Science Part I (solutions) for Class 10 Science Chapter 5 - Heat

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Question 1:

Fill in the blanks and rewrite the sentence.
a. The amount of water vapour in air is determined in terms of its ....
b. If objects of equal masses are given equal heat, their final temperature will be different. This is due to difference in their ....
c. During transformation of liquid phase to solid phase, the latent heat is ....

ANSWER:

a. The amount of water vapour in air is determined in terms of its absolute humidity.
b. If objects of equal masses are given equal heat, their final temperature will be different. This is due to difference in their different specific heat capacity.
c. During transformation of liquid phase to solid phase, the latent heat is latent heat of fusion.

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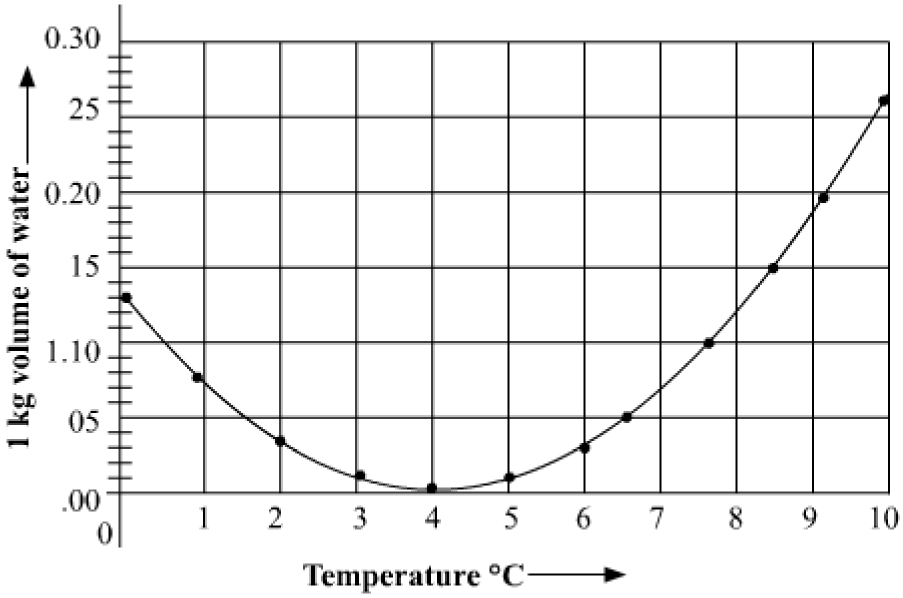
Question 2:

Observe the following graph. Considering the change in volume of water as its temperature is raised from 0°C, discuss the difference in the behaviour of water and other substances. What is this behaviour of water called?



ANSWER:

Most of the substances expand on heating and contract on cooling. Whereas, from the graph, it is clearly visible that water shows a distinct and peculiar behavior between 0^oC to 4^oC. Water, instead of expanding, contracts between 0^oC to 4^oC. After 4^oC, it shows the normal behavior of expansion as is shown by other substances. Thus, at 4^oC, water posses maximum density and minimum volume.
This behavior of water between 0^oC to 4^oC is known as anomalous behavior of water.

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Question 3:

What is meant by specific heat capacity? How will you prove experimentally that different substances have different specific heat capacities?

ANSWER:

Specific heat capacity of a body is the amount of heat energy required to raise the temperature of unit mass of that body through 1°C (or 1 K). It is given as

$s = \frac{\Delta Q}{\Delta T \times m}$

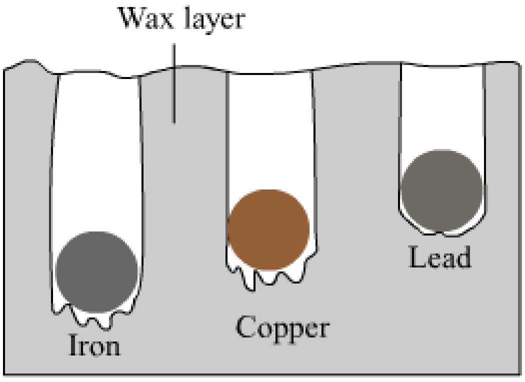
where,

$\Delta Q = \text{Amount of heat energy supplied}$

$\Delta T = \text{Rise in temperature}$

$m = \text{Mass of the body}$

Experiment to prove different substances have different specific heat capacities:



Take three balls of iron, copper and lead of equal mass and put them in boiling water for some time. Then, take them out of the water and measure their temperature. All of them will be at temperature 100°C. Now, put them immediately on the thick slab of wax. Note the depth that each of the ball goes into the wax. The ball which absorbs more heat from the water will give more heat to wax. More wax will thus melt and the ball will go deeper in the wax. It will be observed that the iron ball goes deepest into the wax. Lead ball goes the least and copper ball goes to intermediate depth. This shows that for equal rise in temperature, the three balls have absorbed different amounts of heat. This means that the property which determines the amount of heat absorbed by a ball is different for the three balls. This property is called the specific heat capacity.

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Question 4:

While deciding the unit for heat, which temperature interval is chosen? Why?

ANSWER:

While deciding the unit for heat (which is calorie), the temperature interval chosen is 14.5°C-15.5°C.

We know that the amount of heat released or absorbed by a body is given as

$\Delta Q = ms\,\Delta T$

Now, we also know that one calorie is defined as the amount of heat required to raise the temperature of 1 g of water through 1°C. Thus, for 1 calorie of heat energy, the specific heat capacity of water should be 1 cal g^{-1} $^{o}C^{-1}$. It is found experimentally that the specific heat capacity of water is 1 cal g^{-1} $^{o}C^{-1}$ when the temperature range is 14.5°C-15.5°C.

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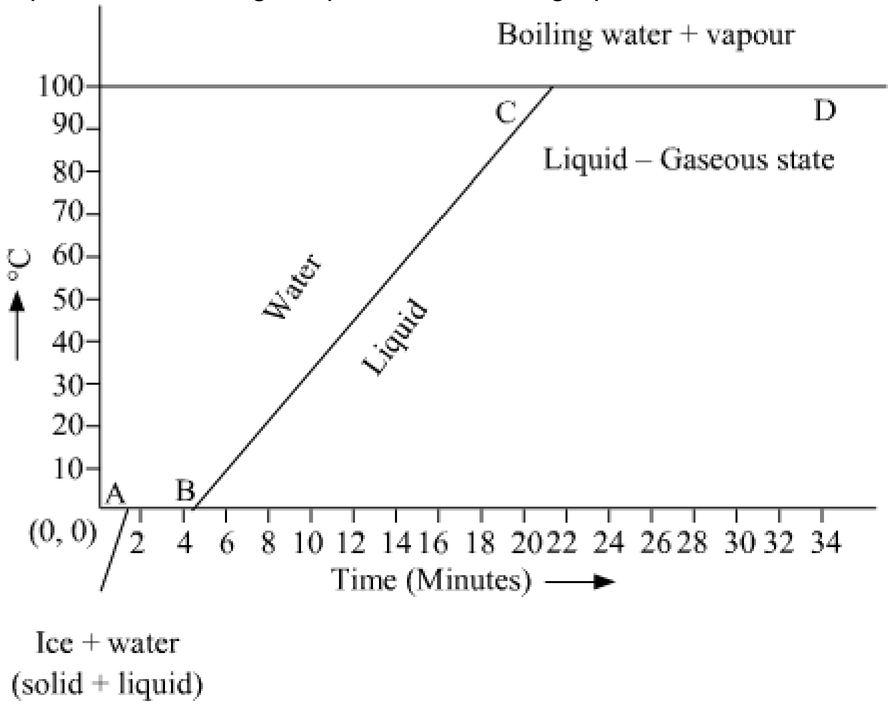
Question 5:

Explain the following temperature vs time graph.



ANSWER:

In the given graph, line AB represents conversion of ice into water at constant temperature. When ice is heated, it melts at 0°C and converts into water maintaining constant temperature of 0°C. This constant temperature, at which the ice converts into water is called the melting point of ice. Also, during this transition, the ice absorbs heat energy. This heat energy is utilised for weakening the bonds between the atoms or molecules in the ice to transform itself into liquid. This heat energy absorbed by ice, at constant temperature, to convert it into liquid is called the latent heat of fusion.

Once all the ice is transformed into water, the temperature of water starts rising. It increases upto 100°C. Line BC in the graph represents rise in temperature of water from 0°C to 100°C. Thereafter, even though heat energy is supplied to water, its temperature does not rise. The heat energy is absorbed by water at this temperature and is used to break the bonds between molecules of the liquid and convert the liquid into gaseous state. Thus, during transformation from liquid phase to gas phase, heat energy is absorbed by the liquid, but its temperature does not change. The constant temperature at which the liquid transforms into gaseous state is called the boiling point of the liquid. The heat energy absorbed at constant temperature during transformation of liquid into gas is called the latent heat of vaporization.

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Question 6:

Explain the following:

a. What is the role of anomalous behaviour of water in preserving aquatic life in regions of

cold climate?
b. How can you relate the formation of water droplets on the outer surface of a bottle taken out of refrigerator with formation of dew?
c. In cold regions in winter, the rocks crack due to anomolous expansion of water.

ANSWER:

a. The anomalous behaviour of water is that it contracts from $0^{o}C$ to $4^{o}C$ and beyond $4^{o}C$ it expands. Thus, the density of water is maximum at $4^{o}C$.
When the surrounding temperature falls, the water in oceans and rivers cools down and say the temperature of whole water reaches $4^{o}C$. Thus, the water reaches its maximum density at this temperature. Below this temperature ($4^{o}C$), the water layer on the surface expands due to anomalous behaviour of water because of which it's density decreases. Thus, this colder layer remains on top and converts into ice which acts as an insulator and does not allow the temperature of water layer below it to fall below $4^{o}C$. In this way, a liveable temperature is maintained for the aquatic life under the oceans and rivers due to the anomalous behaviour of water.

b. In both the given processes, the temperature of the air near the surface of bottle or the leaves (in case of dew formation) decreases to dew point. Thus, the air becomes saturated with water vapour. As a result, water vapour converts or condenses into tiny water droplets which appears on the surface of bottle or leaves.

c. Water has the property of expanding below $4^{o}C$. Thus, in cold regions when the temperature falls below $4^{o}C$, the water content present in rocks expands. Due to this expansion of water or increase in volume of water, the rocks cracks.

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Question 7:

Answer the following:
a. What is meant by latent heat? How will the state of matter transform if latent heat is given off?
b Which principle is used to measure the specific heat capacity of a substance?
c. Explain the role of latent heat in the change of state of a substances?
d. On what basis and how will you determine whether air is saturated with vapour or not?

ANSWER:

a. Latent heat of a body is the amount of heat required to change the state of unit mass of the body from solid to liquid or from liquid to gas without any change in temperature. If latent heat is given off, then the body in liquid state will transform to solid state and the body in vapour state will transform to liquid state. This means the internal energy of the matter decreases when latent heat is given off.

b. Principle of heat exchange is used in the calorimetry method to determine the specific heat capacity of a substance.

c. According to the kinetic model, the total energy of a molecule is the sum of kinetic energy due to its motion (which depends on temperature) and its potential energy (which depends on the force of attraction between the molecules and the separation between them. During the phase change of a substance, its temperature does not increase and hence its kinetic energy. But the potential energy increases or decreases depending on the type of phase transformation (for ex: while melting of ice, the separation between the molecules of ice increases and hence its potential energy). Thus, some energy is required in increases or decreasing the separation between the molecules. Thus, the heat supplied during phase transformation is used up in increasing or decreasing the potential energy and this heat energy is known as latent heat.

d. On the basis of amount of water vapours present in the air, it can be either saturated or unsaturated. If the amount of water vapours exceeds the amount that the air can contain, then it is called saturated. If the amount of water vapour is less than the limit of the amount that air can contain then it is called unsaturated.
We can determine whether the air is saturated with vapour or not in terms of relative humidity. If the relative humidity is 100%, the air will be saturated otherwise not.

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Question 8:

Read the following paragraph and answer the questions.
If heat is exchanged between a hot and cold object, the temperature of the cold object goes on increasing due to gain of energy and the temperature of the hot object goes on decreasing due to loss of energy.
The change in temperature continues till the temperatures of both the objects attain the same value. In this process, the cold object gains heat energy and the hot object loses heat energy. If the system of both the objects is isolated from the environment by keeping it inside a heat resistant box (meaning that the energy exchange takes place between the two objects only), then no energy can flow from inside the box or come into the box.
i. Heat is transferred from where to where?
ii. Which principle do we learn about from this process?
iii. How will you state the principle briefly?
iv. Which property of the substance is measured using this principle?

ANSWER:

(i) Heat is transferred from the object at higher temperature to the object at lower temperature.

(ii) We learn the principle of heat exchange from this process.

(iii) Principle of heat exchange states that the heat energy lost by hot object is always equal to heat gained by cold object provided that the system of both the objects is isolated.

(iv) Specific heat of an object can be measured using this principle.

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Question 9:

Solve the following problems:
a. Equal heat is given to two objects A and B of mass 1 g. Temperature of A increases by 3°C and B by 5°C. Which object has more specific heat? And by what factor?
b. Liquid ammonia is used in ice factory for making ice from water. If water at 20°C is to be converted into 2 kg ice at 0°C, how many grams of ammonia are to be evaporated? (Given: The latent heat of vaporization of ammonia= 341 cal/g)
c. A thermally insulated pot has 150 g ice at temperature 0°C. How much steam of 100°C has to be mixed to it, so that water of temperature 50°C will be obtained? (Given : latent heat of melting of ice = 80 cal/g, latent heat of vaporization of water = 540 cal/g, specific heat of water = 1 cal/g °C)
d. A calorimeter has mass 100 g and specific heat 0.1 kcal/ kg °C. It contains 250 gm of liquid at 30°C having specific heat of 0.4 kcal/kg °C. If we drop a piece of ice of mass 10 g at 0°C, What will be the temperature of the mixture?

ANSWER:

a. Specific heat capacity of a body is given as
$s=\frac{\Delta Q}{m\Delta T}$
Let Q cal of heat is given to both A and B.
For body A,
$s_1=\frac{Q}{1\times 3}=\frac{Q}{3}\ \text{cal g}^{-1}\ {}^{\text{o}}\text{C}^{-1}$
For body B,
$s_2=\frac{Q}{1\times 5}=\frac{Q}{5}\ \text{cal g}^{-1}\ {}^{\text{o}}\text{C}^{-1}$
Now,
$\frac{s_1}{s_2}=\frac{\frac{Q}{3}}{\frac{Q}{5}}=\frac{5}{3}$
$\Rightarrow s_1=\frac{5}{3}s_2$
Thus, specific heat capacity of body A is more than body B and by a factor of $\frac{5}{3}$.

b. Amount of heat energy released in cooling 2 kg water from 20°C to 0°C =
$2\times 1000\times 1\times 20=40000\ \text{cal}$
Amount of heat energy released in converting 2 kg water at 0°C to ice =
$2\times 1000\times 80=160000\ \text{cal}$
Thus, total energy required in converting water at 20°C to ice = 200000 cal
Grams of ammonia to be evaporated = $\frac{200000}{341}$ $=$586.5 g

c. Amount of heat required in converting 150 g ice to 0°C to water at 0°C =
$150\times 80=12000\ \text{cal}$
Amount of heat energy required in heating 150 g water at 0°C to 150 g water at 50°C =

$150 \times 1 \times 50 = 7500 \text{ cal}$

Total heat energy required to convert 150 g ice at 0°C to water at 50°C = 19500 cal

Let *m* g be the amount of steam be mixed with water to bring the final temperature of system at 50°C.

The amount of heat released in converting *m* g of steam at 100°C to water at 100°C =

$m \times 540 = 540m$

The amount of heat released in converting *m* g of water at 100°C to water at 50°C =

$m \times \times 1 \times 50 = 50m$

Total heat energy released to convert *m* g steam at 100°C to water at 50°C = 590*m* cal

Using the principle of calorimetry, we have

590*m* = 19500

$m = \frac{19500}{590} = 33 \text{ g}$

d. Let the final temperature of the mixture be *T*.

Amount of heat required in converting 10 g ice to 0°C to water at 0°C = $10 \times 80 = 800 \text{ cal}$

Total amount of heat required in converting 10 g water to 0°C to water at *T*°C =

$10 \times 1 \times T = 10T$

Total heat energy required to convert 10 g ice at 0°C to water at *T*°C = 800 + 10*T*

Amount of heat released to raise the temperature of calorimeter at 30°C to *T*°C =

$100 \times 0.1 \times (30 - T) = 10(30 - T)$

Amount of heat released to raise the temperature of 250g of eater at 30°C to *T*°C =

$250 \times 0.4 \times (30 - T) = 100(30 - T)$

Total amount of heat released in the process = $110(30 - T)$

Using the principle of calorimetry, we have

$110(30 - T)$ = 800 + 10*T*

$\Rightarrow T = 20.83\ ^\circ\text{C}$