EXERCISE 11(B)

Solution:

(a) The change of phase is a process of change from one state to another at a constant temperature.
(b) No, there is no change in temperature during the change of phase.
(c) Yes, the substance absorb or liberates heat during the change of phase.
(d) The name given to the energy absorbed during a phase change is latent heat.

Solution:

(a) This process is known as melting.
(b) The name given to heat observed by the substance is latent heat of melting.
(c) The average kinetic energy of the molecules does not change as there is no change in temperature.

Solution:

(i) Average kinetic energy of molecules increases.
(ii) Average potential energy of molecules increases.

Solution:

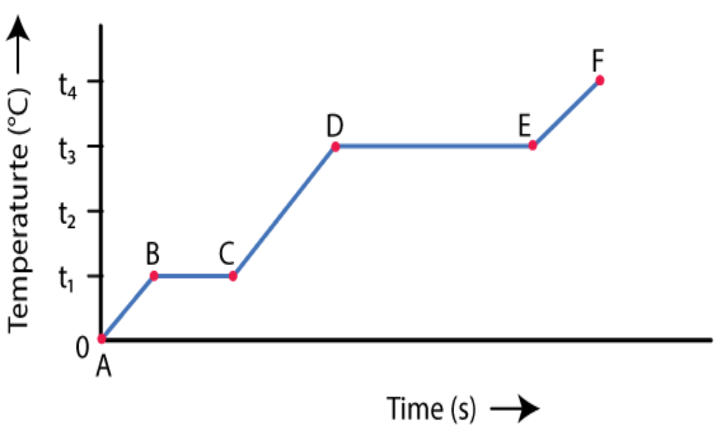
(a) The average kinetic energy of molecules does not change.

(b) Average potential energy of molecules increases.
Explanation: The heat supplied when a substance is heated at constant temperature i.e., during its phase change state makes the vibrating molecules gain potential energy to overcome the intermolecular force of attraction and move about freely. This means that the substance changes its form.
However, this heat does not increase the kinetic energy of the molecules. So, there is no rise in temperature during the change in phase of a substance.
This heat supplied to the substance is called as latent heat and is utilized in changing the state of matter without increase in temperature.

Solution:
The melting point of a substance decreases by the presence of impurities in it.
Use: This is used in making the freezing mixture by adding salt to ice. The freezing mixture is used in preparing kulphies.

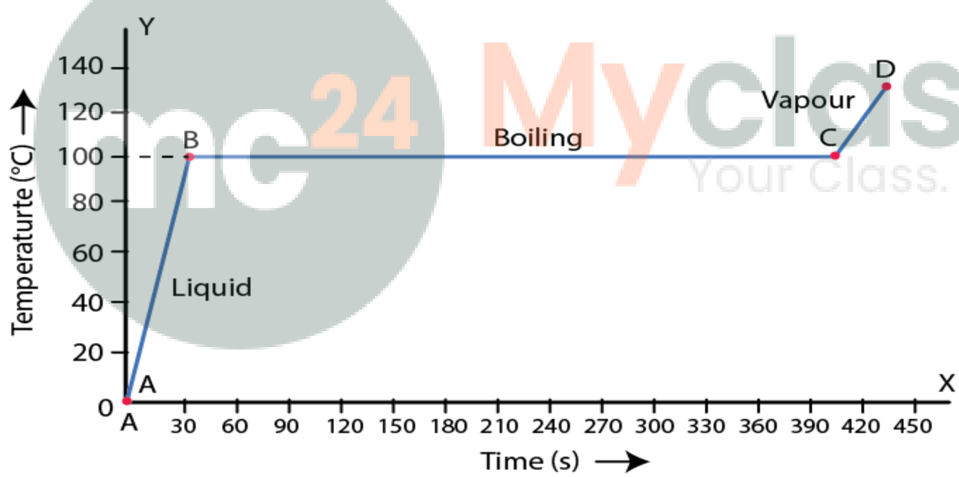
Question: 6
State the effect of increase of pressure on the melting point of ice.
Solution:
By the increase in pressure, the melting point of ice decreases. The melting point of ice decreases by 0.0072^0 C for every one atmosphere rise in pressure.

Question: 7
The diagram shows the change of phases of a substance on a temperature-time graph on heating the substance at a constant rate.



(a) What do parts AB, BC, CD and DE represent?
(b) What is the melting point of the substance?
(c) What is the boiling point of the substance?
Solution:
(a) AB part shows the rise in temperature of solid from 0^0 C to t_1^0 C
BC part shows melting at temperature t_1^0 C
CD part shows rise in temperature of liquid from t_1^0 C to t_3^0 C
DE part shows the boiling at temperature t_3^0 C
(b) The melting point of the substance is t_1^0 C
(c) The boiling point of the substance is t_3^0 C

Question: 8
1 kg of ice at 0° is heated at constant rate and its temperature is recorded after every 30 s till steam is formed at 100° C. Draw a temperature-time graph to represent the change of phases.
Solution:



Question: 9
Explain the terms boiling and boiling point.
Solution:
The change from liquid to gas phase on absorption of heat at a constant temperature is called boiling.
The particular temperature at which vaporization occurs is known as the boiling point of liquid.

Question: 10
How is the volume of water affected when it boils at 100°C?

Solution:
Volume of water increases when it boils at 100^0 C

Question: 11
How is the boiling point of water affected when some salt is added to it?
Solution:
The boiling point of water increases by addition of salt to it. When common salt is added to water, it boils at a temperature higher than 100^0 C. Cooking becomes easier and faster as the salt in water provides sufficient heat energy to its contents before boiling.

Question: 12
What is the effect of increase in pressure on the boiling point of a liquid?
Solution:
The boiling point of a liquid increases with the increase in pressure.

Question: 13
Water boils at 120 °C in a pressure cooker. Explain the reason
Solution:
The boiling point of liquid increases with the increase in pressure and decreases with the decrease in pressure. At one atmospheric pressure, the boiling point of pure water is 100^0 C. In a pressure cooker, steam is not allowed to escape out. The vapour pressure on water inside the cooker becomes nearly 1.75 times the atmospheric pressure. Thus water boils at about 120^0 C to 125^0 C due to increase in pressure.

Question: 14
Write down the approximate range of temperature at which water boils in a pressure cooker.
Solution:
The water boils at about 120^0 C to 125^0 C in a pressure cooker.

Question: 15
It is difficult to cook vegetables on hills and mountains. Explains the reason.
Solution:
Atmospheric pressure is low at high altitudes. Hence boiling point of water decreases and so it does not provide the required heat energy to its contents for cooking. Due to this reason it becomes difficult to cook vegetables on hills and mountains.

Question: 16
Complete the following sentences:

(a) When ice melts, its volume…………
(b) Decrease in pressure over ice....................its melting point.
(c) Increase in pressure .... the boiling point of water.
(d) A pressure cooker is based on the principle that boiling point of water increases with the …………..
(e) The boiling point of water is defined as ………………………..
(f) Water can be made to boil at 115°C by.................pressure over its surface.
Solution:
(a) When ice melts, its volume decreases.
(b) Decrease in pressure over ice increases its melting point.
(c) Increase in pressure increases the boiling point of water.
(d) A pressure cooker is based on the principle that boiling point of water increases with the increase in pressure.
(e) The boiling point of water is defined as the constant temperature at which water changes to steam.
(f) Water can be made to boil at 115^0 C by increasing pressure over its surface.

Question: 17
What do you understand by the term latent heat?
Solution:
Heat energy absorbed or liberated in change of phase is not externally manifested by any rise or fall in temperature is called the latent heat.

Question: 18
Define the term specific latent heat of fusion of ice. State its S.I. unit.
Solution:
The specific latent heat of fusion of ice is the heat energy required to melt unit mass of ice at 0^0 C to water at 0^0 C without any change in temperature.

Question: 19
Write the approximate value of specific latent heat of ice.
Solution:
The approximate value of specific latent heat of ice is 336000 J kg^{-1}

Question: 20
'The specific latent heat of fusion of ice is 336 J g^{-1} '. Explain the meaning of this statement.
Solution:
The specific latent heat of fusion of ice is 336 J g^{-1} means 1 g of ice at 0^0 C absorbs 336 J

of heat energy to convert into water at 0^0 C.

Question: 21
1 g ice at 0^o C melts to form 1 g water at 0^o. State whether the latent heat is absorbed or given out by ice.
Solution:
Latent heat is absorbed by ice

Question: 22
Which has more heat: 1 g of ice at 0^o C or 1 g of water at 0^oC? Give reasons.
Solution:
1 g of water at 0^0 C has more heat because 1 g of water at 0^0 C liberates 80 cal heat to form 1 g of ice at 0^0 C.

Question: 23
(a) Which requires more heat: 1 g ice at 0^o C or 1 g water at 0^oC to raise its temperature to 10^oC? (b) Explain your answer in part (a).
Solution:
(a) 1 g ice at 0^0 C requires more heat to raise its temperature to 10^0 C
(b) 1 g ice at 0^0 C first absorbs 336 J heat to convert into 1 g water at 0^0 C

Question: 24
Ice cream appears colder to the mouth than water at 0^oC. Give reasons.
Solution:
To attain the room temperature ice cream absorbs heat energy as well as the latent heat while water absorbs only heat energy. Thus ice cream absorbs more amount of energy from the mouth as compared to water. For this reason ice cream appears colder to the mouth than water at 0^0 C.

Question: 25
The soft drink bottles are cooled by (i) ice cubes at 0°C, and (ii) iced-water at 0°C. Which will cool the drink quickly? Give reason.
Solution:
1 g of ice at 0^0 C takes 336 J of heat energy from the drink to melt into water at 0^0 C. Hence the bottle losses an additional 336 J of heat energy to 1 g ice at 0^0 C than to 1 g ice-cold water at 0^0 C. It is due to this reason soft drink bottles get cooled more quickly by ice cubes than by iced water.

Question: 26

It is generally cold after a hail storm than during and before the hail storm. Give reasons.

Solution:

It is cold because after the hail storm, ice absorbs the heat energy required for its melting from the surroundings. Thus the temperature of the surroundings falls further down and we feel colder.

Question: 27

The temperature of surroundings starts falling when ice in a frozen lake starts melting. Give reasons.

Solution:

The reason is that heat energy required for melting the frozen lake is absorbed from the surrounding atmosphere. Hence, the temperature of the surrounding falls and it becomes very cold.

Question: 28

Water in lakes and ponds do not freeze at once in cold countries. Give reason.

Solution:

The specific latent heat of fusion of ice is sufficiently high about 336 J g^{-1}. Before freezing, the water in lakes and ponds will have to liberate a large quantity of heat to the surrounding. The layer of ice formed over the water surface, will also prevent the loss of heat from the water of lake being a poor conductor of heat. Hence, water in lakes and ponds does not freeze in cold countries.

Question: 29

Explain the following:

(i) The surroundings become pleasantly warm when water in a lake starts freezing in cold countries.

(ii) The heat supplied to a substance during its change of state, does not cause any rise in its temperature.

Solution:

(i) The specific latent heat of fusion of ice is sufficiently high, so a large quantity of heat has to be released when the water of lake freezes. Thus for this reason, the surrounding temperature becomes pleasantly warm.

(ii) Latent heat of phase change is required to change the phase only. Hence, the heat supplied to a substance does not cause any rise in temperature during its change of state.

MULTIPLE CHOICE TYPE

Question: 1

The S.I. unit of specific latent heat is:

(a) cal g^{-1}
(b) cal g^{-1} K^{-1}
(c) J kg^{-1}
(d) J kg^{-1} K^{-1}
Solution:
The S.I. unit of specific latent heat is J kg^{-1}
Question: 2
The specific latent heat of fusion of water is:
(a) 80 cal g^{-1}
(b) 2260 J g^{-1}
(c) 80 J g^{-1}
(d) 336 J kg^{-1}
Solution:
The specific latent heat of fusion of water is 80 cal g^{-1}

NUMERICALS
Question: 1
10 g of ice at 0^oC absorbs 5460 J of heat energy to melt and change to water at 50^oC. Calculate the specific latent heat of fusion of ice. Specific heat capacity of water is 4200 J kg^{-1} K^{-1}.
Solution:
Given
Mass of ice = 10 g
= 0.01 kg
Amount of heat energy absorbed, Q = 5460 J
Specific latent heat of fusion of ice =?
Specific heat capacity of water = 4200 J kg^{-1} K^{-1}
Amount of heat energy required by 10 g (0.01 kg) of water at 0^0 C to raise its temperature by 50^0 C = 0.01 × 4200 × 50
= 2100 J
Let Specific latent heat of fusion of ice = L Jg^{-1}
Then,
$Q = mL + mc\triangle t$
5460 J = 10 × L + 2100 J
L = 3360 / 10
L = 336 J g^{-1}

Question: 2
How much heat energy is released when 5.0 g of water at 20^o C changes into ice at 0^o

C? Take specific heat capacity of water =4.2 J g^{-1} K^{-1}, specific latent heat of fusion of ice = 336 J g^{-1}.

Solution:

Given

Mass of water m = 5.0 g

Specific heat capacity of water c = 4.2 J g^{-1} K^{-1}

Specific latent heat of fusion of ice L = 336 J g^{-1}

Amount of heat energy released when 5.0 g of water at 20^0 C changes into water at 0^0 C = 5 × 4.2 × 20

= 420 J

Amount of heat energy released when 5.0 g of water at 0^0 C changes into ice at 0^0 C = 5 × 336 J

= 1680 J

Total amount of heat released = 1680 J + 420 J

= 2100 J

Question: 3

A molten metal of mass 150 g is kept at its melting point 800°C. When it is allowed to freeze at the same temperature, it gives out 75000 J of heat energy.

(a) What is the specific latent heat of the metal?

(b) If the specific heat capacity of metal is 200 J kg^{-1} K^{-1}, how much additional heat energy will the metal give out in cooling to - 50°C?

Solution:

Given

Mass of metal = 150 g

Specific latent heat of metal L = Q / m

= 75000 / 150

= 500 J g^{-1}

Specific heat capacity of metal is 200 J kg^{-1} K^{-1}

Change in temperature = 800 – (-50)

= 800 + 50

= 850^0 C (or 850 K)

$\triangle Q = mc\triangle T$

$\triangle Q = 0.15 \times 200 \times 850$

$\triangle Q = 25500$ J

Question: 4

A refrigerator converts 100 g of water at 20°C to ice at -10°C in 73.5 min. calculate the average rate of heat extraction in watt. The specific heat capacity of water is 4.2

J g^{-1} K^{-1}, specific latent heat of ice is 336 J g^{-1} and the specific heat capacity of ice is 2.1 J g^{-1} K^{-1}.

Solution:

Amount of heat released when 100 g of water cools from 20^0 to 0^0 C = 100 × 20 × 4.2
= 8400 J
Amount of heat released when 100 g of water converts into ice at 0^0 C = 100 × 336
= 33600 J
Amount of heat released when 100 g of ice cools from 0^0 C to -10^0 C = 100 × 10 × 2.1
= 2100 J
Total amount of heat = 8400 + 33600 + 2100
= 44100 J
Time taken = 73.5 min
= 4410 s
Average rate of heat extraction (power)
P = E / t
P = 44100 / 4410
P = 10 W

Question: 5

In an experiment, 17 g of ice is used to bring down the temperature of 40 g of water at 34°C to its freezing temperature. The specific heat capacity of water is 4.2 J g^{-1} K^{-1}. Calculate the specific latent heat of ice. State one important assumption made in the above calculation.

Solution:

Given
Mass of ice m_1 = 17 g
Mass of water m_2 = 40 g
Change in temperature = 34 – 0
= 34 K
Specific heat capacity of water is 4.2 J g^{-1} K^{-1}
Assuming there is no loss of heat, heat energy gained by ice (latent heat of ice), Q = heat energy released by water
Q = 40 × 34 × 4.2
Q = 5712 J
Specific latent heat of ice L = Q / m
= 5712 / 17
= 336 J g^{-1}
Assumption: There is no loss of energy.

Question: 6
Find the result of mixing 10 g of ice at -10°C with 10 g of water at 10°C. Specific heat capacity of ice is 2.1 J g^{-1} K^{-1}, specific latent heat of ice = 336 J g^{-1}, and specific heat capacity of water = 4.2 J g^{-1} K^{-1}.
Solution:
Let whole of the ice melts and let the final temperature of the mixture be T^0 C
Amount of heat energy gained by 10 g of ice at – 10^0 C to raise its temperature to 0^0 C = 10 × 10 × 2.1
C = 210 J
Amount of heat energy gained by 10 g of ice at 0^0 C to convert into water at 0^0 C = 10 × 336
C = 3360 J
Amount of heat energy gained by 10 g of water (obtained from ice) at 0^0 C to raise its temperature to T^0 C = 10 × 4.2 × (T – 0)
= 42 T
Amount of heat energy released by 10 g of water at 10^0 C to lower its temperature to T^0 C
= 10 × 4.2 × (10 – T)
= 420 – 42T
Heat energy gained = Heat energy lost
210 + 3360 + 42 T = 420 – 42T
T = -37.5^0 C
This cannot be true because water cannot exist at this temperature.
So whole of the ice does not melt. Let m gm of ice melts. The final temperature of the mixture becomes 0^0C.
So, amount of heat energy gained by 10 g of ice at -10^0 C to raise its temperature to 0^0 C
= 10 × 10 × 2.1
= 210 J
Amount of heat energy gained by m gm of ice at 0^0 C to convert into water at 0^0 C = m ×336 = 336 m J
Amount of heat energy released by 10 g of water at 10^0 C to lower its temperature to 0^0 C
= 10 × 4.2 × (10 – 0)
= 420
Heat energy gained = Heat energy lost
210 + 336 m = 420
m = 210 / 336
m = 0.625 gm

Question: 7
A piece of ice of mass 40 g is added to 200 g of water at 50°C. Calculate the final

temperature of water when all the ice has melted. Specific heat capacity of water = 4200 J kg^{-1} K^{-1} and specific latent heat of fusion of ice =336 x 10^3 J kg^{-1}.

Solution:

Let final temperature of water when all the ice has melted = T^0 C

Amount of heat lost when 200 g of water at 50^0 C cools to T^0 C = 200 × 4.2 × (50 – T)

= 42000 – 840T

Amount of heat gained when 40 g of ice at 0^0 C converts into water at 0^0 C = 40 × 336 J

= 13440 J

Amount of heat gained when temperature of 40 g of water at 0^0 C rises to T^0 C = 40 × 4.2 × (T – 0)

= 168T

We know that,

Amount of heat gained = amount of heat energy lost

13440 + 168T = 42000 – 840T

168T + 840T = 42000 – 13440

1008T = 28560

T = 28560 / 1008

T = 28.33^0 C

Question: 8

250 g of water at 30^o C is contained in a copper vessel of mass 50 g. Calculate the mass of ice required to bring down the temperature of the vessel and its contents to 5^o C. Given specific latent heat of fusion of ice = 336 x 10^3 J kg^{-1}, specific heat capacity of copper = 400 J kg^{-1} K^{-1}, specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

Solution:

Mass of copper vessel m_1 = 50 g

Mass of water contained in copper vessel m_2 = 250 g

Mass of ice required to bring down the temperature of vessel = m

Final temperature = 5^0 C.

Amount of heat gained when 'm' g of ice at 0^0 C converts into water at 0^0 C = m × 336 J

Amount of heat gained when temperature of 'm' g of water at 0^0 C rises to 5^0 C = m × 4.2 × 5

Total amount of heat gained = m × 336 + m × 4.2 × 5

Amount of heat lost when 250 g of water at 30^0 C cools to 5^0 C = 250 × 4.2 × 25

= 26250 J

Amount of heat lost when 50 g of vessel at 30^0 C cools to 5^0 C = 50 × 0.4 × 25

= 500 J

Total amount of heat lost = 26250 + 500

= 26750 J

We know that amount of heat gained = amount of heat lost
m × 336 + m × 4.2 × 5
= 26750
357 m = 26750
m = 26750 / 357
m = 74.93 g
∴ mass of ice required is 74.93 g

Question: 9
2 kg of ice melts when water at 100^{o}C is poured in a hole drilled in a block of ice. What mass of water was used? Given: Specific heat capacity of water = 4200 J kg^{-1} K^{-1}, specific latent heat of ice = 336 × 10^3 J Kg^{-1}.
Solution:
Since the whole block does not melt and only 2 kg of it melts, so the final temperature would be 0^0 C.
Amount of heat energy gained by 2 kg of ice at 0^0 C to convert into water at 0^0 C = 2 × 336000
= 672000 J
Let amount of water poured = m kg
Initial temperature of water = 100^0 C
Final temperature of water = 0^0 C
Amount of heat energy lost by m kg of water at 100^0 C to reach temperature 0^0 C = m × 4200 × 100
= 420000 m J
We know that heat energy gained = heat energy lost
672000 J = m × 420000 J
m = 672000 / 420000
m = 1.6 kg

Question: 10
Calculate the total amount of heat energy required to convert 100 g of ice at -10^o C completely into water at 100^o C. Specific heat capacity of ice = 2.1 J g^{-1} K^{-1}, specific heat capacity of water = 4.2 J g^{-1} K^{-1}, specific latent heat of fusion of ice = 336 J g^{-1}.
Solution:
Amount of heat energy gained by 100 g of ice at – 10^0 C to raise its temperature to 0^0 C = 100 × 2.1 × 10
= 2100 J
Amount of heat energy gained by 100 g of ice at 0^0 C to convert into water at 0^0 C = 100 × 336

= 33600 J
Amount of heat energy gained when temperature of 100 g of water at 0^0 C rises to 100^0 C
= 100 × 4.2 × 100
= 42000 J
Total amount of heat energy gained is = 2100 + 33600 + 42000
= 77700 J
= 7.77×10^4 J

Question: 11
The amount of heat energy required to convert 1 kg of ice at -10°C completely into water at 100°C is 777000 J. calculate the specific latent heat of ice. Specific heat capacity of ice = 2100 J kg^{-1} K^{-1}, Specific heat capacity of water is 4200 J kg^{-1} K^{-1}.
Solution:
Amount of heat energy gained by 1 kg of ice at – 10^0 C to raise its temperature to 0^0 C =
1 × 2100 × 10
= 2100 J
Amount of heat energy gained by 1 kg of ice at 0^0 C to convert into water at 0^0 C = L
Amount of heat energy gained when temperature of 1 kg of water at 0^0 C rises to 100^0 C
= 1 × 4200 × 100
420000 J
Total amount of heat energy gained = 21000 + 420000 + L
= 441000 + L
Given that total amount of heat gained is 777000 J
So,
441000 + L = 777000
L = 777000 – 441000
L = 336000 J kg^{-1}

Question: 12
200 g of ice at 0 °C converts into water at 0 °C in 1 minute when heat is supplied to it at a constant rate. In how much time, 200 g of water at 0 °C will change to 20 °C? Take specific latent heat of ice = 336 J g^{-1}.
Solution:
Given,
Mass of ice, m_{ice}= 200 g
Time for ice to melt, t_1 = 1 min
= 60 s
Mass of water, m_w = 200 g
Temperature change of water, $\Delta T = 20^0$ C

Rate of heat exchange is constant. So, power required for converting ice to water is same as the power required to increase the temperature of water.

$P_{ice} = P_{water}$

$E_{ice} / t_1 = E_{water} / t_2$

$m_{ice}L / t_1 = m_w c_w \Delta T / t_2$

$t_2 = (m_w c_w \Delta T \times t_1) / m_{ice}L$

$t_2 = (200 \times 4.2 \times 20 \times 60) / 200 \times 336$

$t_2 = 15$ s