Unit 5 – PBOM

At the end of this unit, you'll know that…

- ✓ "Differentiate between heterogeneous and homogeneous mixtures
- ✓ Identify the various types of heterogeneous mixtures and their properties – colloid & suspension
- ✓ Identify the various types of homogeneous mixtures and their properties- alloy & solution
- ✓ Define solubility and understand the factors that contribute to solubility - nature of solute and solvent (like dissolves like) & temperature
- ✓ Use Table F to determine if precipitate is formed in a chemical reaction
- ✓ Distinguish between saturated, unsaturated, or supersaturated solutions
- ✓ Read the solubility curve (Table G) to determine if a solution is (1) saturated, (2) unsaturated, or (3) supersaturated
- ✓ Differentiate between dilute and concentrated solutions
- ✓ Calculate various concentrations of a solution using the following: Molarity (M), Percent by Mass, Percent by Volume, Parts per Million (ppm), Prepare a solution of known concentration
- ✓ Explain a solute's effect on a solution (colligative properties) - Freezing Point Depression & Boiling Point Elevation

Term	Definition
Absolute Zero	the lowest possible temperature; the temperature at which all particle movement stops; -273℃ or 0 K.
Alloy	a homogenous mixture/solution containing at least one metal. Ex: brass, steel, bronze
Aqueous	a homogenous mixture/solution in which a solute is dissolved in water.
Avogadro's Law	gases at the same temperature, pressure, & volume have the same number of molecules or particles.
Boiling Point	the temperature at which a liquid undergoes a phase change from liquid to gas; the temperature at which the vapor pressure of a liquid is equal to the atmospheric pressure.
Boiling Point Elevation	the boiling point of a solution is higher than the boiling point of the pure solvent (colligative property)
Colloid	a heterogeneous mixture composed of tiny particles suspended in another material. The particles are larger than the particles in a solution but smaller than particles in a suspension. Ex: milk, blood
Compound	pure substance composed of two or more different elements chemically combined.
Concentrated	Having a relatively large amount of substance present in a unit amount of mixture.
Concentration	A measure of the amount of solute present in a unit amount of mixture. PPM or Molarity
Cooling Curve	diagram showing phase changes for a substance as it loses energy and goes from gas phase all the way to solid phase.
Deposition	phase change from gas to solid.
Dilute	having a relatively low concentration of solute in a mixture.
Element	pure substance composed of one species of atoms.
Energy	the capacity to do work.
Evaporation	phase change from liquid to gas.
Extensive (property)	a physical property that depends on sample size or amount
Freezing Point Depression	the freezing point/melting point of a solution is lower than the freezing point/melting point of the pure solvent (colligative property)
Heat	form of energy measured in Joules (J).
Heat of Fusion	energy required to change 1 g of a substance from solid to liquid.
Heat of Vaporization	energy required to change 1 g of a substance from liquid to gas.
Heat Transfer	energy transferred from a substance with more (hotter) to a substance with less (cooler).
Heating Curve	diagram showing phase changes for a substance as it gains energy and goes from solid phase all the way to gas phase.
Heterogeneous	A sample of matter consisting of more than one pure substance or more than one phase

Term	Definition
Homogeneous	A sample of matter consisting of more than one pure substance with properties that do not vary within the sample
Insoluble	Refers to a substance that does not dissolve in a solvent to any significant degree
Intensive (property)	a physical property that does NOT depend on sample size or amount (Ex: melting point, boiling point, density)
Kinetic Energy	energy of motion; energy associated with a change in temperature.
Kinetic Molecular Theory (KMT)	a model used to explain the behavior of gases in terms of the motion of their particles.
Lattice	the unique crystal structure associated with any given solid.
Matter	anything that has mass and takes up space.
Melting Point	the temperature at which a phase change between solid and liquid occurs.
Miscible	Two liquids are considered "miscible" or mixable if shaking them together results in a single liquid phase with no visible separation
Mixture	two or more pure substance PHYSICALLY combined; a combination of two or more pure substances that can be separated by physical means
Mixture	two or more pure substances physically combined.
Molarity	a measure of concentration; M = moles of solute/liters of solution
Normal Boiling Point	the temperature at which a phase change between liquid and gas occurs at 1 atm or 101.3 kPa; the temperature at which the vapor pressure of a liquid is equal to the atmospheric pressure.
Parts Per Million	a measure of concentration; ppm = parts of solute/million parts of solution
Percent Composition (by mass or volume)	% comp = (part/whole) x 100
Potential (AKA Physical) Energy	energy of position; energy associated with a phase change.
Precipitate	An insoluble substance that has been formed from a chemical reaction between substances dissolved in a solution
Saturated	a solution that has reached equilibrium; a solution which cannot dissolve any more solute
Solubility	a measure of the concentration of a substance in a saturated solution; a measure of how much of a substance can dissolve in a given amount of solvent
Soluble	capable of being dissolved in a solvent
Solute	A substance dissolved in a solvent to make a solution
Solution	a homogenous mixture
Solvent	The most abundant component in a solution
Sublimation	phase change from solid to gas.

Term	Definition
Supersaturated	a solution in which the concentration of solute is higher than the solubility; more solute is dissolved than should be under a given set of conditions
Suspension	A heterogeneous mixture in which relatively large particles are suspended in a liquid
Temperature	a measure of average kinetic energy.
Tyndall Effect	Light passing through a colloid is scattered by suspended particles (the light beam becomes clearly visible)
Unsaturated	A solution with a concentration lower than its equilibrium solubility; a solution in which more solute can be dissolved
Vapor Pressure	the upward pressure of a vapor in equilibrium with its liquid.

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Temperature

1. Convert -83ºC to Kelvin _____
2. What is the relationship between temperature and kinetic energy of the particles in a substance? _____

   _____

   _____
3. How many Celsius degrees separate the freezing and boiling points of water? _____
4. What are these two temperatures? _____ & _____
5. What is the lowest possible temperature in ºC? _____
6. How many Kelvins separate the freezing and boiling points of water? _____
7. What are these two temperatures? _____ & _____
8. What is the lowest possible temperature in Kelvins? _____
9. Using the temperature conversion formula on Table T in your Reference Tables, convert the following temperatures to either Celsius or Kelvin.

°C	K
	383 K
80 °C	
	323 K
10 °C	
- 10 °C	
	243 K

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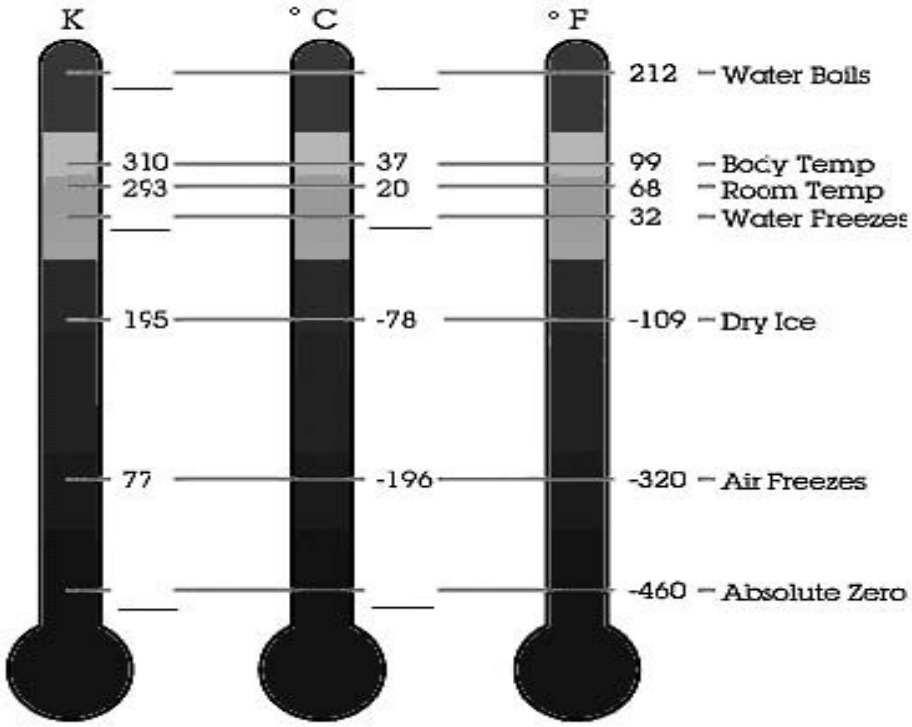
10. Complete the following diagram by filling in temperatures at the designated lines.



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FILL IN THE BLANKS – WORDS CAN BE USED MORE THAN ONCE!

Word Bank: Celsius, Kelvin, Fahrenheit, phases, heat, temperature, higher, lower, energy, kinetic, motion, potential, absolute zero, gases, positive, 273, 0, -273, 373, 100

The particles making up any sample of matter are in random motion. Hence, they have _____ energy, which is defined as the energy of _____. The _____ of a body is a measure of the average _____ energy of the particles making up the body. The form of energy called _____ flows from a body at a _____ temperature to a body at a _____ temperature. We therefore say that the hotter body "heats up" the cooler body. Bodies that have the same _____ are composed of particles that have the same average _____ energy. While a substance changes _____, there is a change in the amount of _____ present, but there is no change in _____. This is because it is the _____ energy of a substance that changes during a phase change. It is important to note that only one type of _____ can change at a time. The temperature scale most closely associated with the metric or the S.I. system is called _____. The melting/freezing point of water according to this scale is _____ degrees, and the boiling point is _____. The coldest temperature possible according to the Celsius scale is _____ degrees. The _____ scale was developed mainly to allow scientists to perform calculations involving _____ because it's a scale that uses only _____ numbers. The melting/freezing point of water according to Kelvin scale is _____, and the boiling point is _____. The coldest temperature possible according to the Kelvin scale is _____, otherwise known as _____.

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Phases of Matter

1. What are the 3 states or phases of matter? _____

2. In each of the 3 boxes below, draw circles to represent the particles in solid, liquid, and gas.

3. Which state will have the least particles in a given volume? _____ Why? _____

   _____

   _____

4. In which state will a given substance have the most energy? _____

5. Which state will H_2O be in at -10^oC? _____ 10^oC? _____

   110^oC? _____

6. Why is it difficult to squash liquids? _____

   _____

7. Can gases be squashed? _____ What does this tell you about the distance between gas particles? _____

   _____

8. Explain how a gas exerts pressure on the sides of its container._____

   _____

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9. What would happen to the pressure of a gas if you increase its temperature in a rigid container? _____

_____

_____

10. Fill the following terms in the table below.

random molecular arrangement
weaker attractive forces
definite volume
particles in fixed positions
constant random motion
no definite shape
no forces of attraction
no definite shape
regular lattice arrangement
definite volume
no definite volume
strong attractive forces
particles free to move
very dense
random molecular arrangement
can't be compressed
constant rapid and random motion
low density
definite shape
particles free to move
fairly dense
particles vibrate about fixed positions
can be compressed
can't be compressed

Solid	Liquid	Gas

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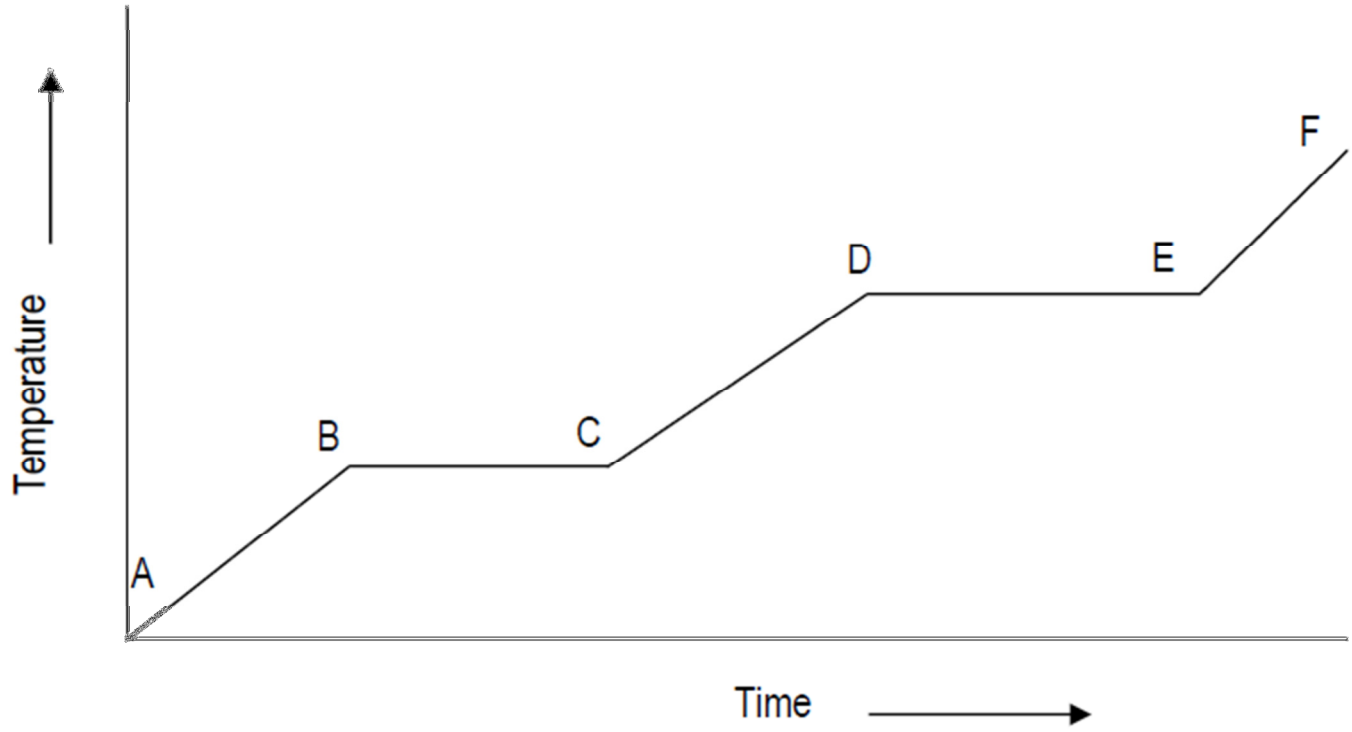
Heating Curve

Directions: Use the phase change diagram below to answer the questions that follow.



1. On the diagram above, label the phases present during each line segment.

2. Determine the line segment(s) that represents the information below.

_____a. Gas, only _____

_____b. Liquid, only _____

_____c. Solid, only _____

_____d. Solid and Liquid, only _____

_____e. Liquid and Gas, only _____

_____f. Melting Point _____

_____g. Boiling Point _____

_____h. Kinetic energy is increasing _____

_____i. Potential energy is increasing _____

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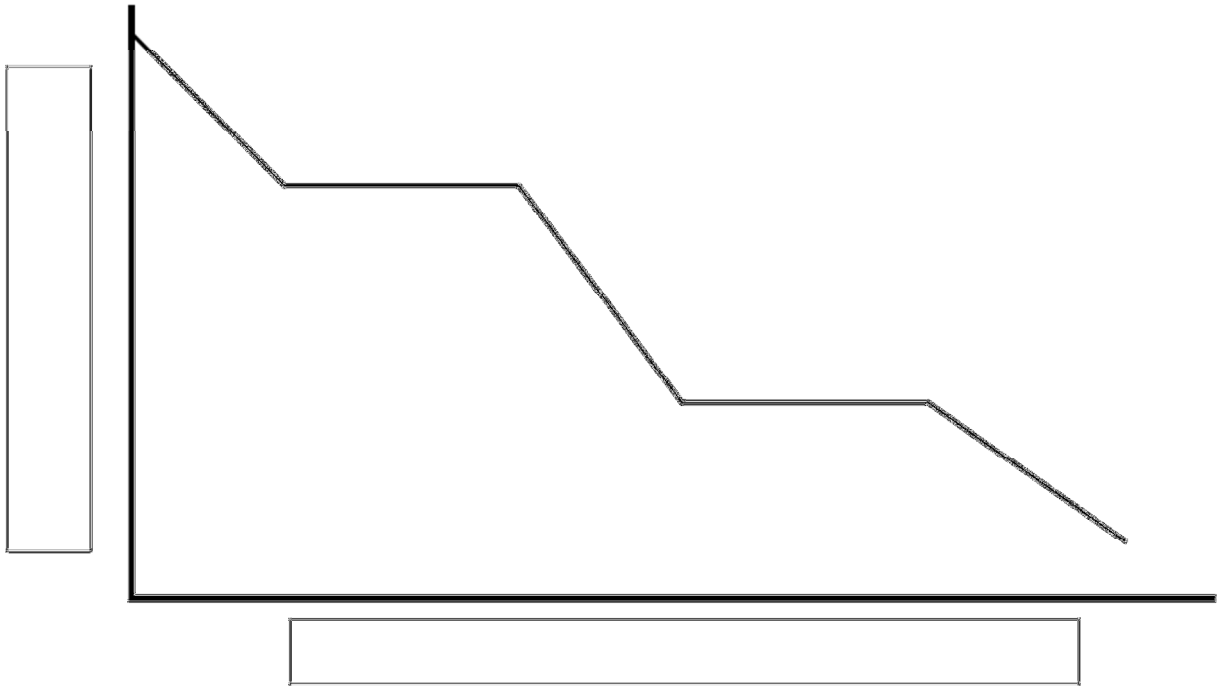
Cooling Curve

Directions: In the space provided below label the cooling curve to represent water vapor as it is cooled to liquid water, and finally to ice. Make sure to place the correct title for each axis in the boxes provided. Then use your diagram to answer the following questions.



1. Place the letter A over any line segment that represents a decrease in kinetic energy.
2. Place the letter B over any line segment in which the kinetic energy is constant.
3. Place the letter C over the line segment that represents the gas phase.
4. Place the letter D over the line segment that represents the liquid phase.
5. Place the letter E over the line segment that represents the solid phase.
6. Place the letter F over the line segment that represents equilibrium between solid and liquid.
7. Place the letter G over the line segment that represents equilibrium between liquid and gas.

8. Which letter (A,B,C,D,E,F, or G) represents condensation? _____

9. Which letter (A,B,C,D,E,F, or G) represents freezing? _____

10. Explain what is happing during a phase change between both kinetic and potential energy. _____

_____

_____

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$q = mC\Delta T$

Specific Heat of ethyl alcohol = 2.44 J/g * °C
Specific Heat of aluminum = 0.900 J/g * °C
Density of Aluminum = 2.70 g/ml

1. How many joules will be given off if a 50.0 gram sample of water is allowed to cool from 50.0 °C to 20.0 °C?

2. A hot piece of iron is put into a bucket containing 3.0 liters of water. The temperature of the water increases from 30. °C to 110 °C. How many joules were put into the bucket?

3. How many joules are needed to heat 4.00 liters of water to 70°C? The initial temperature of the water is 27.0 °C.

4. How many joules will be needed to heat a 4.00 Liters of ethyl alcohol starting from 27.0 °C to 70.0 °C?

5. Using your results from Q 3 & 4, which liquid can store more energy? Explain you answer.

6. If constant heat is applied to both liquids (from Q 3 & 4) simultaneously. Which liquid would reach 70.0 °C first? Why?

7. A 500. ml sample of water has an initial temperature of 95.0°C. What will the final temperature be after 1500. joules of energy is removed?

8. After adding a total of 2500.joules. A container filled with 15 liters of water reached a maximum temperature of 90.0 °C. What was the initial temperature of the water?

9. A 5 gram piece of aluminum, measuring 5.00 cm by 0.500 cm by 2.00 cm, is placed into a graduated cylinder containing 50.0 ml of water. Before entering the water the aluminum was 27.0 °C, after entering the water it was 20.0 °C. How much energy did the aluminum lose?

10. A piece of aluminum is placed into a 100 liter container. The container is then filled with water. The total mass of the aluminum is 20 kg.
    a. What is the volume of the aluminum? (Hint – D=m/v)

    b. What is the volume of the water inside the container? (Hint – subtract the volume of the aluminum)

    c. What is the mass of the water? (Hint – D=m/v)

    d. How many kilojoules will be necessary to heat the aluminum to from 20.0 °C to 60.0 °C?

    e. How many kilojoules will be necessary to heat the water to from 20.0 °C to 60.0 °C?

f. How many kilojoules will be necessary to heat both the water and the aluminum?

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Heat of Fusion and Vaporization

1. Calculate the amount of heat needed to convert 190.0 g of liquid water at 100 ºC to steam at 100. ºC.

2. How much energy is released to the environment by 50.0 grams of condensing water vapor?

3. Is melting endothermic or exothermic? Explain.

4. Calculate the amount of heat needed to melt 35.0 g of ice at 0 ºC. Express your answer in kilojoules.

5. Calculate the amount of heat needed to convert 96 g of ice at 0 ºC to water .

6. Calculate the amount of heat released to the environment as 245 g of steam condenses to water.

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Heat Calculation Practice

Use the Heat Equations on Table T and the Physical Constants for Water on Table B in your CRT's to complete the following problems. SHOW ALL WORK.

1. A 5.00 gram sample of water is heated so that its temperature increases from 10.0°C to 15.0°C. What is the total amount of energy absorbed by the water?

2. When a sample of 25.0 g of water is cooled from 20.0°C to 10.0°C, what is the number of Joules of energy released?

3. A sample of water is heated from 10.0°C to 15.0°C by adding 125.58 Joules of heat. What is the mass of the water?

4. What is the total number of kilojoules of heat needed to change 150. grams of ice to liquid water at 0ºC?

5. How much energy is required to vaporize 10.00 grams of water at its boiling point?

6. How many joules of heat energy are released when 50.0 grams of water are cooled from 70.0 °C to 60.0 °C?

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7. What is the total number of joules of heat energy absorbed when the temperature of 200.0 grams of water is raised from 10.0 °C to 40.0 °C?

8. How many kJ of heat energy are absorbed when 100.0 g of water are heated from 20.0 °C to 30.0 °C?

9. The temperature of a sample of water in the liquid phase is raised 30.0 °C by the addition of 3762 J. What is the mass of the water?

10. When 418. joules of heat energy are added to 10.0 grams of water at 20.0 °C, what will the final temperature of the water be?

11. How many grams of water will absorb a total of 2400 joules of energy when the temperature changes from 10.0 °C to 30.0 °C?

12. How much heat is needed to raise the temperature of 20.0 grams of liquid water from 5.0 °C to 20.0 °C?

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13. How much heat is released by 200.0 grams of water as it cools from 200.0 °C to 150.0 °C?

14. The temperature of 50.0 grams of liquid water was raised to 50.0 °C by the addition of 500. Joules of heat. What was the initial temperature of the water?

15. How many kilojoules are equivalent to 300. J?

16. When 20.0 grams of a substance is completely melted at 0˚C, 3444 J are absorbed. What is the heat of fusion of this substance?

17. What would be the temperature change if 3.0 grams of water absorbed 15 Joules of heat?

18. How many grams of water will absorb a total of 2,400 J of energy when the temperature changes from 10.0°C to 30.0°C?

19. How much heat is needed to raise the temperature of 20.0 grams of liquid water from 5.0°C to 20.0°C?

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20. How much heat is released by 200.0 grams of water as it cools from 200.0°C to 150.0°C?

21. How many joules are equivalent to 30 Kilojoules?

22. What is the total number of joules required to freeze a 10 g sample of water at 0□C?

23. How much energy is required to vaporize 10.00 g of water at its boiling point?

24. Calculate the amount of energy required heat 100. g to the following:
    a. H_2O(s) changes to H2O(l) at 0°C

    b. H_2O(l) changes to H_2O (s) at 0°C

    c. H_2O(l) at 10°C changes to H_2O(l) at 20°C

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25. What is the specific heat of silver if a 93.9 g sample cools from 215.0°C to 196.0°C with the loss of 428 J of energy?

26. What is the total number of kilojoules of heat needed to change 25 g of ice to water at 0°C?

27. In question 26, is heat being absorbed or released? Is this process endothermic or exothermic?

28. What is the total number of kilojoules required to completely boil 50.0 g of water at 100°C?

29. If 100.0 J are added to 20.0 g of water at 30.0°C, what will be the final temperature of the water?

30. At 1 atmosphere of pressure, 25.0 g of a compound at its normal boiling point are converted to a gas by the addition of 34,400 J. What is the heat of vaporization for this compound?

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Heat Calculations

1. In a laboratory where the air temperature is 22°C, a steel cylinder at 100.°C is submerged in a sample of water at 40.°C. In this system, heat flows from

   A) both the air and the water to the cylinder
   B) the air to the water and from the water to the cylinder
   C) the cylinder to the water and from the water to the air
   D) both the cylinder and the air to the water

2. A 50.0-gram block of copper at 10.0°C is carefully lowered into 100.0 grams of water at 90.0°C in an insulated container. Which statement describes the transfer of heat in this system?

   A) The water gains heat and the block loses heat until both are at the same temperature that is between 10.0°C and 90.0°C.
   B) The water loses heat to the block until both are at 10.0°C.
   C) The block gains heat from the water until both are at 90.0°C.
   D) The water loses heat and the block gains heat until both are at the same temperature that is between 10.0°C and 90.0°C.

Base your answers to questions **3** through **5** on the information below.

Heat is added to a 200.-gram sample of $H_2O(s)$ to melt the sample at 0°C. Then the resulting $H_2O(\ell)$ is heated to a final temperature of 65°C.

3. Compare the amount of heat required to vaporize a 200.-gram sample of $H_20(\ell)$ *at its boiling point to the amount of heat required to melt a 200.-gram sample of* $H_2O(s)$ *at its melting point.*

4. In the space below, show a numerical setup for calculating the total amount of heat required to raise the temperature of the $H_2O(\ell)$ from 0°C to its final temperature.

5. Determine the total amount of heat required to completely melt the sample.

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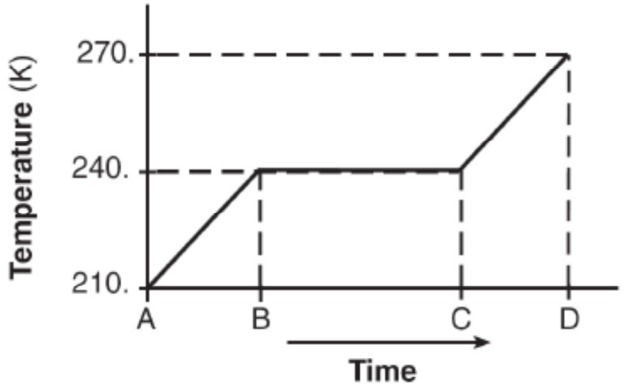
Base your answers to questions **6** and **7** on the information below

A 5.00-gram sample of liquid ammonia is originally at 210. K. The diagram of the partial heating curve below represents the vaporization of the sample of ammonia at standard pressure due to the addition of heat. The heat is *not* added at a constant rate.

Partial Heating Curve for Ammonia



Some physical constants for ammonia are shown in the data table below.

Some Physical Constants for Ammonia

specific heat capacity of $NH_3(\ell)$	4.71 J/g•K
heat of fusion	332 J/g
heat of vaporization	1370 J/g

6. Describe what is happening to *both the potential energy and the average kinetic energy of the molecules in the ammonia sample during time interval BC. Your response must include both potential energy and average kinetic energy.*

7. Calculate the total heat absorbed by the 5.00-gram sample of ammonia during time interval AB. Your response must include *both* a correct numerical setup and the calculated result.

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8. Base your answer to the following question on the following paragraph.

The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. The heat of vaporization of ethanol is 838 joules per gram. A sample of ethanol has a mass of 65.0 grams and is boiling at 1.00 atmosphere.

Calculate the minimum amount of heat required to completely vaporize this sample of ethanol. Your response must include *both* a correct numerical setup and the calculated result.

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9. What is the total amount of heat energy, in joules, absorbed by 25.0 grams of water when the temperature of the water increases from 24.0°C to 36.0°C?

10. Base your answer to the following question on the information below.

At a pressure of 101.3 kilopascals and a temperature of 373 K, heat is removed from a sample of water vapor, causing the sample to change from time gaseous phase to time liquid phase. This phase change is represented by the equation below.

$$H_2O(g) \rightarrow H_2O(\ell) + \text{heat}$$

Determine the total amount of heat released by 5.00 grams of water vapor during this phase change.

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VAPOR PRESSURE PROBLEMS

1. What is the vapor pressure of ethanol at its normal boiling point?

2. What pressure is needed to make ethanol boil at 80˚C?

3. Temperature and intermolecular forces are two factors that affect the rate of evaporation. Explain your reasoning behind this for both factors.

4. Explain how temperature and vapor pressure are related.

5. What happens when the pressure above the surface of a liquid is equal to the vapor pressure of the liquid? Explain.

6. The particles that make up a solid at room temperature are said to be arranged in a regular geometric fashion. Are these particles still moving? Explain.

7. If the pressure on the surface of water in the liquid state is 30 kPa, the water will boil at what temperature?

8. As the pressure on a liquid is changed from 100. kPa to 120.0 kPa, what happens to the boiling point? Explain your answer.

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9. At what pressure will ethanoic acid boil 100˚C?

10. What temperature will propanone boil at standard temperature?

11. If the pressure were 50 kPa, what temperature would water boil?

12. What is the normal boiling point of ethanol?

13. At 150 kPa what is the boil point of water?

14. At 75 kPa, what temperature will ethanoic acid boil?

15. At 75˚C what pressure is required to make ethanoic acid boil?

16. Which liquid has the strongest intermolecular force? How do you know?

17. Which liquid has the weakest intermolecular force? How do you know?

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Vapor Pressure Questions

1. At which temperature is the vapor pressure of ethanol equal to 80. kPa?

   A) 48°C B) 73°C
   C) 80°C D) 101°C

2. Which compound has the *lowest* vapor pressure at 50°C?

   A) ethanol B) water
   C) ethanoic acid D) propanone

3. At standard pressure, a certain compound has a low boiling point and is insoluble in water. At STP, this compound most likely exists as

   A) polar molecules
   B) ionic crystals
   C) metallic crystals
   D) nonpolar molecules

4. Which liquid has the highest vapor pressure at 75°C?

   A) propanone B) ethanoic acid
   C) ethanol D) water

5. Based on intermolecular forces, which of these substances would have the highest boiling point?

   A) CH_4 B) He C) O_2 D) NH_3

6. Using your knowledge of chemistry and the information in Reference Table *H*, which statement concerning propanone and water at 50°C is true?

   A) Propanone has a higher vapor pressure and weaker intermolecular forces than water.
   B) Propanone has a lower vapor pressure and weaker intermolecular forces than water.
   C) Propanone has a higher vapor pressure and stronger intermolecular forces than water.
   D) Propanone has a lower vapor pressure and stronger intermolecular forces than water.

7. According to Reference Table *H*, what is the vapor pressure of propanone at 45°C?

   A) 33 kPa B) 70 kPa
   C) 22 kPa D) 98 kPa

8. As the temperature of a liquid increases, its vapor pressure

   A) decreases B) increases
   C) remains the same

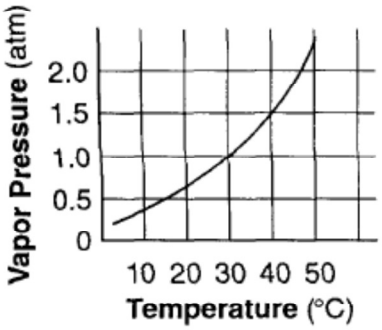
9. Which sample of water has the *lowest* vapor pressure?

   A) 100 mL at 50°C B) 200 mL at 30°C
   C) 300 mL at 40°C D) 400 mL at 20°C

10. Based on Reference Table *H*, which substance has the weakest intermolecular forces?

    A) propanone B) ethanol
    C) water D) ethanoic acid

11. The graph below shows the relationship between vapor pressure and temperature for substance *X*.



What is the normal boiling point for substance *X*?

A) 20°C B) 30°C
C) 50°C D) 40°C

12. When the vapor pressure of water is 30 kPa, the temperature of the water is

    A) 20°C B) 100°C
    C) 70°C D) 40°C

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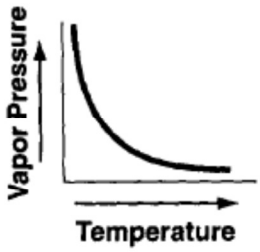
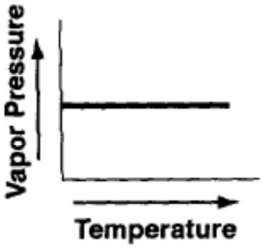
13. Which graph best represents the variation in the vapor pressure of water as temperature changes?

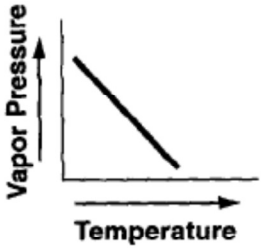
A)



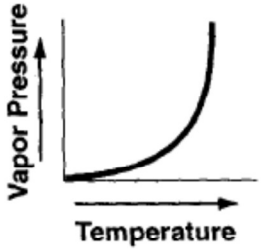
B)



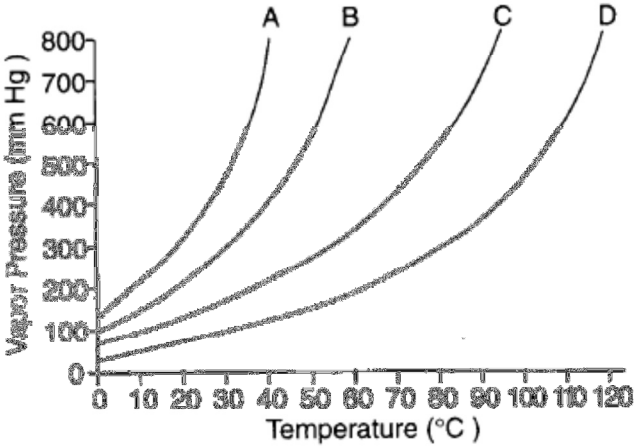
C)



D)



14. Base your answer to the following question on The graph below represents the vapor curves of four liquids.



Which liquid has the highest normal boiling point?

A) *A* B) *B* C) *C* D) *D*

15. Which two compounds readily sublime at room temperature (25°C)?

A) $CO_2(s)$ and $C_6H_{12}O_6(s)$
B) $NaCl(s)$ and $I_2(s)$
C) $CO_2(s)$ and $I_2(s)$
D) $NaCl(s)$ and $C_6H_{12}O_6(s)$

16. In a closed system, as the temperature of a liquid increases, the vapor pressure of the liquid

A) decreases B) increases
C) remains the same

17. When the vapor pressure of a liquid is equal to the atmospheric pressure, the liquid will

A) condense B) melt
C) boil D) freeze

18. If the pressure on the surface of water in the liquid state is 47 kPa, the water will boil at

A) 101.3°C B) 80°C
C) 40°C D) 0.0°C

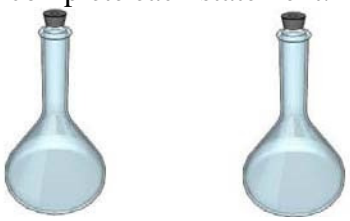
19. When the temperature of a sample of water is changed from 45°C to 70.°C, the change in its vapor pressure is

A) 1.0 kPa B) 20. kPa
C) 25 kPa D) 101.3 kPa

Name _____ Date _____
Period _____

Avogadro's Gas Law I

Questions 1-5 are based on the following information:
Two samples of gas are contained in separate flasks as shown in the drawing. Both flasks have a volume of 1 liter. Choose a phrase from the list A-C below to complete each statement.



Flask 1 (O_2) Flask 2 (N_2)

A - flask number 1 is greater B - flask number 2 is greater C - each flask is the same

1. If each sample is at STP, then the number of molecules in _____
2. If each sample is at STP, then the mass of the contents of _____
3. If each sample is sealed and heated to the same temperature, then the pressure in _____
4. If the temperature of both flasks is doubled, then the average kinetic energy of the molecules in _____
5. If the temperature of both flasks is doubled, then the average kinetic molecular velocity in _____

Question 6-9 are based on the chart below. Please read each question and determine whether Gas A, B, C, or D is the best answer

Sample	Quantity (moles)	Pressure (mmHg)	Temperature (K)
Gas A	2	760	273
Gas B	1	380	273
Gas C	1	760	273
Gas D	2	760	546

6. Which sample contains molecules with the highest average kinetic energy? _____
7. Which sample contains the same number of molecules as sample A? _____
8. Which sample occupies the smallest volume? _____
9. Which is the ratio of the volume of sample D to the volume of sample A? _____

a. $\frac{1}{1}$ b. $\frac{2}{1}$ c. $\frac{1}{2}$ d. $\frac{4}{1}$

Name _____ Date _____

Period _____

KMT and Avogadro's Law

1. Which rigid cylinder contains the same number of gas molecules at STP as a 2.0-liter rigid cylinder containing $H_2(g)$ at STP?

   A) 1.0-L cylinder of $O_2(g)$
   B) 2.0-L cylinder of $CH_4(g)$
   C) 1.5-L cylinder of $NH_3(g)$
   D) 4.0-L cylinder of He(g)

2. The table below shows data for the temperature, pressure, and volume of four gas samples.

Data for Four Gas Samples

Gas Sample	Temperature (K)	Pressure (atm)	Volume (mL)
A	100.	2	400.
B	200.	2	200.
C	100.	2	400.
D	200.	4	200.

Which two gas samples have the same total number of molecules?

A) *A* and *C* B) *A* and *B*
C) *B* and *C* D) *B* and D

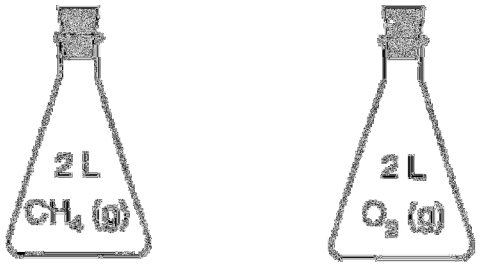
3. A sample of oxygen gas is sealed in container X. A sample of hydrogen gas is sealed in container Z. Both samples have the same volume, temperature, and pressure. Which statement is true?

   A) Container X contains fewer gas molecules than container Z.
   B) Container X contains more gas molecules than container Z.
   C) Containers X and Z both contain the same number of gas molecules.
   D) Containers X and Z both contain the same mass of gas.

4. At the same temperature and pressure, 1.0 liter of CO(g) and 1.0 liter of $CO_2(g)$ have

   A) equal masses and the same number of molecules
   B) equal volumes and the same number of molecules
   C) different volumes and a different number of molecules
   D) different masses and a different number of molecules

5. Each stoppered flask below contains 2 liters of a gas at STP.



Each gas sample has the same

   A) density
   B) number of atoms
   C) number of molecules
   D) mass

6. Equal volumes of all gases at the same temperature and pressure contain an equal number of

   A) molecules B) atoms
   C) protons D) electrons

7. According to the kinetic molecular theory, the particles of an ideal gas

   A) are arranged in a regular, repeated geometric pattern
   B) have no potential energy
   C) have strong intermolecular forces
   D) are separated by great distances, compared to their size

Name _____ Date _____
Period _____

8. Which statement describes the particles of an ideal gas?

A) The volume of the particles is negligible.
B) There are forces of attraction between the particles.
C) The particles move in well-defined, circular paths.
D) When the particles collide, energy is lost.

9. According to the kinetic molecular theory, which statement describes the particles in a sample of an ideal gas?

A) The force of attraction between the gas particles is strong.
B) The motion of the gas particles is random and straight-line.
C) The separation between the gas particles is smaller than the size of the gas particles themselves.
D) The collisions between the gas particles cannot result in a transfer of energy between the particles.

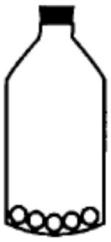
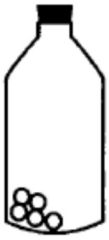
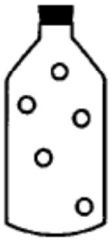
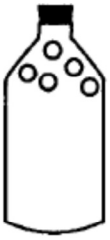
10. Standard pressure is equal to

A) 1 atm B) 273 kPa
C) 1 kPa D) 273 atm

11. A sample of a gas is contained in a closed rigid cylinder. According to kinetic molecular theory, what occurs when the gas inside the cylinder is heated?

A) The volume of the gas decreases.
B) The number of gas molecules increases.
C) The average velocity of the gas molecules increases.
D) The number of collisions between gas molecules per unit time decreases.

12. Which diagram best represents a gas in a closed container?

A) 
B) 
C) 
D) 

13. The concept of an ideal gas is used to explain

A) the mass of a gas sample
B) why some gases are diatomic
C) why some gases are monatomic
D) the behavior of a gas sample

14. Under which conditions does a real gas behave most like an ideal gas?

A) at high temperatures and high pressures
B) at low temperatures and low pressures
C) at low temperatures and high pressures
D) at high temperatures and low pressures

15. Two basic properties of the gas phase are

A) a definite shape and a definite volume
B) no definite shape but a definite volume
C) no definite shape and no definite volume
D) a definite shape but no definite volume

Name _____ Date _____
Period _____

Combined Gas Law Problems

1. A balloon contains 30.0 L of helium gas at 103 kPa. What is the volume of the helium when the balloon rises to an altitude where the pressure is only 25.0 kPa? Assume the temperature remains constant.

2. Nitrous oxide (N_2O) is used as an anesthetic. The pressure on 2.50L of N_2O changes from 105 kPa to 40.5 kPa. If the temperature does not change, what will the new volume be?

3. A gas with a volume of 4.00 L at a pressure of 205 kPa is allowed to expand to a volume of 12.0 L. What is the pressure in the container if the temperature remains constant?

4. A balloon inflated in a room at 24 ^{0}C had a volume of 4.00 L. The balloon is then heated to a temperature of 58^{0}C. What is the new volume if the pressure remains constant?

Name _____ Date _____
Period _____

5. If a sample of gas occupies 6.80 L at 325°C, what will its volume be at 25°C if the pressure does not change?

6. Exactly 5.00 L of air at 50.0°C is warmed to 100°C. What is the new volume if the pressure remains constant?

7. The volume of a gas-filled balloon is 30.0 L at 313 K and 153 kPa pressure. What would the volume be at standard temperature and pressure?

8. A gas at 155 kPa and 25°C has an initial volume of 1.00 L. The Pressure of the gas increase to 605 kPa as the temperature in increased to 125°C. What is the new volume?

9. A 5.00 L air sample has a pressure of 107 kPa at a temperature of 50°C. If the temperature is raised to 102°C and the volume expands to 7.00 L. What will the new pressure be?

Name _____ Date _____
Period _____

More Combined Gas Law Practice

1. A gas has a volume of 50. mL at a temperature of 10.0 K and a pressure of 760. mm Hg. What will be the new volume when the temperature is changed to 20.0 K and the pressure is changed to 380. mm Hg?

2. The volume of a sample of a gas at 273 K is 100.0 L. If the volume is decreased to 50.0 L at constant pressure, what will be the new temperature of the gas?

3. A gas has a volume of 2.00 L at 323 K and 3.00 atm. What will be the new volume if the temperature is changed to 273 K and the pressure is changed to 1 atm?

4. What will be the new volume of 100. mL of gas if the Kelvin temperature and the pressure are both halved?

5. A gas occupies a volume of 500. mL at a pressure of 380. torr and a temperature of 298 K. At what temperature will the gas occupy a volume of 250. mL and have a pressure of 760. torr?

6. A gas at STP has a volume of 1.00 L. If the pressure is doubled and the temperature remains constant, what is the new volume of the gas?

7. A 2.5 L sample of gas is at STP. When the temperature is raised to 373°C and the pressure remains constant what will the new volume of the gas be?

Name _____ Date _____
Period _____

8. A cylinder of a car's engine has a volume of 0.725 L when the piston is at the bottom of the cylinder. When the piston is at the top of the cylinder it has a volume of 0.050L. If the cylinder is filled with air at a pressure of 1 atm when the piston is at the bottom, what is the pressure when the piston is at the top if the temperature remains constant?

9. You are given two equally sized containers of He(g) and H2(g) that both behave as ideal gasses and have equal pressures and temperatures.
    a. Does each container have the same number of particles? Explain.

    b. Do they have the same number of atoms? Explain.

    c. Do they have the same mass? Explain.

10. At a constant temperature, the pressure on 8.0 L of a gas is increased from 1 atm to 4 atm. What will be the new volume of the gas?

11. A gas occupies a volume of 30.0 mL at 273 K. If the temperature is increased to 364 K while the pressure remains constant, what will be the volume of the gas?

12. The volume of 50.0 milliliters of an ideal gas at STP increases to 100. mL at a constant pressure. What will the new temperature be?

13. Equal volumes of all gases at the same temperature and pressure contain an equal number of

    a) electrons b) protons c) molecules d) atoms

Name _____ Date _____
Period _____

14. A 100. mL sample of a gas at a pressure of 380. torr is reduced to 190. torr at constant temperature.What is the new volume of the gas?

15. At a constant pressure, 50.0 mL of a gas at 20.0°C is heated to 30.0°C. What will be the new volume of the gas?

16. Draw a graph to illustrate the relationship between the volume of a gas (V) and its temperature (T) when pressure remains constant.

17. Draw a graph that represents the relationship between volume and pressure for an ideal gas at constant temperature.

18. Draw a graph that represents the relationship between temperature and pressure for an ideal gas at constant volume.

Name: _____

_ 1) Which of the following changes is exothermic?

A) sublimation of iodine
B) vaporization of ethanol
C) freezing of water
D) melting of iron

___ 2) Which physical changes are endothermic?

A) condensation and deposition
B) melting and evaporating
C) condensation and sublimation
D) melting and freezing

___ 3) Two samples of gold that have different temperatures are placed in contact with one another. Heat will flow spontaneously from a sample of gold at 60[illegible] to a sample of gold that has a temperature of [illegible]

A) 60[illegible] °C
B) 80[illegible] °C
C) 50[illegible] °C
D) 70[illegible] °C

___ 4) As the temperature of a substance decreases, the average kinetic energy of its particles

A) decreases
B) remains the same
C) increases

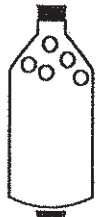
___ 5) At 1 atmosphere and 298 K, 1 mole of $H_2O(l)$ molecules and 1 mole of $C_2H_5OH(l)$ molecules *both* have the same

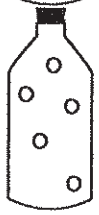
A) vapor pressure
B) average kinetic energy
C) density
D) mass

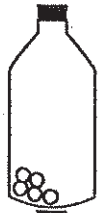
___ 6) Which kelvin temperature is equivalent to -24DC?

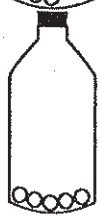
A) 297 K
B) 249 K
C) 273 K
D) 226 K

___ 7) Which diagram *best* represents a gas in a closed container?

A)


B)


C)


D)


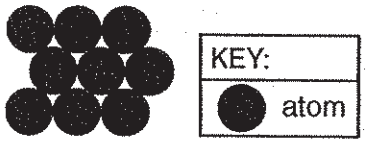
___ 8) Which grouping of the three phases of bromine is listed in order from left to right for increasing distance between bromine molecules?

A) solid, liquid, gas
B) solid, gas, liquid
C) gas, liquid, solid
D) liquid, solid, gas

___ 9) Which 5.0-milliliter sample of NH_3 will take the shape of and completely fill a closed 100.0-milliliter container?

A) $NH_3(aq)$
B) $NH_3(l)$
C) $NH_3(g)$
D) $NH_3(s)$

___ 10) Given the particle diagram:



At 101.3 kPa and 298 K, which element could this diagram represent?

A) Ag
B) Kr
C) Rn
D) Xe

___ 11) In which material are the particles arranged in a regular geometric pattern?

A) $CO_2(g)$
B) NaCl(aq)
C) $C_{12}H_{22}O_{11}(s)$
D) $H_2O(l)$

___ 12) In which equation does the term "heat" represent heat of fusion?

A) $H_2O(l) + HCl(g) \rightarrow H_3O^+(aq) + Cl^-(aq) + heat$
B) $H_2O(l) + heat \rightarrow H_2O(g)$
C) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + heat$
D) $NaCl(s) + heat \rightarrow NaCl(l)$

___ 13) As ice melts at standard pressure, its temperature remains at 0 °C until it has completely melted. Its potential energy

A) remains the same
B) decreases
C) increases

___ 14) How much heat energy must be absorbed to completely melt 35.0 grams of $H_2O(s)$ at 0°C?

A) 79,100 J
B) 11,700 J
C) 146 J
D) 9.54 J

___ 15) What is the total number of joules released when a 5.00-gram sample of water changes from liquid to solid at 0 °C?

A) 11,300 J
B) 2,260 J
C) 334 J
D) 1,670 J

___ 16) What is the freezing point of bromine?

A) 539 °C
B) -7 °C
C) -539 °C
D) 7 °C

___ 17) In which process does a solid change directly into a vapor?

A) solidification
B) deposition
C) sublimation
D) condensation

___ 18) As the pressure on the surface of a liquid decreases, the temperature at which the liquid will boil

A) remains the same
B) increases
C) decreases

___ 19) The vapor pressure of a liquid is 0.92 atm at 60 °C. The normal boiling point of the liquid could be

A) 45DC
B) 55DC
C) 65DC
D) 35DC

___ 20) As the temperature of a liquid increases, its vapor pressure

A) increases
B) remains the same
C) decreases

___ 21) Based on the *Vapor Pressure of Four Liquids* chemistry reference table, which substance has the *weakest* intermolecular forces?

A) ethanoic acid
B) propanone
C) water
D) ethanol

___ 22) According to *Vapor Pressure of Four Liquids* chemistry reference table, what is the vapor pressure of propanone at 45 °C?

A) 98 kPa
B) 70. kPa
C) 33 kPa
D) 22 kPa

___ 23) Using your knowledge of chemistry and the information in the *Vapor Pressure of Four Liquids* chemistry reference table, which statement concerning propanone and water at 50 °C is true?

A) Propanone has a lower vapor pressure and weaker intermolecular forces than water.
B) Propanone has a higher vapor pressure and weaker intermolecular forces than water.
C) Propanone has a lower vapor pressure and stronger intermolecular forces than water.
D) Propanone has a higher vapor pressure and stronger intermolecular forces than water.

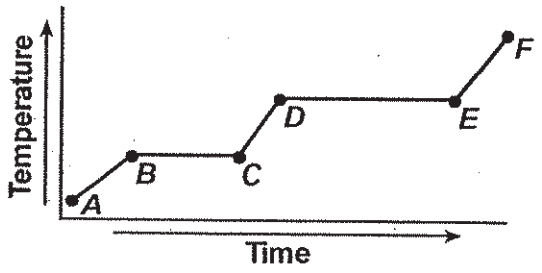
___ 24) Which phase change results in the release of energy?

A) $H_2O(l) \rightarrow H_2O(g)$
B) $H_2O(s) \rightarrow H_2O(g)$
C) $H_2O(g) \rightarrow H_2O(l)$
D) $H_2O(s) \rightarrow H_2O(l)$

___ 25) Which phase change is an exothermic process?

A) $NH_3(g)$ $NH_3(l)$
B) $Hg(l)$ $Hg(g)$
C) $CO_2(s)$ $CO_2(g)$
D) $Cu(s)$ $Cu(l)$

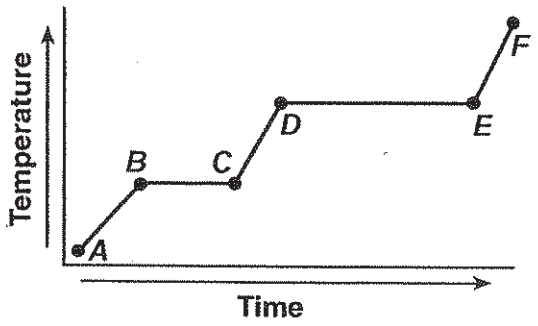
___ 26) The graph below represents the uniform heating of a substance, starting with the substance as a solid below its melting point.



Which line segment represents an increase in potential energy and *no* change in average kinetic energy?

A) *EF*
B) *CD*
C) *BC*
D) *AB*

___ 27) The graph below represents the uniform heating of a substance, starting below its melting point, when the substance is solid.



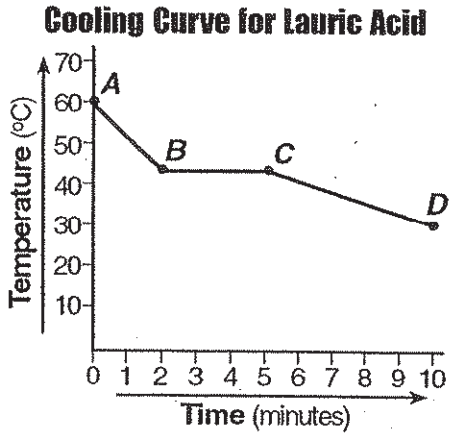
Which line segments represent an increase in average kinetic energy?

A) *DE* and *EF*
B) *BC* and *DE*
C) *AB* and *CD*
D) *AB* and *BC*

___ 28) Calculate the heat released when 25.0 grams of water freezes at 0 °C. [*Show all work. Record your answer with an appropriate unit.*]

___ 29) A liquid's boiling point is the temperature at which its vapor pressure is equal to the atmospheric pressure. Using the *Vapor Pressure of Four Liquids* chemistry reference table, what is the boiling point of propanone at an atmospheric pressure of 70 kPa?

___ 30) Given the graph below that represents the uniform cooling of a sample of lauric acid starting as a liquid above freezing point.



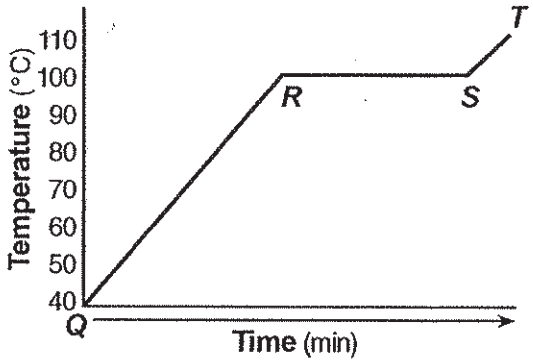
(a) Which line segment represents a phase change, only?

(b) What is the melting point of lauric acid?

(c) At which point do the particles of lauric acid have the *highest* average kinetic energy?

(d) Name the phase change that takes place during this 10-minute cooling time.

___ 31) A sample of water is heated from a liquid at 40.°C to a gas at 110DC. The graph of the heating curve is shown below.



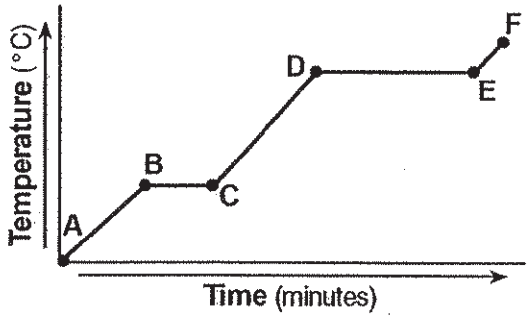
(a) On the heating curve diagram above, label each of the following regions:

Liquid, only
Gas, only
Phase change

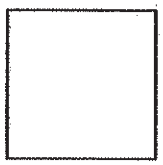
(b) For section *QR* of the graph, state what is happening to the water molecules as heat is added.

(c) For section *RS* of the graph, state what is happening to the water molecules as heat is added.

___ 32) Given the heating curve where substance *X* starts as a solid below its melting point and is heated uniformly:



Using (●) to represent particles of substance *X* in the given diagram, draw at *least* five particles as they would appear in the substance at point *F*. [*Use the box below.*]



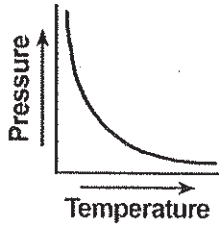
___ 33) The concept of an ideal gas is used to explain

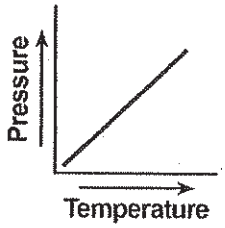
A) why some gases are diatomic
B) why some gases are monatomic
C) the behavior of a gas sample
D) the mass of a gas sample

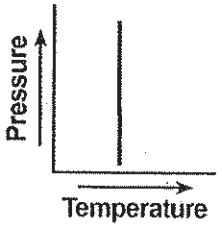
___ 34) The kinetic molecular theory assumes that the particles of an ideal gas

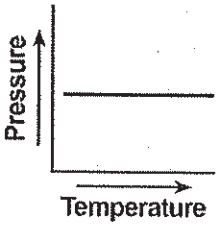
A) have collisions that result in the system losing energy
B) have strong attractive forces between them
C) are in random, constant, straight-line motion
D) are arranged in a regular geometric pattern

___ 35) Which graph shows the pressure-temperature relationship expected for an ideal gas?

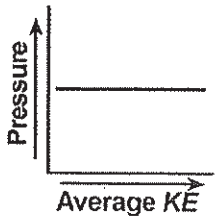
A) 

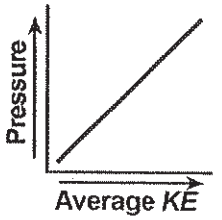
B) 

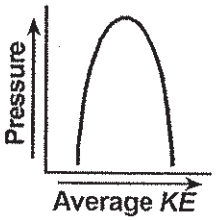
C) 

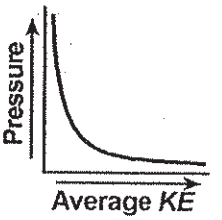
D) 

___ 36) Which graph *best* shows the relationship between the pressure of a gas and its average kinetic energy at constant volume?

A) 

B) 

C) 

D) 

___ 37) In a gaseous system at equilibrium with its surroundings, as molecules of $A(g)$ collide with molecules of $B(g)$ without reacting, the total energy of the gaseous system

A) remains the same
B) increases
C) decreases

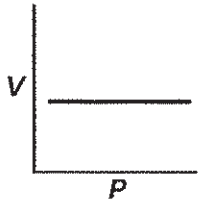
___ 38) A real gas behaves more like an ideal gas when the gas molecules are

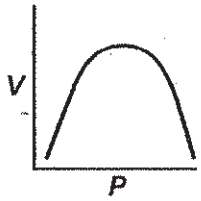
A) close and have strong attractive forces between them
B) far apart and have weak attractive forces between them
C) far apart and have strong attractive forces between them
D) close and have weak attractive forces between them

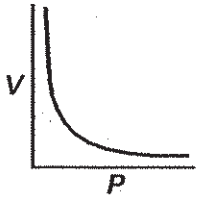
___ 39) Under which conditions of temperature and pressure would a sample of $H_2(g)$ behave *most* like an ideal gas?

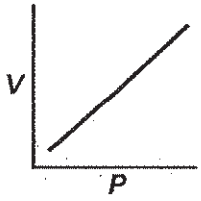
A) 0DC and 100 kPa
B) 150DC and 300 kPa
C) 150DC and 100 kPa
D) 0DC and 300 kPa

___ 40) Which graph *best* represents the pressure-volume relationship for an ideal gas at constant temperature?

A) 

B) 

C) 

D) 

___ 41) A gas occupies a volume of 40.0 milliliters at 20DC. If the volume is increased to 80.0 milliliters at constant pressure, the resulting temperature will be equal to

A) $293\ K \times \frac{40.0\ mL}{80.0\ mL}$
B) $293\ K \times \frac{80.0\ mL}{40.0\ mL}$
C) $20DC \times \frac{40.0\ mL}{80.0\ mL}$
D) $20DC \times \frac{80.0\ mL}{40.0\ mL}$

___ 42) The volume of a gas is 4.00 liters at 293 K and constant pressure. For the volume of the gas to become 3.00 liters, the Kelvin temperature must be equal to

A) $\frac{3.00 \times 293}{4.00}$
B) $\frac{293}{3.00 \times 4.00}$
C) $\frac{3.00 \times 4.00}{293}$
D) $\frac{4.00 \times 293}{3.00}$

___ 43) The temperature of a 2.0-liter sample of helium gas at STP is increased to 27DC and the pressure is decreased to 80. kPa. What is the new volume of the helium sample?

A) 4.0 L
B) 2.0 L
C) 1.4 L
D) 2.8 L

___ 44) A sample of helium gas has a volume of 900. milliliters and a pressure of 2.50 atm at 298 K. What is the new pressure when the temperature is changed to 336 K and the volume is decreased to 450. milliliters?

A) 5.64 atm
B) 14.1 atm
C) 0.177 atm
D) 4.43 atm

___ 45) A gas occupies a volume of 444 mL at 273 K and 79.0 kPa. What is the final kelvin temperature when the volume of the gas is changed to 1,880 mL and the pressure is changed to 38.7 kPa?

A) 2,360 K
B) 292 K
C) 31.5 K
D) 566 K

___ 46) At the same temperature and pressure, 1.0 liter of $CO(g)$ and 1.0 liter of $CO_2(g)$ have

A) equal masses and the same number of molecules
B) equal volumes and the same number of molecules
C) different volumes and a different number of molecules
D) different masses and a different number of molecules

___ 47) A sample of oxygen gas is sealed in container *X*. A sample of hydrogen gas is sealed in container *Z*. Both samples have the same volume, temperature, and pressure. Which statement is true?

A) Containers *X* and *Z* both contain the same mass of gas.
B) Container *X* contains fewer gas molecules than container *Z*.
C) Container *X* contains more gas molecules than container *Z*.
D) Containers *X* and *Z* both contain the same number of gas molecules.

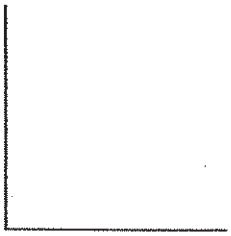
___ 48) At STP, 4 liters of O_2 contains the same total number of molecules as

A) 2 L of Cl_2
B) 8 L of He
C) 4 L of CO_2
D) 1 L of NH_3

Questions 49 and 50 refer to the following:

The diagram below shows a piston confining a gas in a cylinder.

___ 49) Using the set of axes below, sketch the general relationship between the pressure and the volume of an ideal gas at constant temperature.



___ 50) The gas volume in the cylinder is 6.2 milliliters and its pressure is 1.4 atmospheres. The piston is then pushed in until the gas volume is 3.1 milliliters while the temperature remains constant. Calculate the pressure, in atmospheres, after the change in volume. [*Show all work.*]

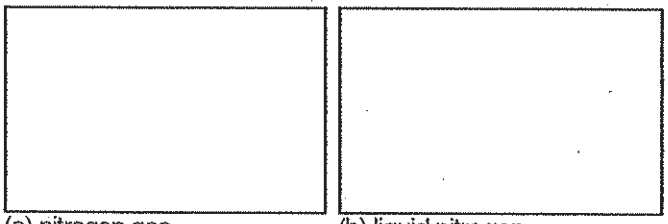
___ 51) A weather balloon has a volume of 52.5 liters at a temperature of 295 K. The balloon is released and rises to an altitude where the temperature is 252 K.

The original pressure of the given weather balloon at 295 K was 100.8 kPa and the pressure at the higher altitude at 252 K is 45.6 kPa. Assume the balloon does not burst. Show a correct numerical setup for calculating the volume of the balloon at the higher altitude.

___ 52) A sample of oxygen gas in one container has a volume of 20.0 milliliters at 297 K and 101.3 kPa. The entire sample is transferred to another container where the temperature is 283 K and the pressure is 94.6 kPa.

Show a correct numerical setup for calculating the new volume of this sample of oxygen gas.

___ 53) The diagram  represents one molecule of nitrogen.



(a) nitrogen gas (b) liquid nitrogen

(a) In the box labeled *(a)* above, draw a particle model that shows *at least* six molecules of nitrogen gas.

(b) In the box labeled *(b)* above, draw a particle model that shows *at least* six molecules of liquid nitrogen.

(c) Describe, in terms of particle arrangement, the difference between nitrogen gas and liquid nitrogen.

(d) Good models should reflect the true nature of the concept being represented. What is a limitation of two-dimensional models?

Name _____ Date _____
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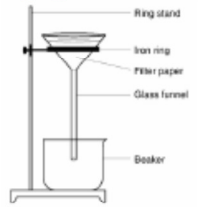
Mixtures and Separation Techniques

1. An example of a heterogeneous mixture is

   A) carbon monoxide B) soil
   C) sugar D) carbon dioxide

2. Which mixture can be separated by using the equipment shown below?



   A) $CO_2(aq)$ and $NaCl(aq)$
   B) $CO_2(aq)$ and $C_6H_{12}O_6(aq)$
   C) $NaCl(aq)$ and $SiO_2(s)$
   D) $NaCl(aq)$ and $C_6H_{12}O_6(aq)$

3. Which formula represents a mixture?

   A) $C_6H_{12}O_6(s)$ B) $LiCl(aq)$
   C) $C_6H_{12}O_6(\ell)$ D) $LiCl(s)$

4. Recovering the salt from a mixture of salt and water could best be accomplished by

   A) evaporation
   B) paper chromatography
   C) density determination
   D) filtration

5. Which statement is an identifying characteristic of a mixture?

   A) A mixture must be homogeneous.
   B) A mixture must have a definite composition by weight.
   C) A mixture can be separated by physical means.
   D) A mixture can consist of a single element.

6. When a mixture of water, sand, and salt is filtered, what passes through the filter paper?

   A) water and sand, only
   B) water, sand, and salt
   C) water and salt, only
   D) water, only

7. Petroleum can be separated by distillation because the hydrocarbons in petroleum are

   A) elements with identical boiling points
   B) compounds with identical boiling points
   C) elements with different boiling points
   D) compounds with different boiling point

8. Which sample of matter can be separated into different substances by physical means?

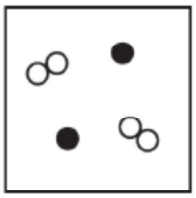
   A) $NH_3(\ell)$ B) $LiCl(aq)$
   C) $NH_3(g)$ D) $LiCl(s)$

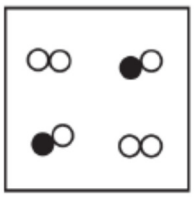
9. A mixture of sand and table salt can be separated by filtration because the substances in the mixture differ in

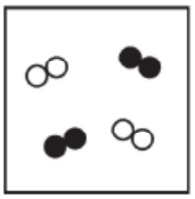
   A) density at STP
   B) freezing point
   C) boiling point
   D) solubility in water

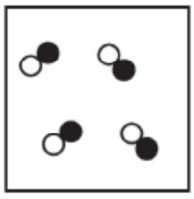
10. Which particle diagram represents a mixture of an element and a compound?

Key
○ = an atom of an element
● = an atom of a different element

A)


B)


C)


D)


11. One similarity between all mixtures and compounds is that both

   A) combine in a definite ratio
   B) are heterogeneous
   C) are homogeneous
   D) consist of two or more substances

Name _____ Date _____
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12. A mixture of crystals of salt and sugar is added to water and stirred until all solids have dissolved. Which statement best describes the resulting mixture?

A) The mixture is heterogeneous and can be separated by filtration.
B) The mixture is homogeneous and cannot be separated by filtration.
C) The mixture is heterogeneous and cannot be separated by filtration.
D) The mixture is homogeneous and can be separated by filtration.

13. A bottle of rubbing alcohol contains both 2-propanol and water. These liquids can be separated by the process of distillation because the 2-propanol and water

A) have combined chemically and have the same boiling point
B) have combined physically and have the same boiling point
C) have combined physically and retain their different boiling points
D) have combined chemically and retain their different boiling points

14. Which property makes it possible to separate the oxygen and the nitrogen from a sample of liquefied air?

A) hardness B) electronegativity
C) boiling point D) conductivity

15. A dilute, aqueous potassium nitrate solution is best classified as a

A) homogeneous compound
B) homogeneous mixture
C) heterogeneous compound
D) heterogeneous mixture

16. Which must be a mixture of substances?

A) solution B) liquid
C) solid D) gas

17. Which of these contains only one substance?

A) distilled water B) rainwater
C) saltwater D) sugar water

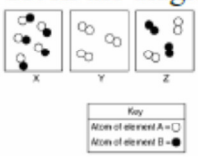
18. A dry mixture of KNO_3 and sand could be separated by

A) adding water to the mixture and evaporating
B) heating the mixture to a high temperature
C) adding water to the mixture and filtering
D) cooling the mixture to a low temperature

19. Which material is a mixture?

A) magnesium B) water
C) methane D) air

20. Given the diagrams *X*, *Y*, and *Z* below:



Which diagram or diagrams represent a mixture of elements *A* and *B*?

A) *X* and *Y* B) *X*, only
C) *Z*, only D) *X* and *Z*

21. At room temperature, a mixture of sand and water can be separated by

A) combustion B) filtration
C) sublimation D) ionization

22. Which formula represents a homogeneous mixture?

A) NaH(s) B) $H_2O(\ell)$
C) $H_2S(g)$ D) HCl(aq)

23. Which of these terms refers to matter that could be heterogeneous?

A) mixture B) solution
C) compound D) element

24. Which process would most effectively separate two liquids with different molecular polarities?

A) conductivity B) fermentation
C) filtration D) distillation

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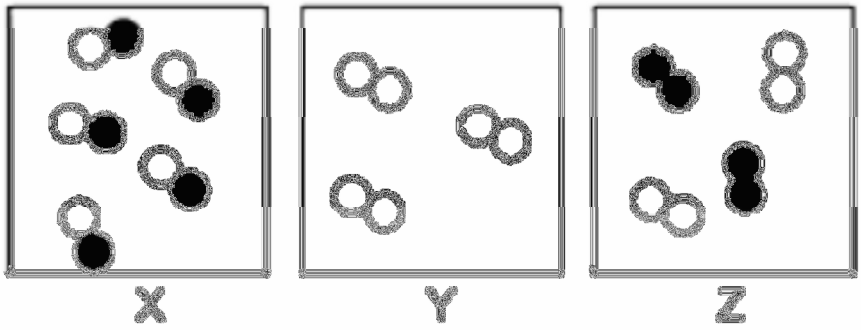
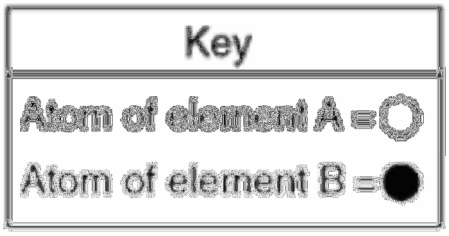
25. Describe diagrams *X*, *Y*, and *Z* using the following terms:

Pure substance
Compound
Element
Mixture of elements
Mixture of compounds

You may use more than one term for each diagram.





X _____

Y _____

Z _____

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Solubility Curves

Using Table G in your Reference Tables, answer the following questions:

Questions 1-5: For each question an amount of solute is given and a temperature is stated. If all of the solute could be dissolved in 100g of water at the stated temperature, would the resulting solution be unsaturated, saturated, or supersaturated?

1. 60 g KCl at 70°C _____
2. 90 g KNO_3 at 60°C _____
3. 110 g $NaNO_3$ at 45°C _____
4. 10 g $KClO_3$ at 10°C _____
5. 60 g NH_4Cl at 70°C _____

Questions 6-10: For each question a solute and temperature are given. Tell how many grams of each solute must be added to 100 g if water to form a saturated solution at the temperature given.

6. $NaNO_3$ at 30°C _____
7. $KClO_3$ at 70°C _____
8. KNO_3 at 45°C _____
9. KCl at 40°C _____
10. NaCl at 90°C _____

Questions 11-13: For each question, tell which solution is more concentrated.

11. At 50°C (A) a saturated solution of KNO_3 or (B) a saturated solution of NH4Cl
12. At 50°C (A) a saturated solution of KNO_3 or (B) an unsaturated solution of $NaNO_3$ consisting of 100 g of the solute dissolved in 100 g of water.
13. At 50°C (A) a saturated solution of $NaNO_3$ or (B) a supersaturated solution of NH_4Cl consisting of 60 g of the solute dissolved in 100 g of water.

14. If 130 g KNO_3 are added to 100 g of water at 40°C, how many grams do not dissolve?

15. If 50 g $KClO_3$ are added to 100 g of water at 10°C, how many grams do not dissolve?

Name _____ Date _____
Period _____

16. Table G shows that at 76°C, the same mass of two solutes will each dissolve in equal masses of water to form saturated solutions. What are these two solutes?

17. What mass of NH_4Cl would be needed to form a saturated solution if the NH_4Cl was dissolved in 200 g of water at 50°C

18. Equal masses of three different solutes will dissolve in equal masses of water at one particular temperature. What are the three solutes and what is the temperature?

19. How many grams of sodium nitrate will dissolve in 100g of water at 20˚C?

20. How many grams of sodium nitrate will dissolve in 100 g of water at 60˚C?

21. How many grams of ammonium chloride will dissolve in 1000 mL of water at 50˚C?

22. Ninety grams of potassium nitrate is added to 100 grams of water at 0˚C. To what temperature must the solution be raised to produce a saturated solution?

Name _____ Date _____
Period _____

23. A saturated solution of potassium chlorate was made with 300 g of water at 40˚C. How much potassium chlorate could be recovered by evaporating the solution to dryness?

24. Five hundred grams of water are used to make a saturated solution of potassium nitrate at 10˚C. How many more grams of potassium nitrate could be dissolved if the temperature was raised to 50˚C?

25. A saturated solution of ammonia gas in 200 grams of water at 20˚C is heated to 50˚C. How much gas will come out of solution?

26. According to the solubility table approximately how many grams of potassium chlorate are needed to saturate 100 grams of water at 40˚C?

27. How many grams of potassium nitrate are needed to saturate 50 grams of water at 70˚C?

28. A solution contains 14 grams of sodium chloride in 100 grams of water at 40˚C. What is the minimum amount of sodium chloride that must be added to make this a saturated solution?

29. Classify the following solutions as saturated, unsaturated or supersaturated.
    a. 14 g of KCl in 100 grams of water at 40˚C

Name _____ Date _____
Period _____

b. 90 g of KNO3 in 100 grams of water at 50˚C

c. 30 g of SO2 in 50 grams of water at 80˚C

d. 145 g of KI in 200 grams of water at 20˚C

e. 100 g of KCl in 200 grams of water at 75˚C

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Solubility

Directions: Please fill out the following table. For each solute listed determine whether the NATURE of the compound is NONPOLAR COVALENT, POLAR COVALENT, or IONIC. Then determine if the solute will be soluble or insoluble in the solvent.

		SOLVENT			
		Water	**Octane (nonpolar)**	**Hexane (nonpolar)**	**Ethanol (polar)**
SOLUTE	NaCl Nature:	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble
	HCl Nature:	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble
	O_2 Nature:	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble
	KCl Nature:	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble
	CO_2 Nature:	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble

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1. In the box below draw a diagram to represent the molecule ion attraction that occurs when NaBr is mixed in water

2. What is the meaning of the word solubility?

3. What happens to the solubility of most solids and liquids when the temperature of the solvent increases?

4. What happens to the solubility of most gases when the temperature of the solvent increases?

5. What happens to the solubility of most solids and liquids when pressure is increased?

6. What happens to the solubility of most gases when pressure is increased?

7. Explain why more CO_2 can be dissolved in a closed soda can compared to an open soda can?

Name _____ Date _____
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Solubility – Table F

Using Table F write the name for the following salts and then determine if they are soluble or insoluble in water.

Salt	Name of Salt	Soluble or Insoluble?
1) $CaCO_3$		
2) Na_2CrO_4		
3) $Mg(OH)_2$		
4) $AgCl$		
5) CaS		
6) NH_4ClO_3		
7) $PbBr_2$		
8) $Zn(HCO_3)_2$		
9) KC_2H3O_2		
10) $NaOH$		
11) $LiNO_3$		
12) $BaSO_4$		
13) Hg_2I_2		
14) $Sr_3(PO4)_2$		
15) $Ra(ClO_4)_2$		
16) $PbSO_4$		
17) $CuCl_2$		
18) $Zn(NO3)_2$		
19) $AgBr$		
20) $Al(OH)_3$		
21) SnS		
22) $Mg_3(PO4)_2$		
23) Na_2CO_3		
24) $NH_4C_2H_3O_2$		
25) $Hg_2(ClO_4)_2$		

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Molarity

1. What is the molarity of a solution that contains 0.40 moles of KBr in a 0.50 L solution?

2. If you have 5.0 moles of NaCl in a 2.0 L solution, what is the molarity of the solution?

3. If you have 60. moles of HCl what should the total volume of solution be to make a 10. M solution of HCl(aq)?

4. Which solution is most concentrated? a) 5 M HCl b) 3 M HCl c) 0.09 M HCl d) 23 M HCl

5. Which solution is most dilute? a) 5 M HCl b) 3 M HCl c) 0.09 M HCl d) 23 M HCl

6. What is the molarity of a solution with 1.75 moles of KNO3 in 3.0 L of solution?

7. What is the molarity of a solution that contains 65.1 g of NH4Cl in 3.50-L of solution?

Name _____ Date _____
Period _____

8. To produce 3.00 L of a 1.90 M solution of sodium hydroxide (NaOH). How many moles of sodium hydroxide must be dissolved?

9. How many grams of sodium hydroxide must you measure out for the solution?

10. What is the molarity of a solution that has 2.5 moles of solute in 3.0 liters of solution?

11. How many moles are present in 0.50 liters of a 12 molar solution?

12. What is the molarity of a NaCl solution that has 58 grams of NaCl dissolved in 4.0 liters of water?

13. If a solution has a molarity of 5.0 M, how many moles are present in 5.0 mL?

14. How much water is needed to make a 0.10 M solution of HCl if you are using 72 grams of HCl? (Assume that HCl(aq) has the same density as water)

15. What is the molarity of a CaCl2 solution containing 330. grams of CaCl2 in 1 liter of solution?

Name _____ Date _____
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16. What is concentration of a solution in parts per million if 20.0 grams of Na2S is dissolved in 4.00 x 105 grams of water?

17. What are the steps to making a 1.0 L of a 3.0 M solution of KBr?

18. If you add 5.0 moles of NaCl to enough water to make 2.0 L of solution, what is the molarity of the solution?

Name _____ Date _____
Period _____

Solubility – PPM

1. A student dissolves 85.0 g of KCl in 925 grams of water. What is the ppm of the solution?

2. A student prepares a solution by dissolving 80. mL of pure ethanol in enough water to make 2500 mL solution. What is the ppm of the ethanol solution?

3. A sample of sewer water has 6.0 milligrams of mercury in 200. grams of water. What is the concentration in parts per million?

4. 2.00×10^3 grams of water contains 0.250 grams of dissolved substance. What is the concentration in parts per million?

Name _____ Date _____
Period _____

5. If 8.77 g of KI are dissolved in sufficient water to make 4.75 L of solution, what is the ppm of the solution?

6. What is the ppm of the solution produced when 14.1 g of NH_3 is dissolved in sufficient water to prepare 0.100 L of solution?

7. A student adds 20.0 g of NaCl(s) to 150.0 mL of water to make a solution. Determine the PPM

8. A student combines 0.50 moles of NH4Cl in enough water to make 125.0 mL of solution. Determine the ppm

Name _____ Date _____
Period _____

How Does Rock Salt Work, Anyway?

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

"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.

Name _____ Date _____
Period _____

5. What is 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, $PbCl_2$, 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.

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

11. Rank 1 mole of the substances $C_{12}H_{22}O_{11}$, NaCl, $PbCl_2$, 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.

SOLUTIONS EXAM

Name: _____

1) In an aqueous solution of potassium chloride, the solute is

A) H_2O B) Cl C) KCl D) K

2) When calcium chloride is dissolved in water, to which end of the adjacent water molecules will a calcium ion be attracted?

A) the oxygen end, which is the negative pole
B) the oxygen end, which is the positive pole
C) the hydrogen end, which is the positive pole
D) the hydrogen end, which is the negative pole

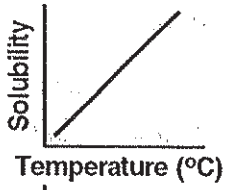
3) Which substance is *most* likely to dissolve in a nonpolar solvent such as hexane?

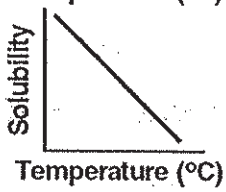
A) KCl(s) B) $NH_4Cl(s)$ C) $C_6H_4Cl_2(s)$ D) $CaCl_2(s)$

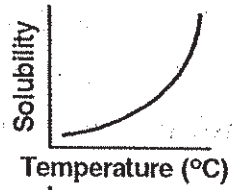
4) Solubility data for salt *X* is shown in the table below.

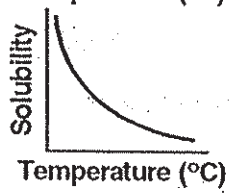
Temperature (°C)	Solubility $\left(\frac{\text{g salt X}}{\text{100g } H_2O}\right)$
10	5
20	10
30	15
40	20
50	30
60	35

Which graph *most* closely represents the data shown in the table?

A)


B)


C)


D)


5) The molarity (*M*) of a solution is equal to the

A) $\frac{\text{number of moles of solute}}{\text{liter of solution}}$
B) $\frac{\text{number of grams of solute}}{\text{liter of solvent}}$
C) $\frac{\text{number of moles of solute}}{\text{liter of solvent}}$
D) $\frac{\text{number of grams of solute}}{\text{liter of solution}}$

6) What is the molarity of a solution that contains 112 grams of KOH in 2.00 liters of solution?

A) 1.00 M B) 2.00 M C) 3.00 M D) 4.00 M

7) Which solution is the *most* concentrated?

A) 2 moles of solute dissolved in 3 liters of solution
B) 4 moles of solute dissolved in 8 liters of solution
C) 1 mole of solute dissolved in 1 liter of solution
D) 6 moles of solute dissolved in 4 liters of solution

8) A 200. gram sample of a salt solution contains 0.050 grams of NaCl. What is the concentration of the solution in parts per million (ppm)?

A) 2.5×10^{-4} ppm B) 5.0×10^{4} ppm C) 250. ppm D) 50. ppm

9) How do the freezing and boiling points of a sample of water change when 1 mole of NaCl is dissolved in it?

A) The freezing point increases and the boiling point increases.
B) The freezing point increases and the boiling point decreases.
C) The freezing point decreases and the boiling point increases.
D) The freezing point decreases and the boiling point decreases.

10) A solution containing 55 grams of NH_4Cl in 100. grams of water is saturated at a temperature of

A) 57°C B) 47°C C) 77°C D) 67°C

11) According to the *Solubility Curves* chemistry reference table, approximately how many grams of $KClO_3$ are needed to saturate 100 grams of H_2O at 40°C?

A) 16 g B) 6 g C) 47 g D) 38 g

12) According to the *Solubility Curves* chemistry reference table, what is the maximum number of grams of NH_4Cl that will dissolve in 200 grams of water at 70°C?

A) 100 g B) 62 g C) 85 g D) 124 g

13) How many grams of $NaNO_3$ per 100 grams of H_2O would produce a supersaturated solution?

A) 110 g at 40°C B) 90 g at 30°C C) 60 g at 10°C D) 80 g at 20°C

14) A solution contains 90 grams of a salt dissolved in 100 grams of water at 40°C. The solution could be an unsaturated solution of

A) NaCl B) KNO_3 C) $NaNO_3$ D) KCl

15) Based on the *Solubility Curves* chemistry reference table, what change will cause the solubility of $KNO_3(s)$ to increase?

A) increasing the temperature
B) decreasing the temperature
C) increasing the pressure
D) decreasing the pressure

16) Based on the *Solubility Guidelines* chemistry reference table, a saturated solution of which salt would be *most* concentrated?

A) AgCl B) $ZnCl_2$ C) $PbCrO_4$ D) $BaSO_4$

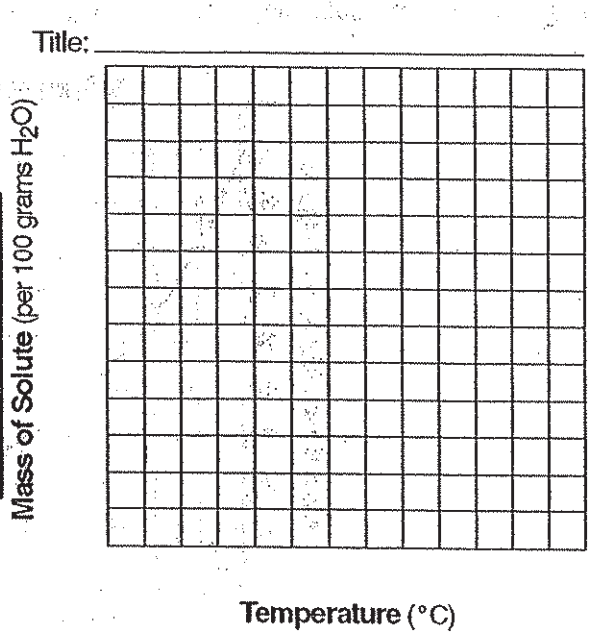
17) Solutions of $AgNO_3(aq)$ and KCl(aq) are mixed. Will a visible reaction occur?

A) No, because KNO_3 is soluble in water.
B) Yes, because KNO_3 will precipitate out of solution.
C) Yes, because AgCl will precipitate out of solution.
D) No, because AgCl is soluble in water.

18) The number of grams of solute *A* that would dissolve in 100. grams of water was measured at several temperatures. The following data was collected:

DATA TABLE

Temperature (°C)	Mass of Solute (per 100 grams H_2O)
10	2.5
20	5.0
30	10.0
40	20.0
50	35.0
60	47.0



(a) Using the information in the data table, construct a line graph on the grid provided according to the following directions.

(1) Mark an appropriate scale on each axis.

(2) Plot the data from the data table. Surround each point with a small circle and draw a best-fit curve for the solubility of solute *A*.

(b) Write an appropriate title on the graph.

(c) State the relationship between temperature and solubility of solute *A*.

(d) During which interval is there the *greatest* increase in solubility?

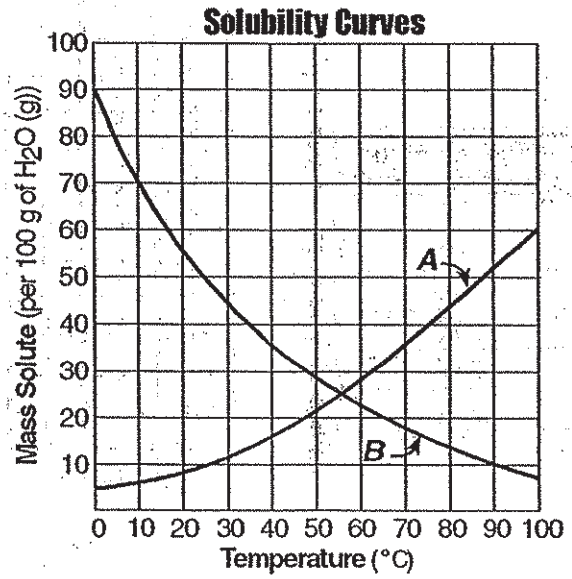
(1) 10°C to 20°C (3) 40°C to 50°C

(2) 30°C to 40°C (4) 50°C to 60°C

(e) Using your graph, predict the solubility of solute *A* at 45°C.

Questions 19 through 21 refer to the following:

The graph below represents the solubility curves for solute *A* and solute *B*.



19) At what temperature are solute *A* and solute *B* equally soluble in 100. grams of water?

20) Which solute, *A* or *B*, is most likely a gas? [*Explain why.*]

21) State the relationship between temperature and solubility of solute *B*.

22) A sample of drinking water was found to contain .0015 grams of chlorine in 500 grams of water. What is the concentration of chlorine in the water sample in parts per million (ppm)? [*Write the correct formula. Show all work.*]

23) $KNO_3(s)$ is added to a beaker containing 100 grams of water at room temperature (25°C) until a saturated solution is created.

(a) Calculate the gram formula mass of KNO_3. [*Round atomic masses from the Periodic Table to the nearest tenth. Show all work. Indicate the correct answer with an appropriate unit.*]

(b) Using the *Solubility Curves* chemistry reference table, determine the number of grams of KNO_3 that should dissolve in 100 grams of water at 25°C.

(c) Calculate the number of moles of KNO_3 that should dissolve in 100 grams of water at 25°C. [*Show all work. Indicate the correct answer with an appropriate unit.*]

(d) Determine the molarity of the saturated KNO_3 solution at 25°C. [*Write the correct formula. Show all work. Indicate the correct answer with an appropriate unit.*]