Heat and Thermodynamics

March 30, 2020

1 Heat and Thermodynamics - Class 11

1.1 Long Questions

1. Define linear expansion, superficial expansion and cubical expansion. Derive the expression for them.
2. Define linear expansivity and superficial expansivity. Derive the relation between them.
3. Define linear expansivity and cubical expansivity. Derive the relation between them.
4. Describe the Pullinger's experiment to determine the linear expansivity of a metallic rod.
5. Define real expansivity and apparent expansivity. Derive the relation between them.
6. Describe the Dulong and Petit's experiment to determine the cubical expansivity of a liquid.
7. State and deduce the expression of Newton's law of cooling.
8. Define water equivalent of a substance. Describe the experiment to determine the specific heat capacity a solid by the method of mixture.
9. Using Newton's law of cooling, explain the experiment to find the specific capacity of a liquid by the method of cooling.
10. Define latent heat of fusion of ice. Describe the experiment to determine the latent heat of fusion of ice by the method of mixture.
11. Describe the experiment to determine the latent heat of evaporation of water by the method of mixture.
12. State and explain (a) Boyle's law and (b) Charle's law.
13. Derive the expression of ideal gas equation.
14. What are the postulates of kinetic theory of gases? Derive the pressure exerted by the gas on a cube.
15. Derive an expression for average kinetic energy per molecule of of an ideal gas.
16. Show that rms speed of the gas molecules is directly proportional to the square root of temperature.
17. Derive the gas laws from kinetic theory of gases.
18. Derive an expression for the rms speed of gas molecules.
19. What is triple point? Show that triple point is single for a substance.
20. On what factors, conduction of heat depends? Derive the expression for rate of heat flow through a conductor. Also define temperature gradient.
21. Explain the Searl's method of determination of thermal conductivity of a conductor.
22. What is black body? State and explain Stefan's law of black body radiation. Also derive the expression for the stefan's Boltzmann law.
23. Differentiate between the molar heat capacities at constant pressure and at constant volume. Show that $C_p - C_v = R$.
24. State isothermal equation . Derive the expression for isothermal work done for the ideal gas.

25. State and derive adiabatic equations.
26. Derive an expression for adiabatic work done.
27. State Kelvin-Planck and Clausius's statement of the second law of thermodynamics.
28. Explain the working principle of Carnot's engine. Deduce its efficiency.
29. Explain the working principle of Petrol engine with PV diagram. Deduce its efficiency.
30. Explain the working principle of Diesel engine with PV diagram.

1.2 Numericals

1.2.1 Thermometry and Thermal expansion

1. Find the temperature when the Fahrenheit scale reading is exactly equal to the Celsius scale. (Ans -40)

2. A rod made by Zinc has length 1 m at 0^0C. Find the length of the same rod at 50^0C. Linear expansivity of Zinc = $26 \times 10^{-6} K^{-1}$(Ans: 1.0013 m)

3. The cross section of a steel rod is 10 cm^2 at 10^0 C. What is the final cross section of the rod when it is heated to 50^0C. Linear expansivity of steel =$12 \times 10^{-6} K^{-1}$. (Ans: 10.0096 cm^2)

4. Volume of a cube made of brass at 15^0C is 50^0C. Calculate the increase in volume of this cube at 65^0C. Linear expansivity of brass = $19 \times 10^{-6} K^{-1}$. (Ans: 0.143 cm^3)

5. What should be the initial lengths of steel and copper rods so that the length of steel rod is 5 cm larger than the copper rod at all temperature? Linear expansivity of copper = $17 \times 10^{-6} K^{-1}$, linear expansivity of steel = $11 \times 10^{-6} K^{-1}$ (Ans: 14.17 cm, 9.17 cm)

6. Difference between two rods made of steel and brass at 0^0C is 20 cm. When they are heated, it is found that their difference in length is same at all tenperatures. Find their length at 0^0C. linear expansivity of steel = $12 \times 10^{-6} K^{-1}$, linear expansivity of brass = $19 \times 10^{-6} K^{-1}$ (Ans: 34.3 cm)

7. A piece of glass weighs 25 gm in air, 16.77 gm in water at 4^0C and 16.89 gm in water at 60^0C. Find the mean coefficient of cubical expansion of water between 4^0C and 60^0C, taking the linear expansivity of glass = $8 \times 10^{-6} K^{-1}$. [0.00029 K^{-1}]

8. A glass vessel contains when full 544 grams of mercury at 0^0C. The mass of mercury which fills it at 100^0C is 535.45 gm. Calculate the cubical expansivity of glass. [Cubical expansivity of mercury = $1.8 \times 10^{-4} K^{-1}$] [Ans: 0.00002 K^{-1}]

9. How much mercury must be placed inside the glass vessel of capacity 500cc, so that the volume of the space unoccupied by mercury always remains constant? [Cubical expansivity of mercury = $1.8 \times 10^{-4}\ {}^0C^{-1}$ and linear expansivity of glass = $9 \times 10^{-6}\ {}^0C^{-1}$] [Ans: 75cc]

10. A glass flask of volume 400 cm^3 is just filled with mercury at 0^0C. How much mercury overflows when the temperature of the system is raised to 80^0C? The coefficient of cubical expansion of glass and mercury are $1.2 \times 10^{-5}/{}^0C$ and $18 \times 10^{-5}/{}^0C$. [HSEB]

11. The height of mercury column in a barometer when measured by a brass scale at 18^0C is observed to be 760 mm. (a) If the scale is correct at 0^0C, find the true height of the column at 18^0C. (b) the corrected height of the barometer. [Linear expansivity of brass = $1.9 \times 10^{-5}/{}^0C$ and cubical expansivity of the mercury = $1.8 \times 10^{-4}/{}^0C$] [Ans: a. 760.26 mm b. 757.8 mm]

12. An Aluminium rod when measured with a steel scale, both being at 25^0C appears to be 1m long. If the scale is correct at 0^0C, what will be the length of the rod at 0^0C? [α for steel = $12 \times 10^{-6} K^{-1}$ and α for Aluminium = $26 \times 10^{-6} K^{-1}$] [Ans: 99.96 cm]

13. A bottle is filled with 250 cc of benzene at 30^0C. If the bottle is cooled to 0^0C, how much air space will there be above the bottle? Neglect the expansion of the bottle. [Cubical expansivity for benzene is $12.4 \times 10^{-4}/^0C$] [Ans: 9cc]

14. The length of an Iron rod is measured by a brass scale. When both of them are at 10^0C, the measured length is 50 cm. What is the length of the rod at 40^0C when measured by the same scale at 40^0C? [Ans: 49.988cm] [Linear expansiivities for brass and iron are respectively $24 \times 10^{-6}/^0C$ and $16 \times 10^{-6}/^0C$.]

15. A clock which has brass pendulum beats seconds correctly when the temperature of the room is 30^0C. How many seconds will it gain or lose per day when the temperature of the room falls to 10^0C? [α for brass = $1.9 \times 10^{-5} K^{-1}$] [Ans: 16.416 sec]

16. A steel wire 8 m long and 4 mm in diameter is fixed to two rigid supports. Calculate the increase in tension when the temperature falls 10^0C. [linear expansivity of steel = $12 \times 10^{-6} K^{-1}$, young's modulus for steel = $2 \times 10^{11} Nm^{-2}$] [Ans: 301.6 N]

17. A piece of steel floats in mercury at 0^0C with 57.35 % of its volume submerged. What percentage of its volume will be submerged when the temperature is raised through 50^0C? Relative densities of steel and mercury are 7.8 and 13.6 respectively] [Linear expansivity of steel = $12 \times 10^{-6} K^{-1}$ and cubical expansivity of mercury = $1.8 \times 10^{-4} K^{-1}$] Ans: 57.76%

1.2.2 Calorimetry and Change of phase

1. How much heat does 100gm of copper give off as it cools from 95°C to 25°C?(specific heat capacity of copper = 0.094cal/gm°C) (Ans: 658cals)

2. Aluminium can of mass 500gm contains 117.5gm of water at temperature of 20°C. A 200 gm block of iron at 75°C is dropped into the can; find the final temperature, assuming no heat loss of to the surrounding. (sp. heat capacity of aluminium = 910J/kgK, sp. heat capacity of iron=470J/kgK) (Ans: 25°C)

3. A ball of copper (specific heat capacity=$400 Jkg^{-1}K^{-1}$) weighing 400gm is transferred from a furnace to 1 kg of water at 20°C. The temperature of water rise to 50°C. What is the original temperature of the ball?(sp. heat capacity of water =$4.2 \times 10^3 J/kgK$) (Ans: 837.5°C)

4. How much heat is required to change 10kg of ice at -10°C to steam at 100°C.[Latent heat of fusion of ice =80cals/gm, Latent heat of water at 100°C=540cals/gm, Specific heat of water =1cals/gmK, Specific heat of ice=0.5cals/gmK] (Ans: 7250 Kcals)

5. Determine the amount of heat required to convert 1kg of ice at-10°C to steam at 100°C.[$L_i = 3.36 \times 10^5 Jkg^{-1}$, $L_v = 2.26 \times 10^6 Jkg^{-1}$, $S_i = 2100 Jkg^{-1}K^{-1}$, $S_w = 4200 Jkg^{-1}K^{-1}$] (Ans: $30.37 \times 10^5 J$)

6. 25gm of water at 100°C is mixed with 25gm of ice at 0°C, Find the resulting temperature. (Ans: 10°C)

7. What is the result of mixing 20gm of water at 90°C with 10gm of ice at -10°C? (sp. heat of ice =0.5, latent heat of fusion of ice =80cal/gm) (Ans: 31.7°C)

8. 2.7gm of ice at 0°C is added to 60gm of water contained in a copper calorimeter weighing 56gm. If the temperature of the calorimeter with its contents changed from 20°C to 16°C, Find the sp. latent heat of fusion of ice. (Sp. heat of copper=0.094cal/gm°C)

9. 10 gm of ice at -20^0C is mixed with 10 gm of water at 40^0C. Calculate the final temperature of the mixture. (sp. heat of ice =0.5, latent heat of fusion of ice =80cal/gm, Latent heat of evaporation of water = 540 cal/gm) (Ans: 0°C, can not melt)

10. What is the result of mixing 100 gm of ice at 0^0C and 100 gm of water at 100^0C? (latent heat of fusion of ice = $3.36 \times 10^5 J/kg$, specific heat of water = $4200 J/kg^0$C) (Ans: 10°C)

11. How much steam must be passed into a mixture of ice and water in order to melt 10 gm of ice? [Ans: 1.25gm]

12. Find the result of mixing 5 gm of water at 30^0C and 5 gm of ice at -20^0C. [Ans: 3.75gm of ice and 6.25 gm of water both at 0^0C]

13. Calculate how much steam from water boiling at 100^0C will just melt 50 gm of wax at 20^0C. [MP of wax = 55^0C, specific heat of wax = 0.7 $calgm^{-1}\,{}^0C^{-1}$, specific latent heat of fusion of wax = 35 cal/gm] [Ans: 5.1 gm]

14. 0.02 kg of ice and 0.1 kg of water at 0^0C are in a container. Steam at 100^0C is passed in until all the ice is just melted. How much water is now in the container? [Specific latent heat of steam = $2.3 \times 10^6 Jkg^{-1}$, Specific latent heat of fusion of ice = $3.4 \times 10^5 Jkg^{-1}$ and specific heat capacity of water = $4.2 \times 10^3 Jkg^{-1}K^{-1}$] [Ans: 0.1225 kg]

15. What is the result of mixing 100 gm of ice at 0^0C into 100 gm of water at 20^0C in an iron vessel of mass 100 gm? Sp. heat of iron = 0.1 cal/g^0C

16. A piece of metal weighing 50 gm and specific heat capacity 0.11 cal/gm^0C is heated to 100^0C. The metal is dropped to a calorimeter containing 60 gm of liquid. The temperature of the calorimeter with its content change from 23.5^0C to 30^0C. If the water equivalent of the calorimeter is 10 gm, calculate the specific heat capacity of the liquid. [0.8 cal/gm^0C]

17. A metal of mass 0.1 kg at 100^0C is dropped into 0.08 kg of water at 20^0C contained in a calorimeter of of mass 0.12 kg and specific heat capacity 400 J/kgK. The temperature of the calorimeter and its content rose to 30^0C. Compute the specific heat capacity of the metal. [Ans: 548.6 J/kgK]

18. At the bottom of a sea where the temperature is 7^0C the pressure is 5.6 atmospheres. An air bubble of diameter 1 cm at the bottom rises to the surface, where the temperature is 27^0C. What is the diameter of the bubble at the surface? [Hint: Use $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$] [1.817 cm]

19. 50 gm of water and an equal volume of kerosene (density 0.8 g/cc) are placed one after another in the same calorimeter of water equivalent 10 gm. They are found to cool from 55^0C to 50^0C in 8 mins and 4.5 mins respectively. What is the sp. heat of kerosene?

1.2.3 Expansion of gases

1. A cylinder contains 150 c.c. of gas at a pressure 750 mm of Hg and temperature 10^0C. Calculate the volume of gas at STP. (Ans: 143 c.c.)

2. Two vessels of capacity 1 litre are connected by a tube of negligible volume. Together they contain 3.42×10^{-4} kg of Helium at a pressure of 800 mm of Hg and temperature 27^0C.

Calculate (a) value of ‘r’ for Helium (b) the pressure developed in the apparatus if one vessel is cooled to 0^0C and other heated to 100^0C, neglecting thermal expansion of the vessel. [Ans: (a) 2078 $Jkg^{-1}K^{-1}$ (b) 841 mm of Hg]

3. Taking the molar gas constant R = 8.31 J mol -1 K-1, estimate the molar volume of the gas at STP.
4. The pressure in the Helium gas cylinder is initially 30 atm. After blowing up many balloons, the pressure has decreased to 6 atm. What fraction of the original gas remains in the cylinder? Assume the temperature remains constant. [1/5]
5. A vessel of 5 ltrs capacity contains air at STP. The vessel is heated to 100^0C with its valve closed. What will be the new pressure? What fraction of mass of air will escape if the valve was opened to the atmosphere? [1038.4 mm, 0.27]
6. 14 gm of Nitrogen, 32 gm of Oxygen and 2 gm of Hydrogen are placed in an enclosure of volume $1m^3$. Calculate the pressure exerted by the mixture at 27^0C. [R = $8.31Jmol^{-1}K^-1$] [Ans: 6232.4 N/m^2]
7. Helium gas with volume 2.60L under a pressure 1.30 atm and temperature of 41.0^0C is warmed until both pressure and volume is doubled (a) what is the final temperature (b) How many gram of helium are there? The molar mass of helium is 4.00 gm/mol) (Ans: 983^0 C, 0.52 gm)
8. An ideal gas, initially at temperature of 300 K is heated until both pressure and volume are doubled. What is the final temperature of the gas?
9. Two bulbs of equal volume are joined by a narrow tube and are filled with a gas at STP when one bulb is kept in melting ice and the other is placed in a hot bath, the new pressure is 877.6 mm of Hg. Calculate the temperature of the bath. [Hint: Use, $PV = mrT$, find masses and use conservation of mass] [Ans: 100^0C]
10. A cylinder of gas has a mass of 10 kg and a pressure of 8 atm at 27^0C. When some gas is used in a cold room at -3^0C, the gas remaining in the cylinder at this temperature has a pressure of 6.4 atm. Calculate the mass of the gas used. [HSEB] [Hint; Use, $PV = mrT$, pressures are different, but volumes are same] [Ans: 1.1 kg]
11. Use the ideal gas law to estimate the number of air molecules in your physics lab room of size $20ft \times 20ft \times 10ft$, assuming all the air is Nitrogen at temperature 20^0C and pressure 1 atm. Also calculate the particle density in the lab (the number of molecules per cm).
12. A vessel contains a mixture of 8 g of oxygen and 7 g of nitrogen at temperature 270C. If the pressure of the mixture is 1 atmosphere, calculate its density. [R=$8.31Jmol^{-1}K^{-1}$] [Ans: $1.22kgm^{-3}$] [Hint: Use partial pressure rule]
13. What volume of liquid oxygen (density $1140kgm^{-3}$) may be made by liquefying completely the contents of a cylinder of gaseous oxygen containing 100 liters of oxygen at 120 atmospheres pressure and 20^0C? Assume that oxygen behaves as an ideal gas in this later region of pressure and temperature. [1atm = $1.01 \times 10^5 Nm^{-2}$, molar gas constant = $8.31Jmol^{-1}K^{-1}$, relative molecular mass of oxygen = 32.0][Ans: $0.014m^3$] [Hint: Use, $PV = mrT$ to find mass and use it to find volume, Use r=R/M; M=molecular mass]

1.2.4 Kinetic Theory of Gases

1. Calculate the rms speed and average KE of a molecule of Oxygen gas at 300 K. [Mass of oxygen molecule = $32 \times 1.66 \times 10^{-27} kg$, R = $8.31 Jmol^{-1}K^{-1}$ and $N_A = 6 \times 10^{23} mol^{-1}$.] [$6.23 \times 10^{-21} J$]

2. Calculate the rms speed of thermal agitation of the molecules of helium at 30^0C. [Density of Helium at STP is $0.1785 kgm^{-3}$] [Ans: 1372.6 m/s]

3. Assuming that Nitrogen molecules have a rms speed of $900 ms^{-1}$ at 27^0C and $10^5 Nm^{-2}$ pressure, calculate the rms speed at i) 127^0C and $10^5 Nm^{-2}$ pressure ii) 27^0C and $2 \times 10^5 Nm^{-2}$. [$1039 ms^{-1}$ and $900 ms^{-1}$]

4. By what factor will the rms speed of a particular gas molecule increase if the temperature is increased from 100^0C to 200^0C? [1.126]

5. Air at STP contains 2.7×10^{25} molecules per cubic meter. How many molecules per cubic meter will there be at a place where the temperature is -182^0C and pressure $3.03 \times 10^5 Nm^{-2}$. [24.3×10^{25}]

6. One mole of Hydrogen gas and one mole of Nitrogen gas are in adjacent containers at the same temperature T and pressure P. If the rms speed of Hydrogen molecule is 1850 m/s, what would be the rms speed of the nitrogen? [494.4 m/s]

7. Assuming the density of oxygen at STP to be $1.251 kgm^{-3}$, find the rms speed of oxygen molecules at 127^0C. [597 m/s]

8. Calculate the total translational KE of 5 moles of an ideal gas at 127^0C. [2.49×10^4J]

9. What is the average KE of the molecules of a gas (a) at 0^0C and (b) 100^0C (R = 8.31 $Jmol^{-1}K^{-1}$, $N_A = 6.02 \times 10^{23} mol^{-1}$) [$565 \times 10^{-23}$ J and $771 \times 10^{-23} J$]

10. Helium gas occupies a volume of $0.08 m^3$ at a pressure of $10^5 Nm^{-2}$ and temperature 27^0C. Calculate (i) the mass of Helium (ii) the rms speed of its molecules (iii) the rms speed at 327^0C (iv) the rms speed of Hydrogen at 27^0C and 327^0C. [Relative molecular mass of helium and hydrogen are 4 and 2 respectively, R = $8.3 Jmol^{-1}K^{-1}$] [Ans: (i) 12.85 gm, (ii) 1366.6 m/s,(iii) 1932.6m/s, (iv) 1932.6m/s, 2733.1 m/s]

1.2.5 Transfer of Heat

1. Estimate the rate at which the ice would melt in a wooden box 2.5 cm thick of inside measurement $100cm \times 60cm \times 40cm$ assuming that the external temperature is 35^0C and thermal conductivity of wood $0.169 Wm^{-1}K^{-1}$. [Ans: $1.736 \times 10^{-3} kgs^{-1}$]. Also find rate of heat lost by conduction through wood.

2. Assuming that the thermal insulation provided by a woolen glove is equivalent to a layer of air 3 mm thick, determine the heat loss per minute from a man's hand, surface area $200 cm^2$ on a winter day when the air temperature is -3^0C. The skin temperature is 34^0C and the thermal conductivity of air as $24 \times 10^{-3} Wm^{-1}K^{-1}$. [Ans: 355.2 $Jmin^{-1}$]

3. A copper rod 50 cm long and of diameter 4cm is covered with insulating materials. One of its end is maintained at 100^0C and other end is places in a vessel containing ice at 0^0C. It is found that 87.8 gm of ice is melted in 5 minutes. Calculate the thermal conductivity of copper. [0.93 $cal/sec\ cm^0$C]

4. A sheet of rubber and a sheet of cardboard, each 2mm thick, are pressed together and their outer faces are maintained respectively at 0^0C and 30^0C, if the thermal conductivity of rubber and cardboard are respectively 0.13 and 0.05 $Wm^{-1}K^{-1}$, find the quantity of heat which flows in one hour across a piece of the composite sheet of area $100cm^2$? [43884 Joules]

5. The element of an electric fire, with an output of 1KW, is a cylinder 25 cm long and 1.5 cm diameter. Calculate its temperature when in use if it behaves as a perfect black body. [Stefen's constant = $5.7 \times 10^{-8} Wm^{-2}K^{-4}$] [Ans: 1104.67K]

6. A filament of an electric lamp can be considered as a 90 % black body radiator. Calculate the energy per second radiated when its temperature is 2000 K if its surface area is $10^{-6}m^2$. [Stefen's constant = $5.7 \times 10^{-8} Wm^{-2}K^{-4}$] [Ans: 0.82 W]

7. The sun is a black body of surface temperature about 6000K. If the sun's radius is $7 \times 10^8 m$, calculate the energy per sec radiated from its surface. The earth is about 1.5×10^{11} m from the sun. Assuming all the radiation from the sun falls on a sphere of this radius, estimate the energy per second per unit area received by the earth (solar constant). [Stefen's constant = $5.7 \times 10^{-8} Wm^{-2}K^{-4}$] [Ans: 1609 Wm^{-2}]

8. Each square cm of the sun's surface radiates energy at the rate of $6.3 \times 10^3 Js^{-1}cm^{-2}$ and the Stefen's constant is $5.7 \times 10^{-8} Wm^{-2}K^{-4}$. Calculate the temperature of the sun's surface. [Ans: 5766K]

9. What is the ratio of the energy per second radiated by the filament of a lamp at 2500 K to that radiated at 2000 K assuming that the filament is a black body radiator. [Ans: 2.44]

10. A metal sphere of 1 cm diameter, whose surface acts as a black body is placed at the focus of a concave mirror with aperture of diameter 60 cm directed towards the sun. If the solar radiation falling normally on the earth is at the rate of $0.14 Wcm^{-2}$. Stefen's constant = $5.7 \times 10^{-8} Wm^{-2}K^{-4}$ and the mean temperature of the surrounding is 27^0C, calculate the maximum temperature which the sphere could attain. [Ans: 2140.69 K]

11. A metal sphere with a black surface and diameter 3 cm is cooled to 73^0C and placed inside an enclosure at a temperature of 127^0C. Calculate the initial rate of rise of temperature of the sphere assuming it to be a black body. [Ans: 0.073 Ks^{-1}] Density of metal = 7500 kgm^{-3} Specific heat of metal = 500 $Jkg^{-1}K^{-1}$ Stefen's constant () = $5.7 \times 10^{-8} Wm^{-2}K^{-4}$

1.2.6 First Law of Thermodynamics

1. 1 cc of water becomes 1671 cc of steam when boiled at a pressure of 1atm. The heat of vaporization at this temperature is 540 cal/g. Compute the external work done and increase in internal energy.

2. For Hydrogen, the molar heat capacities at constant volume and constant pressure are 20.5 and 28.8 $Jmol^{-1}K^{-1}$. Calculate: (i) The heat needed to raise the temperature of 8 gm of H from 10^0C to 15^0C at constant pressure. (ii) The increase in internal energy of the gas (iii) the external work done. [molar mass of hydrogen gas = 2 gm]

3. A gas initially at 27^0C and 760 mm of Hg pressure is compressed isothermally until its volume is halved. It is then expanded adiabatically until its original volume is recorded. Assuming the change to be reversible, find the final temperature and pressure. [γ for air =1.4] [Ans: 227.4K and 568.4mm]

4. In a cylinder, 2 mol of an ideal monoatomic gas initially at 106 Pa and 300 K expands until its volume doubles. Compute the work done if the expansion is, (i) Isothermal (ii) Adiabatic. [= 1.67 and R = 8.31 $Jmol^{-1}K^{-1}$]

5. The density of a gas is 1.775 kgm^{-3} at 27^{0}C and 10^5 Nm^{-2} pressure and its c_p is 846 $Jkg^{-1}K^{-1}$. Find the ratio of c_p and c_v.

6. If the ratio of the principal sp. heat capacities of a certain gas is 1.4 and its density at STP is 0.09 kgm^{-3}. Calculate c_p and c_v [Standard atmospheric pressure is 1.01 × 105 N m-2]

1.2.7 Second Law of Thermodynamics

1. A Carnot engine absorbs 2000 J of heat energy from a reservoir at 127^{0}C and rejects 1000 J of heat energy during each cycle. Calculate (i) efficiency of the engine (ii) temperature of the sink and (iii) amount of useful work done per cycle. [200K, 50%, 1000J]

2. A petrol engine consumes 5 kg of petrol per hour. If the power of the engine is 20 KW and the calorific value of petrol is 11 × 10^3 Kcal per Kg. Calculate the efficiency of the engine. [31.2%] [HSEB]

3. A Carnot engine whose low temperature reservoir is at 280 K has an efficiency of 40%. It is desired to increase this to 50%. By how many degrees must the temperature of the low temperature reservoir be decreased if that of the high temperature reservoir remains constant? [46.7K]

4. An engine with an output of 200 W has an efficiency of 30%. It works at 10cycles/sec. How much heat is absorbed and rejected in each cycle? [66.7 J, 46.7 J]

5. In a petrol engine the rate of production of heat due to combustion of fuel is 7.46x105 Cal/hr. If the efficiency of the engine is 30%, calculate the horse power of the engine. [1cal=4.2J and 1 HP = 740 W] [Ans: 0.35 HP]

1.2.8 Hygrometry

1. On a certain day the air temperature is 17.7^{0}C and the dew point is 5.3^{0}C. Find the relative humidity. [SVP at 5^0, 6^0, 17^0 and 18^0 are 0.654cm, 0.705cm, 1.442cm and 1.546cm respectively] [Ans: 44.18%]

2. On a certain day the relative humidity is 66.67%. The SVP at room temperature is 16.8 mm. Calculate the SVP at dew point. [11.2 mm]

3. Find the mass of water vapour per cubic meter of air at temperature 300 K and relative humidity 50%. The saturated vapour pressure at 300 K is 3600 Pa and R = 8.3 $Jmol^{-1}K^{-1}$. [Ans: 26 grams]