DPP - Daily Practice Problems

Name : | Date :

Start Time : | End Time :

PHYSICS 25

SYLLABUS : Thermodynamics-2 (1st and 2nd laws of thermodynamics, Reversible & irreversible processes, Carnot engine and its efficiency)

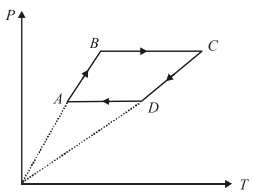
Max. Marks : 112 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 28 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.

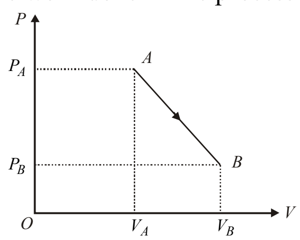
DIRECTIONS (Q.1-Q.19) : There are 19 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 Six moles of an ideal gas performs a cycle shown in figure. If the temperature $T_A = 600K, T_B = 800K, T_C = 2200K$ and $T_D = 1200K$, the work done per cycle is



(a) 20 kJ (b) 30 kJ (c) 40 kJ (d) 60 kJ

Q.2 An ideal gas is taken from point A to the point B, as shown in the $P-V$ diagram, keeping the temperature constant. The work done in the process is



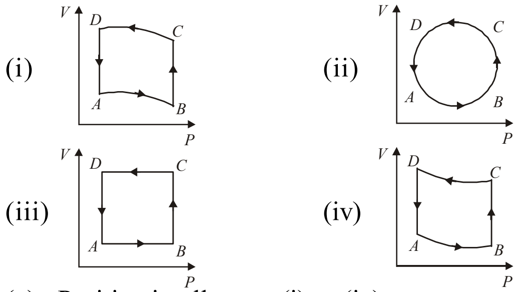
(a) $(P_A - P_B)(V_B - V_A)$ (b) $\frac{1}{2}(P_B - P_A)(V_B + V_A)$

(c) $\frac{1}{2}(P_B - P_A)(V_B - V_A)$ (d) $\frac{1}{2}(P_B + P_A)(V_B - V_A)$

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ

Space for Rough Work

Q.3 In the diagrams (i) to (iv) of variation of volume with changing pressure is shown. A gas is taken along the path *ABCD*. The change in internal energy of the gas will be



(a) Positive in all cases (i) to (iv)
(b) Positive in cases (i), (ii) and (iii) but zero in case (iv)
(c) Negative in cases (i), (ii) and (iii) but zero in case (iv)
(d) Zero in all cases

Q.4 A monoatomic ideal gas, initially at temperature T_1, is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If L_1 and L_2 are the lengths of the gas column before and after expansion respectively, then T_1/T_2 is given by

(a) $\left(\frac{L_1}{L_2}\right)^{2/3}$ (b) $\frac{L_1}{L_2}$ (c) $\frac{L_2}{L_1}$ (d) $\left(\frac{L_2}{L_1}\right)^{2/3}$

Q.5 A gas mixture consists of 2 moles of oxygen and 4 moles argon at temperature *T*. Neglecting all vibrational modes, the total internal energy of the system is
(a) 4 *RT* (b) 15 *RT* (c) 9 *RT* (d) 11 *RT*

Q.6 Two Carnot engines *A* and *B* are operated in succession. The first one, *A* receives heat from a source at $T_1 = 800K$ and rejects to sink at $T_2 K$. The second engine *B* receives heat rejected by the first engine and rejects to another sink at $T_3 = 300K$. If the work outputs of two engines are equal, then the value of T_2 will be
(a) 100K (b) 300K (c) 550K (d) 700 K

Q.7 A Carnot engine whose low temperature reservoir is at 7°C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of the high temperature reservoir be increased
(a) 840K (b) 280 K (c) 560 K (d) 380K

Q.8 An ideal heat engine working between temperature T_1 and T_2 has an efficiency η, the new efficiency of engine if both the source and sink temperature are doubled, will be

(a) $\frac{\eta}{2}$ (b) η (c) 2η (d) 3η

Q.9 Efficiency of a Carnot engine is 50% when temperature of outlet is 500 *K*. In order to increase efficiency up to 60% keeping temperature of intake the same what will be temperature of outlet
(a) 200 K (b) 400 K (c) 600 K (d) 800 K

Q.10 A scientist says that the efficiency of his heat engine which operates at source temperature 120°*C* and sink temperature 27°*C* is 26%, then
(a) It is impossible
(b) It is possible but less probable
(c) It is quite probable
(d) Data are incomplete

Q.11 The efficiency of Carnot's engine operating between reservoirs, maintained at temperatures 27°C and –123°C, is
(a) 50% (b) 24% (c) 0.75% (d) 0.4%

Q.12 The temperature of sink of Carnot engine is 27°C and Efficiency of engine is 25%. Then temperature of source is
(a) 227°C (b) 327°C (c) 127°C (d) 27°C

Q.13 In changing the state of thermodynamics from *A* to *B* state, the heat required is *Q* and the work done by the system is *W*. The change in its internal energy is

(a) $Q + W$ (b) $Q - W$ (c) Q (d) $\frac{Q-W}{2}$

Q.14 The first law of thermodynamics is concerned with the conservation of
(a) Momentum (b) Energy
(c) Mass (d) Temperature

Q.15 A system is given 300 calories of heat and it does 600 joules of work. The internal energy of the system change in this process is
(J = 4.18 Joule/cal)
(a) 654 Joule (b) 156.5 Joule
(c) –300 Joule (d) – 528.2 Joule

RESPONSE GRID					
	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ
	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ
	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ		

Space for Rough Work

Q.16 110 *J* of heat is added to a gaseous system, whose internal energy change is 40 *J,* then the amount of external work done is

(a) 150 J (b) 70 J (c) 110 J (d) 40 J

Q.17 For free expansion of the gas which of the following is true

(a) $Q = W = 0$ and $\Delta E_{int} = 0$

(b) $Q = 0, W > 0$ and $\Delta E_{int} = -W$

(c) $W = 0, Q > 0$, and $\Delta E_{int} = Q$

(d) $W > 0, Q < 0$ and $\Delta E_{int} = 0$

Q.18 In a given process for an ideal gas, $dW = 0$ and $dQ < 0$. Then for the gas

(a) The temperature will decrease

(b) The volume will increase

(c) The pressure will remain constant

(d) The temperature will increase

Q.19 The specific heat of hydrogen gas at constant pressure is $C_p = 3.4 \times 10^3 \text{cal/kg}^\circ\text{C}$ and at constant volume is $C_V = 2.4 \times 10^3 \text{cal/kg}^\circ\text{C}$. If one kilogram hydrogen gas is heated from 10°C to 20°C at constant pressure, the external work done on the gas to maintain it at constant pressure is

(a) 10^5 cal (b) 10^4 cal

(c) 10^3 cal (d) 5×10^3 cal

DIRECTIONS (Q.20-Q.22) : 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.20 Which of the following processes are irreversible?

(1) Transfer of heat by radiation

(2) Electrical heating of a nichrome wire

(3) Transfer of heat by conduction

(4) Isothermal compression

Q.21 For a reversible process, unnecessary conditions are

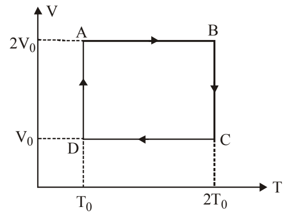
(1) In the whole cycle of the system, the loss of any type of heat energy should be zero

(2) That the process should be too fast

(3) That the process should be slow so that the working substance should remain in thermal and mechanical equilibrium with the surroundings

(4) The loss of energy should be zero and it should be quasistatic

Q.22 One mole of an ideal gas is taken through the cyclic through the cyclic process shown in the V-T diagram, where V = volume and T = absolute temperature of the gas. Which of the following statements are correct



(1) Heat is given out by the gas

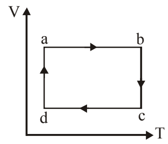
(2) Heat is absorbed by the gas

(3) The magnitude of the work done by the gas is RT_0 (ln 2)

(4) The magnitude of the work done by the gas is V_0T_0

DIRECTIONS (Q.23-Q.25) : Read the passage given below and answer the questions that follows :

V-T graph of a process of monoatomic ideal gas is as shown in figure.



Q.23 Sum of work done by the gas in process abcd is –

(a) zero (b) positive

(c) negative (d) data is insufficient

Q.24 Heat is supplied to the gas in process(s) –

(a) *da*, *ab* and *bc* (b) *da* and *ab* only

(c) *da* only (d) *ab* and *bc* only

Q.25 Change in internal energy of the gas is zero in process(s) –

(a) *da*, *ab* and *bc* (b) *da* and *bc* only

(c) *da* only (d) *da* and *ab* only

RESPONSE GRID					
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ
	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ

Space for Rough Work

DIRECTIONS (Q.26-Q.28) : 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.26 Statement-1 : It is not possible for a system, unaided by an external agency to transfer heat from a body at lower temperature to another body at higher temperature.

Statement-2 : According to Clausius statement, "No process is possible whose sole result is the transfer of heat from a cooled object to a hotter object.

Q.27 Statement-1 : A room can be warmed by opening the door of a refrigerator in a closed room.

Statement-2 : Head flows from lower temperature (refrigerator) to higher temperature (room).

Q.28 Statement-1 : In isothermal process whole of the heat energy supplied to the body is converted into internal energy.

Statement-2 : According to the first law of themodynamics

$$\Delta Q = \Delta U + P\Delta V$$

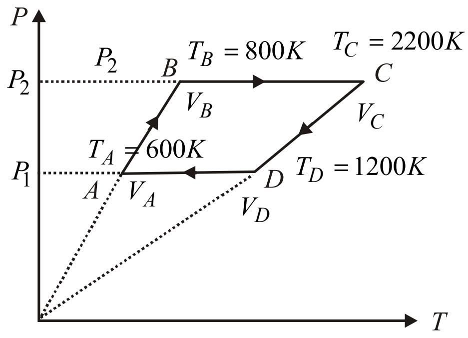
RESPONSE GRID	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 25 - PHYSICS			
Total Questions	28	Total Marks	112
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	26	Qualifying Score	42
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS — PHYSICS SOLUTIONS 25

1. (c) Processes A to B and C to D are parts of straight line graphs of the form $y = mx$



Also $P = \frac{\mu R}{V} T \; (\mu = 6)$

$\Rightarrow P \propto T$. So volume remains constant for the graphs AB and CD.

So no work is done during processes for A to B and C to D *i.e.*, $W_{AB} = W_{CD} = 0$ and

$$W_{BC} = P_2(V_C - V_B) = \mu R(T_C - T_B)$$
$$= 6R(2200 - 800) = 6R \times 1400 J$$

Also $W_{DA} = P_1(V_A - V_D) = \mu R(T_A - T_B)$
$$= 6R(600 - 1200) = -6R \times 600 \; J$$

Hence work done in complete cycle

$$W = W_{AB} + W_{BC} + W_{CD} + W_{DA}$$
$$= 0 + 6R \times 1400 + 0 - 6R \times 600$$
$$= 6R \times 900 = 6 \times 8.3 \times 800 = 40 \; kJ$$

2. (d) W= Area bonded by the indicator diagram with V-axis)

$$= \frac{1}{2}(P_A + P_B)(V_B - V_A)$$

3. (d) For path ab : $(\Delta U)_{ab} = 7000 \; J$

By using $\Delta U = \mu C_V \Delta T$

$$7000 = \mu \times \frac{5}{2} R \times 700 \Rightarrow \mu = 0.48$$

For path ca :

$(\Delta Q)_{ca} = (\Delta U)_{ca} + (\Delta W)_{ca}$ ....(i)

$\therefore (\Delta U)_{ab} + (\Delta U)_{bc} + (\Delta U)_{ca} = 0$

$\therefore 7000 + 0 + (\Delta U)_{ca} = 0 \Rightarrow (\Delta U)_{ca} = -7000 \; J$ .... (ii)

Also $(\Delta W)_{ca} = P_1(V_1 - V_2) = \mu R(T_1 - T_2)$

$= 0.48 \times 8.31 \times (300 - 1000) = -2792.16 \; J$ ......(iii)

on solving equations (i), (ii) and (iii)

$$(\Delta Q)_{ca} = -7000 - 2792.16 = -9792.16 \; J = -9800 J$$

4. (d) In all given cases, process is cyclic and in cyclic process $\Delta U = 0$.

5. (d) $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1} \Rightarrow \frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1} = \left(\frac{L_2 A}{L_1 A}\right)^{\frac{5}{3}-1} = \left(\frac{L_2}{L_1}\right)^{\frac{2}{3}}$

6. (d) Oxygen is diatomic gas, hence its energy of two moles

$$= 2 \times \frac{5}{2} RT = 5RT$$

Argon is a monoatomic gas, hence its internal energy of 4 moles $= 4 \times \frac{3}{2} RT = 6RT$

Total internal energy $= (6+5)RT = 11RT$

7. (c) $\eta_A = \frac{T_1 - T_2}{T_1} = \frac{W_A}{Q_1} \Rightarrow \eta_B = \frac{T_2 - T_3}{T_2} = \frac{W_B}{Q_2}$

$$\therefore \frac{Q_1}{Q_2} = \frac{T_1}{T_2} \times \frac{T_2 - T_3}{T_1 - T_2} = \frac{T_1}{T_2} \therefore W_A = W_B$$

$$\therefore T_2 = \frac{T_1 + T_3}{2} = \frac{800 + 300}{2} = 550K$$

8. (d) Initially $\eta = \frac{T_1 - T_2}{T_1} \Rightarrow 0.5 = \frac{T_1 - (273+7)}{T_1}$

$$\Rightarrow \frac{1}{2} = \frac{T_1 - 280}{T_1} \Rightarrow T_1 = 560K$$

Finally $\eta_1' = \frac{T_1' - T_2}{T_1'}$

$$\Rightarrow 0.7 = \frac{T_1' - (273+7)}{T_1'} \Rightarrow T_1' = 933K$$

$\therefore$ increase in temperature $= 933 - 560 = 373K \approx 380K$

9. (d) In both cylinders A and B the gases are diatomic $(\gamma = 1.4)$. Piston A is free to move *i.e.* it is isobaric process. Piston B is fixed *i.e.* it is isochoric process. If same amount of heat ΔQ is given to both then

$$(\Delta Q)_{isobaric} = (\Delta Q)_{isochoric}$$
$$\Rightarrow \mu C_P (\Delta T)_A = \mu C_\upsilon (\Delta T)_B$$
$$\Rightarrow (\Delta T)_B = \frac{C_P}{C\upsilon}(\Delta T)_A = \gamma(\Delta T)_A = 1.4 \times 30 = 42K$$

10. (b) In first case, $\eta_1 = \frac{T_1 - T_2}{T_1}$

In second case, $\eta_2 = \frac{2T_1 - 2T_2}{2T_1} = \frac{T_1 - T_2}{T_1} = \eta$

11. **(b)** $\eta = 1 - \frac{T_2}{T_1} \Rightarrow \frac{1}{2} = 1 - \frac{500}{T_1} \Rightarrow \frac{500}{T_1} = \frac{1}{2}$ ...(i)

$\frac{60}{100} = 1 - \frac{T_2'}{T_1} \Rightarrow \frac{T_2'}{T_1} = \frac{2}{5}$ ...(ii)

Dividing equation (i) by (ii),

$\frac{500}{T_2'} = \frac{5}{4} \Rightarrow T_2' = 400K$

12. **(a)** $\eta_{max} = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{400} = \frac{1}{4} = 25\%$

So 26% efficiency is impossible.

13. **(a)** $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{(273+123)}{(273+27)} = 1 - \frac{150}{300} = \frac{1}{2} = 50\%$

14. **(c)** $\eta = 1 - \frac{T_2}{T_1} \Rightarrow \frac{25}{100} = 1 - \frac{300}{T_1} \Rightarrow \frac{1}{4} = 1 - \frac{300}{T_1}$

$T_1 = 400K = 127^\circ C$

15. **(b)** $\Delta Q = \Delta U + \Delta W$

$\Rightarrow \Delta U = \Delta Q - \Delta W = Q - W$ (using proper sign)

16. **(b)**

17. **(a)** $J\Delta Q = \Delta U + \Delta W, \Delta U = J\Delta Q - \Delta W$

$\Delta U = 4.18 \times 300 - 600 = 654\ Joule$

18. **(b)** $\Delta Q = \Delta U + \Delta W$

$\Rightarrow \Delta W = \Delta Q - \Delta U = 110 - 40 = 70J$

19. **(a)**

20. **(a)** From FLOT

$\Rightarrow dU = dQ - dW \Rightarrow dU = dQ(<0) \quad (\therefore dW = 0)$

$\Rightarrow dU < 0$ So, temperature will decrease.

21. **(b)** From FLOT $\Delta Q = \Delta U + \Delta W$

Work done at constant pressure

$(\Delta W)_P = (\Delta Q)_P - \Delta U$

$(\Delta Q)_P - (\Delta Q)_V$ (As we know $(\Delta Q)_V = \Delta U$)

Also $(\Delta Q)_P = mc_P \Delta T$ and $(\Delta Q)_V = mc_V \Delta T$

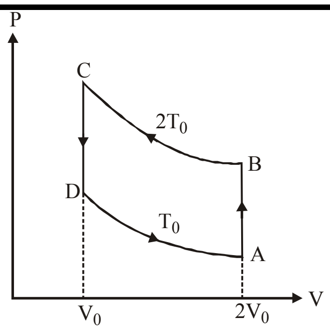
$\Rightarrow (\Delta W)_p = m(c_P - c_V)\Delta T$

$\Rightarrow (\Delta W)_P = 1 \times (3.4 \times 10^3 - 2.4 \times 10^3) 10 = 10^4$ Cal.

22. **(a)** Slow isothermal expansion or compression of an ideal gas is reversible process, while the other given process are irreversible in nature.

23. **(a)** For a reversible process $\int \frac{dQ}{T} = 0$

24. **(d)**

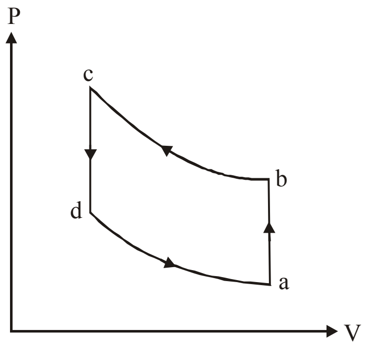


Here $W < 0 \Rightarrow Q < 0$ and $|W| = RT_0 \ln\left(\frac{V_0}{2V_0}\right) + 2RT_0$

$\ln\left(\frac{2V_0}{V_0}\right) = RT_0 \ln 2$

(25) (c) **(26) (b)** **(27) (b)**

(i)



Anticlockwise cycle $\Rightarrow W < 0$

(ii) Process ab : $W_{ab} = 0, \Delta U_{ab} > 0 \Rightarrow Q_{ab} > 0$

Process bc : $W_{bc} < 0, \Delta U_{bc} = 0 \Rightarrow Q_{bc} < 0$

Process cd : $W_{cd} = 0, \Delta U_{cd} < 0 \Rightarrow Q_{cd} < 0$

Process da : $W_{da} > 0, \Delta U_{da} = 0 \Rightarrow Q_{da} > 0$

(iii) da and bc are isothermal process.

28. **(a)** Second law of thermodynamics can be explained with the help of example of refrigerator, as we know that refrigerator, the working substance extracts heat from colder body and rejcts a large amount of heat to a hotter body with the help of an external agency i.e., the electric supply of the refrigerator. No refrigerator can ever work without external supply of electric energy to it.

29. **(d)** When the door of refrigerator is kept open, heat rejected by the refrigerator to the room will be more than the heat taken by the refrigerator from the room (by an amount equal to work done by the compressor). Therefore, temperature of room will increase and so it will be warmed gradually. As according to second law of thermodynamics, heat cannot be transferred on its own, from a body at lower temperature to another at higher temperature.

30. **(c)** As there is no change in internal energy of the system during an isothermal change. Hence, the energy taken by the gas is utilised by doing work against external pressure. According to FLOT

$$\Delta Q = \Delta U + p\Delta V$$

Hence, $\Delta Q = \Delta U = p\Delta V$

Therefore, statement-2 is true and statement-1 is false.