1. Angular momentum remains constant
$I\omega$ = const.
$$\frac{\Delta I}{I}+\frac{\Delta\omega}{\omega}=0$$
$$2\alpha\Delta T+\frac{\Delta\omega}{\omega}=0\therefore\frac{\Delta\omega}{\omega}=-2\alpha\Delta T$$

2. According to wein's law
$$\lambda_m T=\text{constant}\Rightarrow\frac{CT}{v_{max}}=\text{constant}$$
$v_m \propto T$

3. $v=\sqrt{gx}\Rightarrow\frac{dx}{dt}=\sqrt{gx}\Rightarrow\int_0^{L/2}\frac{dx}{\sqrt{gx}}=\int dt$
$$t=\frac{1}{\sqrt{g}}\left[\frac{x^{-1/2+1}}{-\frac{1}{2}+1}\right]_0^{L/2}\Rightarrow t=\frac{2}{\sqrt{g}}\sqrt{\frac{L}{2}}\Rightarrow t=\sqrt{\frac{2L}{g}}$$

4. Nodes are stationary points while all points between two consecutive nodes oscillates with same frequency.

5. Charge density is more at a point closer to point charge

6. $f_b=\frac{v}{2l}-\frac{v}{2(l+x)}=\frac{[(l+x)-l]v}{2l(l+x)}=\frac{vx}{2l^2}$

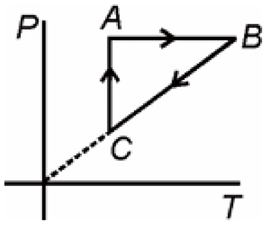
7. Two waves in opposite drections from standing waves.

9. $\Delta Q=\Delta U+W$
W= area under PV curve = $\Delta Q - \Delta U$
$$=18P_0V_0-nC_v\Delta T=18P_0V_0-\frac{3}{2}nR\Delta T$$
$$W=18P_0V_0-\frac{3}{2}\left(P_2V_2-P_1V_1\right)$$
$$=18P_0V_0-\frac{3}{2}\left(9P_0V_0-2P_0V_0\right)$$
$$=18P_0V_0-\frac{21}{2}P_0V_0=7.5P_0V_0$$

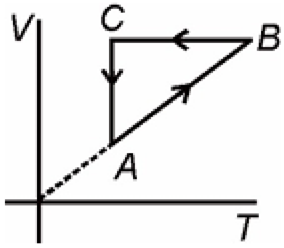
11. Clearly at state A, gas is an ideal one but in state B it is real gas.
So $P_A < P_B$ and $T_A > T_B$

12. $\eta=1-\frac{300}{400}=\frac{1}{4}=\frac{w}{Q_1}\Rightarrow w=\frac{Q_1}{4}=10\text{kJ}$

13. $Q=\Delta U+W\Rightarrow$ In $\rightarrow A\rightarrow B$, $W=0$
Temperature increasing therefore Q will be positive
In process $B\rightarrow C$
$\Delta U=0$, $W>0\Rightarrow Q>0$

14. 

A→B isobaric process temperature is increasing therefore volume increasing
B→C isochoric process temperature is decreasing
C→A isothermal process pressure is increasing volume will decrease.



15. Mechanical work in cycle is positive and equal to area of ellipse.
$$\Delta W=\Delta A=\pi\times\left(\frac{2P_0-P_0}{2}\right)\times\left(\frac{2V_0-V_0}{2}\right)=\frac{\pi}{4}P_0V_0$$

16. $V'=n^{2/3}V=8^{2/3}\times 2\text{volt}$
$=4\times 2\text{volt}=8\text{volt}$

17. The field at point P due to charge Q within the shell and charge induced on the inner surface of the shell is zero. The field at point P is only, due to the induced charge on the outer surface of shell.

$$\therefore E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{\left[3R + \frac{R}{2}\right]^2} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{\left(\frac{7R}{2}\right)^2}$$

18. Equipotential surface due uniformly charged plane sheet corresponding to its electric field will be planar.

19. $F = \frac{K(q - q_1)q_1}{r^2}$

For maximum force $\frac{dF}{dq_1} = 0$

$$\frac{dF}{dq_1} = q - 2q_1 = 0 \Rightarrow q_1 = \frac{q}{2}$$

$$q_1 = \frac{20}{2} \Rightarrow = 10\ \mu C$$

$q - q_1 = 10\ \mu C$

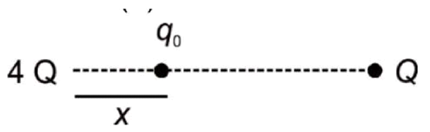
20. Distance will be minimum, when relative speed is zero

$mv = 2mv'$

$$v' = \frac{v}{2}$$

$$\frac{1}{2}mv^2 + 0 = \frac{1}{2}m\frac{v^2}{4} + \frac{1}{2}m\frac{v^2}{4} + \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

$$r = \frac{1}{4\pi\varepsilon_0}\frac{4e^2}{mv^2}$$

22.


$$\frac{K4Qq_0}{x^2} = \frac{KQq_0}{(2-x)^2} \Rightarrow \frac{2}{x} = \frac{1}{2-x}$$

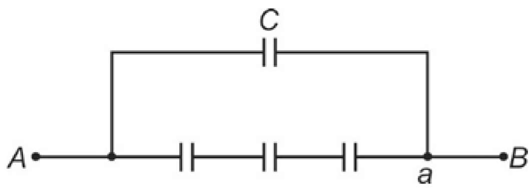
$4 - 2x = x \Rightarrow 4 = 3x \Rightarrow x = 4/3$ m

23. Force $\propto \frac{1}{r^4}$

24. $\frac{\mu}{L} = \frac{e}{2m} \Rightarrow \mu = \frac{eL}{2m}$

25. $V = 18 \times \frac{3}{3+6} \times \frac{6}{6+12} = 2V$

27. Redrawn circuit



$$C_e = \frac{C}{3} + C = \frac{4C}{3}$$

28. $C = \frac{K\varepsilon_0 A}{d} \Rightarrow C \propto \frac{1}{d}$

So capacitance depends on separation between the plates.7

29. $\frac{M}{L} = \frac{q}{2M} \Rightarrow L = I\omega = \frac{MR^2}{2} \times \omega$

$$M = \frac{q}{2M} \times \frac{Mr^2\omega}{2} = \frac{q\omega r^2}{2}$$

30. Net magnetic moment = 0, no unpaired electrons.

31. $\varepsilon_{net} = \frac{\frac{\varepsilon_1}{r_1} - \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{10-5}{1+1} = \frac{5}{2}$

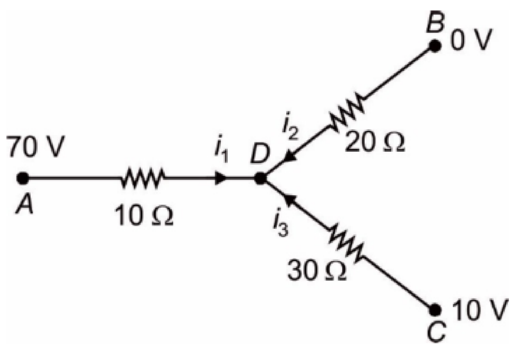
$$i = \frac{\varepsilon_{net}}{R + \frac{r_1 r_2}{r_1 + r_2}} = \frac{\frac{5}{2}}{2 + \frac{1}{2}} = 1A$$

Since b is at higher potential then a, current flows from b to a.

32. $i_1 + i_2 + i_3 = 0$

$$\frac{V_D - 70}{10} + \frac{V_D - 0}{20} + \frac{V_D - 10}{30} = 0 \Rightarrow V_D = 40$$

$i_{AD} = \frac{30}{10} = 3 \Rightarrow i_{BD} = \frac{40}{20} = 2 \Rightarrow i_{CD} = \frac{30}{30} = 1$



33. $v_d = \frac{eE\tau}{m} \Rightarrow v_d \propto E$

34. $R_1 = n^2R = \left(\frac{3}{2}\right)^2 \times 24 = \frac{9}{4} \times 24$

$= 9 \times 6 = 54\Omega$

35. There is only one path joining two loops. In this no current flows.

36. Magnetic force does not do any work.

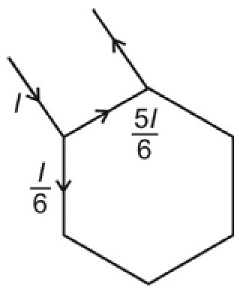
Displacement by $\vec{E}, \vec{S} = \frac{1}{2}\left(\frac{qE}{m}\right)t^2 \hat{i}$

Use work-energy theorem

$\vec{F} \cdot \vec{S} = \frac{1}{2}m\left((2v_0)^2 - v_0^2\right)$

$qE_0 \times \frac{1}{2}\left(\frac{qE_0}{m}\right)t^2 = \frac{1}{2}m\left(3v_0^2\right) \Rightarrow \therefore t = \frac{\sqrt{3}mv_0}{qE_0}$

37. $B = \frac{\mu_0 I}{2r} = \frac{\mu_0}{2r} \times \frac{q}{t} = \frac{\mu_0}{2r} \times \frac{e}{t} = \frac{\mu_0 ev}{2r}$

38. 

$B = \frac{\mu_0 I}{4\pi d}(\sin\alpha + \sin\beta)$

$B_{net} = \frac{5\mu_0 I}{24\pi d}(\sin\alpha + \sin\beta)$

$-5\left(\frac{5\mu_0 I}{24\pi d}(\sin\alpha + \sin\beta)\right) = 0$

39. $r = \frac{\sqrt{2Km}}{qB} = \frac{\sqrt{qVm}}{qB}$

Because V and B are same

$r \propto \sqrt{\frac{m}{q}} \Rightarrow \frac{r_p}{r_\alpha} = \frac{\sqrt{\frac{m}{q}}}{\sqrt{\frac{4m}{2q}}} = \frac{1}{\sqrt{2}}$

$r_P : r_\alpha = 1 : \sqrt{2}$

40. $\frac{\mu_0 / \pi r^2}{2R} = MI \therefore M = \frac{\mu_0 \pi r^2}{2R}$

41. $B_0 = \frac{\mu_0}{4\pi}\frac{i}{a} + \frac{\mu_0}{4\pi}\frac{i}{a}$

$B_{net} = 2 \times \frac{\mu_0 I}{4\pi a}\left(\sin 90^\circ + \sin 45^\circ\right)$ 45?^?)

$B_{net} = \frac{\mu_0 I}{2\pi a}\left(1 + \frac{1}{\sqrt{2}}\right)$

43. For a thermometer ; Reading on any scale

$\frac{- \text{Lower fixed point}}{\text{Upper fixed point} - \text{Lower fixed point}}$

$= \text{constant}$

i.e., $\frac{X - LFP}{UFP - LFP} = \frac{C - 0}{100 - 0}$

$\frac{C - 0}{100 - 0} = \frac{64 - 5}{95 - 5} = \frac{59}{90} = 0.655$

$\Rightarrow C = 65.5^\circ C$

44. $p \propto T \Rightarrow \frac{p_1}{p_2} = \frac{T_1}{T_2} \Rightarrow \frac{p_2 - p_1}{p_1} = \frac{T_2 - T_1}{T_1}$

$\Rightarrow \left(\frac{\Delta p}{p}\right)\% = \left(\frac{251-250}{250}\right) \times 100 = 0.4\%$

45. $P_0 = \frac{1}{3}\frac{mN}{v} \cdot v_{ms}^2$

If E_0 is initial KE of one molecule

$nE_0 = E' \cdot 2n \Rightarrow E' = \frac{E}{2} \Rightarrow \left(\frac{1}{2}mv^2\right)\frac{1}{2} = \frac{1}{2}mv'^2 = v' = \frac{v}{\sqrt{2}}$

Thus KE of every molecule becomes half. Hence temperature becomes $\frac{T_0}{2}$.

$P' = \frac{1}{3}\frac{m2N}{v}\left(\frac{v}{\sqrt{2}}\right)^2 = P_0$, Thus $T' = \frac{T_0}{2}, P' = P_0$

Answer-Key

1. 2	**2.** 2	**3.** 4	**4.** 4	**5.** 4	**6.** 3	**7.** 1	**8.** 4	**9.** 1	**10.** 2
11. 1	**12.** 1	**13.** 3	**14.** 1	**15.** 2	**16.** 3	**17.** 3	**18.** 4	**19.** 2	**20.** 2
21. 2	**22.** 4	**23.** 4	**24.** 4	**25.** 1	**26.** 3	**27.** 4	**28.** 4	**29.** 4	**30.** 1
31. 4	**32.** 1	**33.** 1	**34.** 3	**35.** 1	**36.** 4	**37.** 3	**38.** 4	**39.** 4	**40.** 3
41. 1	**42.** 4	**43.** 4	**44.** 1	**45.** 4	**46.** 4	**47.** 4	**48.** 2	**49.** 2	**50.** 4
51. 3	**52.** 4	**53.** 1	**54.** 4	**55.** 3	**56.** 2	**57.** 2	**58.** 4	**59.** 4	**60.** 3
61. 3	**62.** 3	**63.** 3	**64.** 3	**65.** 4	**66.** 2	**67.** 4	**68.** 4	**69.** 2	**70.** 2
71. 3	**72.** 1	**73.** 2	**74.** 1	**75.** 3	**76.** 2	**77.** 3	**78.** 1	**79.** 3	**80.** 1
81. 3	**82.** 1	**83.** 3	**84.** 1	**85.** 1	**86.** 2	**87.** 2	**88.** 4	**89.** 3	**90.** 1
91. 3	**92.** 3	**93.** 1	**94.** 1	**95.** 3	**96.** 3	**97.** 4	**98.** 3	**99.** 3	**100.** 4
101. 2	**102.** 1	**103.** 3	**104.** 4	**105.** 3	**106.** 4	**107.** 2	**108.** 1	**109.** 3	**110.** 2
111. 1	**112.** 4	**113.** 2	**114.** 4	**115.** 3	**116.** 4	**117.** 3	**118.** 2	**119.** 3	**120.** 1
121. 1	**122.** 1	**123.** 4	**124.** 2	**125.** 3	**126.** 1	**127.** 2	**128.** 1	**129.** 1	**130.** 2
131. 4	**132.** 1	**133.** 4	**134.** 3	**135.** 3	**136.** 2	**137.** 3	**138.** 1	**139.** 3	**140.** 1
141. 3	**142.** 1	**143.** 3	**144.** 2	**145.** 2	**146.** 3	**147.** 2	**148.** 2	**149.** 3	**150.** 1
151. 3	**152.** 1	**153.** 3	**154.** 3	**155.** 3	**156.** 1	**157.** 1	**158.** 3	**159.** 4	**160.** 2
161. 3	**162.** 3	**163.** 2	**164.** 2	**165.** 2	**166.** 3	**167.** 1	**168.** 4	**169.** 2	**170.** 2
171. 4	**172.** 1	**173.** 4	**174.** 4	**175.** 2	**176.** 1	**177.** 2	**178.** 1	**179.** 3	**180.** 4

2. Clearly at state A, gas is an ideal one but in state B it is real gas.
So $P_A < P_B$ and $T_A > T_B$

3. $\eta = 1 - \frac{300}{400} = \frac{1}{4} = \frac{w}{Q_1} \Rightarrow w = \frac{Q_1}{4} = 10\text{kJ}$

4. The field at point P due to charge Q within the shell and charge induced on the inner surface of the shell is zero. The field at point P is only, due to the induced charge on the outer surface of shell.

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For maximum force $\frac{dF}{dq_1} = 0$

$\frac{dF}{dq_1} = q - 2q_1 = 0 \Rightarrow q_1 = \frac{q}{2} \Rightarrow q_1 = \frac{20}{2}$

$= 10\ \mu C \Rightarrow q - q_1 = 10\ \mu C$

7. $v = \sqrt{gx} \Rightarrow \frac{dx}{dt} = \sqrt{gx} \Rightarrow \int_0^{L/2} \frac{dx}{\sqrt{gx}} = \int dt$

$$t = \frac{1}{\sqrt{g}}\left[\frac{x^{-1/2+1}}{-\frac{1}{2}+1}\right]_0^{L/2} \Rightarrow t = \frac{2}{\sqrt{g}}\sqrt{\frac{L}{2}} \Rightarrow t = \sqrt{\frac{2L}{g}}$$

8. Nodes are stationary points while all points between two consecutive nodes oscillates with same frequency.

9. Charge density is more at a point closer to point charge

10. $\frac{\mu}{L} = \frac{e}{2m} \Rightarrow \mu = \frac{eL}{2m}$

11. $V = 18 \times \frac{3}{3+6} \times \frac{6}{6+12} = 2V$

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$\frac{V_D - 70}{10} + \frac{V_D - 0}{20} + \frac{V_D - 10}{30} = 0 \Rightarrow V_D = 40$

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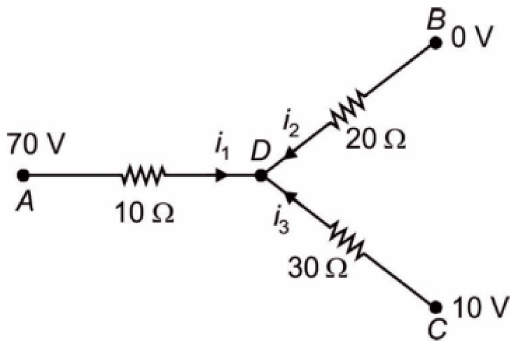

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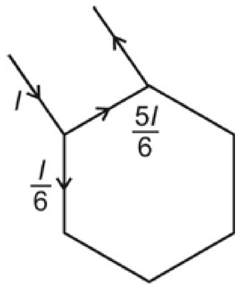
16.


$$B=\frac{\mu_0 I}{4\pi d}(\sin\alpha+\sin\beta)$$

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$$r_p:r_\alpha=1:\sqrt{2}$$

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$$qE_0\times\frac{1}{2}\left(\frac{qE_0}{m}\right)t^2=\frac{1}{2}m\left(3v_0^2\right)$$

$$\therefore t=\frac{\sqrt{3}mv_0}{qE_0}$$

21. $B=\frac{\mu_0 I}{2r}=\frac{\mu_0}{2r}\times\frac{q}{t}=\frac{\mu_0}{2r}\times\frac{e}{t}$

$$=\frac{\mu_0 ev}{2r}$$

22. $B_0=\frac{\mu_0}{4\pi}\frac{i}{a}+\frac{\mu_0}{4\pi}\frac{i}{a}$

$$B_{net}=2\times\frac{\mu_0 I}{4\pi a}\left(\sin 90^\circ+\sin 45^\circ\right)\ 45?^?\ )$$

$$B_{net}=\frac{\mu_0 I}{2\pi a}\left(1+\frac{1}{\sqrt{2}}\right)$$

24. For a thermometer ; Reading on any scale

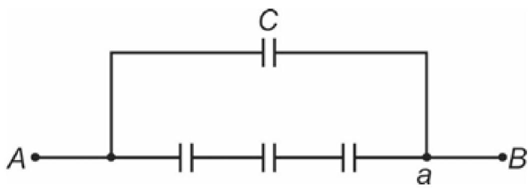
$$\frac{-\text{ Lower fixed point}}{\text{Upper fixed point }-\text{ Lower fixed point}}=\text{constant}$$

i.e., $\frac{X-\text{LFP}}{\text{UFP}-\text{LFP}}=\frac{C-0}{100-0}$

$$\frac{C-0}{100-0}=\frac{64-5}{95-5}=\frac{59}{90}=0.655$$

$$\Rightarrow C=65.5^\circ C$$

25. Redrawn circuit



$$C_e=\frac{C}{3}+C=\frac{4C}{3}$$

26. $C=\frac{K\varepsilon_0 A}{d}\Rightarrow C\propto\frac{1}{d}$

So capacitance depends on separation between the plates.7

27. $\frac{M}{L}=\frac{q}{2M}\Rightarrow L=I\omega=\frac{MR^2}{2}\times\omega$

$$M=\frac{q}{2M}\times\frac{Mr^2\omega}{2}=\frac{q\omega r^2}{2}$$

28. Net magnetic moment = 0, no unpaired electrons.

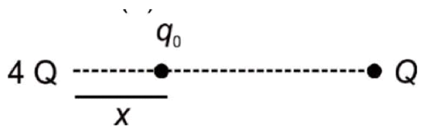
29. Distance will be minimum, when relative speed is zero

mv = 2mv'

$v' = \frac{v}{2}$

$\frac{1}{2}mv^2 + 0 = \frac{1}{2}m\frac{v^2}{4} + \frac{1}{2}m\frac{v^2}{4} + \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$

$r = \frac{1}{4\pi\varepsilon_0}\frac{4e^2}{mv^2}$

31. 

$\frac{K4Qq_0}{x^2} = \frac{KQq_0}{(2-x)^2}$

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

4 – 2x = x

4 = 3x

x = 4/3 m

32. Force $\propto \frac{1}{r^4}$

33. $R_1 = n^2R$

$= \left(\frac{3}{2}\right)^2 \times 24 = \frac{9}{4} \times 24$

$= 9 \times 6 = 54\Omega$

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$\Rightarrow \left(\frac{\Delta p}{p}\right)\% = \left(\frac{251 - 250}{250}\right) \times 100 = 0.4\%$

35. $P_0 = \frac{1}{3}\frac{mN}{v} \cdot v_{ms}^2$

If E_0 is initial KE of one molecule

$nE_0 = E' \cdot 2n \Rightarrow E' = \frac{E}{2} \Rightarrow \left(\frac{1}{2}mv^2\right)\frac{1}{2} = \frac{1}{2}mv'^2 = v' = \frac{v}{\sqrt{2}}$

Thus KE of every molecule becomes half. Hence temperature becomes $\frac{T_0}{2}$.

$P' = \frac{1}{3}\frac{m2N}{v}\left(\frac{v}{\sqrt{2}}\right)^2 = P_0$, Thus $T' = \frac{T_0}{2}, P' = P_0$

36. Q = ΔU + W

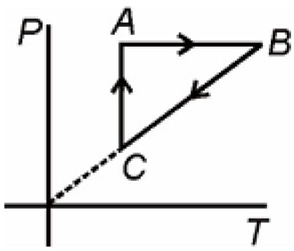
In → A → B, W = 0

Temperature increasing therefore Q will be positive

In process B → C

ΔU = 0, W > 0

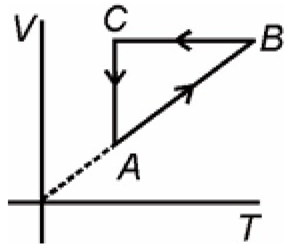
Q > 0

37. 

A→B isobaric process temperature is increasing therefore volume increasing

B→C isochoric process temperature is decreasing

C→A isothermal process pressure is increasing volume will decrease.



38. Mechanical work in cycle is positive and equal to area of ellipse.

$\Delta W = \Delta A = \pi \times \left(\frac{2P_0 - P_0}{2}\right) \times \left(\frac{2V_0 - V_0}{2}\right) = \frac{\pi}{4}P_0V_0$

39. $V' = n^{2/3}V = 8^{2/3} \times 2\text{volt}$

$= 4 \times 2\text{volt} = 8\text{volt}$

40. $f_b = \frac{v}{2l} - \frac{v}{2(l+x)} = \frac{[(l+x)-l]v}{2l(l+x)} = \frac{vx}{2l^2}$

41. Two waves in opposite drections from standing waves.

43. $\Delta Q = \Delta U + W$

W= area under PV curve = $\Delta Q - \Delta U$

$= 18P_0 V_0 - nCv\,\Delta T$

$= 18P_0V_0 - \frac{3}{2}nR\Delta T$

$W = 18P_0V_0 - \frac{3}{2}\left(P_2V_2 - P_1V_1\right)$

$= 18P_0V_0 - \frac{3}{2}\left(9P_0V_0 - 2P_0V_0\right)$

$= 18P_0V_0 - \frac{21}{2}P_0V_0 = 7.5P_0 V_0$

44. Angular momentum remains constant

$I\omega = \text{const.}$

$\frac{\Delta I}{I} + \frac{\Delta\omega}{\omega} = 0$

$2\alpha\Delta T + \frac{\Delta\omega}{\omega} = 0 \therefore \frac{\Delta\omega}{\omega} = -2\alpha\Delta T$

45. According to wein's law

$\lambda_m T = \text{constant}$

$\frac{CT}{v_{max}} = \text{constant} \Rightarrow v_m \propto T$

Answer-Key

1.	2	**2.**	1	**3.**	1	**4.**	3	**5.**	4	**6.**	2	**7.**	4	**8.**	4	**9.**	4	**10.**	4
11.	1	**12.**	3	**13.**	4	**14.**	1	**15.**	1	**16.**	4	**17.**	4	**18.**	3	**19.**	1	**20.**	4
21.	3	**22.**	1	**23.**	4	**24.**	4	**25.**	4	**26.**	4	**27.**	4	**28.**	1	**29.**	2	**30.**	2
31.	4	**32.**	4	**33.**	3	**34.**	1	**35.**	4	**36.**	3	**37.**	1	**38.**	2	**39.**	3	**40.**	3
41.	1	**42.**	4	**43.**	1	**44.**	2	**45.**	2	**46.**	1	**47.**	4	**48.**	3	**49.**	3	**50.**	3
51.	4	**52.**	2	**53.**	3	**54.**	1	**55.**	2	**56.**	1	**57.**	3	**58.**	1	**59.**	2	**60.**	2
61.	4	**62.**	3	**63.**	1	**64.**	1	**65.**	3	**66.**	1	**67.**	3	**68.**	2	**69.**	4	**70.**	4
71.	2	**72.**	4	**73.**	4	**74.**	4	**75.**	3	**76.**	4	**77.**	3	**78.**	3	**79.**	3	**80.**	3
81.	1	**82.**	1	**83.**	3	**84.**	2	**85.**	2	**86.**	2	**87.**	4	**88.**	4	**89.**	2	**90.**	2
91.	4	**92.**	2	**93.**	1	**94.**	4	**95.**	2	**96.**	1	**97.**	4	**98.**	2	**99.**	4	**100.**	2
101.	3	**102.**	1	**103.**	2	**104.**	1	**105.**	1	**106.**	4	**107.**	3	**108.**	3	**109.**	1	**110.**	3
111.	3	**112.**	3	**113.**	3	**114.**	1	**115.**	2	**116.**	3	**117.**	1	**118.**	2	**119.**	4	**120.**	1
121.	1	**122.**	1	**123.**	4	**124.**	3	**125.**	4	**126.**	3	**127.**	3	**128.**	2	**129.**	1	**130.**	3
131.	4	**132.**	3	**133.**	4	**134.**	3	**135.**	3	**136.**	3	**137.**	2	**138.**	2	**139.**	3	**140.**	1
141.	1	**142.**	2	**143.**	2	**144.**	3	**145.**	4	**146.**	4	**147.**	2	**148.**	3	**149.**	1	**150.**	3
151.	1	**152.**	3	**153.**	3	**154.**	3	**155.**	3	**156.**	2	**157.**	2	**158.**	4	**159.**	1	**160.**	1
161.	3	**162.**	4	**163.**	1	**164.**	2	**165.**	1	**166.**	4	**167.**	2	**168.**	3	**169.**	4	**170.**	2
171.	3	**172.**	1	**173.**	3	**174.**	1	**175.**	3	**176.**	2	**177.**	2	**178.**	2	**179.**	3	**180.**	1