NCERT solutions for class 11 physics chapter 11 thermal properties of matter exercise

Q. 11.1 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.

Answer:

The relation between Kelvin and Celcius scale is $T_K = T_C + 273.15$

Triple Point of Neon in Kelvin $T_K = 24.57$ K

Triple Point of Neon in Celcius $T_C = T_K - 273.15 = 24.57 - 273.15 = -248.58\ ^oC$

Triple Point of carbon dioxide in Kelvin $T_K = 216.55$ K

Triple Point of carbon dioxide in Celcius $T_C = T_K - 273.15 = 216.55 - 273.15 = -56.60\ ^oC$

The relation between Celcius and Fahrenheit scale is $T_F = \frac{9}{5}T_C + 32$

Triple Point of Neon in Fahrenheit is

$$T_F = \frac{9}{5} \times (-248.58) + 32$$

$T_F = -415.44\ ^oC$

Triple Point of carbon dioxide in Fahrenheit is

$$T_F = \frac{9}{5} \times (-56.60) + 32$$

$T_F = -69.88\ ^oC$

Q. 11.2 Two absolute scales A and B have triple points of water defined to be $200A$ and $350B$. What is the relation between T_A and T_B ?

Answer:

200 A = 273 K

$$T_K = \frac{273}{200} T_A$$

350 B = 273 K

$$T_K = \frac{273}{350} T_B$$

Equating T_K From the above two equations we have

$$\frac{273}{200} T_A = \frac{273}{350} T_B$$
$$T_A = \frac{4}{7} T_B$$

Q. 11.3 The electrical resistance in ohms of a certain thermometer varies with temperature according to the approximate law :

$$R = R_0 \left[1 + \alpha(T - T_0)\right]$$

The resistance is 101.6Ω at the triple-point of water $273.16\ K$, and $165.5\ \Omega$ at the normal melting point of lead $(600.5\ K)$. What is the temperature when the resistance is $123.4\ \Omega$?

Answer:

$$R = R_0 \left[1 + \alpha(T - T_0)\right]$$

$R_0 = 101.6\Omega$ $T_0 = 273.16K$

R = $165.5\ \Omega$ R = $600.5K$

Putting the above values in the given equation we have

$$\alpha = \frac{165.5 - 101.6}{600.5 - 27316}$$
$$\alpha = 1.92 \times 10^{-2}\ K^{-1}$$

For R = $123.4\ \Omega$

Q. 11.4 (a) Answer the following :

(a) The triple-point of water is a standard fixed point in modern thermometry. Why ? What is wrong in taking the melting point of ice and the boiling point of water as standard fixed points (as was originally done in the Celsius scale)?

Answer:

Unlike the melting point of ice and boiling point of water, the triple point of water has a fixed value of 273.16 K. The melting point of ice and boiling point of water vary with pressure.

Q. 11.4 (b) Answer the following :

(b) There were two fixed points in the original Celsius scale as mentioned above which were assigned the number $0^{\circ}C$ and $100^{\circ}C$ respectively. On the absolute scale, one of the fixed points is the triple-point of water, which on the Kelvin absolute scale is assigned the number $273.16\ K$. What is the other fixed point on this (Kelvin) scale?

Answer:

The other fixed point on the Kelvin scale is 0 K. 0K is the absolute zero

Q. 11.4 (c) Answer the following :

(c) The absolute temperature (Kelvin scale) T is related to the temperature t_c on the Celsius scale by

$$t_c = T - 273.15$$

Why do we have 273.15 in this relation, and not 273.16?

Answer:

This is because 0 ^{o}C on the Celcius scale corresponding to the melting point at standard pressure is equal to 273.15 K whereas 273.16 K is the triple point of water. The triple point of water is 0.01 ^{0}C , not 0 ^{0}C

Q. 11.4 (d) Answer the following :

(d) What is the temperature of the triple-point of water on an absolute scale whose unit interval size is equal to that of the Fahrenheit scale?

Answer:

Let at a certain temperature the reading on Fahrenheit and Kelvin Scale be T_F and T_K respectively

$$T_F - 32 = \frac{9}{5}(T_K - 273) \quad (i)$$

Let at another temperature the reading on Fahrenheit and Kelvin Scale be T'_F and T'_K respectively

$$T'_F - 32 = \frac{9}{5}(T'_K - 273) \quad (ii)$$

Subtracting equation (ii) from (i)

$$T_F - T'_F = \frac{9}{5}(T_K - T'_K)$$

For $T_K - T'_K = 1$ K, $T_F - T'_F = 9/5$

Therefore corresponding to 273.16 K the absolute scale whose unit interval size is equal to that of the Fahrenheit scale

$$T_F = \frac{9}{5} \times 273.16$$
$$T_F = 491.688$$

Q. 11.5 (a) Two ideal gas thermometers A and B use oxygen and hydrogen respectively. The following observations are made :

Temperature	Pressure Thermometer A	Pressure Thermometer B
Triple-point of water	$1.250 \times 10^5 Pa$	$0.200 \times 10^5 Pa$
Normal melting point of sulphur	$1.797 \times 10^5 Pa$	$0.287 \times 10^5 Pa$

(a) What is the absolute temperature of normal melting point of sulphur as read by thermometers A and B?

Answer:

$$PV = nRT$$
$$\frac{P}{T} = \frac{nR}{V}$$

As the moles of oxygen and hydrogen inside the thermometers and the volume occupied by the gases remain constant P/T would remain constant.

The triple point of water(T_1) = 273.16 K

Pressure in thermometer A at a temperature equal to the triple point of water (P_1)
$= 1.250 \times 10^5 Pa$

Pressure in thermometer A at a temperature equal to Normal melting point of sulphur (P_2)
$= 1.797 \times 10^5 Pa$

The normal melting point of sulphur as read by thermometer A T_2 would be given as

$$T_2 = \frac{P_2 T_1}{P_1}$$

$$T_2 = \frac{1.797 \times 10^5 \times 273.16}{1.250 \times 10^5}$$
$$T_2 = 392.69\ K$$

Pressure in thermometer B at a temperature equal to the triple point of water (P'_1)
$= 0.200 \times 10^5 Pa$

Pressure in thermometer B at a temperature equal to Normal melting point of sulphur (P'_2)
$= 0.287 \times 10^5 Pa$

The normal melting point of sulphur as read by thermometer B T'_2 would be given as

Q. 11.5 (b) Two ideal gas thermometers A and B use oxygen and hydrogen respectively. The following observations are made :

Temperature	Pressure Thermometer A	Pressure Thermometer B
Triple-point of water	$1.250 \times 10^5 Pa$	$0.200 \times 10^5 Pa$
Normal melting point of sulphur	$1.797 \times 10^5 Pa$	$0.287 \times 10^5 Pa$

(b) What do you think is the reason behind the slight difference in answers of thermometers A and B? (The thermometers are not faulty). What further procedure is needed in the experiment to reduce the discrepancy between the two readings?

Answer:

The slight difference in answers of thermometers A and B occur because the gases used in the thermometers are not ideal gases. To reduce this discrepancy the experiments should be carried out at low pressures where the behaviour of real gases tend close to that of ideal gases.

Q. 11.6 A steel tape 1m long is correctly calibrated for a temperature of $27.0°C$. The length of a steel rod measured by this tape is found to be $63.0\ cm$ on a hot day when the temperature is $45.0°C$. What is the actual length of the steel rod on that day? What is the length of the same steel rod on a day when the temperature is $27.0°C$? Coefficient of linear expansion of steel $= 1.20 \times 10^{-5} K^{-1}$.

Answer:

At 27 ^{o}C the 63 cm (l_1) mark on the steel tape would be measuring exactly 63 cm as the tape is calibrated at 27 ^{o}C

Coefficient of linear expansion of steel $= 1.20 \times 10^{-5} K^{-1}$.

Actual length when the scale is giving a reading of 63 cm on at 45 ^{o}C is l_2

$$l_2 = l_1(1 + \alpha \Delta T)$$
$$= 63 \times (1 + 1.20 \times 10^{-5} \times (45 - 27))$$
$$= 63.013608 cm$$

The actual length of the steel rod on a day when the temperature is 45 ^{o}C is 63.013608 cm.

Length of the same steel rod on a day when the temperature is 63 cm.

Q. 11.7 A large steel wheel is to be fitted on to a shaft of the same material. At $27^{\circ} C$, the outer diameter of the shaft is $8.70\ cm$ and the diameter of the central hole in the wheel is $8.69\ cm$. The shaft is cooled using 'dry ice'. At what temperature of the shaft does the wheel slip on the shaft? Assume coefficient of linear expansion of the steel to be constant over the required temperature range : $\alpha_{steel} = 1.20 \times 10^{-5} K^{-1}$.

Answer:

Diameter of the steel shaft at 27 ^{o}C (T_1) d_1 = 8.70 cm

The diameter of the central hole in the wheel d_2 = 8.69 cm

Coefficient of linear expansion of the steel $\alpha_{steel} = 1.20 \times 10^{-5} K^{-1}$.

The wheel will slip on the shaft when the diameter of the steel shaft becomes equal to the diameter of the central hole in the wheel.

Let this happen at temperature T

$$d_2 = d_1(1 + \alpha(T - T_1))$$
$$8.69 = 8.7(1 + 1.2 \times 10^5 (T - 27))$$
$$T = -68.79\ ^{o}C$$

Q. 11.8 A hole is drilled in a copper sheet. The diameter of the hole is $4.24\ cm$ at $27.0°C$. What is the change in the diameter of the hole when the sheet is heated to $227°C$? Coefficient of linear expansion of copper $= 1.70 \times 10^{-5} K^{-1}$.

Answer:

Coefficient of linear expansion of copper $\alpha = 1.70 \times 10^{-5} K^{-1}$.

Coefficient of superficial expansion of copper is β

$$\beta = 2\alpha$$
$$\beta = 2 \times 1.7 \times 10^{-5}$$
$$\beta = 3.4 \times 10^{-5} K^{-1}$$

Diameter of the hole at 27 ^{o}C (d_1) = 4.24 cm

Area of the hole at 227 ^{o}C is

Let the diameter at 227 ^{o}C be d_2

$$\pi \left(\frac{d_2}{4}\right)^2 = 14.215$$
$$d_2 = 4.254cm$$

Change in diameter is $d_2 - d_1$ = 4.24 -4.254 = 0.014 cm.

Q. 11.9 A brass wire $1.8\ m$ long at $27°C$ is held taut with little tension between two rigid supports. If the wire is cooled to a temperature of $-39°C$, what is the tension developed in the wire if its diameter is $2.0\ mm$? ? Co-efficient of linear $expansion\ of\ brass = 2.0 \times 10^{-5} K^{-1}$;

$Young's\ modulus\ of\ brass = 0.91 \times 10^{11} Pa.$

Answer:

Youngs Modulus of Brass, $Y = 0.91 \times 10^{11}$

Co-efficient of linear expansion of Brass, $\alpha = 2.0 \times 10^{-5} K^{-1}$

The diameter of the given brass wire, d = 2.0 mm

Length of the given brass wire, l = 1.8 m

Initial Temperature $T_1 = 27\ ^{o}C$

Final Temperature $T_2 = -39\ ^{o}C$

$F = -378N$

The tension developed in the wire is 378 N. The negative sign signifies this tension is inward.

Q. 11.10 A brass rod of length $50\ cm$ and diameter $3.0\ mm$ is joined to a steel rod of the same length and diameter. What is the change in length of the combined rod at $250^{\circ}C$, if the original lengths are at $40.0^{\circ}C$? Is there a 'thermal stress' developed at the junction ? The ends of the rod are free to expand (Co-efficient of linear $expansion\ of\ brass = 2.0 \times 10^{-5} K^{-1},\ steel = 1.2 \times 10^{-5} K^{-1}$).

Answer:

Length of the rods l = 50 cm

Co-efficient of linear expansion of brass, $\alpha_b = 2 \times 10^{-5} K^{-1}$

Co-efficient of linear expansion of steel, $\alpha_s = 1.2 \times 10^{-5} K^{-1}$

Initial Temperature $T_1 = 40.0\ ^{o}C$

Final Temperature $T_2 = 250\ ^{o}C$

Change in length of brass rod is

$$\Delta l_t = l_t \alpha_b \Delta T$$
$$\Delta l_t = 50 \times 2.0 \times 10^{-5} \times (250 - 40)$$
$$\Delta l_t = 0.21 cm$$

Change in length of the steel rod is

$$\Delta l_s = l_s \alpha_s \Delta T$$
$$\Delta l_s = 50 \times 1.2 \times 10^{-5} \times (250 - 40)$$
$$\Delta l_s = 0.126 cm$$

Change in length of the combined rod is

$$\Delta l = \Delta l_s + \Delta l_b$$
$$\Delta l = 0.126 + 0.21$$
$$\Delta l = 0.336 cm$$

Q. 11.11 The coefficient of volume expansion of glycerine is $49 \times 10^{-5} K^{-1}$. What is the fractional change in its density for a $30^{\circ} C$ rise in temperature?

Answer:

Coefficient of volume expansion of glycerine is $\gamma = 49 \times 10^{-5} K^{-1}$

Let initial volume and mass of a certain amount of glycerine be V and m respectively.

Initial density is

$$\rho = \frac{m}{V}$$

Change in volume for a 30 ^{o}C rise in temperature will be

$$\Delta V = V(\gamma \Delta T)$$
$$\Delta V = V(49 \times 10^{-5} \times 30)$$
$$\Delta V = 0.0147V$$

Final Density is

$$\rho' = \frac{m}{V + \Delta V}$$
$$\rho' = \frac{m}{1.0147V}$$
$$\rho' = \frac{0.986m}{V}$$

Fractional Change in density is

$$\frac{\rho' - \rho}{\rho}$$
$$= \frac{\frac{0.986m}{v} - \frac{m}{v}}{\frac{m}{v}}$$
$$= -0.014$$

The negative sign signifies with an increase in temperature density will decrease.

Q. 11.12 A $10\ kW$ drilling machine is used to drill a bore in a small aluminium block of mass $8.0\ kg$. How much is the rise in temperature of the block in 2.5 minutes, assuming $50^{o}/_{o}$ of power is used up in heating the machine itself or lost to the surrounding. $Spcific\ heat\ of\ aluminium = 0.91\ j\ g^{-1}K^{-1}$.

Answer:

Power of the drilling machine, P = 10 kW

Time. t = 2.5 min

Total energy dissipated E is

$$E = Pt$$
$$E = 10 \times 10^3 \times 2.5 \times 60$$
$$E = 1.5 \times 10^6 J$$

Thermal energy absorbed by aluminium block is

$$\Delta Q = \frac{E}{2}$$
$$\Delta Q = \frac{1.5 \times 10^6}{2}$$
$$\Delta Q = 7.5 \times 10^5 J$$

Mass of the aluminium block, m = 8.0 kg

Specific heat of aluminium, c = 0.91 J g^{-1} K^{-1}

Let rise in temperature be ΔT

Q. 11.13 A copper block of mass $2.5\ kg$ is heated in a furnace to a temperature of $500°C$ and then placed on a large ice block. What is the maximum amount of ice that can melt? (Specific heat of copper $= 0.39\ j\ g^{-1}K^{-1}$; heat of fusion of water $= 335\ j\ g^{-1}$).

Answer:

Mass of copper block m = 2.5 kg

Initial Temperature of the copper block, T_1 = 500 °C

Final Temperature of Copper block, T_2 = 0 °C

Specific heat of copper, c = 0.39 J g^{-1} K^{-1}

Thermal Energy released by the copper block is ΔQ

$$\Delta Q = mc\Delta T$$
$$\Delta Q = 2.5 \times 10^3 \times 0.39 \times 500$$
$$\Delta Q = 487500\ J$$

Latent heat of fusion of water, L = 335 j g^{-1}

Amount of ice that can melt is

$$w = \frac{\Delta Q}{L}$$
$$w = \frac{487500}{335}$$
$$w = 1455.22g$$

1.455 kg of ice can melt using the heat released by the copper block.

Q. 11.14 In an experiment on the specific heat of a metal, a $0.20\ kg$ block of the metal at 150 °C is dropped in a copper calorimeter (of water equivalent $0.025\ kg$) containing $150\ cm^3$ of water at $27^\circ C$.The final temperature is $40^\circ C$. Compute the specific heat of the metal. If heat losses to the surroundings are not negligible, is your answer greater or smaller than the actual value for specific heat of the metal?

Answer:

Let the specific heat of the metal be C.

Mass of metal block m = 200 g

Initial Temperature of metal block = 150 ^{o}C

Final Temperature of metal block = 40 ^{o}C

The heat released by the block is

$$\Delta Q = mc\Delta T$$
$$\Delta Q = 200 \times c \times (150 - 40)$$
$$\Delta Q = 22000c$$

Initial Temperature of the calorimeter and water = 27 ^{o}C

Final Temperature of the calorimeter and water = 40 ^{o}C

Amount of water = 150 cm

Mass of water = 150 g

Water equivalent of calorimeter = 25 g

Specific heat of water = 4.186 J g $^{-1}$ K $^{-1}$

Heat absorbed by the Calorimeter and water is $\Delta Q'$

$$\Delta Q' = (150 + 25) \times 4.186 \times (40 - 27)$$
$$\Delta Q' = 9523.15J$$

The heat absorbed by the Calorimeter and water is equal to the heat released by the block

$$\Delta Q = \Delta Q'$$
$$22000c = 9523.15$$
$$c = 0.433\ J\ g^{-1}\ K^{-1}$$

The above value would be lesser than the actual value since some heat must have been lost to the surroundings as well which we haven't accounted for.

Thermal Properties of Matter Excercise:

Question:

Q. 11.15 Given below are observations on molar specific heats at room temperature of some common gases.

Gas Molar specific heat (Cv)

$(cal\ mol^{-1}K^{-1})$

Hydrogen 4.87

Nitrogen 4.97

Oxygen 5.02

Nitric oxide 4.99

Carbon monoxide 5.01

Chlorine 6.17

The measured molar specific heats of these gases are markedly different from those for monatomic gases. Typically, molar specific heat of a monatomic gas is $2.92\ cal/mol\ K.$ Explain this difference. What can you infer from the somewhat larger (than the rest) value for chlorine?

Answer:

Monoatomic gases have only translational degree of freedom but diatomic gases have rotational degrees of freedom as well. The temperature increases with increase in the spontaneity of motion in all degrees. Therefore to increase the temperature of **diatomic gases** more energy is required than that required to increase the temperature of monoatomic gases by the same value owing to higher degrees of freedom in diatomic gases.

If we only consider rotational modes of freedom the molar specific heat of the diatomic gases would be given as

$$c = \frac{fR}{2}$$
$$c = \frac{5}{2} \times 1.92$$
$$c = 4.95\ cal\ mol^{-1}\ K^{-1}$$

The number of degrees of freedom = 5 (3 translational and 2 rotational)

The values given in the table are more or less in accordance with the above calculated one. The larger deviation from the calculated value in the case of chlorine is because of the presence of vibrational motion as well.

Q. 11.16 A child running a temperature of $101^\circ F$ is given an antipyrin (i.e. a medicine that lowers fever) which causes an increase in the rate of evaporation of sweat from his body. If the fever is brought down to $98^\circ F$ in 20 minutes, what is the average rate of extra evaporation caused, by the drug. Assume the evaporation mechanism to be the only way by which heat is lost. The mass of the child is $30\ kg.$. The specific heat of human body is approximately the same as that of water, and latent heat of evaporation of water at that temperature is about $580\ cal\ g^{-1}$.

Answer:

Initial Temperature of the boy = 101 ° F

Final Temperature of the boy = 98 ° F

Change in Temperature is

$$\Delta T = 3\ ^oF$$
$$\Delta T = 3 \times \frac{5}{9}$$
$$\Delta T = 1.67\ ^oC$$

Mass of the child is m = 30 kg

Specific heat of human body = 1000 cal kg $^{-1}$ ^{o}C $^{-1}$

Heat released is ΔQ

$$\Delta Q = mc\Delta T$$
$$\Delta Q = 30 \times 1000 \times 1.67$$
$$\Delta Q = 50000\ cal$$

Latent heat of evaporation of water = 580 cal g $^{-1}$

The amount of heat lost by the body of the boy has been absorbed by water.

Let the mass of water which has evaporated be m'

$$\Delta Q = m'L$$
$$m' = \frac{Q}{L}$$
$$m' = \frac{50000}{580}$$
$$m' = 86.2\ g$$

Time in which the water has evaporated, t = 20 min.

Rate of evaporation is m'/t

$$\frac{m'}{t} = \frac{86.2}{20}$$
$$\frac{m'}{t} = 4.31\ g\ min^{-1}$$

Q. 11.17 A 'thermacole' icebox is a cheap and an efficient method for storing small quantities of cooked food in summer in particular. A cubical icebox of side 30 cm has a thickness

of $5.0\ cm$. If $4.0\ kg$ of ice is put in the box, estimate the amount of ice remaining after 6 h. The outside temperature is $45^{\circ}C$. and co-efficient of thermal conductivity of thermacole is $0.01\ j\ s^{-1}m^{-1}K^{-1}$. $[Heat\ of\ fusion\ of\ water = 335 \times 103\ j\ kg^{-1}]$

Answer:

Side of the box s = 30 cm

Area available for conduction A

$A = 6s^2$

$A=6(30)^2$

$A=5400\ cm^2 = 0.54\ m^2$

Temperature difference = 45 ^{o}C

Co-efficient of thermal conductivity of thermacole is $k = 0.01\ J\ s^{-1}\ m^{-1}\ K^{-1}$

Width of the box is d = 5 cm

Heat absorbed by the box in 6 hours is ΔQ

The heat of fusion of water is $L = 335 \times 10^3\ J\ kg^{-1}$

Amount of ice which has melted is m'

$$m' = \frac{\Delta Q}{L}$$
$$m' = \frac{104976}{335 \times 10^3}$$
$$m' = 0.313\ kg$$

Amount of ice left after 6 hours = 4 - 0.313 = 3.687 kg

Q. 11.18 A brass boiler has a base area of $0.15\ m^2$ and thickness $1.0\ cm.$ It boils water at the rate of $6.0\ kg/min$ when placed on a gas stove. Estimate the temperature of the part of the flame in contact with the boiler. Thermal conductivity of brass $= 109\ j\ s^{-1}m^{-1}K^{-1}$; Heat of vaporisation of water $= 2256 \times 103\ j\ kg^{-1}$.

Answer:

The rate at which water boils, R = 6.0 kg min $^{-1}$

The heat of vaporisation of water, $L = 2256 \times 10^3\ J\ kg^{-1}$

The rate at which heat enters the boiler

$$\frac{dQ}{dT} = RL$$
$$\frac{dQ}{dT} = \frac{6 \times 2256 \times 10^3}{60}$$
$$\frac{dQ}{dT} = 2.256 \times 10^5 Js^{-1}$$

The base area of the boiler, A = 0.15 m ^{2}

Thickness, l = 1.0 cm

Thermal conductivity of brass $= 109\ j\ s^{-1}m^{-1}K^{-1}$;

The temperature inside the boiler = Boiling point of water = 100 ^{o} C

Let the temperature of the flame in contact with the boiler be T

Amount of heat flowing into the boiler is

The temperature of the flame in contact with the boiler is 237.98 ^{o} C

Q. 11.19 (a) Explain why :

(a) a body with large reflectivity is a poor emitter

Answer:

A body with a large reflectivity is a poor absorber. As we know a body which is a poor absorber will as well be a poor emitter. Therefore a body with large reflectivity is a poor emitter.

Q .11.19 (b) Explain why :

(b) a brass tumbler feels much colder than a wooden tray on a chilly day

Answer:

Brass is a good conductor of heat. Therefore once someone touches brass heat from their body flows into it and it feels cold, in case of a wooden tray, no such conduction of heat from the body takes place as wood is a very poor conductor of heat.

Q. 11.19 (c) Explain why :

(c) 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

Answer:

An optical pyrometer relates the brightness of a glowing body with its temperature. In the open because of other sources of light the sensor in the optical pyrometer does not detect the true brightness of a red hot piece of iron and thus does not predict its temperature correctly whereas in the furnace the piece of iron is the only source of light and the sensor detects its brightness correctly thus giving the correct value of the temperature.

Q. 11.19 (d) Explain why :

(d) the earth without its atmosphere would be inhospitably cold

Answer:

The sun rays contain infrared radiations. These are reflected back by the lower part of the atmosphere after being reflected by the surface of the earth and are trapped inside the atmosphere thus maintaining the Earth's temperature at a hospitable level. Without these rays being trapped the temperature of the earth will go down severely and thus the Earth without its atmosphere would be inhospitably cold.

Q. 11.19 (e) Explain why :

(e) heating systems based on circulation of steam are more efficient in warming a building than those based on circulation of hot water

Answer:

Heating systems based on the circulation of steam are more efficient in warming a building than those based on the circulation of hot water because the same amount of steam at 100 ^{o}C contains

more energy available for heat dissipation than the same amount of water at 100 ^{o}C in the form of latent heat of vaporization.

Q. 11.20 A body cools from $80^{\circ}C$ to $50^{\circ}C$ in 5 minutes. Calculate the time it takes to cool from $60^{\circ}C$ to $30^{\circ}C$. The temperature of the surroundings is $20^{\circ}C$.

Answer:

Let a body initially be at temperature T_1

Let its final Temperature be T_2

Let the surrounding temperature be T_0

Let the temperature change in time t.

According to Newton's Law of cooling

where K is a constant.

We have been given that the body cools from 80 ^{o}C to 50 ^{o}C in 5 minutes when the surrounding temperature is 20 ^{o}C.

$T_2 = 50\ ^{o}C$

$T_1 = 80\ ^{o}C$

$T_0 = 20\ ^{o}C$

t = 5 min = 300 s.

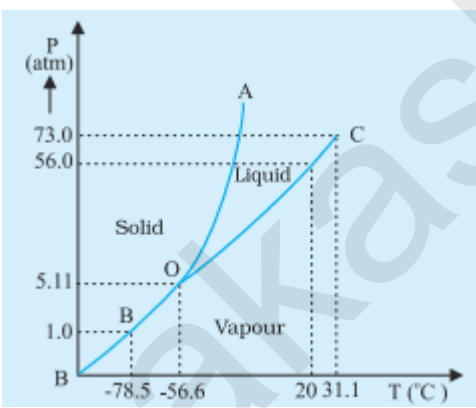
$$ln\left(\frac{50-20}{80-20}\right) = -K \times 300$$
$$K = \frac{ln(2)}{300}$$

For $T_1 = 60\ ^oC$ and $T_2 = 30\ ^oC$ we have

The body will take 10 minutes to cool from 60 ºC to 30 ºC at the surrounding temperature of 20 ºC.

NCERT solutions for class 11 physics chapter 11 thermal properties of matter additional exercise

Q. 11.21(a) Answer the following questions based on the P-T phase diagram of carbon dioxide:

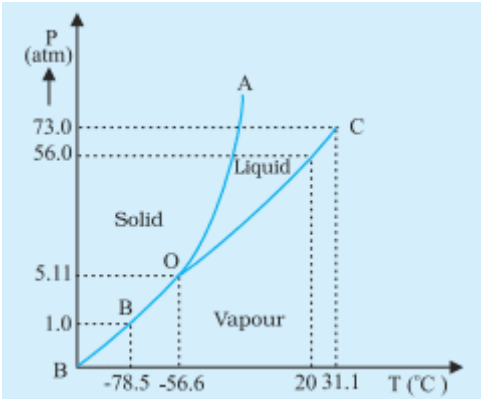


(a) At what temperature and pressure can the solid, liquid and vapour phases of CO_2 co-exist in equilibrium?

Answer:

At the triple point temperature of -56.6 ^{o}C and pressure 5.11 atm the solid, liquid and vapour phases of CO_2 co-exist in equilibrium.

Q. 11.21(b) Answer the following questions based on the P-T phase diagram of carbon dioxide:

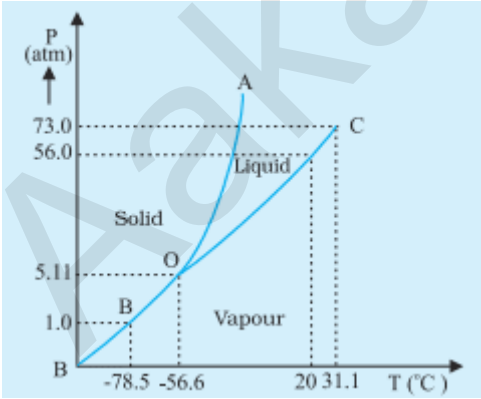


(b) What is the effect of decrease of pressure on the fusion and boiling point of CO_2?

Answer:

Both fusion and boiling point of CO_2 decrease with decrease in pressure. This we can see from the solid lines in the P-T phase diagram of CO_2.

Q. 11.21 (c) Answer the following questions based on the P-T phase diagram of carbon dioxide:

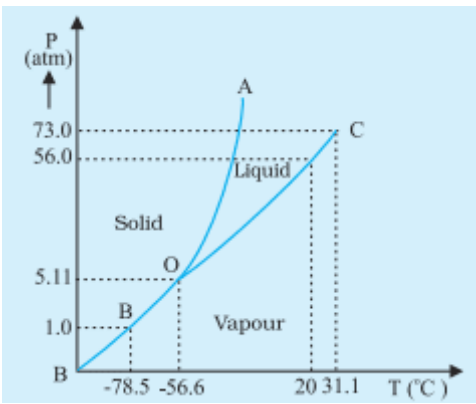


(c) What are the critical temperature and pressure for CO_2? What is their significance?

Answer:

The critical temperature and pressure for CO_2 are 31.1 ^{o}C and 73.0 atm respectively. If the temperature exceeds this critical value of temperature CO_2 would not liquefy no matter how high the pressure is.

Q .11.21 d(a) Answer the following questions based on the P-T phase diagram of carbon dioxide:



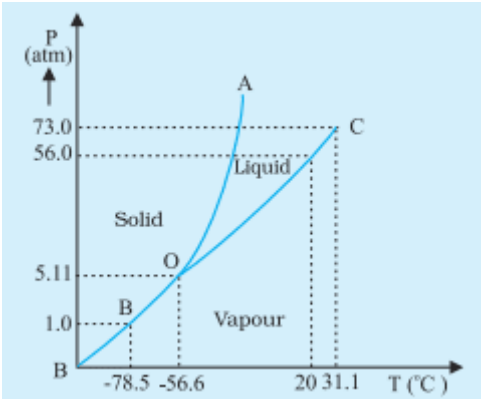
(d) Is CO_2 solid, liquid or gas at

(a) $-70^{\circ}C$ under $1\ atm$,

Answer:

CO_2 is vapour at -70 ^{o}C under 1 atm pressure as the point corresponding to this condition lies in vapour region in the given P-T phase diagram of carbon dioxide.

Q .11.21 d (b) Answer the following questions based on the P-T phase diagram of carbon dioxide:



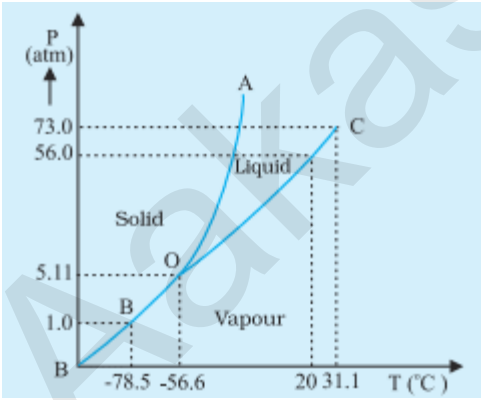
(d) Is $C0_2$ solid, liquid or gas at

(b) $-60^\circ C$ under $10\ atm,$

Answer:

CO_2 is solid at -60 °C under 10 atm pressure as the point corresponding to this condition lies in the solid region in the given P-T phase diagram of carbon dioxide.

Q. 11.21 d(c) Answer the following questions based on the P-T phase diagram of carbon dioxide:



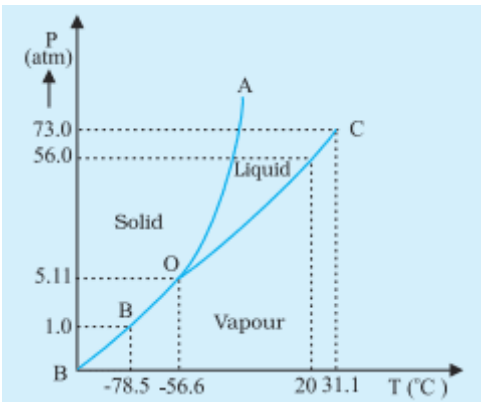
(d) Is CO_2 solid, liquid or gas at

(c) $15^\circ C$ under $56\ atm$?

Answer:

CO_2 is liquid at 15 °C under 56 atm pressure as the point corresponding to this condition lies in the liquid region in the given P-T phase diagram of carbon dioxide.

Q. 11.22 (a) Answer the following questions based on the P – T phase diagram of CO_2 :



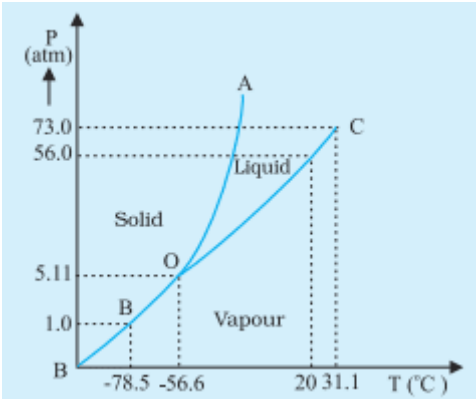
(a) CO_2 at 1 atm pressure and temperature $-60^\circ C$ is compressed isothermally. Does it go through a liquid phase?

Answer:

The temperature -60 °C lies to the left of the triple point of water i.e. in the region of solid and vapour phases. Once we start compressing CO_2 at this temperature starting from 1 atm pressure it will directly convert into solid without going through the liquid phase.

Q. 11.22 (b) Answer the following questions based on the P – T phase diagram of CO_2 :

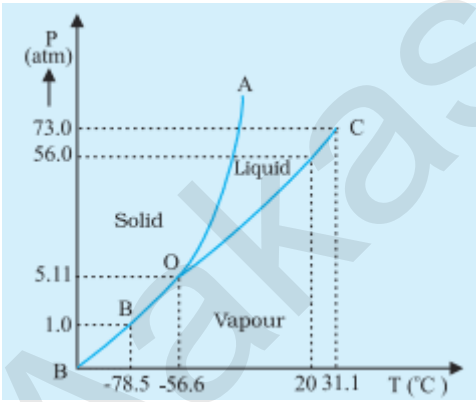
(b) What happens when CO_2 at 4 atm pressure is cooled from room temperature at constant pressure?



Answer:

At room temperature (27 ^{o} C) and 4 atm pressure CO_2 exits in the vapour phase. The pressure 4 atm is less than the pressure at the triple point and therefore points corresponding to all temperatures and this pressure lie in the solid and vapour region. Once we start compressing CO_2 from room temperature at this constant pressure CO_2 turns from vapour to solid directly without going through the liquid phase.

Q. 11.22 (c) Answer the following questions based on the P – T phase diagram of CO_2 :



(c) Describe qualitatively the changes in a given mass of solid CO_2 at $10\ atm$ pressure and temperature $-65^{\circ}C$ as it is heated up to room temperature at constant pressure.

Answer:

At -65 ^{o}C under 10 atm pressure CO_2 is in the solid phase. At room temperature (27 ^{o}C) under 10 atm pressure CO_2 is in the vapour phase. At 10 atm pressure, CO_2 can exist in all three phases depending upon the temperature. Therefore as CO_2 is heated from -65 ^{o}C to room temperature at a constant pressure of 10 atm it goes from the solid phase to liquid phase and then ultimately it goes into the vapour phase.