Chapter = 11

Heat and Thermodynamics

Thermodynamics: A branch of Physics which deals with conversion of heat energy into other forms of energy is called thermodynamics.
Temperature: The degree of coldness or hotness is called temperature. SI unit of temperature is kelvin.
Kinetic molecular theory of gases: Such a theory which explains the behavior of gases and relationship of macroscopic properties (Temp,Volume etc) with microscopic properties(k.E) is called kinetic molecular theory.
Give four Postulates of KMT: There are following postulates of KMT

i. A finite volume of gas consists of very large number of molecules
ii. Size of molecule is much smaller than separation b/w molecules
iii. The gas molecules are in random motion
iv. Collision b/w gas molecules is perfectly elastic.

Pressure of gas: The momentum transferred to the wall of the container per second per unit area due to continuous collision of molecules of gas is called pressure of gas. P=F/A
Effect of pressure and temperature on average translational kinetic energy: Pressure of gas is directly proportional to average translational kinetic energy $P = \frac{1}{3}\rho < v^2 >$

Temperature of an ideal gas is directly proportional to average translational kinetic energy $T \propto < K.E >$
Boyle's law: At constant temperature, pressure of gas is inversely proportional to volume of given mass of gas

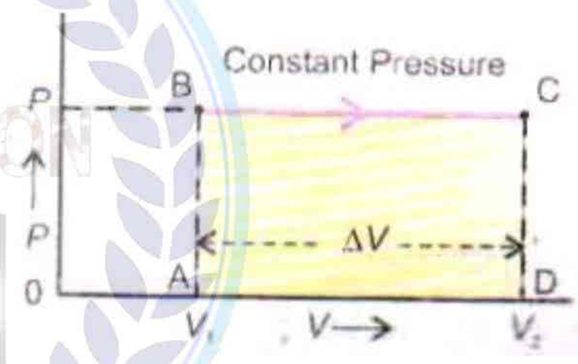
$P = \frac{2N}{3V}\langle K.E\rangle \Rightarrow as\ \langle K.E\rangle remains$ constant so PV = constant

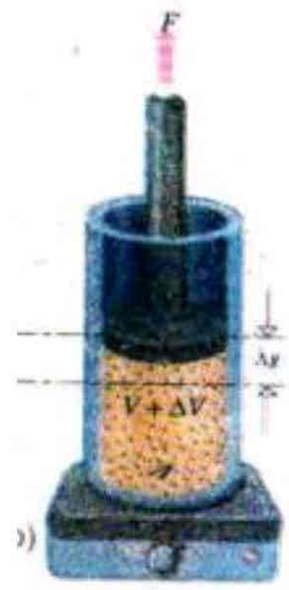
$\mathrm{P} = \frac{\text{constant}}{\mathrm{V}} \Rightarrow P \propto \frac{1}{V}$

Charles law: At constant pressure, volume of given mass of gas is directly proportional to absolute temperature of gases. According to KMT at constant temperature means average kinetic energy is constant so $V \propto T$.

What is internal energy?

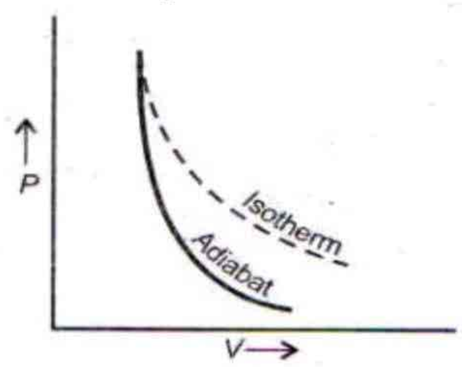
Definition: The sum of all forms of molecular energies of substance such as K.E and P.E is called internal energy. It is directly proportional to its temperature.
We can increase the internal energy by heating a substance or by doing mechanical work. Internal energy is state function as it depends upon the initial and final states of system.
Sign conventions for work and heat: There are following conventions for work and heat
Work done by the system is positive and work done on the system is taken as negative
Heat added to system is taken as positive and heat leaving the system is taken as negative
Derive an Expression for work by gas on piston:
Consider a gas enclosed in cylinder with moveable piston
the force exerted per unit area P = F/A is F = PA
work done by thegas is $W = \vec{F}.\vec{d}$ taking d = Δy
W = FΔΔ= PA(ΔA(= PΔΔ
work is calculated by area under P - V diagram





State First law of thermodynamics. Describe its applications.

Statement: "When heat Q is added to a system, this heat energy appears as increase in internal energy ΔU plus system work on surrounding" Q=ΔU+W.
Examples: For example bicycle pump and human metabolism
Applications of first law of thermodynamics: There are two applications of first law of thermodynamics
Isothermal process: Such a process in which temperature of system is constant is called isothermal process. First law of thermodynamics in isothermal process is Q=W. the curve represent this process is called isotherm.
Adiabatic process: Such a process in heat no heat enters or leave the system is called adiabatic process. For example rapid escape of air and cloud formation in air. First law of thermodynamics in adiabatic process is W=-ΔU.
Such a process in gas is expanded and do external work and temperature of gas falls is adiabatic expansion W=-ΔU
Such a process in gas is compressed and work is done on the gas and increase the temperature is called adiabatic compression –W=ΔU. The curve represent this process is called adiabate.



Define Specific heat of gas. Define Cp and Cv. and prove of Cp-Cv=R

Specific heat: The amount of heat required to increase the temperature of one kilogram of substance upto one kelvin is called specific heat.

Molar specific heat: The amount of heat required to increase the temperature of one mole of gas through 1 kelvin is called molar specific heat. Its unit is $Jmol^{-1}K^{-1}$.

Molar specific heat at constant pressure Cp: The amount of heat at constant pressure required to increase the temperature of 1mole of gas through 1K

Molar specific heat at constant volume Cv: The amount of heat at constant volume required to increase the temperature of 1 mole of gas through 1 K. both are related Cp-Cv=R.

Derivations of Cp-Cv=R: To derive the relation consider one mole of an ideal gas at constant volume so that its temperature rise by ΔT then heat transferred Qv and derived as

$Qv = Cv\Delta v$

Using first law of thermodynamics

$Qv = \Delta U + W$

$Qv = \Delta U + P\Delta V$ As volume is constant so change in volume is zero $\Delta V = 0$

$Cv\Delta T = \Delta U + P(0)$

$\Delta U = Cv\Delta T$ ----------(1)

Now at constant pressure, if one mole of an ideal gas is heated then rise in temperature ΔT and heat transferred is $Qp = Cp\Delta T$

using First law of TD $Qp = \Delta U + P\Delta V$

from equation (1) $\Delta U = Cv\Delta T$ and Qp put in above equation

$Cp\Delta T = Cv\Delta T + P\Delta V$ ----------(2)

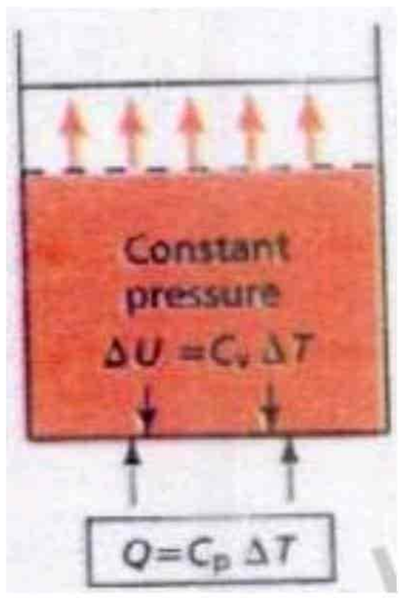
for one mole of an ideal gas equation becomes

$PV = RT \Rightarrow P\Delta V = R\Delta T$ then equation(2) becomes

$Cp\Delta T = Cv\Delta T + R\Delta T$

$Cp = Cv + R$

$Cp - Cv = R$ from this we can say that $Cp > Cv$



What is Reversible process and irreversible process?

A process which can be retraced exactly in reverse order without producing any change in surrounding is called reversible process. i.e liquefaction and evaporation.

A process which cannot be retraced exactly in reverse order, without producing any change in surroundings. For example explosion or work done against friction.

What is Heat engine?

Definition: A device which converts heat energy into mechanical work is called heat engine.

Main parts: It has three main parts. Hot reservoir, cold reservoir and working substance.

State 2nd law of thermodynamics. Why we have to need the 2nd law of thermodynamics.

Kelvin statement: " It is impossible to make a heat engine which converts all the heat absorbed from a hot reservoir into work without rejecting heat into sink".

Need the 2nd law of thermodynamics: As first law of thermodynamics tells us that heat energy can be converted into equivalent amount of work but not give any information about the conditions under which this conversion takes place so we have to need the 2nd law for this conversion.

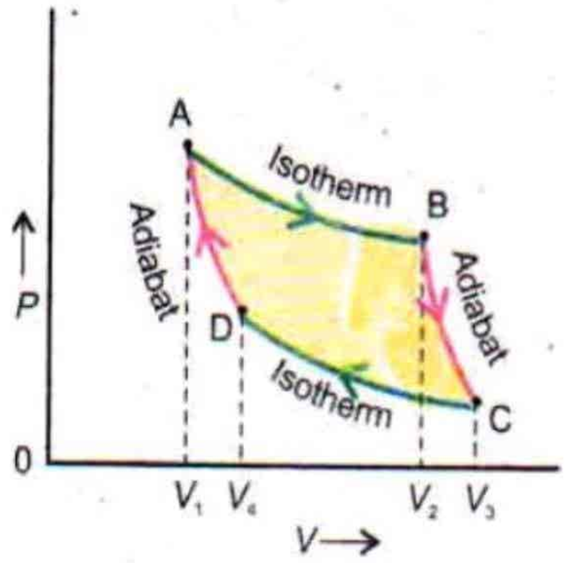
Explain Carnot engine and Carnot cycle. Also derive the relation for efficiency.

In 1840 Sadi Carnot proposed a hypothetical engine that operates in reversible cycle using the isothermal and adiabatic process. He showed that a heat engine operating in an ideal reversible cycle b/w two heat reservoirs at different temperature would be most efficient engine.

Carnot cycle: A Carnot cycle consists of four steps as shown in PV diagram.

Step01: In this step, gas is allowed to expand isothermally at temperature T, absorbing heat from hot reservoir. This process is represented by the curve AB.

Step 02: The gas is then allowed to expand adiabatically until its temperature drops. this process is represented by the curve BC.



Step 03: The gas at this stage is compressed isothermally Rejecting heat to the cold reservoir. This process is represented by the curve CD.

Step04: In this step finally the gas is compressed adiabatically to restore in initial state at temperature .This process is represented by the curve DA.

Efficiency of Carnot engine:

work done during one cycle equals to the area enclosed by path ABCDA of PV diagram.

from first law of thermodynamics $Q = \Delta U + W$

$W = Q_1 - Q_2$

$$\text{Efficiency of heat engine} = \eta = \frac{\text{output(work)}}{\text{input(Energy)}} = \frac{Q_1 - Q_2}{Q_1}$$

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

$\%\eta = (1 - \frac{Q_2}{Q_1}) * 100$ This is the formula for efficiency of carnot engine.

$\%\eta = (1 - \frac{T_2}{T_1}) * 100$ In terms of temperature T_1 = temperature of HTR, T_2 = Temperature of LTR.

Carnot theorem: "No heat engine can be more efficient than a Carnot engine operating b/w the same two temperatures".

What is Thermodynamic scale of temperature? What is triple point cell.

Definition: Such a scale of temperature which is independent of nature of working substance is called thermodynamic scale of temperature. If heat 'Q1' is absorbed at temperature 'T' and heat 'Q2' is absorbed at temperature of triple point of water, then unknown temperature of system (in K) is $T = 273.16\frac{Q_1}{Q_2}$. SI unit is kelvin.

Triple point cell: A triple point cell in which solid ice liquid water and water vapors coexist in thermal equilibrium. Its value is 273.16 K.

Kelvin: one kelvin is defined as 1/273.16 of thermodynamic temperature of triple point of water.

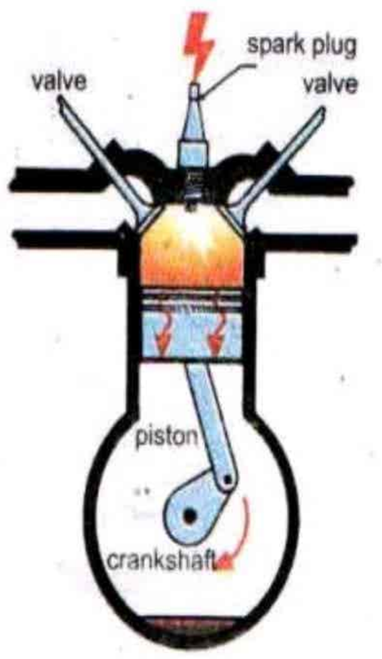
Write a note Petrol engine and Diesel engine?

A typical four stroke petrol engine is based on the principle of Carnot cycle.

Intake Stroke The cycle starts on the intake stroke in which piston moves outward and petrol air mixture is drawn through an inlet valve in to the cylinder from the carburetor at atmospheric pressure.

Compression Stroke On compression stroke, the inlet valve is closed and the mixture is compressed adiabatically by inward movement of the piston.

Power Stroke On power stroke, a spark fires the mixture causing rapid increase in pressure and temperature. The burning mixture expands and forces the piston to move outward. This is the stroke which delivers power to the crank shaft to drive the flywheels.



Exhaust Stroke On the exhaust stroke, the outlet valves opens. The residual gases are expelled and piston moves inward. Efficiency of petrol engine is 25 to 30%.

Diesel engine: No spark is needed in diesel engine. Diesel is sprayed into cylinder at maximum compression because air is at high temperature after compression the fuel mixture ignites on contact with air in cylinder and pushes the piston outward. The efficiency of diesel engine is 35% to 40%.

What is Entropy? Write its formula and unit.

Definition: The measure of disorderness of molecules of system is called entropy. Its formula $\Delta S = \frac{\Delta Q}{T}$ and unit is J/K. It is state function. Concept of entropy was given by Rudolph clausius in 1856.

State 2nd law of thermodynamics in terms of entropy? "If a system undergoes a natural process, it will go in the direction that entropy of system plus the environment increase".

What Heat death of universe? When the entropy of the universe will reach at maximum value, everything will be at same temperature and there will be no way to convert heat into useful work is called heat death of universe.

What is Refrigerator? A refrigerator transfers heat from a low temperature reservoir to higher temperature reservoir with help of external work. It is heat engine operating in reverse order.

DESCRIBE ENVIRONMAENTAL CRISIS AS ENTROPY CRISIS

According to 2nd law of thermodynamics, Environmental crisis is an entropy or disorder crisis. According to which, any increase in the order in a system will produce an even larger increase in entropy in the environment

- Energy methods we use are not very efficient. As a result most of the energy is lost as heat to the environment
- Most energy transformation processes such as heat engines used for transportation and for power generation causes air pollution.

It is because of the reason that even for small changes in temperature, the environment can have significant effects on metabolic rates in plants and animals. This can causes serious disturbance of the overall ecological balance.

Exercise short Questions

1. Why is the average velocity of the molecules in a gas zero but the average of the square of velocities is not zero?

The molecules of the gas moves in random direction. We assume that the same number of molecules move in both directions, so the average of each component velocity is zero. $\langle v \rangle = \frac{v + (-v)}{2} = 0$

But the average of the squares of the velocities of the molecules is not zero because square of negative is positive.

$$\langle v \rangle^2 = \frac{v^2 + (-v)^2}{2} \neq 0$$

2 Why does the pressure of a gas in a car tyre increase when it is driven through some distance?

In driving, the car tyre gets hot due to force of friction. This heat goes inside the tyre and increases translational kinetic energy. So increase of KEtrans makes pressure increase.

3.A system undergoes from state P1 V1 to state P2 V2 as shown in the fig. What will be the change in internal energy?

The change in internal energy (ΔU) will be zero. In the figure the graph is isotherm. It means temperature remain constant. So ΔU = 0

4 Variation of volume by pressure is given in the fig. A gas is taken along the paths ABCDA, ABCA and A to A. What will be the change in internal energy?

In the figure, all three paths returns to the initial state, so there is no change in internal energy.

5.Specific heat of a gas at constant pressure is greater than specific heat at constant volume. Why?

Specific heat at constant pressure (Cp) is greater than Cv , because a part of heat is used to do work on piston and rest of heat is used to increase the temperature through 1K and at constant volume all the heat absorbed is used to increase temperature through 1K.

6 Give an example of a process in which no heat is transferred to or from the system but the temperature of the system changes.

Adiabatic process, for example rapid escape of air from a burst tyre, rapid expansion and compression of air, cloud formation in the atmosphere.

7. Is it possible to convert internal energy into mechanical energy? Explain with example.

Yes. In adiabatic expansion of a gas internal energy converts into mechanical energy or work. Gases can be liquefied by this process.

8 Is it possible to construct a heat engine that will not expel heat into the atmosphere?
No. It is not possible. Because according to 2nd law of thermodynamics it is not possible to construct an engine without a sink or cold body to reject a part of heat to it, the atmosphere (or cold body).

9 A thermos flask containing milk as a system is shaken rapidly. Does the temperature of milk rise?
Yes. As KE of the molecules increases due to rapid shaking, so the temperature of the milk rises.
10 What happens to the temperature of the room, when a air conditioner is left running on a table in the middle of the room?
The temperature of the room remains same. Because heat absorbs from the room is expelled in the same room. Rather the temperature will rise due to work done by the compressor will change into heat.
11.Can the mechanical energy be converted completely into heat energy? If so give an example.
Yes, in a adiabatic compression, work done on the gas, increased the internal energy, i.e. converting mechanical energy (work) into heat energy (ΔU).
12 Does entropy of a system increases or decreases due to friction?
The entropy of the system increases, due to friction. As work done against friction changes into heat and this irreversible process increases its entropy.
13 Give an example of a natural process that involves an increase in entropy.
i) Melting of ice into water: The heat Q transferred to the ice at absolute temperature from the surroundings. $\Delta S = Q / T$ Since heat is added, Q is +ve and entropy increases. ii) Free expansion: In a free expansion of a gas in a chamber, which is irreversible process. Here the gas molecules confined to one half of a box are permitted to fill the entire box, which is irreversible process.
14 .An adiabatic change is the one in which. Correct answer is (a) No heat is added to or taken out of a system in the adiabatic change.
15 Which one of the following process is irreversible?
Correct answer is (d) a chemical explosion is irreversible process
16 An ideal reversible heat engine has
Correct answer is (b), an ideal reversible heat engine has highest efficiency. From the knowledge of 2nd law of TD, a heat engine cannot have 100 % efficiency and is independent of the working substance

Numerical problems

11.1: Estimate the average speed of nitrogen molecules in air under standard conditions of pressure and temperature.

$$\text{Given Data}: \text{STP}, T = 0^{\circ}C, P = 1\text{atm} = 1.01*10^{5}\ \text{pa}, <v> = ?, m = \text{molar mass}/N_A = 28*10-3/6.02*1023 = 4.65*10^{-26} kg$$

$$<v> = \sqrt{\frac{3KT}{m}} = \sqrt{\frac{3*1.38*10^{-23}*273}{4.65*10^{-26}}} = 493 m/s.$$

11.2: Show that ratio of the root mean square speeds of molecules of two different gases at a certain temperature is equal to the square root of the inverse ratio of their masses.

$$\text{As } <V_1>_{rms} = \sqrt{\frac{3KT}{m_1}}, <V_2>_{rms} = \sqrt{\frac{3KT}{m_2}}, \text{ dividing both equations}$$

$$\frac{<V_1>_{rms}}{<V_1>_{rms}} = \frac{\sqrt{\frac{3KT}{m_1}}}{\sqrt{\frac{3KT}{m_2}}} = \sqrt{\frac{m_2}{m_1}} \Rightarrow \frac{<V_1>_{rms}}{<V_1>_{rms}} = \sqrt{\frac{m_2}{m_1}} \text{ which is required result}$$

11.3: A sample of gas is compressed to one half of its initial volume at constant pressure of $1.25\times10^{5}\,Nm^{-2}$. During the compression, 100J of work is done on the gas. Determine the final volume of the gas.

$$\text{Given Data}: V_i = V,\ V_f = V - V/2 = V/2,\ P = 1.25*10^{-5}\,\text{Pa},\ W = -100\text{J},\ V_f = ?$$

$$W = P\Delta V = P(V/2 - V) \Rightarrow W = -PV/2 \Rightarrow -100 = P(-V/2) \Rightarrow V/2 = 100/P, V_f = 100/1.25*105 = 8*10^{-4}\,m^3$$

11.4: A thermodynamic system undergoes a process in which its internal energy decreases by 300 J. If at the same time 120 J of work is done on the system, find the heat lost by the system.

$$\text{Given Data}: \Delta U = -300\text{ J},\ W = -120\text{ J},\ Q = ? \Rightarrow Q = \Delta U + W = -300 + (-120) = -420J$$

11.5: A Carnot engine utilizes an ideal gas. The source temperature is $227^{\circ}C$ and the sink temperature is $127^{\circ}C$. Find the efficiency of the engine. Also find the heat input from the source and heat rejected to the sink when10000 J of work is done.

$$T_1 = 227^{\circ}C = 227 + 273 = 500K,\ T_2 = 127^{\circ}C = 127 + 273 = 400K,\ W = 10000\text{ J},\ \eta = ?,\ Q_1 = ?\ Q_2 = ?$$

$$\eta = (1 - \frac{T_2}{T_1})*100 = (1 - \frac{400}{500})*100 = 0.2 = 20\%, \text{ using formula } \eta = W/Q_1 = 0.2 = 10000/Q1 \Rightarrow Q_1 = 50000J$$

$$\text{Now using } W = Q_1 - Q_2,\ Q_2 = Q_1 - W = 50000 - 10000 = 40000J$$

11.6: A reversible engine works between two temperatures whose difference is $100^{\circ}C$. If it absorbs 746 J of heat from the source and rejects 546 J to the sink, calculate the temperature of the source and the sink.

$$\text{Given Data}: T_1 - T_2 = 100^{\circ}C = 100K,\ Q_1 = 746\text{ J},\ Q_2 = 546\text{ J},\ T_1 = ?\ T_2 = ?$$

$$\eta = 1 - Q_2/Q_1 = 1 - 546/746 = \eta = 0.268 - - - (1)$$

$$\eta = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_1} \Rightarrow 0.268 = \frac{100}{T_1} \Rightarrow T_1 = \frac{100}{0.268} = 373.13K = 373.16 - 273.16 = 100^{o}C$$

$$\text{again using } T_1 - T_2 = 100 \Rightarrow T_2 = T_1 - 100 = 373.16 - 100 = 273.16K = 273.16 - 273.16 = 0^{o}C$$

11.7: A mechanical engineer develops an engine, working between $327^{\circ}C$ and $27^{\circ}C$ and claims to have an efficiency of 52%. Does he claim correctly? Explain.

$$T_1 = 327^{\circ}C = 327 + 273 = 600K,\ T_2 = 27^{\circ}C = 27 + 273 = 300K, \text{claimed } \eta = 52\%, \text{claim} = ?$$

$$\text{using } \eta = (1 - \frac{T_2}{T_1})*100 = (1 - \frac{300}{600})*100 = 50\%, \text{His claim is not correct.}$$

11.8: A heat engine performs 100J of work and at the same time rejects 400 J of heat energy to the cold reservoirs. What is the efficiency of the engine?

$$\text{given data}: W = 100\text{ J},\ Q_2 = 400\text{ J},\ W = Q_1 - Q_2 \Rightarrow Q1 = W + Q_2 = 100 + 400 = 500\text{J},\ \eta = ?$$

$$\%\eta = (1 - \frac{Q_2}{Q_1})*100 = (1 - \frac{400}{500})*100 = 20\%$$

11.9: A Carnot engine whose low temperature reservoir is at $7^{\circ}C$ has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees the temperature of the source be increased?

Given Data : T2 = 7° C = 7 + 273 = 280 K, $\eta_1 = 50\% = 0.5, \eta_2 = 70\% = 0.7, T_1 = ?, T_1' = ?, T_1' - T_1 = ?$

$$\eta_1 = 1 - \frac{T_2}{T_1} \Rightarrow 0.5 = 1 - \frac{280}{T_1} \Rightarrow \frac{280}{T_1} = 0.5 \Rightarrow T_1 = 560K,$$

$$\eta_2 = 1 - \frac{T_2}{T_1'} \Rightarrow 0.7 = 1 - \frac{280}{T_1'} \Rightarrow \frac{280}{T_1'} = 0.3 \Rightarrow T_1' = 933.3K$$

$$T_1' - T_1 = 933.3 - 560 = 373K$$

11.10: A steam engine has a boiler that operates at 450K. The heat changes water to steam, which drives the piston. The exhaust temperature of the outside air is about 300K. What is maximum efficiency of this steam engine?

Sol. $T_1 = 450\text{K}, T_2 = 300K, \eta = ?$ $\%\eta = (1 - \frac{T_2}{T_1}) * 100 = (1 - \frac{300}{450}) * 100 = 33\%$

11.11: 336J of energy is required to melt 1 g ice at $0^\circ C$. What is the change in entropy of 30 g of water at $0^\circ C$ as it is changed to ice at $0^\circ C$ by a refrigerator?

given Data : $L_f = 336\text{ J}, m = 30\text{ g}, T = 0° C = 273\text{ K}, \Delta S = ?$

$$\Delta S = -\frac{\Delta Q}{T} = -\frac{mL_f}{T} = -\frac{30 * 336}{273} = -36.92 J/K$$

Negative sign shows decrease in entropy

Multiple choice questions

1) A diatomic gas molecule has

Translational kinetic energy	Rotational kinetic energy	Vibrational energy	**All of these**

2) The constant downward applied force F acting on frictionless piston is

PA	PV	VT	ma

3) According to Kelvin statement of 2nd law of thermodynamics heat from a source at a single temperature ---- be converted into work

Can	**Cannot**	May	None of these

4) A heat engine operating in reverse order is called

Diesel engine	**Refrigerator**	Petrol engine	Carnot engine

5) A----- transfer heat from a low temperature reservoir to high temperature surrounding with the help of external work

Diesel engine	**Refrigerator**	Petrol engine	Carnot engine

6) A triple point cell in which solid, ice, liquid water and water vapor coexist in ----

High temperature	Low temperature	**Thermal equilibrium**	Neutral equilibrium

7) The value of triple point cell is

273.16 K	273.16°C	0K	32°C

8) Approximate efficiency of electric generator is

70-80 %	70-90%	80-90%	**70-99%**

9) Efficiency of electric motor is

50-60%	60-70%	**50-93%**	90%

10) Efficiency of dry cell battery is

60%	70%	80%	**90%**

11) Efficiency of domestic gas furnace

50-60%	60-70%	**70-85%**	80-90%

12) Efficiency of storage battery is

12%	62%	**72%**	92%

13) Efficiency of hydrogen oxygen fuel cell is

50%	70%	80%	**60%**

14) Efficiency of liquid fuel rocket is

65%	37%	83%	**47%**

15) Efficiency of steam turbine is

35-40%	**35-46%**	35-56%	35-65%

16) Efficiency of fossil fuel power plant is

10-20 %	20-30%	**30-40%**	40-50%

17) Efficiency of nuclear power plant is

10-20 %	20-30%	**30-35%**	40-50%

18) Efficiency of nuclear reactor is

50%	70%	80%	**39%**

19) Efficiency of air craft gas turbine engine

50%	**36%**	87%	60%

20) Efficiency of solid state laser is

50%	70%	80%	**30%**

21) Efficiency of internal combustion gasoline engine

10-20 %	**20-30%**	30-35%	40-50%

22) Efficiency of gallium arsenide solar cells are

>20%	<20%	<10%	<5%

23) Efficiency of florescent lamp is

20%	30%	10%	5%

24) Efficiency of silicon solar cell is

12-14%	**12-16%**	12-18%	12-20%

25) Efficiency of steam locomotive is

5%	**8%**	1%	20%

26) Efficiency of incandescent lamp is

5%	8%	1%	20%

27) Efficiency of watt steam engine is

5%	8%	**1%**	20%

28) The jet engine on air crafts convert

Thermal energy to work	Thermal energy to electrical energy	Thermal energy to heat energy	None

Previous all Punjab Board Exams Solved MCQs

	Questions	Option A	Option B	Option C	Option D
1)	Which is not the example of adiabatic process	Rapid escape of air from burst tyre	Rapid expansion of air	**Conversion of water into ice in refrigerator**	Cloud formation in atmosphere
2)	Isothermal process is carried out at constant	Pressure	Volume	**Temperature**	All of these
3)	The pressure on the other sides and everywhere inside the vessel will be according to the:	**Pascal's Law**	Boyle's Law	Hook's Law	Charles's Law
4)	The entropy of the universe always	Decreases	Remains the same	**Increases**	Both A and B
5)	Boltzmann constant is written as K=?	**R/N_A**	N_AR	N/R	None of these
6)	The efficiency of Carnot engine depends	Sink temperature	Source temperature	**Both A&B**	Working substance

7)	The pressure exerted by column of mercury 76cm high and at 0°C is called	**1atm**	1 N/m2	1 Pascal	None of these
8) 9)	Average translational kinetic energy of molecules for an ideal gas is given by	2/3 KT	$\frac{3KT}{2}$	2T/3K	
10)	Pressure of gas is given by the relation	**1/3 ϱ<v²>**	3/2 ϱ<v²>	ϱ<v²>	None of these
11)	J/K is the unit of	Efficiency	**Entropy**	Heat of fusion	Internal energy
12)	Which of the following relation shows adiabatic process	$W = \Delta U$	$W = -\Delta U$	$W = 0$	$W = Q$
13)	The value of triple point of water is given by	0 K	100 K	**273.16 K**	373.16 K
14)	The relation R/NA = 1.38 x 10^{-23} JK-1 in a gas law is known as	Avogadro's constant	Newton's constant	Charles constant	**Boltzmann's constant**
15)	Number of spark plugs needed in diesel engine is	1	2	3	**0**
16)	Unit of thermodynamics scale of temperature is given as	**Kelvin**	Fahrenheit	Centi grade	Celsius
17)	The relation 'PV = nRT' shows which law of physics	Charles Law	Newton's Constant	Avogadro's Law	**Ideal Gas Law**
18)	When heat is added to a system then entropy change is	**Positive**	Negative	Zero	None
19)	For monoatomic gas Cv=3R/2 then gamma?	3/5	**5/3**	4/15	15/4
Cp-Cv=R, Cp-3R/2=R, Cp=R+3R/2=5R/2, put Cp=5R/2, Cv=3R/2 in γ=Cp/Cv= 5/3					
20)	An ideal reversible heat engine has	100% Efficiency	**Maximum highest Efficiency**	Efficiency depends on working substance	None of these
21)	The efficiency of diesel engine is	25-30%	30-35 %	40-45%	**35-40%**
22)	A process in which no heat enter or leave the system is called	Isothermal process	**Adiabatic process**	Isobaric process	Isochoric process
23)	Thermal pollution is inevitable consequence of thermodynamics	First law	**2nd law**	1st law of motion	None of these
24)	The efficiency of heat engine is increased by increasing temperature of	Engine	Cold reservoir	**Hot reservoir**	None of these
25)	The unit of entropy is	JK	K/J	**J/K**	J
26)	The concept of entropy was introduced by Rudolph clausius in	1840	**1856**	1864	1870
27)	The cloud formation in atmosphere is an example of	Isothermal process	**Adiabatic process**	Isobaric process	Isochoric process
28)	The relationship between absolute temperate of an ideal gas and average translation kinetic energy is T=?	$\frac{2}{3k}\langle\frac{1}{2}mv^2\rangle$	$\frac{3}{2k}\langle\frac{1}{2}mv^2\rangle$	$\frac{3}{2}k\langle\frac{1}{2}mv^2\rangle$	$\frac{2}{3}k\langle\frac{1}{2}mv^2\rangle$

29)	Pressure of the gas depends upon	Only on molecular speed	Only on mass of molecule	Only on number of molecule in a unit volume	**Number of molecule in unit volume and speed of molecule**
30)	No entropy change is associated with	Isothermal process	**Adiabatic process**	Isochoric process	Boyle law
31)	One is an example of reversible process	Work done against friction	Heat produced by a current	**Melting of ice**	Explosion
32)	Gas law $PV^{\gamma} = cons\tan t$ is for	Isothermal process	**Adiabatic process**	Isobaric process	Isochoric process
33)	The highest efficiency of a heat engine whose lower temperature is 17°C and high temperature is 200°C is	70%	60%	**38%**	135%
T_2=17°C=17+273=290K, T_1=200°C=200+273=473K. put T_1=473 K, T_2=290 K in efficiency formula to get result					
34)	The change in entropy of a system is given by	$\Delta S = \frac{\Delta Q}{T}$	$\Delta S = \frac{\Delta T}{Q}$	$\Delta Q = \frac{\Delta T}{S}$	None of these
35)	The efficiency of petrol engine is	**25-30%**	30-35 %	40-45%	35-40%
36)	At constant temperature and pressure, if volume of given mass of a gas is doubled then density	**Half**	Double	One fourth	Remains same
37)	Absolute zero corresponds to	-400°F	**0K**	0°C	273.16°C
38)	Which of the following is the expression of root mean square speed of a gas having n number of molecules contained in the container	$\sqrt{\frac{V_1^2+V_2^2+V_3^2+....V_n^2}{N}}$	$\sqrt{\frac{V_1+V_2+V_3+....V_n}{N}}$	$V_1+V_2+V_3+....V_n$	None of these
39)	The expression for isothermal process is	Q=U	**Q=W**	U=W	U= -W
40)	A gas sample contains three molecules each having speed 1 ms-1, 2 ms-1, 3 ms-1. What is the mean square speed?	**14/3 m/s** $1^2+2^2+3^2/3$ $1+4+9/3=14/3$	2 m/s	6 m/s	$\sqrt{14/3}$ m/s
41)	A heat engine operating according to second law of thermodynamics rejects one fourth of the heat taken from high temperature reservoir. What is the percentage efficiency of heat engine?	100%	50%	25%	**75%**
$T1 = T, T2 = T/4, then\ \eta = (1 - T2/T1)*100 = (1 - \frac{T/4}{T})*100 = (1 - \frac{1}{4})*100 = (\frac{3}{4})*100 = 75\%$					
42)	If 'Q' is the amount of heat supplied to a system and 'W' is the work done, then change in internal energy can be defined as	Q/W	W/Q	**Q – W** Apply first law of thermodynamics	1 + Q/W
43)	If the temperature of sink is decreased the efficiency	Decrease	**Increase**	Remains same	None of these
44)	For an ideal gas, potential energy associated with its molecules is	Maximum	**Zero**	½ kx	None

45)	What is the factor upon which change in internal energy of an ideal gas depends?	Change in volume	**Change in temperature**	Change in temperature and volume	Path followed to change internal energy
46)	Change in entropy of a reversible process is	Positive	Negative	Zero	Maximum
47)	For a heat engine 'A' ratio of Q_1 to Q_2 is 3/2 while that of heat engine 'B', ratio of Q_2 to Q_1 is 1/3. What is the value $\eta_A : \eta_B$?	1:3	2:3	**1:2**	2:1
$Q1 \text{ to } Q2 = 3/2 \text{ so } Q2/Q1 = 2/3, \eta_A = (1 - Q2/Q1) = (1 - 2/3) = 1/3$ $Q2/Q1 = 1/3, \eta_B = (1 - Q2/Q1) = (1 - 1/3) = 2/3 \text{ so } \eta A : \eta B = (1/3) : (2/3) = 1:2$					
48)	Celsius scale starts from	32°F	273°K	**0°C**	373°K
49)	The turbine in a steam power plant takes steam from a boiler at 427 °C and exhausts into a low temperature reservoir at 77 °C. What is the maximum possible efficiency?	**50%**	60%	40%	70%
Apply efficiency formula by putting T1=700 K, T2=350 K,, efficiency=$(1-T_2/T_1)*100$ $(1-350/700)*100 = 50\%$					
50)	In an adiabatic process first law of thermodynamics becomes	$\Delta Q = \Delta U$	**$\Delta W = -\Delta U$**	$\Delta W = \Delta U$	$\Delta Q = W + \Delta U$
51)	Which one of the following is a postulate of kinetic theory of gases?	**Molecules do not exert force on each other**	The size of molecules is much larger than separation between the molecules	A finite volume of gas consists of a very small number of molecules	The gas molecules are not in random motion
52)	The increase in the entropy means increase in	Disorder	Unavailability of energy	Randomness	**All of these**
53)	For a gas of volume V in its equilibrium state, if the pressure does change with time then total kinetic energy of gas is constant because	Collisions between gas molecules occur	**Collisions must be elastic**	Collisions between gas molecules occur linearly	Collisions must be inelastic
54)	Which one is not an irreversible process?	**Slow compression of a gas into a cylinder**	Explosion	Changes due to friction	Dissipation of energy
55)	Which is the average translational kinetic energy of molecule in a gas at temperature 27°C	**$6.21*10^{-21}$ J** See exp 11.1 for solution	$6.21*10^{-26}$ J	$6.23*10^{23}$J	$6.21*10^{26}$J
56)	the value of triple point of water is	373.16 K	**273.16 K**	173.16 K	0K
57)	Which is isothermal process?	Rapid escape of air from burst tyre	**Slow expansion of gas in cylinder at const temp**	Rapid expansion of gas in cylinder	Cloud formation
58)	A gas containing 'N' number of molecules of a gas having mass of each molecule 'm' is in a cubic container having length of	N/a_2	**Nm/a^3** Density is mass per unit volume So density- Nm/a^3	m/a_3	Na_3/m

	each side ‘a’. What is the density of gas contained in cube?				
59)	Entropy remains constant in	Isothermal process	**Adiabatic process**	Isobaric process	Isochoric process
60)	In ‘General Gas Equation PV=nRT’, ‘n’ represents the number of moles of gas. Which of the following represents the relation of ‘n’?	$n = NN_A$	$n = N_A/N$	**$n = N/N_A$**	$n = N + N_A$
61)	A device based upon thermodynamic property of matter is called	Calorimeter	Heat engine	**Thermometer**	Voltmeter
62)	At triple point of water, the pressure of gas is 2680 Pa, by changing ‘T’ the pressure increases to 4870 Pa. Then ‘T’ is:	**496.38 K**	Zero	438.96 K	496.38 ^oF
As pressure is directly proportional to average kinetic energy of molecules/temperature so in this case pressure is increased 1.8 times, so for finding the value of new temperature 1.8*273.16=496.38 k					
63)	The most important factor regarding the significance of Carnot engine is that	It practically possible	Its efficiency is 100%	**It set an upper limit on the efficiency**	It sets a lower limit on the efficiency
64)	Which is called internal energy of an ideal gas ?	Potential energy	Translational kinetic energy	**Both A&B**	Vibrational kinetic energy
65)	The process which is carried out at constant temperature is called	**Isothermal**	Adiabatic	Isochoric	Isobaric
66)	At what temperature both Celsius and Fahrenheit scales give the same reading?	-100^o	-180^o	**-40^o**	-273^o
67)	A heat engine working according to second law of thermodynamics has 50% efficiency. What will be the temperature of its low temperature reservoir if high temperature reservoir is 327°C?	**27°C**	300°C	127°C	600°C
$\eta = 50\% = 0.5, T2 = 600K, \eta = (1 - T2/T1),, 0.5 = (1 - T2/600), T2/600 = 0.5, T2 = 300K = 300 - 273 = 27^\circ C$					
68)	Working cycle of a typical petrol engine consists of	Two strokes	**Four strokes**	Six strokes	Eight strokes
69)	Carnot cycle is	**Reversible**	Irreversible	Both A&B	None of these
70)	Two sample of gases ‘1’ and ‘2’ are taken at same temperature and pressure but the ratio of number of their volume is $V_1:V_2 = 2:3$. What is the ration of number of moles of the gas sample?	3:2	4:9	**2:3** Apply ideal gas eq	$\sqrt{2}:\sqrt{3}$
71)	The curve represents an adiabatic process is called	Isotherm	**Adiabate**	Adiabatic	Isothermal
72)	Which of these is not an example of a irreversible process ?	Work done against friction	Heat produced by current	**Melting of ice**	Explosion

73)	Kinetic energy of an ideal gas at absolute zero will be ?	Infinite	**Zero**	Very high	Below zero
74)	One of the following is true for Carnot engine	$\eta > 1$	$\eta = 1$	$\eta < 1$	W=U
75)	Internal energy of a substance is directly proportional to	Pressure	Volume	**Temperature**	None of these
76)	A carnot engine discharge 3J of heat into the LTR for every 2J of work. The efficiency of carnot engine will be	33%	**40%**	60%	66%
Q2=3J, W= 2J, W=Q1-Q2, Q1=W+Q2=2+3=5J, applying efficiency formula η=W/Q1*100=2/5*100=40%					
77)	An adiabatic process is that which has constant	**Entropy**	Volume	Pressure	Temperature
78)	What is the 273 k on the Celsius scale of temperature?	0.15°C	**-0.15°C**	273.15°C	-273.15°C
As 1C=273.15K so convert Celsius into kelvin subtract it 273-273.15=-0.15°C					
79)	The efficiency of carnot engine depends on	Nature of working substance	Size of engine	Construction of engine	**Temperature of hot and cold reservoir**
80)	When the rate of gas changes without change in temperature, the gas is said to undergo	**Isothermal Process**	Isochoric Process	Adiabatic Process	Isobaric Process
81)	Which of the following processes is practically reversible	Explosion	Human metabolism	**Evaporation**	Cloud formation
82)	An ideal gas is one whose molecule have energy	**K.E only**	P.E only	K.Erot	Vibration &K.E only
83)	Boyle law is applicable to	Isochoric process	Isobaric process	**Isothermal process**	Adiabatic process
84)	For a diatomic Cv=5R/2 then gamma is	5/7	4/35	**7/5**	35/4
Cp-Cv=R, Cp-5R/2=R, Cp=R+5R/2=7R/2, put Cp=7R/2, Cv=5R/2 in γ=Cp/Cv= 7/5					
85)	According to first law of thermodynamics the quantity which is conserved	**Energy**	Force	Momentum	Power
86	A system does 600J of work and at the same time its internal energy increased by 320J. how much heat has been supplied	280J	**920J**	600J	200J
Apply first law of thermodynamics Q=ΔU+W=600+320=920 J					
87)	Latent heat of fusion of ice is Lf	**$3.36*10^5$ J/Kg**	$336*10^5$ J/kg	$3.6*10^{-5}$ J/Kg	$3.36*10^{-5}$ J/kg
88)	If Cv is the molar specific heat at constant volume and ΔT is temperature then CvΔT gives	Area	**Energy**	Volume	Density
89)	Heat is form of	Power	Momentum	**Energy**	Torque
90)	An isothermal process is represented by equation	**PV=constant**	P/V=constant	P/T=constant	None
91)	The ratio of Cp/Cv for diatomic gas is equal to	1.67	1.50	**1.40**	1.29
92)	Environmental crises are known as	Population crises	**Entropy crises**	War crises	Mass crises
	Ideal gas equation is	PT=NUK	P=NKT	**PV=nRT**	P=nRT

93)	Difference between Cp and Cv is equal to	Planks constant	**Universal gas constant**	Molar gas constant	Boltzmann constant
94)	In thermodynamic system internal energy decrease by 100 J and 100 of work is done on the system then heat lost will be?	Zero	100 J	200J	**-200J**
Apply first law of thermodynamics ΔU=-100 J, W=-100 J, so Q=-100+(-100)=-200 J, as work done on system is -iv					
95)	According to Charles law	$V\alpha T$	$P\alpha V$	$V\alpha 1/P$	None of these
96)	Which is an example of irreversible process?	**Explosion**	Evaporation	Slow compression	Liquefaction
97)	The value of molar gas constant R in J/mol K	8314	831.4	**8.314**	83.14
98)	1 mole of a gas occupies volume 1.00×10^{-2} m³ in a gas cylinder whose pressure is equal to 2.50×10^{5} Pa. The temperature of cylinder is	227K	370K By using PV=nRT	**300K**	390K
By using ideal eq $PV=nRT$,,, $2.5*10^5*1*10^{-2}=1*R*T$, $RT=2.5*10^3$, $T=2.5*10^3/8.31=2500/8.31=300$ K					
99)	Estimate pressure of air molecules at 273K, if mean square speed is 500 m²/s² and density of air is 6 kg/m³:	**1×10^3 Pa**	1×10^2 Pa	2.5×10^2 Pa	2.7×10^3 Pa
By using $P=1/3\ \varrho\langle v^2\rangle=1/3*6*500=3000/3=1000$ pa $=1*10^3$ pa					
100)	For obeying Boyle law, if pressure is doubled then volume	**One half**	Double	One fourth	Same
Pressure of gas is inversely proportional to volume so doubling the pressure half the volume					
101)	Pressure of gas is directly proportional to	Potential energy	**Average Kinetic energy**	Wind energy	Sound energy
102)	The dimension of entropy are	$[MLT^{-2}]$	$[ML^2T^{-2}]$	$[ML^2T^{-2}K^{-1}]$	$[ML^2T^{-2}K]$
Apply entropy formula put dimensions heat=$[ML^2T^{-2}]$, Temperature=[K]					
103)	Entropy of universe with passage of time is	**Increase**	Decrease	Remains same	Increase and decrease
104)	An ideal heat engine can only be 100% efficient if its cold temperature reservoir is	**0K**	0°C	273 K	100 K
By using efficiency formula, there is only one condition under which efficiency will be 100% when T_2=0K					
105)	Diatomic molecule has energy	Translational energy	Rotational energy	**Both A&B**	None
106)	For diatomic gas molecule γ=1.4 and Cv= $\frac{5R}{2}$ the value of Cp	$\frac{2}{5}R$	$\frac{9}{2}R$	$\frac{7}{2}R$	$\frac{11}{2}R$
Solution As Cp-Cv=R, so Cp-5R/2=R, Cp=R+5R/2, taking LCM then we get Cp=7R/2					
107)	If the temperature of gas is constant then $\left\langle \frac{1}{2}mv^2 \right\rangle$ of molecules of gas is	**Constant**	Zero	Increased	Decreased
As temperature is directly proportional to average kinetic energy of gas molecules					

108)	A heat engine operating b/w temperatures 400K and 1000 K, its efficiency will be	**<u>60%</u>**	50%	40%	70%
	Apply efficiency formula by putting T1=1000 K, T2=400 K,, efficiency=$(1-T_2/T_1)*100$ (1-400/1000)*100= 60%				