PHYSICS

NCERT - FULL MARKS PHYSICS(TAMIL)

HEAT AND THERMODYNAMICS

Example

1. 'A lake has more rain'.

(b) 'A hot cup of coffee has more heat'.

What is wrong in these two statements?

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2. A student comes to school by a bicycle whose tire is filled with air at a pressure 240 kPa at 27°C. She travels 8 km to reach the school and the temperature of the bicycle tire increases to 39°C. What is the change in pressure in the tire when the student reaches school?

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3. When a person breaths, his lungs can hold up to 5.5 Litre of air at body temperature $37^{\circ} C$ and atmospheric pressure $(1 \mathrm{~atm}=101 \mathrm{~kPa})$. This Air contains 21% oxygen. Calculate the number of oxygen molecules in the lungs.

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4. Calculate the volume of one mole of any gas at STP and at room temperature (300K) with the same pressure 1 atm.

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5. Estimate the mass of air in your class room at NTP. Here NTP implies normal temperature (room temperature) and 1 atmospheric pressure

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6. Eiffel tower is made up of iron and its height is roughlyl 300 m. During winter season (January) in France the temperature is $2^\circ C$ and in hot summer its average temperature $25^\circ C$. Calculate the change in height of Eiffel tower between summer and winter. the linear thermal expansion coefficient for iron

$\alpha = 10 \times 10^{-6} per \quad ^{\circ}C$

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7. If 5 L of water at $50^{\circ}C$ is mixed with 4L of water at $30^{\circ}C$, what will be the final

temperature of water ? Take the specific heat capacity of water as $4184 J \quad kg^{-1} K^{-1}$.

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8. A hot water cools from $92^{\circ} C$ to $84^{\circ} C$ in 3 minutes when the room temperature is $27^{\circ} C$. How long will it take for it to cool from $65^{\circ} C$ to $60^{\circ} C$?

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9. The power radiated by a black body A is E_A and the maximum energy radiated was at the wavelength λ_A. The power radiated by another black body B is $E_B = NE_A$ and the radiated energy was at the maximum wavelength, $\frac{1}{2}\lambda_A$. what is the value of N?

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10. When you mix a tumbler of hot water with one bucket of normal water, what will be the

direction of heat fl ow? Justify.

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11. A student had a breakfast of 200 food calories. He thinks of burning this energy by drawing water from the well and watering the trees in his school. Depth of the well is about 25 m. Th e pot can hold 25L of water and each tree requires one pot of water. How many trees can he water? (Neglect the mass of the pot and the energy spent bywalking.Take

$g = 10ms^{-2}$)

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12. A person does 30 kJ work on 2 kg of water by stirring using a paddle wheel. While stirring, around 5 kcal of heat is released from water through its container to the surface and surroundings by thermal conduction and

radiation. What is the change in internal energy of the system?

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13. Jogging every day is good for health. Assume that when you jog a work of 500 kJ is done and 230 kJ of heat is given off . What is the change in internal energy of your body?

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14. Give an example of a quasi-static process.

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15. A gas expands from volume $1m^3$ to $2m^3$ at constant atmospheric pressure.

(a) Calculate the work done by the gas.

(b) Represent the work done in PV diagram.

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16. A 0.5 mole of gas at temperature 300 K expands isothermally from an initial volume of 2 L to 6 L

(a) What is the work done by the gas?

(b) Estimate the heat added to the gas ?

(c) What is the final pressure of the gas ? (The value of gas constant, $R = 8.31 J \quad mol^{-1} K^{-1}$)

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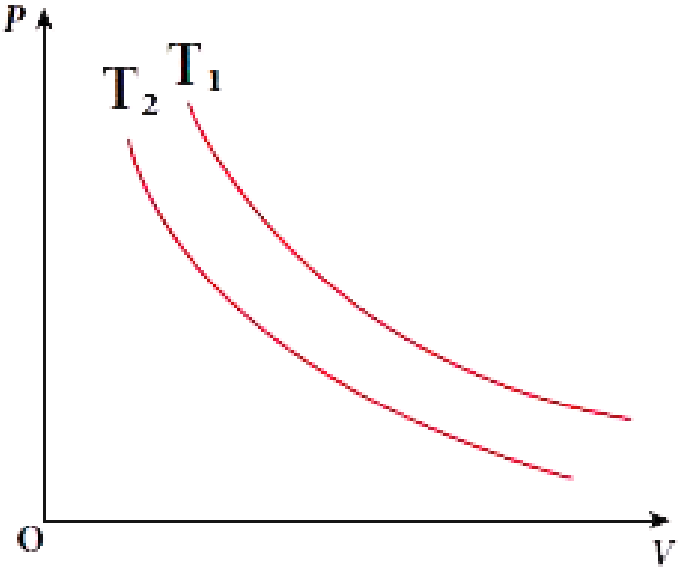
17. The following PV curve shows two isothermal processes for two diff erent temperatures and. Identify the higher temperature of these two.



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18. 

We often have the experience of pumping air into bicycle tyre using hand pump.Consider the air inside the pump as a thermodynamic system having volume V at atmospheric pressure and room temperature, $27^{\circ}C$. assume that the nozzle of the tyre is blocked and you push the pump to a volume 1/4 of V. calculate the final temperature of air the

pump ? (For air, since the nozzle is blocked air will not flow into tyre and it can be treated as an adiabatic compression).

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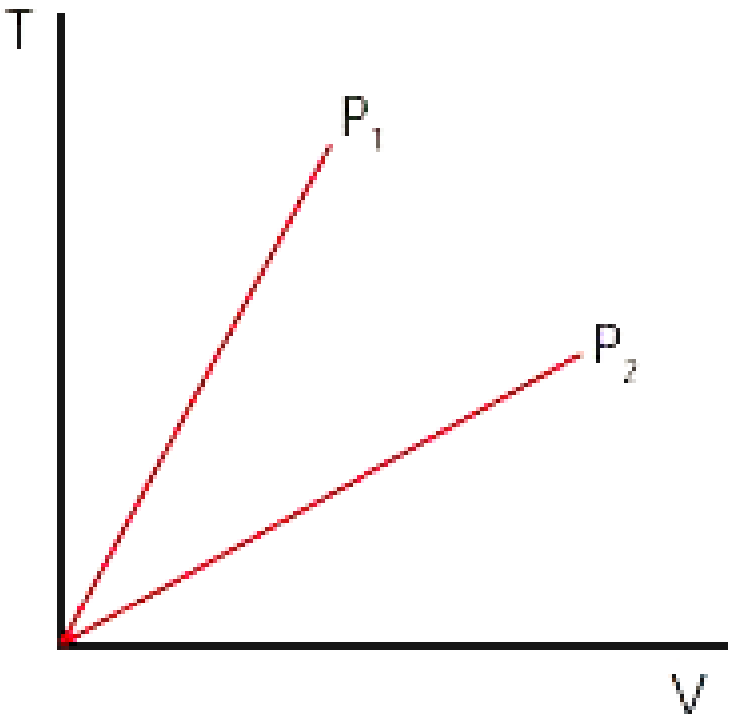
19. The following graph shows a V-T graph for isobaric process at two different presures.

Identify which one occurs at higher pressure.



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20. One mole of an ideal gas intially kept in a cylinder at pressure 1 MPa and temperature $27^{\circ}C$ is made to expand until its volume is doubled.

(a) How much work is done if the expansion is

(i) adiabatic (ii) isobaric

(iii) Isothermal?

(b) Identify the process in which change in internal energy is least and is maximum.

(c) Showeach process on PV diagram.

(d) Name the processes in which the heat

transfer is maximum and minimum. (Take $\gamma = \frac{5}{3}$ and $R = 8.3J \quad mol^{-1}K^{-1}$)

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21. 500 g of water is heated from $30^{\circ}C$ to $60^{\circ}C$. Ignoring the slight expansion of water, calculate the change in internal energy of the water ? (Specific heat of water 4184 J/kg.K)

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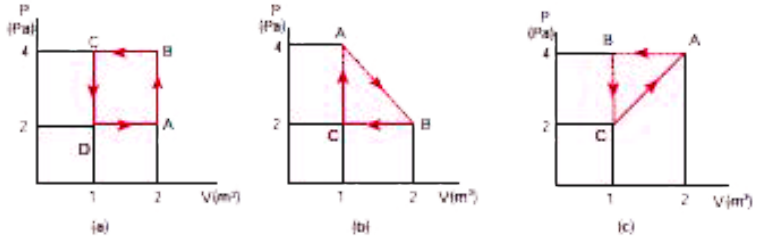
22. The PV diagrams for a thermodynamical system is given in the figure below. Calculate the total work done in each of the cyclic processes shown



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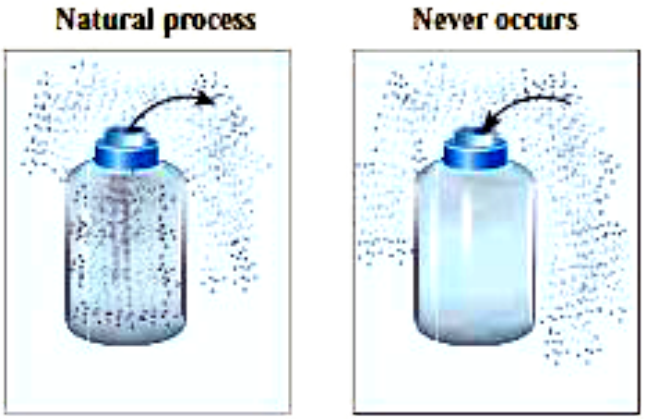
23. Give some examples of irreversible processes. All naturally occuring processes are

irreversible. Here we give some interesting examples. (a) When we open a gas bottle, the gas molecules slowly spread into the entire room. Th ese gas molecules can never get back in to the bottle.



(b) Suppose one drop of an ink is dropped in water, the ink droplet slowly spreads in the water. It is impossible to get the ink droplet

back. (c) When an object falls from some height, as soon as it hits the earth it comes to rest. All the kinetic energy of the object is converted to kinetic energy of molecules of the earth surface, molecules of the object and small amount goes as sound energy. The spreaded kinetic energy to the molecules never collected back and object never goes up by itself.

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24. During a cyclic process, a heat engine absorbs 500 J of heat from a hot reservoir, does work and ejects an amount of heat 300 J into the surroundings (cold reservoir). Calculate the effi ciency of the heat engine?

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25. A steam engine boiler is maintained at $250^{\circ} C$ and water is converted into steam. This steam is used to do work and heat is ejected

to the surrounding air at temperature 300K. Calculate the maximum efficiency it can have?

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26. There are two Carnot engines A and B operating in two different temperature regions. For Engine A the temperatures of the two reservoirs are $150^{\circ}C$ and $100^{\circ}C$. For engine B the temperatures of the reservoirs are $350^{\circ}C$ and $300^{\circ}C$. Which engine has lesser efficiency?

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27. A refrigerator has COP of 3. How much work must be supplied to the refrigerator in order to remove 200 J of heat from its interion?

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Evaluation Multiple Choice Questions

1. In hot summer aft er a bath, the body's

A. internal energy decreases

B. internal energy increases

C. heat decreases

D. no change in internal energy and heat

Answer: A

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2. The graph between volume and temperature in Charles' law is

A. an ellipse

B. a circle

C. a straight line

D. a parabola

Answer: C

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3. When a cycle tyre suddenly bursts, the air inside the tyre expands. Th is process is

A. isothermal

B. aidabatic

C. isobaric

D. isochoric

Answer: B

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4. An ideal gas passed from one equilibrium state (P_1, V_1, T_1, N) to another equilibrium state $(2P_1, 3V_1, T_2, N)$. Then

A. $T_1 = T_2$

B. $T_1 = \frac{T_2}{6}$

C. $T_1 = 6T_2$

D. $T_1 = 3T_2$

Answer: B

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5. When a uniform rod is heated, which of the following quantity of the rod will increase

A. mass

B. weight

C. center of mass

D. moment of inertia

Answer: D

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6. When food is cooked in a vessel by keeping the lid closed, aft er some time the steam pushes the lid outward. By considering the

steam as a thermodynamic system, then in the cooking process

A. $Q > 0, W > 0$

B. $Q < 0, W > 0$

C. $Q > 0, W < 0$

D. $Q < 0, W < 0$

Answer: A

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7. When you exercise in the morning, by considering your body as thermodynamic system, which of the following is true?

A. $\Delta U > 0, W > 0$

B. $\Delta U < 0, W > 0$

C. $\Delta U < 0, W < 0$

D. $\Delta U = 0, W > 0$

Answer: B

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8. A hot cup of coff ee is kept on the table. Aft er some time it attains a thermal equilibrium with the surroundings. By considering the air molecules in the room as a thermodynamic system, which of the following is true

A. $\Delta U > 0, Q = 0$

B. $\Delta U > 0, W < 0$

C. $\Delta U > 0, Q > 0$

D. $\Delta U = 0, Q > 0$

Answer: C

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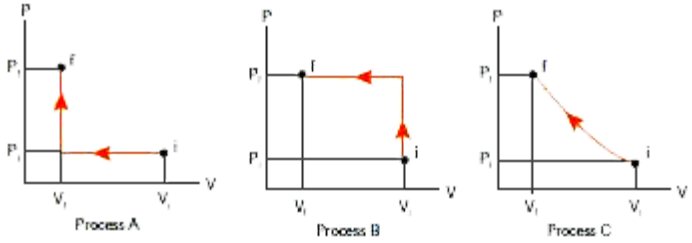
9. An ideal gas is taken from (P_i, V_i) to (P_f, V_f) in three different ways. Identify the process inw hich the work done on the gas the most.



A. Process A

B. Process B

C. Process C

D. Equal work is done in process A,B&C

Answer: B

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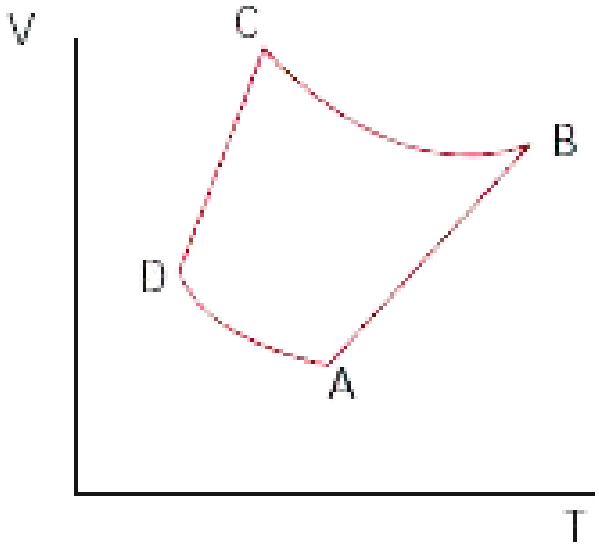
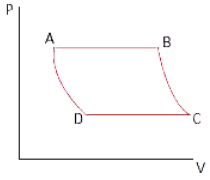
10. The V-T diagram of an ideal gas which goes through a reversible cycle $A \rightarrow B \rightarrow C \rightarrow D$ is shown below. (Processes $D \rightarrow A$ and $B \rightarrow C$ are adiabatic).

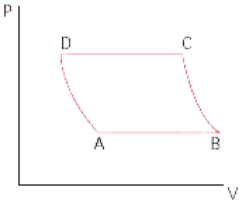


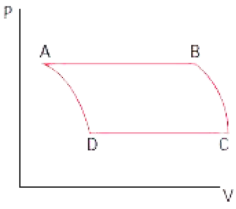
The corresponding PV diagram for the process is (all figures are schematic)

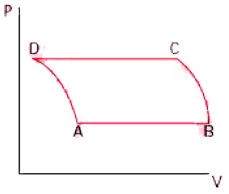
A.



B.



C. 

D. 

Answer: B

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11. A distant star emits radiation with maximum intensity at 350 nm. The temperature of the star is

A. 8208K

B. 5000K

C. 7260K

D. 9044K

Answer: A

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12. Identify the state variables given here ?

A. Q,T,W

B. P,T,U

C. Q,W

D. P,T,Q

Answer: B

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13. In an isochoric process, we have

A. $W = 0$

B. $Q = 0$

C. $\Delta U = 0$

D. $\Delta T = 0$

Answer: A

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14. The efficiency of a heat engine working between the freezing point and boiling point of water is

A. $6.25\ \%$

B. $20\ \%$

C. $26.8\ \%$

D. 12.5%

Answer: B

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15. An ideal refrigerator has a freezer at temperature $-12^{\circ}C$. The coefficient of perfomance of the engine is 5. the

temperature of the air (to which the heat ejected) is

A. 50°

B. 45.2° C

C. $40.2^\circ C$

D. $37.5^\circ C$

Answer: C

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Evaluation Numerical Problems

1. Calculate the number of moles of air is in the inflated balloon at room temperature as shown in the figure

The radius of the balloon is 10 cm, and pressure inside the balloon is 180 kPa.

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2. In the planet Mars, the average temperature is around $-53^{\circ} C$ and atmospheric pressure is 0.9 kPa. Calculate the number of moles of the molecules in unit volume in the planet Mars? Is this greater than that in earth ?

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3. An insulated container of gas has two chambers separated by an insulating partition. One of the chambers has volume V_1 and contains indeal gas at pressure P_1 and temperature T_1. The other chamber has volume V_2 and contains ideal gas at pressure P_2 and temperature T_2. if the partition is removed without doing any work on the gases, calculate the final equilibrium temperature of the container.

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4. The temperature of a uniform rod of length L having a coefficnet of linear expansion α_L is changed by ΔT. Calculte the new moment of inertia of the uniform rod about axis passing through its center and perpendicular to an axis of the rod.

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5. A man starts bicycling in the morning at a temperature around $25^\circ C$, he checked the pressure of tire which is equal to be 500 kPa.

Afternoon he found that the absolute pressure in the tyre is increased to 520 kPa. By assuming the expansion of tyre is negligible, what is the temperature of tyre at afternoon?

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6. Normal human body of the temperature is 98.6° F. During high fever if the temperature increases to 104° F, what is the change in peak wavelength that emitted by our body? (Assume human body is a black body)

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7. In a petrol engine, (internal combustion engine) air at atmospheric pressure and temperature of 20°C is compressed in the cylinder by the piston to 1/8 of its original volume. Calculate the temperature of the compressed air. (For air $\gamma = 1.4$)

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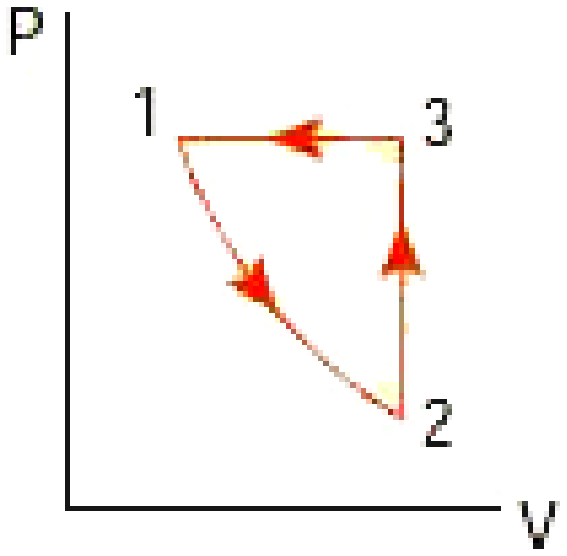
8. Consider the following cyclic process consist of isotherm, isochoric and isobar which is given in the figure.



Draw the same cyclic process qualitatively in the V-T diagram where T is taken along x direction and V is taken along y-direction.

Analyze the nature of heat exchange in each process.

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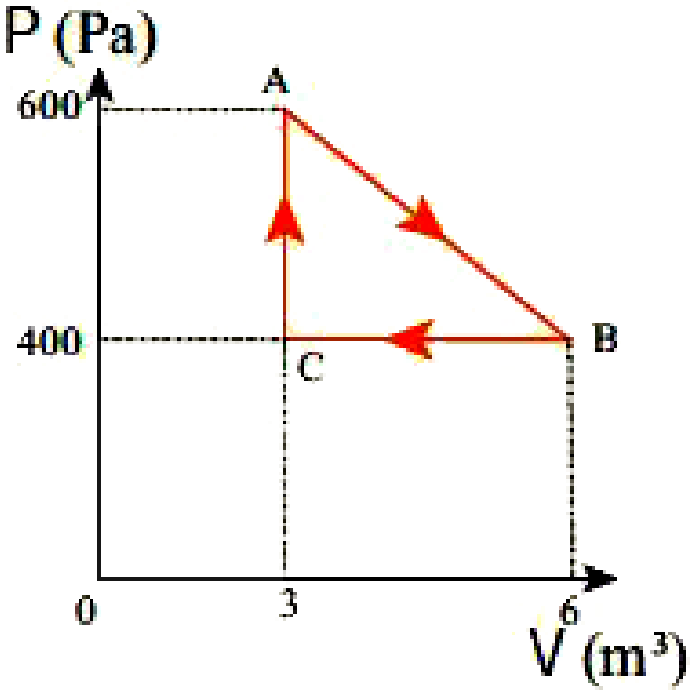
9. An ideal gas is taken in a cyclic process as shown in the figure. Calculate (a) work done by the gas. (b) work done on the gas (c) Net work

done in the process



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10. For a given ideal gas $6 \times 10^5 J$ heat energy is supplied and the volume of gas is increased

from 4 m^3 to 6 m^3 at atmospheric pressure. Calculate (a) the work done by the gas (b) change in internal of the gas (c) graph this process in PV and TV diagram.

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11. Suppose a person wants to increase the efficiency of the reversible heat engine that is operating between 100°C and 300°C. He had two ways to increase the efficiency. (a) By decreasing the cold reservoir temperature

from 100°C to 50°C and keeping the hot reservoir temperature constant (b) by increasing

the temperature of the hot reservoir from 300°C to 350°C by keeping the cold reservoir temperature constant. Which is the suitable method?

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12. A Carnot engine whose efficiency is 45% takes heat from a source maintained at a

temperature of 327°C. To have an engine of efficiency 60% what must be the intake temperature for the same exhaust (sink) temperature?

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13. An ideal refrigerator keeps its content at 0°C while the room temperature is 27°C. Calculate its coefficient of performance.

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