1. What are colligative properties? What is the meaning of the word “colligative” in this context?

2. How is vapor-pressure lowering related to a rise in the boiling point of a solution?

3. Use a phase diagram to show the difference in freezing points and boiling points between an aqueous urea solution and pure water. *hint: use Figure 12.10*

4. What are ion pairs? How does the ease of ion-pair formation have on the colligative properties of a solution? How does the ease of ion-pair formation depend on charges of the ions?

5. What is the van’t Hoff factor? What information does it provide?

6. For each of the following compounds (a) indicate the van’t Hoff factor (assuming no ion pairs) (b) indicate which compound in each of the following groups has a greater tendency to form ion pairs in water
   a. NaCl or Na₂SO₄
   b. MgCl₂ or MgSO₄
   c. LiBr or KBr

7. Which of the following aqueous solutions has (a) the higher boiling point (b) the higher freezing point (c) the lower vapor pressure: 0.35 \text{ m} \text{ CaCl}_2 or 0.90 \text{ m} \text{ urea}? Explain. *Assume CaCl}_2 to undergo complete dissociation.*

8. Arrange the following aqueous solutions in order of decreasing freezing point, and explain your reasoning: 0.50 \text{ m} \text{ HCl}, 0.50 \text{ m} \text{ glucose}, 0.50 \text{ m} \text{ acetic acid}.

9. Both NaCl and CaCl₂ are used to prevent ice on roads and sidewalks in winter. What advantages do these substances have over sucrose or urea in lowering the freezing point of water?

10. Consider the three mercury manometers shown to the right. One of them has 1 mL of water on top of the mercury, another has 1 mL of 1 \text{ m} urea solution on top of the mercury, and the third one has 1 mL of a 1 \text{ m} NaCl solution places on top of the mercury. Which of these solutions is in the tube labeled X, which is in Y, and which is in Z?