Colligative Properties and Phase Diagrams - *answers at end*

Colligative Properties

1) What is the boiling point of 0.10 M $CaCl_{2(}$(aq)? Would the actual boiling point be higher or lower than what you calculated? Why? $K_b = 0.512$

2) 10 grams of a non-ionic solid ($i = 1$) are dissolved into 100 mL of water. The freezing point of the water is depressed 3.32 °C. What is the molar mass of the solid? $K_f = 1.86$

3) Osmotic pressure can be used to determine the formula weight of a compound and is commonly used to calculate the mass of proteins. If 1.00 grams of a protein are dissolved in 100 mL of water, the osmotic pressure will be 92.92 torr. What is the molar mass of the protein? Assume $i = 1$

4) Ocean water has about the same amount of salt in it as 0.82 M NaCl. How much pressure must be exerted if you wanted to turn ocean water into salt water by reverse osmosis? Assume 25 °C.

5) The freezing point depression of a dilute solution of Ammonium Hydroxide (NH_4OH) was used measured and found to have an $i = 1.10$. Since this value should not be rounded and it was not a whole value, what can you conclude about the NH_4OH when it dissolves in water?

6) Why do road crews throw salt on the road when it snows? How does it do it?

Phase Diagrams

1a) Draw the phase diagram for naphthalene. It melts at 80.5 °C, boils at 218 °C, and the solid is more dense that its liquid. You do not have to be perfect. Just give the essential features of the diagram.

1b) Using the diagram just drawn, show how solid naphthalene is more dense than liquid naphthalene.

2) Using the phase diagram for water, explain why an ice skater can glide smoothly across the ice. What is the skater actually gliding on?

3) Sketch a phase diagram for benzene and locate these points: the triple point (5.5 °C and 35.8 torr), the boiling point (80.1 °C) and the critical point (288.5 °C and 47.7 atm). Solid benzene does not float on its liquid.

4) Sketch a phase diagram for dry ice (CO_2) and locate these points: the triple point (-56.4 °C and 5.11 atm), the sublimation point (-78.5 °C) and the critical point (31.1 °C and 73 atm). Solid CO_2 does not float on its liquid.

Colligative Properties

1) What is the boiling point of 0.10 M $CaCl_2$? Would the actual boiling point be higher or lower than what you calculated? Why? $K_b = 0.512$

$\Delta T = 0.512\ (0.1)(3) = 0.1536\ ^\circ C + 100\ ^\circ C = 100.1536\ ^\circ C$. The actual BP would be lower because *i* will not be exactly 3. This is because the ions are not completely separate in solution - they "clump" together a little, making the solution look less concentrated than it really is. We usually ignore this affect when we do our calculations.

2) 10 grams of a non-ionic solid (*i* = 1) are dissolved into 100 mL of water. The freezing point of the water is depressed 3.32 °C. What is the molar mass of the solid? $K_f = 1.86$

$\Delta T = 1.86\ (m)(1) = 3.32^\circ C$ —> m = 1.785 M = (10g/MM)/0.100 L) so MM = 56.02 g/mol.

3) Osmotic pressure can be used to determine the formula weight of a compound and is commonly used to calculate the mass of proteins. If 1.00 gram of a protein is dissolved in 100 mL of water, the osmotic pressure will be 92.92 torr. What is the molar mass of the protein? Assume *i* = 1 and 25 °C.

(92.92 torr/760 torr/atm) = c(0.08206)(298) —> c = 0.005 M (1gram/MM)/(0.100L) =

0.005 M —> MM = 2000 g/mol

4) Ocean water has about the same amount of salt in it as 0.82 M NaCl. How much pressure must be exerted if you wanted to turn ocean water into salt water by reverse osmosis? Assume 25 °C.

$\Pi = (2)(0.82\ M)(0.08206)(298K) = 40.1$ atm or more

5) The freezing point depression of a dilute solution of Ammonium Hydroxide (NH_4OH) was used measured and found to have an *i* = 1.10. Since this value should not be rounded and it was not a whole value, what can you conclude about the NH_4OH when it dissolves in water?

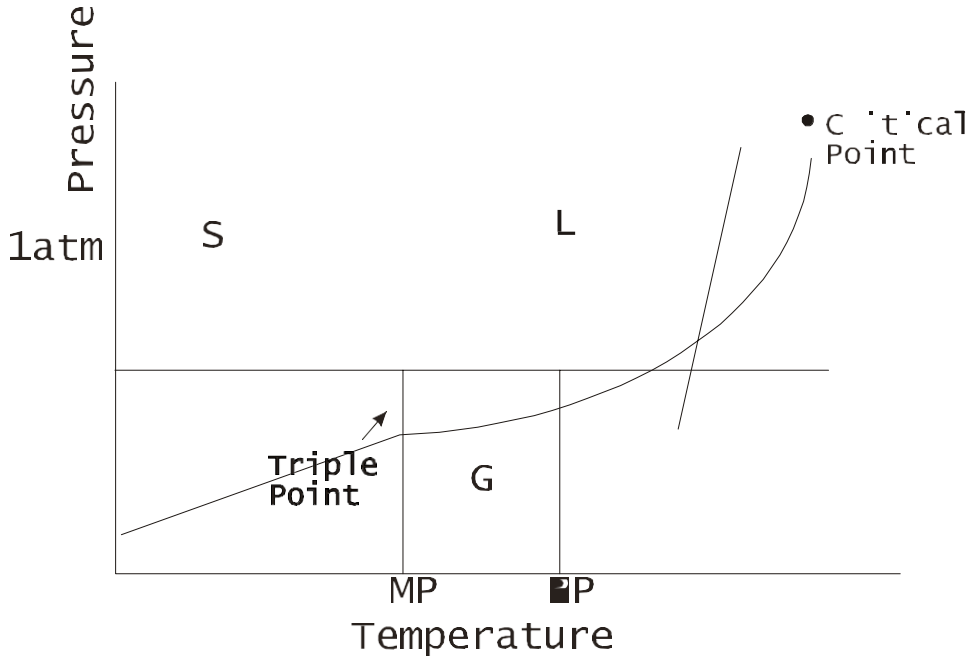
It seems that NH_4OH does not form NH_4^+ and OH^- in water. It stays mostly as NH_4OH and only a small amount becomes NH_4^+ and OH^-.

6) Why do road crews throw salt on the road when it snows? How does it do it?

The salt causes the ice to melt by lowering its freezing point.

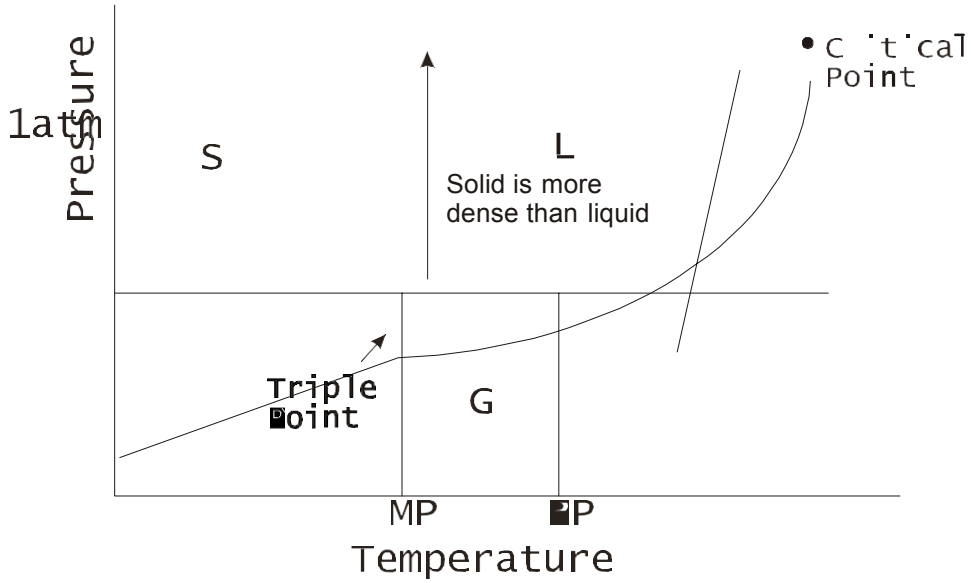
Phase Diagrams

1a) Draw the phase diagram for naphthalene. It melts at 80.5 °C, boils at 218 °C, and the solid is more dense that its liquid. You do not have to be perfect. Just give the essential features of the diagram.



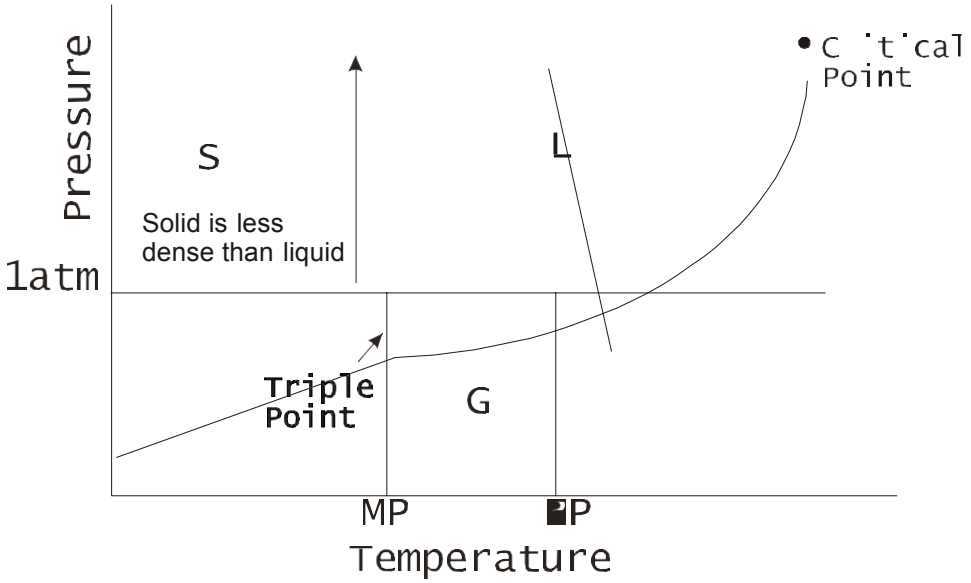
1b) Using the diagram just drawn, show how solid naphthalene is more dense than liquid naphthalene.

As pressure increases you move from the liquid into the solid phase. The more dense medium is the solid so it sinks on the liquid.



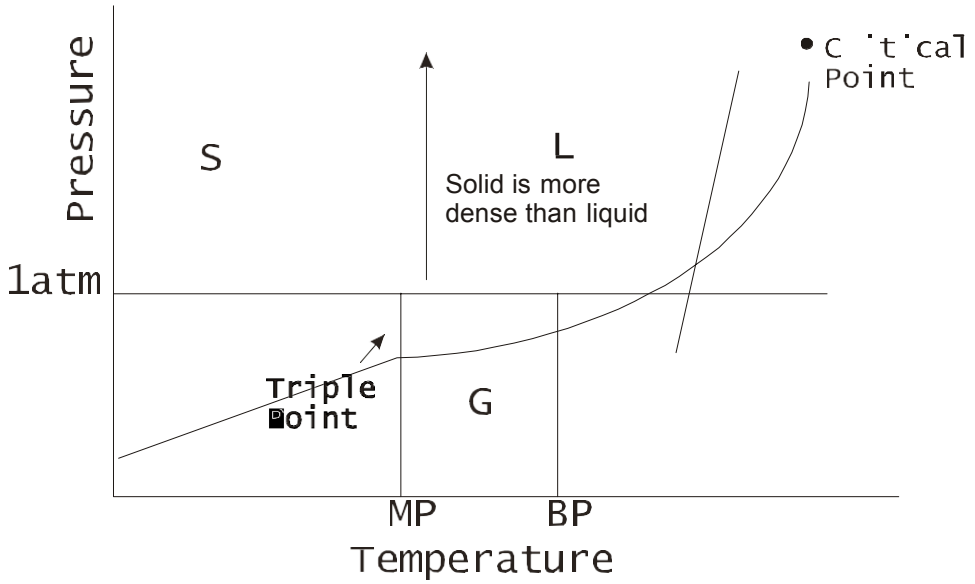
2) Using the phase diagram for water, explain why an ice skater can glide smoothly across the ice. What is the skater actually gliding on?

The pressure from the skate melts the ice so the skater actually skates on a thin layer of water.

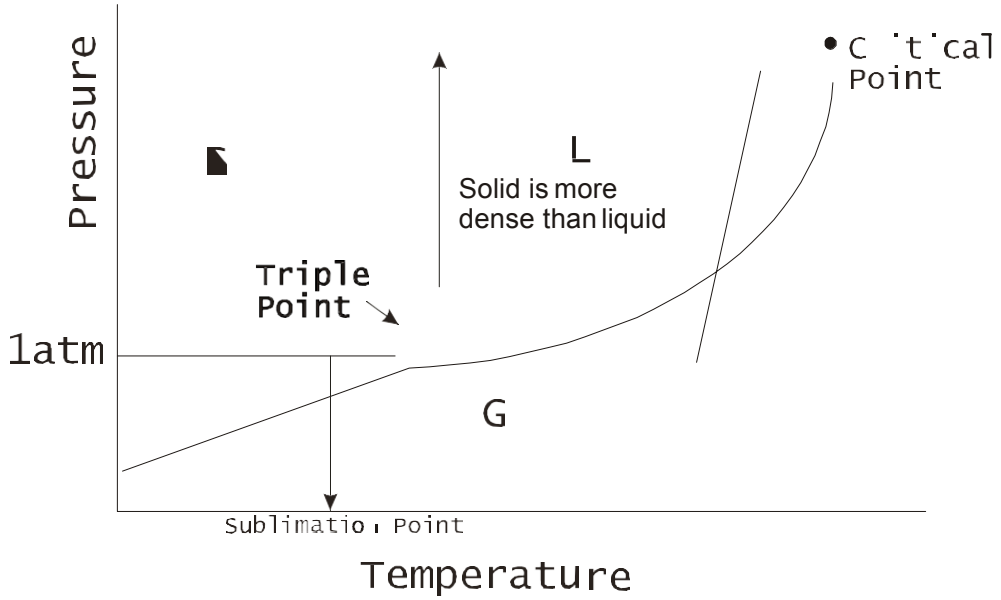


3) Sketch a phase diagram for benzene and locate these points: the triple point (5.5 °C and 35.8 torr), the boiling point (80.1 °C) and the critical point (288.5 °C and 47.7 atm).

The diagrams all look the same. The only thing that changes is the temperature and pressures where stuff happens.



4) Sketch a phase diagram for dry ice (CO_2) and locate these points: the triple point (-56.4 °C and 5.11 atm), the sublimation point (-78.5 °C) and the critical point (31.1 °C and 73 atm). Solid CO_2 does not float on its liquid



In this case, CO_2 does not have a boiling point or melting point. BP and MP are defined as occurring where the 1 atm pressure line crosses the solid/liquid line (melting point) and the liquid gas line (boiling point). The 1 atm line for CO_2 does not cross either of these line but crosses the solid/gas line which is sublimation.