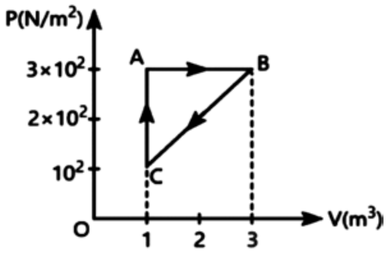
Ultimate KCET Crash Course 2026

PHYSICS

DPP: 1

Thermodynamics + KTG

Q1 For the given cycle, the work done during isobaric process is:

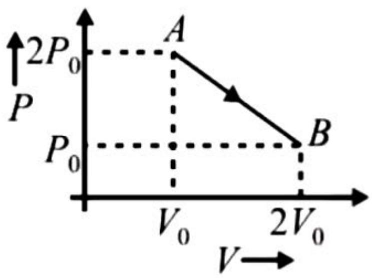


(A) 1.20 J
(B) zero
(C) 400 J
(D) 600 J

Q2 Temperature is a measurement of coldness or hotness of an object. This definition is based on
(A) Zeroth law of thermodynamics
(B) First law of thermodynamics
(C) Second law of thermodynamics
(D) Newton's law of cooling

Q3 When there is no heat change from surroundings in a system, then the process taking place is
(A) Adiabatic (B) Isothermal
(C) Isobaric (D) Isochoric

Q4 A sample of gas follows process A B, then which of the following is incorrect about A B ?

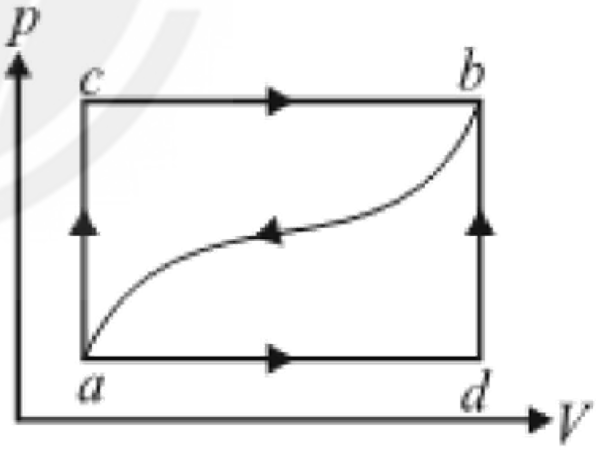


(A) $\Delta U = 0$ (B) W > 0
(C) Q = W (D) $\Delta U < 0$

Q5 In Carnot engine efficiency is 40% at hot reservoir temperature T. For efficiency 50% what will be temperature of hot reservoir?
(A) $\frac{T}{5}$ (B) $\frac{2T}{5}$
(C) 6 T (D) $\frac{6T}{5}$

Q6 The internal energy of perfect gas is
(A) Partly kinetic and partly potential
(B) Wholly potential
(C) Wholly kinetic
(D) Depends on the ratio of two specific heats

Q7 **When a system is taken from state 'a' to state 'b' along the path 'acb', it is found that a quantity of heat Q = 200 J is absorbed by the system and a work W= 80 J is done by it. Along the path 'adb', Q=144 J. If Ud=88 J, and Ub = 160 J heat absorbed for the path 'db' is**

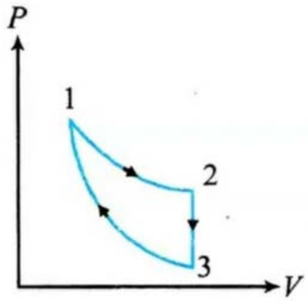


(A) –72 J
(B) 72 J
(C) 144 J
(D) –144 J

Q8 According to the second law of thermodynamics :
(A) heat energy cannot be completely converted to work
(B) work cannot be completely converted to heat energy
(C) for all cyclic processes we have dQ/T < 0
(D) the reason all heat engine efficiencies are less than 100% is friction, which is unavoidable

Q9 1 mole of an ideal gas at STP is subjected to a reversible adiabatic expansion to double its volume. The change in internal energy (γ = 1.4)
(A) 1169 J (B) 769 J
(C) 1373 J (D) 969 J

Q10 Three processes compose a thermodynamic cycle shown in the accompanying P-V, diagram of an ideal gas.
Process $1 \rightarrow 2$ takes place at constant temperature, during this process 60 *J* of heat enters the system.
Process $2 \rightarrow 3$ takes place at constant volume. During this process 40 *J* of heat leaves the system.
Process $3 \rightarrow 1$ is adiabatic.What is the change in internal energy of the system during process $3 \rightarrow 1$?



(A) –40 J (B) –20 J
(C) +20 J (D) +40 J

Q11 In which of the following processes, heat is neither absorbed nor released by a system?
(A) Adiabatic (B) Isobaric
(C) Isochoric (D) Isothermal

Q12 When the door of a refrigerator is kept open then the room temperature starts to
(A) cool down
(B) heat up
(C) first cool down then hot up
(D) neither cool down nor hot up

Q13 A carnot engine shows efficiency of 40% on taking energy at 500 *K*. To increase the efficiency to 50%, at what temperature it should take energy?
(A) 400 K (B) 700 K
(C) 600 K (D) 800 K

Q14 "Heat cannot flow by itself from a body at lower temperature to a body at higher temperature" is a statement or consequence of:
(A) second law of thermodynamics
(B) conservation of momentum
(C) conservation of mass
(D) first law of thermodynamics

Q15 A system is taken from a given initial state to a given final state along various paths represented on a *P-V* diagram. The quantity that is independent of the path is
(A) amount of heat transferred Q
(B) amount of work done W
(C) Both Q and W
(D) (Q – W)

Q16 If the absolute temperature of a gas is increased 5 times, the r.m.s. velocity of the gas molecules will be
(A) 5 times (B) 10 times
(C) $\sqrt{5}$ times (D) 25 times

Q17 The average energy per molecule of a triatomic gas at room temperature T is
(A) $3kT$ (B) $\frac{1}{2}kT$
(C) $\frac{3}{2}kT$ (D) $\frac{5}{2}kT$

Q18 According to the kinetic theory of gases, the root mean square velocity of gas molecules is directly proportional to

(A) T (B) $\sqrt{T}$

(C) T^2 (D) $T^{3/2}$

Q19 A perfect gas at 27°C is heated at constant pressure, so as to double its volume. The increase in temperature of the gas will be:

(A) 300°C (B) 54°C

(C) 327°C (D) 600°C

Q20 The value of $\gamma\left(=\frac{C_p}{C_v}\right)$, for hydrogen, helium and another ideal diatomic gas X (whose molecules are not rigid but have an additional vibrational mode), are respectively equal to

(A) $\frac{7}{5}, \frac{5}{3}, \frac{9}{7}$ (B) $\frac{5}{3}, \frac{7}{5}, \frac{9}{7}$

(C) $\frac{5}{3}, \frac{7}{5}, \frac{7}{5}$ (D) $\frac{7}{5}, \frac{5}{3}, \frac{7}{5}$

Q21 According to law of equipartition of energy, the energy associated with each degree of freedom is:

(A) $\frac{1}{2}K_BT$ (B) $\frac{3}{2}K_BT$

(C) $\frac{1}{3}K_BT$ (D) K_BT

Q22 The volume of a gas at pressure 21×104 N/m^2 and temperature 27°C is 83 litres. If R = 8.3 J/mol/K, then the quantity of gas in gm-mole will be

(A) 15 (B) 42

(C) 7 (D) 14

Q23 One mole ideal monatomic gas is taken at temperature of 300 K . If volume is doubled keeping its pressure constant. The change in the internal energy is

(A) 450 R (B) 550 R

(C) 650 R (D) 750 R

Q24 An ideal gas having molar specific heat capacity at constant volume is $\frac{3}{2}R$, the molar specific heat capacity at constant pressure is

(A) $\frac{1}{2}R$ (B) $\frac{5}{2}R$

(C) $\frac{7}{2}R$ (D) $\frac{9}{2}R$

Q25 Pressure of an ideal gas is increased by keeping temperature constant. What is the effect on kinetic energy of molecules?

(A) Increase

(B) Decrease

(C) No change

(D) Can't be determined

Q26 The average energy of molecules in a sample of oxygen gas at 300 K are 6.21×10^{-21} J. The corresponding values at 600 K are

(A) 12.12×10^{-21} J

(B) 8.78×10^{-21} J

(C) 6.21×10^{-21} J

(D) 12.42×10^{-21} J

Q27 **At constant pressure the r.m.s. velocity c is related to density d as:**

(A) c d

(B) c 1/d

(C) c √d

(D) c 1/ √d

Q28 Increase in temperature of a gas filled in a container would lead to

(A) decrease in intermolecular distance

(B) increase in its mass

(C) increase in its kinetic energy

(D) decrease in its pressure

Q29 Estimate the mean free path and collision frequency of a nitrogen molecule in a cylinder containing nitrogen at 2.0 atm and temperature 17° C. Take the radius of a nitrogen molecule to be roughly 1.0Å

.

(A) 2.0×10^{-7} m, 5.9×10^{2} s^{-1}

(B) 1.1×10^{-7} m, 4.6×10^{9} s^{-1}

(C) 1.5×10^{-7} m, 5.6×10^{9} s^{-1}

(D) 2.5×10^{-7} m, 6.1×10^{2} s^{-1}

Q30 How many degrees of freedom are there in monoatomic gas?

(A) 3 (B) 5

(C) 7 (D) 1

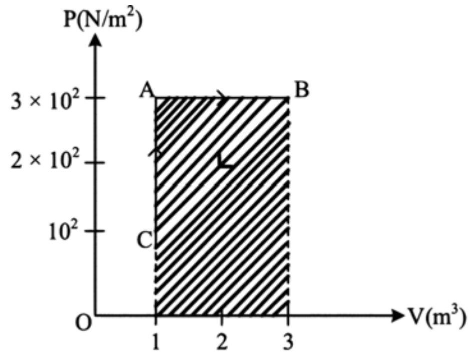
Answer Key

Q1	D
Q2	A
Q3	A
Q4	D
Q5	D
Q6	C
Q7	B
Q8	A
Q9	C
Q10	D
Q11	A
Q12	B
Q13	C
Q14	A
Q15	D
Q16	C
Q17	A
Q18	B
Q19	A
Q20	A
Q21	A
Q22	C
Q23	A
Q24	B
Q25	C
Q26	D
Q27	D
Q28	C
Q29	B
Q30	A

Hints & Solutions

Note: scan the QR code to watch video solution

Q1 Text Solution:



AB is isobaric process

$W_{AB} = P(V_2 - V_1)$

$W_{AB} = 3 \times 10^2(3 - 1)$

$W_{AB} = 3 \times 100 \times 2$

$W_{AB} = 600$ J.

Video Solution:

Q2 Text Solution:

Zeroth law of thermodynamics states the conept of temperature/thermal euqilibrium.

Video Solution:

Q3 Text Solution:

In adiabatic process exchange of heat between system and surrounding is Zero.

Video Solution:

Q4 Text Solution:

$At\ point\ A,\ 2P_oV_o = nRT_A$

$T_A = \frac{2P_oV}{nR}$

$At\ point\ B,\ \ P_o2V_o = nRT_B$

$T_B = \frac{2P_oV}{nR}$

$\Delta U = nC_v \Delta T = nC_v\left(T_B - T_A\right)$

$\Delta U = 0$

$\Rightarrow \Delta Q = \Delta W$

$Since\ the\ gas\ is\ expanding\ from\ A\ to\ B,$

$W \geq 0$

Video Solution:

Q5 Text Solution:

$\eta = 1 - \frac{T_2}{T_2}$

T_1 = Temperature of hot reservoir = T

For $\eta = 40\%$

$\frac{40}{100} = 1 - \frac{T_2}{T} \Rightarrow \frac{T^2}{T} = \frac{3}{5}$

$\Rightarrow T_2 = \frac{3}{2}T \Rightarrow T_2 < T$

For $\eta = 50\%$

$\frac{50}{100} = 1 - \frac{\frac{3}{5}T}{T_1} \Rightarrow T_1 = \frac{6T}{5}$

Video Solution:

Q6 Video Solution:

Q7 Text Solution:

Along the path DB,

Volume = constant

$\Delta V = 0$

Hence from first law, $\Delta Q = \Delta U + \Delta W$

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

$\Delta Q_{DB} = \Delta U_{DB}$

$\Delta Q_{DB} = U_B - U_D$

= 160 - 88

ΔQ_{DB} = 72 J

Video Solution:

Q8 Text Solution:

The efficiency of a heat engine cannot be equal to 1.

means, heat energy supplied cannot be completely converted into work.

Video Solution:

Q9 Text Solution:

For adibatic expansion,

$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

$T_2 = T_2\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 273\left(\frac{1}{2}\right)^{1.4-1}$

$= 206.89K$

$dU = dW = \frac{R}{\gamma-1}(T_1 - T_2)$

$= \frac{1\times8.31}{(1.4-1)}(273 - 206.89) \simeq 1373\,J$

Video Solution:

Q10 Text Solution:

40J

Video Solution:

Q11 **Text Solution:**

In an adiabatic process, the system is completely insulated from the surroundings. Thus, heat is neither absorbed nor released by the system to the surroundings. So, ΔQ = 0.

Video Solution:

Q12 **Text Solution:**

The mechanism of refrigerator involves tranferring the warm air from inside to the environment. But if the door is left open, then the warm air from environment enters the refrigerator, hence now it has to do more work to keep the interior cold. Hence it puts more pressure on the compressor or motor, and more heat is generated which is released in the environment.

Video Solution:

Q13 **Text Solution:**

$\eta = 40\% = \frac{40}{100} = 1 - \frac{T_2}{T_1}$

$1 - \frac{T_2}{500} = \frac{2}{5}$

$\frac{3}{5} = \frac{T_2}{500}$

$T_2 = 300K$

$For\ ,\ \eta = 50\%$

$\frac{50}{100} = 1 - \frac{T_2}{T_1{}'}$

$\frac{1}{2} = 1 - \frac{300}{T_1{}'}$

$T_1{}' = 2 \times 300 = 600K$

Video Solution:

Q14 **Text Solution:**

Clausius statement : (statement of second law of thermodynamics)

Heat cannot flow from a body at lower temperature to a body at higher temperature unless some external work is done.

Video Solution:

Q15 **Text Solution:**

The only quantity (Q – W) which itself is the internal energy of the system is independent of the path.

Video Solution:

Q16 **Text Solution:**

As r.m.s velocity of the gas molecules

$v_{r.m.s} = \sqrt{\frac{3RT}{M}} \ldots \text{(i)}$

Now Temperature '*T*' increased to 5 *T*

From equation (i),

$v_{rms} = \sqrt{\frac{3R(5T)}{M}} = \sqrt{5} v_{rms}$

Video Solution:

Q17 **Text Solution:**

A triatomic (non-linear) gas molecule has 6 degrees of freedom (3 translational, 3 rotational and no vibrational) at room temperature. According to the law of equipartition of energy, the average energy per molecule of a triatomic gas at room temperature *T* is $\overline{E} = \frac{1}{2} fkT = \frac{1}{2} 6kT = 3kT$

Video Solution:

Q18 **Text Solution:**

$v_{\text{rms}} = \sqrt{\frac{3KT}{m}} \therefore v_{\text{rms}} = \sqrt{T}$

Video Solution:

Q19 **Text Solution:**

(1)

According to Charles' law, $\frac{V_1}{V_2} = \frac{T_1}{T_2}$

Given, T_1 =27°*C* + 273 = 300 *K.*

$V_1 = V, V_2 = 2V$

$\therefore \quad \frac{1}{2} = \frac{300K}{T_2}$

$\Rightarrow \quad T_2 = 600K = 600 - 273 = 327°C$

Increase in temperature, $\Delta T = 327 - 27 = 300°C$.

Video Solution:

Q20 **Text Solution:**

$\gamma = 1 + \frac{1}{n}$

For H_2, $\gamma = 1 + \frac{2}{5} = \frac{7}{5}$;

For He, $\gamma = 1 + \frac{2}{3} = \frac{5}{3}$;

For X, $\gamma = 1 + \frac{2}{7} = \frac{9}{7}$;

Video Solution:

Q21 Text Solution:

(1)

Energy associated with each degree of freedom is $\frac{1}{2}K_BT$

Video Solution:

Q22 Text Solution:

$P = 21 \times 10^4 \mathrm{Nm}^{-2}$

T=27+273=300 k

$V = 83\ \mathrm{h} = 83 \times 10^{-3}\ \mathrm{m}^3$

$\mu = ?$

$$M = \frac{PV}{RT} = \frac{\frac{2^7+10^4\times83\times10^{-3}}{85\times300}=7\times10^{1-1}=7}{300}$$

Video Solution:

Q23 Text Solution:

Since pressure is constant, $V \propto T$

$\therefore \ \frac{V_i}{T_i} = \frac{V_f}{T_f}$

or $T_f = \frac{V_f}{V_i}T_i = 2T_i = 2 \times 300 = 600\ \mathrm{K}$

$\therefore \ \Delta \mathrm{U} = \frac{\mathrm{f}}{2}\mathrm{nR}\Delta\mathrm{T}$

$\left(\mathrm{f} = \text{ degrees of freedom }\right)$

$= \frac{3}{2} \times 1 \times \mathrm{R} \times \left(600 - 300\right) = 450\mathrm{R}$

Video Solution:

Q24 Text Solution:

(2)

Here, $C_V = \frac{3}{2}R$

Since, $C_p - C_v = R$

$\Rightarrow \ C_p = C_v + R = \frac{3}{2}R + R = \frac{5}{2}R$

So, molar specific heat capacity at constant pressure $= \frac{5}{2}R$.

Video Solution:

Q25 Text Solution:

Kinetic energy of an ideal gas depends only on its temperture. Hence it remains constant wheler its pressrue in increased or decreased.

Video Solution:

Q26 Text Solution:

The average kinetic energy of molecules in a sample of oxygen gas is given by

$KE_{avg} = \frac{3}{2}k_B T$ or $\frac{(KE_{avg})_1}{(KE_{avg})_2} = \frac{T_1}{T_2}$

Here, $(KE_{avg})_1 = 6.21 \times 10^{-21}$ J, $T_1 = 300$ K,

$T_2 = 600$ K, $(KE_{avg})_2 = ?$

$\frac{6.21\times10^{-21}}{(KE_{avg})_2} = \frac{300}{600} = \frac{1}{2}$ or $(KE_{avg})_2 = 12.42 \times 10^{-21}$ J

Video Solution:

Q27 Text Solution:

c 1/ √d

Video Solution:

Q28 Text Solution:

As per kinetic theory of gases, kinetic energy of gas molecules is directly proportional to the temperature of the gas.

Video Solution:

Q29 Text Solution:

$\lambda = \frac{1}{\sqrt{2}\pi d^2 n_V}$

n_V = no.of molecule per unit volume $\left(\frac{N}{V}\right)$

$PV = nkT$

$n_V = \frac{N}{V} = \frac{P}{kT}$

$\lambda = \frac{kT}{\sqrt{2}\pi d^2 P}$

$= \frac{1.38\times10^{-23}\times290}{1.41\times3.14\times(2\times10^{-10})^2\times(2\times1.01\times10^5)}$

$\lambda = 1.11 \times 10^{-7}$ m

collision frequency $\frac{v_{rms}}{\lambda}$

$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3\times8.31\times290}{28\times10^{-3}}} = 508.26$ m / sec

collision frequency $= \frac{508.26}{1.11\times10^{-7}} = 4.58 \times 10^9\ s^{-1}$

Video Solution:

Q30 Text Solution:

The degree of freedom refers to how many distinct directions a gas molecule may travel in.

In the formal description of the state of a physical system, it is a separate physical parameter. The term "degrees of freedom" describes the variety of spatial motions, rotations, and vibrations that a gas phase molecule may make. When applying the equipartition theorem to calculate the values of various thermodynamic variables, the degree of freedom a molecule has an impact.

Degrees of freedom come in three different categories, including translational, rotational, and vibrational. The number of atoms in a molecule and the shape of the molecule determine how many degrees of freedom of each kind the molecule has.

For translation motion, a monoatomic gas has three degrees of freedom.

Therefore, choice A is right.

Video Solution: