HSPTA MALAPPURAM

PHYSOL_*The solution for learning Physics*

Question Bank

12 Thermodynamics

Each question scores One

1	What is an isobaric process? **Ans:** A thermodynamic process which occurs at a constant pressure is called an isobaric process.
2	What is an isochoric process? **Ans:** A thermodynamic process which occurs at constant volume is called an isochoric process.
3	What is meant by free expansion ? **Ans:** The expansion of a gas against zero external pressure is known as its free expansion.
4	Write the relation among heat energy, work done and change in internal energy. **Ans:** dQ = dU+ dW.
5	Is it possible to increase the temperature of a gas without giving it heat ? **Ans:** Yes, it happens during an adiabatic process.
6	An ideal gas is compressed at constant temperature. Will its internal energy increase or decrease? **Ans:** It will remain same because the internal energy of an ideal gas depends only upon the temperature.
7	Out of the parameters temperature, pressure, work and volume, which parameter does not characterise the thermodynamic state of matter? **Ans:** Work.
8	What is a heat engine? **Ans:** Heat engine is a device for converting heat into mechanical work.
9	Which law forbids the complete conversion of heat energy into mechanical work ? **Ans:** Second law of thermodynamics.
10	What type of process is Carnot's cycle ? **Ans:** Carnot's cycle is a reversible cyclic process.
11	Can a Carnot engine be realized in actual practice? **Ans:** No, Carnot engine is an ideal heat engine.
12	Name the sink in case of steam-engine. **Ans:** Atmosphere is the sink in a steam-engine.
13	Is rusting of iron a reversible process? **Ans:** No. Rusting of iron is an irreversible process.
14	How is the efficiency of a Carnot engine affected by the nature of the working substance? **Ans:** The efficiency of a Carnot engine is independent of the nature of the working substance.
15	On what factors, the efficiency of a Carnot engine depends? **Ans:** Temperatures of source of heat and sink.
16	Rusting of iron is a...... Process? a)isothermal. b) adiabatic. c) isochoric. d) isobaric. Ans: isothermal.
17	Bursting of a balloon is a.... Process?

	a)isothermal. b) adiabatic. c) isochoric. d) isobaric. Ans: adiabatic.
18	Under all conditions first law of thermodynamics hold good.(True /false) Ans: True.
19	Can two objects in thermal equilibrium, if they are not in contact? Ans: yes. If they have same Temperature.
20	Growth of nail comes under...... Process? Ans: Quasi static process.

Each question scores Two

1	State two essential requirements of an ideal heat engine. **Ans:** i)An ideal heat engine should have a source of infinite thermal capacity. ii) It should have a sink of infinite thermal capacity.
2	State the first law of thermodynamics. **Ans:** According to the first law of thermodynamics, the amount of heat ΔQ absorbed by a system capable of doing mechanical work is equal to the sum of the increase in internal energy ΔU of the system and the external work ΔW done by the system. Mathematically, dQ= dU+ dW=dU + PdV.
3	How does the internal energy of an ideal gas differ from that of real gas ? **Ans:** The internal energy of an ideal gas consists of only the kinetic energy of the particles. But for real gases it consists of both the kinetic as well as potential energies.
4	When is the heat supplied to a system equal to the increase in its internal energy ? **Ans:** According to the first law of thermodynamics, dQ=dU+ PdV. If the heat is supplied in such a manner that the volume does not change (for isochoric change, dV = 0). Then the whole of the heat energy supplied to the system will increase internal energy only.
5	An ideal gas is compressed at constant temperature. Will its internal energy increase or decrease ? **Ans:** It will remain same because the internal energy of a gas depends only on its temperature.
6	Cooling is produced when a gas at high pressure suddenly expands. Why ? **Ans:** During its expansion, the gas does work against high pressure. This decreases the internal energy and hence the temperature of the gas.
7	When the air of the atmosphere rises up, it cools. Why ? **Ans:** When the air rises up, it expands due to the decrease in atmospheric pressure. It does work at the expense of its internal energy. So its temperature falls.
8	Is the equation PV= RT valid for isothermal and adiabatic processes ? **Ans:** Yes, the equation PV = RT is valid for all types of the thermodynamically processes
9	Carnot engine cannot have 100% efficiency. Explain, why ? **Ans:** Efficiency, n=1- $\frac{T_2}{T_1}$ The efficiency will be 100% or 1, if T_2, = 0 K. Since, temperature equal to 0 K cannot be realised, a heat engine with 100% efficiency cannot be designed.

10	In a Carnot engine, the temperature of the sink is increased. What will happen to its efficiency? **Ans:** Efficiency, n=1- $\frac{T_2}{T_1}$ If the temperature (T_2) of the sink is increased, the efficiency of the Carnot engine will decrease.
11	Is the efficiency of a heat engine more in hilly areas than in the plains ? **Ans:** In hilly areas, the temperature of the surroundings is lower than that in plains, so the ratio T_2/T_1 is less in hilly areas than that in plains. Hence efficiency nis more in hilly areas than in plains.
12	Can two isothermal curves intersect ? **Ans:** No. If two isotherms intersect, then this would mean that the pressure and volume of a gas are the same at two different temperatures. This is not possible.
13	What is meant by reversible engine ? Explain why the efficiency of a reversible engine is maximum ? **Ans:** The engine in which the process can be retraced at any stage of its operation by reversing the boundary conditions is called reversible engine. Its efficiency is maximum because in such a device no dissipation of energy takes place against friction, etc.
14	Write the 4 steps of operation in the Carnot cycle. **Ans:** The Carnot cycle consists of two isothermal processes and two adiabatic processes. 1)Isothermal expansion 2)Isothermal compression 3)Adiabatic expansion 4) Adiabatic compression
15	Heat engine is a device used to convert ……. energy into ……… energy. **Ans:** Heat, Mechanical
16	Cooling is produced when a gas at high pressure suddenly expands. Explain. Ans. The gas has to perform work against high pressure to expand. This results in a decrease in the internal energy of the gas and consequently its temperature falls.
17	When a gas is suddenly compressed, its temperature rises. Why? Ans. Sudden compression of a gas is an adiabatic change. Work done in compressing the gas is converted into internal energy and as such the temperature of the gas rises.
18	Discuss the results when a thermos flask containing tea is vigorously shaken. Ans. Work done in vigorously shaking a thermos flask is converted into internal energy of the tea inside it which raises its temperature. Further, along with the hot tea, a lot of vapour is also present. Due to an increase in temperature, the pressure of this vapour may further increase and in the extreme case, the cork of the bottle may be blown out.
19	On removing the valve, the air escaping from a cycle tube becomes cool. Explain. Ans. When the valve from a cycle tube is removed, the air inside it expands adiabatically and as such becomes cool. s adiabatically and as such becomes cool
20	A glass of water is stirred and then allowed to stand until the water stops moving. What happens to the kinetic energy of the moving water? Ans. The kinetic energy of the moving water is converted into its internal energy. As a result of this, the temperature of water rises.

Each question scores Three

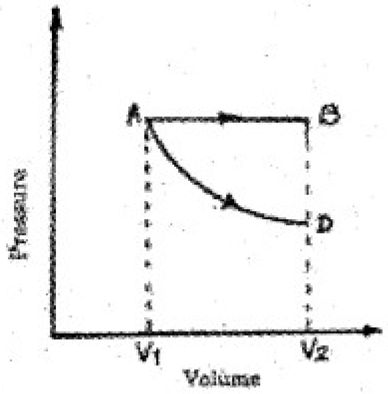
1 Calculate the efficiency of an engine working between steam point and ice point.

$$\text{Efficiency} \quad \eta = \frac{T_1 - T_2}{T_1} = \frac{373 - 273}{373}$$

$$\eta = 0.268$$

$$\eta = \underline{26.8\%}$$

2 P-V diagram of a gas is shown in the figure. In this figure AB represents isobaric process and AD represents isothermal process.



a) Explain isobaric process and isothermal process.
b) Using the above graph, find the process in which the work done is maximum. Give the reason.

Ans:
a) The thermodynamic process at constant pressure is called isobaric process. Thermodynamic process at constant temperature is called isothermal process.
b) The work done is maximum for AB because area under AB is more than that of AD.

3 A gas does work during isothermal expansion. What is the source of mechanical energy so produced ?

Ans: By first law of thermodynamics,
dQ=dU+ dW. But for an isothermal process, dU = 0, so dW = dQ . Thus the energy required for doing mechanical work during an isothermal process is obtained as heat by the gas from the surroundings.

4 The temperature of a gas rises during an adiabatic compression, although no heat is given to the gas from outside. Why ?

Ans: dQ=dU+ dW. For an adiabatic compression, dQ=0
So dU = - dW. That is work is done on the gas which increases its internal energy. Hence temperature of the gas rises.

5 When a gas is suddenly compressed, its temperature rises. Why ?

Ans: Sudden compression of a gas is an adiabatic process. The work done in compressing the gas increases the internal energy of the gas. Hence the temperature of the gas rises.

6 If an inflated tyre bursts, the air escaping out is cooled, why?

Ans: When the tyre bursts, there is an adiabatic expansion of air because the pressure of the air inside is sufficiently greater than the atmospheric pressure. During the expansion, the air does some work against the surroundings, therefore, its internal energy decreases, and as such temperature falls.

7 Is it possible that there is change in temperature of a body without giving heat to it or taking heat from it ?

	Ans: Yes, for example, during an adiabatic compression temperature increases and in an adiabatic expansion temperature decreases, although no heat is given to or taken from the system in these changes.
8 9	Is it possible that there is no increase in the temperature of a body despite being heated ? **Ans:** Yes, for example, during a change of state (from solid to liquid or from liquid to gas), the system takes heat, but there is no rise in temperature. Internal energy of the system increases in each case. Why does air pressure in a car tyre increase during driving? **Ans:** During driving, as a result of the friction between the tyre and the road, the temperature of the tyre and hence that of air inside it, increases. Since the volume of air in the tyre remains constant, pressure of the air increases due to increase of temperature.
10	A Carnot engine working between 527° C and 127° C has a work output of 800 J per cycle. How much heat is supplied to the engine from the source per cycle ? T1=527+273=800k T2=127+273=400k efficiency=1- (400÷800) =1÷2= 0.5 Q=work done÷efficiency =800/0.5 =1600Joule.
11	Explain why mechanical energy can be completely converted into heat energy but the whole of the heat energy cannot be converted into mechanical energy. Ans. The whole of the mechanical energy can be absorbed by the molecules of the system in the form of their kinetic energy. This KE gets converted into heat. But the whole of heat energy cannot be converted into work as a part of it is always retained by the system as its internal energy.
12	Is it theoretically possible to devise a heat engine which will create no thermal pollution? Ans. No, as heat must be exhausted by the engine (hot reservoir) to the atmosphere (cold reservoir). Hence, thermal pollution will always take place. According to second law of thermodynamics, whole of heat can never be converted into work. As such, some part of heat which is not converted into work, will be exhausted into the atmosphere, thereby causing thermal pollution.
13	Can a Carnot engine be realised in practice? Ans. A Carnot engine should consist of: (1) a source of infinite thermal capacity, (ii) a sink of infinite thermal capacity, (iii) a perfect gas as its working substance. Apart from this, the working substance should be a perfect gas contained in a cylinder fitted with a perfectly, frictionless piston. Obviously, it is impossible to obtain all the above conditions. So it is impossible to made in practice.

Each question scores Four

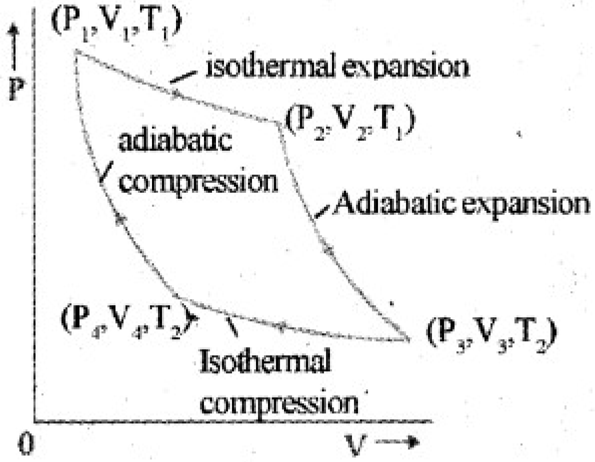
1 Thermodynamics deals with the concept of heat and the exchange of heat energy.
a) Which law of thermodynamics is used to explain the working of heat engine?
b) Explain briefly, the operations of a Carnot's engine, draw the Carnot's cycle and deduce the expression for its efficiency.

Ans:

a) Second law of thermodynamics

b) Carnot's cycle

The Carnot cycle consists of two isothermal processes and two adiabatic processes.



Let the working substance in Carnot's engine be the ideal gas.

Step 1 : The gas absorbs heat Q_1 from hot reservoir at T, and undergoes isothermal expansion from (P_1, V_1 ,T_1) to (P_2, V_2, T_1).

Step 2 : Gas undergoes adiabatic expansion from (P_2, V_2, T_1) to (P_3,V_3, T_2)

Step 3 : The gas release heat Q_2 to cold reservoir at T_2, by isothermal compression from (P_3,V_3,T_2)to(P_4,V_4,T_2).

Step 4: To take gas into initial state, work is done on gas adiabatically (P_4, V_4, T_2) to (P_1, V_1, T_1)

Efficiency of Carnot's engine

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

2 A perfect Carnot engine utilizes an ideal gas. The temperature of the source is 500 K and that of the sink is 375 K. If the k engine takes 600 Kcal per cycle from the source, then calculate:
(i) the efficiency of the engine.
(ii) work done per cycle in Joule.
(iii) heat rejected to the sink per cycle.

Ans:

Here, T_1 = temp, of source = 500 K

T_2 = temp, of sink = 375 K

Q_1 = heat absorbed from the source per cycle

= 600 Kcal

(i) the efficiency of the engine.

Let η = thermal efficiency of the Carnot engine,

then η = T1−T2 T1=500−375500

= 125500 = 0.25

$\therefore \eta = 0.25 \times 100 = 25\%$

(ii) work done per cycle in Joule.
Let W be the work done/cycle, then
η = Work done per cycle Heat absorbed per cycle =WQ1
or
25100=W600
or
$W = 25 \times 6 = 150$ K cal
$= 150 \times 10^3$ cal
$= 150 \times 10^3 \times 4.2$ J
$= 6.3 \times 10^5$ J.

(iii) heat rejected to the sink per cycle.
Let Q_2 = heat rejected to the sink per cycle, then
$Q_1 = W + Q_2$
or
$Q_2 = Q_1 - W$
$= 600 - 150$
$= 450$ K cal.