

CHM 102

Exam I

1. Hydrazine ( $\text{N}_2\text{H}_4$ ) is a reagent that is used in many applications, from polymers to rocket fuel. Pure hydrazine melts at  $2.0\text{ }^\circ\text{C}$ , boils at  $113.5\text{ }^\circ\text{C}$ , and has a density of  $1.011\text{ g / mL}$ .

a) How many moles of hydrazine are present in one liter of pure  $\text{N}_2\text{H}_4$ ?

b) What is the molarity of pure hydrazine?

c) A  $1.00\text{ M}$  aqueous solution of hydrazine is desired for routine lab work. What volume of pure hydrazine must be diluted to  $500\text{ mL}$  to produce this solution?

2. CO<sub>2</sub> is relatively uncommon in that it sublimates at atmospheric pressure (at -78.4 °C). Solid CO<sub>2</sub> has the common name “dry ice” due to this lack of a liquid phase under normal conditions. Dry ice sometimes finds use in theatrical applications where it is placed in a container of warm water and creates a billowing fog that creeps along the ground. This fog is not the CO<sub>2</sub> gas, but is actually water vapor condensed out of the air when it contacts the very cold carbon dioxide.

a) Suppose that you have a sample of dry ice, freshly prepared, at a temperature of -125 °C. You allow it to sublime and warm to room temperature (25 °C). Sketch a plot of the temperature of the carbon dioxide versus time and label the sublimation point on the plot.

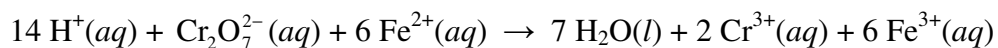
b) Suppose that 1.00 kg of dry ice at -78.4 °C completely sublimates. How much energy does the carbon dioxide absorb as it sublimates? For CO<sub>2</sub>,  $\Delta H_s = 25.2 \text{ kJ / mol}$ .

c) Suppose this process takes place in a container filled with 10.0 L of water at a temperature of 40.0 °C. What is the final temperature of the water? Water has a density of 1.00 g / mL and a heat capacity of  $C = 75.3 \text{ J / mol} \cdot ^\circ\text{C}$ .

3. Potassium dichromate ( $\text{K}_2\text{Cr}_2\text{O}_7$ ) is a reagent used in many analytical reactions because it is stable, easy to obtain in high purity, and has a high molecular weight.

a) Suppose you wanted to prepare 2.00 L of a solution that is 0.100 M potassium dichromate. What mass of  $\text{K}_2\text{Cr}_2\text{O}_7$  must you use?

b) This dichromate solution can then be used to determine the amount of iron (II) in ore samples by the following net ionic reaction:



If a 50.00 mL sample of  $\text{Fe}^{2+}(aq)$  of unknown concentration reacts completely with 34.73 mL of standard 0.100 M dichromate solution, what is the concentration of iron (II) in the unknown solution?

c) Suppose this 50.00 mL sample of iron (II) came from the digestion of a 15.21 g sample of iron ore. What is the percentage of iron (II) by mass in the ore?

4. Explain the following phenomena:

a) Vodka (which is a 40% solution of aqueous  $\text{C}_2\text{H}_5\text{OH}$ ) remains a liquid even if put in the freezer.

b) Methane ( $\text{CH}_4$ ) boils at  $-161.45\text{ }^\circ\text{C}$  while ammonia ( $\text{NH}_3$ ) boils at  $-33.34\text{ }^\circ\text{C}$ .

c) Steam at  $100\text{ }^\circ\text{C}$  causes much worse burns than liquid water at  $100\text{ }^\circ\text{C}$ .

5. We normally do not consider the concentration of water in aqueous solutions, but it is important in some cases. The density of pure water is 1.00 g / mL.

a) What is the molarity of pure water?

b) Seawater is about 3.4% dissolved salt by mass. If the density of seawater is 1.025 g / mL, what mass of *water* is in 1.00 L of seawater?

c) What is the molarity of water in seawater?

d) Why does drinking seawater cause dehydration, despite the fact that seawater is mostly water?

For the remaining questions, circle the letter corresponding to the best answer.

6. A solution is prepared by adding a sufficient amount of a solid solute so that after heating the solution and allowing it to cool there is a visible amount of solid left on the bottom of the beaker. This solution would be considered:

- (A) unsaturated
- (B) saturated
- (C) supersaturated
- (D) dilute
- (E) polar

7. Silver chloride ( $\text{AgCl}$ ) is essentially insoluble in water while sodium chloride ( $\text{NaCl}$ ) is freely soluble. Which of the following statements are *true*?

- I.**  $\text{AgCl}$  is a nonpolar molecular solid so it does not dissolve in the highly polar water.
- II.** The interactions within  $\text{AgCl}$  are stronger than the interactions of silver metal and chlorine gas with water.
- III.** The interactions of silver ions and chloride ions with water are weaker than the interactions between silver ions and chloride ions.
- IV.** The interactions of sodium ions and chloride ions with water are weaker than the interactions between sodium ions and chloride ions.
- V.** The interactions of sodium ions and chloride ions with water are stronger than the interactions between sodium ions and chloride ions.

- (A) **I** only
- (B) **II** only
- (C) **II** and **IV**
- (D) **III** and **IV**
- (E) **III** and **V**

8. How many moles of nitrogen ( $\text{N}_2$ ) can be produced by the complete decomposition of 2.50 moles of TNT,  $\text{C}_7\text{H}_5\text{N}_3\text{O}_6$ ?

- (A) 1.25 moles
- (B) 2.50 moles
- (C) 3.00 moles
- (D) 3.75 moles
- (E) 7.50 moles

9. Which substance has the highest melting point?

- (A)  $\text{C}_2\text{H}_5\text{F}$
- (B)  $\text{C}_2\text{H}_6$
- (C)  $\text{C}_2\text{F}_6$
- (D)  $\text{C}_2\text{H}_5\text{OH}$
- (E) not enough information

10. A 20.0 g sample of phenol ( $\text{C}_6\text{H}_5\text{OH}$ , MW = 94.11 g / mol) requires 2.44 kJ of energy to melt. The heat of fusion of phenol is:

- (A) 0.122 kJ / mol
- (B) 0.213 kJ / mol
- (C) 2.44 kJ / mol
- (D) 11.5 kJ / mol
- (E) 48.8 kJ / mol

11. An insect's ability to walk on water is an example of:

- (A) solubility
- (B) dispersion forces
- (C) viscosity
- (D) surface tension
- (E) colligative properties

12. When sufficient thermal energy is added to reach the boiling point of a substance, what happens to any additional energy added?

- (A) Additional energy raises the temperature of the liquid which in turn increases the rate of boiling.
- (B) Additional energy maintains boiling, since the process is endothermic and thus requires that energy be continually added.
- (C) Additional energy increases the intermolecular interactions between liquid molecules, which increases the volatility of the substance.
- (D) Additional energy will raise the temperature of the vapor and thus make the substance more volatile.
- (E) Additional energy raises the vapor pressure and increases the boiling point, which is why the substance must be continually heated in order to boil.

13. Benzene ( $C_6H_6$ ) melts at  $5.5\text{ }^\circ\text{C}$  and boils at  $80.1\text{ }^\circ\text{C}$ . Consider the following processes:

- I. Heat 100 g of benzene from  $10\text{ }^\circ\text{C}$  to  $15\text{ }^\circ\text{C}$
- II. Heat 100 g of benzene from  $70\text{ }^\circ\text{C}$  to  $75\text{ }^\circ\text{C}$

Which of the following is *true*?

- (A) The amounts of energy required for **I** and **II** are equal.
- (B) The amount of energy required for **I** is less than the amount of energy required for **II** because benzene is at a lower temperature in **I**.
- (C) The amount of energy required for **I** is greater than the amount of energy required for **II** because benzene is nearly boiling in **II**.
- (D) The amount of energy required for **I** will be greater than the amount of energy required for **II** because it takes energy to melt a solid.
- (E) The amount of energy required for these processes cannot be compared without additional information.

14. Dimethylsulfoxide,  $(CH_3)_2SO$ , is a solvent commonly used in organic chemistry that melts at  $18.5\text{ }^\circ\text{C}$  and boils at  $189\text{ }^\circ\text{C}$ . A solution of 119 g of KBr in 1 kg of DMSO melts at  $9.1\text{ }^\circ\text{C}$ .

What is the melting point of a solution of 128 g of naphthalene ( $C_{10}H_8$ ) in 1 kg of DMSO?

- (A)  $23.2\text{ }^\circ\text{C}$
- (B)  $18.5\text{ }^\circ\text{C}$
- (C)  $13.8\text{ }^\circ\text{C}$
- (D)  $9.1\text{ }^\circ\text{C}$
- (E)  $4.4\text{ }^\circ\text{C}$

15. Which of the following substances exhibit hydrogen bonding?

- I.  $CH_4$
- II.  $H_2O$
- III.  $CaH_2$
- IV.  $HF$
- V.  $H_2$

- (A) **II** only
- (B) **V** only
- (C) **II** and **III**
- (D) **II** and **IV**
- (E) all of the above