**Chapter – 11/12 Thermal Properties Of Matter & Thermodynamics**

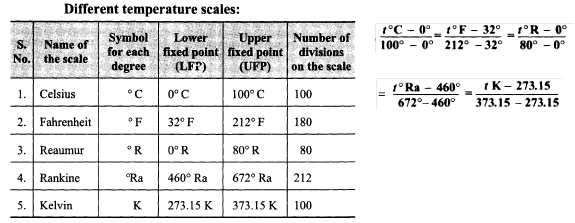
**1.Thermometry**

- Temperature is a macroscopic physical quantity related to our sense of hot and cold.

- Our temperature sense is not always reliable. For example, on a cold winter day, in the same room, an iron chair seems to be much colder to our touch than does a wooden chair, although both are at the same temperature.

-Temperature of a body cannot be lowered up to any extent while it can be raised up to any value. Theoretical lowest temperature is considered to be absolute zero. Highest possible temperature achieved in laboratory is about 108 K while lowest possible temperature attained is 10-8 K.

- Branch of physics dealing with production and measurement of temperatures close to 0 K is known as **cryogenics** while that dealing with the measurement of very high temperatures is called as **pyrometry**.



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*Other special thermometers:*

(i) **Radiation pyrometer:**

(a) These are the devices to measure the temperature by measuring the intensity of radiations received from the body.

(b) They are based on the fact that the amount of radiations emitted from a body per unit area per second is directly proportional to the fourth power of temperature (Stefan's law).

(c) These can be used to measure temperatures ranging from 8000 C to 40000 C

(d) They cannot measure temperature below 8000C because the amount of radiations is too small to be measured.

(ii) **Vapour pressure thermometer:**

(a) These are used to measure very low temperatures.

(b) They are based on the fact that saturated vapour pressure P of a liquid depends on the temperature according to the relation: log P = a + bTk+ c/Tk

(c) The range of these thermometers varies from 120 K to 0.71 K for different liquid vapours.

(iii) **Magnetic thermometers**: Temperatures below 1 K are measured by magnetic thermometers which are based on Curie law.

**Some important points regarding thermometers:**

(i) Hydrogen cannot be used as a thermometric substance above 5000 C because it starts diffusing.

(ii) In liquid thermometers, mercury is preferred over other liquids as its expansion is large and uniform and it has high thermal conductivity and low specific heat.

(iii) Gas thermometers are more sensitive than liquid thermometers as expansion of gases is more than that of liquids.

(iv) Usually platinum is used in resistance thermometers as it has high melting point and for it α is constant.

(v) Below -2000C,the hydrogen and nitrogen cannot be used because they start liquefying.

(vi) Thermoelectric thermometers have low thermal capacity and high thermal conductivity, so can be used to measure quickly changing temperatures.

(vii) Alcohol thermometer is preferred to the mercury thermometer due to the large value of the coefficient of cubic expansion.

(viii) The mercury thermometers with **cylindrical bulbs are more sensitive than those with spherical bulbs**

**2. Thermal Expansion**

**1.Thermal expansion:**

(i) When heat is supplied to matter and its state does not change, then it usually gets expanded. There are also some such substances which contract on heating. Rubber is a very good example of it.

(ii) The basic reason for thermal expansion is asymmetry in potential energy curve.

(iii) Thermal expansion is minimum in case of solids but maximum in case of gases because intermolecular force is maximum in solids but minimum in gases.

(iv) Solids can have all the three types of thermal expansion, i.e ., one-dimensional (linear expansion), two-dimensional (superficial expansion) and three-dimensional (volume expansion) while liquids and gases usually possess only volume expansion.

**2. Coefficient of linear expansion:**

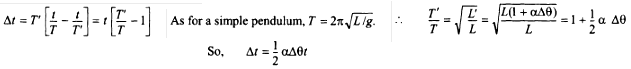
(i) Coefficient of linear expansion α is defined as the increase in length per unit length per unit degree rise in temperature.

α =[Lt-Lo]/Lot therefore Lt = Lo [1 + αt ]

Although α, is defined with respect to Lo, it is usually very small .

(ii) **Effect of linear expansion on pendulum clocks:**

(a) Suppose a pendulum clock gives proper time at temperature θ. If temperature is increased to θ', then due to linear expansion, length of pendulum and hence its time period will increase.

As a result of this increase in time period, the pendulum will now perform (t/T') oscillations in place of (t/T) oscillations in a given time interval t, i.e., pendulum will loose [(t/T) - (t/T')] oscillations. Since, measurement of time is in accordance to counting of oscillation, hence in a time t , a clock with time period T' will lose time by:

(b) Hence, time lost by the clock in a day (= 86400 sec) = ½ α∆θ t = 43200 α∆θ

(c) Clock will gain time, i.e., clock will become fast if θ' < θ.

(d) The gain or loss in time is independent of time period T and depends on the time interval t only.

(e) Since, α for **invar** is very small, hence pendulums are made of invar to show the correct time in all seasons.

(f )If the coefficients of linear expansion of the materials of two rods are in the inverse ratio of their initial lengths, then the difference between lengths of two rods remains constant at all temperatures, i.e., α1/α2 =L2/L1

(iii) **Generation of thermal stress in a clamped rod due to its linear expansion:**

(a) When a rod, whose ends are rigidly fixed such as to prevent expansion or contraction, undergoes a change in temperature, due to thermal expansion or contraction, a compressive or tensile stress is developed in it. These stresses are called thermal stresses.

(b) If ∆θ0 C be the change in temperature of a rod of L then thermal strain = ∆L/L = α∆θ [ as α = ∆L/L∆θ

So, thermal stress = strain x Y = Yα∆θ and thermal force = stress x C.S. area = YAα∆θ



(iv) *Effect of linear expansion on a bimetallic strip:*

(a) A bimetallic strip consists of two strips of equal length but of different metals, riveted together keeping one over the other.

(b) When such a bimetallic strip is heated, it bends with metal of greater α on outer side, i.e., convex side.

(c) This bimetallic strip is specially used in thermostat or auto-cut in electric heating circuits.

3. **Coefficient of superficial expansion**:

Coefficient of superficial expansion β is defined as the increase in **area** per unit area per unit degree rise

in temperature

-Although β is defined with respect to Ao, it is usually very small and hence may be expressed without

much error by the equation

4. **Coefficient of cubical expansion:**

(i) Coefficient of cubical expansion γ is defined as the increase in volume per unit volume per unit degree

rise in temperature.

(ii) **Variation of density with temperature :** If do and dt be the densities of the material of a body at

00C and t0C then

do/dt = (1+ γt) ,where γ is the mean coefficient of cubical expansion of the material of the body.

(iii) **Expansion of liquids:**

(a) Liquids also expand on heating just like solids. Since, liquids have no shape of their own, they suffer only volume expansion.

(b) A liquid is always taken in a vessel for heating. So, if a liquid is heated, the vessel also gets heated and hence both liquid and vessel expand. But expansion of liquid is much greater than that of vessel, still the observed expansion is less than the actual expansion it had. Hence, there are two coefficients of expansion in case of liquids:

(i) Coefficient of real expansion γr and

(ii) Coefficient of apparent expansion γa

(c) Relation between γr and γa

∆Vrel = change in volume of liquid relative to vessel = V γa ∆θ

with γa = γr - γs where γs is the coefficient of cubical expansion of the solid of the vessel



(e) If same liquid is heated in two vessels A and B having coefficients of linear expansion αA and αB respectively, then

5. **Some important points:**

(i) Percentage change in length on heating = α∆θ x 100

Percentage change in area on heating = β∆θ x 100

 Percentage change in volume on heating = γ∆θ x 100

(ii) α:β:γ :: 1: 2: 3 ;Hence, for same rise in temperature,

percentage change in area = 2 x percentage change in length

percentage change in volume = 3 x percentage change in length

(iii) The three coefficients of expansion are not constant for a given solid. Their values depend on temperature

range in which they are measured.

(iv) The values of α,β,γ also depend on the unit of temperature. Values of α,β,γ in unit of per 0C are equal to (9/5) times their numerical values in unit of per 0F.

(v) The values of α,β,γ are independent of units of length, area and volume respectively.

(vi) For anisotropic solids, γ =αx + αy +αz represent the mean coefficients of linear expansion along three mutually perpendicular directions.

*(vii) If there is a hole in a plate (or cavity in a block), the area of hole (or volume of cavity) will increase when plate (or body) expands on heating, just as if the hole (or cavity) were solids of the same material.*

**(viii) Anomalous expansion of water:**

(a) Generally matter expands on heating and contracts on cooling. In case of water, it expands on heating if its temperature is greater than 40C. **In the range O0C to 40C, water contracts on heating and expands on** **cooling, i.e., γ is negative**. This behaviour of water in the range from **O0C to 40C** is called anomalous expansion.

(b) The anomalous behaviour of water arises due to the fact that water has three types of molecules, viz ., H2O, (H2O)2 and (H2O)3 having different volume per unit mass and at different temperatures their properties in water are different.

(c) At 40C, density of water is maximum while its specific volume is minimum.

**Calorimetry - 3**

**Specific heat:**

(i) The amount of heat required to change the temperature of a body depends on:

(a) the material of the body (b) the mass of the body, and (c) the change in temperature.

- Specific heat of hydrogen is maximum

- All specific heats have been found to vary with temperature, particularly at low temperatures.

- Specific heat of substance at its melting point or boiling point is infinite (because ∆T = 0).

- Specific heat of a substance undergoing an adiabatic change is zero (because ∆Q =0).

- A substance can also possess a negative value of specific heat. For example, specific heat of saturated water vapours is negative

- Specific heat of a substance also depends on the conditions under which measurements of specific heat are made. It is an established fact that specific heat of a gas under the condition of constant pressure is greater than its value under the condition of constant volume . This difference is found to be negligible in case of solids and liquids.

- It is worth noting that water has large specific heat, so if used as coolant, it takes away large amount of heat energy and this property makes it a useful coolant.

- Sodium too has high specific heat and molten sodium is used as coolant in nuclear reactors

**Latent heat:**

-No change in temperature is involved when the substance changes its state. That is, **phase transformation is an isothermal change**. Ice at 00C melts into water at 00 C. Water at l000 C boils to form steam at 1000C.

- The amount of heat required to change the mass m of the substance is written as: ∆Q=mL, where L is the

latent heat. Latent heat is also called as **Heat of Transformation**.

- Internal energy of steam at 1000C is more than that of water at 1000c.

- Heat required to change unit mass of solid directly into vapours at a given temperature is called **heat of sublimation** at that temperature.

- **Hoar frost**: Direct conversion of vapours into solid is called hoar frost. This process is just reverse of the process of sublimation, e.g., formation of snow by freezing of clouds.

**Effect of pressure on boiling point and melting point**



(i) According to Classius and Clapeyron's equation

where TK represents boiling point of liquid or melting point of solid, VF and VI are final and initial specific volumes

(ii) **In case of boiling** as VF > VI, hence (dP/dT) is always positive, i.e., *boiling point of every liquid increases with increase in pressure.*

**In case of melting:**

(a) for substances like wax and sulphur, which expand on melting , VF > VI; so melting point rises with increase in pressure

(b) for substances like ice and rubber, which contract on melting VF < VI so melting point decreases with increase in pressure.

**Principle of' Calorimetry:**

(i) When two bodies at different temperatures are placed in contact with each other, then heat will pass from the body at higher temperature to the body at lower temperature until both reach to a common temperature.

In this process, heat lost by one body = heat gained by the other

i.e., principle of Calorimetry is an alternative form of the law of conservation of energy.

(ii) When two bodies at different temperatures are mixed together, then equilibrium temperature of mixture T is always ≥ lower temperature (TL) and ≤ higher temperature (TH ), i.e., a body cannot be cooled below the temperature of cooling body, and also a body cannot be heated above the temperature of heating body.

(iii) It is worth noting here that **rise in temperature of one body is not equal to the fall in temperature of the other body(because of losses).**

**Some more important points:**

(i) A body releases heat if its temperature falls and absorbs heat when its temperature rises.

(ii) When state of a body changes at constant temperature (Melting point or Boiling point), then heat released or absorbed is given by Q = mL.

(a) If solid converts into liquid (at MP) or liquid converts into vapours (at BP), heat is absorbed.

(b) If liquid converts into solid or vapours convert into liquid, heat is released.

(iii) **There will be no exchange of heat between two bodies when they attain the same temperature, e.g.)if we put the beaker containing water in melting ice, the water in the beaker will cool to 00C but will never freeze.**

(iv) There may be no change in temperature due to insufficient quantity of heat, e.g.,if we put some ice in hot water, then temperature of mixture may be at 00C if heat given by water in cooling up to 00 C is not sufficient to melt the ice completely.

(v) Amount of steam at 1000 C required to just melt **m** g of ice at 00C is (m/8) g.

(vi) **If equal amounts of ice and water are mixed and if the temperature of water is ≤ 800C, resultant temperature = 00C.**

(a) If temperature of water = 800C, resultant is all water at 00C.

(b) If temperature of water< 800C some ice is left unmelted.

(vii) If equal amounts of ice and steam are mixed then resultant temperature is 1000C.

(viii) If equal amounts of water and steam are mixed, then resultant temperature is 1000C.

(ix) If a given mass ***m*** of a solid is supplied heat continuously at a constant rate and a graph is plotted between temperature (on y-axis) and time (on x-axis), then the curve so obtained **heating cur**ve. Following important conclusions are obtained from this curve:

(a) specific heat in any state α 1/ slope of curve in that state'

(b) latent heat in any state α length of curve in that state.

**Heat Transfer-4**

1. **Transmission of heat:**

Heat can be transmitted from one place to another by three different mechanisms :

(a) conduction (b) convection (c) radiation

2. **Steady state:** When one end of a rod is heated, then initially the temperature of various points of the rod changes continuously and the rod is said to exist in a variable state. After some time, a state is reached, when the temperature of each cross-section becomes steady. This state is known as steady state. In this state, any heat received by any cross-section is partly conducted to the next section and partly radiated, i.e., no heat is absorbed by the cross-section.

3. **Coefficient of thermal conductivity (K):**

(i) The coefficient of thermal conductivity, K, of a material is defined as the amount of heat that flows in unit time through unit area perpendicular to the direction of flow under unit temperature gradient when steady state has been reached.

(ii) The amount Q of heat flowing in t seconds is given by, Q = KA(θ2 -θ1) t / d

where (θ2 -θ1) is the temperature difference across a rod of length d and cross-sectional area A.

(iii) (a) Unit of K in CGS system – cal/cm-sec-0C (b) Unit of K in MKS system = kcal/m-sec-K

(c) Unit of K in SI system : watt /m-K

(iv) For **a perfect conductor of heat K is infinite and for a perfect insulator K is zero.**

(v) In general, solids are better conductors than liquids and liquids are better conductors than gases. (Heat transfer through process of conduction is possible in liquids and gases also, if they are heated from the top.)

**Metals are much better conductors than non-metals.**

(vi) **Wiedmann-Franz law**: At a given temperature T, the ratio of thermal conductivity to electrical conductivity is constant, i. e., (K /σ T ) = constant, i. e*., a substance which is a good conductor of heat (e.g., silver) is also a good conductor of electricity. Mica is an exception to above law.*

(vii) **Thermometric conductivity or diffusivity**: It is defined as the ratio of coefficient of thermal conductivity to the thermal capacity per unit volume of the material, i.e., **Diffusivity** D = K/ρc.

Diffusivity is a measure of time rate of change of temperature when the body is in variable state.

4.**Thermal resistance:**

(i) The thermal resistance of a body is a measure of its opposition to the flow of heat through it. It is defined as the ratio of temperature difference to the heat current (= rate of flow of heat).



(ii) Now, temperature difference = (θ2 -θ1) Heat Current H =Q/t

(iii) Unit of thermal resistance is 0C x sec/cal or K x sec/k-calorie

5. **Series combination of conductors:**

(i) Suppose two conductors of equal area of cross-section (A) and lengths d1 and d2 and coefficients of thermal conductivities K1 and K2 are connected in series. Let the temperatures of the two outer faces be θ1 and θ2 and the temperature of the junction be θ;then heat current is the same in the two conductors.

K1A(θ1 -θ)/d1 = K2A(θ - θ2)/d2  or K1 (θ1 -θ)/d1 = K2 (θ - θ2)/d2  or K1G1 =K2G2

where G1 and G2 represent temperature gradients in first and second conductors.

Hence, **KG = constant, i.e., temperature gradients are in the inverse ratio of thermal conductivities.**

(ii) Thermal resistance Rs of thermal resistors R1 and R2 in series is equal to the sum of the resistances of the component resistors, i.e., Rs =R1 +R2 and the current through the combination is given by:

H = (θ1 -θ2) /Rs

(iii) R1 = (d1/K1A) ; R2 = (d2/K2A) and Rs = (d1+d2)/(Ks A) As Rs =R1 +R2

therefore (d1+d2)/(Ks A) = (d1/K1A) + (d2/K2A) or **(d1+d2)/Ks  = (d1/K1) + (d2/K2)**

if d1 = d2 then **2/Ks  = 1/K1 + 1/K2 or Ks = 2K1K2/(K1 +K2)**

6. **Parallel combination of conductors:**

(i) Suppose two conductors each of thickness d but with areas of cross-section Al and A2 are connected in parallel to give a plate of thickness or length d and area of cross-section (A1 + A2).

Let the temperatures of the first and second faces be θ1 and θ2. The total heat current Hp is the sum of heat currents H1 and H2 in the first and second conductors respectively, i.e., Hp = H1 + H2 .

Now , H1 = K1A1(θ1 -θ2 )/dand H2 = K2A2(θ1 -θ2 )/dandHp = Kp(A1+A2 )(θ1 -θ2 )/d

as Hp = H1 + H2 therefore Kp(A1+A2 )(θ1 -θ2 )/d= K1A1(θ1 -θ2 )/d + K2A2(θ1 -θ2 )/d

or Kp(A1+A2 ) = K1A1 + K2A2 or **Kp = [K1A1 + K2A2] /(A1+A2 )**

**(ii) if A1 = A2 ; then Kp = [K1 + K2] /2**

7. **Growth of ice on lakes:**

(i) Water in a lake starts freezing if the atmospheric temperature drops below 00C. Let y be the thickness of ice layer in the lake at any instant t and atmospheric temperature is -θ0C. The temperature of water in contact with lower surface of ice will be zero. If A is the area of lake, heat escaping through ice in time *dt* is:

dQ1 = KA [ 0 – (-θ)]dt /y

Now, suppose the thickness of ice layer increases by *dy* in time *dt*, due to escaping of above heat. Then

dQ2 = mL = ρ(*dy* A)L

As dQ1= dQ2, hence, rate of growth of ice will be (*dy/dt*) = Kθ/ρL*y*



(ii) So, time taken by ice to grow a thickness y is,

(iii) It follows from the above equation that time taken to double, triple the thickness will be in the ratio of



and the time intervals to change the thickness from 0 to y from y to 2y and so on will be in the ratio



8. **Convection:**

(i) Convection requires a medium and is the process in which heat is transferred from one place to other by actual movement of heated substance (usually fluid).

(ii) The type of convection which results from difference in densities is called **natural convection** (for example, a fluid in a container heated through its bottom). However, if a heated fluid is forced to move by a blower, fan or pump, the process is called **forced convection**.

(iii) The rate of heat convection from an object is proportional to the temperature difference (∆θ) between the object and convective fluid and the area of contact A, i.e.,(*dQ/dt*)conv. = hA ∆θ where, h represents a constant of proportionality called **convection coefficient** and depends on the properties of fluid such as density, viscosity ,specific heat and thermal conductivity, etc.

(iv) **Some important points:**

(a) Natural convection takes place from bottom to top while forced convection in any direction.

(b) In case of natural convection, convection currents move warm air upwards and cool air downwards. This is why heating is done from base, while cooling from the top.

(c) Natural convection is not possible in a gravity free region such as a freely falling lift or an orbiting satellite.

(d) Natural convection plays an important role in ventilation, in changing climate and weather and in forming land and sea breezes and trade winds.

(e) The forced convection of blood in our body by a pump (heart) helps in keeping the temperature of body constant.

9. **Radiation:**

(i) The process through which heat is transferred directly from one body to another, without requiring any medium is called radiation. Heat from the sun reaches the earth by radiation.

(ii) **Radiation is the fastest mode of heat transfer from one place to another** as in this mode heat energy is propagated at speed of light.

(iii) **All the bodies radiate energy at all temperatures and at all times**. Radiation from a body can never be stopped but can be minimised.

(iv) Radiation does not affect the medium through which it passes

(v) Rough and dark (i.e., black) surfaces are god absorbers while shining and smooth surfaces are good reflectors of heat radiations.

(vi) **Glass and water vapours have the property of transmitting shorter wavelength heat radiations through them while reflecting longer ones.**

(vii) Heat radiations are invisible and like light, travel in straight lines, cast shadow, affect photographic plates and can be reflected by mirrors and refracted by lenses.

(viii) The spectrum of heat radiation is produced and studied with the help of rock salt prism.

10**. Black body:**

(i) A body which absorbs all the radiations incident on it is called a perfectly black body.

(ii) A perfectly black body maintained at a suitable temperature emits radiations of all wavelengths.

(iii) As a perfectly black body neither reflects nor transmits any radiation, it will always appear black whatever be the colour of the incident radiation.

11. **Absorptive power (a):**

(i) Absorptive power of a surface is defined as the ratio of the radiant energy absorbed by it in a given time to the total radiant energy incident on it in the same time.

(ii) For a perfectly black body, absorptive power is maximum and unity.

(iii) It has no units and dimensions.

(iv) Spectral absorptive power is defined as the ratio of the radiant energy of a given wavelength absorbed by a given surface in a given time to the total radiant energy of that wavelength incident in the same time on the same surface within a unit length range. It is represented by aλ and a = ∫ aλ dλ

12. **Emissive power (e):**

(i) For a given surface it is defined as the radiant energy emitted per sec per unit area of the surface.

(ii) If we consider emissive power of a surface for a particular wavelength instead of all wavelengths, it is called **spectral emissive power** and is represented by eλ and e = ∫ eλ dλ

(iii) Emissive power of a surface depends on its nature and temperature.

(iv) It has units W/m2. It is maximum for a perfectly black body and minimum for a smooth shining body.

13**. Kirchhoff’s law:**

(i) According to this law, the ratio of emissive power to absorptive power is same for all surfaces at the same temperature and is equal to the emissive power of a perfectly black body at that temperature.

(ii) If a and e represent absorptive and emissive power of a given surface while A and E for a perfectly black body, then e/a = E/A

(iii) For a perfectly black body, A =1, e/a = E . For a particular wavelength, eλ/aλ = Eλ .

**Since, Eλ is constant at a given temperature, hence according to this law, if a surface is a good absorber of a particular wavelength, it is also a good emitter of that wavelength.**

(iv) **Applications:**

(a) Sand is rough and black, so it is a good absorber and hence in deserts, days will be very hot. Now in accordance with Kirchhoff’s law, nights (when sand emits radiation) will be cold.

(b) When white light is passed through sodium vapours and the spectrum of transmitted light is seen, we find two dark lines in the yellow region. These dark lines are due to absorption of radiation by sodium vapours which it emits when heated.

(c) **Fraunhofer** lines are dark lines in the spectrum of the sun. When white light emitted from the central core of the sun (photosphere) passes through its atmosphere (chromosphere) radiations of those wavelengths will be absorbed by the gases present there which they usually emit (as a good emitter is a good absorber) resulting in dark lines in the spectrum of sun.

(d) ***A red piece of glass appears red as it reflects red and absorbs all other radiations incident on it. So, if a piece of red glass is heated to incandescence, it will reflect red end and will absorb all others. Hence, when seen in dark it will glow with emission of radiations, which it has absorbed, i.e., it will glow with emission of radiations complementary to red (or white deficient in red), i.e., cyan (or bluish).***

14. **Stefan's law:**

(i) According to it, the radiant energy emitted by a perfectly black body per unit area per sec (i.e., emissive power or radiancy or intensity of black body radiation) is directly proportional to the fourth power of its absolute temperature, i.e., **R α T4 or R = σT4**, where σ is called Stefan's constant having dimensions [MT-3θ-4] and value 5.67x10-8 W/m2K4

(ii) If a body is not a perfectly black body, then **R = eσT4**, where e is called **emissivity or relative emittance** and has value 0< e< I depending on the nature of surface. It has no units and dimensions.

15. **Cooling by radiation:**

Rate of cooling of a body at temperature T placed in an environment of temperature T0 (< T) is given by:



**When a body cools by radiation, the rate of cooling depends on:**

(a) nature of radiating surface as (dT/dt) α e, (b) area of radiating surface as (dT/dt) α A,

(c) mass of radiating body as (dT/dt) α 1/ m (d) specific heat of radiating body as (dT/dt) α 1/ c

(e)temperature of radiating body as (dT/dt) α (T4 - To4 ) (f)temperature of surroundings as (dT/dt) α (T4 - To4 )

16. **Newton's law of cooling:**

(i) According to Newton's law of cooling,

i.e., rate of cooling of a hot body is directly proportional to temperature difference between the body and its surroundings provided the temperature of the body is not very different from the surroundings.

(ii) If θ = θ0 ,then (dθ/dt)) = 0, i.e.. a body can never be cooled to a temperature lesser than its surroundings by radiation.

(iii) If a body cools by radiation from θ1 to θ2 0C in time t, then taking

(dθ/dt)) = (θ1 -θ2 )/tand θ = θav = (θ1 +θ2)/2 ; Newton’s law takes the form [(θ1 -θ2 )/t ] = K [(θ1 +θ2)/2 - θo]

(iv) Newton's law of cooling can be used to compare the specific heats of two liquids as: if equal masses of two liquids having same surface area and finish cool from same initial temperature θ1 to same final temperature θ2 with same temperature of surroundings, i.e.,θo, in time intervals t1 and t2 respectively,

t1/t2 = K2/K1 or c1/c2 = t1/t2 [ because K α 1/c ]

17. **Wien's displacement law:**

(i) The quantity of energy radiated out by a body is not uniformly distributed over all the wavelengths emitted by it. It is maximum for a particular wavelength (λ), which is different for different temperatures. As the temperature is increased, the value of the wavelength which carries maximum energy is decreased.

(ii) According to this law, wavelength corresponding to maximum energy is inversely proportional to the absolute temperature of the body, i.e., λm α 1/T or λm T = constant

**Thermodynamics -5**

1. **Thermodynamics:**

(i) The branch of Physics, which deals with the conversion of heat into other forms of energy, is known as **Thermodynamics.**

(ii) A system whose state is completely defined by the variables like Pressure (P), Volume (V), Temperature (T), Internal energy (U), is called a **thermodynamic system**.

(iii) The variables P, V , T, U whose knowledge specifies the state of a thermodynamical system, are called as **thermodynamic variables.**

(iv) All the variables P, V , T , U are not independent as relations, like PV = μRT ; U = 3RT/2, connecting these variables, exist.

(v) One can select pressure P and volume V as two independent thermodynamical variables. A knowledge of these two determines the **state** of a thermodynamical system because other variables can be worked out from the knowledge of P and V.

(vi) A P-V diagram for a system is called an **indicator diagram**. Each dot in a P-V diagram represents a possible state of the system.

(vii) A curve drawn between two points on the indicator diagram shows a **thermodynamic process**.

(viii) **The area under a curve on P'V diagram shows work done on or by the system**.

(ix) **Work done on or by a gas or system depends upon both the initial state, final state and the path adopted between these two states.**

(x) Like work done, heat exchanged by the system or a gas also depends upon both the initial state, the final state and the path.

(xi) Change in internal energy of a gas depends only upon the initial and the final state but not on the path. It is a **unique function** of the point on the indicator diagram.

2. **Different types of thermodynamical processes:**

(i) **Isobaric process:**

(a) It is a thermodynamic process in which pressure is kept constant.

(b) The equation of state for the process is: **(V /T) = constant.**

(c) ***In isobaric compression, temperature decreases and internal energy flows out in the form of heat energy, while in isobaric expansion, temperature increases and heat flows into the system.***

(d) The amount of heat energy ∆Q transferred is given by: ∆Q = μ Cp ∆T [ μ = number of moles ]

(e) In the figure 17.1, graphs I and II represent isobaric expansion and compression respectively.

(f) **The slope of the isobaric curve on a P-V diagram is zero.**

(g) Isobaric expansion of the volume of a gas is given by: Vt = Vo(l + γvt )

where γv = coefficient of volume expansion.



**(ii) Isochoric (Isometric) process:**

(a) It is a thermodynamic process in which the volume of the system is kept constant.

(b) The equation of state for the process is: **(P/T) = constant.**

(c) For increasing (decreasing) the pressure of a gas at constant volume, its temperature must be increased (decreased) by adding (taking out) heat energy into (from) the system.

(d) **For isochoric process: ∆Q = μ Cv ∆T**

(e) In the figure(17.2), graphs I and II represent isometric decrease in pressure at volume Vl and isometric increase in pressure at volume V2 respectively.

(f) **The slope of the isometric curve is infinite on a P-V diagram.**

(g) Isometric expansion of the pressure of a gas is given by: Pt = Po(l + γpt)

where γp = (1/273) per 0C= 0.0037 per 0C = coefficient of pressure expansion.

**(iii) Isothermal process:**

(a) It is a thermodynamical process in which the temperature of the system remains constant.

(b) The equation of state for the process is: **PV = constant.**

(c) During isothermal expansion of a gas, its volume increases while pressure decreases, while in isothermal compression, the volume decreases while pressure increases.

(d) The isothermal curve on P-V diagram is like a **hyperbola** and is shown in the figure (17.3).

(e) The slope of the isothermal curve at any point M is given by: dP/dV = -(P/V)

It is negative and is equal in magnitude to the ratio of P and V at that point.

(f) In an isothermal process, heat may go into or may come out of the system to maintain constant temperature.

**(iv) Adiabatic process:**

(a) It is a process in which heat exchanged by the system to or from the surroundings is zero, i.e., ∆Q =0.

(b) The equation of state for this process is: **PVγ = constt.** where γ is the ratio of specific heats of the gas.

(c) The adiabatic curve on the P-V diagram is shown in the figure(17.4). The slope of the curve at any point is given by: dP/dV = - γ (P/V)

**Slope of adiabatic curve is more in magnitude in comparison to the slope of the isothermal curve.**

(d) **When a gas expands from some initial volume to final volume**, then final pressure is less for adiabatic expansion. But, **when a gas compresses from some initial volume to a final volume**, then the final pressure is more in case of adiabatic compression.

(e) Equation of state for the adiabatic process can be any of the following three types:

(f) In adiabatic expansion, temperature decreases while in adiabatic compression, temperature increases.

(g) Isothermal and adiabatic bulk modulus of a gas are given by: **Biso = P ; Badia = γ P**

3. **Work done in thermodynamic processes** :-

(i) Work done implies flow of energy without a difference of temperature.

(ii) If there occurs an infinitesimal change in volume ∆V at a pressure P, work done ∆W is given by: ∆W=P ∆V.

(iii) Total work done in a process at constant pressure is: W = P(Vf -Vi).

Total work done in a variable pressure process in going from some initial state (Pi,Vi) to final state (Pf ,Vf) is:



This is equal to area under the curve on P-V diagram.

(iv) Work done by a gas during expansion is taken as positive (as ∆V is positive) while during compression it is taken as negative (as ∆V is negative).

**(v) Work done in various thermodynamic processes:**

**(a) Isobaric process: W = P(Vf -Vi).**

**(b) Isometric process: W =0 ( ∆V =0)**

****

**(c) Isothermal process:**



**(d) Adiabatic process:**

(e) **Cyclic process W** = area enclosed in the cycle.

- Work done is **positive** when the cycle is traced out in clockwise direction and work is **negative** when the cycle is traced out in anticlockwise direction.

**4.Heat added or removed from a thermodynamical system:**

(i) (a) When a system (like gas in a cylinder-piston arrangement) undergoes (I) isobaric expansion or (II) isothermal expansion or (III) isometric increase in pressure, then **heat must be added to the system**.

(b) Similarly, heat must be removed from the system when it undergoes (I) isobaric compression or (II) isothermal compression or (III) isometric reduction in pressure.

(ii) The amount of heat added or removed from μ moles of a gas is given by:

Q = μ Cv ∆T (for isometric process) and Q = μCp ∆T (for isobaric process).

(iii) The heat absorbed or liberated in a thermodynamic process depends on the path followed, i.e **Heat like work is dependent on path**

(iv) SI unit of heat is joule while practical unit is calorie [ 1calorie = 4.l860 joule ].

5**. Internal energy of a gas:**

(i) According to kinetic theory of gases, mean kinetic energy of a molecule is: (KE)mean =3KT/2. A gas contains a large number of molecules. The **internal energy** of a gas is equal to sum of the kinetic and potential energies of all the molecules of the gas.

(ii) In practice, we ignore potential energies of the molecules and neglect intermolecular forces. Thus, the total KE of all the molecules of the gas is equal to the internal energy of the gas. If there are N molecules in the gas, then U = N (3/2) KT ; (where K = Boltzmann's constant).

(iii) We may use, μ =N/NA , and R = NAK (where NA is Avogadro's number, μ = number of moles and R is universal gas constant). In that case, **U = μ (3/2) RT** . For one mole of an ideal gas, **U = (3/2) RT** .

(iv) For μ moles of gas, if the system (gas) undergoes a thermodynamic process in which temperature changes by ∆T, then the change in the internal energy is: **∆U = μ (3/2) R∆T**

(v) Internal energy is a parameter of the state only. If the temperature does not change, the internal energy does not change (for an ideal gas, U is a function of temperature only). **Thus, in an isothermal process, the internal energy remains constant.** Similarly, in **a cyclic process, the change in internal energy is zero**.

(vi) The internal energy changes in all those processes in which temperature changes, e.g., in isobaric expansion the temperature increases, so U increases.

6.**Zeroth law of thermodynamics:** When two bodies A and B are in thermal equilibrium with a third body C, then A as well as B are in thermal equilibrium mutually, i.e., if TA = Tc and TB = TC, then TA = TB.

7. **First law of thermodynamics:**

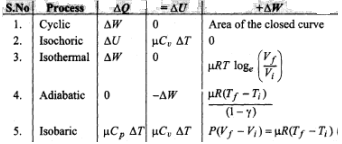
(i) First law of thermodynamics is equivalent to law of conservation of energy.

(ii) When heat energy is supplied to a gas, two things may occur:

(a) the internal energy of the gas may change.

(b) the gas may do external work by expanding.

(iii) According to this law if heat ∆Q is added to a system then it will show up either as a change in internal energy ∆U of the system and/or as work ∆W performed by the system, i.e.,



**∆Q = ∆U + ∆W**

**8. First law of thermodynamics applied to different processes:**

**9. Specific heats of a gas:**

(i) Gases have two specific heats:

(a) **Specific heat of a gas at constant volume (CV ):**It is the amount of heat that must be added to unit mass of a gas to increase its temperature by 10C or I K when the volume is kept constant.

If the amount of mass considered is one mole, then CV is called molar specific heat at constant volume. If we consider μ moles of a gas at constant volume, then dQ =μCV dT = dU (because dW = P dV =0)

(b) **Specific heat of a gas at constant pressure :(CP)** : It is the amount of heat that must be added to unit mass of gas to increase its temperature by 10C or I K when the pressure of gas is kept constant.

If the amount of mass considered is I mole, then Cp is called molar specific heat at constant pressure. If we consider μ moles of a gas at constant pressure, then dQ =μCp dT = dU +dW

**(ii) Mayer's relation between Cp and CV** :For one mole of a gas: **Cp - CV = R**

(iii) **Cp/CV = γ ;** where γ depends on atomicity of gas

(iv) Cp and CV in terms of γ and R: **CV = R /(γ-1) Cp = γCv = γR /(γ-1)**

(v) For any gas: **γ = 1 +2/f** where f represents the degrees of freedom

**10. Degrees of freedom(f):**

(i) The term degrees of freedom of a system refers to the possible independent motions a system can have. The independent motions can be translational rotational or vibrational or any combination of these.

(ii) (a) The molecules of a monoatomic gas (like He, Ar, etc.) possess only three translational degrees of freedom.

(b) The molecules of a diatomic gas (like H2, N2, 02, etc.) possess five degrees of freedom: 3 translational and 2 rotational. Further, in case of diatomic molecules, the atoms within the molecule may also vibrate with respect to each other. In such cases, the molecule will have an additional degree of freedom due to vibrational motion. An object which vibrates in one dimension has two additional degrees of freedom: one for the potential energy and one for the kinetic energy of vibration.

**This is the reason that a diatomic molecule that is free to vibrate will have 7 (=2 + 3 + 2) degrees of freedom.**

(c) A non-linear polyatomic molecule (such as CO2, H2O) can rotate about any of three coordinate axes. Hence, it has **6 degrees of freedom** (in the absence of a vibrational motion): 3 translational and 3 rotational.

(d) An atom in a solid though has no degree of freedom for translational and rotational motion, due to vibration along 3 axes has 3 x 2 = 6 degrees of freedom.

**ll. Law of equipartition of energy:**

(i) According to this law, the energy of a gas molecule is equally distributed among its various degrees of freedom and each degree of freedom is associated with energy ½KT where K is Boltzmann constant and T temperature of gas in kelvin.

(ii) According to equipartition theorem, the mean energy or average energy or internal energy of an ideal gas molecule (i.e., monoatomic gas) will be (3/2)KT as it has three degrees of freedom.

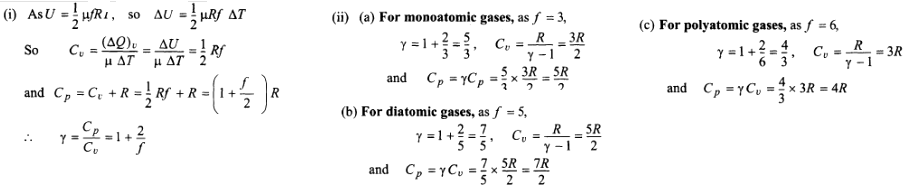
(iii) [n accordance with equipartition of energy, for diatomic and polyatomic gases, the average energy per molecule will be (5/2)KT and (6/2)KT respectively (as degrees of freedom for diatomic gas is 5 while for polyatomic gas is 6), i.e., at same temperature gases with different degrees of freedom (e.g.,He and H2) will have different average energy or internal energy [though all have same average translational kinetic energy equal to the average energy of an ideal gas molecule, i.e., (3/2)KT

(iv) Internal energy of μ moles of an ideal or **monoatomic** gas: Umono = μNA (3/2)KT = (3/2) μRT

In general, the internal energy of μ moles of a gas in which each molecule has *f* degrees of freedom will be:

U = (1/2) μ*f* RT e.g.,for diatomic gas, *f* =5 so U =(5/2)μ RT

**12. Relation between γ and *f* :**

**13. Second law of thermodynamics**

(i) **Kelvin's statement**: It is impossible for an engine operating in a cyclic process to extract heat from a reservoir and convert it completely into work, i.e., whole of heat can never be converted into work though whole of work can be converted into heat, i.e**., a perfect heat engine can never be constructed.**

**(ii) Clausius statement:** It is impossible for a self-acting machine unaided by any external agency to transfer heat from a cold to hot reservoir, i.e., **heat by itself cannot pass from a colder to hotter body.**

**14. Heat engine:**

(i) It is a device which converts heat into work continuously through a cyclic process.

(ii) Every heat engine basically consists of three parts:

(a) a hot body called source (b) a working substance (c) a cold body called sink

(iii) In a heat engine working substance absorbs heat from the source at a higher temperature TH, converts apart of it into useful work (motion of piston) and rejects the rest to the sink (usually atmosphere) at a lower temperature TL and comes back to its initial state.

(iv) Efficiency of a heat engine, η = work done / heat absorbed = W /Q1 = Q1 –Q2 /Q1 = 1 – Q2/Q1

(v) A perfect heat engine is one which converts all heat into work, i.e, W = Q1 so that Q2 = 0 and hence, for

it η=1.

**15. Refrigerator or heat pump:**

(i) A refrigerator or heat pump is basically a heat engine run in reverse direction. In it working substance takes heat Q2 from a body at a lower temperature TL, has a net amount of work done W on it by an external agent (usually compressor) and gives out a larger amount of heat Q1 (=Q2 + W )to a hot body at temperature TH (usually atmosphere).

(ii) A refrigerator or heat pump transfers heat from a cold to a hot body at the expense of mechanical energy supplied to it by an external agent. The working substance here is called refrigerant.

(iii) The coefficient of performance of a refrigerator is defined as:

COP β = heat extracted from the reservoir at low temperature TL / work done to transfer the heat

β = Q2/W = Q2 /(Q1 –Q2)

(iv) A perfect refrigerator is one which transfers heat from a cold to a hot body without doing any work, i.e.,W = 0 so that Ql = Q2 and hence for it β = ∞.

**16. Carnot heat engine:**

**(i) Engine:** It consists of four parts:

(a) A cylinder with perfectly insulating walls and a perfectly conducting base containing a perfect gas as working substance and fitted with an insulating frictionless piston;

(b) a source of infinite thermal capacity maintained at a constant higher temperature TH;

(c) a sink of infinite thermal capacity maintained at constant lower temperature TL, and

(d) a perfectly non-conducting stand for cylinder.

**(ii) Carnot cycle:** It consists of four operations in succession:

(a) isothermal expansion at higher temperature TH

(b) adiabatic expansion between temperatures TH and TL.

(c) isothermal compression at constant lower temperature TL and

(d) adiabatic compression between temperatures TL and TH

(iii) Efficiency of the engine: , η = 1 – Q2/Q1 = 1 – TL / TH

(a) η depends only on temperatures of source and sink and is independent of all other factors.

(b) All reversible heat engines working between same temperatures are equally efficient and no heat engine can be more efficient than Carnot engine.

(c) As on Kelvin scale, temperature can never be negative and TH and TL are finite, efficiency of a heat engine is always lesser than unity, i.e., whole of heat can never be converted into work which is in accordance with second law.

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dQ = μCp dT ; dU = μCV dT : dW = dQ - dU

**Home Assignment- Thermodynamics(Combined)**

1. Name some physical properties based on which thermometers can be designed ?
2. Explain the significance of absolute zero?
3. What do you mean by triple point of water and what are it’s values?
4. Write different relations between three scales of temperature?
5. On a day when the temperature reaches 50°F, what is the temperature in degrees Celsius and in Kelvin?
6. What is the reason of thermal expansion in solids ?
7. What do you mean by coefficient of linear expansion?
8. If you quickly plunge a room-temperature thermometer into very hot water, the mercury level will go down briefly before going up to a final reading. Why?
9. Draw density - temperature graph for water and explain the unusual behaviour of water?
10. Why does the cheese topping causes more burn than the pizza slice ,both at same temperature ?
11. Define Latent heat of fusion and vaporization?
12. What is first law of thermodynamics ? Write it’s expression also?
13. Derive an expression for the work done in Isothermal expansion of gas?
14. What is stefan’s law?
15. What do you mean by an ideal absorber and an ideal reflector?
16. Derive and state Newton’s law of cooling?
17. What do you mean by a heat engine?
18. Derive an expression for thermal efficiency of heat engine?
19. What is Kelvin Planck’s statement of second law of thermodynamics?
20. What do you mean by a Refrigerator and Heat Pump?
21. What is Clausius statement of second law of thermodynamics?
22. What is difference between Reversible And Irreversible Processes?
23. State Carnot’s theorem ?
24. Why does all real engines have to be less efficient than Carnot’s engine?
25. Derive an expression for thermal efficiency of carnot’s heat engine using P-V diagram?
26. Show that the efficiency of a heat engine operating in a Carnot cycle using an ideal gas is given by Equation ec = 1 – Tc/Th .
27. Determine the maximum work that the engine can perform in each cycle if it absorbs 200 J of energy from the hot reservoir during each cycle
28. Derive an expression for coefficient of performance (COP) of a heat pump or refrigerator?

Pardeep (Thermodynamics)

1. Define Quasi static process?
2. Write relation between P & T for an adiabatic process?
3. What are the slopes of isothermal and adiabatic curves?
4. Write expressions for work done in Isothermal and adiabatic processes?
5. Are the heat and work in thermodynamics state variables , Explain?
6. Derive an expression for Cv of a mixture of gases having n1 moles of gas of specific heat Cv1 and n2 moles of gas having specific heat Cv2 ?
7. Write an expression for CP of a mixture of gases having n1 moles of gas of specific heat CP1 and n2 moles of gas having specific heat CP2 ?
8. What are the limitations of first law of thermodynamics?
9. A sample of an ideal gas (γ=1.4) is heated at constant pressure. If an amount of 140J of heat is supplied to the gas, find (a) change in internal energy of the gas (b) work done by the gas
10. What is the relation between efficiency (η)of carnot engine and co-efficient of performance (β) for refrigerator?
11. Write Kelvin Planck and Clausius statement of second law of thermodynamics?
12. Carnot engine takes in a thousand kilo calories of heat from a reservoir at 6270c, and exhausts it to sink at 270c.How much work does it perform? What is the efficiency of the engine?
13. A certain gas at atmospheric pressure is compressed adiabatically so that its volume becomes half of its original volume. Calculate the resulting pressure in N/m2.Take γ=1.4
14. Calculate the fall in temperature of helium initially at 150c,when it is suddenly expanded 8 times its original volume (γ=1.4 )?
15. A gram molecule of a gas at 1270c expands isothermally until its volume is doubled. Find the amount of work done and heat absorbed?
16. The volume of steam produced by 1 gm of water at 1000c is 1650cm3.Calculate the change in internal energy during the change in state. Given J =4.2 erg/cal.,Latent heat of steam = 540 cal/gm ?
17. A Carnot engine intakes steam at 2000c and after doing work, exhausts it to a sink at 1000c.Calculate the percentage of heat which is utilised for doing work?
18. A Carnot engine whose heat sink is at 270c 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?
19. A refrigerator has to transfer an average of 263 J of heat per second from temperature -100c to 250c.Calculate the average power consumed, assuming no energy losses in the process?
20. Refrigerator A works between -100c and 270c,while refrigerator B works between -270c and 170c,both removing heat equal to 2000J from the freezer. Which of the two is better refrigerator?
21. Is the internal energy of a gas is a function of the pressure? Explain.
22. Can water be boiled without heating?
23. The temperature of the surface of sun is about 6000K.Can we produce a temperature of 7000K by converging sun’s rays using a large convex lens?
24. The volume of an ideal gas is V at a pressure P. On increasing the pressure by ∆P, the change in volume of gas is ∆V1 under isothermal conditions and ∆V2 under adiabatic conditions. Is ∆V1 >∆V2 or vice versa and why?

NCERT(CH-11)

1. Show that the coefficient of area expansions, (Δ*A/A*)/Δ*T*, of a rectangular sheet of the solid is twice its

linear expansivity, α.

1. Draw P-T phase diagram for water showing triple point ?
2. A pan filled with hot food cools from 94 °C to 86 °C in 2 minutes when the room temperature is at 20 °C. How long will it take to cool from 71 °C to 69 °C?
3. The triple points of neon and carbon dioxide are 24.57 K and 216.55 K respectively. Express these temperatures on the Celsius and Fahrenheit scales.
4. Two absolute scales *A* and *B* have triple points of water defined to be 200 A and 350 B. What is the relation between *T*A and *T*B ?
5. The coefficient of volume expansion of glycerine is 49 × 10–5 K–1. What is the fractional change in its density for a 30°C rise in temperature?
6. Explain why :
   1. a body with large reflectivity is a poor emitter
   2. a brass tumbler feels much colder than a wooden tray on a chilly day
   3. an optical pyrometer (for measuring high temperatures) calibrated for an ideal black body radiation gives too low a value for the temperature of a red hot iron piece in the open, but gives a correct value for the temperature when the same piece is in the furnace
   4. the earth without its atmosphere would be inhospitably cold
   5. heating systems based on circulation of steam are more efficient in warming a building than those based on circulation of hot water
7. A body cools from 80 °C to 50 °C in 5 minutes. Calculate the time it takes to cool from 60 °C to 30 °C. The temperature of the surroundings is 20 °C.

NCERT - CH12

1. A geyser heats water flowing at the rate of 3.0 litres per minute from 27 °C to 77 °C.If the geyser operates on a gas burner, what is the rate of consumption of the fuel if its heat of combustion is 4.0 × 104 J/g ?
2. Explain why
   1. Two bodies at different temperatures *T*1 and *T*2 if brought in thermal contact do not necessarily settle to the mean temperature (*T*1 + *T*2 )/2.
   2. The coolant in a chemical or a nuclear plant (i.e., the liquid used to prevent the different parts of a plant from getting too hot) should have high specific heat.
   3. Air pressure in a car tyre increases during driving.
   4. The climate of a harbour town is more temperate than that of a town in a desert at the same latitude.
3. Two cylinders *A* and *B* of equal capacity are connected to each other via a stopcock. *A* contains a gas at standard temperature and pressure. *B* is completely evacuated. The entire system is thermally insulated. The stopcock is suddenly opened. Answer the following :
   1. What is the final pressure of the gas in *A* and *B* ?
   2. What is the change in internal energy of the gas ?
   3. What is the change in the temperature of the gas ?
   4. Do the intermediate states of the system (before settling to the final equilibrium state) lie on its *P-V-T* surface ?
4. A steam engine delivers 5.4×108J of work per minute and services 3.6 × 109J of heat per minute from its boiler. What is the efficiency of the engine? How much heat is wasted per minute?
5. An electric heater supplies heat to a system at a rate of 100W. If system performs work at a rate of 75 joules per second. At what rate is the internal energy increasing?
6. A refrigerator is to maintain eatables kept inside at 90C. If room temperature is 360C,calculate the coefficient of performance.

Exemplar Ch-11

1. Is the bulb of a thermometer made of diathermic or adiabatic wall?
2. Why does a metal bar appear hotter than a wooden bar at the same temperature? Equivalently it also appears cooler than wooden bar if they are both colder than room temperature.
3. Calculate the temperature which has same numeral value on celsius and Fahrenheit scale.
4. These days people use steel utensils with copper bottom. This is supposed to be good for uniform heating of food. Explain this effect using the fact that copper is the better conductor.

Exemplar Ch-12

1. Can a system be heated and its temperature remains constant?
2. If a refrigerator’s door is kept open, will the room become cool or hot? Explain.
3. Is it possible to increase the temperature of a gas without adding heat to it? Explain.
4. Consider a Carnot’s cycle operating between *T*1 = 500K and *T*2=300K producing 1 k J of mechanical work per cycle. Find the heat transferred to the engine by the reservoirs.
5. If the co-efficient of performance of a refrigerator is 5 and operates at the room temperature (27°C), find the temperature inside the refrigerator.

**Objective Questions**

**Thermometry -1**

1. The temperature of the gas is a measure of:

(a) the average translational kinetic energy of the gas molecules

(b) the average potential energy of the gas molecules

(c) the average distance of the gas molecules (d) the size of the gas molecules

2. The correct value of 00 C on the Kelvin scale is : (a) 273.15 K (b) 273.16K (c) 273 K (d) 273.2K

3. Triple point temperature of water is: (a) 273.16K (b) 373.16K (c) 273 K (d) 273.15K

4. lf a thermometer reads freezing point of water as 200C and boiling point as l500C, how much thermometer read when the actual temperature is 600C? (a) 980C (b) 1100C (c) 400C (d) 600C

5. Oxygen boils at - 1830C This temperature is approximately: (a) 2150F (b) -2970F (c) 3290F (d) 3610F

6. The reading of centigrade thermometer coincides with that of Fahrenheit thermometer in a liquid. The temperature of the liquid is: (a) -400C (b) 00C (c) 1000C (d) 3000C

7. The Fahrenheit and Kelvin scales of temperature will give the same reading at:

(a) -40 (b) 313 (c) 574.25 (d) 732.75

8. The gas thermometers are thermometers because:

(a) gases expand much more than liquids (b) gases are easily obtained

(c) gases are much lighter (d) gases do not easily change their states

9.The temperature of a substance increases by 270C.On the Kelvin scale this increase is equal to:

(a) 300 K (b) 2.46K (c) 27 K (d)7K

10. A centigrade and a Fahrenheit thermometer are dipped in boiling water. The water temperature is lowered until the Fahrenheit thermometer registers 1400. What is the fall in temperature as registered by the centigrade thermometer? (a) 300 (b) 400 (c) 600 (d) 800

11. Mercury thermometers can be used to measure temperatures upto:

(a) 1000C (b) 2120C (c) 3600C (d) 5000C

12. Which of the following is the smallest temperature? (a) l0R (b) l0 C (c) l0F (d) l K

13. A thermometric liquid which can be used to measure temperature between -400C to 400C is:

(a) water (b) alcohol (c) mercury (d) phenol

14. The temperature at which the reading of a Fahrenheit thermometer will be double that of centigrade thermometer is: (a) 1600 (b) 1800 (c) 320 (d) 1000

15. Two thermometers, one calibrated in Celsius and the other in Fahrenheit scale, are used to measure the temperature of the same object. If the readings are in 0C and 0F, then

(a) C > F (b) F > C (c) C = F (d) F > C , F ≤ C

16. The temperature range measured by hydrogen gas thermometer is

(a) -2000C to 8000C (b) -2000C to 5000C (c) -2600C to 8000C (d) -2600C to 5000C

17. In a resistance thermometer the resistances at 00C and 1000C are 6.74 and7.74 ohm respectively. The temperature corresponding to 6.53 ohm resistance is: (a) 530C (b) 2l0C (c) -530C (d) -210C

18. Of the following thermometers the one which is most useful for the measurement of a rapidly varying temperature is a: (a) platinum resistance thermometer (b) gas thermometer

(c) thermoelectric thermometer (d) saturation vapour pressure thermometer

19. A thermometer is graduated in millimetres. It registers -3 mm when the bulb of thermometer is in pure melting ice and 22 mm when the thermometer is in steam at a pressure of I atmosphere. The temperature in 0C when the thermometer registers 13 mm is

(a) 13 *x* 100/25 (b) 16 *x* 100/25 (c) 13 *x* 100/22 (d) 16 *x* 100/22

20.The resistance of a resistance thermometer has values 2.71 and 3.70 ohm at l00C and 1000C. The temperature at which the resistance is 3.26 ohm is; (a) 400C (b) 500C (c) 600C (d) 700C

21. No other thermometer is as suitable as a platinum resistance thermometer to measure temperature in the entire range of: (a) 00C to 1000C (b) 1000C to 15000C (c) -500C to 3500C (d)-2000C to 6000C

22. The standard fixed point for temperature measurements in use today is:

(a) melting point of ice at one atmospheric pressure

(b) of pure ice and pure water in equilibrium at one atmosphere pressure

(c) at which ice, liquid, water and water vapour coexist (d) none of the above

23. A copper constantan thermocouple produces an emf of 40 microvolt per degree Celsius in the linear range of temperature. A galvanometer of resistance l0 ohm and capable of detecting a current of one microampere is employed. What is the smallest temperature that can be detected by this arrangement?

(a) 0.25 0C (b) 1.00 0C (c) 0.50 0C (d) 2.00 0C

24. In a thermocouple, one junction which is at 00C and the other at t0C, the emf is given by E =at2 -bt3, the neutral temperature (in 0C) is: (a) (a/b) (b) (2a/3b) (c) (3a/2b) (d) (b/2a)

25. At what temperature, the Fahrenheit and the Celsius scales will give numerically equal (but opposite in sign) values? (a) -400F & 400C (b) 11.430F & -11.430C (c) -11.430F & +11.430C (d) +400F & -400C

26. Mercury boils at 3670C. However, mercury thermometers are made such that they can measure temperature up to 5000C. This is done by:

(a) maintaining vacuum above mercury column in the stern of the thermometer

(b) filling nitrogen gas at high pressure above the mercury column

(c) filling nitrogen gas at low pressure above the mercury column

(d) filling oxygen gas at high pressure above the mercury column

27. A temperature degree on the Kelvin scale is the same as:

(a) a temperature degree on the Celsius scale (b) a temperature degree on Fahrenheit scale

(c) a temperature degree on Reaumur scale (d) none of the above

28. Two thermometers X and Y have ice points marked at 150C and 250C and steam points marked as 750C and 1250C respectively. When thermometer X measures the temperature of a bath as 600C on it, what would thermometer Y read when it is used to measure the temperature of the same bath?

(a) 60 0C (b) 75 0C (c) 100 0C (d) 90 0C

**Thermal Expansion -2**

29. Two bars of copper having same length but unequal diameter are heated to the same temperature. The change in length will be: (a) more in thinner bar (b) more in thicker bar

(c) same for both the bars (d) determined by the ratio of length and diameter of the bars

30. A beaker is completely filled with water at 40 C. It will overflow:

(a) when heated but not when cooled (b) when cooled but not when heated

(c) both when heated or cooled (d) neither when heated nor when cooled

31. When a metal rod is heated it expands because:

(a) the size of its atoms increases (b) the distance among its atoms increases

(c) atmospheric air rushes into it (d) the actual cause is still unknown

32. Expansion during heating: (a) occurs only in solids (b) increases the weight of a material

(c) decreases the density of a material (d) occurs at the same rate for all solids and liquids

33. Two rods of lengths L1 and L2 are made of materials whose coefficients of linear expansion are α1 and α2. If the difference between the two lengths is independent of temperature:

(a) (L1/L2) = ( α1 / α2 ) (b) (L1/L2) = ( α2 / α1 ) (c) (L1/L2)2 = ( α2 / α1 ) (d) (L1/L2) = ( α2 / α1 )2

34. When a strip made of iron (α1) and copper (α2 > α1 ) is heated:

(a) its length does not change (b) it gets twisted

(c) it bends with iron on concave side (d) it bends with iron on convex side

35. An iron tyre is to be fitted onto a wooden wheel 1.0 m in diameter. The diameter of the tyre is 6 mm smaller than that of wheel. The tyre should be heated so that its temperature increases by a minimum of: (coefficient of volume expansion of iron is 3. 6 x 10-5 / 0C)

(a) 1670C (b) 3340C (c) 5000C (d) 10000C

36.If the length of a cylinder on heating increases by 2%, the area of its base will increase by:

(a) 0.5% (b) 2% (c) 1% (d) 4%

37.When a copper ball is heated, the largest percentage increase will occur in its:

(a) diameter (b) area (c) volume (d) density

38. A rectangular block is heated from 00C to 1000C. The percentage increase in its length is 0.10%. What will be the percentage increase in its volume? (a) 0.03% (b) 0.1% (c) 0.3% (d) none of these

39. A vertical glass jar is filled with water at 100C. It has one thermometer at the top and another at the bottom. The central region of the jar is gradually cooled. It is found that the bottom thermometer reads 40C earlier than the top thermometer and the top thermometer reads O0C earlier than the bottom thermometer. This happens because: (a) the top thermometer is faulty (b) the bottom thermometer is faulty

(c) both the thermometers are faulty (d) water expands when cooled from 40C to 00C

40. A metallic ball has spherical cavity at its centre. If the ball is heated, what happens to the cavity?

(a) Its volume increases (b) Its volume decreases (c) Its volume remains unchanged

(d) Its volume may decrease or increase depending upon the nature of material

41. A thin copper wire of length L increases in length by l% when heated from 00C to 1000C. If a thin copper plate of area 2L *x* L is heated from 00C to l000C, the percentage increase in its area will be:

(a) 1% (b) 2% (c) 3% (d) 4%

42. Two spheres are made of same metal and have same mass. One is solid and the other is hollow. When heated to the same temperature, which of the following statements is correct about the percentage increase in their diameters? (a) It will be more for hollow sphere. (b) It will be more for solid sphere.

(c) It will be same for both spheres.

(d) It may be more or less depending upon the ratio of the diameters of the two spheres.

43. Coefficient of cubical expansion of water is -ve between 00C and :

(a) 40C (b) 100C (c) 15.5 0C (d) 1000C

44. The coefficient of linear expansion of crystal in one direction is α1 and that in every direction perpendicular to it α2. The coefficient of cubical expansion is:

(a) α1 + α2 (b) 2α1 + α2 (c) α1 + 2α2 (d) none of these

45. A liquid having coefficient of cubical expansion γ is filled in the container having coefficient of linear expansion α.If on heating the liquid overflows, then which of the following relations is correct?

(a) γ = 2α (b) γ < 3α (c) γ > 3α (d) 2γ = 3α

46. A glass flask of volume one litre at 00C is filled, level full of mercury at this temperature. The flask and mercury are now heated to l000C. How much mercury will spill out if coefficient of volume expansion of mercury is l.82 x l0-4 /0C and linear expansion of glass is 0.1 x l0-4 /0C respectively?

(a) 21.2 cc (b) 15.2 cc (c) 1.52 cc (d) 2.12 cc

47. A one litre glass flask contains some mercury. It is found that at different temperatures the volume of air inside the flask remains the same. What is the volume of mercury in this flask if coefficient of linear expansion of glass is 9 x l0-6 /0C while of volume expansion of mercury is l.82 x l0-4 /0C?

(a) 50 cc (b) 100 cc (c) 150 cc (d) 200 cc

48. A piece of metal weighs 45 g in air and 25 g in a liquid of density l.5 x 103 kgm-3 kept at 300C. When the temperature of the liquid is raised to 400C, the metal piece weighs 27 g. The density of liquid at 400C is 1.25 x 103 kg-m-3. The coefficient of linear expansion of metal is :

(a) l.3 x l0-3 /0C (b) 5.2 x l0-3/0C (c) 2.6 x l0-3 /0C (d) 0.26 x l0-3 /0C

49. A vertical column 50 cm long at 500C balances another column of same liquid 60 cm long at 1000C. The coefficient of absolute expansion of the liquid is: (a) 0.005 /0C (b) 0.0005/0C (c) 0.002 /0C (d) 0.0002 /0C

**Calorimetry -3**

50. Which of the following has the highest specific heat? (a) Water (b) Mercury (c) Kerosene (d) Copper

51. Which of the following has the highest specific heat? (a) Hydrogen (b) Water (c) Copper (d) Mercury

52. A liquid is being converted into vapours at its BP; the specific heat of liquid at this temperature will be:

(a) zero (b) infinite (c) positive (d) negative

53. Specific heat of a gas undergoing adiabatic change is:

(a) zero (b) infinite (c) positive (d) negative

54. 10 gm of ice at -200C is added to 10 gm of water at 500C.Specitic heat of water= 1cal/gm-0C, specific heat of ice = 0.5cal/gm-0C. Latent heat of ice : 80 cal/gm. Then, resulting temperature is

(a) -200C (b) 150C (c) 0 0C (d) 500C

55. In Q. 54, the amount of ice in the mixture at the resulting temperature is:

(a) l0 gm (b) 5gm (c) 0 gm (d) 20 gm

56. In Q. 54, the amount of water in the mixture at the resulting temperature is:

(a) l0 gm (b) 20gm (c) 15 gm (d) 0 gm

57. 5 gm of steam at 1000C is passed into 6 gm of ice at 00C. If the latent heats of steam and ice in cal per gm are 540 and 80 respectively. then the final temperature is: (a) 00C (b) 1000C (c) 50 0C (d) 300C

58.In Q. 57, the mixture contains:(a) 11 gm of water (b) 8 gm of water (c) 6 gm of water (d) 5 gm of water

59. Which of the following produces more severe burns?

(a) Boiling water (b) Steam (c) Hot air (d) Sun rays

60. A body cools from 910C to 890C in 5 minutes when the room temperature is 200C. Then, it will cool from 710C to 690C in: (a) 5 minute (b) 3 minute (c) 7 minute (d) 6 minute

61. 310 J of heat is required to raise the temperature of 2 mole of an ideal gas at constant pressure from 250C to 350C. The amount of heat required to raise the temperature of the gas through the same range at constant volume is : (a) 384 J (b) 144J (c) 276 J (d) 452 J

62. Three liquids with masses m1,m2,m3 are thoroughly mixed. If their specific heats are s1,s2,s3 and their temperatures θ1 , θ2, θ3 respectively, then the temperature of the mixture is:



63. Three liquids of equal volumes are thoroughly mixed. If their specific heats are s1,s2,s3 and their temperatures θ1 , θ2, θ3 and their densities d1 ,d2 ,d3 respectively, then the final temperature of the mixture is:



64. 80 gm of water at 300C is poured on a large block of ice at 00C The mass of ice that melts is:

(a) 30 gm (b) 80 gm (c) 150 gm (d) 1600 gm

65. 250 gm of water and equal volume of alcohol of mass 200 gm are replaced successively in the same calorimeter and cool from 600C to 550C in 130 seconds and 67 seconds respectively. If the water equivalent of the calorimeter is 10 gm, then the specific heat of alcohol (in ca/gm-0C) is:

(a) 1.30 (b) 0.67 (c) 0.62 (d) 0.985

66. The melting point of ice at 1 atmospheric pressure is 00C. Its melting point will be reduced to -l0C when the pressure of the surrounding is nearly (V1 =1.091cm3 , V2 =1cm3)where V1 & V2 are volume per unit mass for solid and liquid respectively:

(a) I atmosphere (b) 133 atmosphere (c) 273 atmosphere (d) 1000 atmosphere

67. The sprinkling of water reduces the temperature of a closed room because

(a) the temperature of water is less than that of the room (b) the specific heat of water is high

(c) water has large latent heat of vaporisation (d) water is a bad conductor of heat

68.A test tube containing water is placed in boiling water so that its mouth remains outside the boiling water. Choose the wrong statement.

(a) Water in the test tube will soon begin to boil. (b) Temperature of water inside the tube will rise.

(c) Convection currents will be set up in the water inside the tube.

(d) Volume of water inside the tube will increase.

69.What extinguishes a fire most quickly? (a) Cold water (b) Boiling water (c) Hot water (d) Ice

70. A 10 kg iron bar (specific heat 0.11 cal/gm-0c) at 800C is placed on a block of ice. How much ice melts

(a) 1.1 kg (b) 10 kg (c) 16 kg (d) 60 kg

71.One kg of ice at O0C is mixed with 1 kg of water at l00C .The resulting temperature will be:

(a) between O0C and 100C (b) greater than lO0C (c) lesser than O0C (d) equal to O0C

72. The ratio of radii of two spheres of same material is l: 4.Then, the ratio of their heat capacity will be:

(a) 1/64 (b) 1/32 (c) 1/2 (d) 1/4

73. On heating, the temperature at which water has minimum volume is:

(a) 00C (b) 40C (c) 4K (d) 1000C (e) -2730C

74. l0 gm of ice at -200C is dropped into a calorimeter containing 10 gm of water at l00C ; the specific heat of

water is twice that of ice. When equilibrium is reached, the calorimeter will contain:

(a) 20 gm of water (b) 20 gm of ice (c) l0 gm ice and 10 gm water (d) 5 gm ice and 15 gm water

75. Steam is passed into 54 gm of water at 300C till the temperature of mixture becomes 900C . If the latent heat of steam is 536 cal/gm, the mass of the mixture will be: (a) 80 gm (b) 60 gm (c) 50 gm (d) 24 gm

76. One gm of ice is mixed with one gm of steam. After thermal equilibrium is reached, the temperature of mixture is: (a) 1000C (b) 550C (c) 750C (d) 00C

77. Two spheres A and B have diameters in the ratio 1:2, densities in the ratio 2:1 and specific heats in the ratio 1: 3; find the ratio of their thermal capacities: (a) 1 :6 (b)l:12 (c) 1:3 (d) 1 :4

78.l0 litres of a liquid with specific heat 0.2 cal/gm-0C has the same thermal capacity as that of 20 litres of liquid with specific heat 0.3 cal/gm-0C, find the ratio of their densities (a) 3:1 (b)1:3 (c) 1:6 (d) 6:1

79. When 300 J of heat is added to 25 gm of sample of a material its temperature rises from 250C to 450C. The thermal capacity of the sample and specific heat of the material are respectively given by

(a) 15 J/0C,600 J/kg-0C (b) 600 J/0C,15 J/kg-0C (c) 150 J/0C,60 J/kg-0C (d) none of these

**Heat Transfer -4**

80. Three discs A,B and C having radii 2m, 4m and 6m are coated with carbon black on their outer surfaces The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm respectively. The power radiated by them are QA ,QB & QC respectively : (IIT -2004)

(a) QA is maximum (b) QB is maximum (c) QC is maximum (d) QA = QB = QC

81. If the temperature of a hot body is raised by 5%,then the heat energy radiated would increase by

(a) 5% (b) 10% (c) 11.65% (d) 21.55%

82. If the temperature of the sun is doubled, then:

(a) emission of energy will be doubled (b) emission of energy will become four times

(c) mostly ultraviolet radiation will be emitted (d) mostly infrared radiation will be emitted

83. A solid sphere and a hollow sphere of same material and size are heated to same temperature and allowed to cool in the same surroundings. If the temperature difference between each sphere and its surroundings is T, then: (a) the hollow sphere will cool at a faster rate for all values of T

(b) the solid sphere will cool at a faster rate for all values of T

(c) both spheres will cool at the same rate for all values of T

(d) both spheres will cool at the same rate only for small values of T

84. A thermos flask is polished well: (a) to make it attractive (b) for shining

(c) to absorb all radiations from outside (d) to reflect all radiations from outside

85.If a liquid is heated in weightlessness, the heat is transmitted through:(a) conduction

(b) convection (c) radiation (d) neither, because the liquid cannot be heated in weightlessness

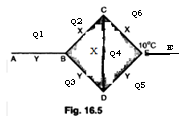
86.A bucket full of hot water is kept in a room and it cools from 750C to 700C in T1 minutes, from 700C to 650C in T2 minutes,& from 650C to 600C in T3 minutes. Then

(a) T1 = T2 =T3 (b) T1 < T2 < T3 (c) T1 > T2 > T3 (d) T1 < T2 >T3

87. One end of a copper rod of uniform cross-section and length 1.5 m is kept in contact with ice and the other end with water at 1000C. At what point along its length should a temperature of 2000C be maintained so that in the steady state, the mass of ice melting be equal to that of the steam produced in same interval of time. Assume that the whole system is insulated from surroundings. [Lice = 80cal/g, Lsteam = 540cal/g ]

(a) 10.34 cm (b) 10.34mm (c) 1.034 cm (d) 1.034 m

88. A room at 200C is heated by a heater of resistance 20 ohms connected to 200 V mains. The temperature is uniform throughout the room and heat is transmitted through a glass window of area 1 m2 and thickness 0.2 cm. Calculate the temperature outside. [K for glass is 0.2 cal/m- 0C -s and J =4.2 J/cal]

(a) 1.5240C (b) 15.240C (c) 200C (d) none of these

89. Three rods of material X and three rods of material Y are connected as shown in figure16.5. All are identical in length and cross-sectional area. If end A is maintained at 600C, end E at 100C, thermal conductivity of X is 0.92 cal/sec-cm- 0C and that of Y is 0.46 cal/sec-cm- 0C, then find the temperature of junctions B,C, D (a) 200C,300C, 200C (b)300C,200C, 200C

(c) 200C,200C, 300C (d) 200C,200C, 200C

90. A black body is at a temperature of 2800 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is U1, between 999 nm and 1000 nm is U2 and between 1499nm and 1500 nm is U3.The Wien's constant b=2.80 x 106 nmK. Then: (a) U1 =0 (b) U3 = 0 (c) U1>U2 (d) U2>U1

91. It is seen that in proper ventilation of a building, windows must be open near the bottom and the top of the walls so as to let pass: (a) in hot air near the roof and cool air out near the bottom

(b) out hot air near the roof (c) in cool air near the bottom and hot air out near the roof (d) in more air

92. A blue glass when heated will glow with (a) red colour (b) blue colour (c) white light (d) yellow colour

93. Following the laws of radiation, a cadmium salt when put into a bunsen flame gives red colour to the flame. If white light from a tungsten filament lamp is made to pass through a bulb containing cadmium vapours, the transmitted light will be: (a) red (b) blue (c) white (d) white light without red part

94. Two rods of equal length and diameter have thermal conductivities 3 and 4 units respectively. If they are joined in series, the thermal conductivity of the combination would be:

(a) 3.43 (b) 3.5 (c) 3.4 (d) 3.34

95. When the temperature of a black body increases, it is observed that the wavelength corresponding to maximum energy changes from 0.26 μm to 0.13 μm. The ratio of the emissive powers of the body at the respective temperatures is : (a) 16/1 (b) 4/1 (c) 1/4 (d) 1/16

96.The rate of emission of radiation of a black body at temperature 270C is E1 . If its temperature is increased to 3270C, the rate of emission of radiation is E2. The relation between El and E2 is:

(a) E2 = 24 E1 (b) E2 = 16 E1 (c) E2 = 8 E1 (d) E2 = 4 E1

97. One feels hotter at the top of a flame than the sides because of:

(a) conduction (b) convection (c) radiations (d) both (b) and (c)

98.Two identical rods with different thermal conductivities Kl and K2 and different temperatures are first placed along length and then along area, then the ratio of rates of heat flow in both cases is:

(a) 4K1K2/(K1+K2)2 (b) K1/K2 (c) (K1+K2)/(K1-K2) (d) none of these

99. Three rods of identical cross-sectional area and made from the same metal form the sides of an isosceles triangle ABC right angled at B(fig 16.8). The points ,A and B are maintained at temperatures T and √2 T ,respectively in the steady state. Assuming that only heat conduction takes place, temperature of point C will be:

(a) 3T/(√2 +1) (b) T/(√2 +1) (c) T/√3 (√2 +1) (d) T/(√2 -1)

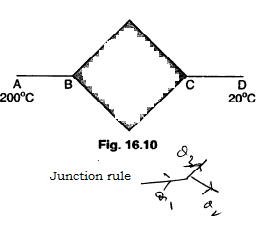
100. The temperature of a room heated by a heater is 200C when outside temperature is -200C and it is l00C when the outside temperature is -400C. The temperature of the heater is:

(a) 800C (b) 1000C (c)400C (d) 600C

101. Consider the two insulating sheets with thermal resistances. Rl and R2 as shown in fig 16.9.The temperature θ is :







102. Six identical conducting rods are joined as shown in fig(16.10) Points A and D are maintained at temperatures 2000C and 200C respectively. The temperature of junction B will be :

(a) 1200C (b) 1000C (c)1400C (d) 800C



103. Two ends of a conducting rod of varying cross-section are maintained at 2000C and 00C respectively(fig 16.11). In steady state:

(a) temperature differences across AB and, CD are equal

(b) temperature difference across AB is greater than that across CD

(c) temperature difference across AB is less than that across CD

(d) temperature difference may be equal or different depending upon thermal conductivity of the rod

104. Four spheres A,B,C and D of different metals but of same radius are kept at same temperature. The ratios of their densities and specific heats are 2:3:5:l and 3:6:2:4. Which sphere will show the fastest rate of cooling (initially)? (a) A (b) B (c) C (d) D

105 One end of a conducting rod is maintained at temperature 500C and at the other end ice is melting at 00C. The rate of melting of ice is doubled it

(a) the temperature is made 2000C and the area of cross-section of the rod is doubled

(b) the temperature is made 1000C and length of the rod is made four times

(c) area of cross-section of the rod is halved and length is doubled

(d) the temperature is made 1000C and area of cross-section of rod and length both are doubled

106. Which of the following statements is true about the radiation emitted by human body?

(a) The radiation is emitted only during the day (b) The radiation emitted is in the infrared region

(c) The radiation emitted lies in the ultraviolet region and hence is not visible

(d) The radiation is emitted during the summers and absorbed during the winters

107. The rate of dissipation of heat by a black body at temperature T is Q. What will be the rate of dissipation of heat by another body at temperature 2T and emissivity 0.25 .

(a) 16Q (b) 4Q (c) 8Q (d) 4.5Q

108. The radiation emitted by a star A is 10000 times that of the sun. If the surface temperatures of the sun and the star A are 6000 K and 2000 K respectively, the ratio of the radii of the star A and the sun is

(a) 300:1 (b) 600:1 (c) 900:1 (d) 1200:1

109. A planet radiates heat at a rate proportional to the fourth power of its surface temperature T. If such a steady temperature of the planet is due to an exactly equal amount of heat received from the sun then which of the following statement is true?

(a) The planet's surface temperature varies inversely as the distance of the sun.

(b) The planet's surface temperature varies directly as the square of its distance from the sun.

(c) The planet's surface temperature varies inversely as the square root of its distance from the sun.

(d) The planet's surface temperature is proportional to the fourth power of its distance from the sun.

110. The graph shown in the figure(16.13) represents energy density Eλ versus λ, for three sources sun, welding arc and tungsten filament. For λmax correct combination will be: (IIT 2005)

(a) 1-tungsten, 2-welding arc, 3-sun (b) 1-sun, 2-tungsten, 3-welding arc

(c) l-sun, 2-welding arc. 3-tungsten (d) l-welding arc, 2-sun, 3-tungsten

111. Assuming the sun to be a spherical body of radius R at a temperature of T K evaluate the total radiant power, incident on the earth, at a distance r from the sun, is:

(a) R2σT4/r2 (b) 4πro2R2σT4/r2 (c) πro2R2σT4/r2 (d) ro2R2σT4/4π r2

112. Three objects coloured black, grey and white can withstand hostile conditions upto 28000C. These objects are thrown into a furnace where each of then attains a temperature of 20000C. Which object will glow the brightest?

(a) The white object (b) The black object (c) All glow with equal brightness (d) Grey object



113. Calculate the surface temperature of the planet, if the energy radiated by unit area in unit time is 5.67 x l04 watt. (a) 12730C (b) 10000C (c)7270C (d) 727 K (e) 1273K

114. Two circular discs A and B with equal radii are blackened. They are heated to same temperature and are cooled under identical conditions. What inference do you draw from their cooling curves fig (16.14) ? (a) A & B have same specific heats

(b) Specific heat of A is less (c) Specific heat of B is less (d) Nothing can be said

115. Flash light equipped with a new set of batteries, produces bright white light. As the batteries wear out: (a) the light intensity gets reduced with no change in its colour

(b) light colour changes first to yellow and then red with no change in intensity

(c) it stops working suddenly while giving white light

(d) colour changes to red and also intensity gets reduced

116. Two bodies A and B having temperature 3270C and 4270C are radiating heat to the surrounding. The surrounding temperature is 270C. The ratio of rate of heat radiation of A to that of B is :

(a) 0.52 (b) 0.31 (c) 0.81 (d) 0.42

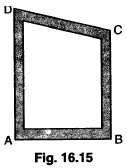
117. The surface temperature of the sun which has maximum energy emission at 500 nm is 6000 K. The temperature of a star which has maximum energy emission at 400 nm will be

(a) 8500K (b) 4500 K (c) 7500K (d) 6500 K

118. A body cools from 620C to 500C in 10 minutes and to 420C in the next l0 minutes. The temperature of the surrounding is: (a) 160C (b) 260C (c)360C (d) 210C (e) 310C

119. A black body emits radiations of maximum intensity for the wavelength of 5000 A when the temperature of the body is 12270C. If the temperature of the body is increased by 10000C, the maximum intensity would be observed at: (a) 1000 A (b) 2000A (c) 5000 A (d) 4000 A (e) 3000A

120. Temperatures of two stars are in ratio 3 : 2. If wavelength of maximum radiation from first body is 4000 A, what is corresponding wavelength of second body? (a) 9000 A (b) 6000 A (c) 2000 A (d) 8000 A

121. Water is enclosed in the glass tube ABCD and is warmed at A with a burner as shown in the figure16.15. Which one of the following is correct? The water:

(a) circulates in clockwise direction. (b) circulates in anticlockwise direction.

(c) circulates in both simultaneously (d) does not circulate at all.



122. The plots of intensity of radiation versus wavelength of three black bodies at temperatures T1, T2 and T3 are shown in fig (16.16). Then:(a) T3 > T2 >T1  (b) T1 > T2 >T3  (c) T2 > T3 >T1  (d) T1 > T3 >T2  (e) T3 > T1 >T2

**Thermodynamics -5**

123. In an isochoric change, there is no: (a) work done only (b) change in volume only

(c) change in volume and work done (d) change in pressure

124. The internal energy of an ideal gas depends on:

(a) pressure (b) volume (c) temperature (d) size of the molecule

125. Heat added to a system is equal to (a) a change in its internal kinetic energy

(b) a change in its internal potential energy (c) work done by it (d) sum of above all the three factors

126. In the condensation of a gas the mean KE (K )and potential energy (U) of molecules change; thus

(a) K decreases, U decreases (b) K increases, U keeps constant

(c) K keeps constant, U decreases (d) K decreases, U increases

127. When 110 J of heat is added to a gaseous system, internal energy increases by 40 J; the amount of work done is: (a) l50J (b) 70J (c) 110J (d)40J

128. A gas has: (a) one specific heat only (b) two specific heats only

(c) infinite number of specific heats (d) no specific heat

129. Mean kinetic energy per gram molecule for diatomic gas is:

(a) 3RT/2 (b) 4RT/2 (c) 5RT/2 (d)6RT/2

130. Molar specific heat at constant volume CV for monoatomic gas is:

(a) 3R /2 (b) 5R /2 (c) 6R /2 (d)4R /2

131. Cp > CV, as in the case- of Cp : (a) more heat is required to increase the internal energy

(b) heat is required to do work against external pressure also

(c) more heat is required to do external work

(d) more heat is required to do external work as well as for increase in internal energy

132. When heat is added to a system, which of the following is not possible :

(a) Internal energy of the system increases (b) Work is done by the system

(c) Neither internal energy increases nor work is done by the system

(d) Internal energy increases and also work is done by the system.

133. A sink ,that is a system where heat is rejected ,is essential for the conversion of heat into work. From which law the above interface follows(a) Zeroth (b) First (c) Second (d) Third

134. The efficiency of a Carnot heat engine:

(a) is independent of the temperature of the source and the sink

(b) is independent of the working substance (c) can be 100%

(d) is not affected by the thermal capacity of the source or the sink

135. An ideal heat engine working between temperatures TH and TL has efficiency η. If both the temperatures are raised by 100 K each, the new efficiency (η') of the heat engine will be:

(a) equal to η (b) greater than η (c) less than η

(d) greater or less than η depending upon the nature of the working substance

136. The efficiency of the reversible heat engine is ηR, and that of irreversible heat engine is ηI. Which ofthe following relations is correct? (a) ηR > ηI (b) ηR < ηI (c) ηR = ηI (d) ηR >1 and ηI <1

137. A reversible engine converts one-sixth of the heat input into work. When the temperature of the sink is reduced by 620C, the efficiency of the engine is doubled. The temperatures of the source and sink are:

(a) 990C,370C (b) 800C,370C (c) 950C,370C (d) 900C,370C

138. lf γ be the ratio of specific heats of a perfect gas, the number of degrees of freedom of a molecule of the gas is: (a) 25(γ -1)/2 (b) (3γ -1)/ (2γ -1) (c) 2/(γ -1) (d) 9(γ -1)/2

139. We consider a thermodynamic system. If ∆U represents the increase in its internal energy and W the work done by the system, which of the following statements is true?

(a) ∆U = -W is an isothermal process (b) ∆U = +W is an isothermal process

(c) ∆U = -W is an adiabatic process (d) ∆U = +W is an adiabatic process

140. If the ratio of specific heats of a gas at constant pressure to that at constant volume is γ, the change in internal energy of the given mass of gas, when the volume changes from V to 2V at constant pressure P is

(a) R/(γ -1) (b) PV (c) PV/(γ -1) (d) γ PV/(γ -1)

141. A Carnot engine uses first an ideal monoatomic gas (γ = 5/3) and then an ideal diatomic gas (γ = 7/5) as its working substance. The source and sink temperatures are 4110C and 690C respectively and the engine extracts 1000 J of heat from the source in each cycle. Then:

(a) the efficiencies of the engine in the two cases are in the ratio 21:25

(b) the area enclosed by the P-V diagram in the first case only is 500J

(c) The area enclosed by the P-V diagram in both the cases is 500J

(d) the heat energy rejected by the engine in the first case is 600J while in the second case is 714.3J

142. If R is the universal gas constant, the amount of heat needed to raise the temperature of 2 moles of an ideal mono atomic gas from 273 K to 373K when no work is done is: (a) 100R (b) 150R (c)300R (d) 500R

143. The temperatures of inside and outside of a refrigerator are 273 K and 303 K respectively. Assuming that the refrigerator cycle is reversible, for every joule of work done, the heat delivered to the surroundings will be nearly: (a) 10J (b) 20J (c) 30J (d) 50J

144. In a thermodynamic process, pressure of a fixed mass of a gas is changed in such a manner that the gas releases 20J of heat and 8J of work is done on the gas. If initial internal energy of the gas was 30 J, what will be the final internal energy? (a) 42J (b) 12J (c) 10J (d) 18J

145. An ideal gas is taken through a cyclic thermo dynamical process through four steps. The amounts of heat involved in these steps are Q1 = 5960 J , Q2 = -5585 J, Q3 = - 2980 J, Q4 = 3645 J respectively. The corresponding works involved are;W1=2200 J , W2= -825 J, W3= -1100 J and W4 respectively. The value of W4 is: (a) 1315 J (b) 275 J (c) 765 J (d) 675 J

146. 70 calories of heat are required to raise the temperature of 2 moles of an ideal gas at constant pressure from 300C to 350C . The amount of heat required to raise the temperature of the same gas through same range (300C to 350C) at constant volume is: (a) 30cal (b) 50 cal (c) 70 cal (d) 90 cal

147. A quantity of hat p is supplied to a mono atomic ideal gas which expands at constant pressure. The fraction of heat that goes into work done by the gas is: (a) 2/5 (b) 3/5 (c) 2/3 (d) 1

148. Four moles of hydrogen, two moles of helium and one mole of water vapour form an ideal gas mixture. What is the molar specific heat at constant pressure of mixture?

(a) 16R /7 (b) 7R /16 (c) R (d)23R /7

149. The pressure of a mono atomic gas increases linearly from 4 x 105 N/m2 to 8 x l05 N/m2 when its volume increases from 0.2 m3 to 0.5 m3. The work done by the gas and increase in internal energy are given by (a) 1.8 x l05J , 1.8 x l05J (b) 4.8 x l05J , 4.8 x l05J (c) 1.8 x l05J , 4.8 x l05J (d) 4.8 x l05J , 1.8 x l05J

150. The pressure of a mono atomic gas increases linearly from 4 x 105 N/m2 to 8 x l05 N/m2 when its volume increases from 0.2 m3 to 0.5 m3. amount of heat supplied and molar heat capacity of the gas are respectively given by: (a) 6.6 x l05 J , 6.6 x l05J (b) 17.14 J/mole-K , 17.14 J/mole-K

(c) 6.6 x l05J , 17.14 J/mole-K (d) 17.14 J/mole-K , 6.6 x l05J

151. A motor-car tyre has a pressure of 2 atmosphere at 270C.lt suddenly bursts. If (CP/CV =1.4) for air, find the resulting temperature(a) 27 K (b) 270C (c) -270C (d) 2460C

152. Find the amount of work done to increase the temperature of one mole of ideal gas by 300C, if it is expanding under the condition V α T2/3  (R= 8.31 J/mol-K) (a) 16.62 J (b) 166.2 J (c) 1662 J (d) 1.662 J

153. For an adiabatic expansion of a perfect gas, the value of ∆P/P is equal to:

(a) ∆V/V (b) γ∆V/V (c) - γ∆V/V (d)- γ2∆V/V

154. In an adiabatic expansion of a gas, the product of pressure and volume:

(a) increases (b) decreases (c) remains unchanged (d) changes erratically

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

(a) 40% (b) 60% (c) 66.67% (d) 33.37%

156. In an adiabatic change, the pressure P and temperature T of a diatomic gas are related by the relation P α TC, where C equals to: (a) 5/3 (b) 2/5 (c) 3/5 (d) 7/2

157. By opening the door of a refrigerator inside a closed room:

(a) you can cool the room to a certain degree (b) you can cool it to the temperature inside the refrigerator

(c) you ultimately warm the room slightly (d) you can neither cool nor warm the room

158.One mole of an ideal mono atomic gas is heated at a constant pressure of one atmosphere from 00C to 1000C. Then, the change in the internal energy is

(a) 6.56 J (b) 8.32x 102 J (c) l2.48 x l02 J (d) 20.80 x l02 J

159. One mole of an ideal mono atomic gas is heated at a constant pressure of one atmosphere from 00C to 1000C. the work done by the gas is: (a) 6.56 J (b) 8.32x 102 J (c) l2.48 x l02 J (d) 20.80 x l02 J

160. One mole of an ideal mono atomic gas is heated at a constant pressure of one atmosphere from 00C to 1000C. the heat taken from the source is: (a) 6.56 J (b) 8.32x 102 J (c) l2.48 x l02 J (d) 20.80 x l02 J

161. One mole of an ideal mono atomic gas is heated at a constant pressure of one atmosphere from 00C to 1000C. the change in the entropy of the gas is:

(a) 6.56 J/K (b) 8.32x 102 J/K (c) l2.48 x l02 J/K (d) 20.80 x l02 J/K

162. An engineer claims to have made an engine delivering l0 kW power with fuel consumption of I gm/sec. The calorific value of fuel is 2 kcal/gm. This claim is:

(a) valid (b) invalid (c) dependent on engine design (d) dependent on load

163. Suppose the distance between the atoms of a diatomic gas remains constant. Its specific heat at constant volume per gram mole is: (a) 5R /2 (b) 3R /2 (c) R (d)R/2

164. Temperature of argon kept in a vessel is raised by l0C at constant volume. Heat supplied to the gas may be taken partly as: (i) translational and partly (ii) rotational kinetic energies. Their respective shares are:

(a) 60% , 40% (b) 50% , 50% (c) 100% , zero (d) 40% , 60%

165. The first law of thermodynamics confirms the law of:

(a) conservation of momentum (b) conservation of energy

(c) flow of heat in a particular direction (d) separate conservation of heat energy and mechanical energy

166. The equation of state, corresponding to 8 kg of O2 is:

(a) PV = RT (b) PV = 8RT (c) PV =RT/2 (d) PV =RT/4

167. In an adiabatic process wherein pressure is increased by 2/3 % .If Cp/Cv =3/2 , then the volume decreases by about (a) 4/9 % (b) 2/3 % (c) 4% (d) 9/4 %

168. The isochoric modulus of elasticity is: (a) equal to isentropic modulus of elasticity

(b) equal to isothermal modulus of elasticity (c) zero (d) infinity

169. If the internal energy does not depend on the path, then the process is called:

(a) isothermal (b) adiabatic (c) both (a) and (b) (d) none of these

170. Isobaric modulus of elasticity is equal to: (a) isochoric modulus of elasticity

(b) isothermal modulus of elasticity (c) zero (d) infinite

171. If Q, E and W denote respectively the heat added, change in internal energy and the work done in a closed cycle process, then: (a) E=0 (b)Q = 0 (c) W = 0 (d) Q =W = 0

172. One mole of an ideal gas at an initial temperature of T K does 6R joules 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 (Tf ) of gas will be : (a) (T + 2.4)K (b) (T - 2.4)K (c) (T + 4)K (d) (T - 4)K

173. In the adiabatic compression, the decrease in volume is associated with:

(a) increase in temperature and decrease in pressure (b) decrease in temperature and increase in pressure

(c) decrease in temperature and decrease in pressure (d) increase in temperature and increase in pressure

174. Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300 K. The piston of ,A is free to move while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in ,A is 30 K, then the rise in temperature of the gas in B is:

(a) 30 K (b) 18 K (c) 50 K (d) 42K

175. Which of the following statements is correct for any thermodynamic system :

(a) The internal energy changes in all processes (b) Internal energy and entropy are state functions

(c) The change in entropy can never be zero (d) The work done in an adiabatic process is always zero

176. A gas under constant pressure of 4.5 x 105 Pa when subjected to 800 kJ of heat, changes the volume from 0.5 m3 to 2.0 m3. The change in internal energy of the gas is:

(a) 6.75 x l05J (b) 5.25 x l05J (c) 3.25 x l05J (d) 1.25 x l05J

177. If for hydrogen CP - CV =m and for nitrogen CP - CV = n, where CP and CV, refer to specific heats per unit mass respectively at constant pressure and constant volume, the relation between m and n is: (Molecular weight of hydrogen :2 and molecular weight of nitrogen: 14)

(a) n = l4m (b) n =7m (c) m = 7n (d) m = l4n

178. 5 moles of hydrogen(γ = 7/5 )initially at STP are compressed adiabatically so that its temperature becomes 4000C. The increase in the internal energy of the gas (in kilo-joules) is: (R = 8.30 J/mol-K)

(a) 21.55 (b) 41.50 (c) 65.55 (d) 80.55

179. A Carnot engine operates between 3270C and 270C.How much heat does it take from the 3270C reservoir for every 100 J of work done? (a) 100 J (b) 200 J (c) 300 J (d) 400 J

180. 1 mole of a gas having γ = 7/5 is mixed with 1 mole of a gas having γ = 4/3. What will be the γ for the mixture? (a) 5/11 (b) 15/13 (c) 15/11 (d) 5/13

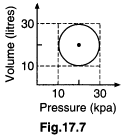
181. While boiling 1 gm of water at pressure l.0l3x l05 N/m3,its volume becomes l47l cm3 from 1 cm3 ; then work done by the system is: (a) 148.911 J (b) 150 J (c) 130.24 J (d) 120.57 J

182.A gas (γ = 1.3) is at a pressure 105 N/m2 in a vessel surrounded by non-conducting medium and having a non-conducting piston. The volume becomes half of its initial value by suddenly pressing the piston. Then, calculate the pressure afterwards:

(a) 20.7 x 105 N/m2 (b) 21.3 x 105 N/m2 (c) 21.4  x 105 N/m2 (d) none of these

183. The specific heats of argon at constant pressure and constant volume are 525J/kg and 315 J/kg respectively. Its density at NTP will be : (a) 1.77 kg/m3 (b) 0.77 kg/m3 (c) 1.77 g/m3 (d) 0.77 g/m3

184. In a cyclic process, work done by the system is: (a) zero (b) equal to heat given to the system

(c) more than the heat given to the system (d) independent of heat given to the system

185. The heat energy absorbed by a system in going through a cyclic process shown in figure17.7 is:(a) 103 π J (b) 102 π J (c) 104 π J (d) 107 π J

186. If 150 J of heat is added to a system and the work done by the system is 110 kJ, then change in internal energy will be: (a) 260 J (b) 150 J (c) 110 J (d) 40 J

187. A Carnot engine takes heat from a reservoir at 6270C and rejects heat to the sink at 270C.Its efficiency will be: (a) 3/5 (b) 1/3 (c) 2/3 (d) 200/209

188. An ideal gas expands isothermally from a volume V1 to V2 and, then compressed to original volume V1 adiabatically. Initial pressure is P1 and final pressure is P3 . The total work done is W. Then:

(a) P3 > P1 ,W > 0 (b) P3 < P1 ,W < 0 (c) P3 > P1 ,W < 0 (d) P3 = P1 ,W = 0

189. A reversible engine and an irreversible engine are operating between the same temperatures. The efficiency of: (a) both the engines will be 100% (b) reversible engine will be 100%

(c) reversible engine will be greater (d) irreversible engine will be greater

190. At 270C,a gas is suddenly compressed such that its pressure becomes 1/8 th of its original pressure. Temperature of the gas will be (γ =5/3) : (a) 420K (b) 3270C (c) 300K (d) - 1420C

191. An ideal gas expands in such a way that its pressure and volume comply with the condition: PV2= constant. During this process, the gas is:

(a) heated (b) cooled (c) first heated then cooled (d) neither heated nor cooled

192. If one mole of a mono atomic gas γ =5/3 is mixed with one mole of a diatomic gas γ =7/5, what is the value of γ for the mixture ? (a) 1.5 (b) 1.53 (c) 1.60 (d) 1.52



193. A thermodynamic system is taken through the cycle PQRSP process fig 17.9. The net work done by the system is: (a) 20 J (b) -20 J (c) 400 J (d) -374 J

194. Which of the following is not a thermodynamic co-ordinate?

(a) P (b) T (c) V (d) R

195. In an adiabatic change, the pressure P and temperature T of a mono atomic gas are related as P α TC, where C equals to: (a) 2/5 (b) 5/2 (c) 3/5 (d) 5/3

196. The latent heat of vaporisation of water is 2240 J. If the work done in the process of vaporisation of I gm is 168 J, then increase in internal energy is: (a) 2408 J (b) 2240 J (c) 2072 J (d) 1904 J

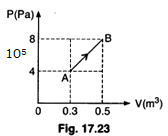
197. An ideal gas after going through a series of four thermodynamic states in order, reaches the initial state

again (cyclic process). The amounts of heat (Q) and work (W) involved in the states are, Q1 =6000J; Q2 = -5500J ; Q3 = -3000J; Q4 = 3500J ; Wl =2500J; W2 =-1000J; W3 =-1200J; W4 = *X* J The ratio of net work done by the gas to the total heat absorbed by the gas in η. The value of *X* and η are nearly.

(a) 500 J ; 7.5% (b) 700J ;10.5% (c) 1000 J ;21% (d) 1500 J; 15%

198. The change in the entropy of a 1 mole of an ideal gas which went through an isothermal process from an initial state (P1 ,V1,T1 ) to the final state (P2 ,V2,T2 )is equal to :

(a) zero (b)R log T (c) R log (V1/V2) (c) R log (V2/V1)

199. The temperature of the system decreases in the process of: (a) free expansion (b) adiabatic expansion (c) isothermal expansion (d) isothermal compression

200. An ideal gas expands along the path AB as shown in the P-V diagram(17.23) . The work done is: (a) 4 J (b) l.2 J (c) 2.4 J (d) none of the above

201.An ideal heat engine works between temperatures T1 = 500K and T2 = 375K. If the engine absorbs 600 J of heat from the source, then the amount of heat released to the sink is : (a) 450 J (b) 600 J (c) 45 J (d) 500J

202. A gas is suddenly expanded such that its final volume becomes 3 times its initial volume. If the specific heat at constant volume of the gas is 2R, then the ratio of initial to final pressure is nearly equal to

(a) 5 (b) 6.5 (c) 7 (d) 3.5

203. Two mole of oxygen is mixed with eight mole of helium. The effective specific heat of the mixture at constant volume is: (a) 1.3R (b) 1.4R (c) 1.7 R (d) 1.9 R (e) 1.2 R

204.A closed gas cylinder is divided into two parts by a piston held tight. The pressure and volume of gas in two parts respectively are ( P, 5V) and (10P,V ).If now the piston is left free and the system undergoes isothermal process, then the volume of the gas in two parts respectively are:

(a) 2V , 4V (b) 3V , 3V (c) 5V , V (d) 4V , 2V (e) 2.5 V , 3.5V

205. A Carnot engine with sink temperature at l70C has 50% efficiency. By how much should its source temperature be changed to increase its efficiency to 60%?

(a) 225 K (b) 1280C (c) 580 K (d) 145 K (e) 1450C

206. During an adiabatic process, the cube of the pressure is found to be inversely proportional to the fourth power of the volume. Then, the ratio of specific heats is : (a) 1 (b) 1.33 (c) 1.67 (d) 1.4

207. A Carnot's engine operates with source at 1270C and sink at 270C.If the source supplies 40 kJ of heat energy, the work done by the engine is: (a) 30 kJ (b) l0 kJ (c) 4 kJ (d) 1 kJ

208. A Carnot engine, having an efficiency of η =1/10 as heat engine, is used as a refrigerator. If the work done on the system is l0 J, the amount of energy absorbed from the reservoir at lower temperature is:

(a) 100 J (b) 99 J (c) 90 J (d) 1 J

209. If CP and CV denote the specific heat of nitrogen per unit mass at constant pressure and constant volume respectively, then:(a) CP - CV =28R (b) CP - CV =R/28 (c) CP - CV = R/l4 (d) CP - CV =R

210. For a heat engine sink temperature is 280 K and its efficiency is 50%. What will be the temperature of source? (a) 327 K (b) 560 K (c) 283 K (d) 227 K

211. Which of the following parameters does not characterise the thermodynamic state of matter?

(a) Temperature (b) Pressure (c) Work (d) Volume

212. In the P-V diagram (fig 17.29), I is the initial state and F is the final state. The gas goes from I to F by (i) IAF, (ii) IBF, (iii) ICF . The heat absorbed by the gas is:

(a) the same in all three processes (b) the same in (i) and (ii)

(c) greater in (i) than in (ii) (d) the same in (i) and (iii) (e) greater in (iii) than in (ii)

213. An ideal mono atomic gas is taken through the thermodynamic states A—B—C-- D via the paths shown in the figure(17.30). If UA,UB,UC and UD represents the internal energy of the gas in state A,B,C and D respectively, then which of the following is not true? (a) UA = UD (b) UB < UA (c) UB = UC (d) UC > UD

214. A box (thermally insulated) has two chambers separated by a membrane- One of volume V contains an ideal gas at temperature T, The other of volume V/2 is evacuated. If the membrane breaks down, the gas temperature will be:

(a) 3T/2 (b) 2T/3 (c) T (d) none of these

215. A refrigerator with coefficient of performance 1/3 releases 200J of heat to a hot reservoir, then the work done on the working substance is: (a) 100/3 J (b) 100 J (c) 200/3 J (d) 150 J (e) 50 J

216. One mole of an ideal gas having initial volume V, pressure 2P and temperature T undergoes a cyclic process ABCDA as shown in figure(17.31): The net work done in the complete cycle is

(a) zero (b) ½RTlog2 (c) RTlog2 (d) 3/2 RTlog2

217. When two moles of oxygen is heated from 00C to 100C at constant volume, its internal energy changes by 420 J. What is the molar specific heat of oxygen at constant volume?

(a) 5.75 J K-l mol-l (b) 10.5 JK-l mol-l (c) 21 JK-l mol-l (d) 42JK-lmol-l

218. A diatomic ideal gas is used in a car engine as the working substance. If during the adiabatic expansion part of the cycle, volume of the gas increases from V to 32 V, the efficiency of the engine is:

(a) 0.5 (b) 0.75 (c) 0.99 (d) 0.25

219. A Carnot engine used first an ideal mono atomic gas and then an ideal diatomic gas. If the source and sink temperature are 41l0C and 690C respectively and the engine extracts 1000 J of heat in each cycle, then area enclosed by PV diagram is : (a) 100 J (b) 300 J (c) 500 J (d) 700 J

220. When a system(fig 17.32) 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) 6 cal (b) 16 cal (c) 66 cal (d) 14 cal

221. During the adiabatic expansion of two moles of a gas the internal energy of a gas is found to decrease by 2 joule. The work done during the process on gas will be equal to: (a) -2 J (b) 3 J (c) 1 J (d) 2 J

222. The latent heat of vaporization of water is 2240 J. If the work done in the process of vaporization of I g is 168 J, then increase in internal energy is: (a) 1940 J (b) 2072J (c) 2240 J (d) 2408 J

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223. Given diagram(17.33) shows an ideal gas taken from state 1 to 2 through optional paths, A,B,C .Let Q,W and U represent the heat supplied to, the work done by, and the internal energy of the gas, respectively. Then which of the following conditions is true?

(a) QA <QB <QC  (b) WA >WB >WC

(c) U1 –U2 = QA - WA (d) QA - WA < QB - WB <QC - WC

224. 5.6 L of helium gas at STP is adiabatically compressed to 0.7 L. Taking the initial temperature to be Tl, the work done in the process is:

(a) - 9RT1/8 (b) 3RT1/2 (c) 15RT1/8 (d) 9RT1/2

225. 100 g of water is heated from 300C to 500C. Ignoring the slight expansion of the water, the change in its internal energy is :(specific heat of water is 4184 J/kg-K) (a) 4.2kJ (b) 8.4 kJ (c) 84 kJ (d) 2.1 kJ

226. A Carnot engine operating between temperatures Tl and T2 has efficiency 1/6 .When T2 is lowered by 62K, its efficiency increases to 1/3. Then T1 and T2 are ,respectively:

(a) 372 K and 310 K (b) 372 K and 330 K (c) 330 K and 268K (d) 310 K and 248K

227. A thermally insulated vessel contains an ideal gas of molecular mass M andratio of specific heats y. It is moving with speed u and is suddenly brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by :

228. A Carnot engine whose efficiency is 40%, receives heat at 500 K. If the efficiency is to be 50%,the source temperature for the same exhaust temperature is: (a) 900 K (b) 600 K (c)700 K (d) 800 K (e) 550 K

229. The ratio of the molar heat capacities of a diatomic gas at constant pressure to that at constant volume is: (a) 7/2 (b) 3/2 (c) 3/5 (d) 7/5 (e) 5/2

230.The thermodynamic process in which no work is done on or by the gas is: (a) isothermal process

(b) adiabatic process (c) cyclic process (d) isobaric process (e) isochoric process

231 If the amount of heat given to a system is 35 J and the amount of work done on the system is l5 J, then the change in internal energy of the system is: (a) - 50 J (b) 20 J (c) 30 J (d) 50J (e) -20J

232. An ideal gas is compressed isothermally until its pressure is doubled and then allowed to expand adiabatically to regain its original volume ( γ =1.4 and 2 1.4 = 0.38). The ratio of the final to initial pressure is:

(a) 0.76 : 1 (b)1 : 1 (c) 0.66 : 1 (d) 0.86 : 1

**ANSWERS OBJECTIVE (THERMAL PROPERTIES AND THERMODYNAMICS)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1. A | 1. A | 1. A | 1. A | 1. B | 1. A |
| 1. C | 1. A | 1. C | 1. B | 1. C | 1. C |
| 1. B | 1. A | 1. D | 1. B | 1. D | 1. C |
| 1. B | 1. C | 1. D | 1. C | 1. A | 1. B |
| 1. B | 1. B | 1. A | 1. C | 1. C | 1. C |
| 1. B | 1. C | 1. B | 1. C | 1. C | 1. D |
| 1. C | 1. C | 1. D | 1. A | 1. B | 1. C |
| 1. A | 1. C | 1. C | 1. B | 1. C | 1. C |
| 1. A | 1. A | 1. A | 1. B | 1. A | 1. C |
| 1. B | 1. C | 1. B | 1. B | 1. B | 1. C |
| 1. B | 1. B | 1. B | 1. A | 1. C | 1. B |
| 1. C | 1. A | 1. B | 1. A | 1. D | 1. A |
| 1. B | 1. C | 1. B | 1. A | 1. B | 1. A |
| 1. A | 1. B | 1. D | 1. C | 1. C | 1. D |
| 1. A | 1. B | 1. A | 1. B | 1. B | 1. D |
| 1. C | 1. D | 1. D | 1. A | 1. D | 1. B |
| 1. D | 1. A | 1. A | 1. D | 1. D | 1. C |
| 1. C | 1. B | 1. D | 1. B | 1. B | 1. C |
| 1. C | 1. A | 1. C | 1. B | 1. C | 1. B |
| 1. D | 1. A | 1. C | 1. B | 1. E | 1. B |
| 1. D | 1. D | 1. C | 1. C | 1. D | 1. C |
| 1. B | 1. C | 1. C | 1. A | 1. B | 1. C |
| 1. C | 1. B | 1. C | 1. A | 1. A | 1. C |
| 1. C | 1. C | 1. C | 1. C | 1. A | 1. D |
| 1. C | 1. B | 1. A | 1. D | 1. C | 1. C |
| 1. C | 1. B | 1. C | 1. B | 1. B | 1. D |
| 1. C | 1. C | 1. B | 1. D | 1. A | 1. B |
| 1. A | 1. C | 1. B | 1. D | 1. A | 1. D |
| 1. C | 1. C | 1. A | 1. D | 1. D | 1. D |
| 1. B | 1. D | 1. D | 1. B | 1. B | 1. C |
| 1. A | 1. B | 1. A | 1. B | 1. B | 1. D |
| 1. C | 1. C | 1. C | 1. D | 1. B | 1. A |
| 1. B | 1. D | 1. B | 1. C | 1. B | 1. D |
| 1. B | 1. B | 1. A | 1. A | 1. C | 1. A |
| 1. D | 1. B | 1. B | 1. C | 1. B | 1. B |
| 1. C | 1. C | 1. B | 1. C | 1. D | 1. C |
| 1. C | 1. B | 1. C | 1. A | 1. A | 1. B |
| 1. B | 1. A | 1. B | 1. A | 1. D | 1. B |
| 1. D | 1. E | 1. D | 1. A |  |  |

**Explanations Objective Questions- Thermal Properties and Thermodynamics**

