DPP - Daily Practice Problems

Name : Date :

Start Time : End Time :

PHYSICS

26

SYLLABUS : Kinetic Theory

Max. Marks : 120 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.21) : There are 21 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 If pressure of a gas contained in a closed vessel is increased by 0.4% when heated by 1°C, the initial temperature must be

(a) 250 K (b) 250°C (c) 2500 K (d) 25°C

Q.2 To double the volume of a given mass of an ideal gas at 27°C keeping the pressure constant, one must raise the temperature in degree centigrade to

(a) 54 (b) 270 (c) 327 (d) 600

Q.3 Under which of the following conditions is the law $PV = RT$ obeyed most closely by a real gas?

(a) High pressure and high temperature
(b) Low pressure and low temperature
(c) Low pressure and high temperature
(d) High pressure and low temperature

Q.4 The pressure P, volume V and temperature T of a gas in the jar A and the other gas in the jar B at pressure $2P$, volume $\frac{V}{4}$ and temperature 2T, then the ratio of, the number of molecules in the jar A and B will be

(a) 1 : 1 (b) 1 : 2
(c) 2 : 1 (d) 4 : 1

Q.5 A flask is filled with 13 gm of an ideal gas at 27°C and its temperature is raised to 52°C. The mass of the gas that has to be released to maintain the temperature of the gas in the flask at 52°C and the pressure remaining the same is

(a) 2.5 g (b) 2.0 g (c) 1.5 g (d) 1.0 g

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

Space for Rough Work

Q.6 The pressure and temperature of two different gases is P and T having the volume V for each. They are mixed keeping the same volume and temperature, the pressure of the mixture will be

(a) $P/2$ (b) P (c) $2P$ (d) $4P$

Q.7 The root mean square velocity of a gas molecule of mass m at a given temperature is proportional to

(a) m° (b) m (c) $\sqrt{m}$ (d) $\frac{1}{\sqrt{m}}$

Q.8 Which of the following statements is true?

(a) Absolute zero temperature is not zero energy temperature

(b) Two different gases at the same temperature and pressure have equal root mean square velocities

(c) The root mean square speed of the molecules of different ideal gases, maintained at the same temperature are the same

(d) Given sample of 1 cc of hydrogen and 1 cc of oxygen both at NTP; oxygen sample has a large number of molecules

Q.9 At room temperature, the *r.m.s.* speed of the molecules of certain diatomic gas is found to be 1930 m/s. The gas is

(a) H_2 (b) F_2 (c) O_2 (d) Cl_2

Q.10 Root mean square velocity of a particle is v at pressure P. If pressure is increased two times, then the *r.m.s.* velocity becomes

(a) 2 v (b) 3 v (c) 0.5 v (d) v

Q.11 In the two vessels of same volume, atomic hydrogen and helium at pressure 1 atm and 2 atm are filled. If temperature of both the samples is same, then average speed of hydrogen atoms $< C_H >$ will be related to that of helium $< C_{He} >$ as

(a) $< C_H > = \sqrt{2} < C_{He} >$ (b) $< C_H > = < C_{He} >$

(c) $< C_H > = 2 < C_{He} >$ (d) $< C_H > = \frac{< C_{He} >}{2}$

Q.12 For a gas at a temperature T the root-mean-square velocity v_{rms}, the most probable speed v_{mp}, and the average speed v_{av} obey the relationship

(a) $v_{av} > v_{rms} > v_{mp}$ (b) $v_{rms} > v_{av} > v_{mp}$

(c) $v_{mp} > v_{av} > v_{rms}$ (d) $v_{mp} > v_{rms} > v_{av}$

Q.13 One mole of ideal monoatomic gas $(\gamma = 5/3)$ is mixed with one mole of diatomic gas $(\gamma = 7/5)$. What is γ for the mixture? $\left(\gamma = \frac{Cp}{Cv}\right)$

(a) 3/2 (b) 23/15 (c) 35/23 (d) 4/3

Q.14 The value of the gas constant (R) calculated from the perfect gas equation is 8.32 Joule/gm mol K, whereas its value calculated from the knowledge of C_p and C_V of the gas is 1.98 cal/gm mole K. From this data, the value of J is

(a) 4.16 J / cal (b) 4.18 J / cal

(c) 4.20 J / cal (d) 4.22 J / cal

Q.15 Gas at a pressure P_0 is contained in a vessel. If the masses of all the molecules are halved and their speeds are doubled, the resulting pressure P will be equal to

(a) $4P_0$ (b) $2P_0$ (c) P_0 (d) $\frac{P_0}{2}$

Q.16 The relation between the gas pressure P and average kinetic energy per unit volume E is

(a) $P = \frac{1}{2}E$ (b) $P = E$ (c) $P = \frac{3}{2}E$ (d) $P = \frac{2}{3}E$

Q.17 Mean kinetic energy (or average energy) per *gm* molecule of a monoatomic gas is given by

(a) $\frac{3}{2}RT$ (b) $\frac{1}{2}KT$ (c) $\frac{1}{2}RT$ (d) $\frac{3}{2}KT$

Q.18 At which of the following temperature would the molecules of a gas have twice the average kinetic energy they have at $20°C$?

(a) 40°C (b) 80°C (c) 313°C (d) 586°C

RESPONSE GRID					
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ		

Space for Rough Work

Q.19 The kinetic energy of one gram molecule of a gas at normal temperature and pressure is $(R = 8.31\ \text{J/mol}-\text{K})$

(a) 0.56×10^4 J (b) 1.3×10^2 J

(c) 2.7×10^2 J (d) 3.4×10^3 J

Q.20 70 calories of heat are required to raise the temperature of 2 moles of an ideal gas at constant pressure from $30°C$ to $35°C$. The amount of heat required to raise the temperature of same gas through the same range $(30^\circ\text{C}$ to $35^\circ\text{C})$ at constant volume $(R = 2\ \text{cal/mol K})$

(a) 30 cal (b) 50 *cal* (c) 70 cal (d) 90 cal

Q.21 A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per O_2 molecule to that per N_2 molecule is

(a) 1 : 1
(b) 1 : 2
(c) 2 : 1
(d) Depends on the moments of inertia of the two molecules

DIRECTIONS (Q.22-Q.24) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes : **(a)** 1, 2 and 3 are correct **(b)** 1 and 2 are correct
(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.22 From the following statements, concerning ideal gas at any given temperature T, select the correct one(s)

(1) The coefficient of volume expansion at constant pressure is same for all ideal gases
(2) In a gaseous mixture, the average translational kinetic energy of the molecules of each component is same
(3) The mean free path of molecules increases with the decrease in pressure
(4) The average translational kinetic energy per molecule of oxygen gas is 3KT (K being Boltzmann constant)

Q.23 Let $\overline{v}$, v_{rms} and v_p respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T, the mass of a molecule is m. Then

(1) $v_p < \overline{v} < v_{rms}$
(2) The average kinetic energy of a molecule is $\frac{3}{4}mv_p^2$
(3) No molecule can have speed greater than $\sqrt{2}v_{rms}$
(4) No molecule can have speed less than $v_p/\sqrt{2}$

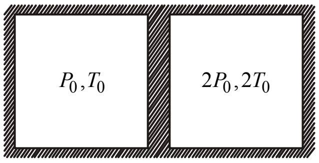
Q.24 A gas in container A is in thermal equilibrium with another gas in container B, both contain equal masses of the two gases in the respective containers. Which of the following can be true

(1) $P_A = P_B, V_A \neq V_B$ (2) $P_A V_A = P_B V_B$

(3) $PA \neq P_B, V_A = V_B$ (4) $\frac{P_A}{V_A} = \frac{P_B}{V_B}$

DIRECTIONS (Q.25-Q.27) : Read the passage given below and answer the questions that follows :

A diathermic piston divides adiabatic cylinder of volume V_0 into two equal parts as shown in the figure. Both parts contain ideal monoatomic gases. The initial pressure and temperature of gas in left compartment are P_0 and T_0 while that in right compartment are $2P_0$ and $2T_0$. Initially the piston is kept fixed and the system is allowed to acquire a state of thermal equilibrium.



Q.25 The pressure in left compartment after thermal equilibrium is achieved is

(a) P_0 (b) $\frac{3}{2}P_0$

(c) $\frac{4}{3}P_0$ (d) None of these

RESPONSE GRID					
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ
	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ			

Q.26 The heat that flown from right compartment to left compartment before thermal equilibrium is achieved is

(a) P_0V_0 (b) $\frac{3}{4}P_0V_0$ (c) $\frac{3}{8}P_0V_0$ (d) $\frac{2}{3}P_0V_0$

Q.27 If the pin which was keeping the piston fixed is removed and the piston is allowed to slide slowly such that a state of mechanical equilibrium is achieved. The volume of left compartment when piston is in equilibrium is

(a) $\frac{3}{4}V_0$ (b) $\frac{V_0}{4}$ (c) $\frac{V_0}{2}$ (d) $\frac{2}{3}V_0$

DIRECTIONS (Qs. 28-Q.30) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.

(c) Statement -1 is False, Statement-2 is True.

(d) Statement -1 is True, Statement-2 is False.

Q.28 **Statement-1 :** Internal energy of an ideal gas does not depend upon volume of the gas.

Statement-2 : Internal energy of an ideal gas depends on temperature of gas.

Q.29 **Statement-1 :** Equal masses of helium and oxygen gases are given equal quantities of heat. There will be a greater rise in the temperature of helium compared to that of oxygen.

Statement-2 : The molecular weight of oxygen is more than the molecular weight of helium.

Q.30 **Statement-1 :** Maxwell speed distribution graph is asymmetric about most probable speed.

Statement-2 : *rms* speed of ideal gas, depends upon it's type (monoatomic, diatomic and polyatomic).

RESPONSE GRID	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 26 - PHYSICS			
Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	30	Qualifying Score	48
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

26

1. (a) Closed vessel *i.e.*, volume is constant

$$\Rightarrow \frac{P_1}{P_2}=\frac{T_1}{T_2}\Rightarrow \frac{P}{P+\left(\frac{0.4}{100}\right)P}=\frac{T}{T+1}\Rightarrow T=250K$$

2. (c) $V\propto T\Rightarrow \frac{V_1}{V_2}=\frac{T_1}{T_2}\Rightarrow \frac{V}{2V}=\frac{(273+27)}{T_2}=\frac{300}{T_2}$

$$\Rightarrow T_2=600K=327^\circ C$$

3. (c) At low pressure and high temperature real gases behaves like ideal gases.

4. (d) $PV=NkT\Rightarrow \frac{N_A}{N_B}=\frac{P_AV_A}{P_BV_B}\times\frac{T_B}{T_A}$

$$\Rightarrow \frac{N_A}{N_B}=\frac{P\times V\times(2T)}{2P\times\frac{V}{4}\times T}=\frac{4}{1}$$

5. (d) $PV=mrT$

Since $P, V, r\rightarrow$ remains same

Hence

$$m\propto\frac{1}{T}\Rightarrow\frac{m_1}{m_2}=\frac{T_2}{T_1}\Rightarrow\frac{13}{m_2}=\frac{(273+52)}{(273+27)}=\frac{325}{300}$$

$$\Rightarrow m_2=12gm$$

i.e., mass released $=13gm$ - $12gm=1gm$

6. (c) $\mu_1=\frac{PV}{RT},\mu_2=\frac{PV}{RT}$

$$P'=\frac{(\mu_1+\mu_2)RT}{V}=\frac{2PV}{RT}\times\frac{RT}{V}=2P$$

7. (d) $v_{rms}=\sqrt{\frac{3kT}{m}}=v_{rms}\propto\frac{1}{\sqrt{m}}$

8. (a)

9. (a) $v_{rms}=\sqrt{\frac{3RT}{M}}\Rightarrow M=\frac{3RT}{v_{rms}^2}\therefore M=\frac{3\times8.3\times300}{(1920)^2}$

$=2\times10^{-3}kg=2gm\Rightarrow$ Gas is hydrogen.

10. (d) *r.m.s* velocity does not depend upon pressure.

11. (c) Average velocity of gas molecule is

$$v_{av}=\sqrt{\frac{8RT}{\pi M}}\Rightarrow v_{av}\propto\frac{1}{\sqrt{M}}$$

$$\Rightarrow\frac{<C_H>}{<C_{He}>}=\sqrt{\frac{M_{He}}{M_H}}=\sqrt{\frac{4}{1}}=2$$

$$\Rightarrow <C_H>$$
$$=2<C_{He}>$$

12. (b) $v_{rms}>v_{av}>v_{mp}$

13. (a) $$\gamma_{mix}=\frac{\frac{\mu_1\gamma_1}{\gamma_1-1}+\frac{\mu_2\gamma_2}{\gamma_2-1}}{\frac{\mu_1}{\gamma_1-1}+\frac{\mu_2}{\gamma_2-1}}=\frac{\frac{1\times\frac{5}{3}}{\left(\frac{5}{3}-1\right)}+\frac{1\times\frac{7}{5}}{\left(\frac{7}{5}-1\right)}}{\frac{1}{\left(\frac{5}{3}-1\right)}+\frac{1}{\left(\frac{7}{5}-1\right)}}=\frac{3}{2}=1.5$$

14. (c) We know that

$$C_P-C_V=\frac{R}{J}\Rightarrow J=\frac{R}{C_P-C_V}$$

$$C_P-C_V=1.98\frac{cal}{gm-mol-K},$$

$$R=8.32\frac{J}{gm-mol-K}$$

$$\therefore J=\frac{8.32}{1.98}=4.20\,J/cal$$

15. (b) $v_{rms}=\sqrt{\frac{3P}{\rho}}=\sqrt{\frac{3PV}{m}}\Rightarrow v_{rms}\propto\sqrt{\frac{P}{m}}$

$$\Rightarrow\frac{v_1}{v_2}=\sqrt{\frac{P_1}{P_2}\times\frac{m_2}{m_1}}$$

$$\Rightarrow\frac{v}{2v}=\sqrt{\frac{P_0}{P_2}\times\frac{m/2}{m}}\Rightarrow P_2=2P_0$$

16. (d) $P=\frac{2}{3}E$

17. (a) For one *gm* mole; average kinetic energy $=\frac{3}{2}RT$

18. (c) Average kinetic energy $\propto$ Temperature

$$\Rightarrow\frac{E_1}{E_2}=\frac{T_1}{T_2}\Rightarrow\frac{E}{2E}=\frac{T_1}{T_2}\Rightarrow T_2=2T_1$$

$$T_2=2(273+20)=586K=313^\circ C$$

19. (d) Kinetic energy per *gm* mole $E=\frac{f}{2}RT$

If nothing is said about gas then we should calculate the translational kinetic energy *i.e.*,

$$E_{Trans}=\frac{3}{2}RT=\frac{3}{2}\times 8.31\times(273+0)=3.4\times10^3\,J$$

20. **(b)** $(\Delta Q)_P=\mu C_P\Delta T$

$$\Rightarrow 2\times C_P\times(35-30)\Rightarrow C_P=7\frac{cal}{mole-K}$$

$$\because C_P-C_V=R$$

$$\Rightarrow C_V=C_P-R=7-2=5\frac{cal}{mole-kelvin}$$

$$\therefore (\Delta Q)_V=\mu C_V\Delta T$$

$$=2\times5\times(35-30)=50\ cal$$

21. **(a)** Average kinetic energy per molecule per degree of freedom $=\frac{1}{2}kT$. Since both the gases are diatomic and at same temperature (300 *K*), both will have the same number of rotational degree of freedom *i.e.* two. Therefore, both the gases will have the same average rotational kinetic energy per molecule

$$\left(=2\times\frac{1}{2}kT=kT\right).$$

Thus $\frac{E_1}{E_2}=\frac{1}{1}$

22. **(a)**
Coefficient of volume expansion at constant pressure is $\frac{1}{273}$ for all gases. The average transnational K.E. is same for molecule of all gases and for each molecules it is $\frac{3}{2}$kT

Mean free path $\lambda=\frac{kT}{\sqrt{2}\pi d^2P}$ (as P decreases, λ increases)

23. **(b)** $v_{rms}=\sqrt{\frac{3RT}{M}},\ v_P=\sqrt{\frac{2RT}{M}}=0.816\ v_{rms}$

$$\bar{v}=\sqrt{\frac{8RT}{\pi M}}=0.92\ v_{rms}\Rightarrow v_P<\bar{v}<v_{rms}$$

Further $E_{av}=\frac{1}{2}mv_{rms}^2=\frac{1}{2}m\frac{3}{2}v_P^2=\frac{3}{4}mv_P^2$

24. **(d)** According to problem mass of gases are equal so number of moles will not be equal i.e. $\mu_A\neq\mu_B$

From ideal gas equation $PV=\mu RT\Rightarrow\frac{P_AV_A}{\mu_A}=\frac{P_BV_B}{\mu_B}$

[As temperature of the container are equal]

From this relation it is clear that if $P_A=P_B$ then

$$\frac{V_A}{V_B}=\frac{\mu_A}{\mu_B}\neq1 \text{ i.e. } V_A\neq V_B$$

Similarly if $V_A=V_B$ then $\frac{PA}{P_B}=\frac{\mu_A}{\mu_B}\neq1$ i.e. $P_A\neq P_B$.

25. **(b)** $n_1C_v(T-T_0)+n_2C_v(T-2T_0)=0$

$$T=\frac{3}{2}T_0$$

$$P_f=\frac{P_iT_f}{T_i}=\frac{3}{2}P_0$$

26. **(c)** $\Delta Q=n_1C_v(T_f-T_0)$

$$=\frac{P_0V_0}{2RT_0}\times\frac{3}{2}R\times\left(\frac{3}{2}T_0-T_0\right)=\frac{3}{8}P_0V_0$$

27. **(c)** Let ΔV is change in volume in any compartment then

$$n_1=\frac{P_0V_0}{2RT_0}=\frac{P_f\left(\frac{V_0}{2}-\Delta V\right)}{RT_f}\quad\text{and}$$

$$n_2=\frac{2P_0V_0}{2RT_0}=\frac{P_f\left(\frac{V_0}{2}+\Delta V\right)}{RT_f}\Rightarrow\Delta V=0$$

28. **(b)** Internal energy of an ideal gas does not depend upon volume of the gas, because there are no forces of attraction/repulsion amongest the molecular of an ideal gas.
Also internal energy of an ideal gas depends on temperature.

29. **(b)** Helium is a monoatomic gas, while oxygen is diatomic. Therefore, the heat given to helium will be totally used up in increasing the translational kinetic energy of its molecules; whereas the heat given to oxygen will be used up in increasing the translational kinetic energy of the molecule and also in increasing the kinetic energy of rotation and vibration. Hence there will be a greater rise in the temperature of helium.

30. **(d)** Maxwell speed distribution graph is asymmetric graph, because it has a long "tail" that extends to infinity.
Also v_{rms} depends upon nature of the gas and it's temperature.