and $(2n \quad 5)\ _0 \quad 210\text{ Hz}$

$2 \quad _0 \quad 60\text{ Hz or } \quad _0 \quad 30\text{ Hz and } n \quad 1$

i.e., vibrations are 3rd, 5th and 7th harmonic.

$$_0 \quad 2l \quad 1.6\text{ m}$$
$$v \quad _0 \; _0 \quad 30\text{ Hz} \quad 1.6\text{ m}$$
$$48\text{ m/s}$$

13. $y \quad y_1 \quad y_2 \quad y_3 \quad 12\sin \quad \frac{}{2}$

$$6\sin(\quad 0) \quad 4\sin \quad \frac{}{2}$$
$$6\sin \quad 12\cos \quad 4\cos$$
$$6\sin \quad 8\cos$$
$$R \quad \sqrt{6^2 \quad 8^2 \quad 2 \quad 6 \quad 8\cos\frac{}{2}}$$
$$\sqrt{100} \quad 10\text{ mm}$$

14. $(2n \quad 1) \; _0 \quad 105\text{ Hz}$

and $(2n \quad 3) \; _0 \quad 175\text{ Hz}$

$$2 \; _0 \quad 70\text{ Hz}$$
$$_0 \quad 35\text{ Hz}$$

15. $l_1 : l_2 : l_3 \quad \frac{1}{_1} : \frac{1}{_2} : \frac{1}{_3} \quad \frac{1}{1} : \frac{1}{3} : \frac{1}{4}$

$$12:4:3$$
$$12x \quad 4x \quad 3x \quad 114\text{ cm}$$
$$x \quad \frac{114}{19}\text{ cm} \quad 6\text{ cm}$$

$l_1 \quad 12x \quad 72\text{ cm}, l_2 \quad 4x \quad 24\text{ cm},$

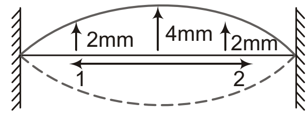
$l_3 \quad 3x \quad 18\text{ cm}$

16. $f \quad \sqrt{T}$

$$\frac{f/2}{f} \quad \sqrt{\frac{V\,g \quad V\,_1 g}{V\,g}} \quad \sqrt{1 \quad \frac{_1}{}} \quad \frac{1}{2}$$
$$1 \quad \frac{_1}{} \quad \frac{1}{4} \quad \frac{_1}{} \quad \frac{3}{4}$$
$$\frac{f/3}{f} \quad \sqrt{\frac{V\,g \quad V\,_2 g}{V\,g}} \quad \sqrt{1 \quad \frac{_2}{}} \quad \frac{1}{3}$$
$$1 \quad \frac{_2}{} \quad \frac{1}{q} \quad \frac{_2}{} \quad \frac{8}{9}$$
$$\frac{_1}{_2} \quad \frac{3/4}{8/9} \quad \frac{27}{32} \quad \frac{_2}{_1} \quad \frac{32}{27} \quad 1.18$$

where $_1$ is density of water and $_2$ is density of the other liquid.

17. $R \quad 2A\sin Kx \quad 4\text{ mm}\sin\frac{2}{}x$



$$4\text{ mm}\sin\frac{2\;x}{3\text{ m}}$$
$$2\text{ mm} \quad 4\text{ mm}\sin\frac{2\;x}{3}$$
$$\frac{2\;x}{3} \quad \frac{}{3}$$
$$x \quad 0.5\text{ m}$$

Thus points 1 and 2 are at 0.5 m from their nearest boundary. So separation between them is

$1.5\text{ m} \quad 2 \quad 0.5\text{ m} \quad 0.5\text{ m} \quad 50\text{ m}$

18. $y \quad A\sin(\quad t \quad kx)$

$$A\sin\; 2 \quad t \quad \frac{2}{v}x$$
$$A\sin(6 \quad t \quad 2\;x)$$

$y(3, t) \quad A \quad A\sin(6 \quad t \quad 6\;)$

$$A\sin(6 \quad 6\;t)$$
$$6 \quad 6\;t \quad \frac{}{2} \quad \frac{11}{2} \quad 6t$$
$$t \quad \frac{11}{12}\text{ s}$$

19. $_1 \quad \frac{2}{} \quad x \quad \frac{2}{} \quad \frac{3}{2} \quad 3$

and $_2 \quad \frac{}{2} \quad 3 \quad \frac{}{2} \quad \frac{5}{2}$

20. $n \; _0 \quad 400\text{ Hz}, (n \quad 1) \quad 450\text{ Hz}$

$$_0 \quad 50\text{ Hz and } n \quad 8$$
$$_0 \quad \frac{1}{2l}\sqrt{\frac{T}{}} \quad l \quad \frac{1}{2\;_0}\sqrt{\frac{T}{}}$$
$$\frac{1}{2 \quad 50}\sqrt{\frac{490}{0.1}} \quad \frac{70}{100} \quad 0.7\text{ m}$$

21. $3\frac{}{2} \quad 1\text{ m}, \quad \frac{2}{3}\text{ m}$

$$v \quad 300\text{ Hz} \quad \frac{2}{3}\text{ m} \quad 200\text{ m/s}$$

22. $l \quad \frac{_1}{2}, \frac{2\;_2}{2}, \frac{3\;_3}{2}$

$$_1 \quad 2l, \quad _2 \quad \frac{2l}{2}, \quad _3 \quad \frac{2l}{3}$$

$$_1 : \, _2 : \, _3 \quad 2l : \frac{2l}{2} : \frac{2l}{3}$$

$$1 : \frac{1}{2} : \frac{1}{3}$$

23. $\frac{2}{} \quad x$

$$\frac{2}{vT} \quad x \quad \frac{2}{300 \quad 0.04} \quad (16 \quad 10)$$

$$\frac{2}{12} \quad 6$$

24. $v \quad \frac{}{k} \quad \frac{30}{1} \quad 30 \text{ m/s}$

$$\sqrt{\frac{T}{}} \quad \sqrt{\frac{T}{A}}$$

$$T \quad Av^2 \quad 8000 \quad 10^{\ 6} \quad 900 \quad 7.2 \text{ N}$$

25. $5 \; _0 \quad 480 \text{ Hz}, 2 \; _0 \quad \frac{2}{5} \quad 480 \text{ Hz}$

$$192 \text{ Hz}$$

26. $\frac{I_r}{I_i} \quad 0.64 \quad \frac{A_r}{A_i}^{\ 2}$

$$\frac{A_r}{A_i} \quad 0.8 \qquad A_r \quad 0.8 \ A_i$$

$$A_r \quad \frac{v_2 \quad v_1}{v_2 \quad v_1} A_i \quad 0.8 \ A_i \quad \frac{4}{5} \mathrm{A}_i$$

$$5v_2 \quad 5v_1 \qquad (4v_2 \quad 4v_1)$$

$$v_2 \quad 9v_1, \frac{1}{9} v_1$$

For, $v_2 \quad v_1$ the boundary is rarer and there will not be any change in phase of reflected wave and for $v_2 \quad v_1$ a phase change of 180° takes place.

$$Y_r \quad 0.8 \ A \sin (kx \qquad t \quad 30 \qquad 180 \ )$$

27. $_A \quad \frac{1}{2l} \sqrt{\frac{T}{\frac{d^2}{4}}} \quad \frac{1}{ld} \sqrt{\frac{T}{}}$

$$_B \quad \frac{1}{2 \quad 2l} \sqrt{\frac{2T}{2 \quad \frac{4d^2}{4}}}$$

$$\frac{1}{4ld} \sqrt{\frac{T}{}} \quad \frac{1}{4} \ _A$$

Third overtone of $_B \quad 4 \ _B \qquad _A$

■ Passage (Q 28 to 30)

$$I_r \quad (100\% \quad 36\%) \ I_i \quad 64\% \ I_i \quad 0.64 \ I_i$$

$$\frac{A_r}{A_i} \quad \sqrt{\frac{I_r}{I_i}} \quad \sqrt{0.64} \quad 0.8 \qquad \frac{v_2 \quad v_1}{v_2 \quad v_1}$$

$$0.8 \, v_2 \quad 0.8 \, v_1 \qquad (v_2 \quad v_1)$$

$$0.2 \, v_2 \quad 1.8 \, v_1$$

$$v_2 \quad 9 v_1$$

for rarer boundary

or $1.8 \, v_2 \quad 0.8 \, v_1 \quad v_2 \quad \frac{1}{9} v_1$

for danser boundary

28. $A_r \quad 0.8 \ A$

29. $Y \quad A \sin \ ax \quad bt \quad \frac{}{2} \quad 0.8$

$$A \sin \ ax \quad bt \quad \frac{}{2}$$

$$A \sin \ ax \quad bt \quad \frac{}{2} \quad 0.8$$

$$A \sin \ ax \quad bt \quad \frac{}{2}$$

$$A \cos (ax \quad bt) \quad 0.8 \ A \cos (ax \quad bt)$$

$$A \cos ax \cos bt \quad A \sin ax \sin bt$$

$$0.8 \ A \cos ax \cos bt$$

$$0.8 \ A \sin ax \sin bt$$

$$0.2 \ A \cos ax \cos bt \quad 1.8 \ A \sin ax \sin bt$$

$$0.2 \ A \cos ax \cos bt \quad 0.2 \ A \sin ax \sin bt$$

$$1.6 \ A \sin ax \sin bt$$

$$0.2 \ A \cos (ax \quad bt)$$

$$1.6 \ A \sin (ax) \sin (bt)$$

$$cA \cos (ax \quad bt) \quad 1.6 \ A \sin ax \sin bt$$

$$e \quad 0.2$$

30. For antinodes, $\sin ax \qquad 1$

$$ax \quad (2n \quad 1) \frac{}{2}$$

$$x \quad (2n \quad 1) \frac{}{2a} \quad \frac{}{2a}, \frac{3}{2a}, \frac{5}{2a}$$

So for second antinode, $x \quad \frac{3}{2a}$

31. $\frac{_0 \quad 15}{_0} \quad \sqrt{\frac{1 \quad 0.21}{1}} \quad 1 \;\; 1$

$15 \quad 0.1 \;_0 \qquad _0 \;\; 150\text{ Hz}$

$\frac{_2}{_1} \quad \sqrt{\frac{T_2}{T_1}} \quad \sqrt{\frac{1.21}{1}} \quad 1.1$

$_2 \quad 110\% \text{ of } v_1$

$_0 \quad 2l$ which do not change

So, (a), (c) and (d) are correct.

32. For interference, sources must be coherent there frequency has to be equal and phase different has to be constant. So, (a) and (d) are correct.

33. Stationary waves are formed due to superposition **(here use of the term 'interference' is literary and not scientific because interference is a different phenomenon than stationary waves)** of waves having some amplitude, same frequency and travelling opposite direction. Here nodes are the points who always remain at rest. Total energy is always conserved.

34. A medium is said to be rarer if speed of wave in it is higher. And as frequency is constant, wavelength increases while frequency is constant, wavelength increases while phase do not change during change in medium.

35. $Y \quad A \sin kx \cos \quad t \quad 2a \sin kx \cos \quad t$

$a \quad \frac{A}{2}$, third overtone means fourth harmonic and wire oscillate with four loops.

$l \quad 4\frac{}{2} \quad 2 \quad 2\frac{2}{k} \quad \frac{4}{k}$

and stationary wave do not propagate.

36. For stationary waves, frequency and amplitude has to be same and direction has to be opposite with constant phase difference.

It is satisfied in (b) and (d) only.

37. $y \quad y_1 \quad y_2 \quad 2A \cos kx \sin \quad t$

$R \sin \quad t$

$R \quad 2A \cos kx$ so at $x \quad 0$ there is antinode.

$\cos kx \qquad 1$

$kx \quad n \;, x \quad \frac{n}{k} \quad 0, \frac{}{4}, \frac{2}{x},$

are antinodes.

JEE Corner

Assertion and Reason

1. $y_1 \quad y_2 \quad A \sin (\quad t \quad kx)$

$A \cos (\quad t \quad kx)$

$A \sin (\quad t \quad kx) \quad A \sin \frac{}{2} \quad t \quad kx$

$2\,A \sin \frac{t \quad kx \quad \frac{}{2} \quad t \quad kx}{2}$

$\cos \frac{t \quad kx \quad \frac{}{2} \quad \cot \quad kx}{2}$

$2A \sin \quad kx \quad \frac{}{4} \quad \cos \quad t \quad \frac{}{4}$

$R \cos \quad t \quad \frac{}{4}$

where, $R \quad 2A \sin \quad kx \quad \frac{}{4}$;

$R(0) \quad 2A \sin \frac{}{4} \quad A\sqrt{2}$

So, at $x \quad 0$, node is not present, *i.e.*, Assertion is false.

2. In stationary waves only nodes are at rest and not other particles. It is so called as energy is not transmitted, thus assertion is false.

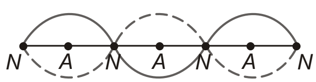
3. In rarer medium speed of wave is higher and as

$$A_t \quad \frac{2v_2}{v_1 \quad v_2} A_i$$

$$A_t \quad A_i$$

so reason is correct explanation to assertion.

4. In second overtone or third harmonic there are three loops or three antinodes or four nodes. And length of the string, $l \quad 3 \frac{}{2}$ so, assertion and reason are both true.



5. As speed of wave is constant in stretched wire, and $v \quad f$, so with increase in frequency, wavelength decreases. So reason is correct explanation of assertion.

6. In stationary waves, amplitude of nodes is zero and it is possible only when superposing waves has same amplitude. But it is not the only condition, there has to be same frequency, opposite direction of propagation and constant phase difference. So assertion is not completely true.

7. Energy lying between conservative node and antinode is constant where it moves to and fro between node and antinode.

8. $$\frac{I_{max}}{I_{min}} \quad \frac{25}{1} \quad \frac{5}{1}^2 \quad \frac{A_1 \quad A_2}{A_1 \quad A_2}^2$$

$$5(A_1 \quad A_2) \quad A_1 \quad A_2$$

$$4A_1 \quad 6A_2 \quad A_1 : A_2 \quad 3:2.$$

Thus reason is the correct explanation of assertion.

9. $$y \quad A \sin \quad \frac{}{2} \quad A \sin$$

$$A \sin \quad \frac{}{2}$$

$$A \cos \quad A \sin \quad A \cos$$

$$A \sin$$

$$R \quad A \quad I_f \quad I_i$$

Assertion and reason are both true but reason do no explain assertion.

10. For two coherent sources phase difference has to be constant and that constant be same at all points as (*t*). Different light sources can never be coherent. So phase difference must be same, thus assertion is false.

Match the Columns

1. $$v_1 \quad \sqrt{\frac{T}{}} \text{ and } v_2 \quad \sqrt{\frac{T}{9}} \quad \frac{v_1}{3}$$

$$\frac{v_1}{v_2} \quad 3$$

$$A_r \quad \frac{v_1 \quad v_1/3}{v_1 \quad v_1/3} A_i \quad \frac{2/3}{4/3} A_i \quad \frac{1}{2} A_i$$

$$\text{and } A_t \quad \frac{2v_2}{v_1 \quad v_2} A_i$$

$$\frac{2\,v_1/3}{v_1 \quad v_1/3} A_i \quad \frac{1}{2} A_i$$

(a) $\frac{A_1}{A_2} \quad \frac{A_r}{A_t} \quad \frac{1/2\,A_i}{1/2\,A_i} \quad 1 \quad$ q

(b) $\frac{v_1}{v_2} \quad 3 \quad$ r

(c) $\frac{I_r}{I_i} \quad \frac{A_r}{A_i}^2 \quad \frac{1}{2}^2 \quad \frac{1}{4}$ and

$$\frac{I_t}{I_i} \quad 1 \quad \frac{1}{4} \quad \frac{3}{4}$$

$$\frac{I_1}{I_2} \quad \frac{I_r}{I_t} \quad \frac{I_r/I_i}{I_t/I_i} \quad \frac{1/4}{3/4} \quad \frac{1}{3} \quad \text{s}$$

(d) $P \quad IS \quad 2 \quad {}^2 \quad {}^2 \quad A^2 \quad v$

$$\frac{1}{2} \quad {}^2 \quad A^2 \quad \sqrt{\frac{T}{}}$$

$$\frac{1}{2} \quad {}^2 \quad A^2 \quad \sqrt{T}$$

$$\frac{P_1}{P_2} \quad \frac{\frac{1}{2} \quad ^2 A_1^2 \sqrt{T \quad _1}}{\frac{1}{2} \quad ^2 A_2^2 \sqrt{T \quad _2}}$$

$$\frac{A_1^2}{A_2^2}\sqrt{\frac{\quad_1}{\quad_2}} \quad \sqrt{9\frac{\quad 1}{\quad 1}}$$

$$\frac{1}{3} \quad \text{s}$$

2. (a) $\frac{\quad_2}{\quad_4} \quad \frac{\frac{3}{2l}v}{\frac{5}{2l}v} \quad \frac{3}{5} \quad r$

(b) Number of nodes in 3rd harmonic is 4 and in Fifth harmonic 6,

so, $\frac{4}{6} \quad \frac{2}{3} \quad p$

(c) Number of antnodes in 3rd harmonic is 3 and in fifth harmonic 5, 50, $\frac{3}{5} \quad r$

(d) $\frac{\quad_2}{\quad_4} \quad \frac{\quad_4}{\quad_2} \quad \frac{5}{3} \quad \text{s}$

3. In danser medium speed of wave is lesser and in rarer medium it is greater.

(a) When wave goes from denser to rarer medium its speed increases p

(b) As frequency do not change with change in medium then with increase in speed wavelength increases p

(c) As $v_t \quad v_i$ then $A_t \quad A_i \quad p$

(d) Frequency remains unchanged r

4. $R \quad \sqrt{A^2 \quad A^2 \quad 2 \quad A \quad A \quad \cos}$

$$2A \cos \frac{}{2}$$

(a) $R(60\ ) \quad 2A\cos\frac{60}{2}$

$$2A\cos 30 \quad 2A \quad \frac{\sqrt{3}}{2} \quad A\sqrt{3} \quad s$$

(b) $R(120\ ) \quad 2A\cos 120\ /2 \quad 2A\cos 60$

$$2A \quad \frac{1}{2} \quad A \quad s$$

(c) $R\ (90\ ) \quad 2A\cos 90\ /2$

$$2A\cos\ 45 \quad A\sqrt{2}$$

$$I_R \quad 2A^2 \quad 2I_i \quad p$$

(d) $R(0\ ) \quad 2A\cos\ (0\ /2) \quad 2A$

$$I_R \quad 4A^2 \quad 4I_i \quad r$$

5. $_2 \quad 3 \quad _0 \quad 210\ \text{Hz} \quad _0 \quad 70\ \text{Hz}$

(a) $_0 \quad 70\ \text{Hz} \quad s$

(b) $_2 \quad 3 \quad _0 \quad 210\ \text{Hz} \quad p$

(c) $_3 \quad 4 \quad _0 \quad 4 \quad 70\ \text{Hz} \quad 280\ \text{Hz} \quad r$

(d) $_1 \quad 2 \quad _0 \quad 140\ \text{Hz} \quad s$

16. Sound Waves

Introductory Exercise 16.1

1. $P_0 \quad S_0 k B$

$$B \quad \frac{P_0}{S_0 k} \quad \frac{P_0}{2 \quad S_0}$$

$$\frac{14 \quad 0.35}{2 \quad 3.14 \quad 5.5 \quad 10^{\quad 6}}$$

$$1.4 \quad 10^5 \ \text{N/m}^2$$

2. $\frac{v}{} \quad _{\text{max}} \quad \frac{1450\ \text{m/s}}{20\ \text{Hz}} \quad 72.5\ \text{m},$

$$_{\text{min}} \quad \frac{1450\ \text{m/s}}{20000\ \text{Hz}} \quad 7.25\ \text{cm}$$

3. Pressure wave and displacement wave has a phase difference of $\frac{}{2}$, so,

(a) When pressure is maximum, displacement is minimum *i.e.*, zero.

(b) $S_0 \quad \frac{p_0}{kB} \quad \frac{p_0}{2 \quad v^2}$

$$\frac{p_0}{2 \quad v^2} \quad \frac{p_0 \ v}{2 \quad v^2} \quad \frac{p_0}{2 \quad v}$$

$$\frac{10}{2 \quad 3.14 \quad 10^3 \quad 1.29 \quad 340} \ \text{m}$$

$$3.63 \quad 10^{\quad 6} \ \text{m}$$

4. $S_0 \quad \frac{P_0}{kB} \quad \frac{P_0}{2 \quad v} \quad \frac{P_0}{v}$

$$\frac{P_0 k}{2}$$

$$\frac{12 \quad 8.18}{1.29 \quad (2700)^2}$$

$$1.04 \quad 10^{\quad 5} \ \text{m}$$

Introductory Exercise 16.2

1. $\frac{v_2}{v_1} \quad \sqrt{\frac{T_2}{T_1}} \quad 2 \quad T_2 \quad 4T_1 \quad 4 \quad 273\ \text{K}$

$$3 \quad 273 \ \text{C} \quad 819 \ \text{C}$$

2. $v_t \quad v_0 \quad 1 \quad \frac{t}{273}^{1/2} \quad v_0 \quad 1 \quad \frac{t}{546}$

$$v_{30} \quad v_3 \quad v_0 \quad 1 \quad \frac{30}{546} \quad 1 \quad \frac{3}{546}$$

$$v_0 \quad \frac{33}{546}$$

$$332 \quad \frac{33}{546} \quad 20.06 \ \text{m/s}$$

3. $v \qquad 250 \quad 8 \quad 2000\ \text{m/s}$

$$B \quad v^2 \quad 900 \quad (2000)^2$$

$$36 \quad 10^8 \ \text{N/m}$$

$$3.6 \quad 10^9 \ \text{Pa}$$

4. $v \quad \sqrt{\frac{Rt}{M}} \quad \sqrt{\frac{\frac{7}{5} \quad 8.314 \quad 273}{32 \quad 10^{\quad 3}}}$

$$315\ \text{m/s}$$

Introductory Exercise 16.3

1. $P_0 \quad S_0 kB \quad 2 \quad v\, S_0$

$2 \quad 3.14 \quad 300 \quad 1.2 \quad 344 \quad 6 \quad 10^{6}$

4.67 Pa

$I \quad \frac{P_0^2}{2\ v} \quad \frac{(4.67)^2}{2 \quad 1.2 \quad 344}$

$2.64 \quad 10^{2}\ \text{W/m}^2$

$L \quad 10\log\frac{I}{I_0} \quad 10\log\frac{2.64 \quad 10^{2}}{10^{12}}$

104 dB

2. $2L \quad L \quad 10\log\frac{I}{I_0} \quad 10\log\frac{I}{I_0}$

$10\log(\ ) \quad 9$ dB

$\log \quad 0.9, \quad 10^{0.9} \quad 7.9$

3. $I \quad \frac{1}{r^2} \quad I \quad \frac{k}{r^2}$

$L_F \quad L_M \quad 10\log\frac{I_F}{I_M}$

$10\log\frac{r_M}{r_F}^{\,2}$

$20\log\frac{3}{0.3} \quad 20$ dB

4. (a) $I \quad \frac{P_0^2}{2\ v}; I_{\max} \quad \frac{(28)^2}{2 \quad 1.29 \quad 345}$

$0.881\ \text{W/m}^2$

$L_{\max} \quad 10\log\frac{0.881}{10^{12}} \quad 119.45$ dB

$I_{\min} \quad \frac{(2 \quad 10^{5})^2}{2 \quad 1.29 \quad 345}$

$4.49 \quad 10^{13}\ \text{W/m}^2$

$L_{\min} \quad 10\log\frac{4.49 \quad 10^{13}}{10^{12}}$ dB

3.48 dB

(b) $S_0 \quad \frac{\text{Po}}{kB} \quad \frac{\text{Po}}{2 \quad v}$

$(S_0)_{\max} \quad \frac{28}{2 \quad 3.14 \quad 500 \quad 1.29 \quad 345}$

$2 \quad 10^{5}$ m

$(S_0)_{\min} \quad \frac{2 \quad 10^{5}}{2 \quad 3.14 \quad 500 \quad 1.29 \quad 345}$

$1.43 \quad 10^{11}$ m

Introductory Exercise 16.4

1. $(2n \quad 1)\frac{\ }{2} \quad 12$ cm

and $(2n \quad 1)\frac{\ }{2} \quad 36$ cm

$36 \quad 12 \quad 24$ cm

$\frac{v}{\ } \quad \frac{330\ \text{m/s}}{0.24\ \text{m}} \quad 1375$ Hz

2. $x \quad \frac{\ }{2} \quad \frac{\ }{2}\ \frac{\ }{3} \quad \frac{\ }{6}$

$\frac{v}{6} \quad \frac{350}{6 \quad 500} \quad 0.117$ m $\quad 11.7$ cm

$\frac{2}{T} \quad t \quad 2 \quad t \quad 2 \quad 500 \quad 10^{3}$

rad $\quad 180$

3. $x_1 \quad 2\sqrt{H^2 \quad \frac{d^2}{4}} \quad d \quad n$

and

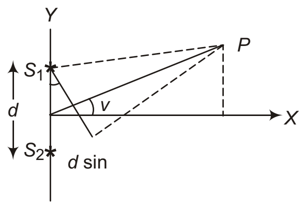
$x_2 \quad 2\sqrt{(H \quad h)^2 \quad \frac{d^2}{4}} \quad d \quad n \quad \frac{1}{2}$

$\frac{\ }{2} \quad 2\sqrt{(H \quad h)^2 \quad \frac{d^2}{4}} \quad 2\sqrt{H^2 \quad \frac{d^2}{4}}$

or $\quad 4\sqrt{(H \quad h)^2 \quad \frac{d^2}{4}} \quad 4\sqrt{H^2 \quad \frac{d^2}{4}}$

$2\sqrt{4(H \quad h)^2 \quad d^2} \quad 2\sqrt{4H^2 \quad d^2}$

4. $x_p \quad d\sin \quad n \quad \frac{1}{2}$ for minima



(a) $d \sin \quad \frac{}{2}$ for first minima

$\sin^{1} \frac{}{2d} \quad \sin^{1} \frac{v}{2\ d}$

$\sin^{1} \frac{340}{2 \quad 600 \quad 2}$

$\sin^{1}(0.142) \quad 0.142\,\text{rad}$

8.14

(b) For, first maxima $d \sin$

$\sin^{1} \frac{}{d} \quad \sin^{1} \frac{340}{1200}$

16.46

(c) $x_{\max} \quad d \quad n \quad d, n \quad \frac{d}{}$

$\frac{2 \quad 600}{340} \quad 3.53$

$n \quad 3$ maxima.

5. (a) For coherent speakers in phase,

$I_R \quad 4I_0 \cos^2 \frac{}{2}$

$\frac{2}{} \quad x \quad \frac{2}{} \quad \frac{}{2}$

$I_R \quad 4I_0 \cos \frac{}{2} \quad 0$

(b) For incoherent sources,

$I_R \quad I_1 \quad I_2 \quad I_0 \quad I_0 \quad 2I_0$

(c) For coherent speakers with a phase difference 180°.

$180 \qquad 2$

$I_R \quad 4I_0 \cos^2 \frac{2}{2} \quad 4I_0$

6. $60\,\text{dB} \quad 10 \log \frac{I_0}{10^{\ 12}}$

$10^6 \quad 10^{\ 12} \quad I_0$

$I_0 \quad 10^{\ 6}\ \text{W/m}^2$

$\frac{2}{} \quad x \quad \frac{2}{v} \quad x$

$\frac{2 \quad 170}{340} \quad (11 \quad 8) \quad 3$

(a) $I_R \quad 4I_0 \cos^2 \frac{}{2} \quad 4I_0 \cos^2 \frac{3}{2} \quad 0$

(b) $3 \qquad 4$

$I_R \quad 4I_0 \cos \frac{4}{2} \quad 4I_0$

$4 \quad 10^{\ 6}\ \text{W/m}^2$

$L_R \quad 10 \log \frac{4 \quad 10^{\ 6}}{10^{\ 12}}$

$10 \log 10^6\ \text{dB} \quad 10 \log 4$

$60\,\text{dB} \quad 2 \log 2\,\text{dB}$

$60\,\text{dB} \quad 6\,\text{dB} \quad 66\,\text{dB}$

(e) $\frac{2}{v} \quad x \quad \frac{2 \quad 85}{340} \quad (11 \quad 8)$

$\frac{3}{2}$

$I_R \quad 4I_0 \cos^2 \frac{3}{4}$

$4I_0 \cos^2 \frac{}{4} \quad 2I_0$

$L_R \quad 10 \log \frac{2 \quad 10^{\ 6}}{10^{\ 12}} \quad 63\,\text{dB}$

7. (a) $I_1 \quad \frac{10^{\ 3}}{4 \quad 2^2} \quad \frac{10^{\ 3}}{16}$

$19.9 \quad 10^{\ 6}\ \text{W/m}^2$

$19.9 \quad \text{W/m}^2$

$I_2 \quad \frac{10^{\ 3}}{4 \quad 3^2} \quad \frac{10^{\ 3}}{36}$

$8.84 \quad 10^{\ 6}\ \text{W/m}^2$

$8.84 \quad \text{W/m}^2$

(b) $(I_P)_{\max} \quad (\sqrt{I_1} \quad \sqrt{I_2})^2$

$(4.46 \quad 2.97)^2$

$55.27 \quad \text{W/m}^2$

(c) $(I_P)_{\min} \quad (\sqrt{I_1} \quad \sqrt{I_2})^2$

$(4.46 \quad 2.97)^2$

$2.22 \quad \text{W/m}^2$

(d) $I_P \quad I_1 \quad I_2 \quad 28.7 \quad \text{W/m}^2$

Introductory Exercise 16.5

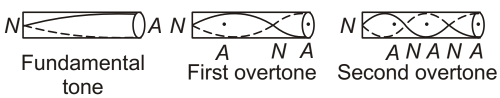
1. (a) $_0 \quad \frac{v}{4l_c} \quad l_c \quad \frac{v}{4\ _0} \quad \frac{345\text{ m/s}}{4 \quad 220\text{ Hz}}$

0.392 m

(b) $\frac{3v}{2l_0} \quad 5\ _0$

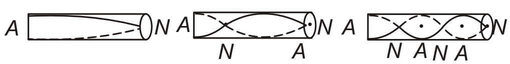
$l_0 \quad \frac{3v}{10\ _0} \quad \frac{3 \quad 345}{10 \quad 220} \quad 0.470\text{ m}$

2. (a)



$d_A \quad l \quad 0.8\text{ m} \quad d_A \quad \frac{l}{3}, l \quad \frac{0.8}{3}\text{ m}, \quad d_A \quad \frac{l}{5}, \frac{3l}{5}, l$
$\frac{0.8}{5}\text{ m}, \frac{2.4}{4}\text{ m}, 0.8\text{ m}$

(b)



$d_A \quad 0_n \qquad d_A \quad 0, \frac{2l}{3} \qquad d_A \quad 0, \frac{2l}{5}, \frac{4l}{5}$
$0, 0.533\text{ m} \qquad 0\text{ m}, 0.32\text{ m}, 0.64\text{ m}$

3.

2 0	400, 560
4	20, 28

HCF of the two shows, 80 and the values, 400 Hz and 560 Hz are odd multiples of 80. These conservative harmonics are odd, which can be seen in closed organ pipe only.

(b) These are 5th and 7th harmonic.

(c) $_0 \quad \frac{v}{4l_c}$

$l_c \quad \frac{v}{4\ _0} \quad \frac{344}{4 \quad 80} \quad 1.075\text{ m}$

4. $v \qquad 1000 \quad 2 \quad 6.77 \quad 10^{\ 2}\text{ m/s}$

135.4 m/s

$v \quad \sqrt{\frac{RT}{M}} \quad r \quad \frac{Mv^2}{RT}$

$\frac{n \quad 127 \quad 10^{\ 3} \quad (135.4)^2}{8.314 \quad 400} \quad 0.7\ n$

As $1 \quad r \quad 2$

$n \quad 2 \quad r \quad 0.7 \quad 2 \quad 1.4 \quad \frac{7}{5}$ diatonic

5. $\frac{(2n \quad 1)v}{4l_1} \quad \frac{(2n \quad 3)v}{4l_2}$

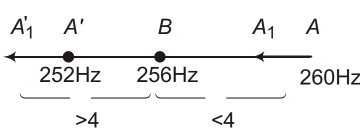
$\frac{2n \quad 3}{2n \quad 1} \quad \frac{l_2}{l_1} \quad \frac{100}{60} \quad \frac{5}{3}$

$n \quad 1$

$v \quad \frac{4l_1}{2n \quad 1} \quad \frac{4 \quad 0.6 \quad 440}{3} \quad 352\text{ m/s}$

Introductory Exercise 16.6

1.



$_A \quad 252\text{ Hz}$

$_A \quad (256 \quad 4)\text{ Hz}$

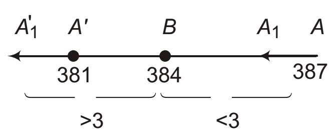
and $_A \quad n \quad (256 \quad 6)\text{ Hz}$

$256 \quad 4 \quad n \quad 256 \quad 6$

$4 \mp 6 \quad n \quad n \quad 4 \quad 6 \quad 2$

$_A \quad 256 \quad 4 \quad 252\text{ Hz}$

2.



$_A \quad 387\text{ Hz}$

$_A \quad (384 \quad 3)\text{ Hz}$

and $_A \quad n \quad 384 \quad m, m \quad 3$

$384 \quad 3 \quad n \quad 385 \quad m$

$3 \quad n \quad m$

$3 \mp m \quad n \quad (\;)$ ve

$n \quad 3 \quad m$

$_A \quad 384 \quad 3 \quad 387$ Hz

$6\text{ Hz} \quad 600\text{ Hz} \quad \frac{1}{2l}\sqrt{\frac{T_A}{\;}}$

and $\quad 600\text{ Hz} \quad \frac{1}{2l}\sqrt{\frac{T_B}{\;}}$

$\frac{606}{600} \quad \sqrt{\frac{T_A}{T_B}} \quad 1.01$

$\frac{T_A}{T_B} \quad 1.02$

4. $256 \quad 4 \quad \frac{v}{2 \quad 0.25}$

and $\quad 256 \quad \frac{v}{2 \quad (0.25 \quad x)}$

$\frac{256}{252} \quad \frac{2 \quad 0.25}{2(0.25 \quad x)} \quad \frac{1}{1 \quad 4x}$

$256 \quad 4 \quad 256x \quad 252$

$4 \quad 4 \quad 256x$

$x \quad \frac{1}{256}\text{ m} \quad \frac{100}{256}\text{ cm} \quad 0.4\text{ cm}$

Introductory Exercise 16.7

1. When source is moving,

$_s \quad \frac{v}{v \quad v_s} \quad \frac{1}{1 \mp \frac{v_s}{v}}$

$1 \mp \frac{v_s}{v}$ ^{1}

$1 \quad \frac{v_s}{v} \quad 1 \quad \frac{u}{v}$

When observer is moving, $_0 \quad \frac{v \quad v_0}{v}$

$1 \quad \frac{v_0}{v} \quad 1 \quad \frac{v}{v}$

So, it can be seen that, $_0$ and $_s$ are equal if $u \quad v$.

2. $\frac{340}{200} \quad 1.7\text{ m}$

(a) $uT \quad 1.7\text{ m} \quad \frac{80}{200} \quad 1.7\text{ m}$

$0.4\text{ m} \quad 1.3\text{ m}$

(b) $\frac{v}{\;} \quad \frac{340\text{ m/s}}{1.3\text{ m}}$

262 Hz

3. For doppler effect there has to be relative motion between source and receiver, but as they are at rest relative to each other that's why there is no shift in wavelength and frequency.

4. $\frac{v}{\;} \quad \frac{344}{500} \quad 0.688\text{ m}$

(a) $_{\text{front}} \quad uT \quad 0.688 \quad \frac{30}{500}$

$0.688 \quad 0.060 \quad 0.628\text{ m}$

(b) $_{\text{behind}} \quad uT \quad 0.688 \quad 0.060$

0.748 m

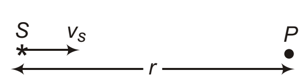
(c) $_{\text{front}} \quad \frac{344}{0.628} \quad 547.8\text{ Hz}$

(d) $_{\text{behind}} \quad \frac{344}{0.748} \quad 459.9\text{ Hz}$

5. $\frac{v \quad w \quad v_0}{v \quad w \quad v_s} \quad \frac{340 \quad 5 \quad 20}{340 \quad 5 \quad 10} \quad 300\text{ Hz}$

$\frac{315}{345} \quad 300\text{ Hz} \quad 273.9\text{ Hz}$

6.



AIEEE Corner

■ Subjective Questions (Level 1)

1. $d \quad d_1 \quad d_2 \quad v\dfrac{t_1}{2} \quad v\dfrac{t_2}{2}$

$\dfrac{v}{2}(t_1 \quad t_2) \quad \dfrac{332}{2} \quad \dfrac{3}{2} \quad \dfrac{5}{2}$

$332 \quad 2 \quad 664 \text{ m}$

The time for third eco is,

$t \quad t_1 \quad t_2 \quad \dfrac{3}{2} \quad \dfrac{5}{2} \quad 4\text{ s}$

2. $v \quad \sqrt{\dfrac{RT}{M}} \quad \sqrt{\dfrac{\frac{7}{5} \quad 8.314 \quad 300}{2 \quad 10^{\ 3}}}$

$\sqrt{21 \quad 8.314 \quad 10^4} \quad 1321 \text{ m/s}$

3. $v \quad \sqrt{\dfrac{p}{\ }}$

$\sqrt{\dfrac{\frac{5}{3} \quad 76 \quad 10^{\ 2} \quad 13.6 \quad 10^3 \quad 9.8}{0.179}}$

$\sqrt{\dfrac{5 \quad 76 \quad 136 \quad 9.8}{3 \quad 0.179}} \quad 971 \text{ m/s}$

4. (a) $B \quad v^2 \quad {}^{2\ 2}$

$1300 \quad 16 \quad 10^4 \quad 64$

$1.33 \quad 10^{10} \text{ N/m}^2$

(b) $Y \quad v^2 \quad \dfrac{l^2}{t^2} \quad \dfrac{6400 \quad (1.5)^2}{(3.9 \quad 10^{\ 4})^2}$

$9.47 \quad 10^{10} \text{ Pa}$

5. $v_t \quad \sqrt{\dfrac{l}{l}}v_l \quad \dfrac{l}{l} \quad \left(\dfrac{v_t}{v_l}\right)^2 ; \dfrac{F}{A} \quad Y\dfrac{l}{l}$

$Y \quad \left(\dfrac{v_t}{t_l}\right)^2 \quad Y\left(\dfrac{1}{30}\right)^2 \quad \dfrac{Y}{900}$

6. $M_{\text{mix}} \quad \dfrac{2 \quad 2 \quad 1 \quad 14}{2 \quad 1} \quad 6 \text{ m/mole}$

$\dfrac{v_{\text{mix}}}{v_{H_2}} \quad \sqrt{\dfrac{M_{H_2}}{M_{\text{mix}}}} \quad \sqrt{\dfrac{2}{6}} \quad \dfrac{1}{\sqrt{3}}$

$v_{\text{mix}} \quad \dfrac{1}{\sqrt{3}}v_{H_2} \quad \dfrac{1}{\sqrt{3}}v_0\sqrt{\dfrac{T_2}{T_1}} \quad \dfrac{v_0}{\sqrt{3}}\sqrt{\dfrac{300}{273}}$

$\dfrac{v_0}{\sqrt{2.73}} \quad \dfrac{1300}{\sqrt{2.73}} \quad 787 \text{ m/s}$

7. $L_1 \quad 10\log\dfrac{10^{\ 6}}{10^{\ 12}} \quad 60\log 10 \quad 60 \text{ dB}$

$L_2 \quad 10\log\dfrac{10^{\ 9}}{10^{\ 12}} \quad 30\log 10 \quad 30 \text{ dB}$

$L_1 \quad 2L_2$

8. $100 \text{ dB} \quad 10\log\dfrac{I}{I_0} \text{ dB}$

$I \quad 10^{10} I_0 \quad 10^{\ 2} \text{ W/m}^2$

$P \quad 4 \ r^2 I \quad 4 \quad (40)^2 \quad 10^{\ 2}$

$64 \quad \text{W} \quad 201 \text{ W}$

9. (a) $60 \text{ dB} \quad 10\log\dfrac{I}{I_0} \text{ dB}$

$I \quad 10^6 I_0 \quad 10^{\ 6} \text{ W/m}^2$

(b) $P \quad AI \quad 120 \quad 10^{\ 4} \quad 10^{\ 6} \text{ W}$

$1.2 \quad 10^{\ 8}$ watt

10. (a) $L \quad 13 \text{ dB} \quad 10\log\dfrac{I_2}{I_1} \text{ dB}$

$I_2 \quad 10^{1.3} I_1 \quad 20 I_1$

(b) As with doubling the intensity, loudness increases by 3 dB irrespective of the initial intensity.

11. $I \quad \dfrac{P}{4 \ r^2} \quad \dfrac{5}{4 \quad (20)^2} \quad \dfrac{5}{4 \quad 400}$

$\dfrac{1}{320} \text{ W/m}^2 \quad 9.95 \quad 10^{\ 4} \text{ W/m}^2$

(b) $I \quad 2 \ {}^2 \ {}^2 a^2 \quad v \quad a \quad \dfrac{1}{\ }\sqrt{\dfrac{I}{2 \quad v}}$

$\dfrac{1}{300}\sqrt{\dfrac{1}{320 \quad 2 \quad 1.29 \quad 330}}$

$\dfrac{1}{300 \quad 10^{12}}\sqrt{\dfrac{1}{85.5}}$

$1.15 \quad 10^{\ 6} \text{ m}$

12. $60\ \text{dB} \quad 10 \log \dfrac{I}{10^{\ 12}}\ \text{dB}$

$I \quad 10^{\ 6}\ \text{W/m}^2$ and $a \quad \dfrac{1}{\ } \sqrt{\dfrac{T}{2 \quad v}}$

$\dfrac{1}{800} \sqrt{\dfrac{10^{\ 6}}{2 \quad 1.29 \quad 330}} \quad 13.6 \quad 10^{\ 9}\ \text{m}$

13. $102\ \text{dB} \quad 10 \log \dfrac{I}{I_0}\ \text{dB}$

$I \quad 10^{10.2}\ I_0 \quad 10^{10.2 \quad 12}$

$10^{\ 1.8}\ \text{W/m}^2$

$P \quad 4 \quad r^2\ I$

$4 \quad 3.14 \quad (20)^2 \quad 10^{\ 1.8}$

$80\ \text{W}$

14. $I \quad 2 \ ^2 v^2 a^2 \quad v$

$2 \quad (3.14)^2 \quad (300)^2$

$(0.2 \quad 10^{\ 3})^2 \quad 1.29 \quad 330\ \text{W/m}^2$

$30.25\ \text{W/m}^2$

$L \quad 10 \log \dfrac{I}{I_0}\ \text{dB} \quad 10 \log \dfrac{30.25}{10^{\ 12}}\ \text{dB}$

$134.8\ \text{dB}$

15. (a) $v_w \quad \sqrt{\dfrac{B}{\ }} \quad \sqrt{\dfrac{2.18 \quad 10^9}{10^3}}$

$1.48 \quad 10^3\ \text{m/s}$

$A_w \quad \sqrt{\dfrac{I}{2 \ ^2 \ ^2 \quad v}} \quad \dfrac{1}{\ } \sqrt{\dfrac{I}{2 \quad v}}$

$\dfrac{1}{3400} \sqrt{\dfrac{3 \quad 10^{\ 6}}{2 \quad 10^3 \quad 1.48 \quad 10^3}}$

$9.44 \quad 10^{\ 11}\ \text{m}$

$_w \quad \dfrac{v_N}{\ } \quad \dfrac{1.48 \quad 10^3}{3400} \quad 0.43\ \text{m}$

(b) $v_a \quad \sqrt{\dfrac{p}{\ }} \quad \sqrt{\dfrac{1.4 \quad 10^5}{1.2}} \quad 341.6\ \text{m/s}$

$A_a \quad \dfrac{1}{3400} \sqrt{\dfrac{3 \quad 10^{\ 6}}{2 \quad 1.2 \quad 341.6}}$

$5.66 \quad 10^{\ 9}\ \text{m}$

$_a \quad \dfrac{341.6}{3400} \quad 0.1\ \text{m}$

(c) $A_a \quad A_w; \dfrac{A_a}{A_w} \quad \dfrac{5.66 \quad 10^{\ 9}}{9.44 \quad 10^{\ 11}} \quad 60$

As bulk modulus of water is much larger than air, such that displacement of particles of medium becomes less.

16. $I \quad \dfrac{p_0^2}{2 \quad v} \quad \dfrac{(6 \quad 10^{\ 5})^2}{2 \quad 1.29 \quad 343}\ \text{W/m}^2$

$4 \quad 10^{\ 12}\ \text{W}$

$L \quad 10 \log \dfrac{I}{I_0} \quad 10 \log \dfrac{4 \quad 10^{\ 12}}{10^{\ 12}}$

$20 \log 2 \quad 6\ \text{dB}$

17. $_o \quad \dfrac{v}{2l} \quad 594\ \text{Hz};$

$_c \quad \dfrac{v}{4l} \quad \dfrac{_0}{2} \quad \dfrac{594}{2}\ \text{Hz} \quad 297\ \text{Hz}$

18. $_0 \quad \dfrac{(n \quad 1)v}{2l} \quad (n \quad 1) \dfrac{344}{2 \quad 0.45}$

$(n \quad 1) \quad 382.2\ \text{Hz}$

$382.2\ \text{Hz}, 764.4\ \text{Hz}, 1146.7\ \text{Hz},$

$_t \quad \dfrac{(2n \quad 1)v}{2l}$

$(2n \quad 1) \dfrac{344}{2 \quad 0.45}$

$(2n \quad 1) \quad 191.1\ \text{Hz}$

$191.1\ \text{Hz}, 573.3\ \text{Hz}, 955.6\ \text{Hz}$

19. $_c \quad \dfrac{v}{4l}$

$v \quad 4l \quad _c \quad 4 \quad 0.15 \quad 500 \quad 300\ \text{m/s}$

$_o \quad \dfrac{v}{2l_o} \quad \dfrac{300}{2 \quad 0.6} \quad 250\ \text{Hz}$

20. $y \quad A \cos kx \cos \quad t$

$A \cos \dfrac{2}{1.6} x \cos 2 \quad \dfrac{330}{1.6} t$

$A \cos 3.93x \cos 1296\ t$

21. $\dfrac{2n \quad 1}{4 \quad 0.5} v \quad \dfrac{2n \quad 3}{4 \quad 0.84} v$

$\dfrac{2n \quad 3}{2n \quad 1} \quad \dfrac{84}{50} \quad 1.68$

$3 \quad 1.68 \quad 2n \quad 0.68$

$n \quad 0.97 \quad 1$ as n is an integer

$v \quad \frac{4lv}{2n \quad 1} \quad \frac{4 \quad 0.5 \quad 512}{3}$ m/s

341.3 m/s

$\frac{2n \quad 5}{4l}$

$l \quad \frac{2n \quad 5}{4} v \quad \frac{7}{4 \quad 512} \quad 341.3$

1.167 m $\quad 116.7$ cm

22. $_c \quad \frac{v}{4l} \quad \frac{340}{4 \quad 1} \quad 85$ Hz

$_s \quad \frac{v}{} \quad \frac{1}{0.4}\sqrt{\frac{F}{}} \quad 85$

$F \quad (85 \quad 0.4)^2 \quad (34)^2 \quad \frac{4 \quad 10^{\quad 3}}{0.4}$

= 11.65 N

23. $_c \quad \frac{v}{4(l \quad e)} \quad v \quad 4 \quad (l \quad l)$

$4 \quad (l \quad 0.3d)$

$4 \quad 480\,(0.16 \quad 0.3 \quad 0.05) \quad 336$ m/s

24. (a) $_e \quad \frac{(2n \quad 1)}{4l}$

$440 \quad \frac{5 \quad 330}{4l}$

$l \quad \frac{5 \quad 330}{4 \quad 440} \quad \frac{15}{16}$ m

(b) 

$\frac{5}{4} \quad l \quad \frac{15}{16}$

$\frac{15}{16} \quad \frac{4}{5} \quad \frac{3}{4}$ m

$p \quad p_0 \cos kx \quad p_0 \cos \frac{2}{3/4} \quad \frac{15}{32}$

$p_0 \cos \frac{15}{12} \quad p_0 \cos \frac{5}{4} \quad \frac{p_0}{\sqrt{2}}$

(c) At open end there is pressure node, so, $p_{max} \quad p_{min} \quad p_0$

(d) At closed end there is pressure antinode, such that, $p_{max} \quad p_0 \quad p_0$ and $p_{min} \quad p_0 \quad p_0$

25. (a) $_c \quad \frac{v}{4l_c}$

$l_c \quad \frac{v}{4 \quad _c} \quad \frac{345}{4 \quad 220} \quad 0.392$ m

(b) $l_0 \quad \frac{5}{4}, l_0 \quad \frac{3}{2} \quad \frac{3}{2}\,\frac{4}{5}\,l_c$

$\frac{6}{5} l_c \quad \frac{6}{5} \quad 0.392$ m $\quad 0.47$ m

26. $_s \quad _c \quad \frac{v_s}{2 \quad 0.8\,l_c} \quad \frac{v_s}{4\,l_c}$

$\frac{v_s}{v_a} \quad \frac{1.6}{4} \quad 0.4$

27. (a) $_s \quad \frac{v}{} \quad \frac{340}{300} \quad \frac{17}{15}$ m $\quad 1.13$ m

(b) $_a \quad v_s T \quad \frac{v \quad v_s}{}$

$\frac{340 \quad 30}{300} \quad \frac{31}{30} \quad 1.03$ m

$_b \quad v_s T \quad \frac{v \quad v_s}{}$

$\frac{340 \quad 30}{300} \quad \frac{37}{30} \quad \frac{37}{30} \quad 1.23$ m

28. $\frac{1}{2l}\sqrt{\frac{F}{}} \quad — \quad \frac{1}{2}\,\frac{F}{F}$

$\frac{F}{F} \quad 2 — \quad 2 \quad \frac{1.5}{440} \quad \frac{3}{440} \quad 0.68\%$

$440 \quad 1.5$

438.5 Hz or 441.5 Hz

29. $v \quad 0.32$ m/s;

$vT \quad 0.32 \quad 1.6$ m $\quad 0.512$ m.

$_a \quad v_s T \quad v_s \quad \frac{}{T} \quad v \quad \frac{}{T}$

$0.32 \quad \frac{0.12}{1.6} \quad 0.245$ m/s

$_b \quad v_s T \quad 0.512$ m $\quad 0.245 \quad 1.6$

$0.512 \quad 0.392 \quad 0.904$ m.

30. (a) $_a \quad \frac{v \quad v_0}{v \quad v_s} \quad \frac{340 \quad 18}{240 \quad 30} \quad 262$ Hz

$\frac{358}{310} \quad 262$ Hz $\quad 302.5$ Hz

(b) $_r \quad \frac{v \quad v_0}{v \quad v_s} \quad \frac{340 \quad 18}{340 \quad 30} \quad 262$

$$\frac{322}{370} \quad 262\text{ Hz} \quad 228\text{ Hz}$$

31. $$\frac{v}{v \quad v_s} \quad \frac{v}{v \quad v_s}$$

$$\frac{2vv_s}{v^2 \quad v_s^2} \sim \frac{2v_s}{v} \quad v \quad \frac{v}{2v_s}$$

$$\frac{340 \quad 4}{2 \quad 1} \quad 680\text{ Hz}$$

32. $$_0 \quad _c \quad 110 \quad 2.2; \quad _c \quad \frac{v}{4l_c}$$

$$l_c \quad \frac{v}{4 \quad _c} \quad \frac{330}{4 \quad 110}$$

$$l_c \quad \frac{3}{4}\text{m}; \quad _0 \quad \frac{2v}{2l_0}$$

$$l_0 \quad \frac{2v}{2 \quad _0} \quad \frac{2 \quad 330}{2(330 \quad 2.2)}$$

0.993 m or 1.007 m

33. $_p$ $_Q$ $\frac{7}{2}$ and $_P$ $_Q$ as beat frequency increases waxing of P.

$$_Q \quad 5 \quad \frac{v}{v \quad v_s} \quad _Q \quad \frac{332}{332 \quad 5} \quad _Q$$

$$\frac{332}{327} \quad _Q \quad 5 \quad \frac{5}{327} \quad _Q$$

$_Q$ 327 Hz and

$$_P \quad 327 \quad \frac{7}{2} \quad 323.5\text{ Hz}$$

When Q gives 5 beats with its own echo.

OR

$$_P \quad _Q \quad \frac{7}{2} \quad _q \quad 5 \quad \frac{332}{327} \quad _Q \quad 5$$

$$5 \quad \frac{7}{2} \quad \frac{5}{327} \quad _Q$$

$$_Q \quad \frac{327 \quad 1.5}{5} \quad 98.1\text{ Hz}$$

$$_P \quad 98.1 \quad 2.5 \quad 94.6\text{ Hz}$$

When P gives 5 beats with the echo of Q.

34. $$\frac{v}{v \quad v_s} \quad \frac{v}{v \quad v_s} \quad \frac{2vv_s}{v^2 \quad v_s^2} \sim \frac{2v_s}{v}$$

$$v_s \quad \frac{v}{2} \quad \frac{340 \quad 2}{2 \quad 680}$$

$$v_s \quad \frac{1}{2}\text{m/s}$$

35. $$(2n \quad 1)\frac{}{2} \quad 11.5\text{ cm}$$

$$(2n \quad 3)\frac{}{2} \quad 34.5\text{ cm}$$

$$\frac{2n \quad 3}{2n \quad 1} \quad \frac{34.5}{11.5} \quad 3 \quad 4n \quad 0 \quad n \quad 0$$

$$\frac{}{2} \quad 11.5\text{ cm} \quad 23\text{ cm}$$

$$v \quad \frac{331.2\text{ m/s}}{0.23\text{ m}} \quad 1440\text{ Hz}$$

36. $$\frac{v}{} \quad \frac{330}{220} \quad 1.5\text{ m}$$

$$x \quad S_2P \quad S_1P \quad 3 \quad \frac{3}{4} \quad \frac{9}{4}\text{m}$$

$$\frac{3}{2} \quad \frac{3}{2} \quad \frac{3}{2} \quad (2n \quad 1)\frac{}{2}$$

Here, $S_1P \quad \frac{3}{4} \quad \frac{1}{2}$

$$_1 \quad \frac{2}{} S_1P \quad \frac{2}{} \quad \frac{}{2}$$

and $S_2P \quad 3 \quad 2 \quad \frac{3}{2} \quad 2$

$$_2 \quad \frac{2}{} \quad 2 \quad 4$$

Destructive interference will take place at P.

$$P_P \quad P_{\min} \quad (\sqrt{P_1} \quad \sqrt{P_2})^2$$

$$(\sqrt{1.8 \quad 10^{\ 3}} \quad \sqrt{1.2 \quad 10^{\ 3}})^2$$

$$0.6 \quad 10^{\ 3}(\sqrt{3} \quad \sqrt{2})^2$$

$$0.6 \quad 10^{\ 3} \quad 0.1 \quad 6 \quad 10^{\ 5}\text{ W}$$

37. $$x \quad 2\sqrt{2^2 \quad \frac{x}{2}^{\ 2}} \quad x \quad n \quad 1$$

$$\frac{360\text{ m/s}}{360\text{ Hz}} \quad 1\text{ m}$$

$$2\sqrt{4 \quad \frac{x^2}{4}} \quad 1 \quad x$$

or $$4 \quad 4 \quad \frac{x^2}{4} \quad 1 \quad 2x \quad x^2$$

$$16 \quad 1 \quad 2x$$

$$x \quad 7.5\text{ m}$$

Objective Questions (Level 1)

1. Sound cannot travel in vacuum, as it is mechanical wave.

2. Longitudinal waves can travel through all mechanical mediums.

3. $\sqrt{\dfrac{RT}{32}} \quad \sqrt{\dfrac{R \quad 288}{28}}$

$T \quad \dfrac{32}{28} \quad 288\text{ K} \quad \dfrac{8}{7} \quad 288\text{ K} \quad 56\ \text{C}$

4. Third overtone is 7th harmonic *ie,* there 4 nodes and 4 antinodes.

5. $\dfrac{v}{l} \qquad \sqrt{T}$ so with increase in temperature, frequency increases.

6. For sound water is rarer medium and air is densor medium so, it bends towards normal while going from water to air.

7. $_c \quad \dfrac{v}{4l_c} \quad _o \quad \dfrac{v}{2l_o} \quad \dfrac{l_c}{l_o} \quad \dfrac{2}{4} \quad 1:2$

8. $\dfrac{\ _2}{\ _1} \quad \sqrt{\dfrac{F_2}{F_1}}$

$F_2 \quad \dfrac{\ _2}{\ _1}^{2} \quad F_1$

$M_2 \quad \dfrac{\ _2}{\ _1}^{2} \quad M_1 \quad \dfrac{256}{320}^{2} \quad 10\text{ kg}$

6.4 kg

$OM \quad M_2 \quad M_1 \quad 6.4 \quad 10 \quad 3.6\text{ kg}$

i.e., Mass has to be decreased by 3.6 kg

9. $_{\text{direct}} \quad \dfrac{v}{v \quad v_s}$ and $_{\text{reflected}} \quad \dfrac{v}{u \quad v_s}$

as $_D \quad _R$ so there will be no beats *i.e.,* beat frequency will be zero.

10. $_2 \quad _1 \quad \dfrac{v}{\ _2} \quad \dfrac{v}{\ _1} \quad v\dfrac{(\ _1 \quad _2)}{\ _1\ _2}$

$v \quad \dfrac{\ _1\ _2}{}$

$$v \quad \frac{1 \quad 1.01 \quad \dfrac{10}{3}}{0.01} \quad 337\text{ m/s}$$

11. $\dfrac{v}{v \quad v} \quad \dfrac{1}{2} \quad n \quad n \quad \dfrac{1}{2} \quad 0.5$

12. $I_{\max} \quad (\sqrt{I} \quad \sqrt{I})^2 \quad 4I \quad NI \quad N \quad 4$

13. $\dfrac{v}{4(l_1 \quad e)} \quad \dfrac{3v}{4(l_2 \quad e)}$

$l_2 \quad e \quad 3l_1 \quad 3e$

$e \quad \dfrac{l_2 \quad 3l_1}{2}$

$e \quad \dfrac{42 \quad 3 \quad 17}{2}\text{cm} \quad 0.5\text{ cm}$

$v \quad 4\ (l_1 \quad e) \quad 4 \quad 500(17 \quad 8.5) \quad 10^{\ \ 2}$

$20 \quad 17.5 \quad 350\text{ m/s}$

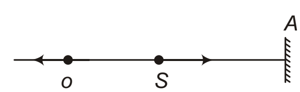
14. At the moment when velocity of source is perpendicular to the line joining source and observer then there is no Doppler effect *i.e.,* $n \quad n_1 \quad n \quad n_1 \quad 0$

15. $\dfrac{(n \quad 1)v}{4l} \quad (2n \quad 1)\dfrac{340}{4 \quad 1} \quad 85(2n \quad 1)$

85, 255, 425, 595, 765, 935

6 frequencies below 1 kHz.

16. $\dfrac{v \quad v_0}{v \quad v_s} \quad \dfrac{v \quad v_0}{v \quad v_s} \quad 1 \quad \dfrac{v \quad v_0}{v \quad v_s}$

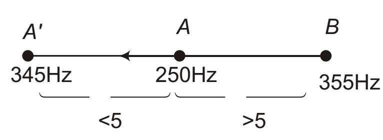


$\dfrac{v_s \quad v_0}{v \quad v_s} \quad \dfrac{10}{360} \quad 180 \quad 5\text{ Hz}$

17. $n \quad _1 \quad _2 \quad \dfrac{v}{\ _1} \quad \dfrac{v}{\ _2}$

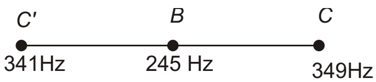
$\dfrac{v(\ _2 \quad _1)}{\ _1\ _2} \quad v \quad \dfrac{n\ _1\ _2}{\ _1 \quad _2}$

18.



As beat frequency between A and B decreases on loading A.

i.e., $_B \quad _A \quad _B \quad 345$ Hz



After loading A, $_A \quad 345 \quad 2 \quad 247$ Hz

and $_A \quad _c \quad 6 \quad _c \quad _A \mp 6$

347 ∓ 6

341 or 353 Hz.

As possible frequency of C are 341 Hz and 249 Hz then only 341 Hz is justified.

19. $e \quad \frac{l_2 \quad 3l_1}{2} \quad \frac{122 \quad 3 \quad 40}{2}$ cm $\quad 1$ cm

So, $\frac{v}{l(l_1 \quad e)} \quad \frac{5v}{4(l_1 \quad e)}$

$l_3 \quad 5l_1 \quad 4l$

$5 \quad 40 \quad 4 \quad 1 \quad 204$ cm

20. — $\frac{1}{2}\frac{F}{F} \qquad \frac{1}{2}\frac{F}{F}$

$\frac{1}{2} \quad 200 \quad \frac{1}{100} \quad 1$ Hz

21. $\frac{2n \quad 1}{4l}v \qquad l \quad \frac{2n \quad 1}{4}v$

$(2n \quad 1)\frac{340}{4 \quad 340} \quad \frac{2n \quad 1}{4}$ m

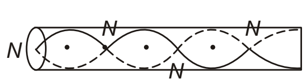
$\frac{1}{4}$m, $\frac{3}{4}$m, $\frac{5}{4}$m.

As, $l_{max} \quad 120$ cm $\quad l \quad 25$ cm 75 cm.

Height of water column

120 cm $\quad 75$ cm $\quad 45$ cm

22. $7\frac{}{4} \quad 105$ cm $\qquad \frac{105 \quad 4}{7} \quad 60$ cm



$\frac{}{4} \quad \frac{60}{4} \quad 15$ cm

So, nodes are at, $\frac{}{4}$, $3\frac{}{4}$, $5\frac{}{4}$ and $7\frac{}{4}$ from closed end *i.e.*, they are at, 15 cm, 45 cm, 75 cm and 105 cm.

23. $_c \quad \frac{v}{4l} \quad 512$ Hz, $_o \quad \frac{v}{2l} \quad 2\frac{v}{4l}$

$2 \; _c \quad 2 \quad 512$ Hz $\quad 1024$ Hz

24. $M_{min} \quad \frac{1 \quad 32 \quad 1 \quad 2}{1 \quad 1} \quad 17$

$\frac{v_{min}}{v \; _2} \quad \sqrt{\frac{M_{H_2}}{M_{min}}} \quad \sqrt{\frac{2}{17}}$

25. $_a \quad f$ and $_r \quad f$ but $_a$ constant and $_r$ cosntant.

So, curve in (b) represents correctly.

26. $u \quad \frac{(2n \quad 1)v}{4l} \quad \frac{(m \quad 1)v}{2l}$

How, $\frac{(2n \quad 1)v}{4 \quad 2l} \quad \frac{(m \quad 1)v}{4 \quad 2l}$

$\frac{4}{2} \quad 2$ beat/s

27. $_a \quad _r \quad \frac{v}{v \quad v_1} \quad \frac{v}{v \quad v_1}$

$\frac{2vv_1}{(v \quad v_1)(v \quad v_1)}$

$\frac{2 \quad 320 \quad 4 \quad 243}{316 \quad 324} \quad 6$ Hz

28. $_c \quad \frac{(2n \quad 1)v}{4l_c} \quad \frac{320}{4 \quad 1}(2n \quad 1)$

$(2n \quad 1) \quad 80$ Hz $\quad 80$ Hz, 240 Hz, 400 Hz,...

$_0 \quad \frac{(n \quad 1)v}{2l_0} \quad \frac{320}{2 \quad 1.6}(n \quad 1)$

$(n \quad 1) \quad 100$ Hz $\quad 100$ Hz, 200 Hz, 300 Hz, 400 Hz,...

$_c \quad _o \quad 400$ Hz

29. $I_{max} \quad 4I_0$

and $I_{max} \quad 4I_{max} \quad 16I_0$

$L \quad 10$dB $\quad 10\log 16$

10 dB $\quad 40\log 2$ dB $\quad 22$ dB

30. $\frac{2}{k} \quad \frac{2}{2} \quad 4$ m

$l \quad 5\frac{}{4} \quad 5 \quad \frac{4}{4}$m $\quad 5$ m

31. $d \quad (2n \quad 1)\frac{}{4} \quad \frac{(2n \quad 1)}{4} \quad \frac{330}{660}$ m

$\frac{330}{24}(2n \quad 1)$ cm $\quad (2n \quad 1) \quad 13.75$ cm.

13.75 cm, 41.25 cm, 68.75 cm, 96.25 cm etc.

32. $\frac{v}{_1} \quad \frac{v}{_2} \quad \frac{v(_2 \quad _1)}{_1 \; _2}$

$\frac{332 \quad 1 \quad 10^{\;2}}{0.49 \quad 0.5} \quad 13.15$ Hz

33. $_B \quad _A \quad _B \frac{300}{300 \quad 30} \quad 300 \quad 300$

33.33 Hz and $_A \quad _B$

So both (a) and (b) options are wrong.

34. $f_a \quad \frac{v \quad v_0}{v} f \quad 1 \quad \frac{v_0}{v} \; f$ and

$f_r \quad 1 \quad \frac{v_0}{v} \; f$

$\frac{f_a}{f_r} \quad \frac{v \quad v_0}{v \quad v_0}$

$(f_a \quad f_r)v \quad (f_a \quad f_r)v_0$

$\frac{v}{v_0} \quad \frac{f_a \quad f_r}{f_a \quad f_r}.$

and

$f_a \quad f_r \quad \frac{2v_0}{v} f \quad 2\frac{f_a \quad f_r}{f_a \quad f_r} \; f$

$f \quad \frac{f_a \quad f_r}{2}.$

JEE Corner

Assertion and Reason

1. $_c \quad (2n \quad 1)\frac{v}{4l} \quad \frac{v}{4l}, \frac{3v}{4l}, \frac{5v}{4l}, \ldots$

while, $_0 \quad \frac{(n \quad 1)v}{2l} \quad \frac{v}{2l}, \frac{2v}{2l}, \frac{3v}{2l}, \frac{4v}{2l}, \ldots$

it can be seen that $_c \quad _o$ at all situation and $_c \quad \frac{1}{2} \quad _o$ so assertion is true but reason is false.

2. Apparent frequency is constant for constant relative velocity so assertion is false.

3. At a point of minimum displacement pressure amplitude is maximum *i.e.*, pressure difference is maximum not pressure. So assertion is false.

4. The deriver receiver two sounds one direct, $_0$ and other $_R \quad \frac{v \quad u}{v \quad u}$ such that be detects beats. So reason is true explanation of assertion.

5. With increase in intensity sound level increases in lograthmic order so assertion is false.

6. Speed of sound $v \quad \sqrt{\frac{p}{}}$, with increase in only pressure density increases such that p remains constant. Again $v \quad \sqrt{\frac{RT}{M}}$ so both assertion and reason are true but reason is not correct explanation of assertion.

7. $_A \quad _B \quad 4$ when A is loaded with little wax then $_A$ sightly decreases and then beat frequency decreases, but if it is heavily loaded with wax then its frequency goes much below $_B$ such that beat frequency increases. So, assertion and reason are both true but reason is not correct explanation of assertion.

8. 150 | 450, 7 50,
3, 5

The frequencies are odd harmonics then the pipe is closed and fundamental frequency is also 150 Hz. So assertion and reason are both true but reason is not correct explanation of assertion.

9. $\frac{1}{l \quad e}$ with increase in diameter end correction, e, increases and decreases. So reason is correct explanation of assertion.

10. With increasing length of air column, number of overtone increases and not the wavelength so assertion is false.

■ Objective Questions (Level 2)

1. At the boundary between two mediums, one part of incident wave gets reflected and other part gets transmitted or refracted.

2. $\frac{3}{2} \quad 3.9 \qquad \frac{3.9}{1.5}$

$k \quad \frac{2}{} \quad \frac{2}{\frac{3.9}{1.5}} \quad \frac{3}{3.9} \quad {}_0 \quad S_0\, kB$

$S_0 \quad \frac{0}{kB} \quad \frac{10^{\;2} \quad 10^5}{\frac{3}{3.9} \quad 1.3 \quad (200)^2}$

$\frac{3.9 \quad 10^{\;1}}{12 \quad 1.3} \quad 0.025\text{ m} \quad 2.5\text{ cm}$

3. $\frac{A_t}{A_i} \quad \frac{2v_2}{v_1 \quad v_2} \quad \frac{2 \quad 100}{200 \quad 100} \quad \frac{2}{3}$

4. $\frac{v}{v \quad v_2} \quad \frac{v}{v \quad v_1}$

$\frac{v\;(v_1 \quad v_2)}{(v \quad v_2)\,(v \quad v_1)} \sim \frac{(v_1 \quad v_2)}{v}$

$v_1 \quad v_2 \quad \frac{v}{} \quad \frac{340 \quad 10}{1700} \quad 2\text{ m/s}$

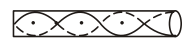
5. $v_s \quad gt \quad 10\text{ m/s}$

$\frac{v \quad v_0}{v \quad v_s} \quad \frac{v \quad v_0}{v \quad v_s}$

$\frac{300 \quad 2}{300 \quad 10} \quad \frac{300 \quad 2}{300 \quad 10} \quad 150\text{ Hz}$

$\frac{302}{290} \quad \frac{298}{310} \quad 150 \quad 12\text{ Hz}$

6. $7\frac{}{2} \quad L \qquad \frac{2L}{7}$



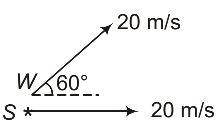
$A \quad a\cos kx \quad a\cos\frac{2}{2\frac{L}{7}}\;\frac{L}{7} \quad a\cos \qquad a$

7. For maxima, $n \quad 3$

$\frac{3}{n}; \quad \frac{v}{} \quad \frac{nv}{3} \quad 110\,n.$

110, 220, 330 Hz, ..etc. maxima will be formed so maximum will not be formed at 120 Hz and 100 Hz.

8.



$\frac{v \qquad \cos 60}{v \quad w\cos 60 \quad v_s}$

$\frac{300 \quad 10}{300 \quad 10 \quad 20} \quad 500\text{ Hz}$

$\frac{310}{290} \quad 500 \quad 534\text{ Hz}$

9. ${}_R \quad {}_0 \quad \frac{v \quad 20}{v \quad 10} \quad \frac{v \quad 20}{v \quad 10} \quad 500$

$\frac{360}{300} \quad \frac{360}{350} \quad 500\text{ Hz} \quad 31\text{ Hz}$

10. $\frac{404}{2} \quad \frac{400}{2} \quad 202 \quad 200 \quad 2\text{ Hz}$

$\frac{I_{\max}}{I_{\min}} \quad \frac{2 \quad 1}{2 \quad 1}^{\;2} \quad 9:1$

11. $3\frac{}{4} \quad 34 \text{ cm} \qquad \frac{4}{3} \quad 34 \text{ cm}$

$\frac{v}{} \quad v_{51} \qquad \frac{136}{3}$

$\frac{v_{16}}{v_{51}} \quad \sqrt{\frac{273 \quad 16}{273 \quad 51}} \quad \sqrt{\frac{289}{324}} \quad \frac{1}{\sqrt{1.121}} \quad \frac{1}{1.1}$

$_{16} \quad \frac{51}{1.1}$

$_{16} \quad \frac{136}{3 \quad 1.1} \quad 41.21 \text{ cm}$

12. $176 \quad \frac{v \quad v}{v \quad 22} \quad 165 \quad \frac{v \quad v}{v}$

$176\, v(v \quad v) \quad 165(v \quad v)\,(v \quad 22)$

$176 \quad 330(330 \quad v) \quad 165(330 \quad v)\,(330 \quad 22)$

or $\quad 1.143\,(330 \quad v) \quad 330 \quad v$

or $\quad 0.143 \quad 330 \quad 2.143\,v \quad v \quad 22 \text{ m/s}$

13. $M_{\text{min}} \quad \frac{2 \quad 32 \quad 3 \quad 48}{2 \quad 3} \quad 41.6$

$\frac{2}{1} \quad \frac{v_2}{v_1} \quad \sqrt{\frac{1}{2}} \quad \sqrt{\frac{32}{41.6}} \quad \sqrt{0.77}$

$= 0.875 \quad 175 \text{ Hz}$

14. $v_0 \quad gt \quad 30 \text{ m/s}$

$1100 \quad \frac{v \quad 30}{v} \quad 1000,\ 1.1v \quad v \quad 30$

$0.1\,v \quad 30 \quad v \quad 300 \text{ m/s}$

Passage (Q 5 to 17)

$v_m \quad v_p \quad 8 \text{ m/s},\ 50v_m \quad 150v_p$

$v_m \quad 3v_p,\ 4v_p \quad 8 \text{ m/s}$

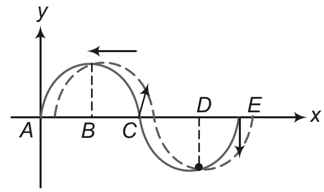
$v_p \quad 2 \text{ m/s and } v_m \quad 6 \text{ m/s}$

15. $\frac{v \quad 2}{v \quad 6} f_0 \quad \frac{332}{324} f_0 \quad \text{constant}$

16. $\frac{v \quad 2}{v \quad 6} f_0 \quad \frac{328}{336} f_0 \quad \text{constant}$

17. $f_0 \quad v$ and graph is (a)

18.



Both (a) and b are correct.

More Than One

19. $\frac{(2n \quad 1)v}{4l}$

$l \quad \frac{v}{4}(2n \quad 1) \quad \frac{330}{4 \quad 264}(2n \quad 1) \text{ m}$

$(2n \quad 1) \quad 31.25 \text{ cm}$

$31.25 \text{ cm},\ 93.75 \text{ cm},\ 156.25 \text{ cm}$

20. (a) $v \quad p^0$, (b) $v \quad \sqrt{T} \quad v^2 \quad T$,

where T is absolute temperature.

(c) $v \quad \sqrt{F}$ (d) $\frac{1}{l}$

(c) and (d) are correct.

21. $P_0 \quad BAk;\ B \quad \frac{p}{\frac{V}{V}} \quad \frac{p}{\frac{p}{p}}$

$\frac{p}{B} \quad BAk\frac{}{B} \quad Ak$

p

Pressure and density equations are in opposite phase *i.e.*, $\frac{}{2}$ and not .

So, (a), (b) and (c) are correct.

22. $\frac{5v}{4l_c} \quad \frac{3v}{2l_o} \quad \frac{1.25}{l_c} \quad \frac{2}{l_o} \quad \frac{l_o}{l_c} \quad \frac{2}{1.25} \quad \frac{8}{5}.$

(a) $_c \quad \frac{v}{4l_c} \quad \frac{v}{4\ \frac{5}{8}l_o} \quad \frac{2v}{5l_o}$

$\frac{4}{5}\ \frac{v}{2l_o} \quad \frac{4}{5} \quad _o \quad _c \quad _o$

(b) $_c \quad \frac{3v}{4l_c} \quad \frac{3v}{4\ \frac{5}{8}l_0} \quad \frac{12}{5}\ \frac{v}{2l_0}$

$\frac{6}{5}\ \frac{2v}{2l_o} \quad \frac{6}{5} \quad _o \quad _c \quad _o.$

(c) $_c \quad \frac{15v}{4l_c} \quad \frac{15v}{4 \quad \frac{5}{8}l_o} \quad \frac{6v}{l_o} \quad 12\frac{v}{2l_o}$

$12v_0$ twelbth harmonic.

(d) Closed organ pipe cannot have tenth harmonic it only has odd harmonics.

23. $f \quad \frac{v}{4(l \quad e)} \quad \frac{1}{4(l \quad e)}\sqrt{\frac{RT}{M}}$

(a) increase in r increase in e decrease in f

(b) increase in T increase in v increase in f

(c) increase in M decrease in v decrease in f

(d) increase in P increase in no change in v no change in f

24. $f_a \quad \frac{v}{v \quad v_s}f$ and $f_r \quad \frac{v}{v \quad v_s}f$ are constants during approach and received.

Match the Columns

1. $_o \quad \frac{v}{2l} \quad f$

(a) $_c \quad \frac{v}{4 \quad 2l} \quad \frac{f}{4} \quad 0.25f \quad s$

(b) $_{c2} \quad \frac{5v}{4 \quad 2l} \quad \frac{5}{4}f \quad 1.25f \quad p$

(c) $_{c1} \quad \frac{3v}{4 \quad 2l} \quad \frac{3}{4}f \quad 0.75f \quad r$

(d) $_{c1} \quad \frac{3v}{4 \quad 2l} \quad 0.75f \quad r$

2. $_1 \quad \frac{v}{v \quad v_s} \quad \frac{v}{v \quad v_s} \quad f \quad \frac{2vv_f}{v^2 \quad v_s^2}f$

$\frac{2v\frac{v}{4}}{v^2 \quad \frac{v^2}{16}}f \quad \frac{16}{15} \quad \frac{1}{2}f \quad \frac{8}{15}f$

$_2 \quad \frac{v \quad v_s}{v \quad v_s} \quad 1 \; f \quad \frac{2v_s}{v \quad v_s}f$

$\frac{2v/4}{v \quad v/4}f \quad \frac{2}{3}f$

$_3 \quad \frac{v}{v \quad v_5} \quad \frac{v}{v \quad v_5} \quad f \quad 0$

(a) $_1 \quad \frac{8}{15}f \quad q$

(b) $_2 \quad \frac{2}{3}f \quad p$

(c) $_3 \quad 0 \quad s$

(d) $_3 \quad 0 \quad s$

3. $f \quad f_T \quad f_S$

(a) If tuning fork is loaded f_T decreases such that beat frequency may increase or decrease depending upon amount of wax r, s

(b) If prongs are filed, beat frequency must increase p

(c) If tension is increased beat frequency may increase or decrease depending upon the amount of change in tension. r, s

(d) If tension is decreased, beat frequency must increase p

4. (a) For point source, $I \quad \frac{1}{r}$, and $A \quad \frac{1}{r} \quad r$

(b) q

(c) For line source, $I \quad \frac{1}{r}$ and

$A \quad \frac{1}{\sqrt{r}} \quad q$

(d) p

5. $\frac{2}{k} \quad \frac{2}{} \quad 2\,\text{m}$

$5\frac{}{4} \quad \frac{5}{2}\text{m} \quad 2.5\,\text{m}$

(a) $l \quad 2.5\,\text{m} \quad s$

(b) $2\,\text{m} \quad r$

(c) $\frac{}{2}, \frac{2}{2} \quad 1\text{m}, 2\text{m} \quad p, r$

(d) $\frac{}{4}, 3\frac{}{4} \quad 0.5\,\text{m}, 1.5\,\text{m} \quad q$

17. Thermometry, Thermal Expansion & Kinetic Theory of Gases

Introductory Exercise 17.1

1. (a) $\frac{C}{5} \quad \frac{F \quad 32}{9}$ for $F \quad 0, C \quad \frac{5}{9} \quad 32$

$17.8 \;\; \mathrm{C}$

(b) $\frac{K \quad 273.15}{5} \quad \frac{F \quad 32}{9}$ for $K \quad 0,$

$F \quad \frac{9}{5} \quad 273.15 \quad 32 \qquad 459.67 \;\; \mathrm{F}$

2. (a) $\frac{x}{5} \quad \frac{2x \quad 32}{9} \qquad x \quad \frac{10x}{9} \quad 17.8$

$17.8 \quad \frac{10}{9} \quad 1 \;\; x$

$x \quad 17.8 \quad 9 \quad 160.2 \;\; \mathrm{C}$

(b) $\frac{x}{5} \quad \frac{x/2 \quad 32}{9} \qquad x \quad \frac{5}{18}x \quad 17.8$

$17.8 \qquad \frac{13}{18}x \qquad x \qquad 24.65 \;\; \mathrm{C}$

3. $\frac{C \quad 5}{99 \quad 5} \quad \frac{F \quad 32}{212 \quad 32}$

$\frac{C \quad 5}{94} \quad \frac{F \quad 32}{180}$

$\frac{52 \quad 5}{94} \quad \frac{F \quad 32}{180}$

$F \quad 32 \quad \frac{180}{94} \quad 47 \quad 122 \;\; \mathrm{F}$

4. $\frac{K \quad 273.15}{5} \quad \frac{F \quad 32}{9}$

$x \quad 273.15 \quad \frac{5}{9}x \quad 17.8$

$\frac{4}{9}x \quad 255.35 \quad x \quad 574.54$

5. $\frac{C}{5} \quad \frac{F \quad 32}{9} \qquad \frac{9}{5}x \quad x \quad 32$

$\frac{4}{5}x \qquad 32$

$x \quad \frac{5}{4} \quad 32 \qquad 40 \;\; \mathrm{C}$

6. $t \quad \frac{1}{2} \quad t$

$\frac{1}{2} \quad 1.2 \quad 10^{5} \quad 86400 \quad 30$

$1.5 \quad 1.2 \quad 8.64 \text{ s} \quad 15.55 \text{ s}$ given.

7. As from 0°C to 4°C, density of water increases so the volume of wooden block above water level increases and as from 4°C to 10°C density of water decreases so the volume of block above water decreases.

8. $V_1 \;\; {}_1 g \quad V_2 \;\; {}_1 g$ and $V_2 \;\; {}_2 g \quad V_2 \;\; {}_2 g$

$\frac{V_1}{V_1} \quad 1 \quad \frac{V_1}{V_1} \qquad 1 \quad \frac{_1}{_1}$

and $\frac{V_2}{V_2} \quad 1 \quad \frac{_2}{_2}$

$\frac{V_2}{V_2} \quad \frac{V_1}{V_1}$

$1 \quad \frac{_2}{_2} \qquad 1 \quad \frac{_1}{_1} \qquad \frac{_1}{_1} \quad \frac{_2}{_2}$

$\frac{_1}{_1} \qquad \frac{_1 (1 \qquad _2 \; T)}{_1 (1 \qquad _1 T)}$

$$\frac{1}{1} \quad \frac{2 \quad\quad 1}{1 \quad\quad 1} \quad T \quad T$$

$$\frac{1}{1} \quad \frac{_1(1 \quad _2 \; T)}{_1(1 \quad _1T)} \quad T$$

$$\frac{1}{1} \quad \frac{2 \quad\quad 1}{1 \quad\quad 1} \quad T$$

9. On cooling brass contracts more than iron ($_B$ $_{Fe}$) such that brass disk gets loosen from hole of iron.

10. $V \quad T \quad V \quad kT \quad \ln V \quad \ln k \quad \ln T$

$$\frac{V}{V} \quad \frac{T}{T} \quad \frac{V}{V\ T} \quad \frac{1}{T}$$

Introductory Exercise 17.2

1. For ideal gases, $pV \quad nRT$

$$T \quad \frac{V}{nR}\ p \quad \frac{VM}{mR}\ p$$

Slope $\frac{VM}{mR}$

As slope $\frac{1}{m} \quad m_2 \quad m_1$

2. $pV \quad nRT \quad \frac{p_2}{p_1} \quad \frac{T_2}{T_1}$

$$\frac{360}{300} \quad \frac{6}{5}$$

$$p_2 \quad \frac{6}{5}\ p_1 \quad \frac{6}{5} \quad 10\ \text{atm} \quad 12\ \text{atm}$$

3. $M_{\text{mix}} \quad \frac{\frac{1}{4} \quad 28 \quad \frac{1}{4} \quad 44}{\frac{1}{4} \quad \frac{1}{4}} \quad \frac{7 \quad 11}{\frac{1}{2}} \quad 36$

$$pV \quad nRT \quad \frac{m}{M}\ RT$$

$$pM \quad \frac{m}{V}\ RT \quad\quad RT \quad\quad \frac{pM}{RT}$$

$$\frac{1.01 \quad 10^5 \quad 36 \quad 10^{\ 3}}{8.31 \quad 290}$$

$$\frac{1.01 \quad 36}{8.31 \quad 2.9} \quad 1.5\ \text{kg/m}^3$$

4. $pV \quad nRT \quad \frac{N}{N_A}\ RT$

$$N \quad \frac{pVN_A}{RT}$$

$$\frac{10^{\ 6} \quad 13.6 \quad 10^3 \quad 10 \quad 250 \quad 10^{\ 6} \quad 6.02 \quad 10^{23}}{8.31 \quad 300}$$

$$\frac{13.6 \quad 5 \quad 6.02}{8.31 \quad 6} \quad 10^{15} \quad 8.21 \quad 10^{15}$$

5. $pV \quad nRT$

$$V \quad \frac{nR}{p}\ T$$

Slope $\frac{1}{\ }$

$p_1 \quad p_2$

6. $pV \quad nRT \quad p \quad (nRT)\ \frac{1}{V}$

$y \quad mx$ is a straight line passing through origin.

Introductory Exercise 17.3

1. Average velocity depends on the direction of motion of gas molecules and as container do not move such that their net effect becomes zero, due to the reason that some molecules are moving in one direction while other are moving in opposite direction. But in case of average speed only magnitudes are in use which do not cancel each other.

2. $\text{KE} \quad \frac{3}{2} kT \quad \frac{3}{2} \quad \frac{8.31}{6 \quad 10^{23}} \quad 300 \text{ J}$

$\frac{3}{4} \quad 8.31 \quad 10^{\ 21} \text{ J}$

$6.21 \quad 10^{\ 21} \text{ J}$

3. $v_{\text{rms}} \quad \sqrt{\frac{3RT}{M}},$

$v_{\text{He}} \quad \sqrt{\frac{3 \quad 8.31 \quad 300}{4 \quad 10^{\ 3}}}$

$1.37 \quad 10^3 \text{ m/s}$

$v_{\text{Ne}} \quad \sqrt{\frac{3 \quad 8.31 \quad 300}{20.2 \quad 10^{\ 3}}} \quad 608.5 \text{ m/s}$

$\text{KE} \quad \frac{3}{2} kT \quad 6.21 \quad 10^{\ 21} \text{ J}$

4. $v_{\text{rms}} \quad \sqrt{\frac{3RT}{M}}$

$T \quad \frac{Mv_{\text{rms}}^2}{3R} \quad \frac{4 \quad 10^{\ 3} \quad 10^6}{3 \quad 8.31}$

160.45 K

5. $\frac{n_1 \ _1 \quad n_2 \ _2}{n_1 \quad n_2} \quad \frac{(1 \quad n_2) \ _1 \quad n_2 \ _2}{1 \quad n_2 \quad n_2}$

$_1 \quad n_2 \ (\ _2 \quad _1)$

$n_2 \quad \frac{\quad _1}{_2 \quad _1} \quad \frac{1.293 \quad 1.429}{1.251 \quad 1.429}$

$\frac{136}{178} \quad 0.764 \quad 76.4\% \text{ by mass}$

6. $\frac{V_2}{V_1} \quad \frac{p_1 T_2}{p_2 T_1} \quad \frac{(p_0 \quad h \ g)}{p_0 \quad 277}$

$\frac{(1.01 \quad 10^5 \quad 40 \quad 10^3 \quad 10) \quad 293}{1.01 \quad 10^5 \quad 277}$

$\frac{5.01 \quad 293}{1.01 \quad 277} \quad 5.25$

$V_2 \quad 5.25 \ V_1 \quad 105 \text{ cm}^3$

7. $N \quad nN_A \quad \frac{1}{18} \quad 6 \quad 10^{23}$

$\frac{1}{3} \quad 10^{23};$

$S \quad 4 \ R^2 \quad 4 \quad 3.14 \quad (6400 \quad 10^3 \quad 10^2)^2$

$5.14 \quad 10^{18} \text{ cm}^2$

$\frac{N}{S} \quad \frac{10^{23}}{3 \quad 5.14 \quad 10^{18}}$

$6.5 \quad 10^3 \text{ molecules/cm}^2$

(a) $nC_V \quad \frac{3}{2} nR \quad 35 \text{ J/K}$

$n \quad \frac{70}{3R} \quad 2.8 \text{ mole}$

(b) $U \quad \frac{3}{2} nRT \quad 35 \text{ J/K} \quad 273 \text{ K} \quad 9555 \text{ J}$

(c) $C_p \quad C_V \quad R \quad \frac{5}{2} R \quad 20.8 \text{ J/K mole}$

8. (a) $n(C_p \quad C_V) \quad nR \quad 29.1 \text{ J/K}$

$n \quad \frac{29.1}{8.314} \text{ mole} \quad 3.5 \text{ mole}$

(b) $C_V \quad nc_V \quad n\frac{3}{2}R \quad 3.5 \quad 1.5 \quad 8.314$

43.65 J/K

$C_p \quad nc_p \quad n\frac{5}{2}R \quad C_V \quad nR$

$43.65 \quad 3.5 \quad 8.314$

72.75 J/K

(c) $C_V \quad nc_V \quad n \quad \frac{5}{3} R \quad 72.75 \text{ J/K}$

$C_p \quad nc_p \quad n \quad \frac{7}{2} R$

$72.75 \quad 3.5 \quad 8.314$

101.85 J/K

10. $v_{\text{rms}} \quad \sqrt{\frac{3RT}{M}}$ and $v_{\text{av}} \quad \sqrt{\frac{8RT}{M}}$

Here $3 \quad \frac{8}{} \quad v_{\text{rms}} \quad v_{\text{av}},$

i.e., the statement is true.

AIEEE Corner

Subjective Questions (Level 1)

1. $\frac{C}{5} \quad \frac{68 \quad 32}{9} \quad \frac{36}{9} \quad 4$

$C \quad 20\ C; \frac{K \quad 273}{5} \quad \frac{68 \quad 32}{9} \quad 4$

$K \quad 293\ K$

$\frac{C}{5} \quad \frac{5 \quad 32}{9} \quad \frac{27}{9} \quad 3$

$C \quad 15\ C; \frac{K \quad 273}{5} \quad \frac{5 \quad 32}{9} \quad 3$

$K \quad 258\ K$

$\frac{C}{5} \quad \frac{176 \quad 32}{9} \quad \frac{144}{9} \quad 16$

$C \quad 80\ C; \frac{K \quad 273}{5} \quad 16$

$K \quad 353\ K$

2. $\frac{30}{5} \quad \frac{F \quad 32}{9} \quad F \quad 54 \quad 32 \quad 86\ F$

$546\ R$

$\frac{5}{5} \quad \frac{F \quad 32}{9} \quad F \quad 9 \quad 32 \quad 41\ F \quad 501\ R$

$\frac{20}{5} \quad \frac{F \quad 32}{9}$

$F \quad 36 \quad 32 \quad 41\ F$

$456\ R$

3. $\frac{x}{5} \quad \frac{x \quad 32}{9} \quad 32 \quad x \quad \frac{9}{5}x \quad \frac{4}{5}x$

$x \quad \frac{5}{4} \quad 32 \quad 40$

$40\ C \quad 40\ F$

4. $\frac{C}{5} \quad \frac{F}{9} \quad F \quad \frac{9}{5} \quad C \quad \frac{9}{5} \quad 40 \quad 72$

$F_2 \quad F_1 \quad 72 \quad 140.2\ F$

5. $\frac{32 \quad 20}{80 \quad 20} \quad \frac{C \quad 0}{100 \quad 0}$

$\frac{12}{60} \quad \frac{C}{100} \quad C \quad \frac{12 \quad 100}{60} \quad 20\ C$

6. $\frac{T_2}{T_1} \quad \frac{p_2}{p_1} \quad \frac{160}{80} \quad 2 \quad T_2 \quad 2T_1$

$T_2 \quad 2 \quad 273.15\ K \quad 546.30\ K$

7. $R_t \quad R_0(1 \qquad)$

$3.50 \quad 2.50\,(1 \quad 100 \quad) \quad 1 \quad 250\ K$

or $\frac{1.0}{250} \quad 4 \quad 10^{\ 3}/°C$

$6.50 \quad 2.50\,(1 \quad 4 \quad 10^{\ 3} \quad)$

$4 \quad 10^{\ 2}$

$400 \qquad _2 \quad 400°C$

$400 \qquad _2 \quad 400\ C$

i.e., boiling point of sulphur is 400°C.

8. $\frac{T_2}{T_1} \quad \frac{p_2}{p_1} \quad \frac{75 \quad 45}{75 \quad 5} \quad \frac{120}{80} \quad \frac{3}{2}$

$T_2 \quad \frac{3}{2}T_1 \quad \frac{3}{2} \quad 300.15\ K$

$450.225\ K \quad 177.08\ C$

9. $(\quad _{Br} \qquad _{Fe})$

$\frac{}{} \quad \frac{1}{_{Br} \qquad _{Fe}}$

$\frac{0.01 \quad 10^{\ 3}}{6 \quad 10^{\ 2}} \quad \frac{1}{_{Br} \qquad _{Fe}}$

$\frac{10^{\ 3}}{6\,(\ _{Br} \qquad _{Fe})}$

$_2 \quad _1 \quad \frac{10^{\ 3}}{6\,(\ _{Br} \qquad _{Fe})}$

$30\ C \quad \frac{10^{\ 3}}{6\,(\ _{Br} \qquad _{Fe})} \quad 30\ C \quad \frac{100}{6 \quad 0.63}$

$57.78\ C.$

10. (a) $l \quad l \quad \sim 88.42 \quad 2.4 \quad 10^{\ 5} \quad 30$

0.064 cm

(b) $l \quad l\,(\ _{Al} \qquad _{St})$

$88.42\,(2.4 \quad 1.2) \quad 10^{\ 5} \quad 30$

0.032 cm

$l_S \quad l \quad l \quad 88.42 \quad 0.032$ cm

88.45 cm

11. $\dfrac{l}{l}$ 100% 100%

$1.2 \quad 10^{5} \quad 35 \quad 100\%$

0.042%

12. $F \quad YA\dfrac{l}{l} \quad YA$

$2 \quad 10^{11} \quad 2 \quad 10^{6} \quad 1.2 \quad 10^{5} \quad 40$

$4 \quad 1.2 \quad 40\,\text{N} \quad 160 \quad 1.2\,\text{N} \quad 192\,\text{N}$

13. $V \; g \quad (50 \quad 45) \quad 10^{3}$ kg

$5 \quad 10^{3}$ kg

$V \quad g \quad (50 \quad 45.1) \quad 10^{3}$ kg

$4.9 \quad 10^{3}$ kg

$V(1 \quad {}_s \;)\dfrac{}{1 \qquad {}_l} \; g \quad 4.9 \quad 10^{3}$

$\dfrac{1 \quad {}_s}{1 \quad {}_l} \quad \dfrac{4.9}{5}$

$5 \quad 5\,{}_s \quad 4.9 \quad 4.9\,{}_e$

${}_l \quad \dfrac{0.1 \quad 5\,{}_s}{4.9} \quad \dfrac{1}{49} \quad \dfrac{5}{4.9} \; {}_s$

${}_s \quad \dfrac{1}{49 \quad 75} \quad \dfrac{5}{4.9} \quad 12 \quad 10^{6}$

$272.1 \quad 10^{6} \quad 12.2 \quad 10^{6}$

$2.84 \quad 10^{4}$ C

14. $M \quad 14 \quad 3 \quad 17$ g/mole

$17 \quad 10^{3}$ kg/mole

$M \quad \dfrac{17 \quad 10^{3}}{6.033 \quad 10^{23}}$ kg/molecule

$2.82 \quad 10^{26}$ kg/molecule

15. $n \quad \dfrac{pV}{RT} \quad \dfrac{1.52 \quad 10^{6} \quad 10^{2}}{8.314 \quad 298.15} \quad 6.13$

$\dfrac{m}{V} \quad \dfrac{nM}{V} \quad \dfrac{6.13 \quad 2 \quad 10^{3}}{10^{2}}$

$1.23\ \text{kg/m}^{3}$

$\dfrac{m}{V} \quad \dfrac{nM}{V} \quad \dfrac{16\,nM}{V} \quad 16$

$19.62\ \text{kg/m}^{3}$

16. $p_2 \quad p_1\dfrac{V_1}{V_2} \quad 1\ \text{atm} \quad \dfrac{76}{6}$

12.7 atm

17. $V_2 \quad \dfrac{p_1V_1}{T_1} \; \dfrac{T_2}{p_2} \quad \dfrac{p_1}{p_2} \; \dfrac{T_2}{T_1} \; V_1$

$\dfrac{1}{0.5} \quad \dfrac{270}{300} \quad 500\ \text{m}^{3} \quad 900\ \text{m}^{3}$

18. $\dfrac{p_1V_1}{T_1} \quad \dfrac{p_2V_2}{T_2}$

$\dfrac{\dfrac{mg}{A} \quad p_0 \quad A \;\, h_i}{293} \qquad \dfrac{\dfrac{mg}{A} \quad p_0 \quad Ah_f}{273}$

$h_f \quad \dfrac{373}{293}\,h_i \quad \dfrac{373}{293} \quad 4\ \text{cm} \quad 50.9\ \text{cm}$

19. $p_1 \quad p_2 \quad \dfrac{n_1}{V_1} \quad \dfrac{n_2}{V_2} \quad \dfrac{25/28}{L_1\,A} \quad \dfrac{40/4}{L_2\,A}$

$\dfrac{L_1}{L_2} \quad \dfrac{25}{28} \quad \dfrac{1}{10} \quad \dfrac{5}{56} \quad 0.089$

$\dfrac{n_1}{n_2} \quad \dfrac{25/28}{40/4} \quad \dfrac{25}{280} \quad \dfrac{5}{56} \quad 0.089$

20. $n \quad n_1 \quad n_2$

$p(V_1 \quad V_2) \quad p_1V_1 \quad p_2V_2$

$p \quad \dfrac{p_1V_1 \quad p_2V_2}{V_1 \quad V_2}$

$p \quad \dfrac{1.38 \quad 0.11 \quad 0.69 \quad 0.16}{0.11 \quad 0.16}\ \text{MP}_a$

$\dfrac{0.1518 \quad 0.1104}{0.27} \quad \dfrac{0.2622}{0.27} \quad 0.97\ \text{MP}_a$

21. $\dfrac{pV_1}{T} \quad \dfrac{pV_2}{T} \quad \dfrac{p_1V_1}{T_1} \quad \dfrac{p_1V_2}{T_2}$

$\dfrac{1\ \text{atm}}{293\ \text{K}} \quad 600\ \text{cm}^{3}$

$p_1 \quad \dfrac{400\ \text{cm}^{3}}{373\ \text{K}} \quad \dfrac{200\ \text{cm}^{3}}{273\ \text{K}}$

$p_1 \quad \dfrac{600/293}{\dfrac{400}{373} \quad \dfrac{200}{273}}\ \text{atm}$

$p_1 \quad \dfrac{3}{293 \quad \dfrac{2}{373} \quad \dfrac{1}{273}}\ \text{atm}$

$\dfrac{3}{1.57 \quad 1.07} \quad \dfrac{3}{2.64}\ \text{atm}$

1.136 atm

22. $V \quad \dfrac{nRT}{p} \quad \dfrac{1 \quad 8.314 \quad 273.15}{1.013 \quad 10^5} \text{ m}^3$

$0.02242 \text{ m}^3 \quad 22.42 \text{ litre}$

23. $p_2 \quad \dfrac{p_1 V_1}{T_1} \dfrac{T_2}{V_2} \quad p_1 \dfrac{V_1}{V_2} \dfrac{T_2}{T_1}$

$1.5 \quad 10^5 \quad \dfrac{0.75}{0.48} \quad \dfrac{430}{300}$

$3.36 \quad 10^5 \text{ Pa}$

24. $p_1 \quad p_1 \quad p_2$

$\dfrac{n_1 RT}{V} \quad \dfrac{n_1 RT}{V} \quad \dfrac{n_2 RT}{V}$

$0.7 \quad \dfrac{1.4}{28} \quad 0.3 \quad \dfrac{1.4}{14} \quad \dfrac{0.4}{4} \quad \dfrac{RT}{V}$

$\dfrac{0.7}{20} \quad \dfrac{0.3}{10} \quad \dfrac{1}{10} \quad \dfrac{8.314 \quad 1500}{5 \quad 10^{\;3}}$

$\dfrac{3.3}{20} \quad 8.314 \quad 3 \quad 10^5 \text{ Pa}$

$4.11 \quad 10^5 \text{ Pa}$

25. RKE $\quad 2 \quad \dfrac{1}{2} kT \quad \dfrac{1}{2} I \quad ^2$

$\sqrt{\dfrac{2kT}{I}} \quad \sqrt{\dfrac{2 \quad 1.38 \quad 10^{\;23} \quad 300}{8.28 \quad 10^{\;38} \quad 10^{\;7}}}$

$10^{12} \sqrt{\dfrac{6 \quad 1.38}{8.28}} \quad 10^{12} \text{ rad/s}$

26. $v \quad \sqrt{\dfrac{\quad p}{\quad}}$

$\dfrac{v^2}{p} \quad \dfrac{1.3 \quad (330)^2}{1.013 \quad 10^5} \quad 1.398$

$\dfrac{f \quad 2}{f} \quad f \quad \dfrac{2}{0.398} \sim 5$

27. $\dfrac{n_1 C_{p_1} \quad n_2 C_{p_2}}{n_1 C_{V_1} \quad n_2 C_{V_2}} \quad \dfrac{3 \quad \frac{5}{2} \quad 2 \quad \frac{7}{2}}{3 \quad \frac{3}{2} \quad 2 \quad \frac{5}{2}}$

$\dfrac{15 \quad 14}{9 \quad 10} \quad \dfrac{29}{19} \quad 1.53$

28. $K \quad \dfrac{3}{2} pV$

$\dfrac{K_2}{K_1} \quad \dfrac{\frac{3}{2} p_2 V_2}{\frac{3}{2} p_1 V_1} \quad \dfrac{3}{2} \; \dfrac{15}{5} \quad 4.5$

$K_2 \quad 4.5 \text{ K}$

29. $C_p \quad \dfrac{f \quad 2}{2} R \quad 29 \quad f \quad \dfrac{58}{R} \quad 2 \quad 5$

$pT \quad p \quad \dfrac{pV}{nR}$

$p^2 V \quad \text{constant}$

$pV^{1/2} \quad \text{constant} \quad a \quad \dfrac{1}{2},$

$c \quad \dfrac{f}{2} R \quad \dfrac{R}{1 \quad \frac{1}{2}} \quad \dfrac{f \quad 4}{2} R \quad 29$

$f \quad \dfrac{58}{R} \quad 4 \quad 3$

30. TKE $\dfrac{3}{5}$ of total energy and RKE $\dfrac{2}{5}$ of total energy, so the gas is diatomic.

TKE $\dfrac{3}{2} kT \quad \dfrac{3}{2} \quad 1.38 \quad 10^{\;23} \quad 300 \text{ J}$

$6.21 \quad 10^{\;21}$ J/molecule

$Q \quad nC_V \quad T \quad 1 \quad \dfrac{5}{2} \quad 8.314 \quad 1 \quad 20.8 \text{ J}$

31. $C_p \quad \dfrac{n_1 C_{p_1} \quad n_2 C_{p_2}}{n_1 \quad n_2}$

$\dfrac{2.5\,R \quad 3.5\,R}{1 \quad 1} \quad 3R$

$C_V \quad \dfrac{n_1 C_{V_1} \quad n_2 C_{V_2}}{n_1 \quad n_2}$

$\dfrac{1.5\,R \quad 2.5\,R}{1 \quad 1} \quad 2R$

$\dfrac{C_P}{C_V} \quad \dfrac{3R}{2R} \quad 1.5$

32. $\dfrac{n_1 C_{p_1} \quad n_2 C_{p_2}}{n_1 C_{V_1} \quad n_2 C_{V_2}} \quad \dfrac{(n_1 \quad n_2) C_{p_1}}{(n_1 \quad n_2) C_{V_1}}$

$\dfrac{C_{p_1}}{C_{V_1}}$

33. $p \quad aV^b \quad pV^{\;b} \quad \text{constant}$

$C \quad \dfrac{Q}{n \quad T} \quad 0$ for adiabatic process for which $pV \quad$ constant comparing, we get, b

34. $p \quad kV \qquad pV^{\ 1} \quad \text{constant}$

$pV \quad a \text{ constant} \quad a \quad 1$

$C \quad C_V \quad \dfrac{R}{1 \quad a} \quad C_V \quad \dfrac{R}{1 \quad 1} \quad C_V \quad \dfrac{R}{2}$

35. $v_{\text{rms}} \quad \sqrt{\dfrac{3RT}{M}} \quad \sqrt{\dfrac{3 \quad 8.314 \quad 373.15}{2 \quad 10^{\ 3}}}$

$2.16 \quad 10^3 \text{ m/s}$

2.16 km/s

36. $v_{\text{rms}} \quad \sqrt{\dfrac{(500)^2 \quad (600)^2 \quad (700)^2 \quad (800)^2 \quad (900)^2}{5}}$

$\dfrac{100}{\sqrt{5}} \sqrt{25 \quad 36 \quad 49 \quad 64 \quad 81}$

714 m/s

$v_{\text{av}} \quad \dfrac{500 \quad 600 \quad 700 \quad 800 \quad 900}{5}$

$20\,(5 \quad 6 \quad 7 \quad 8 \quad 9) \quad 700 \text{ m/s}$

$v_{\text{rms}} \quad v_{\text{av}}$

37. $\text{KE} \quad \dfrac{3}{2}\, pV$

$N \quad 6 \quad 10^{\ 26} \quad 1.5 \quad 2 \quad 10^5 \quad \dfrac{100}{10^{\ 3} \quad 10^{\ 3}}$

$N \quad \dfrac{3 \quad 10}{6 \quad 10^{\ 26}} \quad 5 \quad 10^{26}$

$\dfrac{5000}{6.023} \quad 6.023 \quad 10^{23} \quad 830.15 \text{ Na}$

$n \quad 8300.15 \text{ moles}$

38. Frequency of collision, $\dfrac{v}{2\sqrt{3}\, l} \quad \dfrac{v}{2\sqrt{3} \quad V}$

$\dfrac{1}{2\sqrt{3}V} \sqrt{\dfrac{3RT}{M}}$

$\sqrt{\dfrac{RT}{4VM}} \quad \sqrt{\dfrac{RT}{4 \quad \dfrac{nRT}{p} \quad M}} \quad \sqrt{\dfrac{p}{4nM}}$

$\sqrt{\dfrac{2 \quad 10^{\ 5}}{4 \quad 1 \quad 46 \quad 10^{\ 3}}}$

$41.04 \quad 10^3/\text{s}$

39. $\text{KE} \quad \dfrac{3}{2}\, pV \quad \dfrac{3}{2} \quad 10^5 \quad 2 \quad 10^{\ 6} \quad 0.3 \text{ J}$

$N \quad \dfrac{m}{m_1} \quad \dfrac{50 \quad 10^{\ 6}}{8 \quad 10^{\ 26}} \quad 6.25 \quad 10^{20}$

$K_1 \quad \dfrac{K}{N} \quad \dfrac{0.3}{6.25 \quad 10^{20}} \quad \dfrac{30}{6.25} \quad 10^{\ 22} \text{ J}$

$4.8 \quad 10^{\ 22} \text{ J}$

40. $v_0 \quad \sqrt{\dfrac{3RT_0}{M_0}}$

(a) $\dfrac{v}{v_0} \quad \sqrt{\dfrac{T}{T_0}} \quad \sqrt{\dfrac{573}{293}} \quad 1.4 \qquad v \quad 1.4\, v_0$

(b) $v \quad v_0$ as RMS speed changes with temperature and not with pressure.

(c) $\dfrac{v}{v_0} \quad \sqrt{\dfrac{M_0}{M}} \quad \sqrt{\dfrac{M_0}{3M_0}} \quad \dfrac{1}{\sqrt{3}}$

$v \quad \dfrac{v_0}{\sqrt{3}} \quad 0.58\, v_0$

41. $\sqrt{\dfrac{RT}{M_{H_2}}} \quad \sqrt{\dfrac{RT}{M_{O_2}}} \quad T \quad \dfrac{M_{H_2}}{M_{O_2}} \quad T$

$\dfrac{2}{32} \quad 320 \quad 20 \text{ K} \qquad 253 \text{ C}$

42. $\dfrac{1}{2}\, m v_e^2 \quad \dfrac{GMm}{R_e} \quad g_e R_e m$

$v_e \quad \sqrt{2 g_e R_e} \quad v_{H_2} \quad \sqrt{\dfrac{3RT}{M}}$

$T_e \quad \dfrac{2 g_e R_e M}{3R}$

$\dfrac{2 \quad 9.8 \quad 6.367 \quad 10^6 \quad 2 \quad 10^{\ 3}}{3 \quad 8.314}$

10007 K

and $T_m \quad \dfrac{2 g_m R_m M}{3R}$

$\dfrac{2 \quad 1.6 \quad 1.75 \quad 10^6 \quad 2 \quad 10^{\ 3}}{3 \quad 8.314}$

449 K

43. (a) $\text{KE} \quad \dfrac{3}{2}\, kT \quad \dfrac{3}{2} \quad 1.38 \quad 10^{\ 23} \quad 300 \text{ J}$

$6.21 \quad 10^{\ 21} \text{ J}$

(b) $\text{KE} \quad \dfrac{3}{2}\, kT \;\; N_a \quad 6.023 \quad 10^{23}$

$6.21 \quad 10^{\ 21} \text{ J}$

3740 J

(c) $v_{\text{rms}} \quad \sqrt{\frac{3RT}{M}} \quad \sqrt{\frac{3 \quad 8.314 \quad 300}{32 \quad 10^{\quad 3}}}$

483.6 m/s

■ Objective Questions (Level 1)

1. $v_{\text{av}} \quad \sqrt{\frac{8RT}{M}}$

2. $v_{\text{rms}} \quad \sqrt{\frac{1^2 \quad 0^2 \quad 2^2 \quad 3^2}{4}}$

$\sqrt{\frac{14}{4}} \quad \sqrt{3.5} \text{ m/s}$

3. $\frac{l}{l} \qquad 12 \quad 10^{\quad 6} \quad 50$

$600 \quad 10^{\quad 6} \qquad 6 \quad 10^{\quad 4}$

4. $V \quad T \quad \frac{V_2}{V_1} \quad \frac{T_2}{T_1} \quad 2;$

$\frac{V}{V} \quad \frac{V_2 \quad V_1}{V_1} \quad 2 \quad 1 \quad 1 \quad 100\%$

5. KE $\quad T \quad \frac{K_2}{K_1} \quad \frac{T_2}{T_1} \quad \frac{2E}{E} \quad 2$

$T_2 \quad 2T_1 \quad 2 \quad 283 \text{ K}$

$T_2 \quad 566 \text{ K} \quad 293 \quad \text{C}$

6. TE $\quad \frac{f}{2} kT \quad \frac{n}{2} kT.$

7. $\frac{v_2}{v_1} \quad \sqrt{\frac{T_2}{T_1}} \quad \sqrt{\frac{1200}{300}} \quad 2 \qquad v_2 \quad 2v_1$

8. (a) $p_{\text{av}} \quad m_1 v$ is different for different m_1

(b) $(\text{KE})_{\text{molecule}} \quad \frac{3}{2} kT$ is same for any gas.

(c) $(\text{KE})/V \quad \frac{3}{2} \frac{pV}{V} \quad \frac{3}{2} p$ is different as p is different for different.

(d) $(\text{KE})_m \quad \frac{3}{2} \frac{pV}{m} \quad \frac{3}{2} \frac{p}{}$ is different as $\frac{p}{}$ is different.

9. $\frac{p_1 V_1}{RT_1} \quad \frac{p_2 V_2}{RT_2} \quad \frac{pV_1}{RT} \quad \frac{pV_2}{RT} \quad \frac{p(V_1 \quad V_2)}{RT}$

$T \quad \frac{p(V_1 \quad V_2)}{\frac{p_1 V_1}{T_1} \quad \frac{p_2 V_2}{T_2}} \quad \frac{T_1 T_2 \; p(V_1 \quad V_2)}{p_1 V_1 T_2 \quad p_2 V_2 T_1}$

10. $\frac{l}{l} \quad \frac{0.08 \quad 10^{\quad 3}}{10 \quad 10^{\quad 2} \quad 100}$

$8 \quad 10^{\quad 6} / \quad \text{C}$

$V \quad V \qquad 3V \qquad 3 \quad 100 \text{ cc} \quad 8 \quad 10^{\quad 6} \quad 100$

0.24 cc

$V \quad 100 \text{ cc} \quad 0.24 \text{ cc} \quad 100.24 \text{ cc}$

11. $T \quad T_0 \quad \tan 45 \; V \quad T_0 \quad V$

$pV \quad nRT \quad nR(T_0 \quad V) \quad nRT_0 \quad nRV$

or $p \quad nR \quad \frac{nRT_0}{V} \qquad p \quad a \quad \frac{b}{V}$

ie, p *versus* V graph will be hyperbola.

12. $p^2 V \quad$ constant

$\frac{nRT}{V}^{\;2} \; V \quad$ constant.

$T^2 \quad V$

$\frac{T_2}{T_1} \quad \sqrt{\frac{V_2}{V_1}} \quad \sqrt{\frac{3V_0}{V_0}} \quad \sqrt{3}$

$T_2 \quad \sqrt{3} \; T_1 \quad \sqrt{3} \; T_0$

13. $p \quad \frac{1}{3} \quad v_{\text{rms}}^2 \quad \frac{1}{3} \frac{m}{V} v_{\text{rms}}^2$

$mT \quad$ constant

$\frac{m_1}{m_2} \quad \frac{T_2}{T_1} \quad \frac{310}{280} \quad 1.1$

14. As temperature of vessels A and B are some so is average velocity of O_2, *i.e.*, u.

15. $N \quad nN_a \quad \frac{pV}{RT} N_a$

$\frac{10^{\quad 13} \quad 10^{\quad 6}}{8.314 \quad 300} \quad 6.023 \quad 10^{\quad 23}$

$$\frac{602.3}{8.314 \quad 3} \quad 24$$

16. $\frac{1}{2}mv^2 \quad \frac{GMm}{R} \quad \frac{GMm}{R \quad h} \quad mgh$

$$h \sim \frac{v^2}{2g} \quad \frac{3RT}{2gM}$$

$$h \quad \frac{3 \quad 8.314 \quad 273}{2 \quad 10 \quad 28 \quad 10^{\ 3}} \text{ m}$$

$$12.16 \quad 10^3 \text{ m} \quad 12 \text{ km}$$

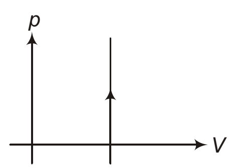
17. $\frac{l_1}{l_2} \quad \frac{\ 2}{\ 1} \quad \frac{19}{11}$ and $l_1 \quad l_2 \quad 30$ cm

$$l_1 \quad \frac{11}{19} l_1 \quad 30 \text{ cm}$$

$$l_1 \quad \frac{19}{8} \quad 30 \text{ cm} \quad 71.25 \text{ cm}$$

and $l_2 \quad \frac{11}{19} l_1 \quad 41.25$ cm

18. $p \quad V \quad T \quad V$ constant



19. $V \quad V_0 \quad \tan \quad T,\ pV \quad nRT \quad \frac{m}{M}RT$

$$p(V_0 \quad \tan \quad T) \quad \frac{m}{M}RT$$

$$\tan \quad \frac{1}{pT}\ \frac{m}{M}RT \quad pV_0$$

or $\tan \quad \frac{mR}{p_M} \quad \frac{V_0}{T}$

tan remains same when $m \quad 2m$ and $p \quad 2p$

20. $n_1 \quad \frac{p_1 V}{RT_1}$ and $n_2 \quad \frac{p_2 V}{RT_2}$

$$\frac{n_1}{n_2} \quad \frac{p_1}{T_1}\ \frac{T_2}{p_2} \quad \frac{10 \quad 300}{5 \quad 330} \quad \frac{600}{330} \quad \frac{20}{11}$$

$$n_2 \quad \frac{11}{20} n_1$$

$$m \quad m_1 \quad m_2 \quad m_1 \quad \frac{11}{20} m_1$$

$$\frac{9}{20} \quad 28 \text{ g} \quad \frac{63}{5} \text{ g}$$

21. $\frac{m}{V} \quad \frac{m}{(n_1 \quad n_2)\ \frac{RT}{p}} \quad \frac{mp}{(n_1 \quad n_2)RT}$

$$\frac{12 \quad 1.01 \quad 10^5 \quad 10^{\ 3}}{(2 \quad 2) \quad 8.314 \quad 300} \quad 0.12 \text{ kg/m}^3$$

22. $p \quad k \quad \frac{kM}{V}$

pV constant is for isothermal process, *i.e.*, T constant

23. $\frac{p^2}{\ }$ constant

p^2Vconstant $\quad pT$ constant

$$\frac{p_2}{p_1} \quad \sqrt{\frac{\ 2}{\ 1}} \quad \sqrt{\frac{\ /2}{\ }} \quad \frac{1}{\sqrt{2}}$$

$$p_2 \quad \frac{p_1}{\sqrt{2}}$$

$$\frac{T_2}{T_1} \quad \frac{p_1}{p_2} \quad \sqrt{2}$$

$$T_2 \quad \sqrt{2}T_1 \quad \sqrt{2}T$$

as pT constant $\quad p \quad \frac{1}{T}$

i.e., p - T graph is hyperbola.

24. p^2V constant

PT constant and $T^2V^{\ 1}$ constant.

$$\frac{p_2}{p_1} \quad \sqrt{\frac{V_1}{V_2}} \quad \sqrt{\frac{V}{4V}} \quad \frac{1}{2}$$

$$p_2 \quad \frac{p_1}{2} \quad \frac{p}{2}$$

$$\frac{T_2}{T_1} \quad \sqrt{\frac{V_2}{V_1}} \quad \sqrt{\frac{4V}{V}} \quad 2$$

$$T_2 \quad 2T_1 \quad 2T$$

as $p \quad \frac{1}{T}$ p-T graph is hyperbola.

25. $\frac{C \quad 0}{100 \quad 0} \quad \frac{F \quad 32}{212 \quad 32} \quad \frac{F \quad \text{MP}}{\text{BP} \quad \text{MP}}$

ice point 32 F and steam point 212 F

26. $p \quad V$ at 'a' $p \quad p_0$ and $V \quad V_0$ and at 'b',

$p \quad 2p_0$ and $V \quad 2V_0$, $\quad \frac{m}{V}$

$$\frac{b}{a} \quad \frac{V_a}{V_b} \quad \frac{V_0}{2V_0} \quad \frac{1}{2}$$

$$b \quad \frac{1}{2}\text{Pa}$$

$$\frac{T_b}{T_a} \quad \frac{P_b V_b}{P_a V_a} \quad \frac{2p_0 \quad 2V_0}{P_0 V_0} \quad 4$$

$$T_b \quad 4T_a$$

$$U \quad T \quad U_b \quad 4U_a$$

as $\quad P \quad V \quad T \quad V^2$

Parabola passing through origin

27. (a) TKE $\frac{3}{2}nRT$ is independent of type of gas true.

(b) In one degree of freedom for one mole of gas, $V \quad \frac{1}{2}RT$

(c) false

(d) false

28. $V \quad T \quad V \quad \tan \quad T$

$$pV \quad nRT \quad \frac{m}{M}RT$$

$$p \quad T\tan \quad \frac{mRT}{M} \quad \tan \quad \frac{mR}{MP}$$

$$\tan{}_1 \quad \tan{}_2 \quad \frac{m_1}{p_1} \quad \frac{m_2}{p_2}$$

all a, b, c and d are possible.

29. $pV \quad nRT$

$$p \quad \frac{n}{V}RT \quad \frac{N_a m/V}{M}RT \quad \frac{m}{M}RT$$

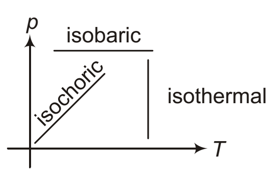
$$v_{\text{rms}} \quad \sqrt{\frac{3RT}{M}} \quad \sqrt{\frac{3kN_a T}{M}} \quad \sqrt{\frac{3kT}{M}}$$

(a) and (d) are correct.

JEE Corner

Assertion & Reason

1. Assertion is false.



2. Assertion and reason are both true but reason is not correct explanation of assertion. As at low temperature atoms in molecules are tightly bound such that they cannot oscillate.

3. $pV \quad nRT \quad \frac{2}{3}\text{ KE}$

$$p \quad \frac{2}{3}\frac{\text{KE}}{V} \quad p \quad \frac{2}{3}E.$$

Assertion and reason are both true but reason cannot explain assertion.

4. Internal energy remains same in train frame of reference, so temperature do not change, but KE of gas molecules in ground frame increases.

5. According to equipartition theory, energy is equally distributed for each degree of freedom, so assertion is false.

6. At high temperature and low pressure intermolecular distance is much larger than size of the molecules and intermolecular forces can be neglected. So, assertion and reason are both true but not correct explanation.

7. At 4°C, volume is minimum or density is maximum *i.e.*, liquid will overflow on increasing or decreasing temperature This reason is false.

8. Temperature remains constant as pressure is double and volume is halfed, so internal energy remains constant. So reason partially explains assertion.

9. Assertion and reason are both true but not correct explanation.

10. $V \quad \frac{nR}{} T \quad \frac{MR}{Mp} T$ slope m; reason is correct explanation.

■ Match The Columns

1.

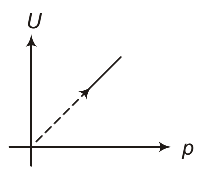
(a) TKE $\frac{3}{2} nRT \quad \frac{3}{2} \quad 2RT \quad 3RT$ r

(b) RKE $\frac{2}{2} nRT \quad \frac{2}{2} \quad 2RT \quad 2RT$ p

(c) PE s

(d) TKE $\frac{5}{2} nRT \quad 5RT$ s

2.



$U \quad p \quad T \quad \frac{1}{V} \quad VT$ constant

pT^2 constant and pV^2 constant

(a) U increases T increases P decreases r

(b) p increase V decreases r

(c) U increases T increases q

(d) $\frac{T}{V} \quad \frac{TV}{V^2} \quad \frac{\text{constant}}{V^2}$ increase as V decreases q

3. $x_1 \quad 3, x_2 \quad \frac{8}{}, x_3 \quad 2$ and $x_4 \quad r$

(a) r, (b) s, (c) q, (d) s

4.

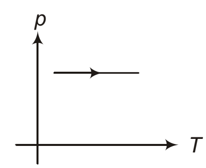
(a) density of water is maximum of 4 C s

(b) depends of change in density of solid and liquid s

(c) depends of change in density of solid and liquid s

(d) $T \quad \frac{1}{2} T$ increases with increasing temperature p

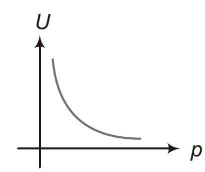
5. (a) p constant q



q

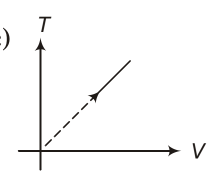
(b) $V \quad T$

$\frac{1}{} \quad U$



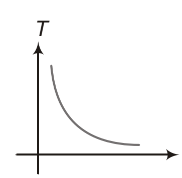
R

(c)



p

(d) $V \quad T \quad \frac{1}{} \quad T$



r

18. First Law of Thermodynamics

Introductory Exercise 18.1

1. (a) $W \quad p \; V \quad 1.7 \quad 10^5 (1.2 \quad 0.8)$ J

$6.8 \quad 10^4$ J

(b) $V \quad 1.1 \quad 10^5$ J

$Q \quad U \quad W \quad 17.8 \quad 10^4$ J

i.e., $1.78 \quad 10^5$ J of heat has flown out of the gas.

(c) No, it is independent of the type of the gas.

2. (a) In p- V graph of cyclic process, clockwise rotation gives positive work and anticlockwise gives negative work. And as loop 1 has greater area than loop 2, that is why total work done by the system is positive.

(b) As in cyclic process change in internal energy is zero, that's why for positive work done by the system, heat flows into the system.

(c) In loop '1' work done is positive so, heat flows into the system and in loop '2' work done is negative so heat flows out of the system.

3. As the box is insulated *i.e.*, no heat exchange takes place with surrounding and as the gas expands against vacuum *i.e.*, zero pressure that's why no work has been done and there is no change in internal energy. Thus, temperature do not change, internal energy and gas does not do any work.

4. $U \quad \frac{f}{2} nRT \quad \frac{3}{2} nRT$

$$n \quad \frac{2U}{3RT} \quad \frac{2 \quad 100}{3 \quad 8.314 \quad 300}$$

0.0267 mole.

5. $Q \quad ms \quad 1 \quad 387 \quad 30\,\text{J} \quad 11610\,\text{J}$

$V \quad V \quad \frac{m}{} \quad 3$

$$\frac{1}{8.92 \quad 10^3} \quad 3 \quad 7 \quad 10^{\;6} \quad 30$$

$7.1 \quad 10^{\;8}\ \text{m}^{\;3}$

$W \quad p \; V \quad 1.01 \quad 10^5 \quad 7.06 \quad 10^{\;8}$

$7.13 \quad 10^{\;3}$ J

$U \quad Q \quad W \quad 11609.99$ J

Introductory Exercise 18.2

1. (a) At constant volume,

$U \quad 0 \quad W \quad 0$

$Q \quad nC_V \quad T$

$$\frac{Q}{nC_V} \quad \frac{200}{1 \quad \frac{3}{2} \quad 8.314} \quad 16.04\ \text{K}$$

$T_f \quad T_i \quad T \quad 300 \quad 16.04 \quad 316.04$ K

(b) At constant pressure,

$$T \quad \frac{Q}{nC_p} \quad \frac{200}{1 \quad \frac{5}{2} \quad 8.314} \quad 9.62\ \text{K}$$

$T_f \quad 300 \quad 9.62\,\text{K} \quad 309.62\,\text{K}$

2. For adiabatic process,

$pV \quad$ constant $\quad c$ (say)

$$^{V_f}_{V_i} \; p\,dV \quad ^{V_f}_{V_i} \frac{c}{V} dV \quad c \; ^{V_f}_{V_i} V \quad dV$$

$$c\frac{V^{\;\;1}}{1}\Bigg|_{V_i}^{V_f} \quad c\frac{V_f^{\;\;1} \quad V_i^{\;\;1}}{1}$$

$$\frac{p_f V_f \; V_f^{\;\;1} \quad p_i V_i \; V_f^{\;\;1}}{1}$$

$$\frac{p_f V_f \quad p_i V_i}{1} \quad \frac{p_i V_i \quad p_f V_f}{1}$$ **(Proved)**

3. W_{AB} 500 J, Q_{AB} 250 J

U_{AB} 250 J

W_{AC} 700 J, Q_{AC} 300 J

U_{AC} 400 J

(a) Path BC is isochoric process, *i.e.*,

W_{BC} 0

Q_{BC} U_{BC} U_{AC} U_{AB}

400 J (250 J) 150 J

(b) W_{CDA} W_{CD} W_{DA}

800J 0 800 J

(Work is negative as volume is decreasing)

U_{CDA} U_{AC} U_{AC} 400 J

Q_{CDA} W_{CDA} U_{CDA}

800 J 400 J 400 J

4. (a) $T \quad \frac{pV}{nR} \quad \frac{1 \quad 10^{\;\;2} \quad 2 \quad 10^5}{1 \quad 8.314}$

240.6 K

(b) $W \quad \frac{p \;\; V}{1} \quad \frac{2 \quad 10^5 \quad 5 \quad 10^{\;\;3}}{\frac{5}{3} \quad 1}$

$\frac{10^3}{2/3}$ J

5. (a)

$$K \quad \frac{p^2}{2m_i} \quad \frac{p^2}{2m_f} \quad \frac{p^2}{2} \quad \frac{1}{m_i} \quad \frac{1}{m_f}$$

$$\frac{(10 \quad 10^{\;\;3} \quad 200)^2}{2} \quad \frac{1}{10 \quad 10^{\;\;3}} \quad \frac{1}{2.01}$$

$$2 \;\; 100 \quad \frac{1}{2} \qquad 199 \text{ J}$$

(b) $Q \quad nC_V \quad T \qquad T \quad \frac{Q}{nC_V} \quad \frac{Q}{\frac{m}{M}C_V}$

$$\frac{M \quad Q}{m \quad 3R} \quad \frac{200 \quad 199}{2010 \quad 3 \quad 8.314}$$

0.8 C

6. $W \quad W_{AB} \quad W_{BC} \quad W_{CD} \quad W_{DA}$

$nRT_1 m \frac{p_1}{p_2} \qquad p_2(V_C \quad V_{BC})$

$nRTm \frac{p_2}{p_1} \qquad p_1(V_1 \quad V_2)$

$nR(T_2 \quad T_1)\ln\frac{p_2}{p_1} \qquad p_1V_2 \quad p_1V_1$

$p_1V_1 \quad p_1V_2$

$(p_2V_2 \quad p_1V_1)\ln\frac{p_2}{p_1}$

7. W_{ABCA} (+)ve W_{AB} (+)ve,

W_{BC} 0, W_{CA} ( )ve

For BC, Q ( )ve U_{BC} ( )ve and

W_{BC} 0

For CA, U ( )ve Q_{CA} ( )ve as W_{CA} ( )ve.

	U	W	Q
AB	+	+	+
BC		0	
CA			
Total	0	+	+

For AB, as U_{ABCA} 0 and U_{BC} ( )ve,

U_{CA} ( ) ve

U_{AB} ( ) ve

As Q_{ABCA} W_{ABCA} ( )ve and

Q_{BC} ( )ve

Q_{CA} ( )ve Q_{AB} ( )ve

In isobaric process, $W \quad p \;\; V \quad nR \;\; T$

0.2 8.314 (300 200) 166.3 J

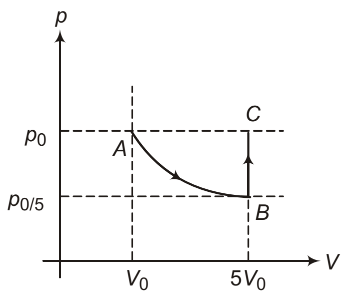
9. $W \quad pdV \quad V^2 dV \quad \frac{1}{3} \;\; V^3$

$\frac{1}{3} \quad 5 \quad 1.01 \quad 10^5 \quad (2^3 \quad 1^3)$

$1.18 \quad 10^6$ J

Introductory Exercise 18.3

1.



$$W_{BB} \quad nRT \ln \frac{V_B}{V_A} \quad 3R \quad 273 \ln 5$$

$$10959 \text{ J}$$

$$W_{BC} \quad 0$$

$$Q \quad U \quad W$$

$$U \quad Q \quad W$$

$$80000 \quad 10959$$

$$69041$$

$$T_f \quad 5T_i \quad 5 \quad 273 \text{ K} \quad 1365 \text{ K}$$

$$Q_{ABC} \quad Q_{AB} \quad Q_{BC}$$

$$W_{BC} \quad 0 \quad 0 \quad U_{BC}$$

$$Q_{BC} \quad nC_V \quad T \quad C_V \quad \frac{Q_{BC}}{n \quad T}$$

$$\frac{69041}{3 \quad 4 \quad 273} \quad 21.07$$

$$C_p \quad C_V \quad R \quad 29.39$$

$$\frac{C_p}{C_V} \quad \frac{29.39}{21.07} \quad 1.4$$

2. $Q \quad U \quad W; \; Q \quad nC_p \quad T$

$$1600 \quad 1 \; C_p \quad 72$$

$$C_p \quad 22.22$$

$$C_V \quad C_p \quad R \quad 13.9 \qquad \frac{C_p}{C_V} \quad 1.6$$

$$W \quad Q \quad U \quad 1600 \quad nC_V \quad T$$

$$1600 \quad 1 \quad 13.9 \quad 72$$

$$1600 \quad 1000.8 \text{ J}$$

$$599.2 \text{ J}$$

and $U \quad nC_V \quad T \quad 1 \quad 13.9 \quad 72$

$$1001$$

$$1 \text{ kJ}$$

3. $W \quad \frac{1}{2} \quad p \quad V$

$$\frac{1}{2} \quad 20 \quad 1.01 \quad 10^5 \quad 1 \quad 10^{\; 3}$$

$$10 \quad 101 \quad 1010 \text{ J}$$

$$p \quad \frac{n \quad W}{t} \quad \frac{100 \quad 1010 \text{ J}}{60 \text{s}}$$

$$1.68 \text{ kW}$$

AIEEE Corner

■ Subjectve Questions (Level 1)

1. $U \quad Q \quad W \quad 254 \text{ J} \quad 73 \text{ J}$

$$327 \text{ J}$$

2. (a) $T \quad \frac{Q}{nC_V} \quad \frac{2 \quad Q}{3nR} \quad \frac{2 \quad 200}{2 \quad 1 \quad 8.314}$

$$16 \text{ K}$$

$$T_f \quad T_i \quad T \quad 316 \text{ K}$$

(b) $T \quad \frac{Q}{nC_p} \quad \frac{2 \quad Q}{5nR} \quad \frac{2 \quad 200}{5 \quad 1 \quad 8.314}$

$$9.6 \text{ K}$$

$$T_f \quad T_i \quad T \quad 309.6 \text{ K}$$

3. $U \quad nC_V \quad T$, in adiabatic process,

$Q \quad 0$ and $U \quad W$

where, $W \quad \frac{nR \quad T}{1}$

$U \quad \frac{nR \quad T}{1}$ for all process.

4. $V \quad 0 \qquad W \quad 0$

$Q \quad U \quad nC_V \quad T \quad n \frac{5}{2} R \quad T$

$\frac{5}{2}(p_f V_f \quad p_i V_i) \quad \frac{5}{2}(p_f \quad V_i) V$

$\frac{5}{2}(5 \quad 10^5 \quad 10^5) \quad 10 \quad 10^{\ 3}$

$\frac{5}{2} \quad 4 \quad 10^5 \quad 10^{\ 2} \quad 10^4$ J

5. $Q_1 \quad U_1 \quad nC_V \quad T \quad n \frac{5}{2} R \,(3T_i \quad T_i)$

$5\, nRT_i$

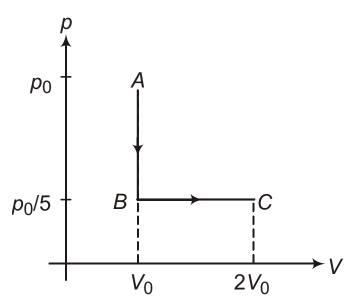
$Q_2 \quad nC_p \quad T \quad n \frac{5}{2} R\,(6T_i \quad 3T_i)$

$7.5\, nRT_i$

$c \quad \frac{Q}{n \quad T} \quad \frac{12.5\, nRT_i}{n\,(6T_i \quad T_i)} \quad \frac{12.5 R}{5} \quad 2.5 R$

6. $W_{AB} \quad 0, \; W_{BC} \quad \frac{p_0}{2} \quad V_0 \quad \frac{1}{2} p_0 V_0$

$\frac{1}{2} \quad nRT_0 \quad 300\, R$



$Q \quad (\;U \quad W)_{AB} \quad (\;U \quad W)_{BC}$

$U_{AB} \quad U_{BC} \quad W_{BC}$

$0 \quad 300\, R$

(As $T_A \quad T_C$)

$2.49 \quad 10^3$ J $\quad 2.49$ kJ

7. $U \quad Q \quad W \quad 1200$ J $\quad 2100$ J

900 J

$T \quad \frac{U}{nC_V} \quad \frac{900}{5 \quad \frac{3}{2} \quad 8.314} \quad 14.43$

$T_f \quad T_i \quad T \quad 127 \;$ C $\quad 14.43 \;$ C

$112.6 \;$ C

8. When gas expands it does positive work on the surrounding and for this purpose heat has to be supplied into the system.

9. $W \quad V \quad (V_f \quad V_i)$

$m \quad \frac{1}{f} \quad \frac{1}{i} \qquad m \quad \frac{1}{1000} \quad \frac{1}{999.9}$

$\frac{10^5 \quad 2 \quad 0.1}{1000 \quad 999.9} \quad 0.02$ J

(work done is negative as volume decreases)

$Q \quad ms \quad 2 \quad 4200 \quad 4$

33600 J

$U \quad Q \quad W \quad 33600.02$ J

10. $W \quad p \quad V \quad pV_f \quad p\frac{m}{}$

$\frac{10^5 \quad 10 \quad 10^{\ 3}}{0.6} \quad 1666.67$ J

$Q \quad ms \quad mL$

$10^{\ 2} \quad 4200 \quad 100 \quad 10^{\ 2} \quad 2.5 \quad 10^6$

4200 J $\quad$ 25000 J $\quad$ 29200 J

$U \quad Q \quad W \quad 29200$ J $\quad 1666.67$ J

27533.33 J $\quad 2.75 \quad 10^4$ J

11. $W \quad p \quad V$

$1.013 \quad 10^5 \quad 1670 \quad 10^{\ 6}$

$1.013 \quad 167$ J $\quad 169.2$ J

$Q \quad mL \quad 10^{\ 3} \quad 2.256 \quad 10^6$ J

2256 J

$U \quad Q \quad W \quad (2256 \quad 169.2)$ J

2086.8 J $\quad$ 2087 J

12. $W \quad p \quad V \quad 2.3 \quad 10^5 \quad 0.5$

$1.15 \quad 10^5$ J

$U \quad 1.4 \quad 10^5$ J

$Q \quad U \quad W$

$(1.4 + 1.15) \quad 10^5$ J

$2.55 \quad 10^5$ J

Thus, $2.55 \quad 10^5$ J of heat flows out of the system and it is independent of the type of the gas.

13. In a cyclic process, $U \quad 0 \qquad Q \quad W$

(a) $W \quad (Q_1 \quad Q_2 \quad Q_3 \quad Q_4)$
$(W_1 \quad W_2 \quad W_3)$

$(5960 \quad 5585 \quad 2980 \quad 3645)$
$(2200 \quad 825 \quad 1100)$

$1040 \quad 275 \quad 765$ J

(b) $\dfrac{\text{work done}}{\text{heat supplied}} \quad \dfrac{1040}{9605} \quad 10.83\%$

14. (a) $W \quad \frac{1}{2}\mathbf{AB} \quad \mathbf{AC} \quad \frac{1}{2} \quad 2p_0 \quad V_0$

p_0V_0

(b) $T_C \quad \dfrac{2\,p_0V_0}{nR}$ and $T_A \quad \dfrac{p_0V_0}{nR}$

$Q_{CA} \quad nC_p \quad T \qquad nC_p \quad \dfrac{p_0V_0}{nR}$

$\frac{5}{2}R \quad \dfrac{p_0V_0}{R} \qquad \frac{5}{2}p_0V_0$

$T_B \quad \dfrac{3\,p_0V_0}{nR}, \quad Q_{AB} \quad nC_V \quad T$

$n \quad \frac{3}{2}R \quad \dfrac{3\,p_0V_0}{nR} \quad \dfrac{p_0V_0}{nR}$

$\frac{3}{2} \quad 2\,p_0V_0 \quad 3\,p_0V_0$

(c) $Q_{AB} \qquad Q_{BC} \qquad Q_{CA} \qquad W$

$3\,p_0V_0 \qquad Q_{BC} \quad \frac{5}{2}\,p_0V_0 \quad p_0V_0$

$Q_{BC} \quad \dfrac{p_0V_0}{2}$

(d) Temperature is maximum at a point D lying somewhere between B and C where the product pV is maximum.

$p \quad \dfrac{2p_0}{V_0} \quad 5p_0$

$pV \quad \dfrac{2p_0}{V_0}V \quad 5p_0 \quad V$

$\dfrac{2p_0}{V_0}V^2 \quad 5p_0V$

For pV maximum $\dfrac{d}{dV}(pV) \quad 0$

$2V \quad \dfrac{2p_0}{V_0} \quad 5p_0 \quad 0$

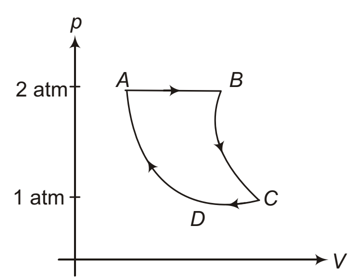
$V \quad \dfrac{5V_0}{4}$

$p \quad \dfrac{2p_0}{V_0} \quad \dfrac{5V_0}{4} \quad 5p_0 \quad \frac{5}{2}p_0$

$T_{\max} \quad \dfrac{(pV)_{\max}}{nR}$

$p \quad \dfrac{\frac{5}{2}p_0 \quad \frac{5}{4}V_0}{1 \;\; R} \quad \dfrac{25\,p_0V_0}{8R}$

15. $V_A \quad \dfrac{nRT_A}{p_A} \quad \dfrac{2R \quad 300}{2 \quad 10^5} \quad 3 \quad 10^{\;3}R$



$V_B \quad \dfrac{2R \quad 400}{2 \quad 10^5} \quad 4 \quad 10^{\;3}R,$

$V_C \quad \dfrac{2R \quad 400}{10^5} \quad 8 \quad 10^{\;3}R$

$V_0 \quad \dfrac{2R \quad 300}{10} \quad 6 \quad 10^{\;3}R$

$W \quad 2 \quad 10^5(4 \quad 3) \quad 10^{\;3}R$

$2R \quad 400\ln\frac{8}{4} \quad 1 \quad 10^5(6 \quad 8) \quad 10^{\;3}$

K

$2R \quad 300\ln\frac{3}{6}$

$W \quad 200R \quad 800R\ln 2 \quad 200R$

$600R\ln 2$

$2000R\ln 2 \quad 1153$ J

As $Q \quad W \quad 1153$ J and $U \quad 0$ cyclic process.

16. $W \quad \frac{1}{2}\frac{3V_0}{2} \quad \frac{V_0}{2}(p_B \quad p_0)$

$\frac{1}{2}\frac{3V_0}{2} \quad \frac{V_0}{2}(p_0 \quad p_0)$

$\frac{1}{2}V_0(p_B \quad p_0) \quad \frac{1}{2}V_0(p_0 \quad p_D)$

$\frac{1}{2}V_0(p_B \quad p_D)$

where, $p_B \quad p_0 \quad \frac{p_0}{V_0} \quad \frac{V_0}{2} \quad \frac{3p_0}{2}$

and $p_D \quad p_0 \quad \frac{p_0}{V_0} \quad \frac{V_0}{2} \quad \frac{p_0}{2}$

$W \quad \frac{1}{2}V_0 \quad \frac{3}{2}p_0 \quad \frac{1}{2}p_0 \quad \frac{1}{2}p_0V_0$

$W_{ABC} \quad p_0 \quad \frac{3V_0}{2} \quad \frac{V_0}{2} \quad \frac{1}{2}\frac{3V_0}{2} \quad \frac{V_0}{2}$

$(p_B \quad p_0) \quad p_0V_0 \quad \frac{1}{2}V_0 \quad \frac{3}{2}p_0 \quad p_0$

$\frac{5}{4}p_0V_0$

$U_{ABC} \quad nC_V(T_C \quad T_A)$

$n \quad \frac{3}{2}R \quad \frac{p_0 \frac{3V_0}{2}}{nR} \quad \frac{p_0 \frac{V_0}{2}}{nR} \quad \frac{3}{2}p_0V_0$

$Q_{\text{supplied}} \quad \frac{5}{4}p_0V_0 \quad \frac{11}{4}p_0V_0$

$\frac{\frac{1}{2}p_0V_0}{\frac{11}{4}p_0V_0} \quad \frac{2}{11} \quad 0.1818 \quad 18.18\%$

17. (a) As the cyclic process is clockwise *i.e.*, work done is positive, so heat is absorbed by the system.

(b) In cyclic process work done is equal to the net heat absorbed (as change in internal energy is zero) so, work done in one cycle is 7200 J.

(c) In anticlockwise rotation, work done is negative and heat is liberated by the system, and its magnitude is 7200 J.

18. (a) As area under clockwise loop is more than that at anticlockwise loop, so network done is positive.

(b) In loop I work done is positive and in loop II work done is negative.

(c) As network done in one cycle is positive so heat flows into the system.

(d) In loop I heat flows into the system and in loop II heat flows out of the system.

19. $T_A \quad \frac{p_AV_A}{nR} \quad \frac{1.01 \quad 10^5 \quad 22.4}{10^3 \quad 8.314}$

$273\,\text{K}$

$T_B \quad \frac{p_BV_A}{nR} \quad \frac{2p_AV_A}{nR} \quad 2T_A$

$546\,\text{K} \quad T_c$

$V_c \quad \frac{nRT_c}{p_c} \quad \frac{nRT_c}{p_A} \quad \frac{nRT_B}{p_A}$

$\frac{2nRT_A}{p_A} \quad 2V_A \quad 44.8\,\text{m}^3$

20. (a) $W \quad AB \quad BC$

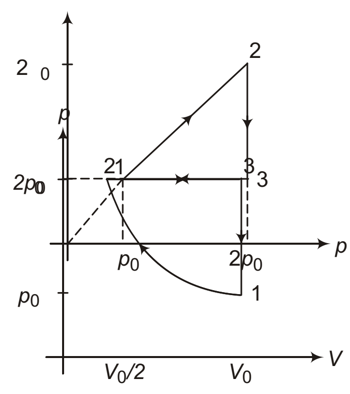
$(4 \quad 1.5) \quad 10^{\ 6} \quad (4 \quad 2) \quad 10^5$

$2.5 \quad 0.2 \quad 0.5\,\text{J}$

(b) $Q \quad W$ as $U \quad 0$ in a cycle

$Q \quad 0.5\,\text{J}$

21. As $\frac{1}{V}$



(a) $W_{12} \quad nRT_0 \ln \frac{V_0/2}{V_0}$

$p_0 V_0 \ln 2 \quad p_0 \frac{M}{0} \ln 2$

$W_{23} \quad 2p_0 \quad V_0 \quad \frac{V_0}{2} \quad p_0 V_0$

$p_0 \frac{M}{0}; \quad W_{31} \quad 0$

(b) $Q_{231} \quad Q_{23} \quad Q_{31}$

$nC_V \quad T_{23} \quad W_{23} \quad nC_V \quad T_{31}$

$$n \quad \frac{3}{2}R \quad \frac{2p_0V_0}{nR} \quad \frac{2p_0 \frac{V_0}{2}}{nR} \quad p_0V_0$$

$$n \quad \frac{3}{2}R \quad \frac{p_0V_0}{nR} \quad \frac{2p_0 \quad \frac{V_0}{2}}{nR}$$

$p_0 V \quad \frac{3}{2} p_0 V_0 \quad p_0 V_0 \quad \frac{5}{2} p_0 V_0$

Heat rejected $\quad Q_{231} \quad W$

$\frac{5}{2} p_0 V_0 \quad p_0 V_0 \quad p_{V_0} \ln 2$

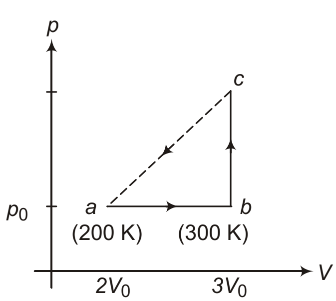
$\frac{3}{2} p_0 V_0 \quad p_0 V_0 \ln 2$

$p_0 V_0 \quad \frac{5}{2} \quad \ln 2 \quad \frac{p_0 M}{p_0} \quad \frac{3}{2} \quad \ln 2$

(c) $\frac{\text{work done}}{\text{heat supplied}} \quad \frac{W}{Q_{231}}$

$$\frac{p_0V_0 \quad p_0V_0 \ln 2}{\frac{5}{2} p_0 V_0} \quad \frac{2}{3}(1 \quad \ln 2)$$

22. $W_{AB} \quad p_0(3V_0 \quad 2V_0) \quad p_0 V_0;$



$W_{BC} \quad 0, \quad W_{CA} \quad ?$

$Q \quad W_{AB} \quad W_{BC} \quad W_{CA}$

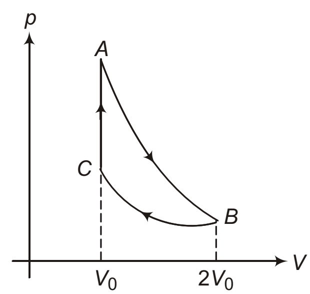
$800 \text{ J} \quad P_0 V_0 \quad 0 \quad W_{CA}$

$W_{CA} \quad 800 \text{ J} \quad p_0 V_0$

$800 \text{ J} \quad \frac{1}{2} nRT_A$

$W_{CA} \quad 800 \text{ J} \quad 200R \quad 2463 \text{ J}$

23. $W_{AB} \quad \frac{p_BV_B \quad p_AV_A}{1}$



$\frac{3}{2}(p_AV_A \quad p_BV_B)$

$\frac{3}{2} nR(T_A \quad T_B) \quad \frac{3}{2} nRT_B \quad \frac{T_A}{T_B} \quad 1 \; ; TV \quad 1$

$\frac{3}{2} nRT_B \quad \frac{2}{T}^{\frac{5}{3} \; 1} \quad 1 \quad \frac{3}{2} nRT_B(2^{2/3} \quad 1)$

$W_{BC} \quad nRT_B \ln \frac{V_0}{2V_0}$

$nRT_B \ln 2$ and $\quad W_{CA} \quad 0$

Heat Supplied

$Q_{CA} \quad U_{CA} \quad \frac{3}{2} nR(T_A \quad T_C)$

$\frac{3}{2} nR(T_A \quad T_B)$

$\frac{3}{2} nR \, T_B \quad \frac{T_A}{T_D} \quad 1 \quad \frac{3}{2} nRT_B(2^{2/3} \quad 1)$

$\frac{W}{Q_{CA}}$

$$\frac{\frac{3}{2} nRT_B(2^{2/3} \quad 1) \quad nRT_B \ln 2 \quad 0}{\frac{3}{2} nRT_B(2^{2/3} \quad 1)}$$

$$1 \quad \frac{2}{3} \quad \frac{\ln 2}{2^{2/3} \quad 1} \quad 1 \quad 0.7867 \quad 0.213$$

21.3%

Objective Questions (Level 1)

1. $U \quad nC_V T \quad \frac{3}{2} \quad 1 \quad RT \quad \frac{3}{2} RT$

$T \quad \frac{2U}{3R}$

$T_D \quad \frac{2V_0}{3R} \quad 300\,\text{K} \quad U_0 \quad 450R,$

$T_A \quad \frac{4V_0}{3R} \quad 600\,\text{K}$

$W \quad W_{AB} \quad W_{CD} \quad nRT_A \ln \frac{2V_0}{V_0}$

$nRT_D \ln \frac{V_0}{2V_0} \quad nR(T_A \quad T_D) \ln 2$

$1 \quad R \quad (600 \quad 300) \ln 2$

$300R \ln 2 \quad Q$

2. $W_{12} \quad p \quad V \quad nR \quad T$

$2R \quad 300 \quad 600R$

$W_{23} \quad ?; \quad W_{31} \quad 0.$

As, $Q \quad W_{12} \quad W_{23} \quad W_{31}$

$300\text{ J} \quad 600R \quad W_{23} \quad 0$

$W_{23} \quad 300\text{ J} \quad 600R \quad 5288\text{ J}$

3. $nC_p \quad T_1 \quad nC_V \quad T_2$

$\frac{7}{2} \quad 30 \quad \frac{5}{2} \quad T_2$

$T_2 \quad 42\,\text{K}$

4. $TV^{n \quad 1}$ constant

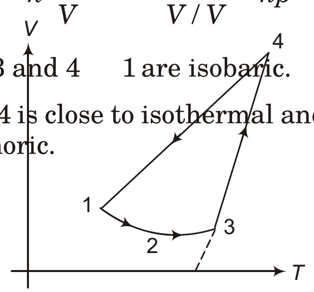
$pV \quad V^{n \quad 1} \quad pV^n$ constant

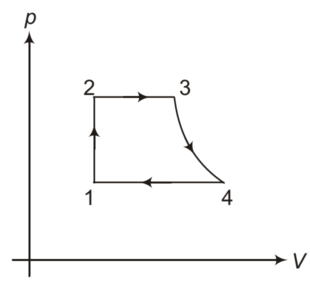
$\ln p \quad n \ln V \quad \ln c$

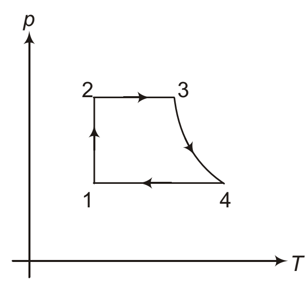
$\frac{p}{p} \quad n\frac{V}{V} \quad \frac{p}{V/V} \quad np \quad B$

5. 2 3 and 4 1 are isobaric.

3 4 is close to isothermal and 1 2 is isochoric.







6. $W \quad pdV \quad kVdV \quad \frac{k}{2} V^2$

$\frac{1}{2} pV \quad \frac{1}{2} nR(T_2 \quad T_1) \quad \frac{R}{2}(T_2 \quad T_1)$

7. $p \quad V^2, W \quad pdV \quad kV^2 dV$

$\frac{1}{3} kV^3 \quad \frac{1}{3} pV$

$\frac{1}{3} nR(T_f \quad T_i) \quad (\;)\text{ve}$

8. $W \quad nRT \ln \frac{V_f}{V_i}$

$nRT \ln \frac{1}{2} \quad nRT \ln 2$

9. $U \quad 600\text{ J} \quad 150\text{ J} \quad 450\text{ J}$

$nC_V \quad T \quad \frac{3}{2} R \quad n \quad T$

$$C \quad \frac{Q}{n \quad T} \quad \frac{600\text{ J}}{\frac{450\text{ J}}{\frac{3}{2}R}} \quad \frac{3}{2}R \quad \frac{600}{450}$$

$$\frac{3}{2}R \quad \frac{4}{3} \quad 2R$$

10. $W_1 \quad (\ )\text{ve}, \quad W_2 \quad 0, \quad W_3 \quad (\ )\text{ve}$

and $U_1 \quad U_2 \quad U_3$

as $\quad Q \quad U \quad W \quad Q_1 \quad Q_2 \quad Q_3$

11. $U \quad 2p_0 2V_0 \quad 2p_0 V_0 \quad 2p_0 V_0$

and $W \quad p_0(2V_0 \quad V_0) \quad p_0 V_0$

$Q \quad U \quad W \quad 3p_0 V_0$

12. In adiabatic compression, temperature of the gas increases and as $pV \quad T$ so, pV increases.

13. As $W_1 \quad W_2$ while $U_1 \quad U_2$

$Q_1 \quad Q_2$

$C_1 \quad C_2$

$\frac{C_1}{C_2} \quad 1$

14. $$W \quad nR(4T \quad T) \quad \frac{nR(5T \quad 4T)}{1}$$

$$nR(3T \quad 5T) \quad \frac{nR(T \quad 3T)}{1}$$

$$3nRT \quad 2nRT \quad \frac{nRT}{1} \quad \frac{2nRT}{1}$$

$$nRT \quad \frac{nRT}{1}$$

$$\frac{nRT}{1}(\quad 1 \quad 1) \quad \frac{}{1}nRT$$

$$\frac{5/3}{5/3 \quad 1} \quad 1RT \quad 2.5RT$$

15. Up constant

$$\frac{3}{2}nRT \quad \frac{nM}{V} \quad \frac{3}{2}n^2 MR\frac{T}{V}$$

$T \quad V$ *i.e.*, isobaric process.

$$\frac{U}{W} \quad \frac{U}{Q \quad U} \quad \frac{3/2}{\frac{5}{2} \quad \frac{3}{2}} \quad \frac{3}{2}$$

$$\frac{C_V}{C_p \quad C_V} \quad \frac{C_V}{R}$$

16. $W \quad 50 \quad (0.4 \quad 0.1) \quad \frac{1}{2} \quad 50 \quad (0.2 \quad 0.1)$

$15 \quad 2.5 \quad 27.5\text{ J}$

$U \quad 2.5\text{ J}$

$Q \quad U \quad W \quad 20\text{ J}$

17. $W_1 \quad {}_{V_0}^{2V_0} pdV \quad p(2V_0 \quad V_0) \quad pV_0$

$W_2 \quad {}_{V_0}^{2V_0} kVdV \quad \frac{1}{2}kV^2$

$\frac{1}{2}k(4V_0^2 \quad V_0^2) \quad \frac{3}{2}kV_0^2 \quad \frac{3}{2}PV_0$

$W_1 \quad W_2$

18. $W \quad r_1 r_2 \quad ab$

$$\frac{r_2 \quad r_1}{2} \frac{(p_2 \quad p_1)}{2}$$

$$\frac{}{4}(p_2 \quad p_1)(V_2 \quad V_1)$$

19. $W \quad PdV \quad \frac{nRT}{V \quad b}dV \quad nRT \frac{dx}{x}$

$x \quad V \quad b$

$dx \quad dV$

$nRT \ln x \quad nRT \ln (V \quad b)\Big|_V^{2V}$

$nRT\,[\ln (2V \quad b) \quad \ln (V \quad b)]$

$nRT \ln \frac{2V \quad b}{V \quad b} \quad RT \ln \frac{2V \quad b}{V \quad b}$

as $n \quad 1$ mole

20. AB is isochoric process, so, $W_{AB} \quad 0$

BC is isothermal process, so,

$$W_{BC} \quad nRT_2 \ln \frac{V_2}{V_1} \quad RT_2 \ln \frac{V_2}{V_1}$$

CA is close to isobaric process, so,

$W_{CA} \quad nRT \quad nR(T_1 \quad T_2)$

$R(T_1 \quad T_2)$

21. $Q \quad U \quad W \quad Q \quad W$

$W \quad 2 \quad Q$

$$U \quad nC_V \quad T \quad n\frac{f}{2}R \quad T \quad \frac{n}{1}R \quad T;$$

$$\frac{f \quad 2}{f} \quad 1 \quad \frac{2}{f}$$

$$f \quad \frac{2}{\quad 1}$$

$$W \quad p\,dV \quad 2 \quad Q \quad \frac{2n}{\quad 1} R \quad T$$

$$\frac{2\,nR \quad T}{1} \quad \frac{nR \quad T}{1 \quad a}$$ for polytropic process with pV^a constant

$$\frac{2}{1} \quad \frac{1}{1 \quad a} \quad 1 \quad a \quad \frac{1}{2}$$

$$1 \quad \frac{1}{2} \quad \frac{}{2} \quad a$$

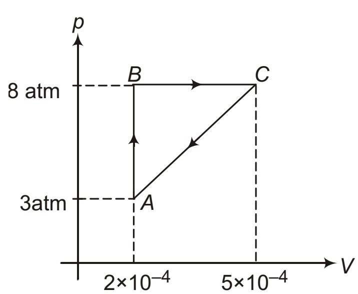
or $$a \quad \frac{1}{2} \quad \frac{1}{2}$$

$$pV^a \quad \text{constant}$$

$$TV^{a \quad 1} \quad TV^{\frac{1}{2} \quad 1}$$

$$TV^{\frac{1}{2}} \quad \text{constant}$$

22. $W_{AB} \quad 0, \; U_{AB} \quad 600\text{ J}$



$$W_{BC} \quad 8 \quad 10^5(5 \quad 2) \quad 10^{\quad 4} \quad 240\text{ J}$$

$$U_{BC} \quad Q_{BC} \quad W_{BC} \quad 200 \quad 240$$

$$40\text{ J}$$

$U \quad U_{AB} \quad U_{BC} \quad U_{CA} \quad 0$ in cyclic process.

$$U_{CA} \quad U_{AB} \quad U_{BC}$$

$$600\text{ J} \quad 40\text{ J} \quad 560\text{ J}$$

23. Starting and ending points along x-axis in graph are not clear, so nothing can be said about the magnitude of work.

It can only be said that work done in ABC is negative and that in DEF is positive. Looking at the graph, area can be assumed to be equal so,

$$W_{DEF} \quad W_{ABC}.$$

24. $W_{\text{isobaric}} \quad p \quad V \quad p(2V \quad V) \quad pV$

$$W_{\text{isothermal}} \quad nRT\ln \frac{2V}{V} \quad pV\ln 2$$

$$0.693\,pV$$

$$W_{\text{adiabatic}} \quad \frac{p_f \quad 2V \quad p_i V}{1}$$

$$\frac{p_i \left(\frac{V}{2V}\right)^{r} \quad 2V \quad p_i V}{1} \quad \frac{pV(2^{1 \quad r} \quad 1)}{1 \quad r}$$

$$pV \frac{1 \quad 2^{1 \quad r}}{r \quad 1} \quad pV \frac{1 \quad 4^{\quad 1/3}}{2/3}$$

$$0.55\,pV$$

So, work done is minimum in adiabatic process.

25. $Q \quad U \quad W$

$$\frac{7}{2}RT_0 \quad 10 \quad \frac{5}{2}R \quad T \quad 10R \quad T \quad 35R \quad T$$

$$T_0 \quad 100T \quad 10(T \quad T_0)$$

$$11T_0 \quad 10T$$

$$T \quad 1.1T_0$$

$$\frac{pV_0}{RT_0} \quad \frac{pV}{R \quad 1.1T_0}$$

$$V \quad \frac{11}{10}V_0 \quad 1.1V_0$$

26. $W \quad (3p_0 \quad p_0)(2V_0 \quad V_0) \quad 2p_0V_0$

$$Q_{\text{supplied}} \quad n\frac{3}{2}R \quad \frac{3p_0V_0}{nR} \quad \frac{p_0V_0}{nR}$$

$$n \quad \frac{5}{2}R \quad \frac{3p_0 \quad 2V_0}{nR} \quad \frac{3p_0V_0}{nR}$$

$$\frac{3}{2}nR \quad \frac{2p_0V_0}{nR} \quad \frac{5}{2}nR\frac{3p_0V_0}{nR}$$

$$3p_0V_0 \quad \frac{15}{2}p_0V_0 \quad \frac{21}{2}p_0V_0$$

$$\frac{W}{r} \quad \frac{2p_0V_0}{\frac{21}{2}p_0V_0} \quad \frac{4}{21}$$

27. $W_{12} \quad W_{13}$ can be seen from area under the curve, while $V_1 \quad V_2$

$Q_{12} \quad Q_{13}$

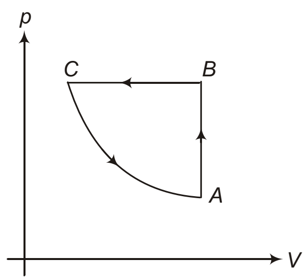
$Q_2 \quad Q_1$ or $Q_1 \quad Q_2$

28. $W_{CA} \quad p_0(V_0 \quad 2V_0) \quad p_0 V_0$

and $U_{CA} \quad \frac{3}{2} p_0 V_0$

$Q_{CA} \quad \frac{5}{2} p_0 V_0$

29. $Q_{AB} \quad 200\,\text{kJ} \quad nC_V \quad T;$



$U_{BC} \quad 100\,\text{kJ}$ and $W_{BC} \quad 50\,\text{kJ}$

$W_{AB} \quad 0 \quad U_{AB} \quad 200\,\text{kJ}, \quad Q_{CA} \quad 0$

$U_{ABC} \quad U_{AB} \quad U_{BC} \quad U_{CA} \quad 0$

or 200 kJ $\quad$ 100 kJ $\quad U_{CA} \quad 0$

$U_{CA} \quad 100$ kJ

$Q_{AB} \quad Q_{BC} \quad Q_{CA}$

200 kJ $\quad$ ($\quad$ 100 kJ $\quad$ 50 kJ) $\quad$ 0

50 kJ

$W_{AB} \quad W_{BC} \quad W_{CA}$

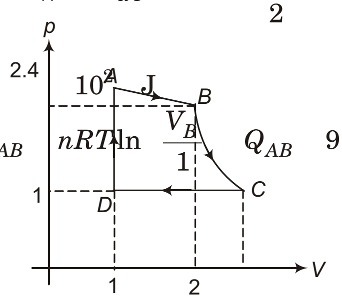
0 $\quad$ 200 kJ $\quad W_{CA}$

$Q_{ABC} \quad 50$ kJ

$W_{CA} \quad 150$ kJ

30. $Q \quad W \quad ab \quad \frac{20 \quad 10^{\ 3}}{2} \quad \frac{20 \quad 10^3}{2}$

10^4 J



31. $W_{AB} \quad nRT \ln \frac{V_B}{1} \quad Q_{AB} \quad 9 \quad 10^4$ J

$800\,T \ln V_B \quad 9 \quad 10^4$ J

$T \ln V_D \quad \frac{225}{2}$

$W_{ABCD} \quad W_{AB} \quad W_{BC}$

$W_{CD} \quad W_{DA}$

$nRT \ln \frac{V_B}{V_A} \quad \frac{p_C p_C \quad p_B p_B}{1}$

$p_C(V_D \quad V_C) \quad 0$

$9 \quad 10^4 \quad \frac{10^5 \quad nRT_B}{1 \quad \frac{5}{3}} \quad 10^5 (2 \quad 1)$

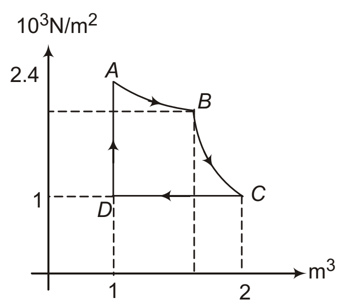
$19 \quad 10^4 \quad \frac{3}{2}(10^5 \quad 800\,T_B)$

$4 \quad 10^4 \quad 1200\,T_B$

$4 \quad 10^4 \quad 1200 \quad \frac{2.4 \quad 10^5 \quad 1}{100 \quad 8}$

$4 \quad 10^5$ J

31. $W \quad W_{AB} \quad \frac{p_C V_C \quad p_B V_B}{1} \quad W_{CD}$



$9 \quad 10^4 \quad \frac{2 \quad 10^5 \quad 9 \quad 10^4}{1 \quad 5/3} \quad 1 \quad 10^5$

$9 \quad 10^4 \quad \frac{3}{2} \quad 11 \quad 10^4 \quad 10 \quad 10^4$

$\frac{33}{2} \quad 1 \quad 10^4 \quad 15.5 \quad 10^4$

32. $W \quad pdV \quad kVdV \quad \frac{1}{2}kV^2$

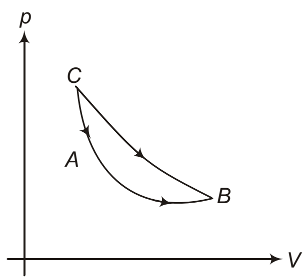
$$\frac{1}{2}pV \quad \frac{1}{2}nRT_0 \quad \frac{1}{2}RT_0$$

$$U \quad nC_V \quad T \quad 1 \; \frac{3}{2}RT_0$$

$$Q \quad \frac{3}{2} \quad \frac{1}{2} \; RT_0 \quad 2RT_0$$

33. pT constant $p\dfrac{pV}{nR} \quad \dfrac{p^2V}{nR}$

p^2V constant



$$p_0^2V_0 \quad \frac{p_0}{2}^{2} \; V \quad V \quad 4V_0$$

$$T \quad \frac{\frac{p_0}{2} \; 4V_0}{nR} \quad 2\frac{p_0V_0}{nR} \quad 2T_0$$

$$U \quad nC_V \quad T \quad 2 \quad \frac{3}{2}R\,(2T_0 \quad T_0)$$

$$3R \; \frac{p_0V_0}{2R} \quad \frac{3}{2}\,p_0V_0$$

35. $W_{BC} \quad nRT_0 \; \ln \dfrac{V_C}{V_B}$

$$nRT_0 \ln \frac{p_B}{p_C} \quad 2 \;\; nRT_0 \ln \frac{V_B}{V_A}$$

$$2nRT_0 \ln \frac{p_A}{p_B}$$

$$\ln \frac{p_B}{p_C} \quad \ln \frac{p_0}{p_0/2}^{2} \quad \ln 4$$

$$p_B \quad 4p_C$$

$$p_C \quad \frac{p_B}{4} \quad \frac{p_0}{8}$$

36. As, $W_a \quad W_b \quad W_1 \quad W_2$

while, $U_1 \quad U_2 \quad Q_1 \quad Q_2$

37. $1 \quad \dfrac{T_{\text{sink}}}{T_{\text{source}}} \quad 1 \quad \dfrac{300}{600}$

$$1 \quad \frac{1}{2} \quad 0.5 \quad 50\%$$

38. As the volume is adiabatically decreased, temperature of the gas increases and as the time elapsed, temperature normalizes *i.e.*, decreases and so pressure also decreases.

39. As the compression is quick , the process is adiabatic while leads to heating of the gas.

40. pV constant

$$\frac{nRT}{V}V \quad nRTV \quad 1$$

$$TV \quad 1 \quad \text{constant}$$

$$\frac{T_1}{T_2} \quad \frac{V_2}{V_1} \quad 1 \quad \frac{L_2}{L_1}^{\frac{5}{3} \; 1} \quad \frac{L_2}{L_1}^{\frac{2}{3}}$$

41. pV constant $p \; \dfrac{n \;\; T}{p}$

$$p^1 \quad T \quad \text{constant}$$

$$p \quad 1 \quad T$$

$$p \quad T \quad \overline{} \; 1$$

As $\dfrac{}{1} \quad \dfrac{7/5}{\frac{7}{5} \quad 1} \quad \dfrac{7}{2}$ for diatom gases.

$$p \quad T^{3.5} \qquad 3.5$$

42. pV^x constant , $W \quad \dfrac{nR \;\; T}{1 \quad x}$,

$$U \quad n \; \frac{5}{2}R \;\; T$$

$$C \quad \frac{Q}{n \;\; T} \quad \frac{\frac{nR \;\; T}{1 \quad x} \quad \frac{5}{2}nR \;\; T}{n \;\; T}$$

$$\frac{5}{2}R \quad \frac{R}{1 \quad x} \quad 0$$

$$\frac{5}{2}R \quad \frac{R}{x \quad 1} \quad x \quad 1 \quad \frac{2}{5}$$

$x \quad \frac{7}{5} \quad x \quad 1.4$ but $x \quad 1$ as for $x \quad 1$,

C will become positive.

$1 \quad x \quad 1.4$

43. $C_V \quad \frac{n_1 C_{V_1} \quad n_2 C_{V_2}}{n_1 \quad n_2} \quad \frac{13}{6}R$

(a) $\frac{2 \quad \frac{5}{2}R \quad 4 \quad \frac{5}{2}R}{2 \quad 4} \quad \frac{15}{6}R$

(b) $\frac{2 \quad \frac{5}{2}R \quad 4 \quad \frac{3}{2}R}{2 \quad 4} \quad \frac{11}{6}R$

(c) $\frac{2 \quad \frac{3}{2}R \quad 4 \quad \frac{5}{2}R}{2 \quad 4} \quad \frac{13}{6}R$ and

(d) $\frac{2 \quad \frac{6}{2}R \quad 4 \quad \frac{3}{2}R}{2 \quad 4} \quad \frac{12}{6}R$

Passage 44 & 45

44. $W_{ABCA} \quad \frac{1}{2} \quad p \quad V \quad \frac{pV}{2} \quad Q_{net}$

45. CA isobaric and BC isochoric,

$\frac{C_p}{C_v} \quad \frac{5}{3}$

46. pV constant $\quad p \quad \frac{nRT}{p}$

$p^1 \quad T$ constant

$T \quad p^{\frac{\quad 1}{}}$

$T \quad p^{\frac{5/3 \quad 1}{5/3}} \quad T \quad p^{2/5}$

$\frac{T_B}{T_A} \quad \left(\frac{p_B}{p_A}\right)^{2/5} \quad \left(\frac{2p_c}{3p_c}\right)^{2/5} \quad 0.85$

$T_B \quad 0.85 T_A \quad 850\text{ K}$

47. $W_{AB} \quad \frac{nRT}{1} \quad \frac{1 \quad \frac{25}{3} \quad 150}{\frac{5}{3} \quad 1}$

$75 \quad 25\text{ J} \quad 1875\text{ J}$

48. $W_{BC} \quad 0, \; Q_{BC} \quad U_{BC}$

$n \quad \frac{3}{2}R(T_C \quad T_B)$

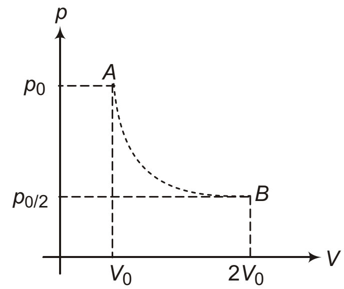
$n \quad \frac{3}{2}R \quad \frac{p_C V}{nR} \quad \frac{p_B V}{nR}$

$\frac{3}{2} \quad \frac{1}{3}p_A \quad \frac{2}{3}p_A \quad V$

$\frac{1}{2}p_A V \quad \frac{1}{2} \quad \frac{3}{2}p_B V \quad \frac{3}{4} \quad nRT_B$

$\frac{3}{4} \quad 1 \quad \frac{25}{3} \quad 850 \quad 5312.5\text{ J}$

49. W_{AB} ( ) ve, $T_A \quad T_B$



$p \quad \frac{p_0}{2V_0}V \quad \frac{3}{2}p_0$

$\frac{nRT}{V} \quad \frac{p_0}{2V_0}V \quad \frac{3}{2}p_0$

or $\quad T \quad \frac{p_0}{2nRV_0}V^2 \quad \frac{3p_0}{2nR}V_0$

$y \quad ax^2 \quad bx$ is parabola .

Again, $p \quad \frac{p}{2V_0} \quad \frac{nRT}{p} \quad \frac{3}{2}p_0$

is also equation of parabola.

While going from A to B temperature first increases ad than decreases.

50. pV^2 constant

$W \quad p\,dV \quad \frac{k}{V^2}dV \quad k \quad \frac{1}{V}$

$pV\big|_i^f \quad p_i V_i \quad p_f V_f$

$nR(T_i \quad T_f) \quad nR(T_f \quad T_i)$ ( ) ve

as $T_f \quad T_i$

as $T_i \quad T_f \quad U_i \quad U_f$

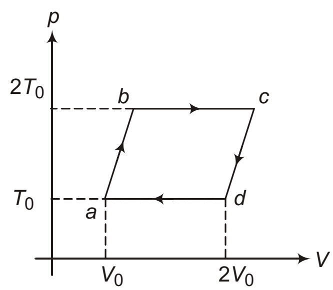
U ( ) ve

$Q \quad nC_V \quad T \quad nR \quad T \quad n(C_V \quad R) \quad T$

( ) ve as $C_V \quad R$

i.e., heat is given to the system.

51. In cyclic process, $U \quad 0$



$$W \quad 0 \quad nR2T_0 \ln \frac{2V_0}{V_0}$$

$$0 \quad nRT_0 \ln \frac{V_0}{2V_0}$$

$$2nRT_0 \ln 2 \quad nRT_0 \ln 2$$

$$nRT_0 \ln 2 \quad (\ ) \text{ve}$$

i.e., $W \quad 0$

$$Q_{\text{supplied}} \quad U_{ab} \quad W_{bc}$$

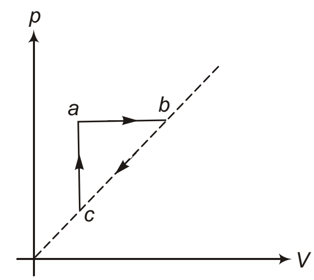
$$nC_V(2T_0 \quad T_0) \quad nR2T_0 \ln \frac{2V_0}{V_0}$$

$$2 \quad \frac{3}{2}RT_0 \quad 4RT_0 \ln 2$$

$$3RT_0 \quad 4RT_0 \ln 2$$

52. ab isochoric, bc isobaric and

ca isothermal.



$$W_{ab} \quad 0, \quad U_{ca} \quad 0$$

as in ca density is increasing, so volume is decreasing *i.e.,*

$$W_{ca} \quad (\ ) \text{ve}, \ i.e., \quad W_{ca} \quad 0$$

in isochoric process Q_{ab} is positive for increase in temperature.

53. In isochoric process $W \quad 0$.

and in adiabatic process

$Q \quad 0 \quad Q_3$ to be minimum

$$Q_2 \quad Q_1 \quad Q_3$$

JEE Corner

■ Assertion & Reasons

1. In adiabatic expression, $W \quad (\ )$ve while $Q \quad 0$ and as according to first law of thermodynamics,

$$Q \quad U \quad W \quad U \quad W$$

i.e., $U \quad (\ )$ve this implies decrease in temperature. So, Assertion and reason are both true but not correct explanation.

2. Assertion is false, as work done is a path function and not a state function i.e., it depends on the path through which the gas was taken from initial to find state.

3. Assertion is false, as first law can be applied for both real and ideal gases.

4. During melting of ice its volume decreases, so work done by it is negative and that by atmosphere is positive. So, reason is true explanation of assertion.

5. As $Q \quad U \quad W \quad U \quad Q \quad W$, where U is state function while Q and W are path function as for definite initial and final state U is constant and so is $Q \quad W$. Thus assertion and reason are both true but not correct explanation.

6. Carnot's engine is ideal heat engine with maximum efficiency but it is not also 100%. So assertion and reason are both true but not correct explanation.

7. $pT \quad \text{constant} \quad p \quad \frac{pV}{R} \quad \frac{p^2V}{nR}$

$p^2V \quad \text{constant}$

$W \quad pdV \quad \sqrt{k}\frac{dV}{\sqrt{V}} \quad \sqrt{k} \quad \frac{V^{1/2}}{1/2}$

$2\sqrt{k}\sqrt{V} \quad 2\sqrt{kV} \quad 2\sqrt{p^2/V}$

$2pV \quad 2nR\,(T_f \quad T_i) \quad 2nRT \quad T$

$W \quad (\ )\text{ve for } T \quad (\ )\text{ve}$

and $\frac{nRT}{V}T \quad \text{constant.}$

$T^2 \quad V$

or, $V \quad T^2$

Thus assertion is true but reason is false.

8. In adiabatic changes for free expansion, $Q \quad 0, W \quad 0$ and $U \quad 0$

as in free expansion no work is done against any force.

For ideal gases pV constant as $U \quad 0$
T constant So, assertion and reason are both true but not correct explanation.

9. Assertion and reason are both true and correct explanation.

10. Assertion and reason are both true and correct explanation.

■ Match the Columns

1. (a) $W \quad p\ dV \quad pV \quad nR\,(T_f \quad T_i)$

$nRT \quad 2RT \qquad r$

(b) $U \quad nC_VT \quad 2 \quad \frac{3}{2}R\,(2T \quad t)$

$3RT \qquad p$

(c) $W \quad \frac{nR\,(2T \quad T)}{1 \quad 5/3} \quad \frac{3}{2} \quad 2RT$

$3RT \qquad s$

(d) $U \quad nC_V \quad T \quad 3RT \qquad p$

2. (a) In ab slope is more so, pressure is less as $V \quad \frac{nR}{p} \quad T$, but is constant and in isobaric process. $W \quad p \quad V \quad nR \quad T$ and as T is same in both process so, W is same for both $\quad r$

(b) As $U \quad nC_V \quad T$ is same for both process $\quad r$

(c) As $Q \quad U \quad W$, it is also same for both process $\quad s$

(d) Nothing can be said about molar heat capacity $\quad s$

3. (a) $W \quad pdV$

$\sqrt{\frac{k}{V}}dV \quad \sqrt{k}\,\frac{dV}{\sqrt{V}}$

$2\sqrt{kV} \quad 2pV \quad 2nR \quad T \qquad p$

(b) $U \quad nC_V \quad T \quad \frac{3}{2}nR \quad T \qquad s$

(c) $Q \quad 2nR \quad T \quad \frac{3}{2}nR \quad T$

$\frac{7}{2}nR \quad T \qquad s$

(d) $\quad s$

4. (a) $W \quad p \quad V \quad nR \quad T$ and $U \quad nC_V \quad T$

$W \quad U \qquad q$

(b) $W \quad 0 \quad Q \quad U,\ U \quad (\ )\text{ve} \quad p, r$

(c) $W \quad (\ )\text{ve}, \quad U \quad (\ )\text{ve}, \quad Q \quad 0 \quad p$

(d) $W \quad (\ )\text{ve}, \quad U \quad 0, \quad Q \quad (\ )\text{ve} \quad p$

5. (a) $W_{AB} \quad p_0V_0 \quad \frac{1}{2}p_0V_0$

$\frac{3}{2} p_0 V_0 \quad s$

(b) $U_{AB} \quad Q \quad W$

$6 p_0 V_0 \quad \frac{3}{2} p_0 V_0 \quad \frac{9}{2} p_0 V_0 \quad s$

(c) $Q \quad 6 p_0 V_0$

$nC \; \frac{4 p_0 V_0}{nR} \quad \frac{p_0 V_0}{nR}$

$\frac{3 p_0 V_0}{R} C$

$C \quad 2R \quad p$

(d) U

$nC_V \; \frac{4 p_0 V_0}{nR} \quad \frac{p_0 V_0}{nR}$

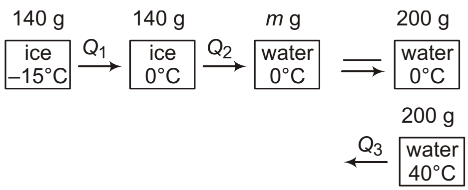
$3C_V \frac{p_0 V_0}{R} \quad \frac{9}{2} p_0 V_0$

$C_V \quad \frac{3}{2} R \quad s$

19. Calorimetry and Heat Tansfer

Introductory Exercise 19.1.

1.



As Heat gain Heat loss

$Q_1 \quad Q_2 \quad Q_3$

$140 \quad 0.53 \quad 15 \quad m \quad 80$

$200 \quad 1 \quad 40$

$m \quad \frac{8000 \quad 1113}{80} \quad 86$ g is the mass of ice melt

Mass of water

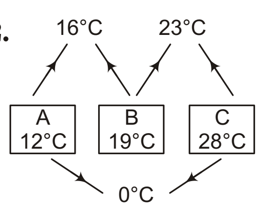
$200 \text{ g} \quad 86 \text{ g} \quad 286 \text{ g}$

and mass of ice

$140 \text{ g} \quad 86 \text{ g} \quad 54 \text{ g}$

while final temperature of mixture is 0°C.

2.



$ms_A \; (16 \quad 12) \quad ms_B \; (19 \quad 16)$

$4s_A \quad 3s_B$

$ms_B \; (23 \quad 19) \quad ms_C \; (28 \quad 23)$

$4s_B \quad 5\, s_C$

$ms_A \; (\quad 12) \quad \frac{4}{5}\, ms \; (28 \quad)$

or $\quad \frac{3}{4}\, s_B \; (\quad 12) \quad \frac{4}{5}\, s_B \; (28 \quad)$

or $\quad 15 \, (\quad 12) \quad 16 \, (28 \quad)$

or $\quad 31 \quad 448 \quad 180$

$20.26 \;\; C$

3. $mL \quad ms$

$80 \text{ cal} \quad 1 \text{ cal/°C} \; (\quad 0 \;\; C)$

$80 \;\; C$

4. As Heat gain Heat loss

$(100 \quad m) \quad 529 \quad m \quad 80$

$100 \quad 529 \quad 609 \text{ m}$

$m \quad \frac{100 \quad 529}{609} \text{ g} \quad 86.86$ g of ice will be formed.

5. $P \quad \frac{d}{dt} \quad \frac{d}{dt}(ms \quad) \quad \frac{dm}{dt}\, s$

$\frac{dm}{dt} \quad \frac{P}{s}$

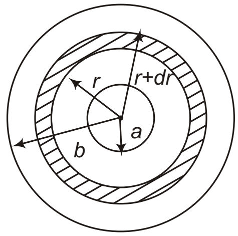
$\frac{dm}{dt} \quad \frac{500 \quad 10^6 \text{ J/s}}{4200 \text{ J/kg} \;\; C \quad 10 \;\; C}$

$\frac{5}{4.2} \quad 10^4 \text{ kg/s} \quad 1.2 \quad 10^4 \text{ kg/s}$

Introductory Excersise 19.2

1. Rest of the liquid will be heated due to conduction and not convection.

2. $\frac{dQ}{dt} \quad \frac{k \; 4 \; r^2 \; (\quad d \quad)}{dr}$



$$\frac{dQ}{dt} \frac{dr}{r^2} \quad 4 \; k \; d$$

or $\frac{dQ}{dt} \; {}_a^b \frac{dr}{r^2} \quad 4 \; k \; {}_{T_1}^{T_2} \; d$

or $\frac{dQ}{dt} \; \frac{1}{a} \quad \frac{1}{b} \quad 4 \; k \, (T_2 \quad T_1)$

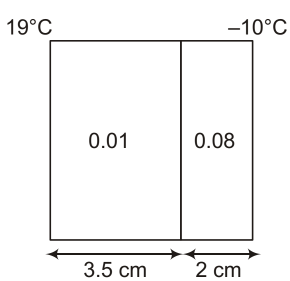
$$\frac{dQ}{dt} \quad \frac{4 \; k \, (T_1 \quad T_2)}{\frac{1}{a} \quad \frac{1}{b}} \quad 4 \; kab \; \frac{T_1 \quad T_2}{b \quad a}$$

3. $\frac{dQ}{dt} \quad \frac{kA}{t}$

$$k \quad \frac{dQ}{dt} \; \frac{t}{A}$$

Unit of k $\quad$ watt $\frac{\text{m}}{\text{m}^2 \text{-} k}$ $\quad$ W/m - K

4. $\frac{K_1 A \quad {}_1}{l_1} \quad \frac{K_2 \; A \quad {}_2}{l_2}$



$$\frac{0.01(19 \quad)}{3.5} \quad \frac{0.08 \, (\quad 10)}{2}$$

or $2(19 \quad) \quad 28 \, (\quad 10)$

or $38 \quad 280 \quad 30$

or $\frac{242}{30} \quad 8.07 \; \text{C}$

$$\frac{dQ}{dt} \quad \frac{0.01 \quad 1 \quad (19 \quad 8.1)}{3.5 \quad 10^{\;\; 2}}$$

$$7.74 \; \text{W/m}^2$$

5. $\frac{dQ}{dt} \quad \frac{dm}{dt} \; L \quad \frac{0.44 \; \text{kg}}{300 \; \text{s}} \quad 2.256 \quad 10^6 \, \text{J/kg}$

$$3308.8 \; \text{J/s}$$

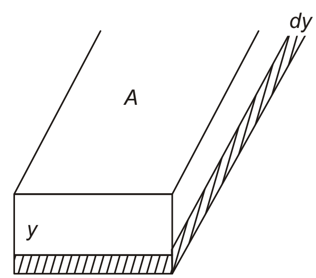
$$\frac{kA}{t} \quad \frac{50.2 \quad 0.15 \quad (\qquad 100)}{1.2 \quad 10^{\;\; 2}}$$

$$627.5 \, (\qquad 100)$$

$$100 \quad \frac{3308.8}{627.5} \quad 5.27$$

$$105.27 \; \text{C}$$

6. $\frac{dQ}{dt} \quad \frac{kA \, [0 \quad (\quad)]}{y} \quad \frac{dm}{dt} \; L$



$$\frac{dV}{dt} \; L \quad A \, \frac{dy}{dt} \; L$$

$$\frac{kA}{y} \quad AL \, \frac{dy}{dt}$$

$$\frac{dy}{dt} \quad \frac{k}{L \; y}$$

(Proved)

7. $\frac{dQ}{dt} \quad e \; AT^4$

$$4 \quad 5.67 \quad 10^{\;\; 8} \quad 4 \quad (4 \quad 10^{\;\; 2})^2 \quad (3000)^4$$

$$0.4 \quad 4 \quad 5.67 \quad 4^2 \quad 3^4 \; \text{J/s}$$

$$3.7 \quad 10^4 \; \text{watt}$$

8. $\frac{dQ}{dt} \quad \frac{\quad}{R_{\text{th}}} \quad R_{\text{th}} \quad \frac{\quad}{\frac{d}{dt}} \quad \frac{K}{W} \quad \text{KW}^{\;\; 1}$

AIEEE Corner

■ Subjective Questions (Level-1)

1. ice (0 C) $\xrightarrow{Q_1}$ Water (0 C) $\xrightarrow{Q_2}$ Water (100 C) $\xrightarrow{Q_3}$ steam (100 C)

$Q \quad Q_1 \quad Q_2 \quad Q_3 \quad mL_f \quad ms \quad mL_v$

$10 [80 \quad 1 \quad 100 \quad 540]$

$10 \quad 720 \text{ cal} \quad 7200 \text{ cal}$

2. 10 g of water at 40°C do not have sufficient heat energy to melt 15 g of ice at 0°C , so there will be a mixture of ice-water at 0°C. Let the mass of ice left is *mg*.

$(15 \quad m) \quad 80 \quad 10 \quad 1 \quad 40$

$15 \quad m \quad 5 \quad m \quad 10 \text{ g}$

Mass of ice 10 g

and mass of water (10 5) g 15 g

3. $4 \quad s_P \ (60 \quad 55) \quad 1 \quad s_R \quad (55 \quad 50)$

$4s_P \quad s_R$

$1 \quad s_P \ (60 \quad 55) \quad 1 \quad s_Q \ (55 \quad 50)$

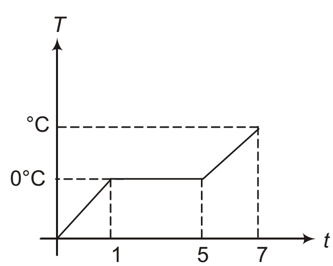
$s_P \quad s_Q$

$1 \quad s_Q \ (60 \quad) \quad 1 \quad s_R \ (\quad 50)$

or $s_P \ (60 \quad) \quad 4s_P \ (\quad 50)$

$260 \quad 5 \quad \frac{260}{5} \quad 52 \text{ C}$

4. $\frac{dQ}{dt} \quad \frac{m \quad 336 \quad 10^3 \text{ J/kg}}{4 \quad 60 \text{ s}}$



1400 J/kg

1400 mW/kg

$\frac{m \ s}{t} \quad \frac{m \quad 4200 \ (\quad 0) \text{ c}}{2 \quad 60 \text{ s}}$

$\frac{1400 \quad 2 \quad 60}{4200}$

40 C

5. $Q \quad \frac{1}{2} \quad \frac{1}{2} mv^2 \quad ms \quad mL$

$v \quad \sqrt{4 (s \quad L)}$

$v \quad \sqrt{4 (125 \quad 300 \quad 2.5 \quad 10^4)}$

$\sqrt{4 \quad (3.75 \quad 2.5)} \quad 10^4$

$\sqrt{4 \quad 6.25 \quad 10^4} \quad 500 \text{ m/s}$

6. $mg \quad h \quad ms$

$\frac{g \ h}{s} \quad \frac{0.4 \quad 10 \quad 0.5}{800} \quad \frac{1}{400} \text{ C}$

$2.5 \quad 10^{3} \text{ C}$

7. $\frac{K_1 A (\quad 0)}{l} \quad \frac{K_2 A (100 \quad)}{l}$

$(K_1 \quad K_2) \quad 100 \ K_2$

$\frac{100 \ K_2}{K_1 \quad K_2} \quad \frac{100 \quad 46}{390 \quad 46} \quad 10.55 \text{ C}$

8. $i_{CD} \quad i_{AC} \quad i_{CB}$

$\frac{KA(\quad 25)}{l} \quad \frac{KA(100 \quad)}{l/2} \quad \frac{KA(\quad 0)}{l/2}$

or $\quad 25 \quad 2(100 \quad) \quad 2$

or $\quad 5 \quad 225 \quad 45 \text{ C}$

$i_{CD} \quad \frac{}{R_{\text{th}}} \quad \frac{45 \quad 25}{5} \quad 4 \text{ W}$

9. $i_A \quad i_C \quad i_D$

$\frac{KA \ (T_1 \quad)}{l} \quad \frac{KA(\quad T_3)}{3l/2} \quad \frac{KA(\quad T_2)}{3l/2}$

$T_1 \quad \frac{2}{3}(\quad T_3) \quad \frac{2}{3}(\quad T_2)$

or $T_1 \quad \frac{2}{3}(T_2 \quad T_3) \quad 1 \quad \frac{4}{3}$

$\frac{T_1 \quad \frac{2}{3}(T_2 \quad T_3)}{7/3}$

$\frac{3T_1 \quad 2(T_2 \quad T_3)}{7}$

10. $\frac{KA(200 \quad _1)}{l} \quad \frac{2KA(\ _1 \quad _2)}{l}$

$$\frac{3KA(\ _2 \quad 100)}{l}$$

$$200 \quad _1 \quad 2(\ _1 \quad _2) \quad 3(\ _2 \quad 100)$$

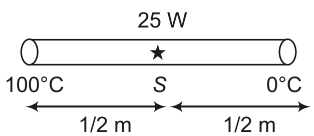
$$3 \ _1 \quad 2 \ _2 \quad 200$$
$$_1 \quad 3 \ _2 \quad 500$$
$$11 \ _2 \quad 1300$$

$$_2 \quad \frac{1300}{11} \quad 118.2 \ \text{C}$$

$$_1 \quad \frac{1}{3}[200 \quad 2 \ _2] \quad 145.45 \ \text{C}$$

11. $25 \quad \frac{400 \quad 10^{\ 4}(\quad 100)}{1/2}$

$$\frac{400 \quad 10^{\ 4}(\quad 0)}{1/2}$$



$$25 \quad 8 \quad 10^{\ 2}[\quad 100 \quad]$$

or $\quad 312.5 \quad 2 \quad 100$

$$\frac{412.5}{2} \quad 206.25$$

$$_1 \quad 106.25 \text{ and } \quad _2 \quad 206.25$$

$$\frac{\ _1}{l} \quad \frac{106.25 \ \text{C}}{1/2 \ \text{m}} \quad 212.5 \ \text{C/m}$$

and $\quad \frac{\ _2}{l} \quad \frac{206.25 \ \text{C}}{1/2 \ \text{m}} \quad 412.5\,°\text{C/m}$

12. $\frac{dQ}{dt} \quad e \ AT^4 \quad 0.6 \quad 5.67 \quad 10^{\ 8}$

$$2 \quad (0.1)^2 \quad (1073)^4$$

$$0.6 \quad 5.67 \quad (10.73)^4 \quad 10^{\ 2} \quad 2$$

$$902 \ \text{W}$$

13. $\left(\frac{dQ}{dt}\right)_1 \quad e \ AT^4$ and $\left(\frac{dQ}{dt}\right)_2 \quad AT^4$

$$e \quad \frac{(dQ/dt)_1}{(dQ/dt)_2} \quad \frac{210}{700} \quad 0.3$$

14. $\frac{(80 \quad 50)_c}{5} \quad \frac{80 \quad 50}{2} \quad 20 \ c$

$$K \quad \frac{6}{45};$$

$$\frac{(60 \quad 30)}{t} \quad \frac{6}{45}$$

$$\frac{60 \quad 30}{2} \quad 20 \qquad t \quad 9 \ \text{min}$$

Objective Questions (Level-1)

1. $\frac{3KA(35 \quad)}{10} \quad \frac{KA(\quad 0)}{20}$

$$6(35 \quad)$$

$$\frac{6 \quad 35}{7} \quad 30 \ \text{C}$$

$$_A \quad 35 \quad 30 \quad 5 \ \text{C}$$

2. $\frac{T_S}{T_N} \quad \frac{\ _N}{\ _S} \quad \frac{350}{510} \quad 0.69$

According to Wien's law

3. $\left(\frac{dQ}{dt}\right)_2 \Big/ \left(\frac{dQ}{dt}\right)_1 \quad \frac{\frac{1}{4}\frac{K \quad 4A}{l/2}}{\frac{K}{l}} \quad 2$

$$\left(\frac{dm}{dt}\right)_2 \quad 2 \left(\frac{dm}{dt}\right)_1 \quad 0.2 \ \text{g/s}$$

4. $\frac{dQ}{dt} \quad \frac{4 \ K(\quad 0)}{\frac{2a \quad a}{a \ 2a}} \quad \frac{4 \quad K(100 \quad)}{\frac{3a \quad 2a}{3a \ 2a}}$

$$2 \quad 6(100 \quad)$$

$$\frac{6}{8} \quad 100 \quad 75 \ \text{C}$$

5. $\frac{K_1A(T_2 \quad T_1)}{d} \quad \frac{K_2A(T_3 \quad T_2)}{3d}$

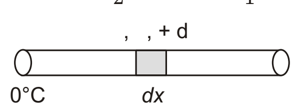
$$K_1(T_2 \quad T_1) \quad \frac{1}{3}K_2(T_3 \quad T_2)$$

$$K_1 \quad \frac{1}{3}K_2 \qquad K_1 : K_2 \quad 1:3$$

6. $\left(\frac{dQ}{dt}\right)_2 \Big/ \left(\frac{dQ}{dt}\right)_1 \quad \frac{2K \ 2A}{2l} \Big/ \frac{KA}{l} \quad 2$

$$\left(\frac{dQ}{dt}\right)_2 \quad 2\left(\frac{dQ}{dt}\right)_1 \quad 8 \ \text{cal/s}$$

7.



$$P \quad \frac{dQ}{dt} \quad \frac{K \quad Ad}{dx} \quad \frac{K_0(1 \quad ax)A\,d}{dx}$$

$$\int_0^l \frac{dx}{1 \quad ax} \quad \frac{K_0 A}{P} \int_0^{100} d$$

$$\frac{1}{a} \ln(1 \quad ax)|_0^l \quad \frac{10^2 \quad 10^{\ \ 4}}{1} \quad |_0^{100} \quad 1$$

$$\ln(1 \quad al) \quad \ln 1 \quad 1$$

$$\ln(1 \quad al) \quad \ln 1 \quad 1$$

$$\ln(1 \quad al) \quad 1$$

or $1 \quad al \quad e^1$

or $l \quad \frac{1}{a}(e \quad 1) \quad e \quad 1 \quad 1.7$ m

8. $\frac{\ \ 2}{\ \ 1} \quad \frac{T_1}{T_2} \quad \frac{2}{3} \qquad {}_2 \quad \frac{2}{3} \quad {}_m$

9. Heat required to boil 1 g of ice is 180 cal while 1 g of steam can release 540 cal during condenstion. So, temperture of the mixture will be 100°C with 2/3 g steam and 4.3 g water.

10. $T_1 \quad T_2 \quad T_3$ as temperature of a body decreases in rate of cooling also decreases such that time increases for equal temperature difference.

11. Conduction is maximum for which thermal resistance is minimum, as $R_{\text{th}} \quad \frac{l}{r^2}$ then for

(a) 50 (b) 25 (c) 100 (d) 33.33,

So option 'b' has minimum resistance.

12. Slope of temperature *versus* heat graph gives increase of specific heat or heat capacity and the portion *DE* is the gaseous state.

13. $dQ \quad m\,sdt \quad maT^3dT$

$$\frac{Q}{m} \quad \frac{a}{4}T^4|_1^2 \quad \frac{a}{4}(16 \quad 1) \quad \frac{15a}{4}$$

14. Resistance becomes 1/4th in parallel of that in series, so times taken will also become 1/4th *ie*, 12/4 3 min.

15. $ms_1 \quad 12 \quad ms_2 \quad 8 \qquad s_1 : s_2 \quad 2:3$

16. $\frac{KA(T \quad T_c)}{\sqrt{2}\,l} \quad \frac{KA(T_c \quad \sqrt{2}\,T)}{l}$

$$\frac{T}{\sqrt{2}} \quad \sqrt{2}T \quad T_c \quad \frac{T_c}{\sqrt{2}}$$

$$\frac{3}{\sqrt{2}}T \quad \frac{1 \quad \sqrt{2}}{\sqrt{2}}T_c$$

$$T_c \quad \frac{3}{1 \quad \sqrt{2}}T$$

17. $P \quad (1000 \quad 160)$ W $\quad 840$ W

$$\frac{2 \quad 4200 \quad 50}{t}$$

$$t \quad \frac{42 \quad 10^4}{840} \quad 500\text{ s} \quad 8\text{ min }20\text{ s}$$

18. $\frac{dQ}{dt} \quad \frac{KA(T_2 \quad T)}{x} \quad \frac{2KA(T \quad T_1)}{4x}$

$$T_2 \quad T \quad \frac{1}{2}T \quad \frac{1}{2}T_1$$

$$T_2 \quad \frac{1}{2}T_1 \quad \frac{3}{2}T$$

$$T \quad \frac{2}{3} \quad T_2 \quad \frac{1}{2}T_1 \quad \frac{1}{3}(2T_2 \quad T_1)$$

$$\frac{dQ}{dt} \quad \frac{KA}{x} \quad T_2 \quad \frac{1}{3}(2T_2 \quad T_1)$$

$$\frac{KA}{x}[3T_2 \quad 2T_2 \quad T_1] \quad \frac{1}{3}$$

$$\frac{KA}{x}(T_2 \quad T_1) \quad \frac{1}{3}$$

$$f \quad \frac{1}{3}$$

19. $\frac{1}{K}$

$$\frac{\ \ {}_A}{\ \ {}_B} \quad \frac{K_B}{K_A} \quad \frac{1}{2}$$

$${}_A \quad \frac{1}{2} \quad {}_B \quad 18\ \ \text{C}$$

■ More than One Correct Options

20. Amount of heat radiated or absorbed depends upon. Surface type, surface area, surface temperature and temperature of surrounding, so (a) and (b) are correct.

21. $\frac{KA(40 \quad)}{l} \quad \frac{KA(\quad 30)}{l} \quad \frac{KA(\quad 20)}{l}$

$40 \quad 2 \quad 50$

$3 \quad 90$

or $\quad 30$ C

So, (b) and (d) are correct.

22. $m \quad s \quad (2 \quad _0) \quad m \quad 2s \quad (_0 \quad)$

$4 \quad 3 _0 \quad _0 \frac{4}{3}$

$c_1 : c_2 \quad m_1 : s_2 \quad s_1 : s_2 \quad 1:2$

So, (b) and (c) are correct.

23. In series rate of $R \quad R_1 \quad R_2$

$\frac{1}{q} \quad \frac{1}{q_1} \quad \frac{1}{q_2} \quad q \quad \frac{q_1 q_2}{q_1 \quad q_2}$

In parallel $\frac{1}{R} \quad \frac{1}{R_1} \quad \frac{1}{R_2}$

$q \quad q_1 \quad q_2$ as $q \quad \frac{1}{R}$

So, (b) and (c) are correct.

24. (a), (c) and (d) are correct.

JEE Corner

Assertion and Reason

1. Assertion is false.
2. According to Wien's law assertion and reason are correct.
3. Assertion and reason are true but not correct explanation.
4. Assertion is true but reason is false as resistance becomes 1/4th.
5. Assertion and reason are both false.
6. Assertion is false as this statement was not given by Newton.
7. Assertion and reason are both true with correct explanation.
8. Both are true but not correct explanation.
9. Assertion is false as temperature at different points become different.
10. As mass of follow sphere is less so cooling will be faster. So, both are true with correct explanation.

Match the Columns

1.

(a)	$\frac{(dQ/dt)}{AT^4} \quad \frac{ML^2T^{\ 2}T^{\ 1}}{L^{2 \ \ 4}}$ $[MT^{\ 3 \ \ 4}]$	s
(b)	$b \quad T \quad L$	p
(c)	$\frac{E}{At} \quad \frac{[ML^2T^{\ 2}]}{[L^2T]} \quad [MT^{\ 3}]$	r
(d)	Rth $\frac{d}{dQ/dt} \quad \overline{[ML^2T^{\ 2}T^{\ 1}]}$ $[M^{\ 1}L^{\ 2}T^3$	s

2.

(a)	Slope of line ab	s
(b)	Length of line $bc \quad m$	r
(c)	Solid liquid bc	s
(d)	Only liquid cd	q

3. $\frac{KA(100 \quad _b)}{l} \quad \frac{KA(_b \quad _d)}{l}$

$\frac{KA(_d \quad 80)}{l}$

$100 \quad _b \quad _b \quad _d$ and

$100 \quad _b \quad _d \quad 80$

$_d \quad 2 _b \quad 100$

$_d \quad _b \quad 20$

$3 _b \quad 120$

$_b \quad 40$ C $\quad _d \quad 20$ C

$_c \quad _f \quad \frac{40 \quad 20}{2} \quad 10$ C

(a) q, (b) p, (c) p, (d) r

4. (a) $ms(_1 \quad) \quad 2ms(2 \quad _1)$

$3 _1 \quad 5 \quad _1 \frac{5}{3} \quad q$

(b) $ms(\ _2\ \ )\ \ 3ms(3\ \ \ _2)$

$4\ _2\ \ 10\ \ _2\ \frac{5}{2}\ \ p$

(c) $2ms(\ _3\ \ 2\ )\ \ 3ms(3\ \ \ _3)$

$5\ _3\ \ 13\ \ _3\ \frac{13}{2}\ \ s$

(d) $ms(\ _4\ \ )\ \ 2ms(\ _4\ \ 2\ )$

$3ms(3\ \ \ _4)$

$6\ _4\ \ 14\ \ _4\ \frac{7}{3}\ \ r$

5.

(a)	$s\ \ \frac{1}{m}\frac{dQ}{d}\ \ \frac{\text{J}}{\text{kg C}}$	q
(b)	$c\ \ ms\ \ m\frac{dQ}{md}\ \ \text{J /C}$	s
(c)	$i\ \ \frac{dQ}{dt}\ \ \text{J/s}$	r
(d)	$L\ \ \frac{E}{m}\ \ \text{J/kg}$	s