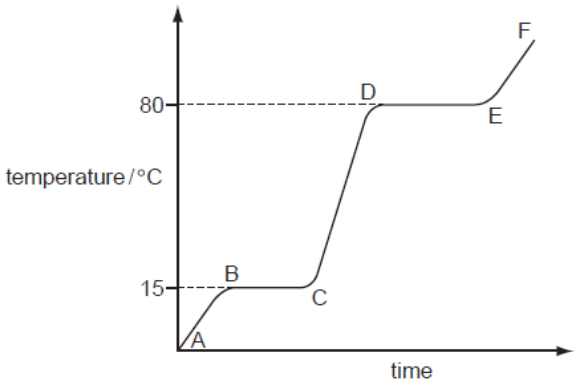
Melting/Boiling/Evaporation

Explaining the change of state on the basis of kinetic theory



- Between A -B:The temperature of the solid increases. This is because increasing the heat energy increases the vibration of the particles in the solid.
- Between B-C:The force of attraction between the particles is weakened so the particles are able to slide past over each other. The temperature does not increase as all the heat supplied goes into overcoming the forces between the particles instead of raising the temperature. The substance melts.
- Between C-D. As time progresses the average kinetic energy of the liquid particles increases. Hence the temperature increases.
- Between D-E: The force of attraction between the particles is further weakened, so much so that the particles move well away from each other. The temperature is constant because the energy supplied goes into overcoming the forces between the particles instead of raising the temperature. The substance boils.
- Between E and F:The average kinetic energy of the particles increases and hence the speed of the particles also increases. Hence the temperature increases. The gas particles are now further away from each other.
- Note: In the region BC, The equation of the equilibrium is:

$$\text{Solid} \rightleftharpoons \text{Liquid} \qquad X(s) \rightleftharpoons X(l)$$

- The graph proves that a pure substance was used as the substance has a sharp melting point (at BC) and a sharp boiling point (at DE.)
- The temperatures 15^0C and 80^0C are important as they represent the melting and the boiling points.
- If an impure sample would have been used, the line BC would have been lower and the line DE would have been higher.

	C TO D	E TO F
Separation between particles	Close and touching	Far apart
Movement of particles	Random and slow	Fast and random
Can the particles move apart to fill the volume	Cannot move apart	Can move apart

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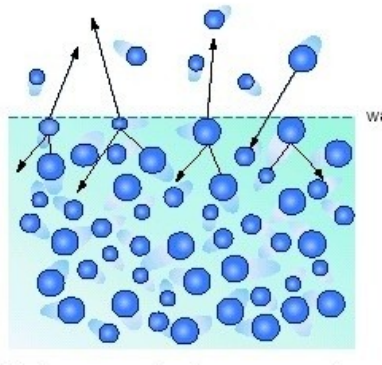
Process of evaporation:

There are weak attractive force between the molecules in a liquid. When a liquid is heated , the kinetic energy of the molecules increases, Molecules with sufficient kinetic energy are able to break away from the neighbouring molecules and escape.



[Note that energy is used to overcome the attractive forces existing between molecules, so only the molecules with highest kinetic energy escape. Also work is done during evaporation]

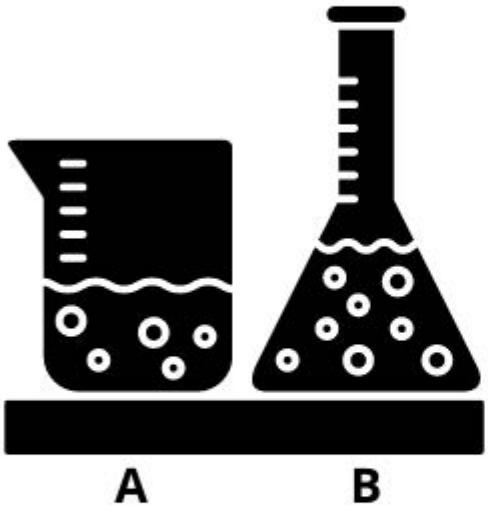
Evaporation causes cooling:

The molecules with the highest kinetic energy escape. Hence the average kinetic energy of the molecules decreases. So the liquid becomes cooler after evaporation takes place.

Factors affecting rate of evaporation:

- Temperature , surface area and a draught of air

EFFECT OF SURFACE AREA ON THE RATE OF EVAPORATION



- Consider same type of hot liquid taken at the same starting temperature and kept in insulating cans A and B , of the same material but of shapes and sizes as shown in the figure aside.
- The liquid in container A will cool faster as it has a large surface area exposed to air as compared to liquid in container B

Explanation: Evaporation is a surface phenomenon. With larger surface area, more liquid molecules have enough kinetic energy to overcome the intermolecular forces of attraction and break away from the liquid and escape into the atmosphere as a gas (or vapour).

EFFECT OF TEMPERATURE ON THE RATE OF EVAPORATION

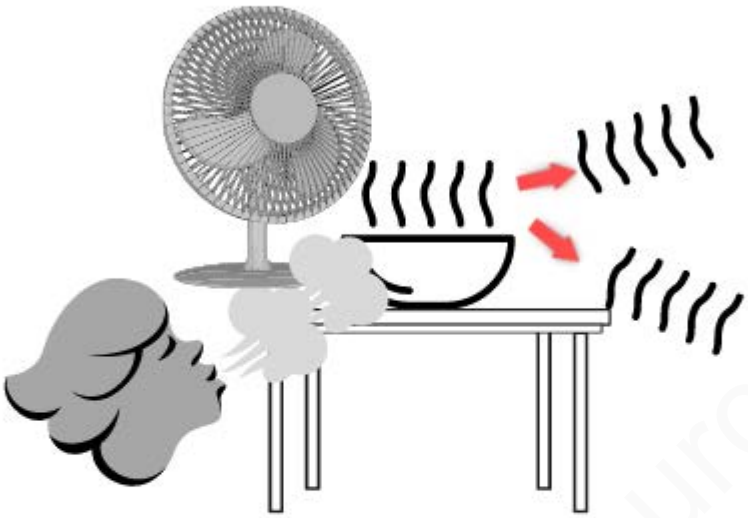
Liquid kept over a flame in figure **A** will evaporate faster as compared to the liquid in the bowl **B**.

EXPLANATION:

in the figure **A**, as the temperature increases, the molecules start moving faster and more molecules have sufficient energy to break the intermolecular forces of attraction and escape

In figure **B**, The evaporation will be slower as very few molecules have the energy needed to break the intermolecular bonds and escape as vapour

EFFECT OF DRAUGHT OF AIR ON THE RATE OF EVAPORATION



A draught of air over a hot surface helps to cool it faster as more molecules of the liquid evaporate

EXPLANATION: After molecules have left the liquid surface, they tend to form a vapour cloud over the liquid surface. A higher wind speed helps remove this vapour cloud. This helps the relative humidity stay unsaturated near the liquid surface. When the air is saturated, the amount of water vapour that evaporates into the air is minimized. Higher windspeed thus helps in faster evaporation by allowing more molecules with sufficient energy to leave the liquid surface and escape after having broken their bonds with their neighbouring molecules

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Uses of evaporation:

- Making salt in salt pans: Salt is made in salt pans by evaporating the water from it.
- Wet clothes will dry faster on a hot day because more of the water molecules have sufficient energy to escape from the surface of the liquid.
- Hot tea gets cooled over time due to evaporation.

Difference between evaporation and boiling:

Sr. No	Evaporation	Boiling
1	Evaporation is a surface phenomenon. (or it does not happen within the liquid)	Boiling happens throughout the liquid
2	Evaporation happens at any temperature	Boiling happens at the liquid's boiling point
3	Evaporation causes cooling	Boiling does not cause cooling, the temperature stays constant.
4	There is no bubbling in evaporation	There is bubbling during boiling

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APPLICATION BASED QUESTIONS:

MCQ:

13 During evaporation, molecules escape rapidly from the surface of a liquid.

What happens to the average energy of the molecules of the remaining liquid and what happens to the temperature of the remaining liquid?

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	average energy of remaining molecules	temperature of remaining liquid
A	decreases	decreases
B	decreases	increases
C	stays the same	decreases
D	stays the same	increases

13 Evaporation occurs when molecules escape from a liquid surface into the air above it. During this process the temperature of the liquid falls.

Why does the temperature of the liquid fall?

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A The molecules in the vapour expand because the pressure is less.

B The molecules left in the liquid have more space to move around.

C The molecules move more slowly when they escape into the air.

D The molecules with the highest energies escape into the air.

5 (a) Fig. 5.1 shows a tank used for evaporating salt solution to produce crystals. 88

M/J/2006-P3

Fig. 5.1

Suggest two ways of increasing the rate of evaporation of the water from the solution. Changes may be made to the apparatus, but the rate of steam supply must stay constant. You may assume the temperature of the salt solution remains constant.

1. .....

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2. .....

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3 Water molecules evaporate from a puddle and escape to the atmosphere. Water molecules also escape to the atmosphere from water boiling in a kettle. 1,3/

(a) State two ways in which *evaporation* differs from *boiling*.

1. .....

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2. .....

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[2]

5 **(a)** Puddles of water form on a path after rainfall on a windy day.

In terms of molecules, state and explain how the rate of evaporation of the puddles is affected by

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(i) a reduction of wind speed,

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(ii) an increase of water temperature.

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(b) Fig. 5.1 shows two puddles.

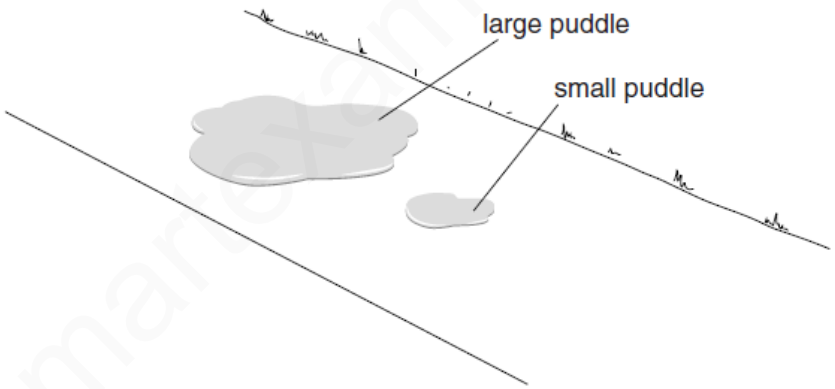

Fig. 5.1

State and explain how the rate of evaporation from the large puddle compares to that from the small puddle under the same conditions.

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3 Water molecules evaporate from a puddle and escape to the atmosphere. Water molecules also escape to the atmosphere from water boiling in a kettle. **M/J/13-P32**

(a) State two ways in which *evaporation* differs from *boiling*.

1. .....

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2. .....

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[2]

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5 **(a)** On a hot day, sweat forms on the surface of a person's body and the sweat evaporates.

Explain, in terms of the behaviour of molecules, **m/j/13-p31**

(i) the process of evaporation,

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(ii) how this process helps the body to cool down.

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(b) In a place where refrigeration is not possible, a person attempts to keep a bottle of milk cool by using the procedure illustrated in Fig. 7.2.

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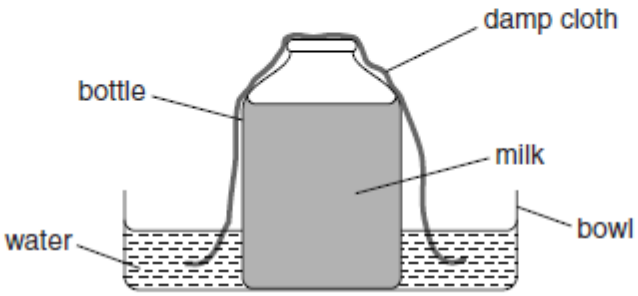

Fig. 7.2

Explain in terms of molecules why this procedure would be successful.

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6 (a) Two students hang out identical T-shirts to dry at the same time in the same neighbourhood. The only difference between the drying conditions is that one T-shirt is sheltered from any wind and the other is in a strong breeze, as shown in Fig. 6.1.

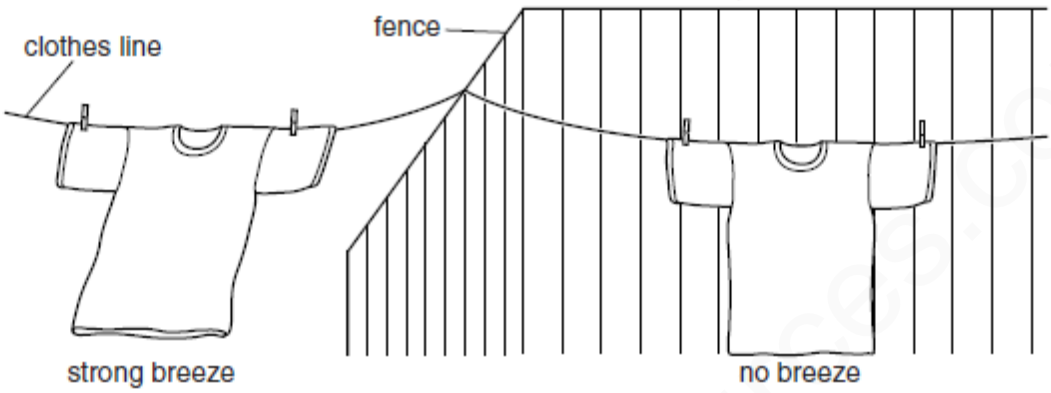

Fig. 6.1

State and explain, in terms of water molecules, the difference between the drying times of the T-shirts.

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Kindly refer to the markschemes of the past papers if the study note board exam questions do not have the markschemes given to you