

Review

Ions in Aqueous Solutions and Colligative Properties (Chapter 13)

1. Determine if each of the following are soluble or insoluble based on the solubility rules in your notes (pink reference sheet):

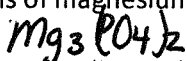
- magnesium nitrate: soluble
- barium sulfate: insoluble
- calcium carbonate: insoluble
- ammonium phosphate: soluble

2) 1.0 mole of magnesium acetate is dissolved in water.

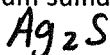
- Write the formula for magnesium acetate: $Mg(C_2H_3O_2)_2$
- How many total ions are released into solution? 3

3. Write the formula for the precipitate that is formed:

- when solutions of magnesium chloride and potassium phosphate are combined.

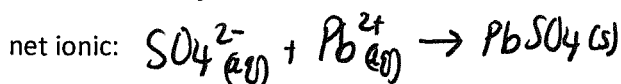
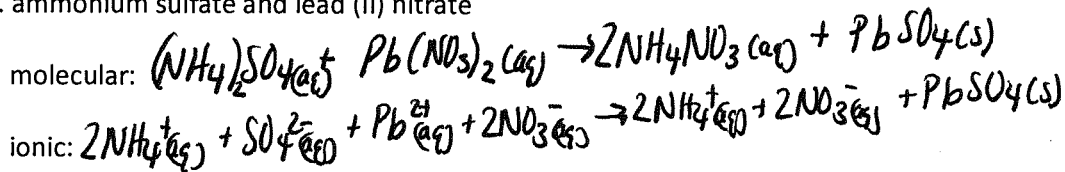


- when solutions of sodium sulfide and silver nitrate are combined.

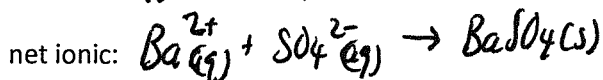
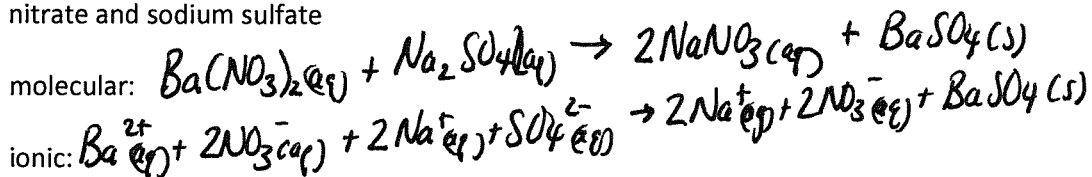


4. Write the conventional, ionic, and net ionic equation for each of the following:

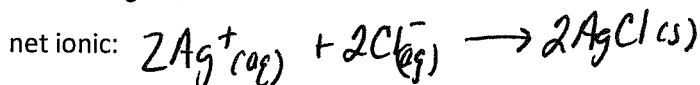
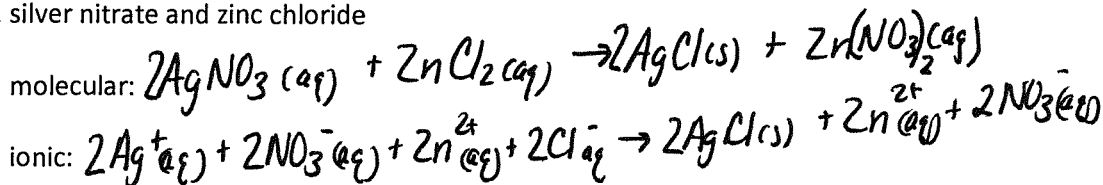
a. ammonium sulfate and lead (II) nitrate



b. barium nitrate and sodium sulfate

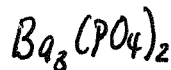


c. silver nitrate and zinc chloride



5. The following solutions are combined in a beaker: NaCl, Na₃PO₄, and Ba(NO₃)₂.

Determine any precipitates that will form from the combination of substances above.



Determine all of the spectator ions that are present in solution.

Precipitate(s): $Ba_3(PO_4)_2$

Spectator ions: Na^+ , Cl^- , NO_3^-

6. How many solute particles are in each of the following substances? (i.e. What is the i value)

- a. ethyl alcohol $C_2H_5OH = 1$
- b. iron (III) sulfate $Fe_2(SO_4)_3 = 5$
- c. a nonelectrolyte $= 1$
- d. calcium carbonate $CaCO_3 = 2$

7. Consider the nonvolatile nonelectrolytes dissolved in various liquid solvents to complete the following statements:

solute a. The change in boiling point does not vary with the identity of the _____ (solute, solvent), assuming all other factors remain constant.

solvent b. The change in boiling point varies with the identity of the _____ (solute, solvent), assuming all other factors remain constant.

increases c. The change in boiling point becomes greater as the concentration of the solute in solution _____ (decreases, increases).

8. A water solution containing an unknown quantity of a nonelectrolyte solute is found to have a freezing point of $-0.23^\circ C$. What is the molality of the solution?

$-23 - 0 = -23^\circ C = \Delta T_f$ $-23 = -1.86 \cdot m \cdot 1$
 $\Delta T_f = K_f \cdot m \cdot i$ $0.124 m$

9. What is the boiling point of a solution of ethyl alcohol, C_2H_5OH , that contains 20.0g of the solute dissolved in 250g of water?

$\frac{20.0g}{46g} \cdot \frac{1mol}{C_2H_5OH} = .43mol$ $m = \frac{.43mol}{.250kg} = 1.74m$ $\Delta T_b = .512 (1.74m)(1)$
 $\Delta T_b = .89^\circ C$
 $B.P_{soln} = 100 + .89 = 100.89^\circ C$

10. How many grams of ethylene glycol $C_2H_4(OH)_2$ must a researcher add to 500 g of water to yield a solution that will freeze at $-7.44^\circ C$?

$-7.44 - 0 = -7.44 = \Delta T_f$ $-7.44 = -1.86 (m)(1)$ $4 = \frac{x \text{ moles}}{.500} = 2 \text{ moles } C_2H_4(OH)_2$
 $\Delta T_f = K_f \cdot m \cdot i$ $m = 4.0$ $\frac{62g}{1mol} = 124g$

11. Which of the following two solutes will raise the boiling point of water in a car's radiator more 1.00 mol of ethylene glycol or 1.00 mol of ethyl alcohol? Explain.

Both in H_2O so K_b is same, i value is both 1 and same amount so m same. Same effect because

12. Which of the following solutes will lower the freezing point of water on the roads in winter more 1.00 mol of sodium chloride or 1.00 mol of strontium chloride? Explain.

$i = 2$ NaCl SrCl₂
 Strontium chloride has greater effect because i value larger

13. Some insects survive cold winters by generating an antifreeze inside their cells. The antifreeze produced is glycerol, $C_3H_5(OH)_3$, a nonvolatile, nonelectrolyte that is quite soluble in water.

What must the molality of a glycerol solution be to lower the freezing point of water to $-25^\circ C$?

$-25 = -1.86 \cdot m \cdot 1$
 $m = 13.44$

14. What is the temperature at which a solution containing 1.50g of potassium nitrate, KNO_3 , in 35 g of water begins to freeze?

$$\frac{1.50 \text{ g KNO}_3}{101 \text{ g}} \left| \frac{1 \text{ mol KNO}_3}{101 \text{ g}} \right| = \frac{0.0149 \text{ mol KNO}_3}{0.035 \text{ kg H}_2\text{O}} = .424 \text{ m}$$

$$\Delta T_f = (-1.86 \times .424 \times 2)$$

$$\Delta T_f = -1.58$$

$$0 + -1.58 = \boxed{-1.58^\circ\text{C}}$$

15. How many grams of methanol, CH_3OH , should be added to 200g of acetic acid to lower its freezing point by 1.30°C .

$$\Delta T_f = -1.30 \quad \Delta T_f = K_f \cdot m \cdot i$$

$$-1.30 = -3.90 (m \times 1)$$

$$m = .333$$

$$.333 \text{ m} = \frac{\text{moles}}{.200 \text{ kg}}$$

$$.0667 \text{ mole CH}_3\text{OH} \left| \frac{32}{1 \text{ mol}} \right| = \boxed{2.13 \text{ g CH}_3\text{OH}}$$

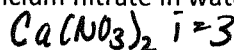
16. What is the boiling point of a 2.35m solution of calcium nitrate in water?

$$\Delta T_b = K_b \cdot m \cdot i$$

$$\Delta T_b = .512 \cdot 2.35 \text{ m} \cdot 3$$

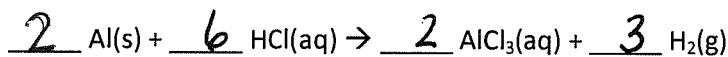
$$\Delta T_b = 3.61$$

$$100 + 3.61 = \boxed{103.61^\circ\text{C}}$$



Solvent	Normal freezing point $^\circ\text{C}$	K_f ($^\circ\text{C}/\text{m}$)	Normal boiling point $^\circ\text{C}$	K_b ($^\circ\text{C}/\text{m}$)
Acetic acid	16.6	-3.90	117.9	3.07
Water	0	-1.86	100	0.51

17. It is possible to have spectator ions present in many types of chemical reactions, not just double replacement reactions. Consider the following example:



a. Balance the equation above.

b. There is one spectator ion in the equation above. Is it $\text{Al}^{3+}(\text{aq})$, $\text{H}^+(\text{aq})$ or $\text{Cl}^-(\text{aq})$? Cl^-

c. If 9.0 g of Al metal reacts with excess HCl according to the equation above, what volume of hydrogen gas at STP will be produced? Show all work!

$$\frac{9.0 \text{ g Al}}{26.98 \text{ g Al}} \left| \frac{1 \text{ mol Al}}{1 \text{ Al}} \right| \left| \frac{3 \text{ H}_2}{1 \text{ Al}} \right| \left| \frac{22.4 \text{ L}}{1 \text{ mol Al}} \right| = \boxed{22.42 \text{ L H}_2}$$