Kinetic theory of gases (Shashikant Sir)

Level - 01

3. On increase in temperature no of collisions will increase.

5. $$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\therefore \frac{\not{4}^{2} \times 150\not{0}}{30\not{0}} = \frac{\not{2} \times V}{270}$$

$$2 \times 5 \times 270 = V$$

$$2700\ m^3 = V$$

6. $$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{\not{P_1} \not{V_1}}{300} = \frac{2\not{P_1}\ 2\not{V_1}}{T_2}$$

$$\therefore T_2 = 4 \times 300$$

$$= 1200\,k$$

$$\therefore T_2 = 927^\circ C$$

7. $$\frac{P_1}{n_1 T_1} = \frac{P_2}{n_2 T_2}$$

$$\frac{720\ kPa}{n_1\ 313} = \frac{P_2}{\frac{3}{4} n_1 \times 626}$$

$\therefore P_2 = \frac{\cancel{720}^{180} \times \cancel{620}}{\cancel{315}} \times \frac{3}{4}$ = 1080 kpa.

8. $\frac{P_1}{T_1 n_1} = \frac{P_2}{T_2 n_2}$.

$\therefore \frac{10 \times \cdot}{300 \times n_1} = \frac{P_2}{360 \times \left(\frac{n_1}{2}\right)}$

$\therefore P_2 = \frac{360}{300} \times \frac{1}{2} \times 10^5 =$ 6 atm.

9. $PV = nRT$

$n = \frac{m}{M}$

$\therefore PV = \frac{m'}{M} RT$

$\therefore PM = \frac{m'}{V} RT$ (M = m molar mass / is mass of each molecule).

$\therefore PM = \rho RT$

$\therefore \rho = \frac{PM}{RT} = \frac{Pm}{RT}$

~~10~~. 21 Dalton's law.

22. $P_1' \propto n_1$

$P_2 \propto n_2$

$\therefore P_1 + P_2 =$ Total pressure $\propto n_1 + n_2$

$\propto 2 + 0.5$

$\propto 2.5$

$$\therefore \frac{P_2}{P_1+P_2} = \frac{n_2}{n_1+n_2} = \frac{0.5}{2.5} = \frac{1}{5}$$

(No need for molar mass of gas).

27.

$$C_p - C_v = R$$

~~Con~~ R is $8.314 \frac{J}{mol\ K}$

$$= \frac{8.314 \times \cancel{\ }}{4.18} \frac{cal}{mol\ kelvin}$$

$$= 1.99 \frac{cal}{mol\ kelvin}.$$

28.

$$\Delta U = n C_v \Delta T$$

$$Q = n C_p \Delta T$$

$$\therefore \frac{\Delta U}{Q} = \frac{C_v}{C_p} = \frac{\left(\frac{3R}{2}\right)}{\left(\frac{5R}{2}\right)} = \frac{3}{5}$$

29. $\Delta U = n C_v \Delta T$

$\therefore 420 = 2 \times C_v 10$

$\therefore C_v = \frac{420}{20} = 21 \frac{J}{K^* mol}$

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

$n C_p \Delta T = n C_v \Delta T + \Delta W$

$n C_p \Delta T = n C_v \Delta T + \Delta PV$

$= n C_v \Delta T + P \Delta V$

$= n C_v \Delta T + n R \Delta T$

$\therefore C_p = C_v + R$

$n \Delta T C_v = U$

$\therefore C_v = \frac{dU}{dT} \quad (n = 1)$

$\therefore C_p = \frac{dU}{dT} + R$

Level - 02.

1. mean value would not change because of velocity v.

2. $F = \frac{2mv}{\Delta t} = \frac{2 \times 4 \times 10^{-30} \times 10^{7} \times 10^{23}}{1}$

$\therefore \frac{F}{A} = P = \frac{2 \times 4 \times 10^{30} \times 10^{-30}}{4 m^2} = 2$ pascal.

3. Collision frequency $\propto v$

$\therefore \frac{f_H}{f_O} = \frac{v_H}{v_O} = \frac{\sqrt{\frac{3RT}{M_H}}}{\sqrt{\frac{3RT}{M_O}}}$

$= \sqrt{\frac{M_O}{M_H}} = \sqrt{\frac{32}{2}} = \sqrt{16} = 4$

$\therefore \frac{f_H}{f_O} = 4:1$

5. $$\frac{P_1}{n_1} = \frac{P_2}{n_2}$$

$$\frac{2.5\ atm}{n_1} = \frac{2}{n_2}$$

$$\therefore \frac{n_2}{n_1} = \frac{2}{2.5}$$

$$\therefore \frac{n_2}{n_1} \times 100 = \frac{2}{2.5} \times 100 = 80\%$$

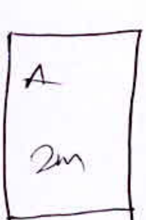
80% of gas is inside hence 20% has escaped.

6. $$P_1 V_1 = P_2 V_2$$

$$\therefore 80(\text{cm of Hg}) \times 5 = P_2 \times 8$$

$$\therefore P_2 = 10(\text{cm of Hg}) \times 5$$
$$= 50(\text{cm of Hg})$$

7. $n_A = 2n_B$



$$\therefore P_A V_A = n_A RT$$

$$P_B V_B = n_B RT$$

$$P_A = P_B$$

$$\therefore V_A = 2V_B$$

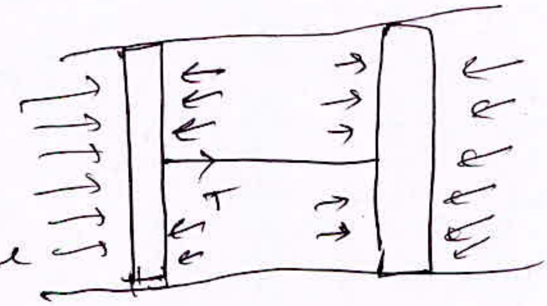
$$\therefore \frac{V_A}{V_A + V_B} = \frac{2V_B}{3V_B} = \frac{2}{3}$$

8. $\rho = \dfrac{PM}{RT}$

$\rho_0 = \dfrac{P_0 M}{R T_0}$

$\rho_B = \dfrac{P_B M}{R T_B} = \dfrac{3 P_0 M}{R(2T_0)} = \dfrac{3}{2}\left(\dfrac{P_0 M}{R T_0}\right) = \dfrac{3}{2}\rho_0$

9. Inner pressure was equal to outer pressure initial.
After $2T_0$ temperature raise inner pressure becomes $2P_0$



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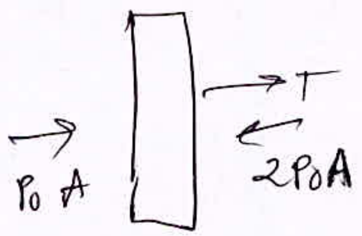


$T + P_0 A = 2P_0 A$

$\therefore T = P_0 A$

10. $P = \dfrac{P_0}{1 + \left(\dfrac{V_0}{V}\right)^2}$

$\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$\dfrac{P_0}{1+1^2} \times \dfrac{V_0}{T_1} = \dfrac{P_0}{1+\left(\frac{1}{2}\right)^2} \times \dfrac{2V_0}{T_2}$

$\therefore T_2 = T_1\left(\dfrac{16}{5}\right)$

$\therefore T_2 - T_1 = \dfrac{T_1}{5} \times 11$

Change in temperature = $\frac{T_1}{5} \times 4$

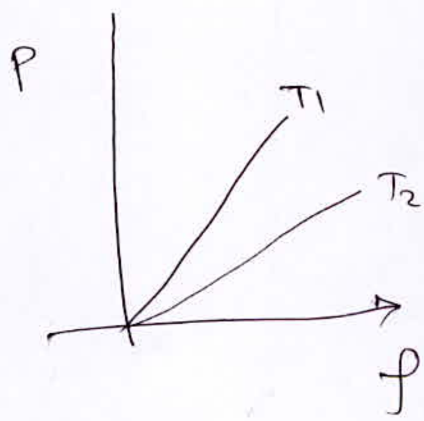
$\frac{P_0 V_0}{2} = 1 \times R T_1$

$T_1 = \frac{P_0 V_0}{2R}$

$\therefore$ Change = $\frac{P_0 V_0 \times 4}{10 R}$.

14. $\rho = \frac{PM}{RT}$

$\therefore P = \left(\frac{RT}{M}\right) \rho$



$y = mx$

m is more when T is more

$\therefore T_1 > T_2$

15. $V \propto T$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\therefore$ $\frac{200 ml \times 293}{253} = V_2 = 172.6 ml$

16.

$$\rho = \frac{PM}{RT}$$

$$n = \frac{\text{no of molecules}}{N_A} = \frac{m}{M}$$

$$\therefore \quad PV = \left(\frac{\text{no of molecules}}{N_A}\right) RT$$

$$\therefore \quad \frac{\text{no of molecules}}{V} = \frac{P N_A}{RT}$$

$$= \frac{1 \times 10^{-11} \times 6 \times 10^{23}}{R \times 300} \frac{\cdot}{m^3}$$

$$= \frac{6 \times 10^{12}}{R \times 300} \times \frac{}{(10^{+2})^3 \ cm^3}$$

$$= \frac{6 \times 10^{10-6}}{3 \times R}$$

$$= \frac{2}{8.314} \times 10^4$$

$$= 0.24 \times 10^4$$

$$= 2400$$

17. H_2 & O_2

$\therefore r \propto \frac{1}{\sqrt{M}}$

$\frac{r_{H_2}}{r_{O_2}} = \frac{\sqrt{M_{O_2}}}{\sqrt{M_{H_2}}} = \frac{1}{4} = \frac{1}{1}$

$\therefore \frac{M_{O_2}}{M_{H_2}} = \frac{1}{16}$

$\therefore \frac{M_{H_2}}{M_{O_2}} = \frac{16}{1}$

18.

$P_1 + P_2 = 2atm$

$\frac{n_{H_2}RT}{V} + \frac{n_{He}RT}{V} = 2\ atm$

$n_{H_2} + n_{He} = \frac{2\ atm \times V}{RT} =$

$\frac{m_{H_2}}{2} + \frac{m_{He}}{4} = \frac{2 \times 20}{0.821 \times 293}$

$m_{H_2} + m_{He} = 5$

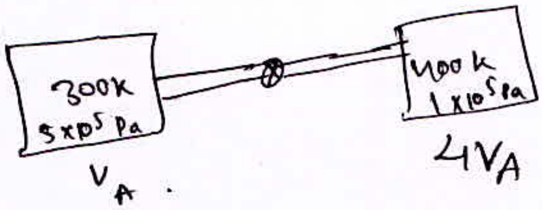
$m_{H_2} = 5 - m_{He}$

$\frac{5 - m_{He}}{2} + \frac{m_{He}}{4} = 0.166$

$2.5 - 0.166 = \frac{m_e}{4}$

Solving we get, 0.46

19.



$5\times10^5 \times V_A = n_A R \times 300$

$\therefore n_A = \dfrac{5\times10^5 V_A}{R\times300}$

$n_B = \dfrac{1\times10^5 \times 4V_A}{R\times 400}$

$n_A + n_B = \dfrac{V_A}{R\times100}\times10^5\left[\dfrac{5}{3}+\dfrac{4}{4}\right] = \dfrac{V_A\times10^5}{R\times100}\times\dfrac{8}{3}$

For the system after value opening,

$P(5V_A) = (n_A+n_B)RT$

$= \dfrac{V_A\times10^5}{R\times100}\times\dfrac{8}{3}\times R\ 350$

$\therefore P = 200\ \text{kPa}$

20. $\dfrac{nKT}{2}$.

Assertion & Reasons.

3. specific heat is depend on mass as well the process.

4. Above critical temperature gas cannot be liquified.
On increasing pressure the temperature of gas increases keeping other things constant.

5. $\therefore Q = nC\Delta T$

n is greater for He_2

7. $\frac{C_p}{C_v} = \frac{5}{3}$ $\quad \frac{C_p}{C_v} = \frac{7}{5}$

$= 1.66$ $\quad = 1.4$

for diatomic gamma i.e $\frac{C_p}{C_v}$ is less.

diatomic have more degree of freedom.

18. $v_{rms} = \sqrt{\frac{3RT}{M}}$ independent of wheater it is diatomic or mono-atomic.

maxwell speed distribution is not symmetric about most probable speed.

Previous Year's Questions.

1.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\therefore \frac{1 atm \times 500}{300} = \frac{0.5 \times V}{270}$$

$$\therefore V = \frac{1 \times 5}{0.5 \times 3} \times 270 = 900 \; m^3$$

2. $$\frac{V_1}{V_2} = \frac{T_1}{T_2} \quad \therefore \quad 2 = \frac{T_1}{300}$$

$$T_1 = 600$$

$$\therefore T_1 - T_2 = 300$$

3. $$P_0 V_0 = 2P_0 V_1$$

$$V_1 = \frac{V_0}{2}$$

$$2P_0 \cdot V_1^{\gamma} = P_2 V_2^{\gamma} = P_2 V_0^{\gamma}$$

$$\therefore P_2 = 2P_0 \times \left(\frac{V_1}{V_0}\right)^{\gamma} = 2P_0 \, 2^{-\gamma} = 2P_0 \, 2^{-1.4}$$

$$\therefore \frac{P_2}{P_0} = \frac{2}{2^{+1.4}} = 2 \times 0.38 = 0.76$$

4. Aqueous tension does not depends upon volume. It remains same. (vapour pressure of water or Aqueous tension).

5. $$P = \frac{RT}{2V-b} - \frac{a}{4b^2}$$

$P = \frac{RT}{2V-b} - \frac{a}{4b}$

$\therefore P = \frac{nRT}{(V-nb)} \ldots\ldots$

comparing $n = \frac{1}{2}$

6. $\rho = \frac{PM}{RT}$

$\therefore P = \left(\frac{RT}{M}\right)\rho$.

$T_1 > T_2$

7. $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{P_2}{P_1} = \frac{1.1}{1}$

$\therefore T_2 = 1.1\,T_1$

$\therefore 0.1\,T_1 = 1\,k$

$\therefore T_1 = 100\,k$.

8. $n_1T_1 = n_2T_2$

~~$\therefore \frac{V_1}{333} = \frac{\frac{3}{4}V_1}{T_2}$~~

~~$\therefore T_2 = 333\times\frac{3}{4}$~~

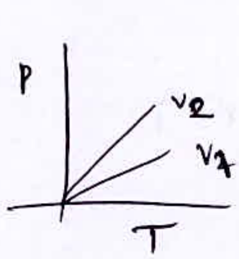
$n_1\,333 = \frac{3}{4}n_1 T_2$

$\therefore 444\,k = T_2$

$\therefore T_2 = 171\,°C$.

9. wrong ~~question~~ answer.

$V_1 > V_2$



10. $\frac{20}{300 \cdot \cancel{n}} = \frac{P}{350 \frac{\cancel{n}}{2}}$

$P = 10 \times \frac{350}{300} = 11.7$

~~16.~~ 15. $P_1V_1 = P_2V_2$

$\therefore \frac{P_2}{P_1} = \frac{V_1}{V_2} = \frac{1}{0.9}$

$P_1 = 0.9\ P_2$

$\therefore \frac{P_2 - P_1}{P_1} = \frac{0.1}{0.9} \times 100 = 11.1$

17. $76 \times 0.1 = 0.19 \times P$

$\therefore \frac{76 \times}{1.9} = P = 40$

18. $Q = nC_p \Delta T$

$= \left(\frac{14}{28}\right)_2 \left(\frac{7R}{2}\right) \times 40$

$= 70R.$

19. $PV = nRT \cdot PV = \frac{N}{N_A}RT \quad \therefore N = \frac{PVN_A}{RT}$

20. $n_A + n_B = 2n$

$\therefore \quad P_T V = (2n)RT$

$pV = nRT \quad \therefore P_T = 2p$

21. $\frac{\rho}{P} = \frac{M}{RT} = x = \frac{M}{R \times 283}$ $\therefore \frac{M}{R} = 283x$

$\therefore \frac{\rho}{P} = \frac{M}{R} \cdot \frac{M}{R \times 383} = \frac{283}{383} x.$

22. Repeat of ques 1.

25. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

26. $\frac{P_1}{P_2} = \frac{V_2}{V_1} =$

$\therefore \frac{P_1}{0.8P_1} = \frac{V_2}{V_1}$

$\therefore V_1 = 0.8V_2$

$\frac{V_2 - V_1}{V_1} = \frac{0.2 V_2}{0.8 V_2} \times 100 = \frac{1}{4} \times 100 = 25\%.$

27. $PV = nRT$

$n = \frac{\text{no of molecules}}{N_A}$

$PV = \frac{(\text{no of mol})}{N_A} RT$

$\therefore \frac{PN_A}{RT} = \frac{\text{no of molecules}}{V} =$ same for both.

28. Same as ques 26.

32. $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

33. $P_a V_a = nRT = P_b V_b$ (in thermal equilibrium temp is same)

34. With increase in volume product pv will remain constant.

35. $\frac{V_1}{V_2} = \frac{T_1}{T_2}$

$$\frac{\Delta V}{V} = \frac{\Delta T}{T} = \frac{1}{T}$$

Various Speeds of gas.

1. depends only on temprature.

2. $V_{rms} = \sqrt{\frac{3RT}{M}}$

$$\frac{T}{M_O} = \frac{300}{M_H}$$

$$\therefore T = \frac{32}{2} \times 300 = 4800K$$

3. Average velocity of a single molecule is zero.

4. $V_{mp} = \sqrt{\frac{2KT}{M}} = \sqrt{\frac{2 \times 8.314 \times 421}{28 \times 10^{-3}}} = 500\ m/s$

5. $$\frac{T}{M_O} = \frac{1}{4} \frac{273}{M_{H_2}} = 4$$

$$T = 4 \times 273 = 1092\ K = 819\ °C$$

6. $480 = 4 \times 120$

$$V \propto \sqrt{T}$$

$$\therefore V_1 \propto \sqrt{4T} \propto 2\sqrt{T}$$

$$\therefore V_1 = 2V$$

7. $$\frac{T}{M_{H_2}} = \frac{320}{M_{O_2}}$$

$$T = 20K$$

8. $v_{av} = \frac{1+3+5+7}{4} = \frac{16}{4} = 4$

$v_{rms} = \sqrt{\frac{1^2+3^2+5^2+7^2}{4}} = \sqrt{\frac{84}{4}} = \sqrt{21}$

$= 4.583$

$\therefore$ diffrence = 0.583.

10 $\frac{3}{2} k T = \frac{1}{3}\left(\frac{3}{2} k T'\right)$

$T = \frac{1}{3}(453) = 151 = -122°C$

12. $v_{O_2} = \sqrt{\frac{3RT'}{M_{O_2}}}$ $v_{H_2} = \sqrt{\frac{3RT}{M_{H_2}}}$

$\therefore \frac{v_{O_2}}{v_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$

13. same as 5.

14. $v_{rms} = \sqrt{\frac{3RT}{M}}$

$\frac{1}{2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{T_1}{600}}$

$T_1 = \frac{600}{4} = 150\,k = -123°C$

$\therefore$

15. $M_{mix} = \frac{4\times 2 + 1\times 32}{5} = \frac{40}{5} = 8$

$\frac{1270}{v} = \sqrt{\frac{M_{mix}}{2}} = \sqrt{4} = 2$

$\therefore v = \frac{1270}{2} = 635\ m/s$

16. Both proportional to $\sqrt{T}$

18. $v = \sqrt{\frac{P}{\rho}} = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{\gamma P}{d}}$

$\frac{v_1}{v_2} = \sqrt{\frac{d_2}{d_1}}$

20. $\sqrt{\frac{3RT}{M_{H_2}}} = 7\sqrt{\frac{3R300}{M_{N_2}}}$

$\frac{T}{M_{H_2}} = \frac{49\times 300}{M_{N_2}}$

$T = \frac{49\times 300}{14} \times 2 = 7\times 150 = 1050k$

21. $V_s = \sqrt{\frac{\gamma RT}{M}} = 1150$

$V_{rms} = \sqrt{\frac{3RT}{M}}$

$\frac{V_{rms}}{1150} = \frac{\sqrt{3}}{\sqrt{\gamma}}$

$\therefore V_{rms} = 1150 \times \frac{\sqrt{3}}{\sqrt{\gamma}}$

$C_P = \frac{f}{2}R$ $\therefore f = 5$

$\therefore \gamma = 5/3$

$$V_{rms} = 1150 \times \sqrt{\frac{3}{5/3}} = 1150 \frac{\times 3}{\sqrt{3}} = 1582.14$$

22. $$\sqrt{\frac{2 \times 16}{3 \times 16}} = \sqrt{\frac{M_{O_2}}{M_{O_3}}}$$

23. $$V_{rms} = \sqrt{\frac{3RT}{M_{O_2}}} = V$$

$$V_{rms} = \sqrt{\frac{3R(2T)}{M_O}} = 2\sqrt{\frac{3RT}{M_{O_2}}} = 2V$$

26. $$V = \sqrt{\frac{1^2+2^2+3^2+4^2}{4}} = \frac{\sqrt{15}}{2}.$$

Pressure & Energy of gas.

2. $K.E = \frac{3}{2}KT = \frac{3}{2} \times 8.3 \times 273 = 3.4 \times 10^3 J$

8. $K.E = \frac{3}{2}KT$ depends only on temp.

9. Same as 2.

10. $M_{CO} = 28 = M_{N_2}$ Hence same moles

11. ~~No~~ Depends on temp.

12. First gas' pressure will reduce then vapours will have constant pressure.

13. V_{av} has increased.

15. $C = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{\rho}}$

$\therefore C \propto \frac{1}{\sqrt{\rho}}$

16. $\Delta U_1 + \Delta U_2 = \Delta U_{system}$

$n_1 C T_1 + n_2 C \cdot T_2 = (n_1 + n_2) C T$

$\therefore T = \frac{n_1 T_1 + n_2 T_2}{n_1 + n_2}$

17.

$$v_{av} = \sqrt{\frac{8RT}{\pi M}}$$

$$v' = 2v_{av}$$

$$\sqrt{\frac{8RT'}{\pi M}} = 2\sqrt{\frac{8R293}{\pi M}}$$

$$\therefore T' = 4\times 293$$

$$T' =$$

$$\frac{3}{2}kT' = 2\left(\frac{3}{2}kT\right)$$

$$\therefore T' = 2T$$

$$= 2\times 293 = 586\,K = 313$$

18. $$\frac{E'}{E} = \frac{\frac{3}{2}kT'}{\frac{3}{2}kT} = \frac{400}{300} = 1.33.$$

Degrees of freedom & Specific Heat.

1. $C_p - C_v = R$,

$\gamma = \frac{C_p}{C_v}$

$\therefore \gamma C_v = C_p$

$\therefore \gamma C_v - C_v = R$

$\therefore C_v = \frac{R}{\gamma - 1}$

2. $PV^{\gamma} =$ contant.

$P \propto T^3$ $\qquad T = \frac{PV}{nR}$.

$\therefore P \propto P^3 V^3$

$\therefore p^{2} v^{+3} =$ constent,

$\therefore P V^{3/2} =$ constent

$\therefore \gamma = \frac{3}{2}$

γ is $\frac{C_p}{C_v}$.

7. $P_0 V_0 = 2P_0 V_1$

$\therefore V_1 = \frac{V_0}{2}$

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma} = (0.75 P_0) V_0^{\gamma}$

$$2P_0 \left(\frac{V_0}{2}\right)^{\gamma} = 0.75 P_0 V_0^{\gamma}$$

$$\frac{2 \times 4}{3} = 2^{\gamma}$$

$$\frac{8}{3} = 2^{\gamma}$$

$$\therefore \gamma = 1.41$$

9. Same as 1

10. $1163.4 J = C_p \Delta T.$

$$1163.4 = \frac{5}{2} R \Delta T$$

$$\therefore \Delta T = \frac{2 \times 1163.4}{5R}$$

$$= 40 k.$$

11. $C_p = \frac{7}{2} R$

$$C_v = C_p - R$$

$$= \frac{5}{2} R$$

$$\therefore \frac{C_p}{C_v} = \frac{7}{5}$$

12 = $C_V = \frac{f}{2} R$

$C_V = 3R$

14. $Q = n C_p \Delta T$

$Q' = n C_V \Delta T$

$\frac{Q'}{310} = \frac{C_V}{C_p}$

$Q' = \frac{310 \times}{\gamma}$

15. $Q = n C_p 300$

$Q = n C_V \Delta T$

$\Delta T = \frac{C_p}{C_V} \times 300$

$= \frac{7}{5} \times 300$

$= 420 k$

18. $P_1 = \frac{P}{2}$

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

$\frac{P}{2}(2V)^{\gamma} = P_2 (16V)^{\gamma}$

$P_2 = \frac{P}{2} \left(\frac{1}{8}\right)^{\gamma} = \frac{P}{2} \times \frac{1}{(2^3)^{5/3}} = \frac{P}{2 \times 32} = \frac{P}{64}$