# PHYSICS

# BOOKS - S CHAND PHYSICS (ENGLISH)

# INTERNAL ENERGY

## Example

**1.** 4 mole of helium gas at temperatures of 300 K is taken in a cylinder. (i) What is the heat required to increase its temperature to 600 K, if it is heated at constant volume (ii) what is the heat required to raise the temperature of the gas at constant pressure to 600 K ? (iii) What is the work done by the gas during the process ? Given $C_v = 12.5 J/molK, C_p = 20.8 J/mol$ K.

Watch Video Solution

**2.** Calculate the specific heat capacities at constant volume and constant pressure for

$CO(2)$, Given

$\gamma = 1.30, R = 8.33 J mol^{-1} K^{-1}$.

Watch Video Solution

**3.** A cylinder of volume $10m^3$ contains hydrogen gas at 300 K. What is the quantity of heat required to raise the temperature of the gas to 303 K? Using this energy a body of mass m can be lifted to a height of 10 m. What is the body ? Density of hydrogen is $8.9 \times 10^{-2} Kg/m^2 - C_v = 20.4 J mol^{-1} K^{-1}$.

Watch Video Solution

**4.** A gas at a pressure of 1 atm is compressed at a constant pressure from $10.0$ litres to $2.0$ litres. If 500 J of heat energy leaves the gas calculate (i) the work done by the gas and (ii) the change in its internal energy.

Watch Video Solution

**5.** Calculate the difference in temperature between the water at the top and bottom of a water fall 200 m high. Specific heat capacity of water $42000 J kg^{-1} K^{-1}$.

Watch Video Solution

6. A lead bullet strikes an iron wall with a velocity of $400 ms^{-1}$. If the bullet falls dead and the heat produced is equally shared between bullet and the wall find the rise in temperature of the bullet. Given, specific heat of bullet $= 125.6 J kg^{-1} K^{-1}$.

Watch Video Solution

**7.** A certain amount of water of mass m, at a temperature $T_2$ cools.to temperature $T_1$. The heat given out by the water is absorbed by n mole of an ideal gas. The gas expands at constant temperature T and changes its volume from $V_i$ to $V_f$ What is its initial volume ?

Watch Video Solution

**8.** A copper bar of mass $1.5kg$ is heated at atmospheric pressure. Its temperature is increased from $30^\circ C$ to $60^\circ C$

(i) What is the work done by the copper ?

(ii) Calculate the amount of heat energy transferred to the copper.

(iii) What is the increase in internal energy of the copper ?

Coefficient of volume expansion of copper is $5.1 \times 10^{-5} (^\circ C)^{-1}$. Density of copper is $8.92 \times 10^3 kg/m^3$. Specific heat capacity of copper is $387 J kg^{-1} K^{-1}$.

Watch Video Solution

**9.** Four moles of an ideal gas at a pressure of 4 atm and at a temperature of $70^{\circ} C$ expands is othermally to four times its initial volume : What is (i) the final temperature and (ii) the final volume ?

Watch Video Solution

**10.** $0.5$ litre of an ideal gas at a pressure of 20 atm expands to a final volume of $0.5m^3$. The process obeys the equation PV = a constant, (i) Find the value of this constant (ii) What is the final pressure ? And (iii) Find, the work done by the gas,

Watch Video Solution

**11.** A glass bulb can withstand a pressure of 2 atm. It constains air at a temperature of 303 K and at one atmospheric pressure. What is the temperature at which the bulb bursts ? (Neglect the expansion of the bulb) $\gamma = 1.4$

Watch Video Solution

12. One gm mole of an ideal gas at S.T.P is subjected to a reversible adiabatic expansion to double its volume. Find the change in internal energy in the process. Given $\gamma = 1.4[E.Q.]$

Watch Video Solution

13. One litre of an ideal gas at a pressure of 6 atm undergoes an adiabatic expansion until its pressure drops to one atmosphere and volume increases to 2 litre. Find the word done during the process. $[\gamma = 1.4]$.

Watch Video Solution

14. The volume of a certain mass of gas at a pressure of $5 \times 10^4 Pa$ is doubled

adiabatically. What is the final pressure of the gas ? $[\gamma = 1.4]$

Watch Video Solution

**15.** A cylinder has a movable piston on its top. The piston has a mass of 7 kg and an area of $6 \times 10^{-4} m^2$. The piston can slide up and down, keeping the pressure of the ideal gas enclosed in the cylinder constant. What is the work done if the temperature of 0.5 mol of the gas in raised from $30^{\circ}C$ to $250^{\circ}C$? $\left[R=8.31 Jmol^{-1}K^{-1}\right]$

Watch Video Solution

**16.** During an isobaric heating process the work done by oxygen gas is 4 J. Calculate the amount of heat transferred to the gas. $[\gamma = 1.4]$

Watch Video Solution

**17.** Three moles of an ideal gas at a pressure $P_A$ and temperature $T_A$ is isothermally expanded to twice its initial volume. It is then compressed at constant pressure to its original , volume. Finally the gas is compressed at constant volume to its original pressure $P_A$

(a) Sketch the P-V and P-T diagrams for the complete process.

(b) Calculate the net work done by the gas, and net heat supplied to the gas during the complete process.

Watch Video Solution

**18.** Four moles of a diatomic gas (g = 1.4) at a temperature of 300 K were cooled isochorically, so that the final pressure was 1/3 times the original pressure. The gas was allowed to expand isobarically till its temperature got back to its original value. Calculate the total amount of heat absorbed during the process. R = 8.31 J $mol^{-1}K^{-1}$.

Watch Video Solution

**19.** Two moles of an ideal gas was heated isobarically so that its temperature was raised by 100 K. The heat absorbed during the process was 4000 J. Calculate (i) the work done by the gas, (ii) the increase in internal energy and (ii) the value of y for the gas $\left[R = 8.31 Jmol^{-1}K^{-1}\right]$.

Watch Video Solution

## Solved Examples

**1.** Calculate the efficiency of a carnot engine working between the two temperatures: $30^{\circ} C$ and $100^{\circ} C$

Watch Video Solution

**2.** One of the most efficient engines ever developed operates between 2100 K and 700 K. Its actual efficiency is 40%. What percentage of its maximum possible efficiency is this?

Watch Video Solution

**3.** Calculate the efficiency of an engine whose working substance absorbs 3000 J of heat from the source and rejects 2000 J of heat to the sink.

Watch Video Solution

**4.** The power output of a carnot engine is 100 kW. The engine operates between two reservoirs at $30^{\circ}C$ and $300^{\circ}C$ (i) How much heat is absorbed per hour ? (ii) How much heat is Tost per hour ?

Watch Video Solution

**5.** Find the theoretical maximum efficiency of a steam engine using an intake steam temperature of $100^\circ C$, if it is operated in a place where the exhaust temperature is $0^\circ C$. If super heated steam at $200^\circ C$ is used, what is the maximum possible efficiency?

Watch Video Solution

**6.** In a reciprocating steam engine, the average pressure of steam is $10^4 N/m^2$, The length of the stroke is 1 m and the area of the piston is $0.15m^2$. Calculate the power of the engine, if it makes 5 strokes per second.

Watch Video Solution

**7.** Calculate the efficiency of a petrol engine if its compression ratio is 5. Given y = 1.4. If the power of the engine is 25kW what is its input power ?

Watch Video Solution

8. Calculate the coefficient of performance of an ideal refrigerator working between $-13^\circ C$ and $27^\circ C$ ?

Watch Video Solution

**9.** A carnot refrigerator absorbs heat from water at $0^\circ C$ and gives it to a room at $27^\circ C$. Find the work done by the refrigerator and the coefficient of performance of the machine when it changes 2 kg of water at $0^\circ C$ to ice at $0^\circ C$. Specific latent heat of ice $= 333 \times 10^3 Jkg^{-1}$?

Watch Video Solution

## Additional Solved Problems

**1.** One mole of an ideal gas undergoes a cyclic change ABCD. Calculate from the diagram. (P is in atm, and V in litre)

(i) Work done along AB, BC, CD and DA.

(ii) What is the net work done in the process ?

(iii). What is the efficiency of the process ?

(iv) What is the net change in internal energy of the gas ?

Given $1atm = 1.01 \times 10^5 Nm^{-2}$

View Text Solution

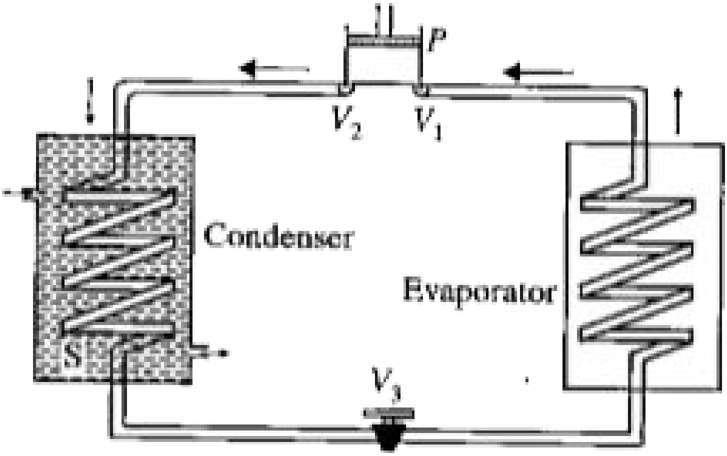
**2.** a thermodynamic system is taken from the state i to statef along the path iaf. It is found that the heat absorbed by the system is 40 cal and work done by the system is 16.19 cal. Along the path i bf, the heat absorbed is 35 cal.

(a) Find the work done along the path i bf.

(b) If W = - 10 cal for the curved return path fi, what is for this path ?

(c) Take $U_b = 20cal,$ what is $U_f$ ?

(d) If $U_b = 20$ cal, what is for the process ib?




Watch Video Solution

**3.** 1 g of water at $100^{\circ} C$ is converted into steam at the same temperature. If the volume of steam is 1671 cc find the change in internal energy of the system. Latent heat of steam $= 2256 J g^{-1}$.

Watch Video Solution

4. One mole of a gas at $27^{\circ} C$ and 3 atmospheric pressure is compressed to 1/3 of its volume (a) slowly (b) suddenly. What is the resulting temperature ? $\gamma = 1.4$.

Watch Video Solution

**5.** A tyre has air pumped at a pressure of 4 atmosphere at the room temperature $27^{\circ}C$. If the tyre bursts suddenly calculate the final temperature. $\gamma = 1.4$

Watch Video Solution

**6.** Specific heat capacity at constant pressure and at constant volume for nitrogen are respectively

$1040 Jkg^{-1} K^{-1}$ and $743 Kg^{-1} K^{-1}$.

Calculate the universal gas constant ?[E.Q.]

Watch Video Solution

**7.** If the specific heat capacity of air at constant pressure is $993 Jkg^{-1} K^{-1}$ calculate specific heat capacity at constant volume ? Density of air at N.T.P. is $1.293 Kg/m^3$. [E.Q.)

Watch Video Solution

**8.** The value of the specific heat at constant pressure for hydrogen is $3.4 kcal kg^{-1} {}^\circ C^{-1}$. Determine $C_V$ for hydrogen if J = 4.2 J/cal. Density at NTP is `8.9 x 10^(-5) kg/litre. [E.Q]

Watch Video Solution

**9.** If f is the number of degrees of freedon of a gas, show that $\gamma = 1 + \frac{2}{f}$.

Watch Video Solution

**10.** The efficiency of a cannot's engine is 20%. When the temperature of the source is increased by $25^{\circ}C$, then its efficiency is found to increase to 25%. Calculate the temperature of source and sink.

Watch Video Solution

**11.** Ice melts at the rate of 5 kg per hour in a cold storage when the temperature outside is 300 K. Calculate the minimum power of the motor is to be used to drive a refrigerator to just prevent the melting of ice. Specific latent heat of usion of ice $= 3.3 \times 10^5 Jkg^{-1}$. [E. Q]

Watch Video Solution

**12.** In a heat engine, the temperature of the source and sink are are 500K and 375 K. If the engine consumes $25 \times 10^5$J per cycle, the work done per cycle is

Watch Video Solution

## Conceptual Short Answer Questions With Answers

**1.** Distinguish between a closed system and an open system.

Watch Video Solution

**2.** What is meant by zero isothermal ?

Watch Video Solution

**3.** Show that $C_V = \dfrac{R}{\gamma - 1}$

Watch Video Solution

**4.** Distinguish between isobaric and isochoric process.

Watch Video Solution

**5.** Adiabatic expansion produces cooling, why?

Watch Video Solution

**6.** Define latent heat of fusion and latent heat of vaporisation.

Watch Video Solution

**7.** Can you cool a room by keeping the fridge open ?

Watch Video Solution

**8.** What is the use of the indicator diagram or PV diagram?

Watch Video Solution

**9.** What is meant by a cyclic process ?

Watch Video Solution

**10.** What is significance of first law of thermodynamics ?

Watch Video Solution

**11.** Give the limitations of the first law of thermodynamics.

Watch Video Solution

**12.** "Steam engine is called a reciprocating double-acting engine". Why?

Watch Video Solution

**13.** "The efficiency of all real engines are less than that of the carnot engine." Why?

Watch Video Solution

**14.** What is a heat pump ?

Watch Video Solution

**15.** Under what conditions can a Carnot engine have 100% efficiency?

Watch Video Solution

16. "A carnot engine is called an ideal engine." Why?

Watch Video Solution

17. Why is it impossible for a ship to use the internal energy of sea water to operate its engine?

Watch Video Solution

## Long Answer Questions

**1.** What are the two specific heat capacities of a gas and why are they different? Find the difference between the two molar heat capacities in terms of the constant R.

Watch Video Solution

**2.** An ideal gas has its volume doubled under (i) isothermal conditions and (ii) isobaric (constant pressure) conditions:

(i) Write down expressions for the work done by the gas in the two cases and calculate their ratio.

(ii) In which case does the internal energy of the gas increase?

Watch Video Solution

**3.** The Zeroth law of thermodynamics leads to the concept of

Watch Video Solution

**4.** The volume of an ideal gas Vis filled in a cylinder fitted with a piston at pressure P: The volume of the gas is changed to 4V each time by three different processes : (i) Change at constant pressure (ii) Adiabatic change (iii) Isothermal changes. Show these changes on P-V diagram. State giving reason in which change the work done is maximum.

Watch Video Solution

**5.** What is meant by (i) an adiabatic and (ii) an isothermal change of state of a gas. An ideal gas is expanded adiabatically from volume $V_1$ to volume $V_2$ is then compressed isothermally to its original volume $V_1$ Draw the P-V curves representing the above changes. How will you show. in your graph the net work done by the gas?

Watch Video Solution

**6.** What are the two specific heat capacities of a gas and why are they different? Find the difference between the two molar heat capacities in terms of the constant R.

Watch Video Solution

**7.** (a) What is a heat engine ?

Name the important part of a heat engine.

(b) Explain the working of a Carnot engine. Obtain an expression for its efficiency.

Watch Video Solution

8. (a)Compare the otto cycle with diesel cycle.

(b)Explain the working of a diesel engine. Derive an expression for its efficiency.

Watch Video Solution

## Short Answer Questions

1. Is there any difference between the phrases 'change of state' and 'change of phase' when

used in thermodynamics?

Watch Video Solution

**2.** Explain first law of thermodynamics. What'is its physical significance ?

Watch Video Solution

**3.** Define internal energy of a gas. Why do we say that internal energy is an exact differential ?

Watch Video Solution

**4.** Distinguish between external work and internal work.

Watch Video Solution

**5.** Show that heat is a path function.

Watch Video Solution

**6.** What is the use of the indicator diagram or PV diagram?

Watch Video Solution

**7.** What do you mean by saying that the work done by a system is a path function?"

Watch Video Solution

**8.** What is the difference between (i) heat capacity (ii) specific heat capacity and (iii) molar specific heat capacity.

Watch Video Solution

**9.** Can we define specific heat capacity at constant temperature?

Watch Video Solution

**10.** Define molar specific heat capacities of a gas at constant pressure and constant volume. Why are they called 'principal specific heat capacities?

Watch Video Solution

**11.** What is $\gamma$ ? Obtain the value of $\gamma$ for (i) monatomic (ii) diatomic and (iii) triatomic gas.

Watch Video Solution

**12.** Using first law of thermodynamics show that Q and W are path functions.

Watch Video Solution

**13.** Distinguish between reversible and irreversible processes.

Watch Video Solution

**14.** For an isothermal process

Watch Video Solution

**15.** For an adiabatic compression the quantity pV

Watch Video Solution

**16.** Derive an expression for the work done during adiabatic process.

Watch Video Solution

**17.** Write down the relation for an adiabatic process in terms of (i) P and V (ii) T and V and (iii) P and T.

Watch Video Solution

**18.** Show that the adiabatic curve is steeper than the isothermal curve.

Watch Video Solution

**19.** Explain the difference between isobaric and isochoric processes.

Watch Video Solution

**20.** Draw P-V diagrams to show (i) isobaric process and (ii) isochoric process.

Watch Video Solution

**21.** How will you find the change in internal energy of a system when it melts ?

Watch Video Solution

**22.** On a phase diagram draw the fusion curve, vaporisation curve and sublimation curve. Define triple point.

Watch Video Solution

**23.** A gas has more than one specific heats, whereas a liquid and solid have only one. Why?

OR

Why gas has two principle specific heat capacties.

Watch Video Solution

**24.** The slope of a line in the standard (x,y) coordinate plane is 4. What is the slope of a line perpendicular to that line ?

Watch Video Solution

**25.** The temperature of an ideal gas is increased from $27^{\circ} C \text{to} 127^{\circ} C$, then percentage increase in $v_{rms}$ is

Watch Video Solution

**26.** Assertion : The efficiency of a heat engine can never be unity.

Reason : Efficiency of heat engine is

fundamental limitation given by first law of thermodynamics.

Watch Video Solution

**27.** Draw a Carnot cycle and on the diagram mark the work done by the engine.

Watch Video Solution

**28.** Name the working substance used in (i) Camot engine, (ii) Steam engine, (iii) Petrol engine, and (iv) diesel engine.

Watch Video Solution

**29.** Draw the diesel cycle and give the name of the four strokes. Show the work done by the engine on the diagram

Watch Video Solution

**30.** State and explain the second law of thermodynamics.

Watch Video Solution

## Very Short Answer Questions

**1.** "A match stick can be lighted by rubbing it against a rough surface". Why?

Watch Video Solution

**2.** In what way does the temperature of water at the bottom of a waterfall differ from the temperature at the top ? Explain the reason.

Watch Video Solution

3. "It is not advisable to put on wet clothes". Why?

Watch Video Solution

4. Is it possible that the specific heat capacity of a gas is zero as well as infinity ?

Watch Video Solution

**5.** Is it possible to heat a body without causing any rise in temperature ?

Watch Video Solution

**6.** Mention two factors on which the degrees of freedom of a gas depends.

Watch Video Solution

**7.** Which one of the following substances has highest specific heat capacity at room temperature and atmospheric pressure ? a) Water b) Ice c) Aluminum d) Mercury

Watch Video Solution

**8.** Weight of a body of mass m decreases by 1% when it is raised to height h above the earth's surface. If the body is taken to a depth h in a mine, change in its weight is:

Watch Video Solution

**9.** What is the change in internal energy of a system undergoing a cyclic process, at the end of a cycle ?

Watch Video Solution

**10.** The relationship between enthalpy and internal energy change is

Watch Video Solution

**11.** Is it possible in increase the temperature of a gas without adding heat to it ? Explain.

Watch Video Solution

**12.** A planet in a distant solar system is 10 times more massive than the earth and its radius is 10 times smaller. Given that the escape velocity from the earth is 11 km $s^{-1}$, the escape velocity from the surface of the planet would be $x \times 11$ km/s. Find x.

Watch Video Solution

**13.** The second law of thermodynamics is a fundamental law of science. In this problem, we consider the thermodynamics of an ideal gas, phase transition, and chemical equilibrium.

Three moles of $CO_2$ gas expands isothermally (in thermal contact with the surroundings, temperature $= 15.0^{\circ} C$) against a fixed external pressure of $1.00^{-}$. The initial and final volumes of the gas are $10.0L$ and $30.0L$, respectively.

Assuming $CO_2$ to be an ideal gas, $\Delta_{sys} S$ is

Watch Video Solution

**14.** Milk is poured into a cup of tea and is mixed with a spoon. Is this an example of a reversible process ? Give reason in support of your answer.

Watch Video Solution

**15.** What is the effect of pressure on the fusion and boiling point of water?

Watch Video Solution

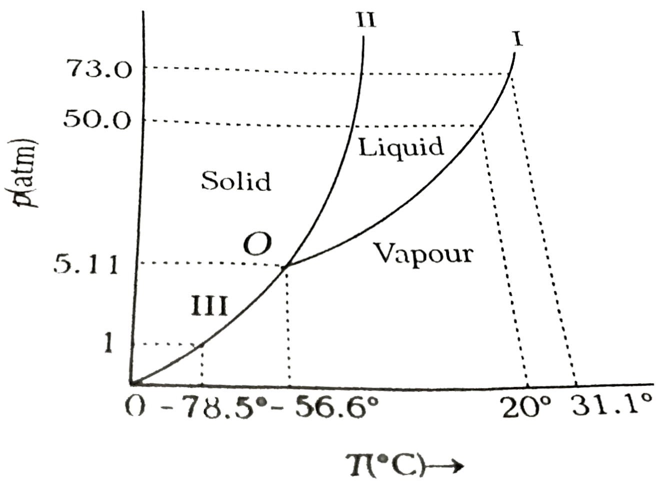
**16.** Answer the following questions based on the p-T phase diagram of carbon dioxide as shown in the figure .

(i) At what temperature and pressure can the solid , liquid and vapour phases of $C0_2$ co-exist in equilibrium?

(ii) What is the effect of decrease of pressure on the fusion and boiling point of $C0_2$ ?

(iii) What are the critical temperature and pressure for $C0_2$ ? what is their significance ?

(iv) Is $C0_2$ solid , liquid, or gas at (a) $-70^\circ C$ under 1 atm (b) $-60^\circ C$ under 10 atm (c) $15^\circ C$ under 56 atm ?




Watch Video Solution

**17.** The energy that is transferred from a body at a higher temperature to a body at a lower temperature

Watch Video Solution

## Selected Problems From Specific Heat Capacity C P And C V

**1.** In the temperature range 0 to $1000^{\circ}C$ the average specific heat of copper is

$378Jkg^{-1}K^{-1}$. $If 2kg$ of copper is heated from 0 to $1000^{\circ}C$ by how much does its mass increase ?

Watch Video Solution

**2.** In variation of specific heat capcity of a substance with temperature is given by $C = A + BT^2$, where A and B are constnts and T is the temperature, Calculate the mean specific heat in a temperature range T = 0 to T =T and the specific heat at the mid-point $T/2$.

Watch Video Solution

**3.** A geyser heats water flowing at the rate of 3 kg per minute from $27^{\circ}C$ to $77^{\circ}C$ . If the geyser operates on a gas burner, what is the rate of consumption of fuel if the heat of combustion is $4 \times 10^{4} J/g$? Given specific heat of water is $4.2 \times 10^{3} J/kg/K$.

Watch Video Solution

**4.** A 10 kW drilling machine is used to drill a bore in a small aluminium block of mass 8.0 kg. How much is the rise in temperature of the block 'in 2.5 minutes, assuming 50% of power is used up in heating the machine itself or lost to the surroundings ? Specific heat of aluminium $0.91 J g^{-1} {}^{\circ} C^{-1}$.

Watch Video Solution

**5.** Chemical reactions are invariably associated with the transfter of energy either in the form of heat or light. In the laboratory, heat changes in physical and chemical processes are measured with an instrument called calorimeter. Heat change in the process is calculated as

$$\begin{aligned} q &= ms\Delta T \qquad & s &= \text{Specific heat} \\ &= c\Delta T & c &= \text{Heat capacity} \end{aligned}$$

Heat of reaction at constant volume is measured using bomb calorimeter.

$q_V = \Delta U =$ Internal energy change

Heat of reaction at constant pressure is measured using simple or water calorimeter.

$$q_p = \Delta H$$

$$q_p = q_V + P\Delta V$$

$$\Delta H = \Delta U + \Delta nRT$$

The enthalpy of fusion of ice is $6.02 kJmol^{-1}$.

The heat capacity of water is $4.18 Jg^{-1}C^{-1}$.

What is the smallest number of ice cubes at $0^{\circ}C$, each containing one molw of water, the are needed to cool $500g$ of liquid water from $20^{\circ}C \to 0^{\circ}C$?

Watch Video Solution

**6.** A cylinder witih fixed capacity of 67.2 lit contains helium gas at STP. The amount of heat needed to raise the temperature of the gas by $20^{\circ}$ C is ________ J. [Given that R = 8.31 $Jmol^{-1}K^{-1}$]

Watch Video Solution

**7.** Calculate the amount of heat that must be supplied to 40 gm of nitrogen to raise its temperature by $45^{\circ}C$ at constant pressure if it is at room temperature. $R = 8.3 J mol^{-1} K^{-1}$.

Watch Video Solution

**8.** Calculate the specific heat capacities at constant volume and at constant pressure for helium. Given $\gamma = \frac{5}{3}, R = 8.3$ joule $mol^{-1} K^{-1}$.

Watch Video Solution

**9.** The specific heat capacity of hydrogen at constant'pressure and constant volume are $14280 J kg^{-1} K^{-1}$ and $10110 J kg^{-1} K^{-1}$ respectively. Calculate the value of the universal gas constant.

Watch Video Solution

**10.** The gas constant for one kg of oxygen is 259.3 $J kg^{-1} K^{-1}$. Find the value of $C_p$ and $C_v$ in $J mol^{-1} K^{-1} \gamma = 1.4$

Watch Video Solution

**11.** Calculate the difference between the two principal specific heat capacities for hydrogen, Given density of hydrogen at a temperature of 270 K and pressure $10Nm^{-2} is 0.090 kgm^{-3}$.

Watch Video Solution

**12.** If the ratio of principal specific heat capacities of a certain gas is 1:4 and its density at STP is 0.09 $kgm^{-3}$ calculate the values of specific heat capacity at constant pressure and constant volume. [Standard atmospheric pressure $= 1.01 \times 10^5 Nm^{-2}$

Watch Video Solution

## Selected Problems From First Law Of Thermodynamics

**1.** Calculate the difference in temperature between the water at the top and bottom of Niagra falls of height 500 m assuming that the whole K.E. due to fall is converted into heat. Specific beat capacity of water 4200 $Jkg^{-1}K^{-1}$.

Watch Video Solution

**2.** From what height must a piece of lead be dropped if the heat generated on impact with the ground is just sufficient to melt it. Assume that all the heat is confined to lead. The initial temperature of lead is $27^{\circ}C$ and its final temperature is $327^{\circ}C$. Specific heat capacity of lead $0.125 \times 10^3 J / Kg / K$. Latent heat of fusion of lead $= 31 \times 10^3 J / kg$.

Watch Video Solution

3. A bullet moving with a velocity of 230 m/s is stopped by a block of wood. Calculate the rise in temperature of the bullet assuming that all the heat generated is retained by the bullet. Specific heat capacity of lead = 126 J/kg/K.

Watch Video Solution

**4.** 1 kg of water having a volume of $10^{-3}m^3$ becomes $1.67m^3$ of steam when boiled at a pressure of one atmosphere. The heat of vapourization at this pressure is 540 kcal/kg. Calculate the increase in internal energy and the work done in expansion.

Watch Video Solution

**5.** A lead bullet just melts when stopped by an obstacle. Assuming that 25% of heat is absrobed by the obstacle find the velocity of the bullet if the initial temperature was $27^\circ C$. Melting point of lead $= 327^\circ C$, specific heat of lead $= 0.03 cal g^{-1} {}^\circ C^{-1}$. Latent heat of fusion of lead $= 6 cal g^{-1}$.

Watch Video Solution

**6.** From what height must a piece of lead be dropped if the heat generated on impact with the ground is just sufficient to melt it. Assume that all the heat is confined to lead. The initial temperature of lead is $27^\circ C$ and its final temperature is $327^{\circ} C$. Specific heat capacity of lead $0.125 \times 10^{3} J / Kg / K$. Latent heat of fusion of lead $= 31 \times 10^{3} J / kg$.

Watch Video Solution

## Selected Problems From Isothermal And Adiabatic Processes

**1.** A quantity of dry air at $27^{\circ} C$ is compressed (a) slowly and (b) suddenly to 1/3 of its volume.

Find the change in temperature in both case assuming y = 1.4 for dry air.

Watch Video Solution

2. One litre of air at 76 cm of mercury is compressed to a pressure of 152 cm of mercury under isothermal conditions. What is the new volume ?

Watch Video Solution

**3.** The volume of a given mass of gas at NTP is compressed adiabatically to 1/5th of its original volume. What is the new pressure ? $\gamma = 1.4.$

Watch Video Solution

**4.** A tyre has air pumped at a pressure of 4 atmosphere at the room temperature $27^{\circ} C$. If the tyre bursts suddenly calculate the final temperature. $\gamma = 1.4$

Watch Video Solution

**5.** A given mass of air at one atmosphere and 273K is allowed to expand to four times its original volume adiabatically. Calculate the final temperature.

Watch Video Solution

**6.** A given mass of gas at a pressure of 0.75 m of mercury is compressed isothermally until its volume is reduced to 3/4th of its volume. It is then made to expand adiabatically to a volume 1/5 times greater than its original volume. Calculate the final temperature if its initial temperature was 290 K.(Y=1.4)

Watch Video Solution

**7.** The pressure $\left(10^5 Nm^{-2}\right)$ of air filled in a vessel is decreased adiabatically so as to increase its volume three times. Calculate the pressure of air. Given $\gamma -$ for air = 1.4

Watch Video Solution

**8.** The pressure of a certain mass of ideal gas is increased from 1 atm to 20 atm adiabatically. If y=1.4, (i) by what factor does the volume change and (ii) by what factor does the temperature change?

Watch Video Solution

**9.** A glass bulb $30^{\circ}C$ contains air at atmospheric pressure. If the bulb can withstand a pressure of 2 atm find the temperature at which it will burst? Neglect the expansion of the vessel.

Watch Video Solution

**10.** An ideal gas having initial pressure P, volume Vand temperature T is allowed to expand adiabatically until its volume becomes 5.66 V while the temperature falls to T/2. How many degrees of freedom do the gas molecule have ?

Watch Video Solution

## Selected Problems From Work Done And Indicator Diagram

**1.** In changing the state of a gas adiabatically from an equilibrium state A to another equilibrium state B, an amount of work equal to 22.3 J is done on the system. If the gas is taken from state A to B, via a process in which the net heat absorbed by the system is 9.35 cal, how much is the net work done by the system in the latter case ?

Watch Video Solution

**2.** When a gas is heated its volume increases from 100 cc to 500cc, at a constant pressure of 1 atmospher. Calculate the heat needed for doing external work.

Watch Video Solution

**3.** For a particular gas $\gamma = \frac{5}{3}$ and is heated at constant pressure. Calculate the percentage of total heat supplied, used for external work.

Watch Video Solution

**4.** A certain quantity of air is adiabatically compressed so that its pressure increases from 1 atmosphere to 150 atmosphere. If the initial temperature of air is $27^\circ C$. Calculate (i) rise in temperature and (ii) the work done of air Y= 1.4).

Watch Video Solution

**5.** A gas occupying a volume of $10^{-2} m^3$. at a pressure of 5 atmospheres expands isothermally to a pressure of 1 atmosphere. Calculate the work done.

Watch Video Solution

**6.** Calculate the minimum work that must be done to compress 1.0 gm of hydrogen at N.T.P. to half its initial volume. Given $R = 8.314 J mol^{-1} K^{-1}$.

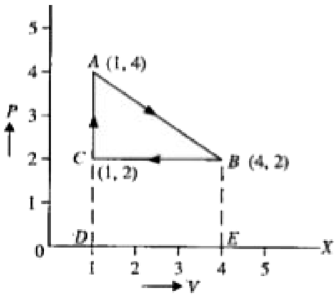
Watch Video Solution

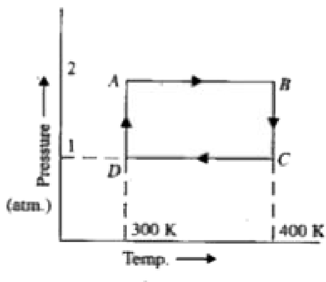
**7.** An ideal gas of volume 1 litre and at a pressure 8 atm undergoes an adiabatic expansion until its pressure drops to 1 atm and volume increase to 4 liters. Calculate the work done in the process (y = 1.5).

Watch Video Solution

**8.** The PV diagram for cyclic process is a triangle ABC see Fig. drawn in order. The co-ordinates of A, B and Care (4,1), (2,4) and (2,1).

The co-ordinates are in order of P and V in which P is $\frac{N}{m^2}$ and volume is in litre. Calculate the work done during the process from A to B, B to C and C to A. Also calculate the work done in the complete cycle.




Watch Video Solution

**9.** Two moles of helium gas undergo a cyclic process as shown in Fig. 19.2.14. Assuming the gas to be ideal, calculate the following quantitites in this process

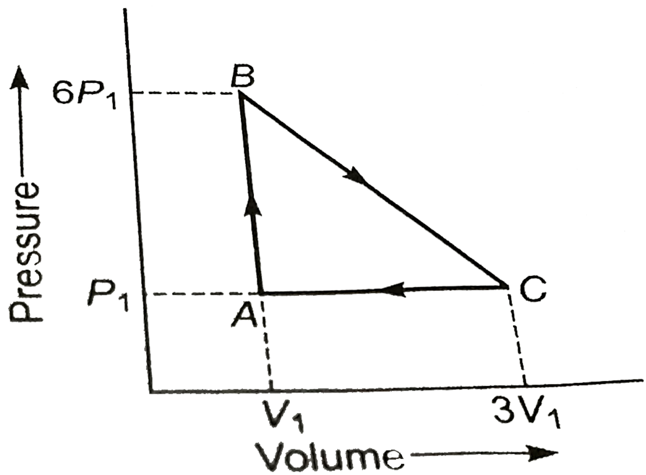
(a) the net change in heat energy

(b) the net work done

(c) the net change in internal energy.

Watch Video Solution

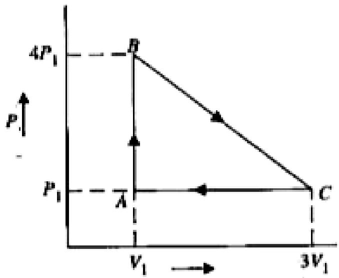
**10.** An ideal gas is taken around the cycle ABCA as shown in P-V diagram. The net work done during the cycle is equal to :

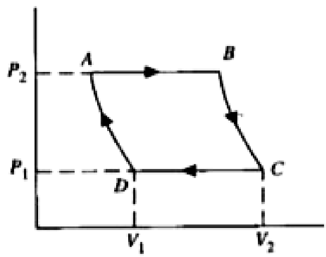



Watch Video Solution

**11.** An ideal gas undergoes a thermodynamic process as shown in Fig. The process consists of two isobaric and two isothermal steps. Show that the network done during the whole process is

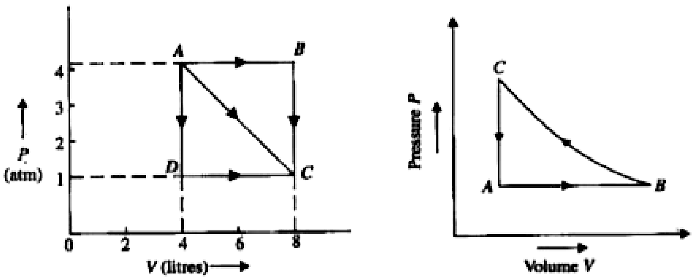
$$W_{(Net)} = P_1(V_2 - V_1)\log_e \frac{P_2}{P_1}$$



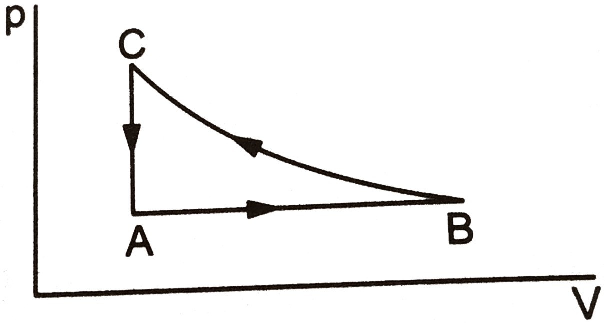

Watch Video Solution

**12.** A gas expands from A to C along three different paths as shown in Fig. What is the work done by the gas along the path ABC, AC and ADC?




Watch Video Solution

**13.** consider the cyclic process ABCA on a sample of 2.0 mol of an ideal gas as shown in the fig. temperature of the gas at A and B are 300 K and 500 k respectively. A total of 1200 J heat is withdrawn from the sample in the process. Find the work done by the gas in part BC. take $R = 8.3 JK^{-1} mol^{-1}$




Watch Video Solution

## Selected Problems From Heat Engines

**1.** What is the efficiency of a carnot engine working between ice point and steam point ?

Watch Video Solution

**2.** The efficiency of an engine is found to increase from 0.3 to 0.4 when the temperature of the sink is lowered by $50^\circ C$. Calculate the temperature of sink and source.

Watch Video Solution

**3.** A carnot's engine working between an unknown temperature and ice point gives an efficiency of 50%. What is the unknown temperature ?

Watch Video Solution

**4.** The heat absorbed by a carnot engine from the source in each cycle is 500 J and the efficiency of the engine is 20%. Calculate the work done in each cycle ?

Watch Video Solution

**5.** A carnot engine is operated between two reserviors at temperatures of 500 K and 400 K. The engine receives 840 Joules of heat from the source in each cycle. Calculate (a) the amount of heat rejected to sink in each cycle (b) the efficiency of the engine, and (c) the work done in each cycle.

Watch Video Solution

**6.** The efficiency of a carnot engine is 40%, whose sink is at a temperature of 300 K. By how much should be temperature of the source be increased be get an efficiency of 60% ?

Watch Video Solution

**7.** A carnot engine has the same efficiency (i) between 100 K and 500 K and (ii) between T K and 900 K. Calculate the temperature of the sink.

Watch Video Solution

**8.** Calculate the thermal efficiency and compression ratio of a petrol engine, if the suction temperature was 375 K and the temperature at the end of the compression was 577 K (y = 1.41)

Watch Video Solution

**9.** Calculate the efficiency of a petrol engine if the compression ratio is 9. y=1.4. If the power of the engine is 30 kW, what is its input power ?

Watch Video Solution

**10.** An engine consumes 20 kg of fuel per hour. The calorific value of the fuel is $12Kcalg^{-1}$. Calculate the efficiency of the engine if the power of the engine is 42 kW.

Watch Video Solution

**11.** A carnot's engine working between an unknown temperature and ice point gives an efficiency of 50%. What is the unknown temperature ?

Watch Video Solution

**12.** The efficiency of a camot's engine is 2/5. When the temperature of the source is increased by $20^{\circ}C$ then its efficiency is found to increase to 9/20. Calculate the temperature of source and sink.

Watch Video Solution

**13.** A carnot engine works between $200^\circ C$ and $0^\circ C$ first and then between $0^\circ C$ and $-200^\circ C$. Compare the values of efficiencies in the two cases.

Watch Video Solution

**14.** A reversible engine converts one-sixth of heat input into work. When the temperature of sink is reduced by $62^\circ C$, its efficiency is doubled. Find the temperature of the source and the sink,

Watch Video Solution

**15.** A carnot engine has an efficiency 0.4. When the temperature of the source is increased by $20^\circ C$ and the sink is reduced by $20^\circ C$, its efficiency is found to increase to 0.5. Calculate the temperature of source and sink.

Watch Video Solution

**16.** One of the most efficient engine even developed operates between 1800 K and 600 K, Its actual efficiency is 40%. What percentage of its maximum possible efficiency is this?

Watch Video Solution

**17.** A carnot's engine whose source is at 300°C takes in 5000 J of heat in each cycle and gives at 3000 J of heat to the sink. Find the temperature of the sink.

Watch Video Solution

**18.** Calculate the coefficient of performance of refrigerator working between the temperatures $0^{\circ}C$ and $30^{\circ}C$.

Watch Video Solution

**19.** A refrigerator is working between the temperature of melting ice and room temperature, which is 290 K. Calculate work done by the refrigerator to freeze 2 kg of water.

Watch Video Solution

**20.** Ice melts at the rate of 5 kg per hour in a cold storage when the temperature outside is 300 K. Calculate the minimum power of the motor is to be used to drive a refrigerator to just prevent the melting of ice. Specific latent heat of usion of ice $= 3.3 \times 10^5 Jkg^{-1}$. [E. Q]

Watch Video Solution

**21.** How much heat energy is gained when 5kg of water at $20^\circ C$ is brought to its boiling point (Specific heat of water = $4.2kJkg^{-1^\circ}C^{-1}$

Watch Video Solution