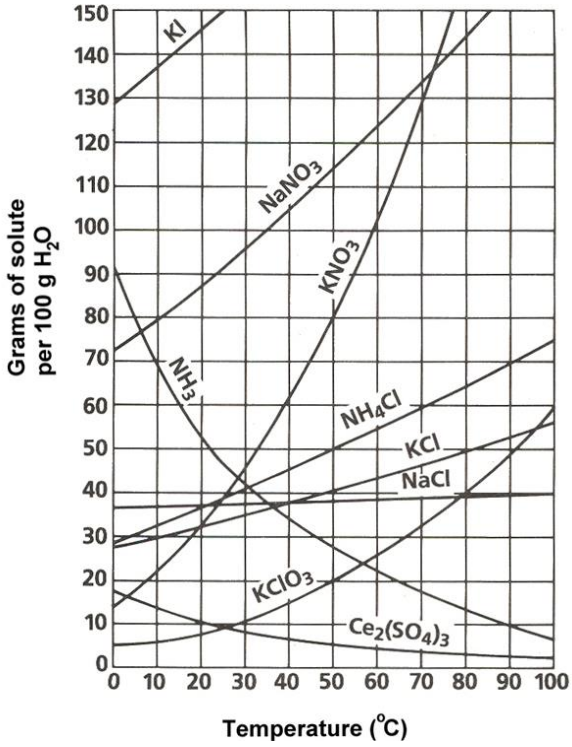
LESSON 10.1: Solubility Curves and Table G

Objective:
Calculate Molar Mass (gram formula mass)

1. Use the graph to the right to find the mass of solute that will dissolve in 100 mL of water at the following temperatures to make saturated solutions.



a. KNO_3 at 70°C = _____

b. NaCl at 100°C= _____

c. NH_4Cl at 90°C= _____

d. Which of the **above** three substances is most soluble in water at 15°C? _____

2. Use Table G to determine the type of solution (saturated, unsaturated or supersaturated) described.

a) a solution that contains 70g of $NaNO_3$ at 30°C in 100 mL H_2O _____

b) a solution that contains 50g of NH_4Cl at 50°C in 100 mL H_2O _____

c) a solution that contains 21g of $KClO_3$ at 50°C in 100 mL H_2O _____

d) a solution that contains 130g of KI at 0°C in 200 mL H_2O _____

e) a solution that contains 60g of KCl at 90°C in 100 mL of H_2O _____

3. A saturated solution of KCl at 90°C is cooled to 60°C. How many grams of KCl will precipitate out?

4. A mass of 80 g of KNO_3 is dissolved in 100 g of water at 70ºC. How many more grams of potassium nitrate must be added to make the solution saturated?

Directions: Determine if the following solutions are saturated (S), unsaturated (U) or supersaturated (SS).

_____ 1) 100 g of $NaNO_3$ dissolved in 100 g of water at 50°C

_____ 2) 20 g of $KClO_3$ dissolved in 100 g of water at 30°C

_____ 3) 90 g of KNO_3 dissolved in 100 g of water at 70°C

_____ 4) 10 g of NaCl dissolved in 100 g of water at 20°C

_____ 5) 145 g of KI dissolved in 100 g of water at 20°C

_____ 6) 70 g of NH_4Cl dissolved in 100 g of water at 80°C

Directions: Answer the following questions based on Table G.

7) How many grams of SO_2 would have to be dissolved in 100 g of water at 0°C to make a saturated solution?

8) How many grams of KI could be dissolved in 100 g of water at 10°C to be considered an unsaturated solution?

9) How many grams of KCl could be dissolved in 100 g of water at 90°C to be considered a supersaturated solution?

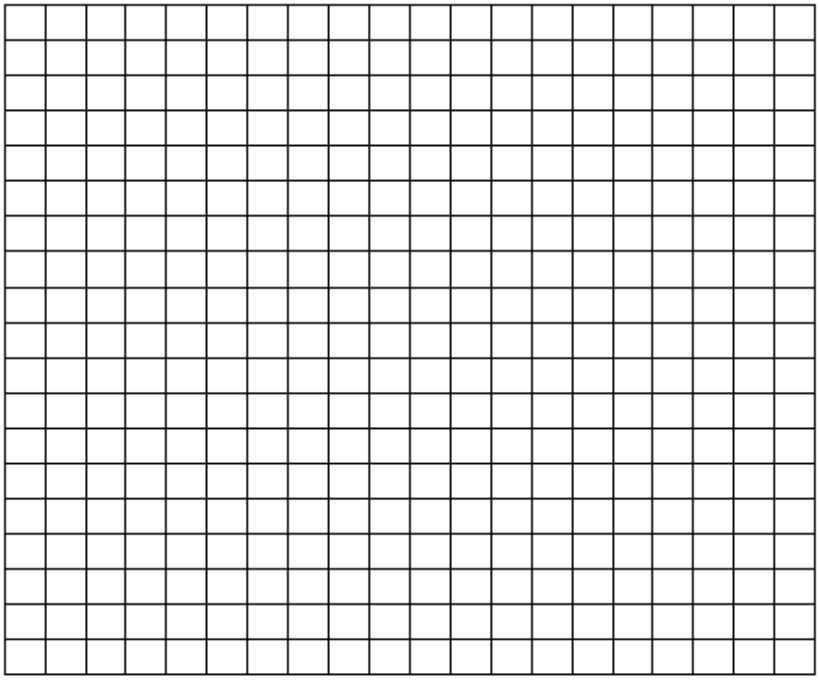
Drawing Solubility Curves

Substance X Solubility

Temperature (°C)	Solubility (g of solute/100 mL of H_20)
0	35.7
10	35.8
20	35.9
30	36
40	36.4
60	37.1
80	38
90	38.5
100	39.2

Copper Sulfate Solubility

Temperature (°C)	Solubility (g of solute/100 mL of H_20)
0	23
10	27.5
20	32
30	38
40	44.5
60	62
80	84
100	114



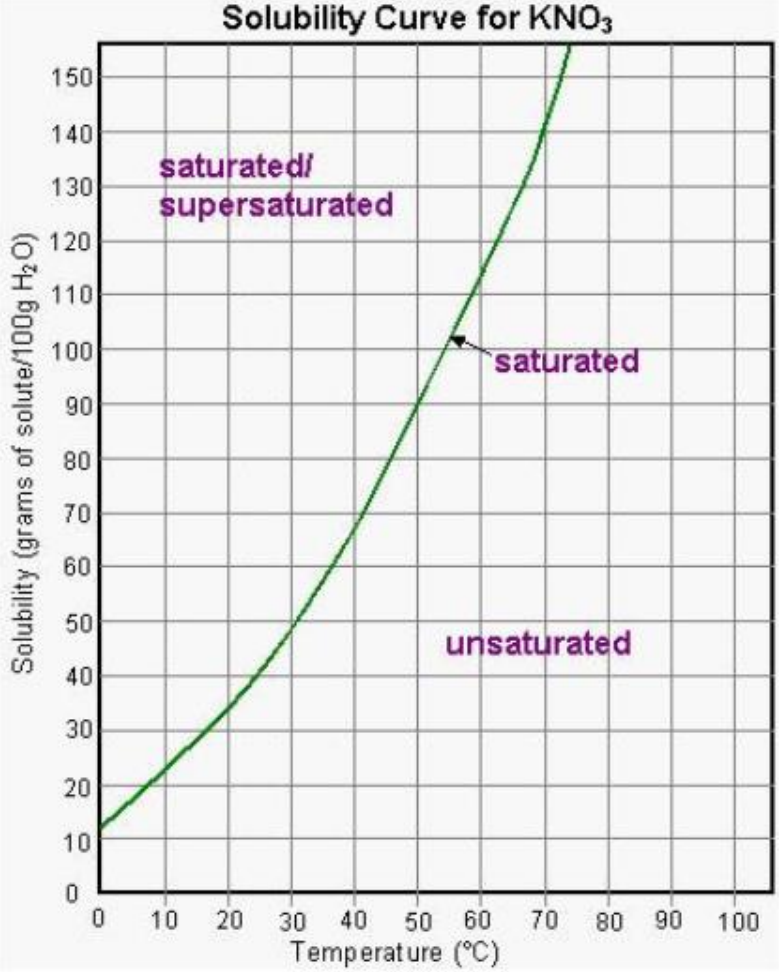
1) a. Which substance is more soluble at 0°C? _____ b. Which substance is more soluble at 100°C? _____

2) Compare the solubility curve of Substance X to the known solubility curves in your reference tables. What could Substance X be? _____

3) According to your graph, how many grams of copper sulfate can be added to 100ml of water at 90°C to make a saturated solution?

4) How much more solute could you add to a solution containing 30 grams of Substance X at 80°C to make the solution saturated?

Solubility Curves



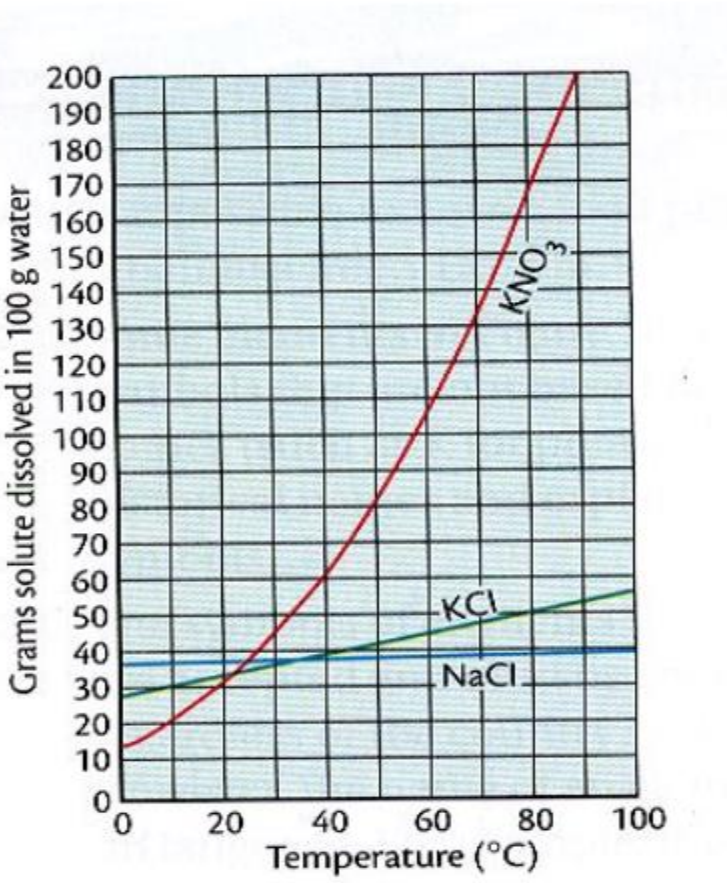
1. How much KNO_3 can be dissolved at 40° C ?

2. At what temperature can you dissolve 70 grams of KNO_3 ?

3. What kind of solution is 80 grams of KNO_3 at 50° C ?

4. What kind of solution is 60 grams of KNO_3 at 60° C ?

5. What kind of solution is 40 grams of KNO_3 at 10° C ?



1. How much KCl can be dissolved at 40° C ?

2. At what temperature can you dissolve 40 grams of KNO_3 ?

3. What kind of solution is 80 grams of NaCl at 50° C ?

4. What kind of solution is 60 grams of KNO_3 at 60° C ?

5. What kind of solution is 40 grams of KCl at 45° C ?

6. At what temperature can you dissolve 40 grams of NaCl?

Table G: Solubility Curve Questions

1) What much solute can be dissolved of KNO_3 at 70°C ?

2) At what temperature is water saturated with 15 grams of NH_3?

3) Which of the three substances (NaCl, KNO_3, NH_4Cl) is most soluble in water at 15°C?

4) Is 50g of KCl at 80°C saturated, unsaturated or supersaturated?

5) How much KNO_3 can be dissolved in 100 g of water at 25°C?

6) How much KNO_3 can be dissolved in 50 g of water at 30°C?

7) How many grams of $NaNO_3$ will precipitate (fall) out of a 100ml solution when a saturated solution at 45^0C is cooled to 10^0C?

8) Given a 100ml solution containing 10 grams of NaCl at 90°C, how many more grams of NaCl are required to reach saturation?

MORE TABLE G PRACTICE

Determine the **type of solution** (unsaturated, saturated, supersaturated) produced.

1) 10 g of NH_3 dissolved in 100 g of water at 90ºC _____
2) 30 g of NH_4Cl dissolved in 100 g of water at 40ºC _____
3) 105 g of KNO_3 dissolved in 100 g of water at 50ºC _____
4) 5 g of NaCl dissolved in 100 g of water at 0ºC _____
5) 51 g of KCl dissolved in 100 g of water at 80ºC _____

Ex 1) How much HCl should be dissolved in **100 g of water** to make a saturated solution at 30ºC?

Ex 2) How much HCl should be dissolved in **50 g of water** to make a saturated solution at 30ºC?

Ex 3) How much HCl should be dissolved in **200 g of water** to make a saturated solution at 30ºC?

1) How much $KClO_3$ should be dissolved in 50 g of water at 40ºC to make a saturated solution? _____

2) How much NaCl should be dissolved in 200 g of water at 90ºC to make a saturated solution? _____

3) How much KNO_3 should be dissolved in 50 g of water at 60ºC to make a saturated solution? _____

4) How much KCl should be dissolved in 200 g of water at 50ºC to make a saturated solution? _____

Ex 1) A solution of $NaNO_3$ at 30ºC is saturated. How much salt **will precipitate out** if the solution is cooled to 10ºC?

Ex 2) A solution of KI at 20ºC is saturated. How much salt **will precipitate out** if the solution is cooled to 10ºC?

1) A solution of NaCl at 90ºC is saturated. How much salt will precipitate out if the solution is cooled to 0ºC?

2) A solution of $NaNO_3$ at 50ºC is saturated. How much salt will precipitate out if the solution is cooled to 30ºC?

3) A solution of $KClO_3$ at 80ºC is saturated. How much salt will precipitate out if the solution is cooled to 30ºC?

4) A solution of NH_4Cl at 10ºC is saturated. How much salt will precipitate out if the solution is cooled to 0ºC?

Ex 1) If 100 g of KI are dissolved in 100 g of water at 20ºC, **how much more** KI would need to be added to make a saturated solution?

Ex 2) If 20 g of NaCl are dissolved in 100 g of water at 100ºC, **how much more** NaCl would need to be added to make a saturated solution?

1) If 5 g of SO_2 are dissolved in 100 g of water at 10ºC, how much more SO_2 would need to be added to make a saturated solution?

2) If 30 g of NH_4Cl are dissolved in 100 g of water at 80ºC, how much more NH_4Cl would need to be added to make a saturated solution?

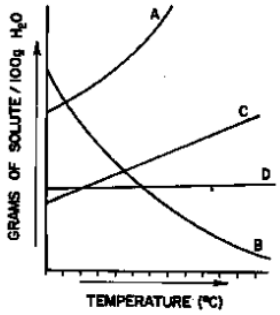
3) If 80 g of KNO_3 are dissolved in 100 g of water at 60ºC, how much more KNO_3 would need to be added to make a saturated solution?

4) If 20 g of HCl are dissolved in 100 g of water at 90ºC, how much more HCl would need to be added to make a saturated solution?

General Understanding of Table G Questions

1) The graph below represents four solubility curves. Which curve best represents the solubility of a gas in water?

(1) A (3) C
(2) B (4) D



2) Which salt has the greatest change in solubility between 30ºC and 50ºC?
(1) KNO_3 (2) KCl (3) $NaNO_3$ (4) NaCl

3) Based on Reference Table G, which of the following substances is most soluble at 50ºC?
(1) $KClO_3$ (2) NH_3 (3) NaCl (4) NH_4Cl

4) According to Reference Table G, which of the following substances is least soluble in 100 grams of water at 50ºC?
(1) NaCl (2) KCl (3) NH_4Cl (4) HCl

5) Solubility data for four different salts in water at 60ºC are shown in the table below. Which salt is most soluble at 60ºC?

Salt	Solubility in Water at 60°C
A	10 grams / 50 grams H_2O
B	20 grams / 60 grams H_2O
C	30 grams / 120 grams H_2O
D	40 grams/ 80 grams H_2O

(1) A (2) B (3) C (4) D

LESSON 10.3: Concentration

Objective:

- ***Calculate the concentration of various solutions***

MOLARITY

$$\text{Molarity (M)} = \frac{\text{moles (mol)}}{\text{liters (L)}}$$

You need to fill in 2 of the 3 boxes to find what's missing. Be careful with units!

*You may have to convert from mL to L (K H D U d c m) or grams to moles.

SHOW ALL WORK!!!

1. How many moles of H_2SO_4 are present in 1.63 liters of a 0.954 M solution?

2. How many liters of solution are needed to make a 1.66 M solution containing 2.11 moles of $KMnO_4$?

3. What volume of a 0.25 M solution can be made using 0.55 moles of $Ca(OH)_2$?

For all of the problems below you will need to do a mole-mass conversion. Each problem will involve two steps.

4. What is the molarity of a solution containing 63 grams of NaCl that has a volume of 0.65L?

5. How many grams of $Ca(OH)_2$ are needed to produce 0.5L of 1.66 M $Ca(OH)_2$ solution?

6. What volume of a 0.88 M solution can be made using 130. grams of $FeCl_2$?

PERCENT BY MASS

USEFUL EQUATIONS

Percent by Mass $\frac{\text{mass solute}}{\text{mass solution}} \times 100$

Percent by Volume $\frac{\text{mass solute}}{\text{mass solution}} \times 100$

Solution = solute + solvent

1 kg = 1000 g 1 L = 1000 mL

1. What is the percent by mass of 5.0 g of iron (II) sulfate dissolved in 75.0 g of water?

2. A solution is made by adding 25 mL of benzene to 80 mL of toluene. What is the percent by volume of benzene?

3. A solution is formed by adding 35 g of ammonium nitrate to 250 g of water. What is the percent by mass of ammonium nitrate?

4. What is the percent by volume of a solution formed by mixing 25 mL of isopropanol with 45 mL of water?

5. What is the mass percent of each component in the mixture formed by adding 12 g of calcium sulfate, 18 g of sodium nitrate, and 25 g of potassium chloride to 500 g of water?

6. What is the percent by volume of a solution formed by added 15 L of acetone to 28 L of water?

7. An experiment requires a solution that is 80% methyl alcohol by volume. What volume of methyl alcohol should be added to 200 mL of water to make this solution?

PARTS PER MILLION

1. Calculate the concentration of chlorine in ppm in a swimming pool if there is 0.02 g of chlorine in 10,000 g of pool water.

2. Exposure to lead has been linked to delays in physical and mental development and attention deficit disorders in children as well as kidney problems in adults. One source of this toxic heavy metal is drinking water in older homes whose plumbing contains lead. Water with a lead concentration of below 0.015ppm is considered safe to drink. A 100 g water sample taken from a home contains 1.2×10^{-6} grams of lead. Is this water considered safe to drink?

3. A solution of lead sulfate ($PbSO_4$) contains 0.425 g of lead sulfate in 100.0 g of water. What is this concentration in ppm?

4. A 900.0 g sample of sea water is found to contain 6.7×10^{-3} g of zinc. Express this concentration in ppm.

5. If you make a 2,000 gram solution containing 0.011 grams of sulfuric acid dissolved in water, what is the concentration of the solution in ppm?

6. The health of fish depends on the amount of oxygen dissolved in the water. A dissolved oxygen (DO) concentration between 6 parts per million and 8 parts per million is best for fish health. A DO concentration greater than 1 part per million is necessary for fish survival. Fish health is also affected by water temperature and concentrations of dissolved ammonia, hydrogen sulfide, chloride compounds, and nitrate compounds. A student's fish tank contains fish, green plants, and 3800 grams of fish-tank water with 2.7×10^{-2} gram of dissolved oxygen.

a.) State how an increase in the temperature of the fish-tank water affects the solubility of oxygen in the water.

b.) Determine if the DO concentration in the fish tank is healthy for fish. Your response must include:
- a correct numerical setup to calculate the DO concentration in the water in parts per million
- the calculated result
- a statement using your calculated result that tells why the DO concentration in the water is or is not healthy for fish

c) Explain, in terms of molecular polarity, why oxygen gas has low solubility in water. Your response must include *both* oxygen and water.

d.) Under what kind of conditions of temperature and pressure would oxygen gas be most soluble in water?

CHALLENGE: Sharks can smell blood in water with as little of a concentration as 1 ppm. How many grams of blood would have to be spilled for a shark to smell the blood in a tank that has 11,593,000 grams of water?

CONCENTRATION MIXED PRACTICE

*MUST SHOW CORRECT NUMERICAL SET-UP AND SOLVE!!

1) What is the total number of moles of $Ca(NO_3)_2$ needed to make 0.250 liter of the 0.200 M $Ca(NO_3)_2$ solution?	2) A 1000 gram aqueous solution has 0.0070 gram of oxygen dissolved in it. Calculate the dissolved oxygen concentration of this solution in parts per million.
3) Calculate the volume of a 12M solution which contains 0.5 mol of H_3PO_4.	4) What is the percent by mass of glucose in a 200 gram solution that has 5 grams of glucose dissolved in water?
5) What is the percent by volume of alcohol if 70 ml of isopropyl alcohol is dissolved in 105 ml of water?	6) How many liters of a 1.2 M solution can be prepared with 0.50 moles of $C_6H_{12}O_6$?
7) How many grams of NaCl must be dissolved in water to make a 1.5M solution with a volume of 2L?	8) What is the molarity of a 450.0 ml solution that contains 88.0 grams of dissolved CO_2?
9) What is the molarity of a 600 mL solution containing 3.6 moles of dissolved HCl?	10) What is the concentration, in ppm, if 0.808 g of $CaCl_2$ is dissolved in 250.0 g of water?

LESSON 10.4: Properties of Solutions

Objective:

- ***Differentiate between boiling point elevation and freezing point depression and the factors that influence them***

1. Complete the following chart:

	Is the compound Ionic or Molecular (covalent)	*Electrolyte or Nonelectrolyte*	*How many particles the compound break up into*	*Rank in order of which substance affects the boiling and freezing points the least to most 1= affects them least 4= affects them most*
$BaBr_2$				
LiF				
C_2H_6O				
$Fe(NO_3)_3$				

Directions: Read the following passage and then answer the corresponding questions.

How Does Rock Salt Work, Anyway?

"How come adding rock salt to your ice cream maker makes the ice cream freeze and putting it on the road makes ice melt?"

That's a good question, and here's the answer: in both of these scenarios, humans take advantage of the same scientific properties to achieve two different objectives.

Adding sodium chloride (otherwise known as table salt) to water acts to depress the freezing point of the salt-water solution. In other words, salt water freezes at a lower temperature than fresh water. The exact temperature depends on the concentration of salt and the type of salt used.

When rock salt is added to an ice cream maker, the resulting salt water solution can bathe the metal canister at a temperature less than 32°F (or 0ºC). As the human adds ice, the temperature drops below 0ºC, but the salt water solution doesn't freeze. The result? Harder ice cream!

When rock salt is added to the street, it depresses the freezing point of any water which dissolves it. This salt water solution can exist as a liquid at lower temperatures than fresh water. The result? Salty water, instead of clean ice, if the solution is strong enough to withstand the surface temperature.

Speaking of Melting Ice ...

Pouring table salt on snowy (or pre-snowy) roads isn't the only way to melt ice. Sodium chloride is used because it is cheap and easy to obtain in large quantities. But, as any New Yorker with a car can tell you, salt can be quite corrosive. And as hard as it is on cars, it's just as hard on roadways and bridge decks. This is costly in the long run.

So, alternative methods to road salting are desirable. One type of alternative is using a different kind of salt. Some salts are more effective than others at lowering freezing points, and some salts are more environmentally friendly (and road-, car-, and bridge-friendly). However, these salts are typically much more expensive than ordinary sodium chloride.

written by Derek Arndt
Meteorologist with the Oklahoma MesoNet

1. Why do we put salt on snow covered roads?

2. How does adding rock salt to an ice cream maker make the ice cream harder?

3. Why is it better to use salt on roads instead of sugar ($C_6H_{12}O_6$)?

4. Name two advantages to using NaCl on snowy roads instead of another type of salt.

5. What the scientific term used to describe the fact that adding salt to water decreases its freezing point?

6. Explain why some people add salt to water. Does it make the water boiling faster? What exactly does the salt do to the water that would be a benefit for cooking?

7. Explain why adding a molecular solid to water will not elevate boiling point as much as adding salt to water.

8. If you add 2.0-g of MgO to water what will happen to the freezing and boiling points of water?

9. Rank 1 mole of the substances $C_{12}H_{22}O_{11}$, NaCl, and $CaBr_2$ from least to most effective on snowy roads. Be sure to explain your answer—and you may need your reference tables for this one.

REGENTS PRACTICE

1. A solution consists of 0.50 mole of $CaCl_2$ dissolved in 100. grams of H_2O at 25°C. Compared to the boiling point and freezing point of 100. grams of H_2O at standard pressure, the solution at standard pressure has

   A) a lower boiling point and a lower freezing point
   B) a lower boiling point and a higher freezing point
   C) a higher boiling point and a lower freezing point
   D) a higher boiling point and a higher freezing point

2. Which aqueous solution of KI freezes at the lowest temperature?

   A) 1 mol of KI in 500. g of water
   B) 2 mol of KI in 500. g of water
   C) 1 mol of KI in 1000. g of water
   D) 2 mol of KI in 1000. g of water

3. Which solution has the lowest freezing point?

   A) 10. g of KI dissolved in 100. g of water
   B) 20. g of KI dissolved in 200. g of water
   C) 30. g of KI dissolved in 100. g of water
   D) 40. g of KI dissolved in 200. g of water

4. Which solution has the highest boiling point at standard pressure?

   A) 0.10 M KCl(aq) B) 0.10 M K_2SO_4(aq)
   C) 0.10 M K_3PO_4(aq) D) 0.10 M KNO_3(aq)

5. Compared to the freezing point and boiling point of water at 1 atmosphere, a solution of a salt and water at 1 atmosphere has a

   A) lower freezing point and a lower boiling point
   B) lower freezing point and a higher boiling point
   C) higher freezing point and a lower boiling point
   D) higher freezing point and a higher boiling point

MORE COLLIGATIVE PROPERTIES PRACTICE

___1. Why is salt (NaCl) put on icy roads and sidewalks in the winter?
(1) It is ionic and lowers the FP of water.
(2) It is ionic and raises the FP of water.
(3) It is covalent and lowers the FP of water.
(4) It is covalent and raises the FP of water.

___2. Assume equal aqueous concentrations of each of the following substances. Which has the lowest freezing point?
(1) $C_6H_{12}O_6(aq)$ (2) $CH_3OH(aq)$ (3) $C_{12}H_{22}O_{11}(aq)$ (4) $NaOH(aq)$

___3. What occurs when sugar is added to water?
(1) The FP and the BP of the water will decrease.
(2) The FP will decrease and the BP will increase.
(3) The FP will increase and the BP will decrease.
(4) The FP and BP of water will increase.

M stands for Molarity which is a unit for concentration.
The bigger the M, the more dissolved particles there are.

___4. Which solution has the highest boiling point?
(1) 1.0M KNO_3 (2) 2.0M KNO_3 (3) 1.0M $Ca(NO_3)_2$ (4) 2.0M $Ca(NO_3)_2$

___5. Which property of distilled water solution will not be affected by adding 50ml of CH_3OH to 100ml of water solution at 25°C?
(1) conductivity (2) mass (3) freezing point (4) boiling point

___6. How do the colligative properties of salt water differ from pure water?
(1) Salt water has a lower FP and BP
(2) Salt water has a lower FP and a higher BP
(3) Salt water has a higher FP and a lower BP
(4) Salt water has a higher FP and BP

___7. Which substance, when dissolved it water, will raise water's BP the most?
(1) CH_3OH (2) $C_6H_{12}O_6$ (3) LiOH (4) $CaCl_2$

___8. Which aqueous solution will have the lowest FP?
(1) 1M NaCl(aq) (2) 2M NaCl(aq) (3) 1M $MgCl_2(aq)$ (4) 2M $MgCl_2(aq)$

___9. Which substance will NOT affect the conductivity of water?
(1) LiOH (2) NaCl (3) $MgCl_2$ (4) C_2H_4

___10. Which solution would have the highest boiling point?
(1) 2.0 moles of NaCl in 100 ml of water
(2) 2.0 moles of NaCl in 200 ml of water
(3) 2.0 moles of $MgBr_2$ in 100 ml of water
(4) 2.0 moles of $MgBr_2$ in 200 ml of water

___11. According to Table F, which compound would be the *strongest* electrolyte?
(1) AgCl (2) $MgCO_3$ (3) $NaSO_4$ (4) Li_3PO_4

EXAM REVIEW

1. Which of the following would make an **unsaturated** solution in 100 grams of water at 40°C?

   a) 100 grams $NaNO_3$
   b) 100 grams NaCl
   c) 100 grams KNO_3
   d) 100 grams HCl

2. Under which conditions are gases most soluble in water?

   a) high temperature and high pressure
   b) low temperature and high pressure
   c) high temperature and low pressure
   d) low temperature and low pressure

3. 5 grams of NaCl is stirred into **50 g of water** at 100°C until it dissolves. The water is considered to be

   a) saturated b) unsaturated c) supersaturated d) the solute

4. In a beaker, 40 grams of NaCl is stirred into 50 grams of water**,** but not all of it dissolves. What term best describes all of the contents of the beaker together?

   a) a heterogeneous mixture and the water is saturated
   b) a homogeneous mixture and the water is unsaturated
   c) a heterogeneous mixture and the water is unsaturated
   d) a homogeneous mixture and the water is saturated

5. Which combination of solute and solution would produce the **least** concentrated solution

   a) 1 mole of solute, 1 liter of solution
   b) 3 moles of solute, 4 liters of solution
   c) 1 moles of solute, 4 liters of solution
   d) 4 moles of solute, 1 liter of solution

6. Which of the following solutes would be the **greatest** conductor in solution?

   a) Cl_2 b) CO_2 c) $MgCl_2$ d) KNO_3

7. Which of these substances is **most** soluble at 80°C?

   a) NH_3 b) NaCl c) KCl d) NH_4Cl

8. Which of the following would have the **greatest** solubility in water?

   a) HCl b) H_2 c) Cl_2 d) CH_4

9. Which aqueous solution will have the lowest freezing point?

   a) 1.0M $C_6H_{12}O_6$
   b) 1.0M KNO_3
   c) 2.0M $C_6H_{12}O_6$
   d) 2.0M KNO_3

10. A solution of $NaNO_3$ is saturated at 40°C. How many grams of $NaNO_3$ will precipitate out if the solution is cooled to 10°C?

    a) 105 g b) 80 g c) 25 g d) 185 g

11. 40 grams of NH_3 is added to 100 grams of water at 70°C. How could you describe this solution?

a) dilute and unsaturated
b) dilute and supersaturated
c) concentrated and saturated
d) concentrated and supersaturated

12. What is the concentration of O_2 (g), in parts per million, in a solution that contains .008 gram of O_2(g) dissolved in a 1000 gram solution?

a) .8ppm b) 8 ppm c) 80 ppm d) 800 ppm

13. What is the molarity of a solution containing 20 **grams** of NaOH in 0.5 L of solution?

a) 1 M b) 2 M c) .04 M d) .5 M

14. How many total moles of KNO_3 must be dissolved in water to make 1.5 liters of 2.0 M solution?

a) .5 mol b) 2.0 mol c) 3.0 mol d) 1.3 mol

15. Compared to pure water, an aqueous solution of calcium chloride has a

a) higher boiling point and higher freezing point
b) higher boiling point and lower freezing point
c) lower boiling point and higher freezing point
d) lower boiling point and lower freezing point

16. Which of the following will not be affected if $C_6H_{12}O_6$ is dissolved in water?

a) mass b) freezing point c) boiling point d) conductivity

17. Which of the following solutions will have the highest boiling point?

a) 1M $C_{12}H_{22}O_{11}$ b) 2M $C_{12}H_{22}O_{11}$ c) 1M $MgBr_2$ d) 2M $MgBr_2$

18. According to Table F, which of the following compounds is soluble in water?

a) NaOH b) BaS c) PbI_2 d) Ag_2SO_4

19. Which of the following liquids has the highest normal boiling point?

a) propanone b) ethanol c) water d) ethanoic acid

20. What is the vapor pressure of ethanol at 60°C?

a) 47 kPa b) 38 kPa c) 101.3 kPa d) 11 kPa

21. Which statement describes how NaCl dissolves in water?

a) Na+ ions are attracted to the hydrogen-end of the water which is the positive end.

b) Na+ ions are attracted to the oxygen-end of the water which is the negative end.

c) Cl- ions are attracted to the hydrogen-end of the water which is the negative end.

d) Cl- ions are attracted to the oxygen-end of the water which is the positive end.

22. A 2.2 M solution contains 8.0 moles of solute. What is the volume of the solution? Show the correct numerical set-up and solve.

23. What is the mass of $KNO_3(s)$ that must dissolve in 200. grams of water to form a saturated solution at 50.°C?

24. Chemical concepts are applied in candy making. A recipe for making lollipops is shown below.

Hard-Candy Lollipops Recipe

Ingredients: 414 grams of sugar, 177 grams of water, 158 milliliters of light corn syrup

Step 1: In a saucepan, mix the sugar and water. Heat this mixture, while stirring, until all of the sugar dissolves.
Step 2: Add the corn syrup and heat the mixture until it boils.
Step 3: Continue boiling the mixture until the temperature reaches 143°C at standard pressure.
Step 4: Remove the pan from the heat and allow it to stand until the bubbling stops. Pour the mixture into lollipop molds that have been coated with cooking oil spray.

a) Explain, in terms of the polarity of sugar molecules, why the sugar dissolves in water.

b) Determine the concentration, expressed as percent by mass, of the sugar dissolved in the mixture produced in step 1.

c) Explain, in terms of the concentration of sugar molecules, why the boiling point of the mixture in step 3 increases as water evaporates from the mixture.