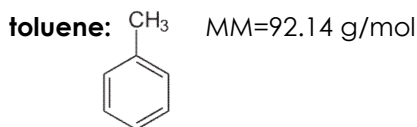
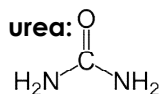


**Part One: Multiple Choice (45 points - 3 points each)**

Select the best answer to each question. There is only one correct answer.

Molecules:



**chloroform:** CHCl<sub>3</sub>  
**ethyl alcohol:** C<sub>2</sub>H<sub>5</sub>OH  
**ethylene glycol:** C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>  
**glucose:** C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>  
**methanol:** CH<sub>3</sub>OH

- What is the mole fraction of urea in a solution that contains 2.0 mol of urea and 3.0 mol of water?  
 a. 0.25      **b. 0.40**      c. 0.50      d. 0.60      e. 0.80
- If 0.100 mol chloroform is dissolved in 400.0 g toluene the molality is:  
**a. 0.250**      b. 0.500      c. 0.750      d. 1.00      e. 2.00
- What is the mole fraction of urea in an aqueous solution that is 46% urea by mass?  
**a. 0.20**      b. 0.25      c. 0.30      d. 0.40      e. 0.80
- What is the molality of ethyl alcohol in an aqueous solution that is 50.% by mass ethyl alcohol?  
 a. 11      b. 15      c. 18      **d. 22**      e. 33
- What is the molarity of an HCl solution that is 20.2 % by mass HCL and has a density of 1.096 g/ml?  
 a. 0.220      b. 5.54      **c. 6.07**      d. 6.93      e. 14.1
- Determine the freezing point of a 0.25 m solution of glucose in water ( $K_f = 1.86 \text{ }^\circ\text{C/m}$ ).  
 a. 0.93 °C      b. -0.93 °C      c. 0.46 °C      **d. -0.46 °C**      e. 0.23 °C
- What is the osmotic pressure for 0.10 M sodium phosphate at 20.0°C? (Note: the solute is ionic!)  
 a. 2.4 atm      b. 4.8 atm      c. 7.2 atm      **d. 9.6 atm**      e. none of these
- A 12.0% sucrose solution has a density of 1.05 g/cm<sup>3</sup>. The number that gives the best value for the mass of sugar in 55mL of this solution is:  
 a. 6.6 g      b. 6.60 g      c. 13.8 g      **d. 6.93 g**      e. 58 g
- What is the freezing point of an aqueous 0.750 molal NH<sub>4</sub>I solution? ( $K_f = 1.86^\circ\text{C/m}$ )?  
 a. -1.40 °C      b. +1.40 °C      c. -1.86 °C      d. +1.86 °C      **e. -2.80 °C**
- Which of the following molecules exhibits hydrogen bonding?  
**a. HNF<sub>2</sub>**      b. H<sub>2</sub>S      c. B<sub>2</sub>H<sub>6</sub>      d. HBr      e. CaH<sub>2</sub>
- The strongest intermolecular forces between molecules of PH<sub>3</sub> are:  
 a. ionic bonds      b. hydrogen bonds      **c. dipole-dipole**      d. London forces
- How many grams of a 5.000 % (w/w) glucose solution provide 80.00 g of glucose?  
 a. 400. g      b. 1200. g      c. 100.0 g      **d. 1600. g**      e. none of these
- A semi-permeable membrane separates a 2% (w/w) solution of starch from an 8% (w/w) solution of starch. Which statement is correct:  
**a. Initially water will flow from the 2% solution to the 8% solution**  
 b. Initially water will flow from the 8% solution to the 2% solution  
 c. Starch will flow through the membrane until the concentrations are equal  
 d. nothing will happen

14. Which of the following, when 10.0 g are dissolved in 1 liter of water, will result in the lowest freezing point for the solution?  
a.  $C_2H_5OH$     **b. NaCl**    c.  $CaCl_2$     d.  $CH_3CO_2H$     e. they will freeze at the same temperature
15. Which substance is most likely to exist as a solid at room temperature?  
a.  $NH_3$     b.  $PH_3$     **c. AlH\_3**    d.  $CH_4$     e.  $SiH_4$

**Part Two: Short Answer (20 points - 4 points each)**

Write your answer in the space provided

1. What is a super critical fluid? (You may refer to the phase diagrams on the last page.)

**A super critical fluid is one that is at a temperature and a pressure greater than the critical temperature and critical pressure. Methanol becomes super critical above about 250 degrees and 1200 psi.**

2. Xenon boils at 165.05 K. Helium boils at 4.22 K. Why is the boiling point of helium so much lower than that of xenon? Explain this in terms of intermolecular forces.

**Helium is a smaller atom and therefore has smaller dispersion forces. The smaller the intermolecular forces the lower the boiling point of a liquid.**

3. What has to exist for hydrogen bonding to occur? Give an example of hydrogen bonding.

**Hydrogen must be attached to a very electronegative atom like N, O, or F and there must be lone pairs available for bonding. For example: (there are many examples...)**

4. Why does the vapor pressure of a liquid increase with increasing temperature?

**The molecules have more kinetic energy and so a greater percentage of the surface molecules have enough energy to escape into the vapor state.**

5. Which solvent, water or carbon tetrachloride, would you chose to dissolve HF? Why?

**I would chose water because HF has a dipole and is a polar molecule and carbon tetrachloride is nonpolar as all the dipoles cancel. Water is polar and would be the best solvent for a polar solute.**

**Part Three: Problem Solving** Show your work to receive credit.

1. If the human eye has an osmotic pressure of 8.00 atm at 25°C, what molarity of solute particles in water will provide an isotonic eye drop solution (a solution with equal osmotic pressure)? **(5 points)**

$$8.00 \text{ atm} = M \times 0.0821 \text{ L-atm/mol-K} \times 298 \text{ K}$$

$$M = 0.327$$

2. An aqueous solution of sodium chloride has a density of 1.01 g/mL. The freezing point of this solution is -1.28°C. What is the percent composition of sodium chloride by mass? ( $K_f$  for H<sub>2</sub>O is 1.86°C/m) **(5 points)**

$$1.28 = 2 \times 1.86 \times m$$

$$m = 0.344$$

assume 1 kg of water

$$0.344 \text{ moles} \times 58.44 \text{ g/mol} = 20.10 \text{ grams}$$

$$20.10 \text{ grams} / 1020.10 \text{ grams solution} = \underline{1.97\% \text{ by mass}}$$

**Note: Even though the density is given it is not used in this problem.**

3. What volume of ethylene glycol, a nonelectrolyte, must be added to 15.0 L of water to produce an antifreeze solution with a freezing point of -25.0°C? The density of ethylene glycol is 1.11 g/mL and the density of water is 1.00 g/mL **(5 points)**

$$25.0 = 1.86 \times m$$

$$m = 13.44$$

$$15.0 \text{ L water} \times 1.00 \text{ kg/L} = 15.0 \text{ kg water}$$

$$15.0 \text{ kg water} \times 13.44 \text{ moles Ethylene glycol/kg water} = 201.6 \text{ moles Ethylene glycol}$$

$$201.6 \text{ moles} \times 62.08 \text{ g/mol} \times 1 \text{ mL/1.11 grams} = 11291 \text{ mL} = \underline{11.3 \text{ L Ethylene glycol}}$$

**Note: these are densities of pure liquids. The first task is to find percentage by volume.**

4. Answer these questions using the phase diagrams of methanol and carbon dioxide provided on the next page **(20 points)**:

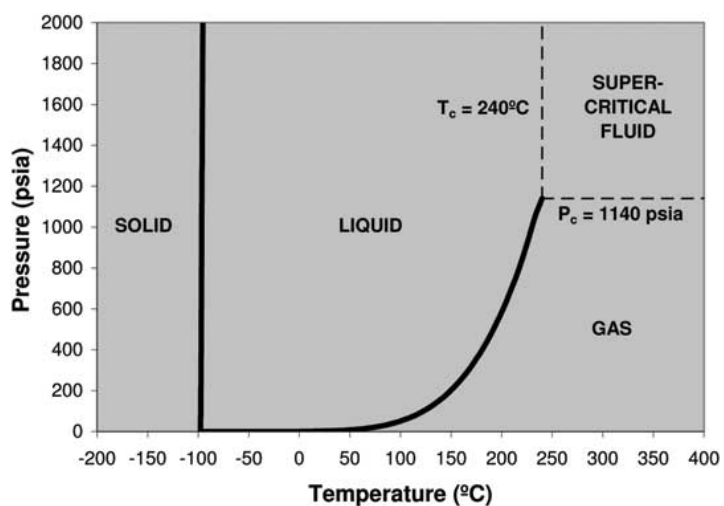
a. At what temperature will CO<sub>2</sub> sublime at atmospheric pressure? **-78.5 degrees Celsius**

b. What is the boiling point of methanol at 200 psia? **150 degrees Celsius**

c. At approximately what temperature does methanol freeze? **-100 degrees Celsius at all pressures.**

d. At what temperature and pressure are gas, liquid and solid phases in equilibrium for CO<sub>2</sub>?

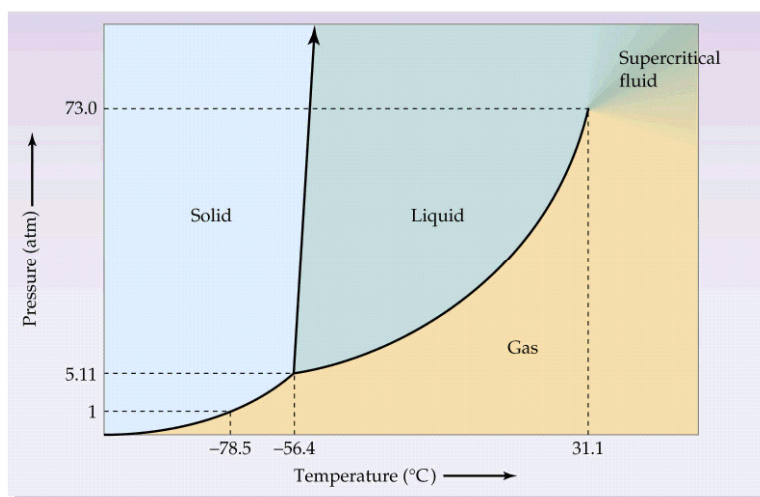
**-56.4 degrees Celsius and 5.11 atmospheres.**



Phase Diagram of Methanol

14.7 psia = 1.00 atm

(pounds per square inch absolute)



Phase Diagram of Carbon Dioxide