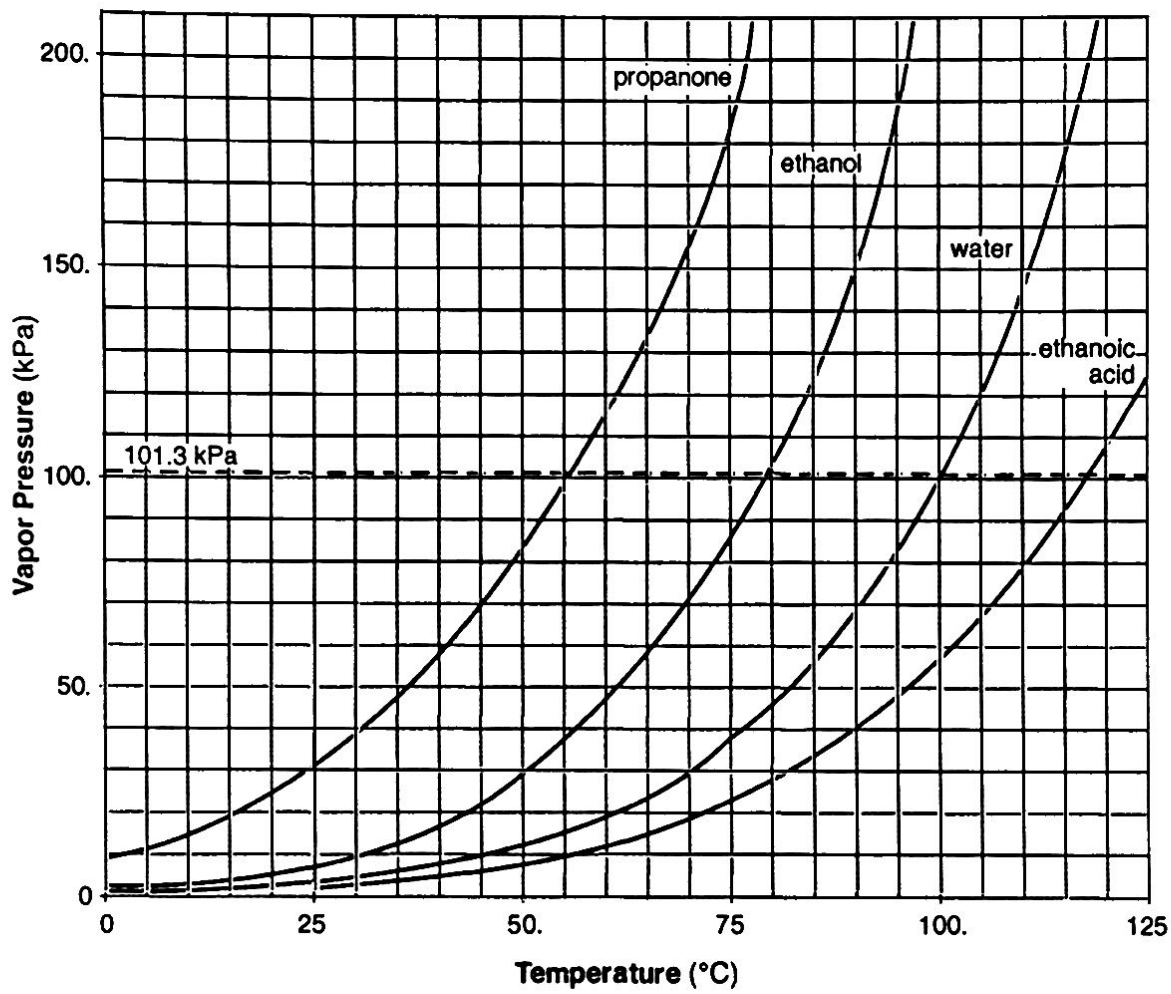


Key

Table H

Vapor Pressure of Four Liquids



Overview:

A liquid is the form of matter that has definite volume but no definite shape. A liquid takes the shape of the container it is in. Above the surface of a liquid, there is always found the gaseous form of that liquid, called a vapor. The term vapor refers to the gas phase of a substance that is ordinarily a solid or liquid at that temperature. This vapor above the surface of a liquid exerts a characteristic pressure called vapor pressure.

The Table:

This table shows the vapor pressure, in kPa, of four liquids as a function of temperature. The graph shows that propanone has the greatest vapor pressure at any given temperature compared to the other three liquids, while ethanoic acid has the lowest vapor pressure at any given temperature compared to the other three liquids. To determine the vapor pressure of a liquid at a specific temperature, move directly up from the given temperature until you reach the intersection point of the liquid's vapor pressure curve. Reading across to the vapor pressure axis gives the vapor pressure of that liquid at that temperature. The dotted horizontal line labeled 101.3 kPa is standard pressure (see Table A).

Temperature vs. Vapor Pressure

As the temperature increases, the vapor pressure increases. This is due to an increased amount of vapor and the greater average kinetic energy of the vapor particles. As the pressure on the surface of a liquid increases, the boiling point of the liquid increases. This is caused by the need to reach a higher vapor pressure to equal the increased pressure on the surface of the liquid.

Boiling Point and Vapor Pressure

The boiling point of a liquid is the temperature at which the vapor pressure is equal to the atmospheric pressure on the surface of the liquid. Therefore, when a liquid is boiling, the atmospheric pressure on the liquid can be read from the vapor pressure axis since they are equal to each other. When the atmospheric pressure is equal to standard pressure, the boiling point is called the normal boiling point. Reading from the graph at standard pressure (101.3 kPa), the normal boiling points of propanone, ethanol, water and ethanoic acid are 56°C, 79°C, 100°C and 117°C, respectively.

Intermolecular Attraction

A higher boiling point for a liquid indicates a greater attraction between the molecules of that liquid. The vapor pressure curves on Table H indicate that propanone has the weakest intermolecular attraction and ethanoic acid has the greatest intermolecular attraction.

Additional Information:

- The vapor pressure depends only upon the nature of the liquid and the temperature. It does not depend upon the amount of liquid.
- If a temperature-pressure point lies on one of the vapor pressure curves, the liquid is boiling, changing from the liquid to the gas phase. If the intersection point of the temperature and atmospheric pressure (read from the vapor pressure axis) of the substance is to the left of its vapor pressure curve, that substance is a liquid. If the intersection point lies to the right of the vapor pressure curve, it is a gas. For example, at 25°C and 150 kPa pressure, propanone is in the liquid phase, while at 25°C and 20 kPa pressure, propanone is in the gaseous phase.

Set 1 — Vapor Pressure of Four Liquids

1. Which substance has the lowest vapor pressure at 75°C?

- (1) water
- (2) ethanoic acid
- (3) propanone
- (4) ethanol

1 2

2. According to Reference Table H, what is the vapor pressure of propanone at 45°C?

- (1) 22 kPa
- (2) 33 kPa
- (3) 70. kPa
- (4) 98 kPa

2 2

3. The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. What is the boiling point of propanone if the pressure on its surface is 48 kilopascals?

- (1) 25°C
- (2) 30.°C
- (3) 35°C
- (4) 40.°C

3 3

4. At which temperature is the vapor pressure of ethanol equal to the vapor pressure of propanone at 35°C?

- (1) 35°C
- (2) 60.°C
- (3) 82°C
- (4) 95°C

4 2

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

- (1) decreases
- (2) increases
- (3) remains the same

5 2

6. As the pressure on the surface of a liquid decreases, the temperature at which the liquid will boil

- (1) decreases
- (2) increases
- (3) remains the same

6 1

7. Using your knowledge of chemistry and the information in Reference Table H, which statement concerning propanone and water at 50°C is true?

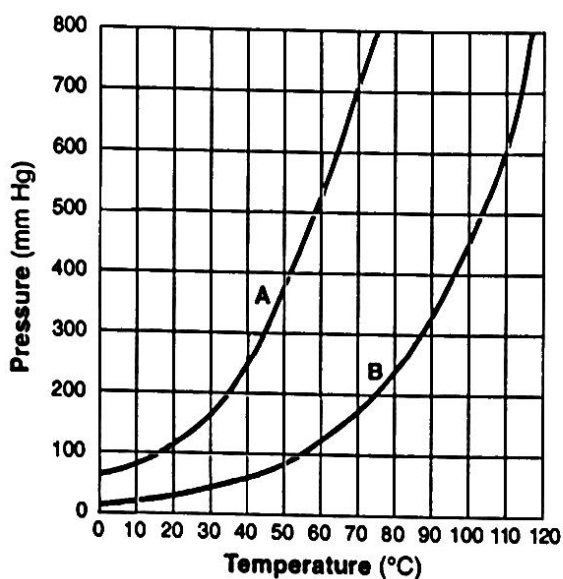
- (1) Propanone has a higher vapor pressure and stronger intermolecular forces than water.
- (2) Propanone has a higher vapor pressure and weaker intermolecular forces than water.
- (3) Propanone has a lower vapor pressure and stronger intermolecular forces than water.
- (4) Propanone has a lower vapor pressure and weaker intermolecular forces than water.

7 2

8. A liquid boils when the vapor pressure of the liquid equals the atmospheric pressure on the surface of the liquid. Using Reference Table H, determine the boiling point of water when the atmospheric pressure is 90. kPa.

98°C

Base your answers to question 9 using your knowledge of chemistry and on the graph below, which shows the vapor pressure curves for liquids *A* and *B*. Note: The pressure is given in mm Hg – millimeters of mercury.



9. a) What is the vapor pressure of liquid *A* at 70°C? Your answer must include correct units.

700 mm Hg

b) At what temperature does liquid *B* have the same vapor pressure as liquid *A* at 70°C? Your answer must include correct units.

115°C

c) At 400 mm Hg, which liquid would reach its boiling point first?

A

d) Which liquid will evaporate more rapidly? Explain your answer in terms of intermolecular forces.

"A" will evaporate more rapidly because the particles are not as attracted to one another; "A" has weaker intermolecular forces.

Set 2 — Vapor Pressure of Four Liquids

10. At 65°C, which compound has a vapor pressure of 58 kilopascals?

- (1) ethanoic acid (3) propanone
 (2) ethanol (4) water 10 2

11. Which liquid has the highest vapor pressure at 75°C?

- (1) ethanoic acid (3) propanone
 (2) ethanol (4) water 11 3

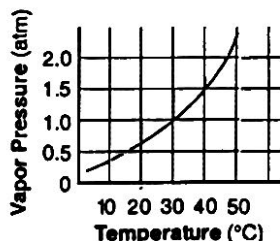
12. When the vapor pressure of water is 70 kPa the temperature of the water is

- (1) 20°C (3) 60°C
 (2) 40°C (4) 91°C 12 4

13. According to Reference Table H, what is the boiling point of ethanoic acid at 80 kPa?

- (1) 28°C (3) 111°C
 (2) 100°C (4) 125°C 13 3

14. The graph below shows the relationship between vapor pressure and temperature for substance X.



What is the normal boiling point for substance X?

- (1) 50°C (3) 30°C
 (2) 20°C (4) 40°C 14 3

15. The table below shows the normal boiling point of four compounds.

Compound	Normal Boiling Point (°C)
HF(l)	19.4
CH ₃ Cl(l)	-24.2
CH ₃ F(l)	-78.6
HCl(l)	-83.7

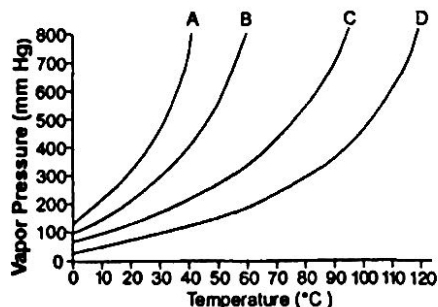
Which compound has the strongest intermolecular forces?

- (1) HF(l) (3) CH₃F(l)
 (2) CH₃Cl(l) (4) HCl(l) 15 1

16. Based on Reference Table H, which substance has the weakest intermolecular forces?

- (1) ethanoic acid
 (2) ethanol
 (3) propanone
 (4) water 16 3

17. The graph below represents the vapor pressure curves of four liquids.



Which liquid has the highest boiling point at 600 mm Hg?

- (1) A (3) C
 (2) B (4) D 17 4

18. A liquid's boiling point is the temperature at which its vapor pressure is equal to the atmospheric pressure. Using Reference Table H, what is the boiling point of propanone at an atmospheric pressure of 70 kPa?

45°C

19. Explain, in terms of molecular energy, why the vapor pressure of propanone increases when its temperature increases.

As temperature increases, the molecules gain more energy, allowing some to go from liquid to vapor. As the amount of vapor increases, the vapor pressure also increases.

20. The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. The heat of vaporization of ethanol is 838 joules per gram. A sample of ethanol has a mass of 65.0 grams and is boiling at 1.00 atmosphere.

Based on Table H, what is the temperature of this sample of ethanol? 80°C

21. A sample of ethanoic acid is at 85°C. At a pressure of 50 kPa, what increase in temperature is needed to reach the boiling point of ethanoic acid? 11°C

22. Based on Reference Table H, which substance has the:

strongest intermolecular forces – ethanoic acid

weakest intermolecular forces – propanone

23. At 70 kPa, determine the boiling point of:

propanone – 45 °C

ethanol – 70 °C

water – 91 °C

ethanoic acid – 106 °C