Name:_____ **Period:**_____ **Date:**_____

Regents Chemistry **3rd Quarter Cumulative Review** **2017-2018**

1. Base your answer to the following question on the information below and on your knowledge of chemistry.

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 standards 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.

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.

Base your answers to questions **2** through **5** on the information below

The element boron, a trace element in Earth's crust, is found in foods produced from plants. Boron has only two naturally occurring stable isotopes, boron-10 and boron-11.

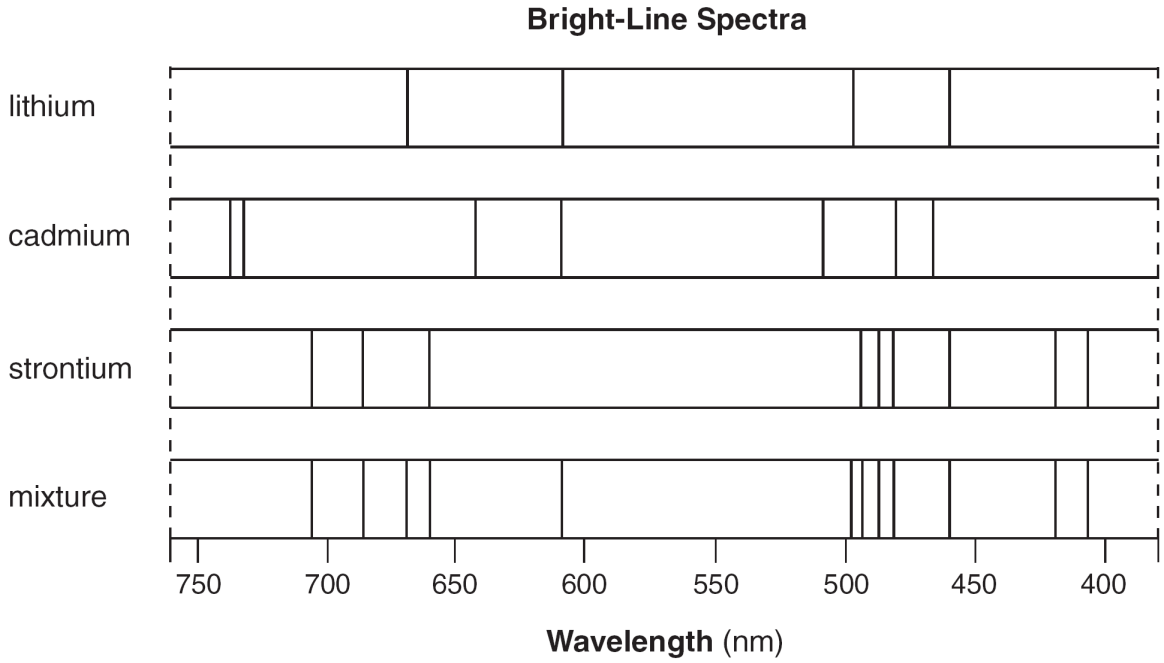
2. One sample of a green vegetable contains 0.0035 gram of boron. Determine the total number of moles of boron in this sample.

3. State, in terms of subatomic particles, *one* difference between the nucleus of a carbon-11 atom and the nucleus of a boron-11 atom.

4. Write an isotopic notation of the heavier isotope of the element boron. Your response must include the atomic number, the mass number, and the symbol of this isotope.

5. Compare the abundance of the two naturally occurring isotopes of boron.

Base your answers to questions **6** through **8** on the information below.
The bright-line spectra for three elements and a mixture of elements are shown below.



6. State the total number of valence electrons in a cadmium atom in the ground state.

7. Identify *all the elements in the mixture.*

8. Explain, in terms of *both electrons and energy, how the bright-line spectrum of an element is produced.*

9. Explain, in terms of protons and neutrons, why U-235 and U-238 are different isotopes of uranium.

Base your answers to questions **10** through **12** on on the information below.

In the modern model of the atom, each atom is composed of three major subatomic (or fundamental) particles.

10. What is the sign of the net charge of the nucleus?

11. State the charge associated with *each* type of subatomic particle contained in the nucleus of the atom.

12. Name the subatomic particles contained in the nucleus of the atom.

13. Draw the electron-dot (Lewis) structure of an atom of chlorine.

14. Draw the electron-dot (Lewis) structure of an atom of calcium.

Base your answers to questions **15** and **16** on the information below.

Naturally occurring elemental carbon is a mixture of isotopes. The percent composition of the two most abundant isotopes is listed below.

- 98.93% of the carbon atoms have a mass of 12.00 atomic mass units.
- 1.07% of the carbon atoms have a mass of 13.00 atomic mass units.

15. Describe, in terms of subatomic particles found in the nucleus, one difference between the nuclei of carbon-12 atoms and the nuclei of carbon-13 atoms. The response must include both isotopes.

16. In the space provided in your answer booklet, show a correct numerical setup for calculating the average atomic mass of carbon.

17. Base your answer to the following question on the data table below, which shows three isotopes of neon.

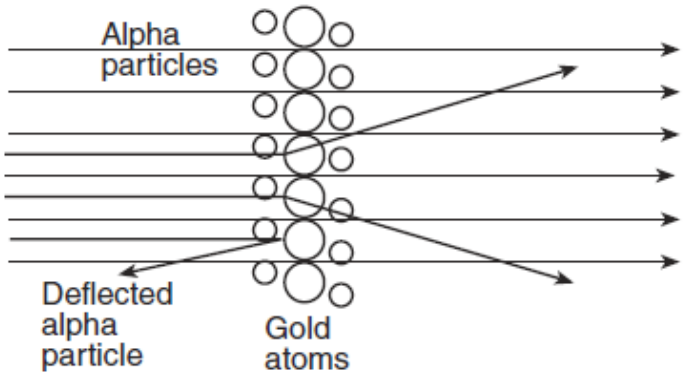
Isotope	**Atomic Mass** (atomic mass units)	**Percent Natural Abundance**
^{20}Ne	19.99	90.9%
^{21}Ne	20.99	0.3%
^{22}Ne	21.99	8.8%

Based on natural abundances, the average atomic mass of neon is closest to which whole number?

Base your answers to questions **18** through **20** on the information and diagram below.

One model of the atom states that atoms are tiny particles composed of a uniform mixture of positive and negative charges. Scientists conducted an experiment where alpha particles were aimed at a thin layer of gold atoms.

Most of the alpha particles passed directly through the gold atoms. A few alpha particles were deflected from their straight-line paths. An illustration of the experiment is shown below.



18. How should the original model be revised based on the results of this experiment?

19. A few of the alpha particles were deflected. What does this evidence suggest about the structure of the gold atoms?

20. Most of the alpha particles passed directly through the gold atoms undisturbed. What does this evidence suggest about the structure of the gold atoms?

Base your answers to questions **21** and **22** on the information below and on your knowledge of chemistry.

When magnesium is ignited in air, the magnesium reacts with oxygen and nitrogen. The reaction between magnesium and nitrogen is represented by the unbalanced equation below:

$$\mathrm{Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)}$$

21. Explain, in terms of electrons, why an atom of the metal in this reaction forms an ion that has a smaller radius than its atom.

22. In the ground state, which noble gas has atoms with the same electron configuration as a magnesium ion?

Base your answers to questions **23** through **25** on the elements in Group 2 on the Periodic Table.

23. Explain, in terms of atomic structure, why the elements in Group 2 have similar chemical properties.

24. State, in terms of the number of electron shells, why the radius of a strontium atom in the ground state is larger than the radius of a magnesium atom in the ground state.

25. State the general trend in first ionization energy for the elements in Group 2 as these elements are considered in order from top to bottom in the group.

Base your answers to questions **26** and **27** on the information below.

Densities of Group 14 Elements

Element	Density at STP (g/cm^3)
C	3.51
Si	2.33
Ge	5.32
Sn	7.31
Pb	11.35

26. Calculate the volume of a tin block that has a mass of 95.04 grams at STP. Your response must include *both* a numerical setup and the calculated result

27. Identify *one* element from this table for *each* type of element: metal, metalloid, and nonmetal.

Base your answers to questions **28** through **31** on the information below.

Two sources of copper are cuprite, which has the IUPAC name copper(I) oxide, and malachite, which has the formula $Cu_2CO_3(OH)_2$. *Copper is used in home wiring and electric motors because it has good electrical conductivity. Other uses of copper not related to its electrical conductivity include coins, plumbing, roofing, and cooking pans.Aluminum is also used for cooking pans.*
At room temperature, the electrical conductivity of a copper wire is 1.6 times greater than an aluminum wire with the same length and cross-sectional area. At room temperature, the heat conductivity of copper is 1.8 times greater than the heat conductivity of aluminum. At STP, the density of copper is 3.3 times greater than the density of aluminum.

28. Identify *one* physical property of aluminum that could make it a better choice than copper for a cooking pan.

29. Identify *one* physical property of copper that makes it a good choice for uses that are not related to electrical conductivity.

30. Determine the oxidation number of oxygen in the carbonate ion found in malachite.

31. Write the chemical formula of cuprite.

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32. Explain, in terms of subatomic particles, why the radius of a chloride ion is larger than the radius of a chlorine atom.

Base your answers to questions **33** and **34** on the table below.

First Ionization Energy of Selected Elements

Element	Atomic Number	First Ionization Energy (kJ/mol)
lithium	3	520
sodium	11	496
potassium	19	419
rubidium	37	403
cesium	55	376

33. Explain, in terms of atomic structure, why cesium has a *lower* first ionization energy than rubidium.

34. State the trend in first ionization energy for the elements in the table as the atomic number increases.

Base your answers to questions **35** through **37** on the information below.

Potassium ions are essential to human health. The movement of dissolved potassium ions, K^+ (aq), in and out of a nerve cell allows that cell to transmit an electrical impulse.

35. What property of potassium ions allows them to transmit an electrical impulse?

36. Explain, in terms of *atomic structure*, why a potassium ion is smaller than a potassium atom.

37. What is the total number of electrons in a potassium ion?

38. In the 19th century, Dmitri Mendeleev predicted the existence of a then unknown element *X* with a mass of 68. He also predicted that an oxide of *X* would have the formula X_2O_3. On the modern Periodic Table, what is the group number and period number of element *X*?

Base your answers to questions **39** through **41** on the information below.

A safe level of fluoride ions is added to many public drinking water supplies. Fluoride ions have been found to help prevent tooth decay. Another common source of fluoride ions is toothpaste. One of the fluoride compounds used in toothpaste is tin (II) fluoride.
A town located downstream from a chemical plant was concerned about fluoride ions from the plant leaking into its drinking water. According to the Environmental Protection Agency, the fluoride ion concentration in drinking water cannot exceed 4 ppm. The town hired a chemist to analyze its water. The chemist determined that a 175-gram sample of the town's water contains 0.000 250 grams of fluoride ions.

39. How many parts per million of fluoride ions are present in the analyzed sample? Is the town's drinking water safe to drink? Support your decision using information in the passage and your calculated fluoride level.

40. What is the chemical formula for tin (II) fluoride?

41. Draw a Lewis electron-dot diagram for a fluoride ion.

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42. Based on the Periodic Table, explain why Na and K have similar chemical properties.

Period:_____

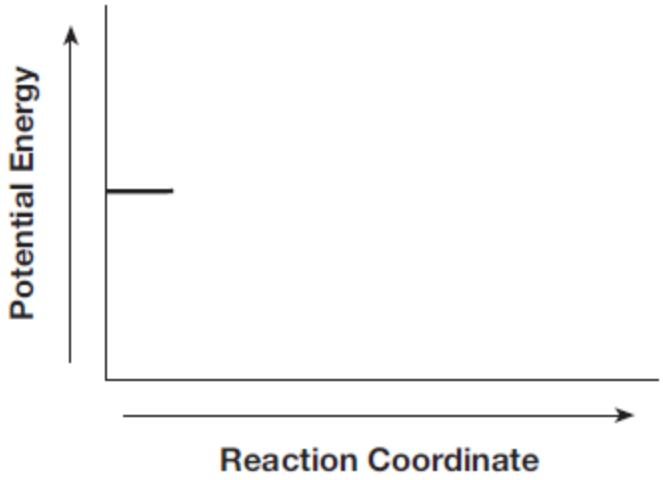
Base your answers to questions **43** through **45** on the information below and on your knowledge of chemistry.

One process used to manufacture sulfuric acid is called the contact process. One step in this process, the reaction between sulfur dioxide and oxygen, is represented by the forward reaction in the system at equilibrium shown below.

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) + 394\,kJ$$

A mixture of platinum and vanadium(V) oxide may be used as a catalyst for this reaction. The sulfur trioxide produced is then used to make sulfuric acid.

43. On the labeled axes below, complete the potential energy diagram for the forward reaction represented by this equations.



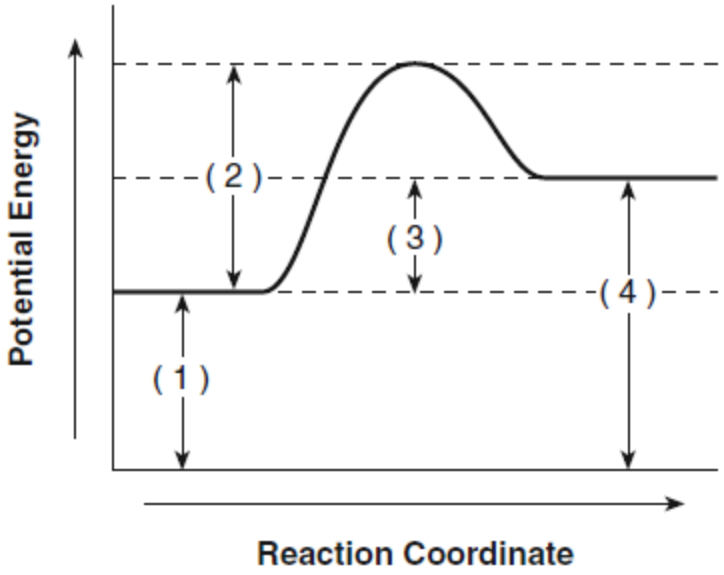
44. Write the chemical formula for vanadium(V) oxide.

45. Determine the amount of energy released when 1.00 mole of sulfur trioxide is produced.

Period:_____

Base your answers to questions **46** through **48** on the information below.

The potential energy diagram and balanced equation shown below represent a reaction between solid carbon and hydrogen gas to produce 1 mole of $C_2H_4(g)$ at 101.3 kPa and 298 K.



$$2C(s) + 2H_2(g) + 52.4kJ \rightarrow C_2H_4(g)$$

46. Identify *one* change in the reaction conditions, other than adding a catalyst, that can increase the rate of this reaction.

47. Determine the net amount of energy absorbed when 2.00 moles of $C_2H_4(g)$ are produced.

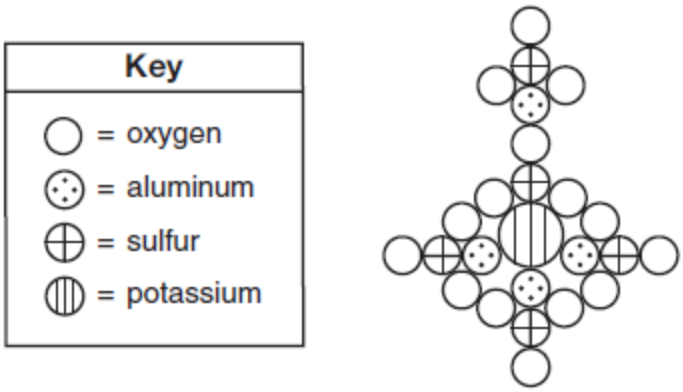
48. State what interval 3 represents.

Period:_____

Base your answers to questions **49** and **50** on the information below.

John Dalton, an early scientist, sketched the structure of compounds using his own symbols for the elements known at the time. Dalton's symbols for four elements and his drawing of potassium aluminum sulfate are represented by the diagram below.

Dalton's Drawing for Potassium Aluminum Sulfate



Today, it is known that the chemical formula for potassium aluminum sulfate is $KAl(SO_4)_2 \bullet 12H_2O$. It is a hydrated compound because water molecules are included within its crystal structure. There are 12 moles of H_2O for every 1 mole of $KAl(SO_4)_2$. The compound contains two different positive ions. The gram-formula mass of $KAl(SO_4)_2 \bullet 12H_2O$ is 474 grams per mole.

49. Show a numerical setup for calculating the percent composition by mass of water in $KAl(SO_4)_2 \bullet 12H_2O$.

50. Identify *one* positive ion in the hydrated compound. Your response must include *both* the chemical symbol and charge of the ion.

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

A 4.86-gram sample of calcium reacted completely with oxygen to form 6.80 grams of calcium oxide. This reaction is represented by the balanced equation below.

$2Ca(s) + O_2(g) \rightarrow 2CaO(s)$

Determine the total mass of oxygen that reacted.

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

The balanced equation below represents the reaction between magnesium metal and hydrochloric acid to produce aqueous magnesium chloride and hydrogen gas.

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

A piece of Mg(s) has a volume of 0.0640 cubic centimeters. This piece of Mg(s) reacts completely with HCl(aq) to produce $H_2(g)$. The $H_2(g)$ produced has a volume of 112 milliliters and a pressure of 1.00 atmosphere at 298 K.

The volume of the piece of Mg(s) is expressed to what number of significant figures?

Base your answers to questions **53** through **55** on the following paragraph.

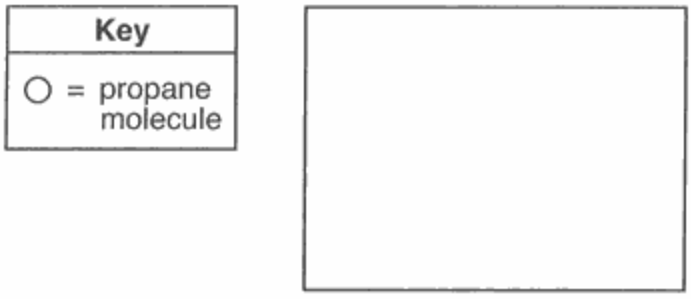
A portable propane-fueled lantern contains a mesh silk bag coated with metal hydroxides. The primary metal hydroxide is yttrium hydroxide. When the silk bag is installed, it is ignited and burned away, leaving the metal hydroxide coating. The coating forms metal oxides that glow brightly when heated to a high temperature.
During a test, a propane lantern is operated for three hours and consumes 5.0 moles of propane from the lantern's tank. The balanced equation below represents the combustion of propane.

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ + energy

53. Write the formula for the primary metal hydroxide used in the lantern.

54. Determine the total number of moles of CO_2 produced during the lantern test.

55. At standard pressure, the boiling point of propane is 231 K. In the box below, draw a particle diagram to represent the phase of the propane as it leaves the tank at 294 K. Your response must include *at least six* molecules.



Base your answers to questions **56** and **57** on the following information.

A piece of magnesium ribbon is reacted with excess hydrochloric acid to produce aqueous magnesium chloride and hydrogen gas. The volume of the dry hydrogen gas produced is 45.6 milliliters. The temperature of the gas is 293 K, and the pressure is 99.5 kilopascals.

56. Calculate the volume this dry hydrogen gas would occupy at STP. Your response must include *both* a correct numerical setup and the calculated result.

57. Balance below using the smallest whole-number coefficients.

____$Mg(s)$ + ____$HCl(aq)$ → ____$MgCl_2(aq)$ + ____$H_2(g)$

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58. Base your answer to the following question on the following information.

A flashlight can be powered by a rechargeable nickel-cadmium battery. In the battery, the anode is $Cd(s)$ and the cathode is $NiO_2(s)$. The unbalanced equation below represents the reaction that occurs as the battery produces electricity When a nickel-cadmium battery is recharged, the reverse reaction occurs.

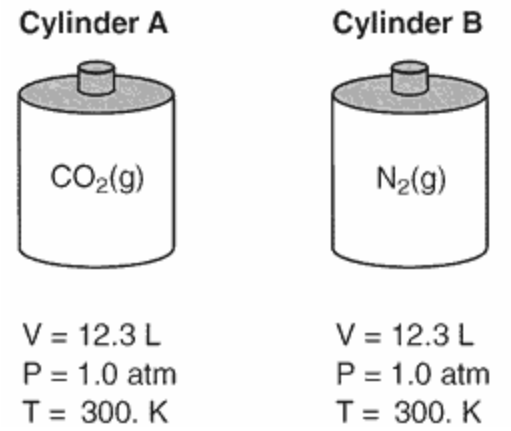
$Cd(s) + NiO_2(s) + H_2O(\ell) \rightarrow Cd(OH)_2(s) + Ni(OH)_2(s)$

Balance the equation below for the reaction that produces electricity, using the smallest whole-number coefficients.

_____ $Cd(s)$ + _____ $NiO_2(s)$ + _____ $H_2O(\ell)$ → _____ $Cd(OH)_2(s)$ + _____ $Ni(OH)_2(s)$

Period:_____

59. Cylinder Acontains 22.0 grams of $CO_2(g)$ and cylinder Bcontains $N_2(g)$. The volumes, pressures, and temperatures of the two gases are indicated under each cylinder.



Explain why the number of molecules of $N_2(g)$ in cylinder *B*is the same as the number of molecules of $CO_2(g)$ in cylinder *A*.

60. Given the balanced equation:

$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

What is the total number of moles of $O_2(g)$ that must react completely with 8.0 moles of Al(s) in order to form $Al_2O_3(s)$?

Base your answers to questions **61** and **62** on the information below.

A scientist in a chemistry laboratory determined the molecular formulas for two compounds containing nitrogen and oxygen to be NO_2 and N_2O_5

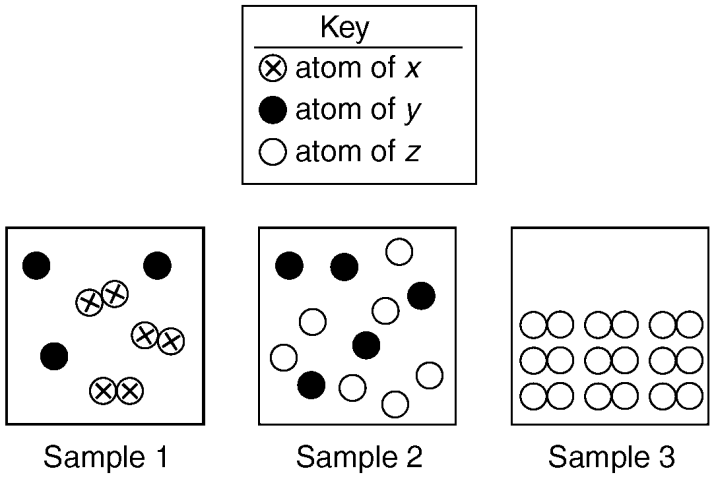
61. In the space provided in your answer booklet, show a correct numerical setup for calculating the percent composition by mass of oxygen in NO_2.

62. Write an IUPAC name for the compound N_2O_5.

63. Show a correct numerical setup for calculating the number of moles of CO_2 (gram-formula mass = 44 g/mol) present in 11 grams of CO_2.

64. What is the gram-formula mass of $(NH_4)_2CO_3$? Use atomic masses rounded to the nearest whole number.

65. Base your answer to the following question on the particle diagrams below, which show atoms and/or molecules in three different samples of matter at STP.



Explain why (x)(x) does *not* represent a compound.

Base your answers to questions **66** through **68** on the information below.

Rust on an automobile door contains $Fe_2O_3(s)$. The balanced equation representing one of the reactions between iron in the door of the automobile and oxygen in the atmosphere is given below.

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

66. Identify the type of chemical reaction represented by this equation.

67. Determine the gram-formula mass of the product of this reaction.

68. Write the IUPAC name for Fe_2O_3.

Base your answers to questions **69** and **70** on the information below and on your knowledge of chemistry.

The balanced equation below represents a reaction.

$$O_2(g) + \text{energy} \rightarrow O(g) + O(g)$$

69. Explain, in terms of bonds, why energy is absorbed during this reaction.

70. Identify the type of chemical bond in a molecule of the reactant.

Base your answers to questions **71** through **74** on the information below.

Ammonium chloride is dissolved in water to form a 0.10 M $NH_4Cl(aq)$ solution. This dissolving process is represented by the equation below.

$$NH_4Cl(s) + \text{heat} \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$$

71. Determine the minimum mass of $NH_4Cl(s)$ required to produce a saturated solution in 100. grams of water at 40.°C.

72. Explain, in terms of ions, why a 10.0-milliliter sample of 0.30 M $NH_4Cl(aq)$ is a better conductor of electricity than a 10.0-milliliter sample of the 0.10 M $NH_4Cl(aq)$.

73. State evidence that indicates the dissolving of ammonium chloride is an endothermic process.

74. Determine the number of moles of $NH_4Cl(s)$ used to produce 2.0 liters of this solution.

Base your answers to questions **75** through **77** on the information below.

In 1864, the Solvay process was developed to make soda ash. One step in the process is represented by the balanced equation below.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

75. In the space draw a Lewis electron-dot diagram for the reactant containing nitrogen in the equation.

76. Explain, in terms of electronegativity difference, why the bond between hydrogen and oxygen in a water molecule is more polar than the bond between hydrogen and nitrogen in an ammonia molecule.

77. Write the chemical formula for *one* compound in the equation that contains both ionic bonds and covalent bonds.

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78. Base your answer to the following question on the table below.

Physical Properties of Four Gases

Name of Gas	hydrogen	hydrogen chloride	hydrogen bromide	hydrogen iodide
Molecular Structure	H–H	H–Cl	H–Br	H–I
Boiling Point (K) at 1 Atm	20.	188	207	237
Density (g/L) at STP	0.0899	1.64	?	5.66

Explain, in terms of electronegativity difference, why the bond in H–Cl is more polar than the bond in H–I.

79. Base your answer to the following question on the balanced equation below.

$2Na(s) + Cl_2 \rightarrow 2NaCl(s)$

Draw a Lewis electron-dot diagram for a molecule of chlorine, Cl_2.

80. Draw an electron-dot diagram for *each* of the following substances:

    a calcium oxide (an ionic compound)

    b hydrogen bromide

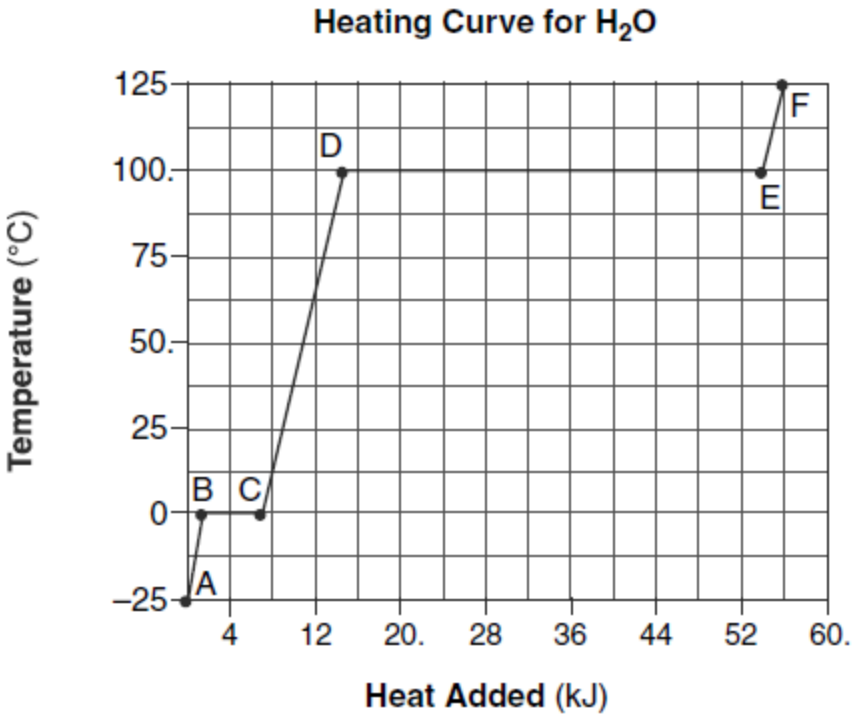
    c carbon dioxide

81. Draw the electron-dot (Lewis) structure of calcium chloride.

Period:_____

Base your answers to questions **82** through **84** on the information below and on your knowledge of chemistry.

Starting as a solid at –25°C, a sample of H_2O is heated at a constant rate until the sample is at 125°C. This heating occurs at standard pressure. The graph below represents the relationship between temperature and heat added to the sample.



82. Explain, in terms of heat of fusion and heat of vaporization, why the heat added during interval *DE* is greater than the heat added during interval *BC* for this sample of water.

83. Using the graph, determine the total amount of heat added to the sample during interval *CD*.

84. Describe what happens to both the potential energy and the average kinetic energy of the molecules in the H_2O sample during interval *AB*.

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

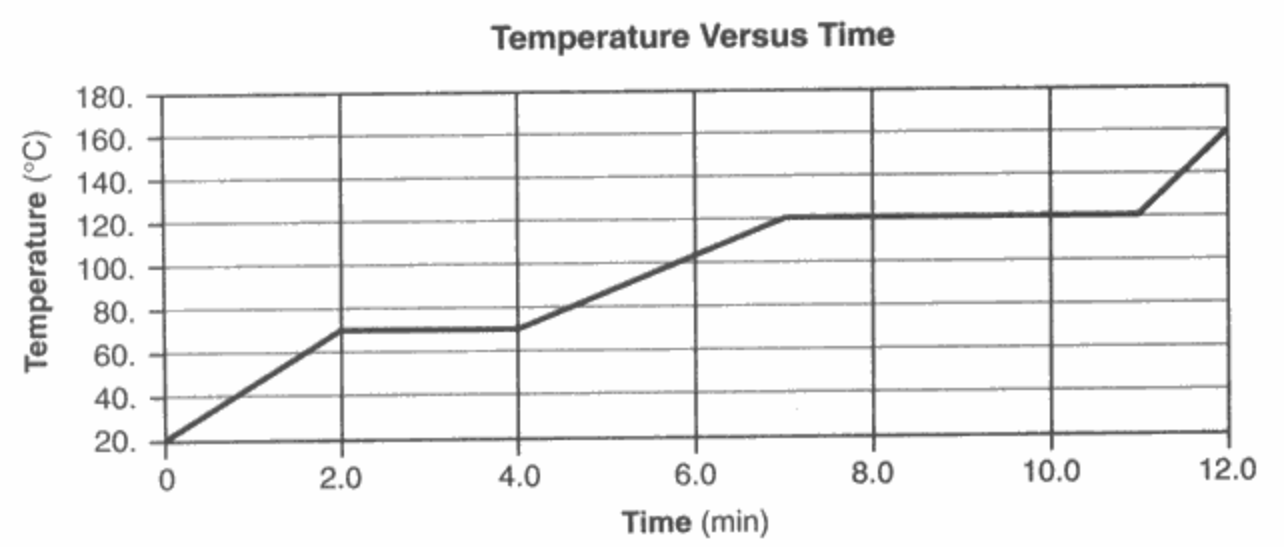
A total of 1.4 moles of sodium nitrate is dissolved in enough water to make 2.0 liters of an aqueous solution. The gram-formula mass of sodium nitrate is 85 grams per mole.

Determine the molarity of the solution.

86. What is the mass of $KNO_3(s)$ that must dissolve in 100. grams of water to form a saturated solution at 50.°C?

Base your answers to questions **87** through **90** on the information below.

The temperature of a sample of a substance is increased from 20.°C to 160.°C as the sample absorbs heat at a constant rate of 15 kilojoules per minute at standard pressure. The graph below represents the relationship between temperature and time as the sample is heated.



87. Determine the total amount of heat required to completely melt this sample at its melting point.

88. What is the total time this sample is in the liquid phase, only?

89. Use the key below to draw at least nine particles in the box, showing the correct particle arrangement of this sample during the first minute of heating.

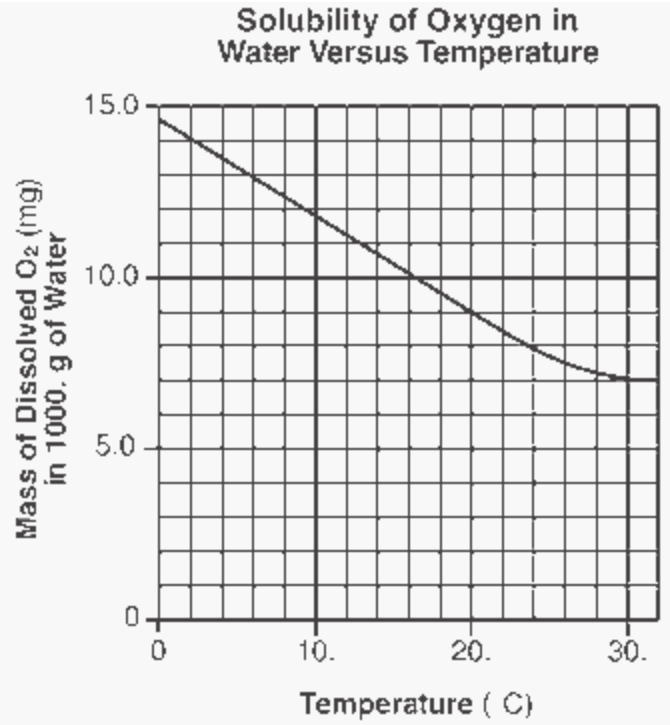
Key
◯ = particle of the substance

90. What is the boiling point of this sample?

Period:_____

Base your answers to questions **91** through **93** on the information below

Scientists who study aquatic ecosystems are often interested in the concentration of dissolved oxygen in water. Oxygen, O2, has a very low solubility in water, and therefore its solubility is usually expressed in units of milligrams per 1000. grams of water at 1.0 atmosphere. The graph below shows a solubility curve of oxygen in water.



91. An aqueous solution has 0.0070 gram of oxygen dissolved in 1000. grams of water. Calculate the dissolved oxygen concentration of this solution in parts per million. Your response must include *both* a correct numerical setup and the calculated result.

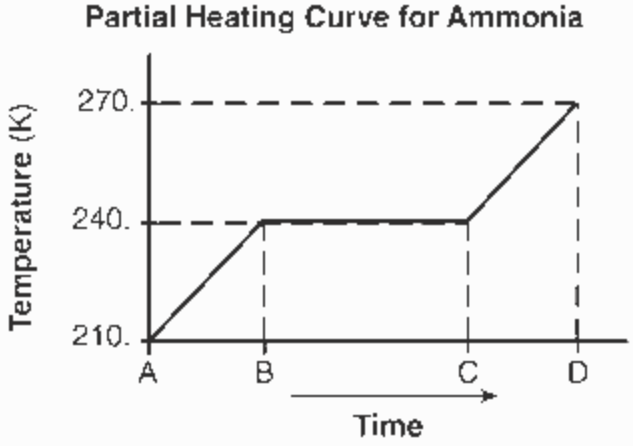
92. Explain, in terms of molecular polarity, why oxygen gas has low solubility in water. Your response must include *both* oxygen and water.

Period:_____

93. A student determines that 8.2 milligrams of oxygen is dissolved in a 1000.-gram sample of water at 15°C and 1.0 atmosphere. In terms of saturation, what type of solution is this sample?

Base your answers to questions **94** and **95** 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.



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

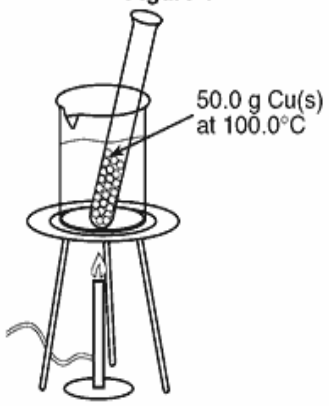
94. Determine the total amount of heat required to vaporize this 5.00-gram sample of ammonia at its boiling point.

95. 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.

Period:_____

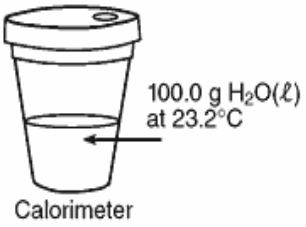
Base your answers to questions **96** and **97** on the information below.

Figure 1



In a laboratory investigation, a 50.0-gram sample of copper is at 100.0°C in a boiling water bath.

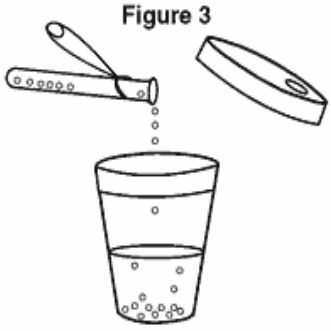
Figure 2



Calorimeter

A Styrofoam cup with a lid is used as a calorimeter. The cup contains 100.0 grams of distilled water at 23.2°C.

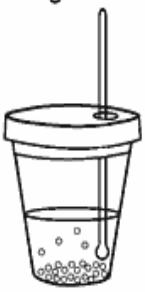
Figure 3



Calorimeter

The hot copper is poured into the cup of water, and the cup is quickly covered with the lid.

Figure 4



Calorimeter

A thermometer is inserted through the lid. The copper and water are gently stirred in the cup. The temperature is checked periodically. The highest temperature noted is 26.3°C.

Data Table

Quantity Measured	**Data** (units are given)
Mass of copper	g
Temperature of hot copper	°C
Mass of H_2O in calorimeter	g
Initial temperature of H_2O in calorimeter	°C
Final temperature of H_2O and copper	°C

96. In this investigation, the change in heat of the copper is greater than the change in heat of the water. What error could account for this apparent violation of the Law of Conservation of Energy? Do not use human error as part of the answer.

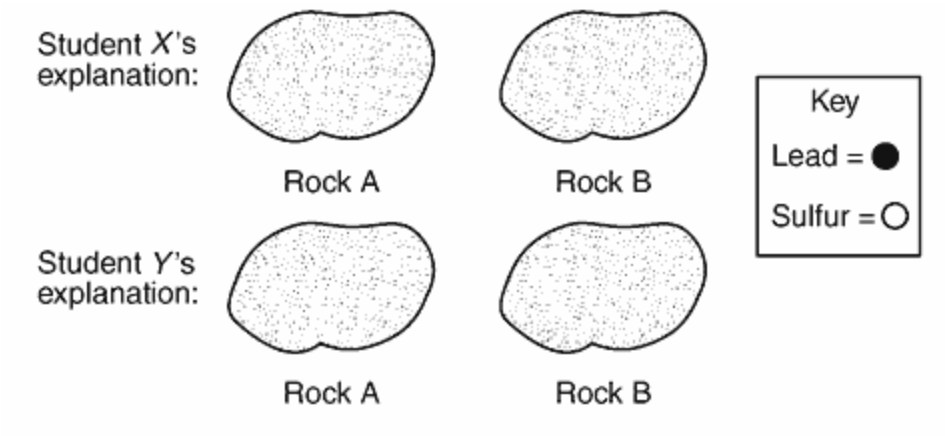
_____

97. In the space below show a correct numerical setup for calculating the number of joules of heat gained by the water.

_____

98. On a field trip, Student *X* and Student *Y* collected two rock samples. Analysis revealed that both rocks contained lead and sulfur. One rock contained a certain percentage of lead and sulfur by mass, and the other rock contained a different percentage of lead and sulfur by mass. Student *X* stated that the rocks contained two different mixtures of lead and sulfur. Student *Y* stated that the rocks contained two different compounds of lead and sulfur. Their teacher stated that both students could be correct.

    Draw particle diagrams in *each* of the rock diagrams *below* to show how Student *X*'s and Student *Y*'s explanations could both be correct. Use the symbols in the key provided *below* to sketch lead and sulfur atoms.



Base your answers to questions **99** through **101** on the information below.

At standard pressure, hydrogen peroxide, H_2O_2, melts at –0.4°C, boils at 151°C, and is very soluble in water. A bottle of aqueous hydrogen peroxide, $H_2O_2(aq)$, purchased from a pharmacy has a pressure-releasing cap. Aqueous hydrogen peroxide decomposes at room temperature, as represented by the balanced equation below.

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g) + 196.0kJ$$

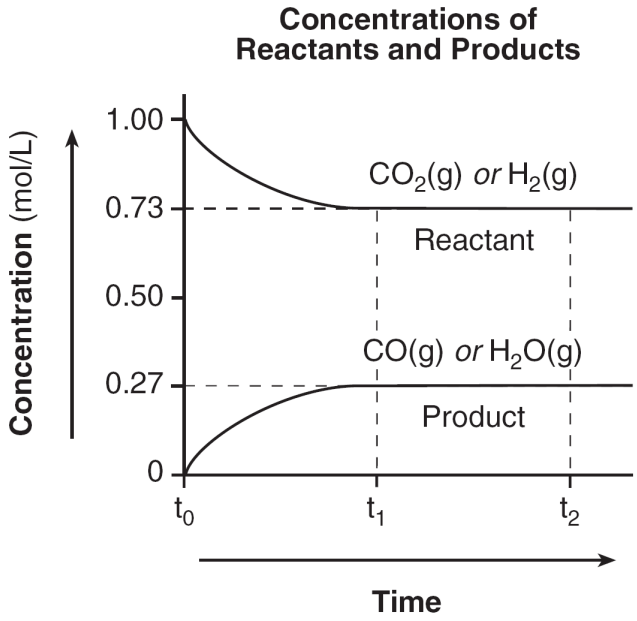
99. Explain why a hydrogen peroxide bottle needs a pressure-releasing cap.

100. State evidence that indicates the decomposition of $H_2O_2(aq)$ is exothermic.

101. State, in terms of *both* melting point and boiling point, why H_2O_2 is a liquid at room temperature.

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

At 550°C, 1.00 mole of $CO_2(g)$ and 1.00 mole of $H_2(g)$ are placed in a 1.00-liter reaction vessel. The substances react to form $CO(g)$ and $H_2O(g)$. Changes in the concentrations of the reactants and the concentrations of the products are shown in the graph below.



What can be concluded from the graph about the concentrations of the reactants and the concentrations of the products between time t_1 and time t_2?

Base your answers to questions **103** and **104** on the information below.
The balanced equation below represents the decomposition of potassium chlorate.

$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

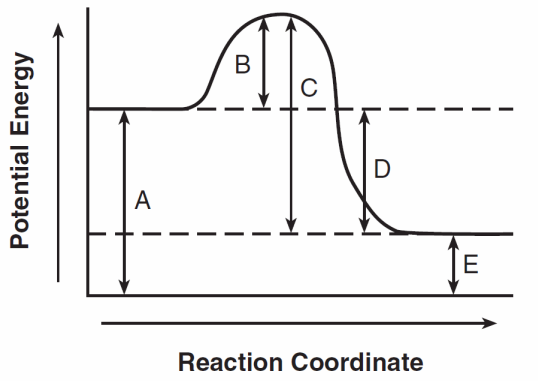
103. State why the entropy of the reactant is less than the entropy of the products.

104. Determine the oxidation number of chlorine in the reactant in the equation.

---

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

The chemical reaction between methane and oxygen is represented by the potential energy diagram and balanced equation below.



$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell) + 890.4\ kJ$

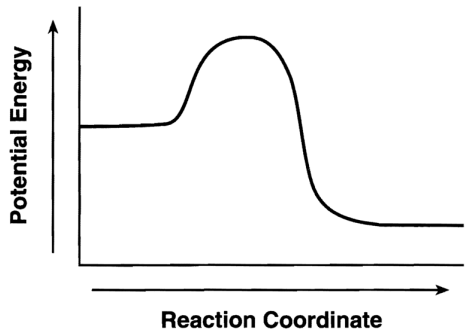
Explain, in terms of collision theory, why a lower concentration of oxygen gas *decreases* the rate of this reaction.

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

The catalytic converter in an automobile changes harmful gases produced during fuel combustion to less harmful exhaust gases. Inthe catalytic converter, nitrogen dioxide reacts with carbon monoxide to produce nitrogen and carbon dioxide. Inaddition, some carbon monoxide reacts with oxygen, producing carbon dioxide in the converter. These reactions are represented by the balanced equations below.

Reaction 1: $2NO_2(g) + 4CO(g) \rightarrow N_2(g) + 4CO_2(g) + 1198.4\ kJ$
Reaction 2: $2CO(g) + O_2(g) \rightarrow 2CO_2(g) + 566.0\ kJ$

The potential energy diagram below represents reaction 1 without a catalyst. On the same diagram, draw a dashed line to indicate how potential energy changes when the reaction is catalyzed in the converter.



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

At room temperature, a reaction occurs when $KIO_3(aq)$ is mixed with $NaHSO_3(aq)$ that contains a small amount of starch. The colorless reaction mixture turns dark blue after a period of time that depends on the concentration of the reactants.
In a laboratory, 12 drops of a 0.02 M $NaHSO_3(aq)$ solution containing starch were placed in each of six test tubes. A different number of drops of 0.02 M $KIO_3(aq)$ and enough water to maintain a constant volume were added to each test tube and the time for the dark-blue color to appear was measured. The data were recorded in the table below.

Data Table

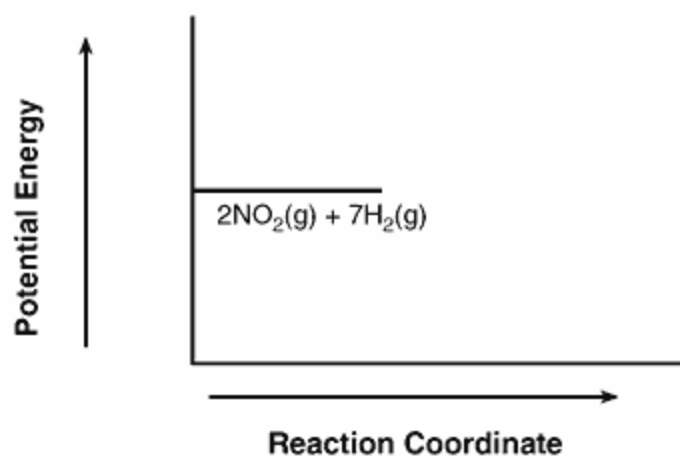
Test Tube	A	B	C	D	E	F
Number of Drops of 0.02 M KIO_3(aq)	2	4	6	8	10	12
Time for Dark-Blue Color to Appear (s)	210.	88	49	39	33	27

State how increasing the number of drops of 0.02 M $KIO_3(aq)$ used in the reaction affects the rate of reaction.

Base your answers to questions **108** and **109** on the information below.

Given the reaction at equilibrium:

$2\ NO_2(g) + 7\ H_2(g) \leftrightarrow 2\ NH_3(g) + 4\ H_2O(g) + 1127\ kJ$

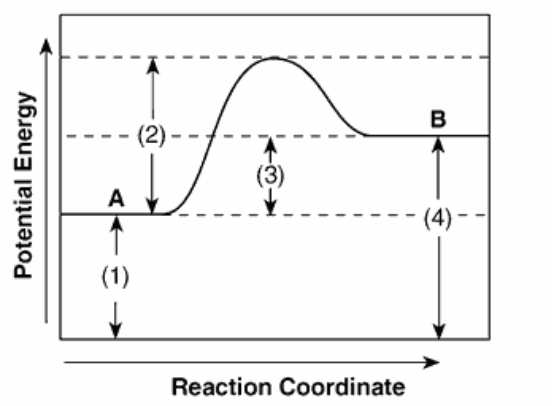


108. Explain, in terms of Le Chatelier's principle, why the concentration of $NH_3(g)$ *decreases* when the temperature of the equilibrium system increases.

109. Complete the potential energy diagram above for the forward reaction. Be sure your drawing shows the activation energy and the potential energy of the products.

Period:_____

Base your answers to questions **110** through **112** on the potential energy diagram and the equation below.



$2\ C(s) + H_2(g) + 227.4\ kJ \rightarrow C_2H_2(g)$

110. Describe how the potential energy diagram will change if a catalyst is added.

111. If 682.2 kilojoules are absorbed, how many moles of $C_2H_2(g)$ are produced?

112. The letter B represents which chemical formula or formulas in the equation?

---

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

Given the equilibrium equation at 298 K:

$KNO_3(s) + 34.89\ kJ \leftrightarrow K^+(aq) + NO_3^-(aq)$

Describe, in terms of *LeChatelier's principle*, why an increase in temperature increases the solubility of KNO_3.

114. Base your answer to the following question on the information and equation below.

Human blood contains dissolved carbonic acid, H_2CO_3, in equilibrium with carbon dioxide and water. The equilibrium system is shown below.

$H_2CO_3(aq) \leftrightarrow CO_2(aq) + H_2O(\ell)$

Explain, using LeChatelier's principle, why decreasing the concentration of CO_2 decreases the concentration of H_2CO_3.

Base your answers to questions **115** through **117** on the information below.

A student wishes to investigate how the reaction rate changes with a change in concentration of HCl(aq).

Given the reaction:

$Zn(s) + HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$

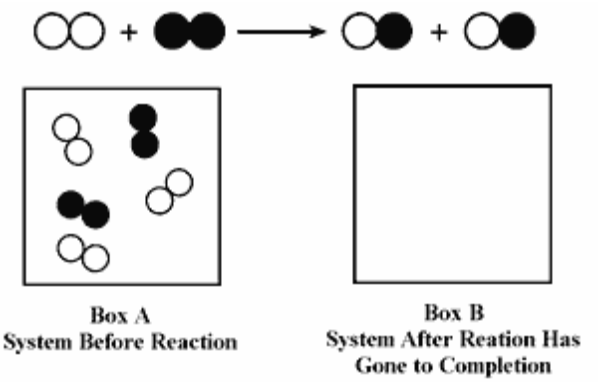
115. Describe the effect of increasing the concentration of HCl(aq) on the reaction rate and justify your response in terms of *collision theory*.

116. Identify one other variable that might affect the rate and should be held constant during this investigation.

117. Identify the independent variable in this investigation.

Period:_____

118. Given below the reaction between two different elements in the gaseous state. Box *A* below represents a mixture of the two reactants before the reaction occurs. The product of this reaction is a gas. In Box *B* provided below, draw the system after the reaction has gone to completion, based on the Law of Conservation of Matter.



119. Based on data collected during a laboratory investigation, a student determined an experimental value of 322 joules per gram for the heat of fusion of H_2O. Calculate the student's percent error. Your response must include a correct numerical setup and the calculated result.

120. A student determines the density of zinc to be 7.56 grams per milliliter. If the accepted density is 7.14 grams per milliliter, what is the student's percent error?

Answer Key
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1. –The boiling point of the mixture increases as water evaporates because the concentration of dissolved molecules increases. –An increase in the concentration of sugar particles increases the boiling point.
2. 0.000 32 mol *or 3.2 × 10^{-4}mol*
3. –The carbon-11 nucleus has one more proton than the nucleus of boron-11. –A B-11 atom has a different number of neutrons than a C-11 atom.
4. $^{11}_{5}\mathrm{B}$
5. –Boron-11 is about four times more abundant than boron-10. –The B-10 is less abundant.
6. – 2
7. – lithium and strontium
8. – When electrons in an excited state return to a lower energy state, specific amounts of energy are emitted. These energies are associated with specific wavelengths of light that are characteristic of the bright-line spectrum of an element. – Energy is emitted when excited electrons fall back to lower shells.
9. – A U-235 atom has 92 protons and 143 neutrons, and a U-238 atom has 92 protons and 146 neutrons. – A U-235 atom and a U-238 atom have the same number of protons but a different number of neutrons.
10. positive or (+)
11. Protons are positively charged (+) and neutrons have no charge (0).
12. protons and neutrons
13. example:

14. example:

Ca:
15. Responses include, but are not limited to: Carbon-12 has six neutrons and carbon-13 has seven neutrons • Carbon-13 has one more neutron than carbon-12 • C-12 has 6n, C-13 has 7n.
16. Resposes include, but are not limited to:
•(12.- 00)(0.9893) + (13.00)(0.0107)
•((12- .00)(98.93) + (13.00)(1.07))/100
17. 20
18. Examples:
– The atom has a positively charged nucleus; negative electrons surround the outside.
– The positive charges are in the nucleus; electrons are not mixed in the nucleus.
– nucleus smaller than atom
19. Examples:
– Alpha particles were deflected by the positively charged nucleus.
– nucleus — charged
20. Examples:
– The atom is mostly empty space.
– The volume of the atom is mostly unoccupied.
21. – An atom of magnesium loses its outer shell electrons to form the Mg^{2+} ion. – The electron configuration of a magnesium atom is 2-8-2, and the electron configuration of the magnesium ion is 2-8. – An atom of the metal loses electrons to form the ion.
22. Ne *or* neon
23. –In the ground state, an atom of each element has two valence electrons. –The number of electrons in the outermost shell of each atom is the same.
24. A strontium atom in the ground state has two more electron shells than a magnesium atom in the ground state.
25. as atomic number increases, first ionization energy decreases.
26. 7.31 g/cm^3 = $\frac{95.04g}{V}$
27. –Metal: Tin or Sn or Lead or Pb
–Metalloid: Silicon or Si or Germanium or Ge
–Nonmetal: Carbon or C

Answer Key
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28. –An aluminum pan has less mass than a copper pan of the same size because aluminum is less dense. –Aluminum is less dense than copper. –A Cu pan would weigh more.

29. Copper is very malleable *or* a good conductor of heat *or* a high melting point

30. –2

31. Cu_2O

32. –A Cl^- ion has 18 electrons and 17 protons, so there is less attraction by the nucleus for the electron shells, allowing the electron shells to expand. –The radius of Cl^- is larger because the nucleus can't hold 18 electrons as close as it can hold 17 electrons

33. Acceptable responses include, but are not limited to:
As atomic radius increases, valence electrons are more easily removed.
The force of attraction between the nucleus and the valence electrons decreases down the group.
cesium has more shells, easier to remove electrons

34. Acceptable responses include, but are not limited to:
As atomic number increases, first ionization energy decreases. Ionization energy decreases.

35. charge *or* mobility *or* size

36. potassium atom 2–8&nd- ash;8–1 and potassium ion 2–8–8 *or* The K^+ ion has only three electron shells

37. 18

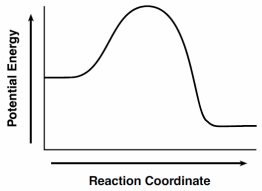
38. Group 13 and Period 4

39. The water has a fluoride level of 1.43 ppm, which is below the maximum contaminant level for fluoride, so it is safe to drink; F^- below 4 ppm, safe, below max level; Safe: 1.43 ppm < 4 ppm

40. SnF_2

41. 

42. Acceptable responses: They have the same number of valence electrons; form 1^+ ions; are located in same group; both alkali metals.

43. 

44. $-V_2O_5$ $-O_5V_2$

45. 197 kJ

46. –Increase the temperature –Increase the pressure –Increase the concentration of $H_2(g)$ –Increase the surface area of the carbon

47. 104.8 kJ

48. – Interval 3 represents the difference in potential energy between the products and the reactants. –Interval 3 represents the heat of reaction, 52.4 kJ. $-\Delta H$

49. $\frac{12(2\,g/mol+16\,g/mol)}{474\,g/mol} \times 100$ *or* $\frac{216}{474} \times 100$

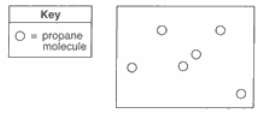
50. —K^+ —Al^{3+}

51. 1.94 g

52. 3

53. $Y(OH)_3$

54. 15 mol

55. 

56. $V_2 = \frac{(99.5\text{ kPa})(45.6\text{ mL})(273\text{ K})}{(293\text{ K})(101.3\text{ kPa})}$

$\frac{(99.5)(45.6)}{293} = \frac{(101.3)x}{273}$

57. ___Mg(s) + _2 _HCl(aq) → ___$MgCl_2$(aq) + ____H_2(g)

58. Cd(s) + NiO_2(s) + $2H_20(\ell) \rightarrow$ $Cd(OH)_2$(s) + $Ni(OH)_2$(s).

59. Equal volumes of two gases at the same temperature and pressure contain equal number of particles.

60. 6

61. $\frac{32}{46} \times 100$

62. Responses include, but are not limited to, these examples: dinitrogen pentoxide • nitrogen(V) oxide

63. 11 g $\times \frac{1mole}{44g}$ *or* $\frac{11}{44}$

64. 96

65. Acceptable responses: A compound must contain two or more different elements, only 1 kind of atom present.

66. *Examples:* – synthesis – redox – oxidation

67. 160.g/mol.

68. iron(III) oxide

69. –Energy is needed to break the bonds in O_2.

70. –covalent –double covalent –nonpolar –double

71. 47 g ± 1 g.

Answer Key
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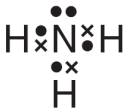
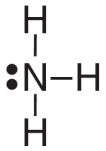
72. –The 0.30 M NH_4Cl(aq) sample has more mobile ions in solution. –The 0.10 M NH_4Cl solution has a lower concentration of ions.

73. –The process requires heat to dissolve NH_4Cl. –Energy is absorbed as NH_4Cl dissolves. –The energy term is positive on the left side of the equation arrow. –The heat of reaction is positive.

74. 0.20 mol

75.



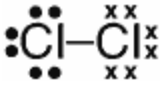


76. – The electronegativity difference is 1.4 for H and O, which is higher than the 0.9 for H and N. – The difference in electronegativity between hydrogen and oxygen is greater than that for hydrogen and nitrogen.

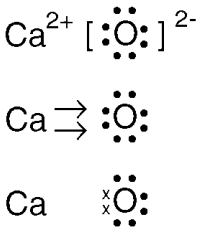
77. $NaHCO_3$ *or* NH_4Cl.

78. Examples: – The electronegativity difference for HCl is 1.1, which is higher than the 0.6 for HI. – The difference for HCl is greater.

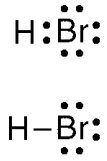
79.



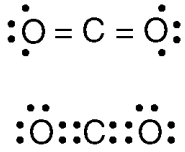
80. *a.*



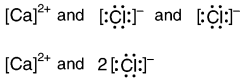
b.



c.



81. examples:



82. –The heat of vaporization of water is 2260 J/g and the heat of fusion for water is only 334 J/g. –The heat of fusion of water is much less than its heat of vaporization.

83. 8 kJ ± 1 kJ

84. –The potential energy remains the same, but the average kinetic energy of the H_2O molecules increases. –There is no change in potential energy. There is an increase in the average kinetic energy.

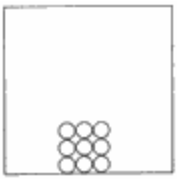
85. 0.70 M

86. 84g ± 2g

87. 30.kJ ± 3kJ

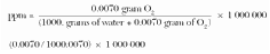
88. 3.0 min ± 0.2 min

89.



90. 120.°C ± 2°C.

91.



92. Oxygen molecules are nonpolar and water molecules are polar.

93. The sample is an unsaturated solution.

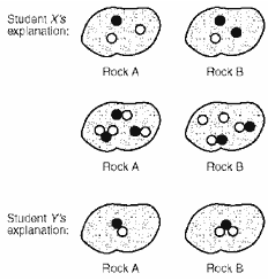
94. 6850 J

95. *q = mCΔT = (5.00 g)(4.71 J/g • K)(30. K)*
(5)(4.71)(30)
710 J

96. Responses include, but are not limited to, these examples: heat lost to surroundings • heat absorbed by the thermometer; heat absorbed by the calorimeter

97. q= (100.0 g) (4.18 J/g•°C) (3.1°C)

98.



99. —The excess pressure due to the production of oxygen gas in the bottle needs to be gradually released. —As O_2(g) is produced, the pressure inside of the bottle might increase and the bottle might burst without the pressure-releasing cap.

100. —More energy is released than absorbed. —Heat is a product of the reaction.

Answer Key
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101. —Room temperature is above the melting point and below the boiling point of H_2O 2. —Room temperature is between –0.4°C and 151°C. — –0.4°C < room temperature < 151°C

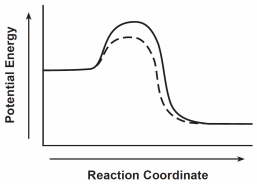
102. – Between time t_1 and time t_2, the concentrations of the reactants and the concentrations of the products are no longer changing. – The concentrations of the reactants and the products remain constant. – The concentration of each reactant is 0.73 mol/L, and the concentration of each product is 0.27 mol/L.

103. – The gaseous product is more disordered than the solid reactant. – The solid reactant is more ordered than the products.

104. – $^{+}5$

105. Acceptable responses include, but are not limited to: • A lower concentration of oxygen gas decreases the number of effective collisions between O_2 molecules and CH_4 molecules.

106. An appropriate line is drawn.

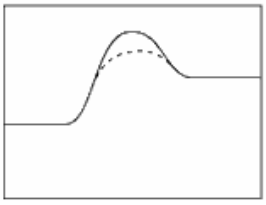


107. –Increasing the number of drops of KIO_3(aq) increases the rate of reaction. –The reaction takes less time if more drops of KIO_3 are used. –The reaction occurs faster.

108. An increase in temperature favors the endothermic (reverse) reaction.

109.

110.



Responses include, but are not limited to: Arrow 2 gets shorter • The activation energy would be lower • The peak of the curve is lower

111. three

112. C_2H_2(g)

113. Increasing the temperature favors the forward, endothermic reaction *or* Adding heat shifts the reaction to the right

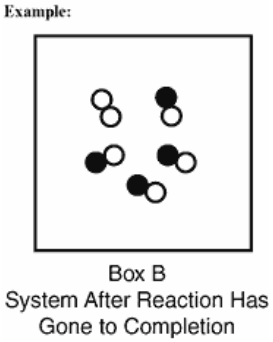
114. Acceptable responses: Removing CO_2 disrupts equilibrium and thus the system must shift to create more CO_2 from the H_2CO_3 in order to restore equilibrium; Equilibrium shifts to the right; H_2CO_3 decreases to remove the stress of changing the CO_2.

115. Examples: – rate ↑, more collisions; – The rate will increase because the higher concentration of HCl will lead to a greater number of collisions.

116. Examples: – temperature; – surface area of Zn; – amount of Zn; – Zn; – concentration of Zn; – [Zn]

117. Examples: – concentration of HCl; – HCl(aq); – HCl; – [HCl]

118.



119. $\frac{332\text{ J/g} - 334\text{ J/g}}{334\text{ J/g}} \times 100$

Examples: –3.6%; 4%

120. $\frac{7.58-7.14}{7.14}$

5.88 or 5.9 or 6