PHYSICS

BOOKS - PRADEEP PHYSICS (HINGLISH)

THERMODYNAMICS

Sample Problems

1. A sample of gas $(\gamma = 1.5)$ is taken through an adiabatic process in which the volume is compressed from $1600 cm^3$ to $400 cm^3$. If the initial pressure is $150kPa$, (a) what is the final pressure and (b) how much work is done by the gas in the process?

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2. A gram molecule of gas at $27^{\circ}C$ expands isothermally untill its volume is doubled. Find the amount of work done and heat absorbed. Take $R = 8.31 Jmole^{-1}K^{-1}$.

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3. $200J$ of work is done to compress an ideal gas isothermally. How much heat flows from the gas during the compression process?

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4. Suppose $300J$ of work done on a system and $70cal$ of heat is extracted from the system. What are the values of dW, dQ and dU with proper signs?

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5. A sample of ideal gas $(\gamma = 1.4)$ is heated at constant pressure. If an amount $140J$ of heat is supplied to the gas, find (a) the changes in internal energy of the gas, (b) the work done by the gas.

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6. At $0^\circ C$ and normal atmospheric pressure, the volume of 1 gram of water increases from $1c.\ cto1.091c.\ c$ on freezing. What will be the change in its internal energy? Normal atmospheric pressure is $1.013 \times 10^5 N/m^2$ and latent heat of melting of ice $= 80cal/gram.$

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Curiosity Question

1. The search of a perpetual motion machine has kept inventors occupied for centuries comment on this statement.

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2. Which chemical compounds are used in refrigerators and air conditioners? What are their merits and demerits?

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Solved Examples

1. Three moles of an ideal gas kept at a constant temperature of $300K$ are compressed from a volume of 4 litre to 1 litre. Calculate work done in the process. $R = 8.31 Jmole^{-1}K^{-1}$.

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2. Air in the cylinder of a diesel engine is compressed to $\frac{1}{15}$ of its initial volume. If initial temperature is $300K$ and initial pressure is $10^5 Pa$, find the final temperature and final pressure. Take $\gamma = 1.4$.

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3. A gas is suddenly compressed to $\frac{1}{4}th$ of its original volume. Caculate the rise in temperature when original temperature is $27^\circ C. \gamma = 1.5.$

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4. A sample of hydrogen of mass $6g$ is allowed to expand isothermally at $27^\circ C$ till its volume is doubled.

(a) How may moles of hydrogen are there?

(b) What is final temperature of H_2?

(c) Caculate work done during expansion.

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5. Calculate the fall in temperature of helium initially at $15^{\circ} C$, when it is suddenly expanded to $8 \times$ its original volume $(\gamma = 5/3)$.

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6. A gram molecule of a gas at $127^{\circ} C$ expands isothermally until its volume is doubled. Find the amount of work done and heat absorbed.

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7. A cylinder containing one gram molecule of the gas was compressed adiabaticaly untill its tempertaure rose from $27^\circ C$ to $97^\circ C$. Calculate the work done and heat produced in the gas $(\gamma = 1.5)$.

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8. The $P - V$ diagram for a cyclic process is a triangle ABC drawn in order (figure). The co-ordinates of A,B,C are $(4, 1), (2, 4)$ and $(2, 1)$ respectively. The co-ordinates are in the order (P, V) Pressure is in Nm^{-2} and volume is in liter. Calculate work done during the process from A to B, B to C and C to A. Also, calculate work done in the complete cycle.

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9. Three moles of an ideal gas kept at a constant temperature of $300K$ are compressed from a volume of 4 litre to 1 litre. Calculate work done in the process. $R = 8.31 J mole^{-1} K^{-1}$.

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10. A quantity of an ideal gas at $17^{\circ}C$ is compressed adiabatically to `1/8th of its initial volume. Calculate the final temp. if the gas in monoatomic.

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11. When one mole of monoatomic gas is mixed with 3 moles of diatomic gas, then find C_p, C_v, f and γ for this mixture. Here, f stands for degrees of freedom.

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12. 5 mole of oxygen are heated at constant volume from $10^{\circ} C \text{to} 20^{\circ} C$. What will be the change in internal energy of the gas? Gram molar specific heat of gas at constant pressure $= 8 cal. \text{Mole}^{-1}.^{\circ} C^{-1}$ and $R = 8.36 J \text{mole}^{-1}.^{\circ} C^{-1}$.

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13. A metal of mass 1 kg at constant atmospheric pressure and at initial temperature $20^{\circ} C$ is given a heat of 20000J. Find the following

(a) change in temperature,

(b) work done and

(c) change in internal energy.

(Given, specific heat $= 400 J/kg-^{\circ}C$, cofficient of cubical expansion, $\gamma = 9 \times 10^{-5}/^{\circ}C$, density $\rho = 9000 kg/m^3$, atmospheric pressure $= 10^5 N/m^2$)

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14. Calculate the change in internal energy of a block of copper of mass $200g$ when it is heated from $25^{\circ} C to 75^{\circ} C$. Given specific heat of copper $= 0.1 cal. g^{-1}.^{\circ} C^{-1}$ and assume that change in volume is negligible.

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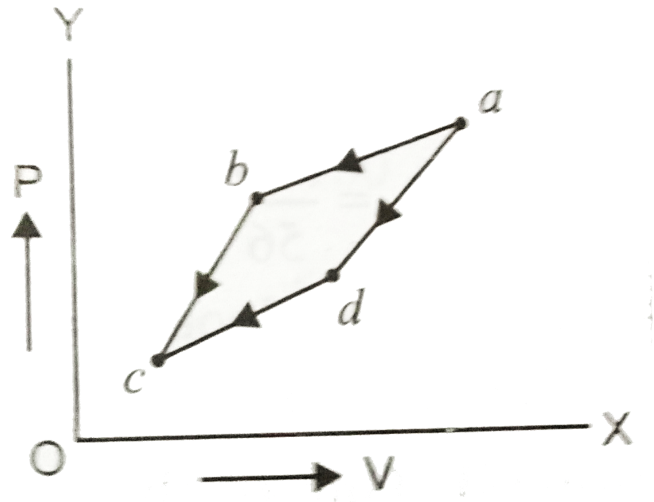
15. A system is taken from state a to state c along the path adc (figure). The amount of heat absorbed is $10 cals$ and work done on the gas is $138 J$. Calculate the work done on//by the gas when $20 cals$ of heat are absorbed in taking the system from state a to state c along the path

abc



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16. The volume of steam produced by $1g$ of water at $100^{\circ} C$ is $1650 cm^3$. Calculate the change in internal energy during the change of state. Given $J = 4.2 \times 10^7 erg$.

$cal.^{-1}$, $d = 981cm^{s-2}$. Latent heat of stream

$= 540cal.G^{-1}$

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17. Calculate the change in internal energy when $5g$ of air is heated from internal energy when $5g$ of air is heated from $0^{\circ} C \text{to} 2^{\circ} C$. Specific heat of air at constant volume is $0.172cal/g/^{\circ} C$.

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18. A cyclinder contains 0.5 mole of an ideal gas at $310K$. As the gas expands isothermally from an initial volume $0.31m^3$ to a final volume of $0.45m^3$, find the amount of heat that must be added to the gas in order to maintain a constant temperature.

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19. A carnot engine absorbs $1000J$ of heat energy from a reservoir at $127^\circ C$ and rejecs $600J$ of heat energy during each cycle. Calculate

(i) efficiency of the engine, (ii) temperature of sink, (iii) amount of useful work done per cycle.

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20. A carnot engine whose heat sink is at $27^{\circ}C$ has an efficiency of 40%. By how many degrees should the temperature of source be changed to increase the efficiency by 10% of the original efficiency?

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

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22. A carnot engine absorbs $500J$ of heat from a reservoir at $227^{\circ}C$ and rejects of seek (ii) efficiency of engine (iii) amount of useful work done per cycle.

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23. A carnot engine whose heat sink is at $27^{\circ} C$ has an efficiency of 40%. By how many degrees should the temperature of source be changed to increase the efficiency by 10% of the original efficiency?

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24. A Carnot engine takes in heat from a reservoir of heat at $427^{\circ} C$. How many calories of heat must it take from the reservoir in order to procuce useful mechanical work at the rate of $357wa$?

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25. The temperatures T_1 and $T(2)$ of two heat reservoirs in an ideal carnot engine are $1500^\circ C$ and $500^\circ C$. Which of these (a) increasing $T_1 by 100^\circ C$ or (b) decreasing $T_2 by 100^\circ C$ would result in greater improvement of the efficiency of the engine?

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26. A refrigerator has to transfer an average of 263J of heat per second from temperature $-10^{\circ}C$ to $25^{\circ}C$. Calculate the average power consumed, assuming no enegy losses in the process.

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27. Refrigerator A works between $-10^{\circ}C$ and $27^{\circ}C$, while refrigerator B works between $-27^{\circ}C$ and $17^{\circ}C$, both removing heat equal to

2000J from the freezer. Which of the two is the better refrigerator?

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28. A refrigerator has to transfer an average of $506J$ of heat per second from. Temp. $-20^{\circ}C \text{to} 25^{\circ}C$. Caculate the average power consumed, assuming no energy losses in the process.

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29. How much energy in watt hour may be required to convert $2kg$ of water into ice at $0^{\circ}C$, assuming that the refrigerator is ideal? Take room temp. $= 25^{\circ}C$, which is also the initial temp. of water and temp. of freezer is $-15^{\circ}C$.

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30. How many kg of water at $0^{\circ}C$ can a freezer with a coefficient of performance 5 make into ice cubes at $0^{\circ}C$ with a work input of $3.6MJ$?

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31. A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10J, the amount of energy absorbed from the reservoir at lower temperature is

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32. A refrigerator is driven by $1000W$ electric motor having an efficiency of 60%. The refrigerator is considerd as a reversible heat engine operating between $273K$ and $303K$. Calculate the time required by it to freeze $32.5kg$ of water at $0^{\circ}C$. Heat losses may be rejected. Latent heat of fusion of ice $= 336 \times 10^{3} Jkg^{-1}$.

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33. A carnot cycle is performed by $1 mole of air (\gamma = 1.4)$ initially at $327^{\circ}C$. Each stage represents a compression or expansion in the ratio $1:6$. Calcultate (a) the lowest temperature (b) net work done during each cycle and (C) efficiency of the engine.

Take $R = 8.31 Jmole^{-1}K^{-1}$.

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34. A carnot engine having a perfect gas aas the working substance is driven backwards and is used for freezing water already at $0^{\circ}C$. If the engine is driven by $500W$ electric motor with an efficiency of 60% how long will it take to freeze $15kg$ of water? The working temps of the engine are $15^{\circ}C$ and $0^{\circ}C$. The system involves no energy losses. Given latent heat of ice $= 333 \times 10^3 Jkg^{-1}$.

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Conceptual Problems

1. The volume of an ideal gas is V at pressure P. On increasing the pressure by ΔP, change in volume of gas is ΔV_1, under isothermal conditions and ΔV_2 under adiabatic conditions. Which is more and why?

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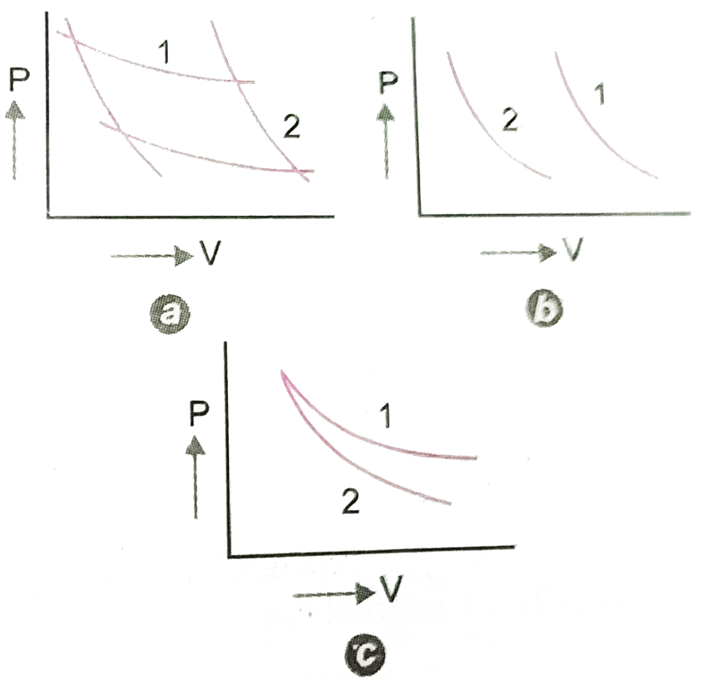
2. Identify isothermal and adiabatic process in the following diagram



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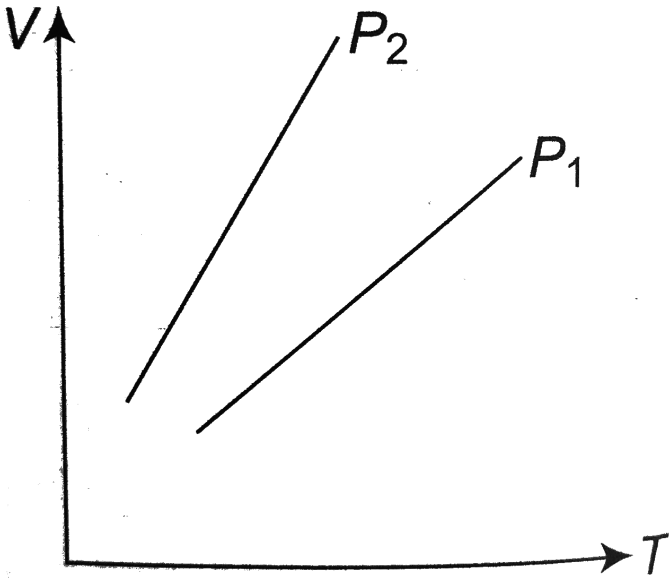
3. Figure shows the volume versus temperature graph for the same mass of a gas (assumed ideal) corresponding to two different pressure P_1 and P_2. Then



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4. Can water be boiled without heating?

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5. Can we increase the temperature of a gas without supplying heat to it?

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6. Is the heat supplied to a system always equal to the increase in its internal energy?

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7. Is the internal energy of a gas a function of the pressure? Explain.

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8. Why is conversion of heat into work not possible without a sink at lower temperature?

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9. First law of thermodynamics does not forbid flow of heat from lower teperature to higher temperature. Comment.

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10. If on giving $40 jo\underline{e}$ of heat to a system, work done on the system is 10joul e`, what will be the change in internal energy of the system?

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11. How does internal energy of a gas change in (i) isothermal expansion (ii) adiabatic expansion?

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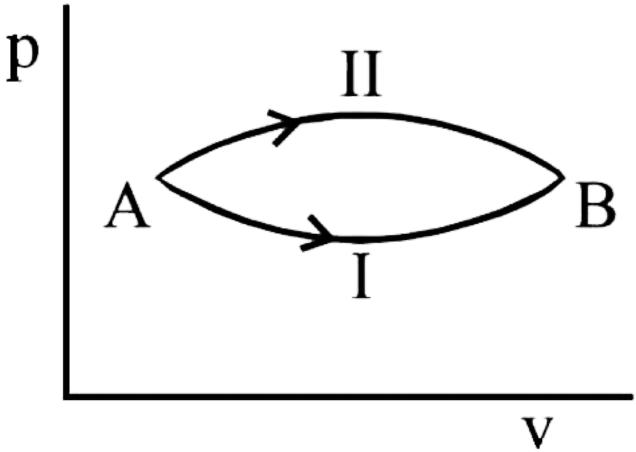
12. A system goes from A and B via two processes. I and II as shown in figure. If ΔU_1 and ΔU_2 are the changes in internal energies in the processes I and II respectively,

then



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13. Give two examples of reversible processes. Discuss their reversibility?

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14. A refrigerator transfers heat from the cold coling coils to the warm surroundings. Is it against the second law of thermodynamics? Justify your answer?

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15. Can the Carnot engine be realised in practice?

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16. No real engine can have an efficiency greater than that of a carnot engine working between the same two temperatures, why?

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17. A heat engine coverts disordered mechanical motion into ordered mechanical motion. Comment.

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18. What is meant by reversible process? Explain why the efficiency of a reversible engine is maximum?

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19. Why can a ship not use the internal energy of sea water to operate its engine?

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20. What is the significance of area of closed curve on P-V diagrams?

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21. Can the work done during a cyclic process be zero?

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22. Heat equivalent to $30J$ is supplied to a thermodynamic system and $10J$ of work is done on the system. What is change in its internal energy?

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Very Short Answer Questions

1. What is an isobaric process ?

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2. What is an isochoric process ?

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3. Can the temperature of an isolated system remain constant?

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4. Which kind of process is superheating of steam.

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5. To an expanding gas, no external energy is suppiled. Will the gas do any work? If yes, what will be the source of energy?

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6. Does the internal energy of an ideal gas change in an isothermal process? In an adiabatic process?

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7. A sample of an ideal gas in a cyclinder is compressed adiabatically to $\frac{1}{3}rd$ of its volume. Will final pressure be more or less than $3 \times$ the initial pressure?

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8. Can two isothermal curves intersect each other?

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9. In summer, when the valve of a bicycle tube is removed, the escaping air appears cold. Why?

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10. When air of the atmosphere rises up, it cools. Why?

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11. Can heat be added to a substance without causing the temperature of the body of rise? If so does this contradict the concept of heat as energy in the process of transfer because of temperature differece?

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12. What thermodynamics variable is defined by (a) Zeroth law (b) First law?

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13. Is it possible to convert internal energy into works?

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14. An ideal gas is compressed at a constant temperature, will its internal energy increase or decrease?

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15. Which type of motion of the molecules is responsible for internal energy of a monoatomic gas?

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16. A piece of leads is hammered. Does its internal energy increase? Does the heat enter the lead from outside ?

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17. In a thermodynamics process, 300 joule of heat is supplied to a gas and 200 joule of work is done by the gas. What is the change in internal energy of the system?

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18. Why does a gas get heated on compression?

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19. Can we decide whether change in internal energy of a system is due to heating or performance of work?

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20. Can whole of work be converted into heat?

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21. Can whole of heat be converted into work?

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22. Which molecules, ice at $10^{\circ} C$ or water at $0^{\circ} C$ have greater potential energy and why?

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23. What is specific heat of gas in isothermal changes?

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24. What is the nature of $P - V$ diagram for isobaric and isochoric processes?

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25. Give one example of a heat pump.

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26. Is it possible to construct a heat engine, which is free from thermal pollution?

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27. How is efficiency of carnot engine affected by the nature of working substance?

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28. Is rusting of iron a reversible process?

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29. Can we increase the coefficient of performance of a refrigerator by increasing the amount of working substance?

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30. A refrigerator transfers heat from the cold coling coils to the warm surroundings. Is it against the second law of thermodynamics? Justify your answer?

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31. Is cofficient of performance of refrigerator always constant?

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Short Answer Questions

1. Ice at $0^\circ C$ is converted into steam at $100^\circ C$. State the isothermal changes in this process?

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2. If a drop of water falls on a very hot irion, it takes long time to evaporate. Explain why?

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3. During adiabatic changes, $V \propto 1/T^2$. How will pressure of the gas vary with temperature?

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4. Is the equation $PV = RT$ valid for both, isothermal and adiabatic changes?

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5. A gas expands in such a way that $PV^2 = cons\tan t$. Will the gas cool get heated on expansion?

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6. The temperature of the surface of sun is about $6000K$. Can we produced a temp. of $7000K$ by converging sun's rays using a large convex lens?

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7. If an electric fan be switched on in a closed room, will the air of the room be cooled? If not, why do we feel cold?

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8. Which one among a solid, liquid and gas of same mass and at the same temp. has the greatest internal energy? Which one least? Why?

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9. A thermos flask contains coffee. It is shaken vigorously. (i) Has any heat been added to it.

(ii) Has any work been done on it.

(iii) Does it internal energy change?

(iv) Does its temp. rise?

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10. By what method can the internal energy of an ideal gas be changed?

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11. Internal energy of a compressed gas is less than that of a rarefield gas, at the same temperature.

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12. On a hot summer day we want to cool our room by opening the refrigerator door annd closing all the windows and doors. Will the process work ?

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13. Discuss whether the following phenomena are reversible?

(i) Water fall (ii) Rusting of iron

(iii) Electrolysis.

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14. Is the efficiency of a heat engine more in hilly areas than in plains?

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15. To increase the efficiency of a carnot engine, will you prefer to (i) increase the temp. of source by $10K$ or (ii) decrease the temp. of sink by $10K$?

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16. Give briefly the concept of internal energy.

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17. Define the four thermodynamic processes. What is meant by indicator diagram?

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18. State the sign conventions used in all thermodynamic processes?

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19. What do you learn by applying first law of thermodynamics to isothermal and adiabatic processes?

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20. Show that the slope of $p - V$ diagram is greater for an adiabatic process as compared to an isothermal process.

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21. Discuss work done in an isothermal/adiabatic process in terms of indicator diagram.

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22. Briefly discuss the limitations of first law of thermodynamics.

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23. State second law of thermodynamics.

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Long Answer Questions

1. Explain what is meant by isothermal operations. Give some examples.

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2. What are adiabatic operations? Enumerate some examples. State equations representing these operations.

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3. Obtain an expression for work done by a gas in an isothermal expansion.

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4. Derive an expression for work done in an adiabatic process.

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5. State Zeroth law of thermodynamics. How does it lead to the concept of temperature?

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6. State and explain first law of thermodynamics. Establish the relation between two principle specific heats of a gas on the basis of this law.

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7. Discuss briefly any three applications of first law of thermodynamics.

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8. Establish relation between two principle specific heats of a gas.

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9. What are cyclic and non cyclic processes? Calculate work done in such processes.

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10. What are reversible and irreversible processes? Give some examples of each.

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11. What is a heat engine? Obain an expression for its efficiency. Mention different types of heat engines.

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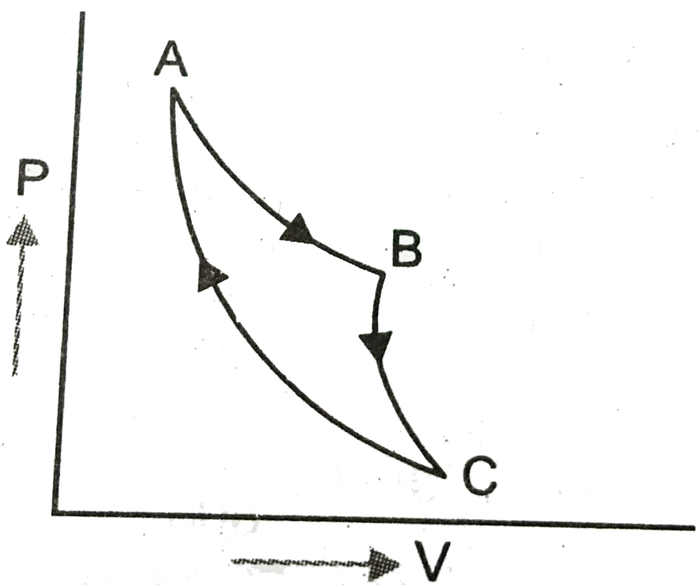
Advanced Problems For Competitions

1. An ideal gas expands isothermally along AB and does $700J$ of work. How much heat does the gas exchange along AB? The gas then expands adiabarically along BC and does $400J$ of work. When the gas returns to A along CA, it exhausts $100J$ of heat to the surroundings. How much work is done on the gas along this path?



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2. An ideal gas having initial pressure P, volume V and temperature T is allowed to expands adiabatically until its volume becomes 5.66V while its temperature falls to T/2.

(i) How many degrees of freedom do the gas molecules have?

Obtain the work done by the gas during the expansion as a function of the initial pressure P and volume V.

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3. What is a polytropic process, Obtain expressions for work done in a polytropic process and specific heat of gas in such a process.

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4. Two Carnot engines are operated in succession. The first engine receives heat from a source at $T = 800K$ and rejects to sink at T_2K. The second engine receives heat rejected by the first engine and rejects to another sink at

$T_3 = 300K$. If work outputs of the two engines are equal, then find the value of T_2.

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5. One mole of a monoatomic gas is mixed with three moles of a diatomic gas. What is the molecular specific heat of mixture at constant volume? $R = 8.31 J mol^{-1} K^{-1}$.

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6. At $27^{\circ}C$ two moles of an ideal monoatomic gas occupy a volume V. The gas expands adiabatically to a volume 2V. Calculate (i) the final temperature of the gas, (ii) change in its internal energy, and (iii) the work done by the gas during this process.

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7. The pressure of one gram mole of a monoatomic gas increases linearly from $4 \times 10^{5} N / M^{2}$ to $8 \times 10^{5} N / m^{2}$. Calculate

(i) Work done by the gas,

(ii) increase in internal energy, (iii) amount of heat supplied,

(iv) molar heat capacity of the gas.

Take $R = 8.31 J mole^{-1} K^{-1}$.

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8. (Figure) shows that two $P - V$ curves AB and BC for a gas: one is for isothermal process and other is for adiabatic process.

(i) Which curve denotes which change and why?

(ii) How much work will be done by the gas in change AB? Will the internal energy of gas increase or decrease? How much heat will the gas give or take?

(iii) Discuss all the above things in change BC.

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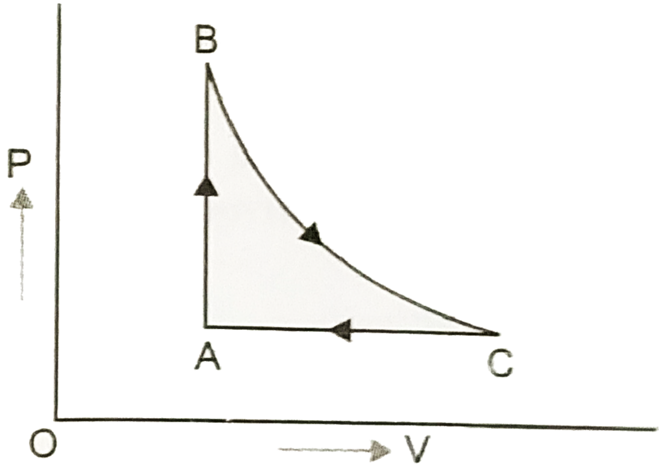
9. Gas with in a chamber, passes through the cycle shown in (figure). Determine the net heat added to the system during process AB is $Q_{AB} = 20J$. No heat is transferred during process BC and net work done during the cycle is $15J$



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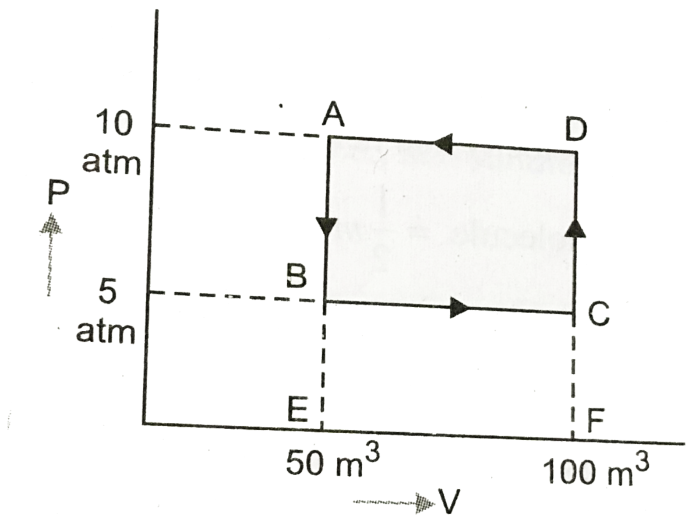
10. One mole of an ideal gas is taken through the cyclic process ABCDA, as shown in (figure). Using the graph, calculate

(i) Work done in the processes

$A \rightarrow B, B \rightarrow C, C \rightarrow D$ and $D \rightarrow A$

(ii) Work done in complete cycle ABCDA

(iii) Heat rejected by the gas in one complete cycle.



Very Short Answer Questions Ncert

1. Can a system be heated and its temperature remains constant?

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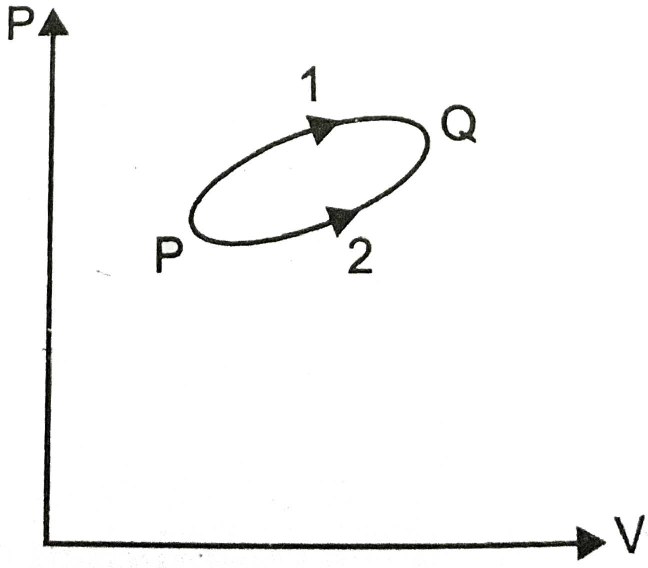
2. A system goes from P to Q by two different paths in the $P-V$ diagram as shown in (figure). Heat given to the system in path 1 is $1000J$. The work done by the system along path 1 is more than path 2 by $100J$. What is the exchange by the system in path 2?



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3. On a hot summer day we want to cool our room by opening the refrigerator door annd closing all the windows and doors. Will the process work ?

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4. Can we increase the temperature of a gas without supplying heat to it?

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5. Air pressure in a car tyre increases during driving. Explain.

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Short Answer Questions Ncert

1. Consider a Carnot's cycle operating between $T_1 = 500K$ and $T_2 = 300K$ producing $1KJ$ of mechanical work per cycle. Find the heat transferred to the engine by the reservoirs.

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2. A person of mass $60Kg$ wants to lose $5kg$ by going up and down a $10m$ high stairs. Assume he burns twice as much fat while going up than coming down. If $1kg$ of fat is burnt on expending $7000kilo$ calories, how many times must be go up and down to reduce his weight by $5kg$?

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3. Consider a cycle tyre being filled with air by a pump. Let V be the volume of the tyre (fixed) and at each stroke of the pump $\Delta V(< < V)$ of air is transferred to the tube adiabatically . What is the work done when the pressure in the tube is increased from $P_1 \rightarrow P_2$?

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4. In a refrigerator, one removes heat from a lower temperature and deposites to the surrounding at a higher temperature. In this process, machanical work has to be done, which is provided by an elecrtic motor. If the motor is of $1KV$ power, and heat is transferred from

$-3^{\circ} C \text{to} 27^{\circ} C$, find the heat taken out of the refrigerator per second assuming its efficiency is 50% of a perfect engine.

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5. If the co-efficient of performance of a refrigerator is 5 and operates at the room temperature $(27^{\circ} C)$, find the temperature indide the refrigerator.

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6. The initial state of certain gas is (P_i, V_i, T_i). It undergoes expansion till its volume become V_f.

Consider the following two cases :

(a) the expansion takes place at constant temperature.

(b) the expension takes place at constant pressure.

Plot the $P-V$ diagram for each case. In which of the two cases, is the work done by the gas more?

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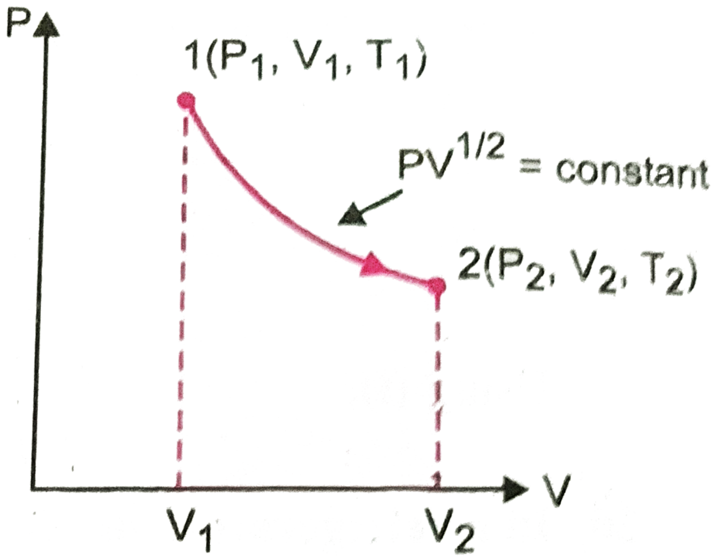
Long Answer Questions Ncert

1. Consider a $P-V$ diagram in which the path followed by one mole of perfect gas in a cyclinderical container is shown in (figure)

(a) Find the work done when the gas is taken from state 1 to state 2.

(b) What is the ratio of temperatures $T_1/T_2, \quad \text{if} \quad V_2 = 2V_1$?

(c) Given the internal energy for one mole of gas at temperature $Tis(3/2)RT$, find the heat supplied to the gas when it is taken from state 1 to 2, with $V_2 = 2V_1$.



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2. A cycle followed by an engine (made of one mole of perfect gas in a cyclinder with a piston) is shown in (figure)

A to B: volume constant B to C: adiabatic

C to D: volume constant D to A: adiabatic

$V_c = V_D = 2V_A = 2V_B$

(a) In which part of the cycle heat is supplied to the engine fron outside?

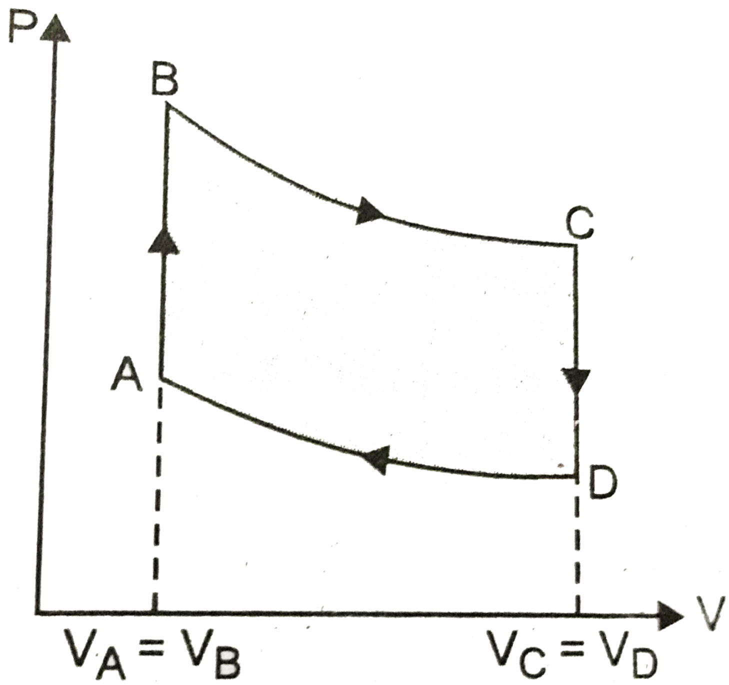
(b) In which part of the cycle heat is being given to the surrounding by the engine?

(c) What is the work done by the engine in one cycle? Write your answer in term of P_A, P_B, V_A.

(d) What is the efficiency of the engine?

$(\gamma = 5/3 \text{for the gas}),$

$$\left(C_v = \frac{3}{2}R \text{for one mole}\right)$$



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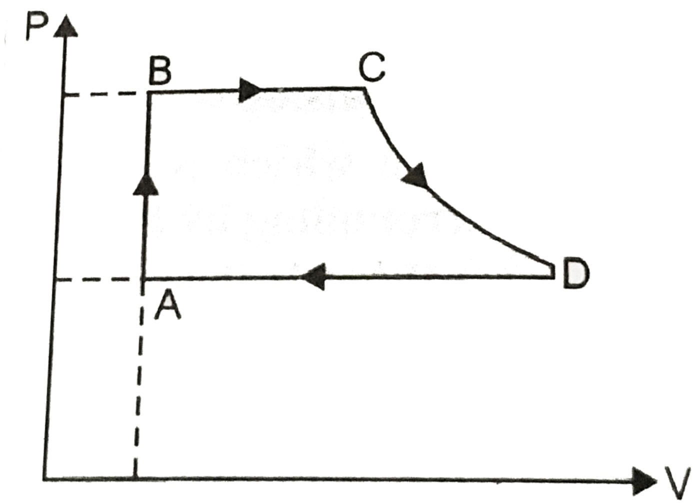
3. A cycle followed by an engine (made of one mole of an ideal gas in a cyclinder with a piston) is shown in (figure). Find heat exchanged by the engine, with the surrounding for each section of the cycle. $[C_V = (3/2)R]$

AB : constant volume BC : constant pressure

CD : adiabatic DA : constant pressure.



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4. Consider that an ideal gas $(nmoles)$ is expanding in a process given by $P = f(V)$, which passes through a point (P_0, V_0). Show that the gas is absorbing heat at (P_0, V_0) if the slope of the curve $P = f(V)$ is larger than the slope of the adiabat passing through (p_0, V_0).

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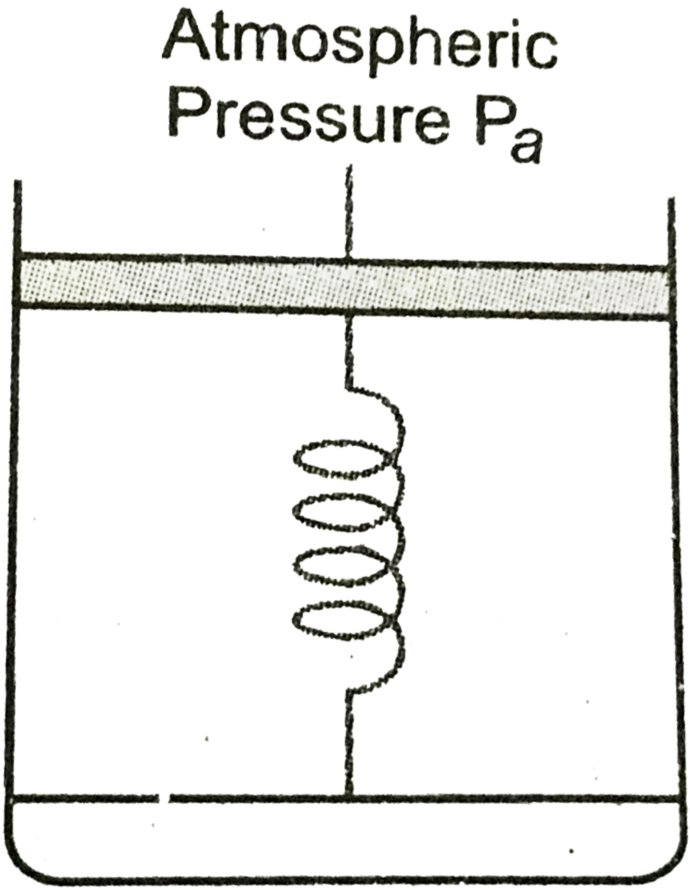
5. Consider one mole of a perfect gas in a cyclinder of unit cross section with a piston attached, (figure) A spring (spring constant K) is attached (unstretched length L) to the piston and the bottom of the cylinder. Initially, the spring is unstretched and the gas is in equilibrium. A certain amount of heat Q is supplied to the gas causing an increase of volume from $V_0 \mathrm{to} V$.

(a) What is the initial pressure of the system?

(b) What is the final pressure of the system?

(c) Using the first law of thermodynamics, write down a relation between Q, P_a, V, V_0 and K.



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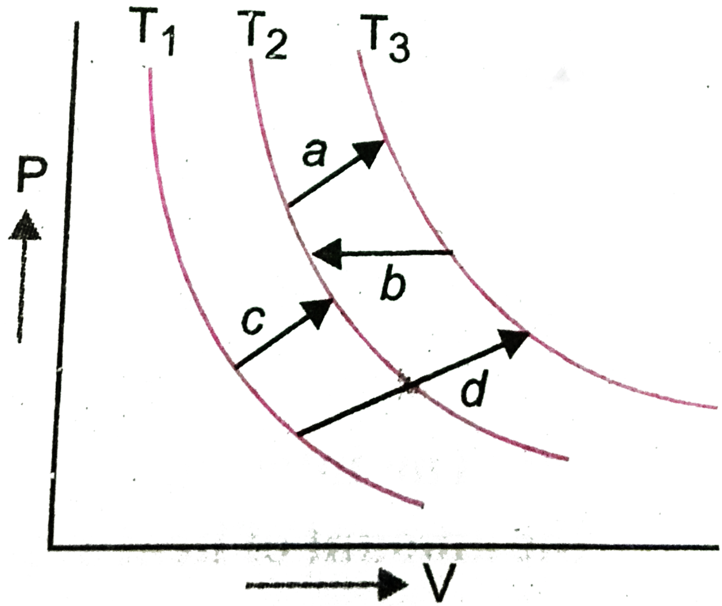
Higher Order Thinking Skills

1. (Figure) Shows three isothermal curves at temp T_1, T_2 and T_3

$T_3 > T_2 > T_1$. A system changes its state by four paths a, b, c, and d, .Identify the path in which changes in internal energy of the system is maximum.



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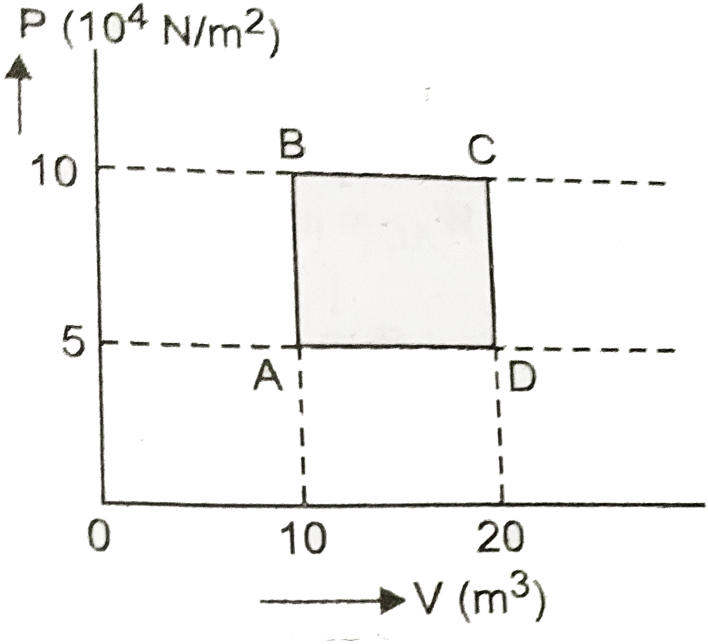
2. A sample of $2kg$ of monoatomic helium (assumed ideal) is taken through the process ABC and another sample of $2kg$ of the same gas is taken through the process ACD as shown in (figure). Given molecular mass of He $= 4$ and $R = 8.3 J mole^{-1} K^{-1}$

(i) What is the temperature of He in each of the states A, B, C and D?

(ii) How much is the heat involves in process , ABC and ADC?



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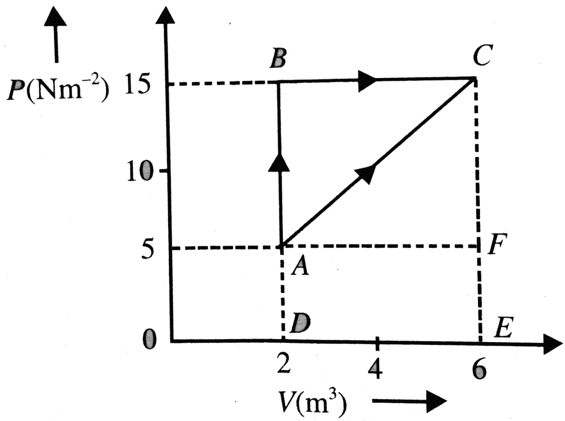
3. Figure. Shows an ideal gas changing its state A to state C by two different path ABC and AC.

a. Find the path along which the work done is the least.

b. The internal energy of the gas at A is $10J$ and the amount of heat supplied to change its state to C through the path AC is $200J$. Find the internal energy at C.

c. The internal energy of the gas at state B is

$20J$. Find the amount of heat supplied to the gas to go from state A to state B.



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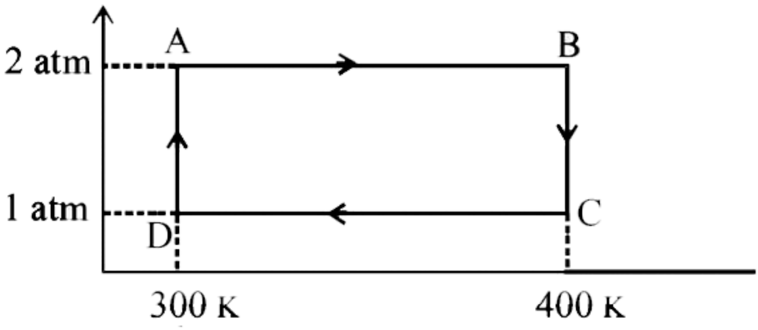
4. Two moles of helium gas undergo a cyclic process as shown in Fig. Assuming the gas to be ideal, calculate the following quantities in this process



(a) The net change in the heat energy

(b) The net work done

(c) The net change in internal energy

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5. A thermos flask contains coffee. It is shaken vigorously. (i) Has any heat been added to it.

(ii) Has any work been done on it.

(iii) Does it internal energy change?

(iv) Does its temp. rise?

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6. At $27^{\circ}C$ two moles of an ideal monatomic gas occupy a volume V. The gas expands adiabatically to a volume $2V$. Calculate

(a) final temperature of the gas

(b) change in its internal energy and

(c) the work done by the gas during the process.

$[R = 8.31 J/mol - K]$

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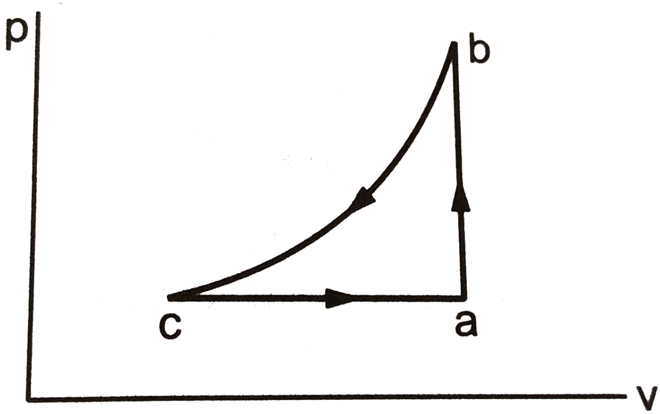
7. A sample of an ideal gas is taken through the cyclic process $abca$. It absorbs $50J$ of heat during the part ab, no heat during bc and rejects $70J$ of heat during ca. $40J$ of work is done on the gas during the part bc.

(a) Find the internal energy of the gas at b and c if it is $1500J$ at a.

(b) Calculate the work done by the gas during the part ca.



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8. The initial volume of an ideal gas is V_1 and the initial pressure is $P_1 = 6$ atmosphere. It expands isothermally to a volume V_2 and pressure $P_2 = 3atm$, and then adiabatically to a volume V_3 and pressure $P_3 = 2atm$. Draw a rough sketch of these changes. Calculate the value of V_2 / V_1 and V_3 / V_2.

Take $\gamma = 1.4$.

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9. About 0.014 kg nitrogen is enclosed in a vessel at temperature of $27^\circ C$ How much heat has to be transferred to the gas to double the rms speed of its molecules ? $(R = 2cal / molK)$

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Value Based Questions

1. A change in pressure and volume of a gas without any change in its temperature is called an isothermal change. In such a change there is free exchange of heat between the gas and its surroundings. Two essential conditions for a perfect isothermal change are :

(i) Walls of the container must be perfectly conducting

(ii)The process of compression or expansion must be slow.

Read the above passege and answer the

following questions:

(i) A gas atmospheric pressure is compressed isthermally to one third of its volume. What is the final pressure?

(ii) What values of life do you learn from this study?

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2. A change in pressure and volume of a gas when no heat is allowed to enter into a escape from the gas is called an adiabatic change. Obviously, temperature of gas will change in adiabatic changes.

Two essential conditions for a perfect adiabatic chage are:

(a) the wall of the container must be perfectly non conducting.

(b) the process of compression or expansion must be sudden.

Read the above passage and answer the following questions:

(i) Pressure on a certain volume of air is doubled adiabatically. Will its volume become half, more than half or less than half? Justify.

(ii) What value of life do you learn from this study?

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3. First law of thermodynamics is the general law of conservation of energy as applied to heat energy. According to this law, whenever heat is added to a system, it transforms to an equal amount of some other forms of energy. If $dQ =$ a small amount of heat supplied to the system, $dW =$ small amount of work done by the system and $dU =$ small change in internal energy of the system, then $dQ = dU + dW$.

Read the above passage and answer the following questions:

(i) The amount of heat obsorbed by a gas is $10 cals$ and work done on the gas in $58 J$. Calculate increase in internal energy of the gas.

(ii) What values of life do you learn fron this law?

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4. A refrigerator is a device used for cooling things. Working substance would absorb a certain quantity of heat Q_2 from the sink at lower temperature T_2 and reject a larger amount of heat Q_1 to the source (surrounding air) at higher temperature T_1 (= room temperature) with the help of an external agency supplying energy W to the system.

Clearly, $w = Q_1 - Q_2$

Cofficient of performance of refrigerator,

$$\beta \frac{T_2}{T_1 - T_2} = \frac{1 - \eta}{\eta}$$

Read the above passage and answer the following questions:

(i) What is the cofficient of performance of a refrigerator working between $-10^{\circ}C$ and

$25^\circ C$?

(ii) 'Refrigerator is an efficient room heater'. Do you agree with the statement? Justify.

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Ncert Questions

1. A geyser heats water flowing at the rate of 3.0 litre per minute from $27^\circ C$ to $77^\circ C$. If the geyser operates on a gas burner and its heat of combustion is $4.0 \times 10^4 J / g$, then what is the rate of combusion of fuel (approx.)?

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2. What amount of heat must be supplied to $2 \times 10^{-2} Kg$ of nitrogen at room temperature to rise its temperature by $45^{\circ} C$ at constant pressure? Given molecular mass of nitrogen is 28 and $R = 8.3 J mole^{-1} K^{-1}$

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3. Explain why

(a) Two bodies at different temperature

T_1 and T_2 if brought in thermal contact do not necessarily settle to the mean temperature $(T_1 + T_2)/2$?

(b) The coolant in a chemical or nuclear plant (i.e., the liquid used to prevent different parts of a plant from getting too hot)should have high specific heat. Comment.

(c) Air pressure in a car tyre increases during driving . Why?

(d) The climate of a harbour town is more temperature (i.e., without extremes of heat and cold) than that of a town in a desert at the same latitude. Why?

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4. A cyclinder with a movable piston contains $3mols$ of hydrogen at standard temperature and pressure. The walls of the cyclinder are made of a heat insulator, and the piston is insulated by having a pile of sand on it. By what factor does the pressure of the gas increases, if the gas is compressed to half its original volume? Given $\gamma = 1.4$.

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5. In changing the state of a gas adiabatically from an equilibrium state A to another equilibrium state B, an amount of work equal to $22.3J$ 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 $9.35cal.$, How much is the net work done by the system in the later case? (Take $1cal. = 4.9J$)

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6. Two cyclinder A and B of equal capacity are connected to eachother via a stopcock. The cyclinder A contains an ideal gas at standard temperature and pressure, while the cyclindr B is completely evacuated. The entire system is thermally insulated. The stopcock is suddenly opened. Answer the following:

(a) What is the final pressure of the gas in A and B?

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

(c) What is the change in temperature of a gas?

(d) Do the intermidiate states of the system (before settling to the final equilibrium state)lie on its $P - V - T$ surface?

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7. A steam engine delivers $5.4 \times 10^8 J$ of work per minute and absorbs $3.6 \times 10^9 J$ of heat per minute from its boiler. What is the efficiency of the engine? How much heat is wasted per minute?

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8. An electric heater supplies heat to a system at a rate of $100W$. If sustem performs work at a rate $74Jo\underline{e}s$ per second, at what rate is the internal energy increasing?

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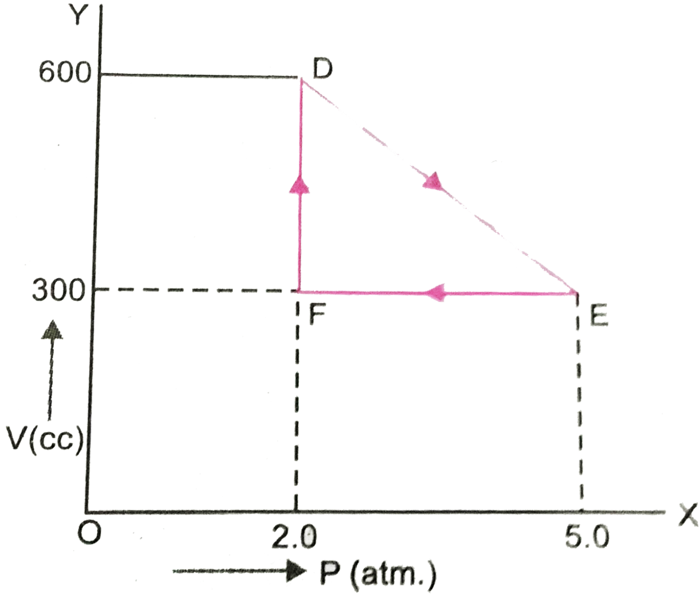
9. A thermodynamic system is taken from an original state D to an intermediate state E by the linear process shown in (figure)



Its volume is then reduced to the original value from E to D via F by an isobaric process. Calculate the total work done by the gas from D to E to F to D.

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10. A refrigerator is to maintain eatables kept inside at $9^{\circ}C$, if room temperature is $36^{\circ}C$. Calculate the cofficient of performance.

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Multiple Choice Questions

1. The physical quantity that determins whether or not a given system A is in thermal equilibrium with another system B is called

A. Pressure

B. Volume

C. temperature

D. none of these

Answer: C

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2. The physical quantity that determins whether or not a given system A is in thermal equilibrium with another system B is called

A. Pressure

B. Volume

C. temperature

D. none of these

Answer: C

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3. Specific heat of a gas during an isothermal change is

A. Zero

B. Positive

C. negative

D. infinity

Answer: D

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4. During an adiabatic change, specific heat of a gas is

A. Zero

B. Positive

C. negative

D. infinity

Answer: A

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5. In case of compression, isothermal curve lies.....the adiabatic curve. Fill in the blanks

A. above

B. below

C. sometimes above and other time below

D. cannot say

Answer: B

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6. The adiabatic relation between P and T is

A. $P^{1-\gamma}.T^{\gamma} =$ constant

B. $PT^{\gamma} = \text{ constant}$

C. $P^{\gamma}T^{1-\gamma} = \text{ constant}$

D. $P^{\gamma}T^{\gamma-1} = \text{ constant}$

Answer: A

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7. Internal energy of an ideal gas depends upon

A. Volume only

B. temperature only

C. both, volume and temperature

D. neither volume nor temperature

Answer: B

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8. In the relation $dQ = dU + dW$, the quantity which remains the same for all process is

A. dQ

B. aW

C. dU

D. all of the above

Answer: C

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9. Efficiency of carnot engine working between ice point and steam point is

A. 0.732

B. 1

C. 0.268

D. none of these

Answer: C

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10. A gas absorbs $100 Cal$ or ie of heat and performs $150 J$ of work. Increase energy of the gas in the process is

A. $420 J$

B. $570 J$

C. $270J$

D. none of these

Answer: C

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11. The coefficient of performance of a refrigerator, which extracts $100cal \text{ or } ie$ of heat// cycle from the sink and releases $140cal \text{ or } ie$ of heat//cycle to the source is

A. 2.5

B. 5

C. 3.5

D. 4

Answer: A

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12. The specific heat of a substance depends on

A. mass of the substance

B. temperature of the substance

C. nature of material of the substance

D. both (a) and (b)

Answer: D

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13. Specific heat of water:

A. $4.2 Jkg^{-1}K^{-1}$

B. $420 Jkg^{-1}K^{-1}$

C. $1 cal kg^{-1}K^{-1}$

D. $4200 Jkg^{-1}K^{-1}$

Answer: D

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14. Which law of cooling holds for really larege temperature differences ?

A. Newton's law of cooling

B. Wien's law

C. Stefan's law

D. Stefan Boltzmann law

Answer: D

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15. Newton's law of cooling is valid when differences in temperature of liquid and surronding is of the order of

A. $30^{\circ} C$

B. $300^{\circ} C$

C. $3000^{\circ} C$

D. $0.3^\circ C$

Answer: A

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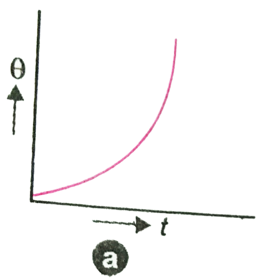
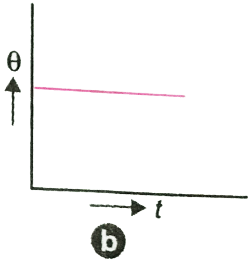
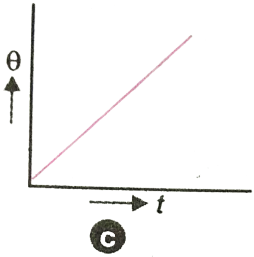
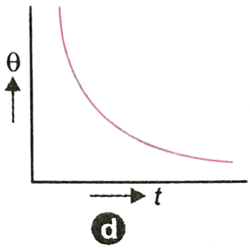
16. The variation of temperature of a liquid with time is represented correctly by (figure)

A. 

B. 

C. 

D. 

Answer: D

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17. The water equivalent of a calorimeter is $0g$.

Its thermal capacity is

A. $10 cal / ^\circ C$

B. $100 cal / ^\circ C$

C. $1 cal / ^\circ C$

D. $10 cal / ^\circ F$

Answer: A

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18. Equal masses of two liquid- one at $20^\circ C$ and other at $40^\circ C$ are mixed together.The temperature of the mixture is $32^\circ C$. The ratio of their specific heats is

A. $3:2$

B. $1:1$

C. $2:3$

D. $1:3$

Answer: C

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Problems For Practice

1. A cylinder containing one gram molecule of the gas was compressed adiabaticaly untill its tempertaure rose from $27^{\circ} C$ to $97^{\circ} C$. Calculate the work done and heat produced in the gas $(\gamma = 1.5)$.

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2. A sample of gas $(\gamma = 1.5)$ is taken through an adiabatic process in which the volume is compressed from $1600cm^3$ to $400cm^3$. If the initial pressure is $150kPa$, (a) what is the final pressure and (b) how much work is done by the gas in the process?

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3. $200cm^3$ of a gas is compressed to $100cm^3$ at atmospheric pressure $(10^6 \text{dyne}/cm^2)$. Find the resultant pressure if the change is (i) slow (ii) sudden Take $\gamma = 1.4$.

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4. An ideal monoatomic gas is taken around the cycle ABCDA, wher co-ordinates of A, B, C and D on and D on $P - V$ diagram are A (p, V), $B(2p, V)$, $C(2p, 2V)$ and $D(p, 2V)$. Calculate work done during the cycle.

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5. A quantity of air at $27^{\circ}C$ and atmospheric pressure is suddenly compressed to half its original volume. Find the final (i) pressure and (ii) temperature.

Given $\gamma f \text{ or } air = 1.42.$

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6. A cyclinder containing one gram mole of a gas was put on boiling water bath and compressed adibatically till its temperature rose by $70^{\circ}C$. Calculate the work done and heat developed in the gas, $\gamma = 1.5, R = 2cal. mole^{-1}K^{-1}$

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7. One gram mole of an ideal gas at $N.T.P$ is first expanded isothermally to twice the origional volume. It is then compressed at constant volume, till its pressure is raised to the original value. Calculate the total amount of work done. Given $R = 8.3 mole^{-1} K^{-1}$.

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8. A tyre pumped to a pressure of $6atmosphere$ bursts suddenly. Calculate the temperature of escaping air. Given initial room temperature is $15^\circ C$ and gamma for air is 1.4`.

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9. Find the final value of a gram molecule of a gas after an isothermal expansion at $127^\circ C$, if the original volume is $400c.\ c$ Given amount of work done by a gram molecule of a gas during expansion is

$2302.6 \text{joule}, R = 8.3 \text{joule mole}^{-1} K^{-1}$

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10. A quantity of air at normal temperature is compressed (a) slowly (b) suddenly to one third of its volume. Find the rise in temperature, if any in each case, $\gamma = 1.4$.

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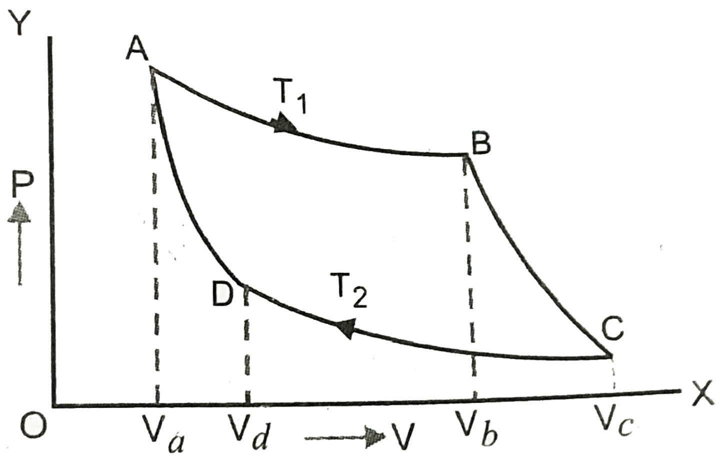
11. Two different adiabatic curves for the same gas intersect two isothermals at T_1, and T_2 as shown in $P-V$ diagram, (figure). How does the ratio (V_a/V_d) compare with the ratio (V_b/V_c) ?



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12. If at $50^\circ C$ and $75cm$ of mercury pressure, a definite mass of gas is compressed (i) slowly (ii) suddenly, than what will be the final pressure and temp. of the gas in each case, if the final volume is one fourth of the initial volume? $\gamma = 1.5.$

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13. An ideal monoatomic gas is taken around the cycle ABCDA, wher co-ordinates of A, B, C and D on and D on $P-V$ diagram are A

$(p, V), B(2p, V), C(2p, 2V)$ and $D(p, 2V)$.

Calculate work done during the cycle.

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14. Calculate net work done by the gas whose thermodynamical behaviour is represented by right angled triangle ABC on $P - V$ diagram. The $P - V$ diagram co-ordinates are : $A(20, 6), B(10, 12)$ and $C(10, 6)$ where P is in Nm^{-2} and V is in m^3

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15. One mole of an ideal gas is heated from 273K to 546K at constant pressure of 1 atmosphere. Calculate the work done by the gas in the process.

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16. Three moles of an ideal gas at $127^{\circ}C$ expands isothermally untill the volume is doubled. Calculate the amount of work done and heat absorbed.

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17. A volume of $10m^3$ of a liquid is supplied with $100kal$ of heat and expands at a constant pressure of $10atm$ to a final volume of $10.2m^3$. Calculate the work done and change in internal energy.

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18. At $0^\circ C$ and normal atmospheric pressure, the volume of 1 gram of water increases from $1c. cto1.091c. c$ on freezing. What will be the change in its internal energy? Normal atmospheric pressure is $1.013 \times 10^5 N/m^2$ and latent heat of melting of ice $= 80 cal/gram$.

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19. A sample of ideal gas $(\gamma = 1.4)$ is heated at constant pressure. If an amount $140 J$ of heat is supplied to the gas, find (a) the changes in internal energy of the gas, (b) the work done by the gas.

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20. One kg of water at $373K$ is converted into steam at the same temperature. The volume $1cm^3$ of water becomes $1671cm^3$ on boiling. Calculate the change in internal energy of the system , if heat of vaporisation is $540calg^{-1}$. Given standard atmospheric pressure $= 1.013 \times 10^5 Nm^{-2}$.

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21. When a gas is taken from one state a to another state b via one path, it absorbs

$25 cal$ or ies of heat while doing $70J$ of work. How much heat much heat has to be supplied in taking the same gas from state a to state b via another path when it performs $200J$ of work?

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22. $1g$ mole of an ideal gas at STP is subjected to a reversible adiabatic expansion to double its volume. Find the change in internal energy $(\gamma = 1.4)$

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23. If $1 gram$ of oxygen at $760 mm$ pressure and $0^{\circ} C$ has its volume double in an adiabatic change , calculate the change in internal energy.

Take

$R = 2 cal. Mole^{-1} K^{-1} = 4.2 J cal^{-1}$ and $\gamma = 1.4$

.

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24. Ten mole of hydrogen at $N.T.P$ is compressed adiabatically so that it temperature becomes $400^{\circ} C$. How much work is done on the

gas? Also, Calculate the increase in internal energy of the gas. Take $R = 8.4 J mole^{-1} K^{-1}$ and $\gamma = 1.4$.

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25. Calculate the increase in internal energy of $1 kg$ of water at $100^{\circ} C$ when it is converted into steam at the same temperature and at $1 atm$ ($100 kPa$). The density of water and steam are $1000 kgm^{-3}$ and $0.6 kgm^{-3}$ respectively. The latent heat of vaporization of water $= 2.25 \times 10^{6} J kg^{1}$.

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26. The internal energy of a monatomic ideal gas is $1.5nRT$.One mole of helium is kept in a cylinder of cross section $8.5cm^2$. The cylinder is closed by a light frictionless piston. The gas is heated slowly in a process during which a total of $42J$ heat is given to the gas. If the temperature rise through $2^\circ C$, find the distance moved by the piston. atmospheric pressure $= 100kPa$.

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27. A carnot engine has the same efficiency

(i) between $100K$ and $500K$ and

(ii) between $TK$and $900K$. Caculate the temperature T of the sink.

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28. A heat engine operates between a cold reservoir at tempreture $T_2 = 300K$ and a hot reservior at tempreture T_1. It takes $200J$ of heat from the hot reservior and delivers $120J$ of heat to the cold reservior in a cycle. What sould be the minimum temperature of the hot reservior ?

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29. A carnot engine takes in $1000 Kcal$ of heat from a reservoir at $627^\circ C$ and exhausts heat to sink at $27^\circ C$. What is its efficiency? What is useful work done//cycle by the engine.

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30. A Carnot engine, whose temperature of the source is $400K$ receives $200cal$ or ies of heat at this temperature and rejects $150calaroies$ of heat to the sink. What is the temperature of the sink? Also, calculate the efficiency of the engine

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31. The efficiency of a Carnot cycle is $1/6$. By lowering the temperature of sink by $65K$, it increases to $1/3$. The initial and final temperature of the sink are

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32. In a Carnot engine, the temperature of the source and sink are $500K$ and $375K$ respectively. If the engine consumes 600×10^3 cals./cycle, find

(i) the efficiency of engine (ii) work done/cycle

(iii) heat rejected per cycle.

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33. A reversible engine takes in heat from a reservoir of heat at $527^\circ C$, and gives out to the sink at $127^\circ C$ How many calories per second must it take from the reservoir in order to produce useful mechanical work at the rate of $750 watt? 1 cal. = 4.2 J.$

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34. A reversible engine converts one fifth of heat which it absorbs from source into work. When the temp. of sink is reduced by $70^\circ C$, its efficiency is doubled. Calculate the temperature of the source and sink.

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35. Efficiency of a carnot engine is 0.4, when temp. of sink is $300K$. What is temp. of source? If temp. of source is kept same and that of sink is lowered by $50^{\circ} C$, what would be the efficiency?

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36. A perfect carnot engine has source temp. $227^{\circ} C$ and sink temp. $127^{\circ} C$. Find the efficiency of the engine, If $10000 J$ of external work is to be done, find heat received from source and heat released to the sink.

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37. An ideal engine operates by taking in steam from a boiler at $327^{\circ} C$ and rejecting heat to a sink at $27^{\circ} C$. The engine runs at $500 r \pm$ and heat taken is $600 kcal$ in each revolution. Calculate(i) efficiency of engine (ii) work done in each cycle (iii) heat rejected in each revolution and (iv) power output of engine.

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38. Two carnot engines A and B are operated in series. The first one A receives heat at $900K$ and rejects it to a reservoir at TK. The second engine B receives the heat rejected by the first engine and rejects it to a heat reservoir at $400K$. Calculate the value of T, when the efficiency ot two engines is the same.

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39. A carnot engine is designed to operate between $480K$ and $300K$. Assuming that the engine actually produces, 1.2 KJ` of mechanical energy per Kcal of heat absorbed. Compare the actual efficiency with the theoretiacal maximum efficiency.

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40. A carnot engine absorbs $2000J$ of heat from the source of heat engine at $227^{\circ}C$ and rejects

$1200J$ of heat to the sink during each cycle. Calculate

(i) Temp.of sink (ii) efficiency of engine

(iii) amount of work done during each cycle.

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41. In a refrigerator, heat from inside at $270K$ is transferred to a room at $300K$. How many calories of heat will be delivered to the room for each joule of electrical energy consumed ideally?

View Text Solution

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42. Assuming that a domestic refrigerator can be regarded as a reversivle engine working between the temperature of melting ice and that of the atmosphere $(170^\circ C)$, calculate the energy which muct be supplied to freeze one kilogram of water already at $0^\circ C$.

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43. In a cold storage, ice melts at the rate of $2kg/h$ when the external temperature is $20^\circ C$.

Find the minimum power output of the motor used to drive the refrigerator which just prevents the ice from melting. Latent heat of fusion of $ice = 80cal/g$

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44. A refrigerator, whose coefficient performance β is 5, extracts heat from the collingcompartment at the rate of 250 J per cycle.

(a) How much work per cycle is required to operate the refrigerator?

(b) How much heat per cycle is discharges the room which acts as the high temperature reservoir?

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45. A refrigerator freezes 5 kg of water at $0^{\circ} C$ into ice at $0^{\circ} C$ in a time internal of 20 minutes. Assume that the room temperature is $20^{\circ} C$. Calculate the minimum power needed to accomplish it.

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46. Calculate the least amount of work that must be done to freeze one gram of wate at $0^{\circ} C$ by means of a refrigerator. Temperature of surroundings is $27^{\circ} C$. How much heat is passed on the surroundings in this process? Latent heat of fusion $L = 80 cal / g$.

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47. Refrigerator A works between- $10^{\circ} C$ and $27^{\circ} C$ while refrigerator B works between $-20^{\circ} C$ and $17^{\circ} C$, both removing

$2000J$ from the freezer. Which of the two is better refrigerator?

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48. In a refrigerator, heat from inside at $277K$ is transferred to a room at $300K$. What is the cofficient of performance of the refrigerator. How many joule of heat will be deliverd to the room for each joule of electric energy consumed ideally?

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49. One mole of an ideal gas undergoes a cyclic change ABCD where the (P,V) co-ordinates are A (5,1), B (5,3), C (2,3) and D (2,1). P is atmosphere and V is in litre. Calculate work done along AB, BC, CD and DA and also net work done in the process. Given $1 atmosphere = 1.01 \times 10^5 Nm^{-2}$.

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50. Calculate the heat absorbed by a system in going through the cyclic process shown in figure ,

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51. A diatomic gas $(\gamma = 1.4)$ does $200J$ of work when it is expanded isobarically. Find the heat given to the gas in the process.

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52. Two Carnot engines are operated in succession. The first engine receives heat from a source at $T = 800K$ and rejects to sink at $T_2 K$. The second engine receives heat rejected by the first engine and rejects to another sink at $T_3 = 300K$. If work outputs of the two engines are equal, then find the value of T_2.

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53. The adiabatic compression ratio in a carnot reversible cycle is 9, when the temperature iof the source is $227^\circ C$. Calculate the temperature of the sink. Given $\gamma = 1.5$

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54. Five moles of an ideal gas are taken in a Carnot engine working between $100^\circ C$ and $30^\circ C$. The useful work done in one cycle is 420 joule. Calculate the ratio the volume of the gas at the end beginning of the isothermal expansion. $R = 8.4 JMo \le^{-1} K^{-1}$.

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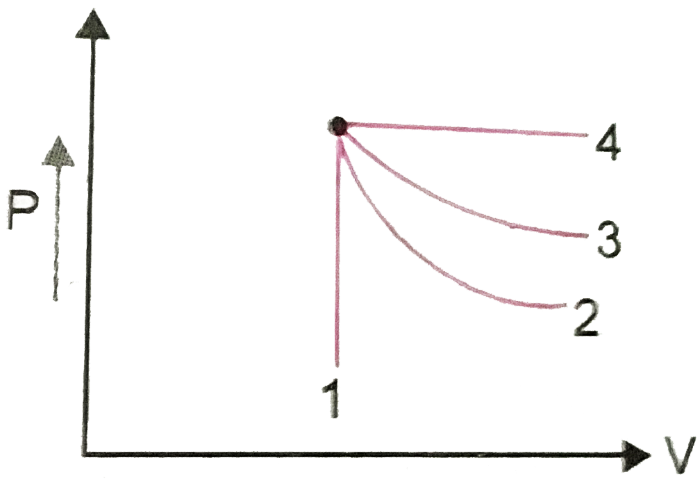
Multiple Choice Questions Ncert

1. An ideal gas undergoes four different processes from the same initial state (figure). Four process are adiabatic, isothermal, isobaric and isochloric. Out of 1, 2, 3, and 4 which one is idabatic.



A. 4

B. 3

C. 2

D. 1

Answer: C

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2. If an avarage person jogs, he produces $14.5 \times 10^4 cal / \min$. This is removed by the evaporation of sweat. The amount of sweat evaporated per minute (assuming $1kg$ requites 580×10^3 cal for evaporation) is

A. $0.25kg$

B. $2.25kg$

C. $0.05kg$

D. $0.20kg$

Answer: A

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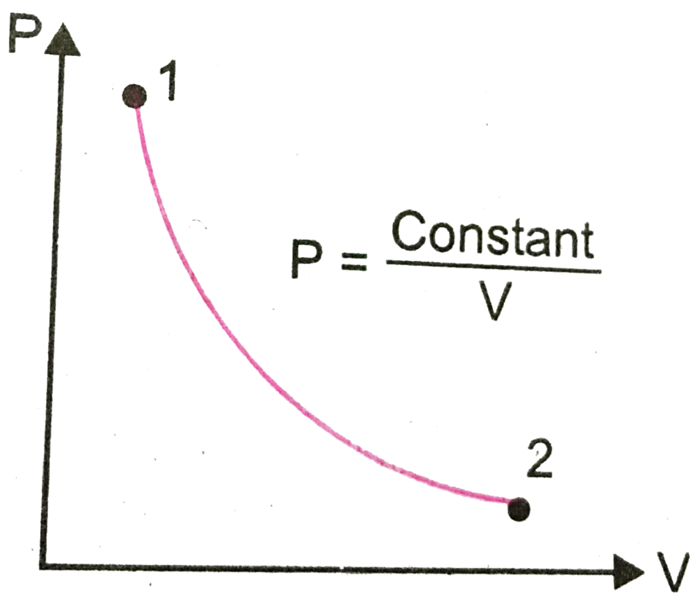
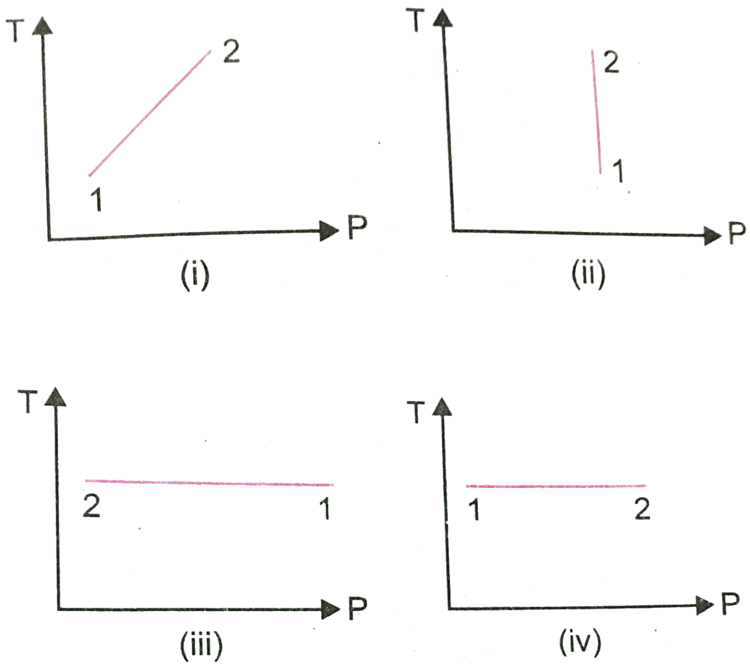
3. Consider $P-V$ diagram for an ideal gas shown in figure.



Out of following diagrams(figure). Which represents the $T-P$ diagram?



A. (iv)

B. (ii)

C. (iii)

D. (iv)

Answer: C

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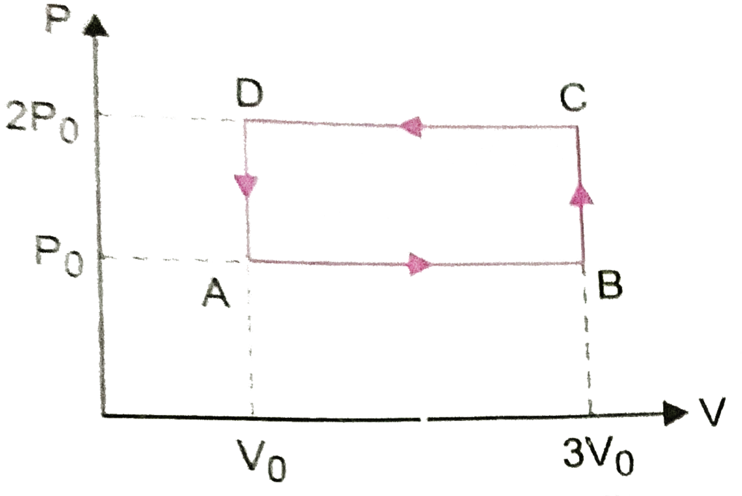
4. An ideal gas underoges cyclic process of ABCDA as shown in Given $P-V$ diagram (figure)



The amount of work done by the gas is

A. $6P_0V_0$

B. $-2P_0V_0$

C. $+2P_0V_0$

D. $+4P_0V_0$

Answer: B

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5. Consider two containers A and B containing identical gases at the same pressure, volume and temperature. The gas in container A is compressed to half of its original volume isothermally while the gas in container B is compressed to half of its original value adiabatically. The ratio of final pressure of gas in B to that of gas in A is

A. $2^{\gamma - 1}$

B. $\left(\frac{1}{2}\right)^{\gamma - 1}$

C. $\left(\frac{1}{1-\gamma}\right)^{2}$

D. $\left(\frac{1}{\gamma-1}\right)^{2}$

Answer: A

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6. Three copper blocks of masses M_1, M_2 and $M_3 kg$ respectively are brought into thermal contact till they reach equlibrium. Before contact, they were at

$T_1, T_2, T)(3), (T_1 > T_2 > T_3)$. Assuming there is no heat loss to the surroundings, the equilibrium temperature T is $(sisspec$ if $icheatofcopper)$

A. $T = \frac{T_1 + T_2 + T_3}{3}$

B. $T = \frac{M_1T_1 + M_2T_2 + M_3T_3}{3(M_1 + M_2 + M_3)}$

C. $T = \frac{M_1T_1 + M_2T_2 + M_3T_3}{M_1 + M_2 + M_3}$

D. $T = \frac{M_1T_1s + M_2T_2s + M_3T_3s}{M_1 + M_2 + M_3}$

Answer: B

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7. Which of the process described below are irrevesible?

A. The increase in temperature of an iron rod by hammering it.

B. A gas in small container at a temperature T_1 is brought in contact with a big reservoir at a higher temperature of the gas.

C. A quasi- static isothermal expansion of an ideal gas in cyclinder fitted with a frictionless piston.

D. An ideal gas is enclosed in a piston cyclinder arrangement with adiabatic walls. A weight W is added to the piston, resulting in compression of gas.

Answer: A::B::D

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8. An ideal gas undergoes isothermal process from some initial state i to final state f. Choose the correct alternatives.

A. $dU = 0$

B. $dQ = 0$

C. $dQ - dU$

D. $dQ = dW$

Answer: A::D

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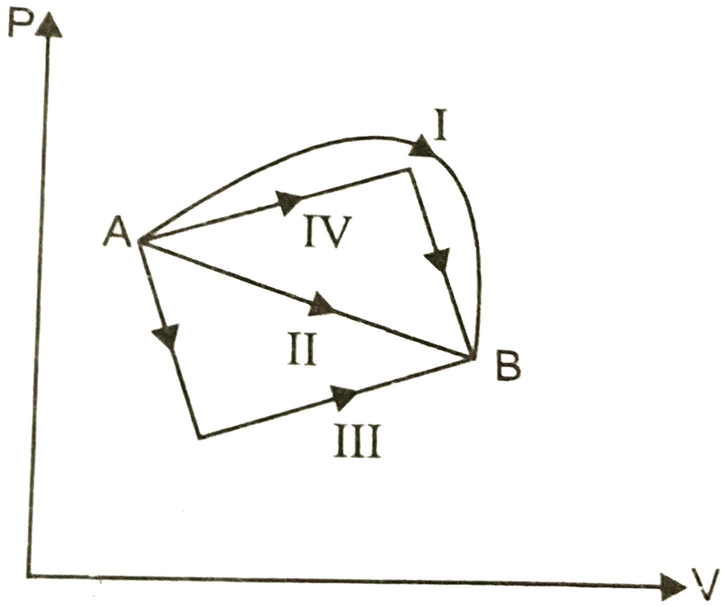
9. (figure). Shows the $P - V$ diagram of an ideal gas undergoing a change of state from A to B.

Four different process I, II, III, IV, as shown in (figure) may lead to the same change of state.



A. Change in internal energy is same in IV and III cases, bit not in I and II.

B. Change in internal energy is same in all the four cases.

C. Work done is maximum in case I

D. Work done in minimum in case II.

Answer: B::C

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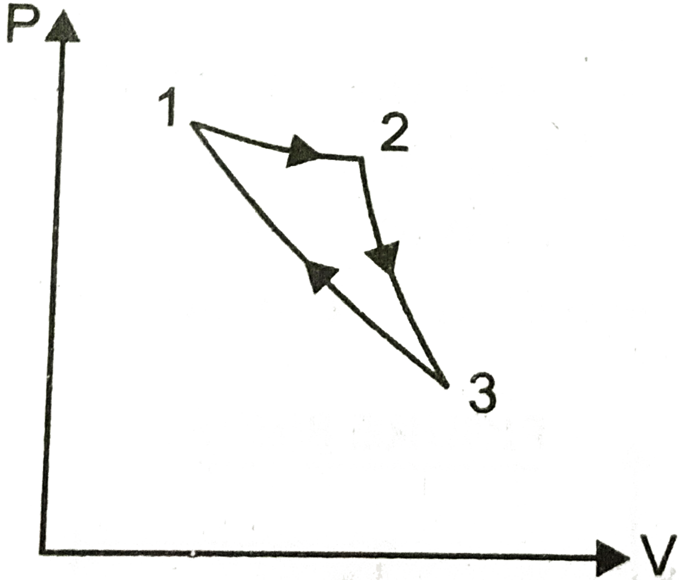
10. Consider a cycle followed by an engine, (figure)



1 to 2 is isothermal 2 to 3 is adiabatic 3 to 1 is adiabatic

such a process does not exist because

A. heat is completely converted to mechanical energy in such a process, which is not possible.

B. mechanical energy is completely converted to heat in this process, which is not possible.

C. curves representing two adiabatic processes don’t intersect.

D. curves representing an adiabatic process and an isothermal process don't intersect.

Answer: A::C

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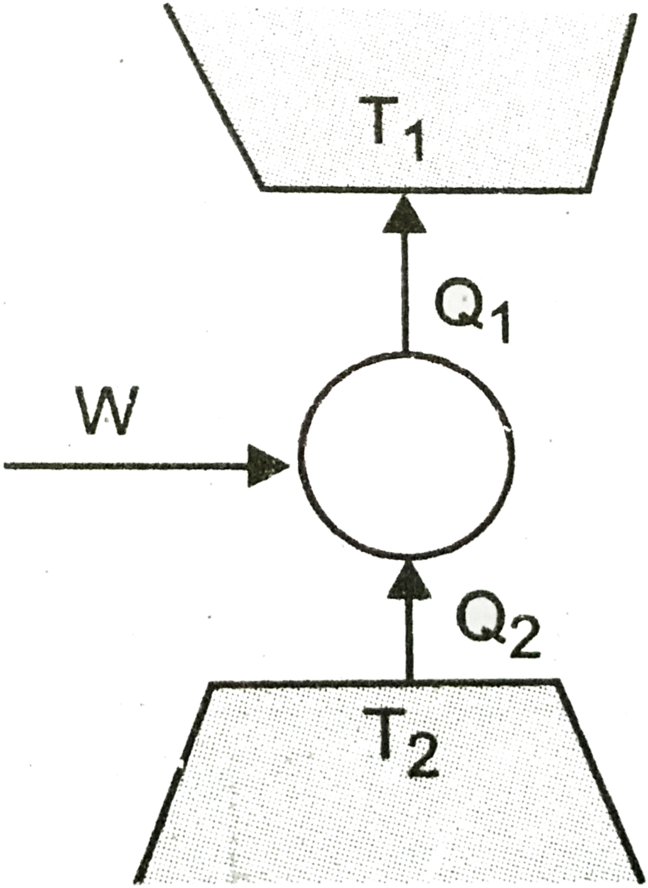
Multiple Choice Questions

1. Consider a heat engine as shown in (figure). Q_1 and Q_2 are heat added to heat bath T_1 and heat taken from T_2 one cycle of engine. W is the mechanical work done on the engine.



If $W > 0$, then possibillities are:

A. $Q_1 > Q_2 > 0$

B. $Q_2 > Q_1 > 0$

C. $Q_2 < Q_1 < 0$

D. $Q_1 < 0, Q_2 > 0$

Answer: A::C

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2. Consider two containers A and B containing identical gases at the same pressure, volume and temperature. The gas in container A is compressed to half of its original volume isothermally while the gas in container B is compressed to half of its original value adiabatically. The ratio of final pressure of gas in B to that of gas in A is

A. $2^{\gamma - 1}$

B. $\left(\frac{1}{2}\right)^{\gamma - 1}$

C. $\left(\frac{1}{1-\gamma}\right)^2$

D. $\left(\frac{1}{\gamma - 1}\right)^2$

Answer: A

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3. Consider a spherical shell of radius R at temperature T. The black body radiation inside it can be considered as an ideal gas of photons with internal energy per unit volume $u = \frac{U}{V} \propto T^4$ and pressure $P = \frac{1}{3}\left(\frac{U}{V}\right)$. If the shell now undergoes an adiabatic expansion the relation between T and R is :

A. $T \propto e^{-R}$

B. $T \propto e^{-3R}$

C. $T \propto \frac{1}{R}$

D. $T \propto \frac{1}{R^3}$

Answer: C

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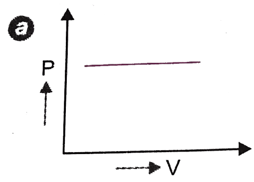
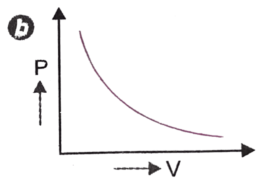
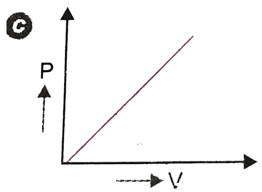
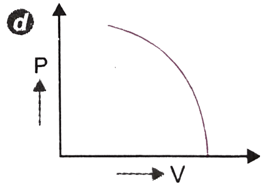
4. Which of the following $P-V$ diagrams best represents an isothermal process?

A. 

B. 

C. 

D. 

Answer: B

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5. The pressure of a gas is increased by 50% at constant temperature. The decrease in volume will be nearest to

A. 66%

B. 33%

C. 17%

D. 8%

Answer: B

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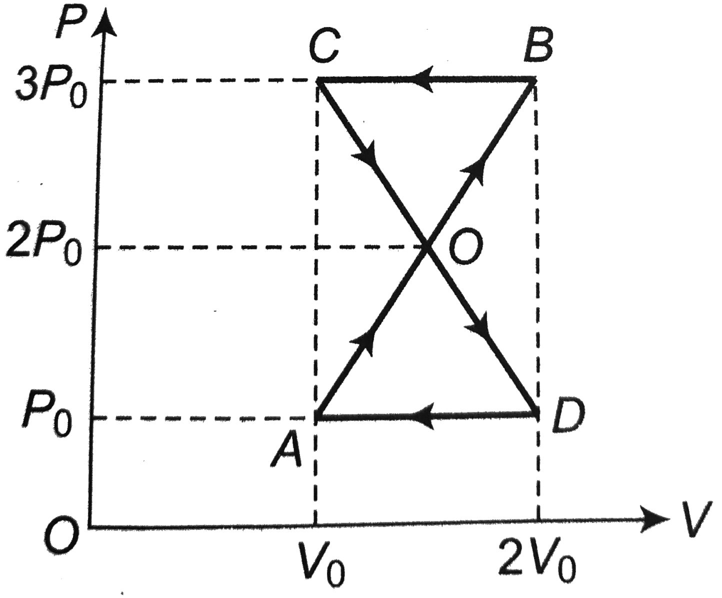
6. A thermodynamic system undergoes cyclic process $ABCDA$ as shown in figure. The work done by the system is



A. P_0V_0

B. $2P_0V_0$

C. $\frac{P_0V_0}{2}$

D. Zero

Answer: D

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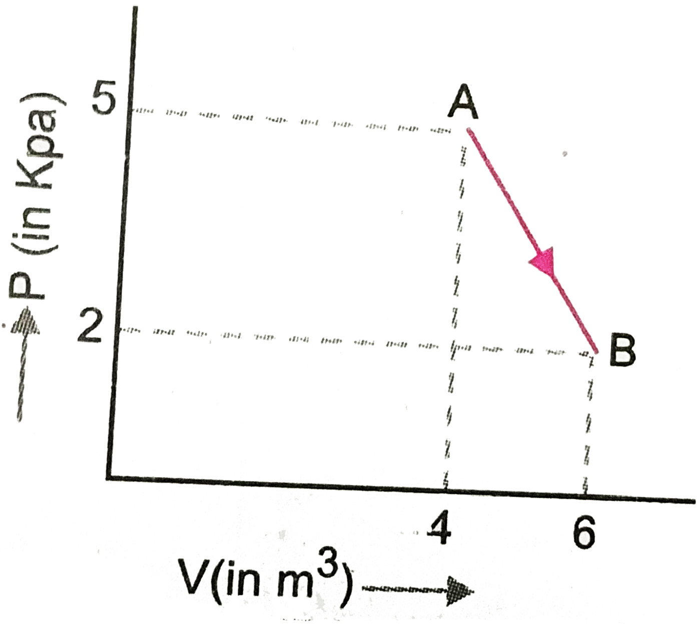
7. One mole of an ideal diatomic gas undergoes a transition from A to B along a path AB as shown in (figure). The change in internal energy of the gas during the transition is $(\gamma = 3/5)$



A. $-20KJ$

B. $20KJ$

C. $-12KJ$

D. $20KJ$

Answer: A

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8. At $27^{\circ}C$ two moles of an ideal monoatomic gas occupy a volume V. The gas expands adiabatically to a volume 2V. Calculate (i) the final temperature of the gas, (ii) change in its internal energy, and (iii) the work done by the gas during this process.

A. $179K$

B. $189K$

C. $213K$

D. $219K$

Answer: B

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9. In the above question, change in internal energy of gas is

A. $-2660.23J$

B. $-2777.23J$

C. $-2767.23J$

D. $-2600J$

Answer: C

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10. $400cc$ volume of gas having $\gamma = \frac{5}{2}$ is suddenly compressed to $100cc$. If the initial pressure is P, the final pressure will be

A. $P/32$

B. $8P$

C. $32P$

D. $16P$

Answer: C

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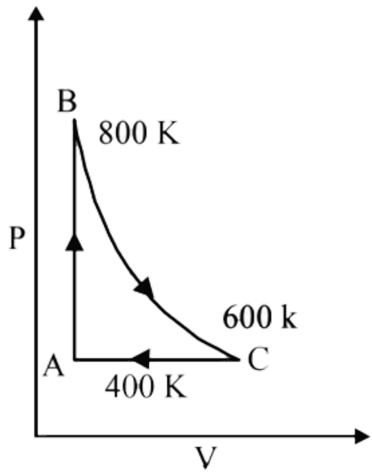
11. One mole of a diatomic ideal gas undergoes a cyclic process ABC as shown in figure. The process BC is adiabatic. The temperature at A,B and C are 400K, 800K and 600K respectively.

Choose the correct statement:



A. change in internal energy in the process

AB $= 350R$

B. change in internal energy in the process

BC is $-500R$

C. change in internal energy in the whole

cyclic process is $250R$

D. change in internal energy in the process CA is $700R$

Answer: B

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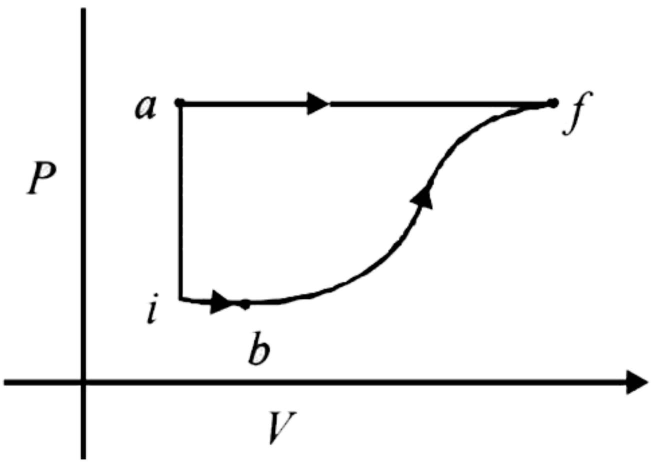
12. A thermodynamic system is taken from an initial state I with internal energy $U_i = -100J$ to the final state f along two different paths iaf and ibf, as schematically shown in the figure. The work done by the system along the pat af, ib and bf are $W_{af} = 200J$, $W_{ib} = 50J$ and $W_{bf} = 100J$ respectively. The heat supplied to the system along the path iaf, ib and bf are Q_{iaf}, Q_{ib}, Q_{bf} respectively. If the internal energy of the system in the state b is $U_b = 200J$ and $Q_{iaf} = 500J$, The ratio $\frac{Q_{bf}}{Q_{ib}}$ is



A. 1

B. 2

C. 3

D. 4

Answer: B

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13. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_P/C_V for the gas is

A. $\frac{3}{2}$

B. $\frac{2}{3}$

C. $\frac{4}{3}$

D. $\frac{5}{3}$

Answer: A

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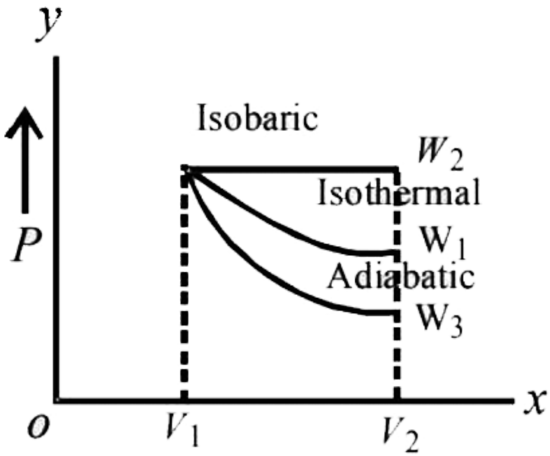
14. Starting with the same initial conditions, an ideal gas expands from volume $V_1 \rightarrow V_2$ in three different ways. The work done by the gas is W_1 if the process is purely isothermal, W_2if purely isobaric and W_3 if purely adiabatic. Then



A. $W_2 > W_1 > W_3$

B. $W_2 > W_3 > W_1$

C. $W_1 > W_2 > W_3$

D. $W_1 = W_2 = W_3$

Answer: A

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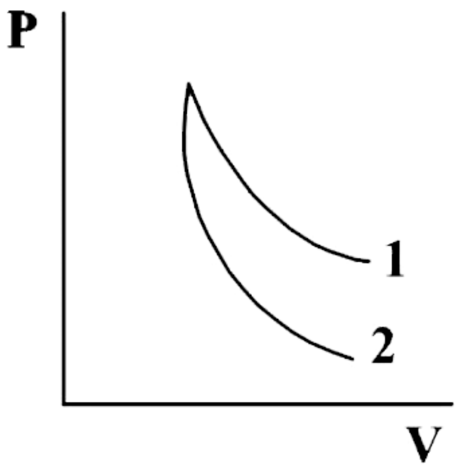
15. P-V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should corresponds respectively to



A. He and O_2

B. O_2 and He

C. He and Ar

D. O_2 and N_2

Answer: B

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16. The work of 142kJ is performed in order to compress one kilo mole of gas adiabatically and in this process the temperature of the gas increases by $7^{\circ} C$. The gas is $(R = 8.3 J mol^{-1} K^{-1})$

A. triatomic

B. monoatomic

C. diatomic

D. mixture of monoatomic and diatomic

Answer: C

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17. One mole of an ideal gas at an initial temperature true of TK does $6R$ joule of work adiabatically. If the ratio of specific heats of this gas at constant pressure and at constant volume is $5/3$, the final temperature of the gas will be

A. $(T+4)K$

B. $(T-4)K$

C. $(T+2.4)K$

D. $(T-2.4)$

Answer: B

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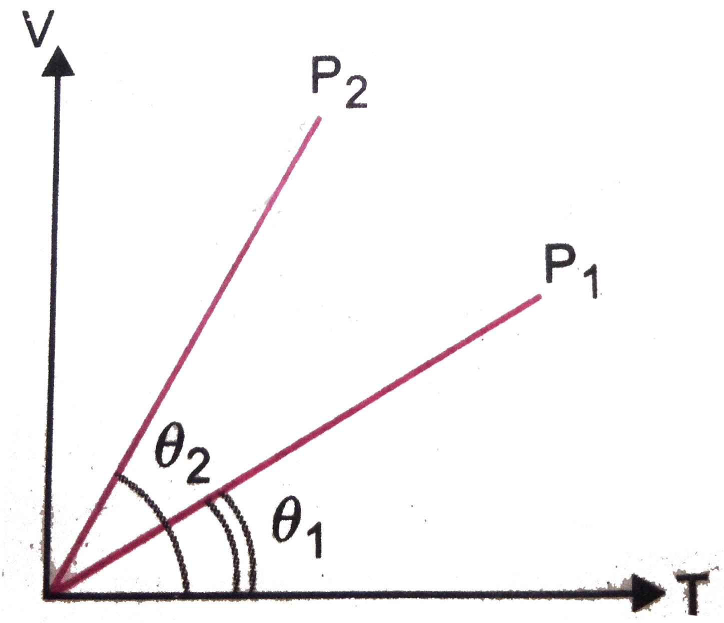
18. In the given (V-T) diagram, what is the relation between pressure P_1 and P_2 ?



A. $P_2 = P_1$

B. $P_2 > P_1$

C. $P_2 < P_1$

D. cannot say

Answer: C

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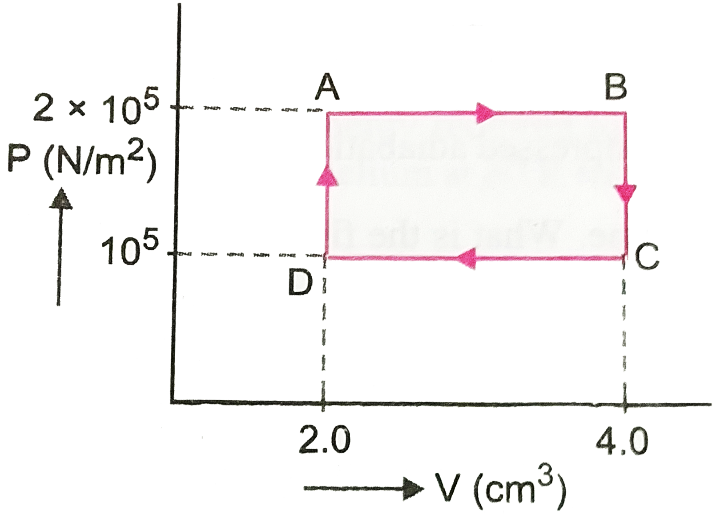
19. The $P - V$ diagram of a gas undergoing a cyclic process ABCDA is shown in (figure). Where P is in N/m^2 and V is in cm^3. Identify the incorrect statement



A. $0.4J$ of work is done by the gas from A to

B

B. $0.2J$ of work is done on the gas from C to

D

C. No work is done by the gas in going from B to C

D. Work done by the gas in going from B to C and on the gas from D to A

Answer: D

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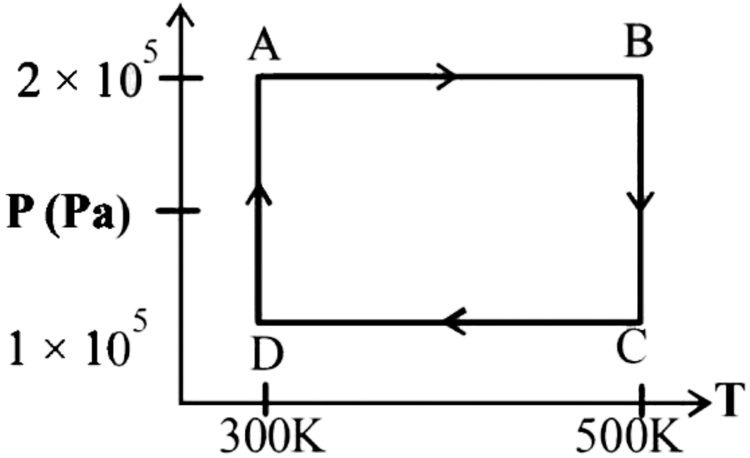
20. Two moles of helium gas are taken over the cycle ABCDA, as shown in the P-T diagram



Assuming the gas to be ideal the work done on the gas in taking it form A to B is :

A. $300R$

B. $400R$

C. $500R$

D. $200R$

Answer: B

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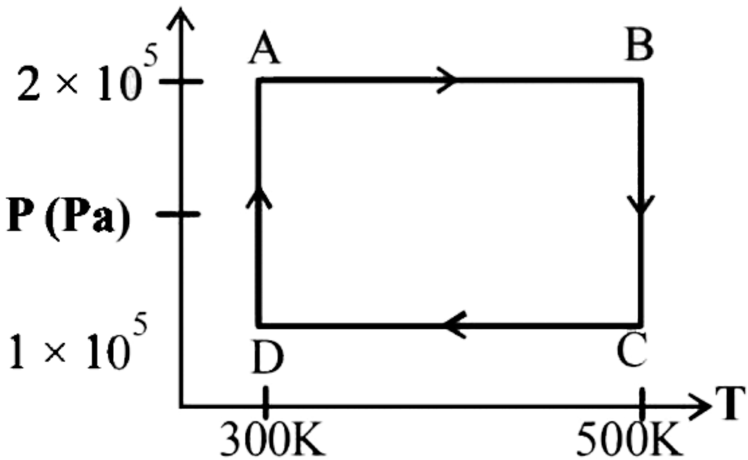
21. Two moles of helium gas are taken over the cycle ABCDA, as shown in the P-T diagram



The work done on the gas in taking it from D to A is :

A. $+414R$

B. $-690R$

C. $+690R$

D. $-414R$

Answer: A

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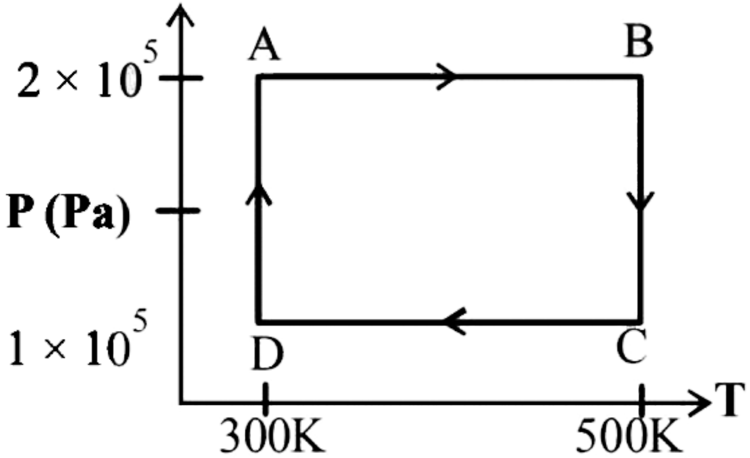
22. Two moles of helium gas are taken over the cycle ABCDA, as shown in the P-T diagram



The net work done on the gas in the cycle ABCDA is :

A. $277R$

B. $1076R$

C. $1904R$

D. Zero

Answer: A

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23. A monoatomic gas at pressure P_1 and volume V_1 is compressed adiabatically to $\frac{1}{8}th$ of its original volume. What is the final pressure of gas.

A. $64P_1$

B. P_1

C. $16P_1$

D. $32P_1$

Answer: D

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24. An ideal gas is made go to through a cyclic thermodynamics process in four steps. The $Q_2 = 300J, Q_3 = -400J, Q_4 = -100J$ respectively. The corresponding works involved are $W_1 = 300J, W_2 = -100J, W_3 = 100J$ and W_4. What is the value of W_4?

A. $100J$

B. $500J$

C. $-700J$

D. $-400J$

Answer: D

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25. A thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heats γ. It is moving with speed v and it's suddenly brought to rest. Assuming no heat is lost to the surroundings, Its temperature increases by:

A. $\frac{(\gamma-1)}{r\gamma R} M v^{2} K$

B. $\frac{\gamma M v^{2}}{2 R} K$

C. $\frac{(\gamma-1)}{2 R} m v^{2} K$

D. $\frac{(\gamma-1)}{2(\gamma+1) R} M v^{2} K$

Answer: C

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26. During an isothermal expansion, a confined ideal gas does $-150J$ of work aginst its surroundings. This implies that

A. $150J$ of heat has been removed from the gas

B. $300J$ of heat has been added to the gas

C. no heat is transferred because the process is isothermal

D. $150J$ of heat been added to the gas

Answer: D

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27. When $1kg$ of ice at $0^{\circ} C$ melts to water at $0^{\circ} C$, the resulting change in its entropy, taking latent heat of ice to be $80cal / g$ is

A. $273cal / K$

B. $8 \times 10^{4} cal / K$

C. $80cal / K$

D. $293cal / K$

Answer: D

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28. A mass of diatomic gas$(\gamma = 1.4)$ at a pressure of 2 atomphere is compressed adiabitically so that its temperature rises from $27^{\circ} C$ to $927^{\circ} C$. The pressure of the gas in the final state is

A. $28 atm$

B. $68.7 atm$

C. $256 atm$

D. $8 atm$

Answer: C

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29. 5.6 liter of helium gas at STP is adiabatically compressed to 0.7 liter. Taking the initial temperature to be T_1, the work done in the process is

A. $-\frac{9}{8}RT_1$

B. $\frac{3}{2}RT_1$

C. $\frac{15}{8}RT_1$

D. $\frac{9}{2}RT_1$

Answer: A

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30. Two moles of ideal helium gas are in a rubber balloon at $30^\circ C$. The balloon is fully expandable and can be assumed to require no energy in its expansion. The temperature of the gas in the balloon is slowly changed to $35^\circ C$. The amount of heat required in raising the temperature is nearly (take R

$= 8.31 J / mol. K)$

A. $62 J$

B. $104 J$

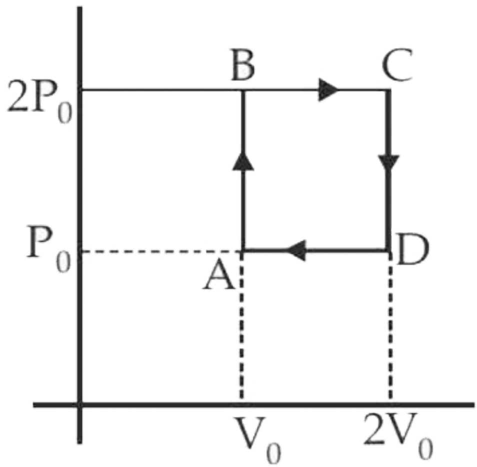
C. $124 J$

D. $208 J$

Answer: D

Watch Video Solution

31. Helium gas goes through a cycle ABCDA (consisting of two isochoric and isobaric lines) as shown in figure Efficiency of this cycle is nearly: (Assume the gas to be close to ideal gas)



A. $15.4\ \%$

B. $9.1\ \%$

C. $10.5\ \%$

D. 12.5%

Answer: A

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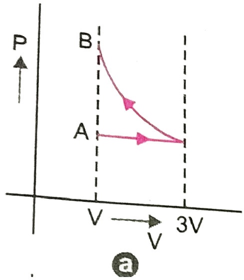
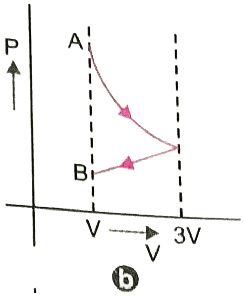
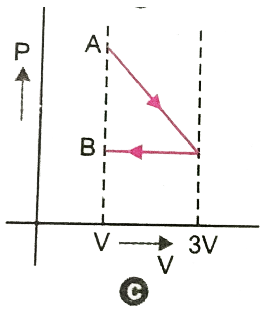
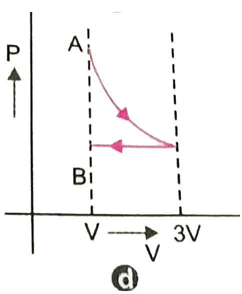
32. One mole of an ideal gas goes from an initial state A to final state B via two processess : It first undergoes isothermal expansion from volume V to $3V$ and then its volume is reduced from $3V$ to V at constant pressure. The correct $P-V$ diagram representing the two process in (figure)

A. 

B. 

C. 

D. 

Answer: D

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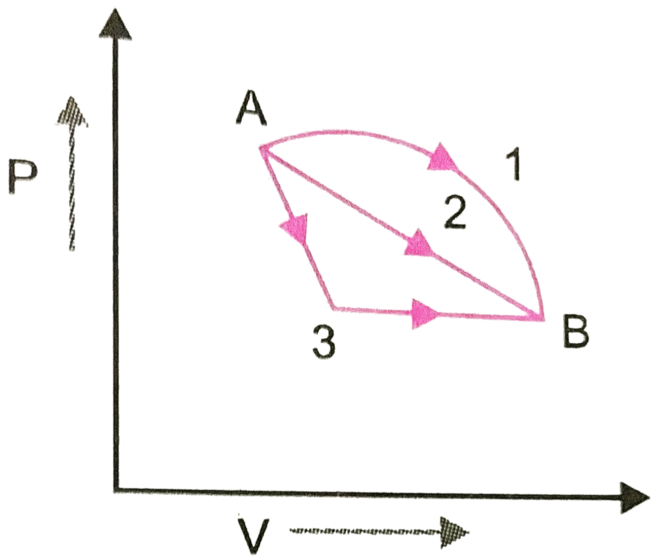
33. An ideal gas goes from State A to state B via three different process as indicate in the $P - V$ diagram.



If Q_2, Q_3 indicates the heat absorbed by the gas along the three processes and $\Delta U_1, \Delta U_2, \Delta U_3$ indicates the change in internal energy along the three processes respectively, then

A. $Q_1 > Q_2 > Q_3$ and $\Delta U_1 = \delta U_2 = \Delta U_3$

B. $Q_3 > Q_2 > Q_1$ and $\Delta U_1 = \Delta U_2 = \Delta U_3$

C. $Q_1 = Q_2 = Q_1$ and $\Delta U_1 > \Delta U_2 > \Delta U_3$

D. $Q_3 > Q_2 Q_1$ and $\Delta U_1 > \Delta U_2 > \Delta U_3$

Answer: A

Watch Video Solution

34. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_P / C_V for the gas is

A. $\frac{3}{2}$

B. $\frac{4}{3}$

C. 2

D. $\frac{5}{3}$

Answer: A

Watch Video Solution

35. The amount of heat energy required to raise the temperature of $1g$ of Helium at NTP, from T_1K to T_2K is

A. $\frac{3}{4}N_ak_B\left(\frac{T_2}{T_1}\right)$

B. $\frac{3}{8}N_aK_B(T_2 - T_1$

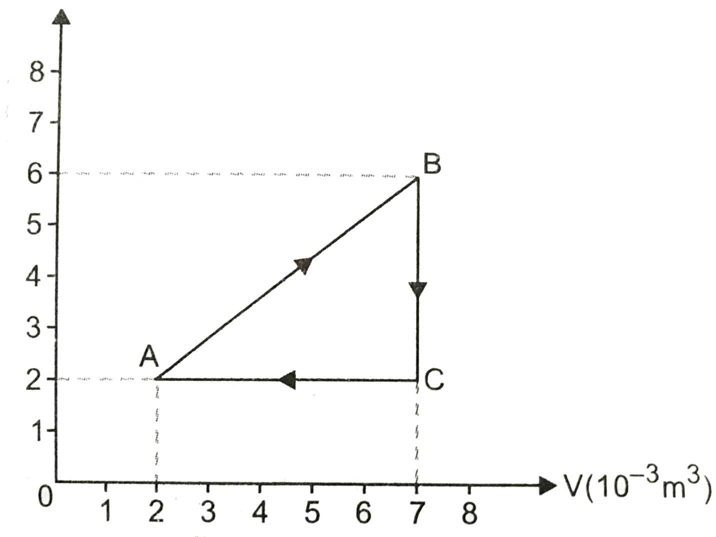
C. $\frac{3}{2}N_aK_B(T_2 - T_1$

D. $\frac{3}{4}N_aK_B(T_2 - T_1$

Answer: B

Watch Video Solution

36. A gas is taken through the cycle $A \rightarrow B \rightarrow C \rightarrow A$, as shown in figure, what is the net work done by the gas?



A. $-2000J$

B. $2000J$

C. $1000J$

D. Zero

Answer: C

Watch Video Solution

37. Steam at $100^\circ C$ is passed into $20g$ of water at $10^\circ C$ when water acquire a temperature of $80^\circ C$, the mass of water present will be

[Take specific heat of water $= 1calg^{-1}.^\circ C^{-1}$ and latent heat of steam $= 540calg^{-1}$]

A. $24g$

B. $31.5g$

C. $42.5g$

D. $22.5g$

Answer: D

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38. A body at a temperature of $727^{\circ}C$ and having surface area $5cm^2$, radiations $300J$ of energy each minute. The emissivity is(Given

Boltzmann constant

$= 5.67 \times 10^{-8} W m^{-2} K^{-4}$

A. $e = 0.18$

B. $e = 0.02$

C. $e = 0.2$

D. $e = 0.15$

Answer: A

Watch Video Solution

39. A black body emit heat at the rate of $20W$, when its tempertaure is $227^\circ C$ Another black body emits heat at the rate of $15W$, when its temperature is $227^\circ C$. Compare the area of the surface of the two bodies, if the surrounding is at NTP

A. $16 : 1$

B. $1 : 4$

C. $12 : 1$

D. $1 : 12$

Answer: D

Watch Video Solution

40. According to Wien's law

A. $\lambda_m T = \text{ constant}$

B. $\frac{\lambda_m}{T} = \text{ constant}$

C. $\lambda_m \sqrt{T} = \text{ constant}$

D. $\frac{\lambda_m}{\sqrt{T}} = \text{ constant}$

Answer: A

Watch Video Solution

41. On observing light from three different stars P, Q and R, it was found that intensity of violet colour is maximum in the spectrum of P, the intensity of green colour is maximum in the spectrum of R and the intensity of red colour is maximum in the spectrum of Q. if T_P, T_Q and T_R are respective absolute temperature of P, Q and R. then it can be concluded from the above observation that

A. $T_p > T_R > T_Q$

B. $T_P < T_R < T_Q$

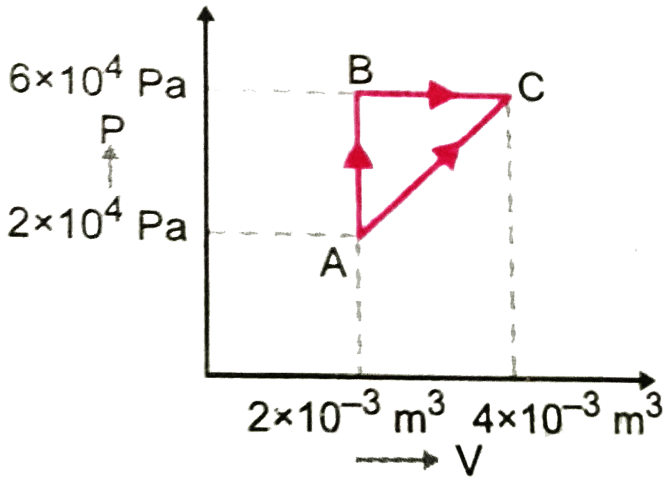
C. $T_P < T_Q < T_R$

D. $T_P < T_Q > T_R$

Answer: A

Watch Video Solution

42. In (figure). shows two path that may be taken by a gas to go from a state A to state C



In the process AB, $400J$ of heat is added to the system and in process Bc, $100J$ of heat is added to the system. The heat absorbed by the system in the process AC will be

A. $500J$

B. $460J$

C. $300J$

D. $380J$

Answer: B

Watch Video Solution

43. The two ends of a metal rod are maintained at temperature $100^\circ C$ and $110^\circ C$. The rate of heat flow in the rod is found to be $4.0J/s$. If the ends are maintained at temperature s $200^\circ C$ and $210^\circ C$. The rate of heat flow will be

A. $16.8J/s$

B. $8.0J / s$

C. $4.0J / s$

D. $44.0J / s$

Answer: C

Watch Video Solution

44. An ideal gas is compressed to half its initial volume by means of several peocesses. Which of the process results in the maximum work done on the gas ?

A. Isothermal

B. Adiabatic

C. Isobaric

D. Isochoric

Answer: B

Watch Video Solution

45. The value of coefficient of volume expansion of glycerin is $5 \times 10^{-4} K^{-1}$. The fractional change in the density of glycerin for a rise of $40^\circ C$ in its temperature is

A. 0.010

B. 0.015

C. 0.020

D. 0.025

Answer: C

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46. The balck body specturm of an object O_1 is such that its radiant intensity (i.e., intensity per unit wavelength interval) is maximum at a wavelength of $200 nm$. Another object Q_2 has the maximum radiant intensity at $600 nm$. The ratio of power emitted per unit area by source Q_1 to that of souce O_2 is

A. $1 : 81$

B. $1 : 9$

C. $9 : 1$

D. $81 : 1$

Answer: D

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47. Three rods of Copper, Brass and Steel are welded together to from a Y shaped structure. Area of cross-section of each rod $= 4cm^2$. End of copper rod is maintained at $100^\circ C$ where as ends of brass and steel are kept at $0^\circ C$. Lengths of the copper, brass and steel rods are 46, 13 and 12 cm respectively. The rods are thermally insulated from surroundings excepts at ends. Thermal conductivities of copper, brass and steel are 0.92, 0.26 and 0.12 CGS units respectively. Rate of heat flow through copper rod is :

A. $4.8 cal / s$

B. $6.0 cal / s$

C. $1.2 cal / s$

D. $2.4 cal / s$

Answer: A

Watch Video Solution

48. A solid body of constant heat capacity $1J/^{\circ}C$ is being heated by keeping it contact with reservoirs in two ways:

(i) Sequentially keeping in contact with 2 reservoirs such that each reservoir supplies same amount of heat.

(ii) Sequentially keeping in contact with 8 reservoir such that each reservoir supplies same amount of heat.

In both the cases body is brought from initial temperature 100^{C} to final temperature $200^{\circ}C$.

Entropy change of the body in the tow cases respectively is :

A. In 2,4, in 2

B. In 2, In 2

C. In 2, 2 In 2

D. 2 In 2, 8 In 2

Answer: B

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49. A gas is compressed isothermally to half its initial volume. The same gas is compressed separately through an adiabatic process untill its volume is again reduced to half. Then

A. Compressing the gas through adiabatic process will require more work to be done

B. Compressing the gas isothermally or adiabatically will required the same amount of work

C. Which of the case(Whehter compression through isothermal of through adiabatic process) requires more work will depends upon the atomicity of the gas

D. Compressing the gas isothermally will require more work to be done

Answer: A

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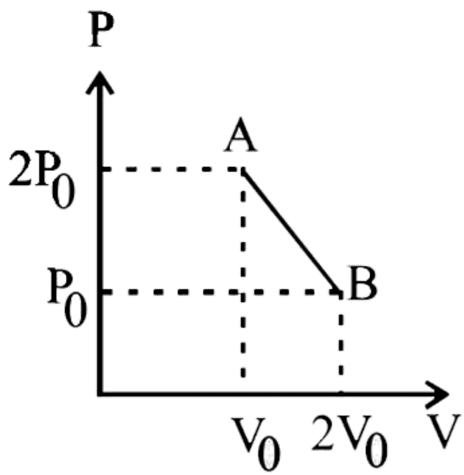
50. n' moles of an ideal gas undergoes a process $A \rightarrow B$ as shown in the figure. The maximum temperature of the gas during the process will be:



A. $\dfrac{9P_0V_0}{4nR}$

B. $\dfrac{3P_0V_0}{2nR}$

C. $\dfrac{9P_0V_0}{2nR}$

D. $\frac{9P_0V_0}{nR}$

Answer: A

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

A. temperature will decrease

B. volume will increase

C. pressure will remain constant

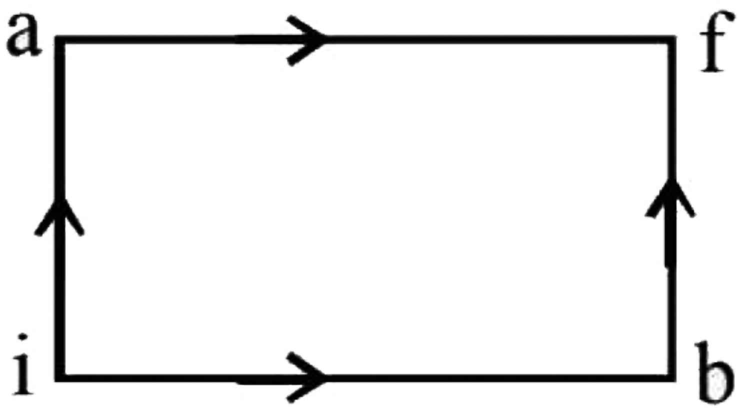
D. temperature will increase

Answer: A

Watch Video Solution

52. When a system is taken from state i to state f along the path iaf, it is found that $Q = 50 cal$ and $W = 20 cal$. Along the path ibf

$Q = 36cal.$ W along the path ibf is



A. $14cal.$

B. $6cal.$

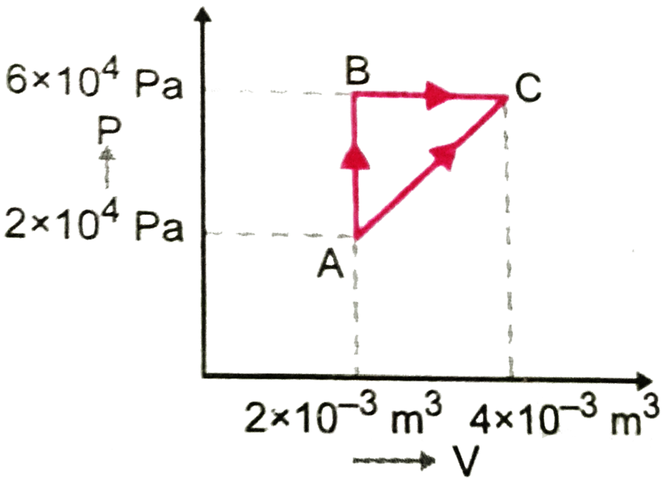
C. $16cal.$

D. $66cal.$

Answer: B

Watch Video Solution

53. In (figure). shows two path that may be taken by a gas to go from a state A to state C



In the process AB, $400J$ of heat is added to the system and in process Bc, $100J$ of heat is added to the system. The heat absorbed by the system in the process AC will be

A. $500J$

B. $460J$

C. $300J$

D. $380J$

Answer: B

Watch Video Solution

54. How much heat energy should be added to a mixture of $10g$ of hydrogen and $40g$ of helium to change the temp. by $50^{\circ} C$ kept in a closed vessel? Given $R = 2cal / moleK$

A. $2000cal$

B. $2500cal$

C. $2750cal$

D. $3000cal$

Answer: C

Watch Video Solution

55. If C_p and C_v denote the specific heats (per unit mass of an ideal gas of molecular weight M), then

where R is the molar gas constant.

A. $C_p - C_v = R/M^2$

B. $C_p - C_v = R$

C. $C_p - C_v = RM$

D. $C_p - C_v = MR$

Answer: C

Watch Video Solution

56. An ideal gas under goes a quasi static, reversible process in which its molar heat capacity C remains constant. If during this process the relation of pressure P and volume V is given by $PV^n = cons\tan t$, then n is given by (Here C_P and C_V are molar specific heat at constant pressure and constant volume, respectively):

A. $n = \frac{C_P}{C_V}$

B. $n = \frac{C - C_P}{C - C_V}$

C. $n = \frac{C_P - C}{C - C_V}$

D. $n = \frac{C - C_V}{C - C_P}$

Answer: B

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57. A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10J, the amount of energy absorbed from the reservoir at lower temperature is

A. $99J$

B. $90J$

C. $1J$

D. $100J$

Answer: B

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58. The temperature T_1 and T_2 of heat reservoirs in the ideal carnot engine are $15000^{\circ}C$ and $500^{\circ}C$ respectivley. If T_1 increases by $100^{\circ}C$, what will be the efficiency of the engine?

A. 62%

B. 59%

C. 95%

D. 100%

Answer: B

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59. A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10J, the amount of energy absorbed from the reservoir at lower temperature is

A. $1J$

B. $90J$

C. $99J$

D. $100J$

Answer: B

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60. Certain quantity of water cools from $70^\circ C$ to $60^\circ C$ in the first 5 minutes and to $54^\circ C$ in the next 5 minutes. The temperature of the surrounding is

A. $45^\circ C$

B. $20^\circ C$

C. $42^\circ C$

D. $10^\circ C$

Answer: A

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61. The cofficient of performance of a refrigerator is 5. If the temperature inside freezer is $-20^{\circ} C$, the temperature of the surroundings to which it rejects heat is :

A. $21^{\circ} C$

B. $31^{\circ} C$

C. $41^{\circ} C$

D. $11^{\circ}C$

Answer: B

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62. A refrigerator works between $4^{\circ}C$ and $30^{\circ}C$. It is required to remove $600cal$ or ies of heat every second in order to keep the temperature of the refrigerator space constant.The power required is (Take $1cal$ or $ie = 4.2J$)

A. $23.65W$

B. $236.5W$

C. $2365W$

D. $2.365W$

Answer: B

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63. A carnot engine working between $300K$ and $600K$ has work output of $800J$ per cycle. What is amount of heat energy supplied to the engine from source per cycle?

A. $800J$

B. $1600J$

C. $3200J$

D. $6400J$

Answer: B

Watch Video Solution

64. A Carnot engine takes $3 \times 10^6 cal.$ of heat from a reservoir at $62^\circ C$, and gives it to a sink at $27^\circ C$. The work done by the engine is

A. $4.2 \times 10^6 J$

B. $8.4 \times 10^6 J$

C. $16.8 \times 10^6 J$

D. Zero

Answer: B

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65. The door of a running refrigerator inside a room is left open. The correct statement out of the following ones is

A. The room will be cooled slightlt

B. The room will be warmed up gradually

C. The room will be cooled to the temperature inside the refrigerator

D. The temperature of the room will remain uneffected.

Answer: B

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66. A cannot engine has efficiency $\frac{1}{6}$. If temperature of sink is decreased by $62^{\circ} C$ then its efficiency becomes $\frac{1}{3}$ then the temperature of source and sink:

A. $956^{\circ} C, 37^{\circ} C$

B. $80^{\circ} C, 37^{\circ} C$

C. $99^{\circ} C, 37^{\circ} C$

D. $90^{\circ} C, 37^{\circ} C$

Answer: C

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67. An ideal gas heat engine operates in Carnot cycle between $227^\circ C$ and $127^\circ C$. It absorbs $6x10^4 cals$ of heat at higher temperature. Amount of heat converted to work is

A. $4.8 \times 10^4 cals$

B. $2.4 \times 10^4 cals$

C. $1.2 \times 10^4 cals$

D. $6 \times 10^4 cals$

Answer: C

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68. A Carnot engine whose sinl is at $300K$ has an efficiency of 40%. By how much should the temperature of source be increased so as to increase its efficiency by 50% of original efficiency.

A. $380K$

B. $275K$

C. $325K$

D. $250K$

Answer: D

Watch Video Solution

69. A cannot engine has efficiency $\frac{1}{6}$. If temperature of sink is decreased by $62^\circ C$ then its efficiency becomes $\frac{1}{3}$ then the temperature of source and sink:

A. $37^\circ C$

B. $62^\circ C$

C. $99^\circ C$

D. $12^\circ C$

Answer: C

Watch Video Solution

70. A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10J, the amount of energy absorbed from the reservoir at lower temperature is

A. $100J$

B. $99J$

C. $90J$

D. $1J$

Answer: C

Watch Video Solution

71. A refrigerator with $COP = 1/3$ release $200J$ at heat to a reservoir. Then the work done on the working substance is

A. $\frac{100}{3}J$

B. $100J$

C. $\frac{200}{3}J$

D. $150J$ of heat been added to the gas

Answer: D

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72. A Carnot engine operating between temperature T_1 and T_2 has efficiency 1/6. When T_2 is lowered by 62K its efficiency increase to 1/3. Then T_1 and T_2 are, respectively:

A. $372K$ and $330K$

B. $330K$ and $268K$

C. $310K$ and $248K$

D. $372K$ and $310K$

Answer: D

Watch Video Solution

73. An ideal gas heat engine operates in a Carnot cycle between $227^\circ C$ and $127^\circ C$. It absorbs $6 Kcal.$ of heat at higher temperature.

The amount of heat in $kcal$ rejected to sink is

A. 4.8

B. 2.4

C. `1.2

D. 6.0

Answer: A

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74. A Carnot engine, whose efficiency is $40\,\%$, takes in heat from a source maintained at a temperature of 500K. It is desired to have an engine of efficiency $60\,\%$. Then, the intake temperature for the same exhaust (sink) temperature must be:

A. efficiency of carnot engine cannot be made larger than $50\,\%$

B. $1200K$

C. $750K$

D. $600K$

Answer: C

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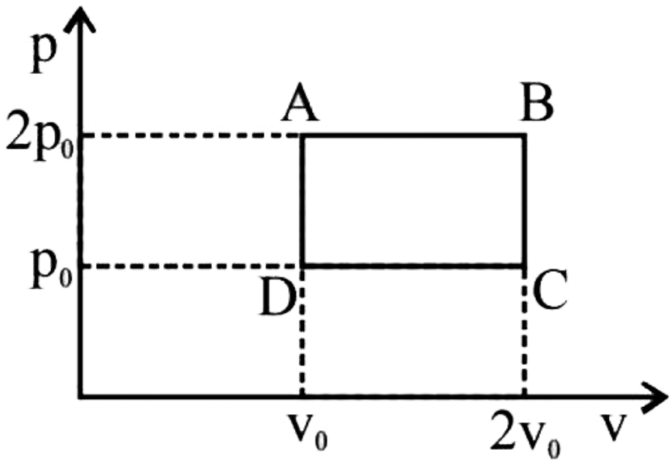
75. 

The above p-v diagram represents the thermodynamic cycle of an engine, operating with an ideal monoatomic gas. The amount of heat, extracted from the source in a single cycle is

A. P_0V_0

B. $\left(\frac{13}{2}\right)P_0V_0$

C. $\left(\frac{11}{2}\right)P_0V_0$

D. $4P_0V_0$

Answer: B

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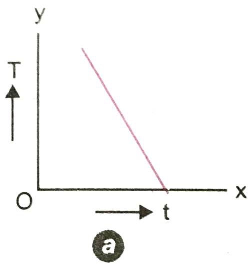
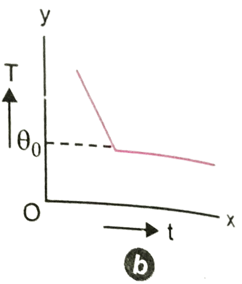
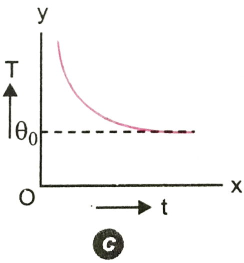
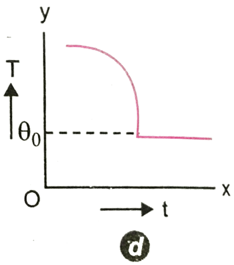
76. If a piece of metal is heated to temperature θ and the allowed to cool in a room which is at temperature θ_0, the graph between the temperature T of the metal and time t will be closet to

A. 

B. 

C. 

D. 

Answer: C

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77. The work done in which of the following processes is zero

A. Cyclic

B. Free expansion

C. Isochoric

D. Adiabatic

Answer: B::C

Watch Video Solution

78. In which of the following process (es), there is no change in the internal energy of the system?

A. Isothermal

B. Adiabatic

C. Free expansion

D. Cyclic

Answer: A::C::D

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79. In a process on a system, the initial pressure and volume are equal to the final pressure and volume.

A. The initial energy must be equal to the final internal energy

B. The net heat given to the system in the process must be zero

C. The net work done by the system in the process must be zero

D. The initial temperature must be equal to the final temperature

Answer: A::D

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80. The pressure p and volume V of an ideal gas both increase in a process.

A. The temperature of the system must increase

B. The work done by the system is positive

C. Heat supplied to the gas equal to change in internal energy

D. such a process is not possible

Answer: A::B

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81. Let Q and W denote the amount of heat given to an ideal gas and the work done by it in an adiabatic process.

A. $Q = W$

B. $Q \neq W$

C. $Q = 0$

D. $W = 0$

Answer: B::C

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82. A gas kept in a container of finite conductivity is suddenly compressed . The process

A. may be very nearly adiabatic

B. may be nearly isothermal

C. must be very nearly adiabatic

D. must be very nearly isothermal

Answer: A::B

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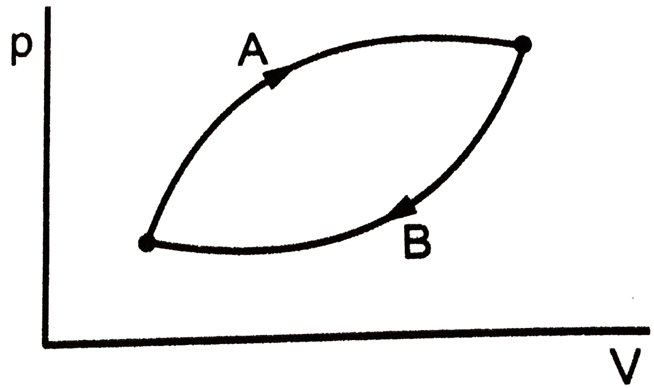
83. Refer to figure ΔU_1 and ΔU_2 be the changes in internal energy in the system in process $A+B$ and ΔW be the net work done by the system in the process $A+B$,



A. $\Delta Q - \Delta W = 0$

B. $\Delta Q + \Delta W = 0$

C. $\Delta U_1 - \Delta U_2 = 0$

D. $\Delta U_1 + \Delta U_2 = 0$

Answer: A::D

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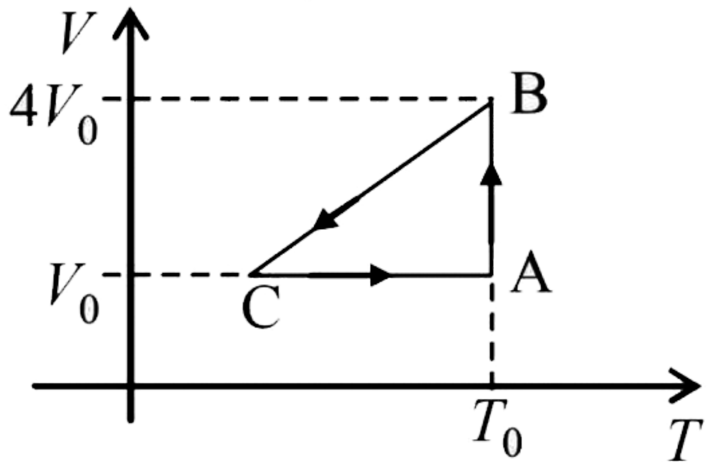
84. One mole of an ideal gas in initial state A undergoes a cyclic process ABCA, as shown in the figure. Its pressure at A is P_0. Choose the correct option (s) from the following



A. Internal energies at A and B are the same

B. Work done by the gas process AB is P_0V_0

in 4

C. Pressure at C is $\frac{P_0}{4}$

D. Temperature at C is $\frac{T_0}{4}$

Answer: A::B

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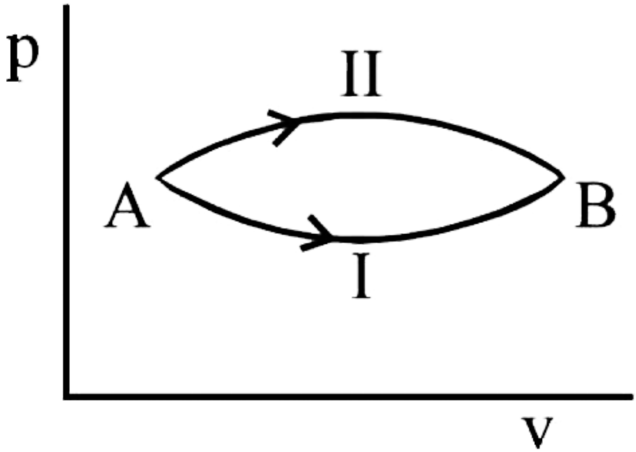
85. A system goes from A and B via two processes. I and II as shown in figure. If ΔU_1 and ΔU_2 are the changes in internal energies in the processes I and II respectively, then



A. $\Delta U_2 < \Delta U_1$

B. $\Delta U_2 > \Delta U_1$

C. relation between ΔU_1 and ΔU_2 cannot be determined

D. $\Delta U_1 = \Delta U_2$

Answer: D

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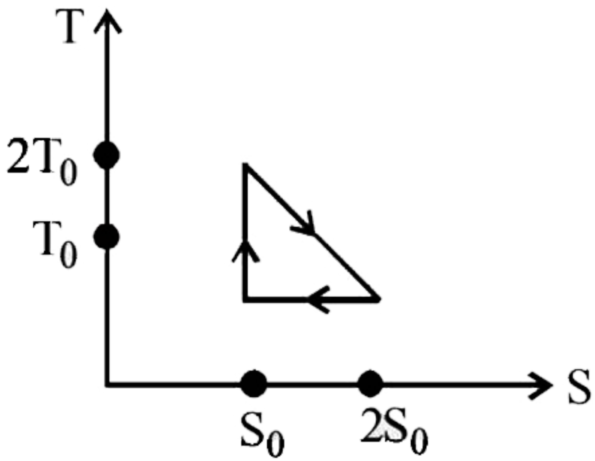
86. The temperature -entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is



A. $\frac{2}{3}$

B. $\frac{1}{3}$

C. $\frac{1}{4}$

D. $\frac{1}{2}$

Answer: B

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87. The internal enegy of an ideal gas decreases by the same amount as the work done by the system.

A. The temperature of the system must deccrease

B. The process must be adiabatic

C. The process must be isothermal

D. The process must be isobaric.

Answer: A::B

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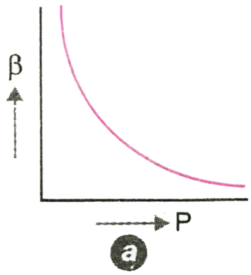
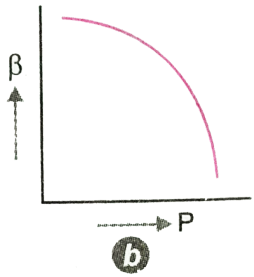
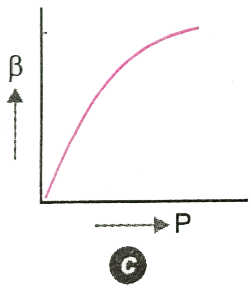
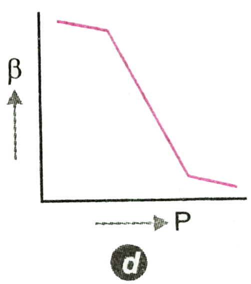
88. Which of the following graphs correctly represents the variation of $\beta = -\frac{dV/dP}{V}$

with P for an ideal gas at constant temperature?

A.


B.


C.


D.


Answer: A

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89. A gas is copmressed isothermally to half its volume. BY what factor does the pressure of the gas increase ? Given $\gamma = 1.4$

A. 2

B. < 2

C. > 2

D. $\frac{1}{2}$

Answer: A

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90. A gas is compressed adiabatically to half its volume. By what factor does the pressure of the gas increase?

A. 2

B. 2.64

C. 1.4

D. 2.4

Answer: B

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91. A gas is suddenly compressed to $\frac{1}{4}th$ of its original volume. Caculate the rise in temperature when original temperature is $27^{\circ}C. \gamma = 1.5.$

A. $300^{\circ}C$

B. $327^{\circ}C$

C. $327K$

D. $600K$

Answer: A

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92. A Carnot engine absorbs $6 \times 10^5 cal$. At $227^\circ C$. Heat rejected to the sink at $127^\circ C$ is

A. $6 \times 10^5 cal$

B. $4.8 \times 10^5 cal$

C. $4 \times 10^5 cal$

D. $5 \times 10^5 cal$

Answer: B

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93. Work done //cycle by the engine in the above questions is

A. $5.04 \times 10^5 J$

B. $5.04 \times 10^5 cal$

C. $4.8 \times 10^5 cal$

D. $4.8 \times 10^5 J$

Answer: A

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94. Efficiency of the engine in the above questions is

A. 30%

B. 10%

C. 20%

D. 80%

Answer: C

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95. At what temperature should the sink be maintained to increase the efficiency by 10% ?

A. $77K$

B. $300K$

C. $300^{\circ}C$

D. $77^\circ C$

Answer: D

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96. What should be the temperature of the source to increases the efficiency to 30%

A. $298.4^\circ C$

B. $298.4K$

C. $400K$

D. $600K$

Answer: A

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Interger Type Questions

1. Find the change in internal energy (in joule) of a gas when it absorbs $40cal$ or ies of heat and performs work equal to $16J$.

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2. Calculate the pressure (in atm) required to compress a gas adiabatically at atmospheric pressure to one third of ite volume. Given $\gamma = 1.47$

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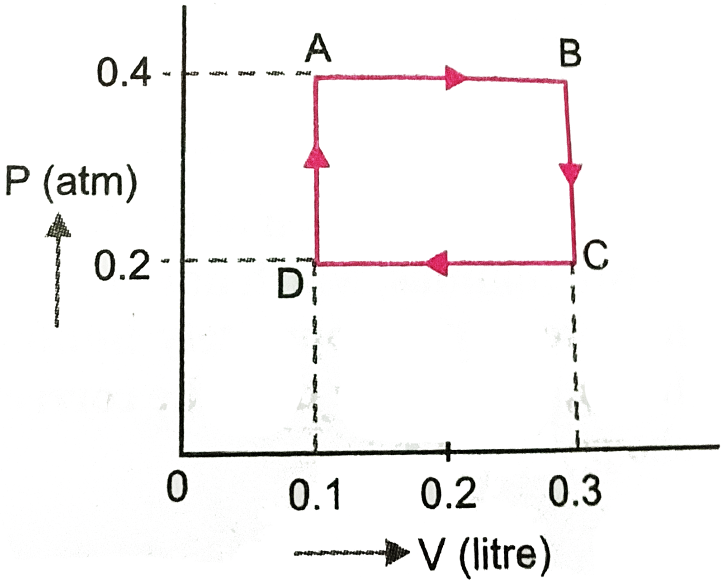
3. One mole of an ideal gas undergoes a cyclic change ABCDA as shown in (figure). What is the net work done (in joule) in the process? Take

$1atm = 10^5 Pa.$



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4. A carnote engine absorbs $8KJ$ of energy at $400K$. If sink is maintained at $300K$, Calculate useful work done per cyclic (in joule) by the engine.

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5. Two carnot engine A and B operate respectively between $500K$ and $400K$, and $400K$ and $300K$. What is the percentage difference in their efficiencies ?

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6. In a refrigerator, heat from inside at $270K$ is transferred to a room at $300K$. How many joule of heat energy is drawn from the sink for each joule of electrical energy consumed ideally ?

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7. A refrigerator whose coefficient of performance is 12.5 extracts heat from the cooling compartment at the rate of $100J/\text{cycle}$. How much electric energy (in joule) is consumed/cycle. How much electric energy (in joule) is consumed/cycle is by the refrigerator?

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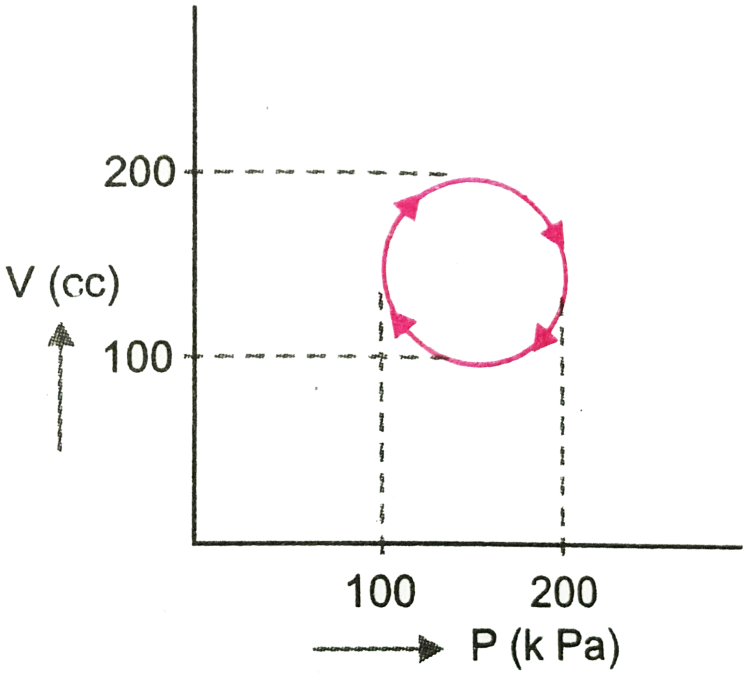
8. Calculate heat (in joule) absorbed by a system going once through the cyclic process shoen in

(figure)



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9. During adiabatic expension of $10 moles$ of a gas , internal energy decrease, by $700 J$. Work done during the process is $\times x10^2 J$. What is x?

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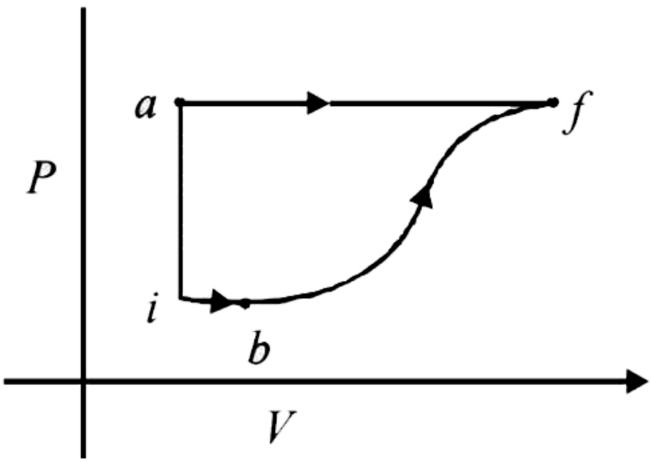
10. A thermodynamic system is taken from an initial state I with internal energy $U_i = -100J$ to the final state f along two different paths iaf and ibf, as schematically shown in the figure. The work done by the system along the pat af, ib and bf are $W_{af} = 200J, W_{ib} = 50J$ and $W_{bf} = 100J$ respectively. The heat supplied to the system along the path iaf, ib and bf are Q_{iaf}, Q_{ib}, Q_{bf}

respectively. If the internal energy of the system in the state b is $U_b = 200J$ and $Q_{iaf} = 500J$,

The ratio $\frac{Q_{bf}}{Q_{ib}}$ is



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11. Two spherical starts A and B emit black body radiation. The radius of A is 400 times that of B and A emits 10^4 times the power emitted from B. The ratio (λ_A / λ_B) of their wavelengths λ_A and λ_B at which the peaks oc cur in their respective radiation curves is :

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Assertion Reason Type Questions

1. Assertion : Internal energy of an ideal gas does not depend upon volume of the gas.

Reason : This is because internal energy of ideal gas depends only on temperature of gas.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: B

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2. Assertion: In an isothermal proces, whole of heat energy supplied to the body id converted into work.

Reason: According to first law of thermodynamics $\Delta Q = \Delta U + P \Delta V$

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the

Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: B

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3. Assertion: The efficiency of a carnot engine cannot be 100% .

Reason: This is because sink of heat engine cannot be maintained at $0K$.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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4. Assertion : Water kept in an open vessel will quickly evaporate on the surface of the moon.

Reason : The temperature at the surface of the moon is much higher than boiling point of the water.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the

Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: C

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5. Assertion: The efficiency of a carnot engine cannot be 100%.

Reason: This is because sink of heat engine cannot be maintained at $0K$.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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6. Asssertion: It is not possible for a system, unaided by an external agency to transfer heat from a body at lower temp. to another at a higher temp.

Reason: It is not possible to violate the second law of thermodynamics.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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7. Assertion: Two systems, which are in thermal equilibrium with a third system, are in thermal equilibrium with each other.

Reason: The heat flows spontaneously from a system at a higher temp. to a system at a lower temp.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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8. Assertion: The internal energy of an ideal gas does not change during an isothermal process.

Reason: The decrease in volume of a gas is compensated by a corresponding increase in perssure, when its temp. is held constant.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: B

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9. Assertion: Specific heat of a body is always greater than its thermal capacity.

Reason: Thermal capacity is the heat required for raising temperature of unit mass of the body through unit degree

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the

Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: D

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10. Assertion : A hollow metallic closed container maintained at a uniform temperature cab act as a source of black body radiation.

Reason : All metals act as a black body.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: C

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11. Aseertion: Thermodynamics process in nature are irreversible.

Reason: Dissipactive effects cannot be eliminated.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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12. Assertion : For higher temperature, the peak emission wavelength of a black body shifts to lower wavelengths.

Reason : Peak emission wavelength of a black body is proportional to the fourth power of temperature.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: C

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13. Statement-1 : In an adiabatic process, change in internal energy of a gas is equal to work done on/by the gas in the process.

Statement-2 : This is because temp.of gas remains constant in an adiabatic process.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the

Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: C

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14. Statement-1 : Change in internal energy in the melting process is due to change in internal potential energy.

Statement-2 : This is because in melting, distance between molecules increases but temperature remains constant.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the

Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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15. Statement-1 : As temperature of a black body is raised, wavelenght corresponding to which energy emitted is maximum, reduces.

Statement-2 : Higher temperature would mean higher energy and hence higher wavelength.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: C

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16. Statement-1 : When temperature of a black body is doubled, energy radiated/sec/area becomes 16 times.

Statement-2 : This is per Stefan's law.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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17. Statement-1 : When temperature of a black body is halved, wavelength corresponding to which energy radiate is maximum become twice.

Statement-2 : This is as per Wien's Law.

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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18. Statement-1 : Heat from the sun reaches the earth by convection.

Statement-2 : Air can be heated only by convection

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: D

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19. Statement-1 : A Carnot engine working between $100K$ and $400K$ has an efficiency of

75 %

Statement-2 : It follows from $\eta = 1 - \frac{T_2}{T_1}$

A. If both, Assertion and Reason are true and Reason is the correct explanation of the Asserrion.

B. If both,Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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