The Nature of Liquids

Key

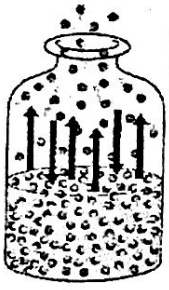
The particles of a liquid are held together by attractive forces between the molecules. The strength of these intermolecular attractions influences how easily the substance can turn into a vapor.

stronger IMF, higher bp, lower vapor pressure

Vaporization vs. Evaporation

Vaporization is the process by which a liquid changes into a gas or vapor. Vaporization can occur in the form of boiling or evaporation.

Evaporation occurs on the surface of liquids at all temperatures. Even at cold temperatures, some water molecules have enough energy to evaporate. As temperature increases more and more molecules enter the gas phase. This process is related to the strength of the forces holding the molecules in the liquid phase. The weaker the forces, the faster the molecules will escape from the liquid into the gas phase. A liquid with weak intermolecular forces will have a relatively large amount of vapor (gas phase) present above its surface. Evaporation can occur in both an open container and a closed container.



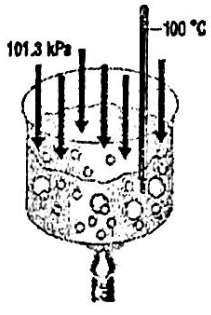
In an open container... water molecules evaporate from the liquid state & escape from the container

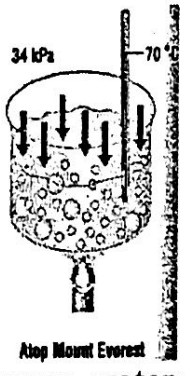
In a closed container... water molecules go into the vapor state, but they cannot escape from the system. They collect as a vapor above the liquid.

Vapor Pressure: the pressure produced when vapor particles above a liquid in a sealed container collide w/ the container walls

Boiling Point: the temperature at which the vapor pressure of the liquid is equal to the external pressure. ∴ the boiling point of a liquid changes if the external pressure changes.

Normal boiling point: → the boiling point of a liquid at standard pressure (1 atm or 101.3 kPa)





} demo of boiling water in bell jar

Ex. The normal boiling point of water is 100°C. However, water can boil at different temperatures when the external pressure changes.

⊗ The stronger the IMF, the higher the bp & the lower the vapor pressure (not as many molecules in vapor phase to collide w/ container)

TASK: Place an equal amount of ethanol, acetone (propanone), and water on three separate cotton balls. Wipe the cotton balls on the desk at the same time. Observe the relative rate of evaporation for the liquids. Record your observations below.

OBSERVATIONS:

ANALYSIS:

1. Which liquid evaporated at the fastest rate? acetone
2. Which liquid evaporated at the slowest rate? water
3. Based on your observations, which of the three liquids has the highest vapor pressure? Support your answer with your observations.

acetone, since it evaporated first. More molecules in vapor phase to collide w/ container walls, so higher vapor pressure

stronger IMF, higher bp, lower vapor pressure

4. Which of the three liquids has the strongest intermolecular forces? Support your answer with an explanation.

water. Evaporated @ slowest rate, indicating it had the highest bp, due to the strongest IMF.

5. Predict which of the three liquids would have the highest boiling point. Support your answer with an explanation.

Water

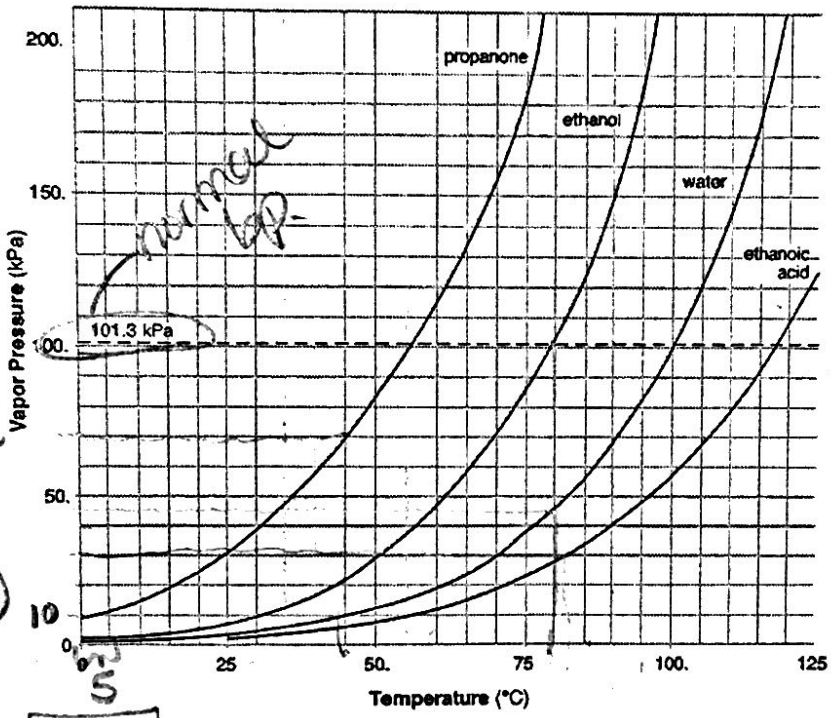
same reasoning

Vapor Pressure Curves (TABLE H)

As the temperature of a liquid increases, vapor pressure increases.

(more particles in vapor phase, so higher vapor pressure)

Table H
Vapor Pressure of Four Liquids



How to use:

any point along a curve the substance is boiling

*note scales of axes x=5 y=10

6. What is the normal boiling point of ethanol? 80°C

7. What is the vapor pressure if a sample of water is boiling at 80°C? 45 kPa

8. What is the atmospheric pressure if a sample of propanone is boiling at 45°C? (= to vapor pressure when boiling) 70 kPa

9. What is the boiling point of ethanoic acid, when the vapor pressure is 30 kPa? ~82°C

10. Which of the liquids listed has the lowest normal boiling point? propanone

11. Which of the liquids has the strongest intermolecular attractions? → highest bp, ethanoic acid

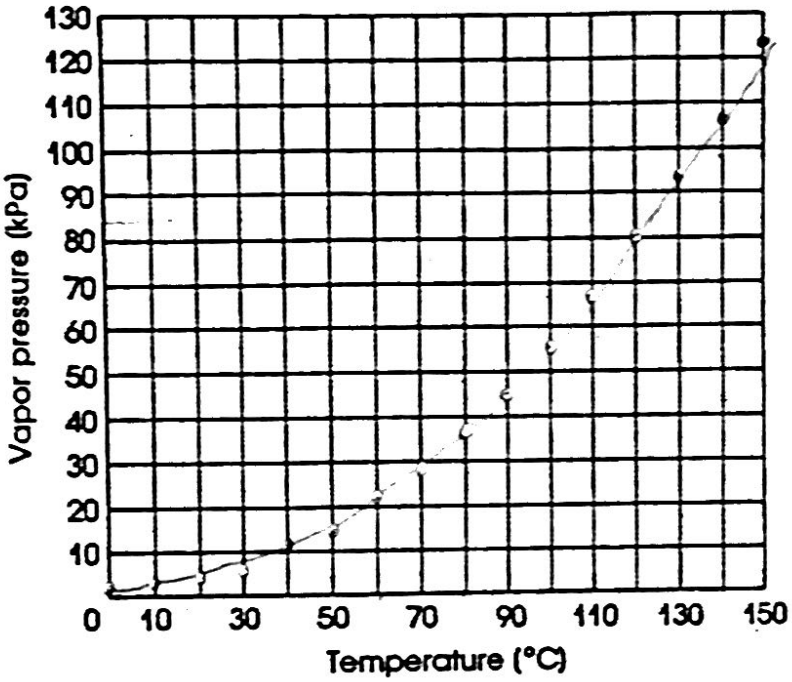
12. Compare your observations from the activity on the previous page to the information provided on Table H. Do they correspond? Why or why not?

yes

Questions 13 through 18 refer to the information below.

The following table shows the vapor pressure of a liquid at various temperatures. Plot the data on the graph provided.

Temp °C	Pressure (kPa)	Temp °C	Pressure (kPa)	Temp °C	Pressure (kPa)
0	1	60	22	120	80
10	2	70	29	130	93
20	4	80	37	140	107
30	7	90	46	150	122
40	11	100	56		
50	16	110	68		



13. What effect does increasing temperature have on vapor pressure?

↑ temp, ↑ vapor pressure

14. What normal boiling point of the boiling point of a liquid?

typo?

15. If atmospheric pressure was 85 kPa, what would be the boiling point of the substance whose vapor pressure you graphed?

~122°C

16. What is the atmospheric pressure if a sample of the substance is boiling at 35°C?

↳ same as vapor pressure

17. What would happen to the boiling point if the atmospheric pressure would begin to increase?

bp would ↑.

18. How would the cooking time of an egg that is to be hard boiled be affected by high altitude? Explain.

high altitude, lower pressure, bp would be lower temp, but it would then take longer for it to cook