The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Thursday, January 24, 2013 — 1:15 to 4:15 p.m., only

The possession or use of any communications device is strictly prohibited when taking this examination. If you have or use any communications device, no matter how briefly, your examination will be invalidated and no score will be calculated for you.

This is a test of your knowledge of chemistry. Use that knowledge to answer all questions in this examination. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*. You are to answer *all* questions in all parts of this examination according to the directions provided in this examination booklet.

A separate answer sheet for Part A and Part B–1 has been provided to you. Follow the instructions from the proctor for completing the student information on your answer sheet. Record your answers to the Part A and Part B–1 multiple-choice questions on this separate answer sheet. Record your answers for the questions in Part B–2 and Part C in your separate answer booklet. Be sure to fill in the heading on the front of your answer booklet.

All answers in your answer booklet should be written in pen, except for graphs and drawings, which should be done in pencil. You may use scrap paper to work out the answers to the questions, but be sure to record all your answers on your separate answer sheet or in your answer booklet as directed.

When you have completed the examination, you must sign the statement printed on your separate answer sheet, indicating that you had no unlawful knowledge of the questions or answers prior to the examination and that you have neither given nor received assistance in answering any of the questions during the examination. Your answer sheet and answer booklet cannot be accepted if you fail to sign this declaration.

Notice. . .

A four-function or scientific calculator and a copy of the *2011 Edition Reference Tables for Physical Setting/Chemistry* must be available for you to use while taking this examination.

DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL THE SIGNAL IS GIVEN.

Part A

Answer all questions in this part.

Directions (1–30): For *each* statement or question, record on your separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

1 Which particles have approximately the same mass?

(1) alpha particle and beta particle
(2) alpha particle and proton
(3) neutron and positron
(4) neutron and proton

2 Which phrase describes an atom?

(1) a negatively charged nucleus surrounded by positively charged protons
(2) a negatively charged nucleus surrounded by positively charged electrons
(3) a positively charged nucleus surrounded by negatively charged protons
(4) a positively charged nucleus surrounded by negatively charged electrons

3 An orbital is defined as a region of the most probable location of

(1) an electron
(2) a neutron
(3) a nucleus
(4) a proton

4 The bright-line spectrum of an element in the gaseous phase is produced as

(1) protons move from lower energy states to higher energy states
(2) protons move from higher energy states to lower energy states
(3) electrons move from lower energy states to higher energy states
(4) electrons move from higher energy states to lower energy states

5 An atom of lithium-7 has an equal number of

(1) electrons and neutrons
(2) electrons and protons
(3) positrons and neutrons
(4) positrons and protons

6 In which type of chemical reaction do two or more reactants combine to form one product, only?

(1) synthesis
(2) decomposition
(3) single replacement
(4) double replacement

7 Which statement explains why neon is a Group 18 element?

(1) Neon is a gas at STP.
(2) Neon has a low melting point.
(3) Neon atoms have a stable valence electron configuration.
(4) Neon atoms have two electrons in the first shell.

8 Which element has chemical properties that are most similar to the chemical properties of fluorine?

(1) boron
(2) chlorine
(3) neon
(4) oxygen

9 What occurs as two atoms of fluorine combine to become a molecule of fluorine?

(1) A bond is formed as energy is absorbed.
(2) A bond is formed as energy is released.
(3) A bond is broken as energy is absorbed.
(4) A bond is broken as energy is released.

10 What is the number of pairs of electrons that are shared between the nitrogen atoms in a molecule of N_2?

(1) 1
(2) 2
(3) 3
(4) 6

11 Which set of values represents standard pressure and standard temperature?

(1) 1 atm and 101.3 K
(2) 1 kPa and 273 K
(3) 101.3 kPa and 0°C
(4) 101.3 atm and 273°C

12 Which statement about one atom of an element identifies the element?

(1) The atom has 1 proton.
(2) The atom has 2 neutrons.
(3) The sum of the number of protons and neutrons in the atom is 3.
(4) The difference between the number of neutrons and protons in the atom is 1.

13 A substance is classified as either an element or a

(1) compound
(2) solution
(3) heterogeneous mixture
(4) homogeneous mixture

14 A solid element that is malleable, a good conductor of electricity, and reacts with oxygen is classified as a

(1) metal
(2) metalloid
(3) noble gas
(4) nonmetal

15 Three forms of energy are

(1) chemical, exothermic, and temperature
(2) chemical, thermal, and electromagnetic
(3) electrical, nuclear, and temperature
(4) electrical, mechanical, and endothermic

16 What is the total amount of heat required to vaporize 1.00 gram of $H_2O(\ell)$ at 100.°C and 1 atmosphere?

(1) 4.18 J
(2) 334 J
(3) 373 J
(4) 2260 J

17 What is required for a chemical reaction to occur?

(1) standard temperature and pressure
(2) a catalyst added to the reaction system
(3) effective collisions between reactant particles
(4) an equal number of moles of reactants and products

18 Which compound is soluble in water?

(1) PbS
(2) BaS
(3) Na_2S
(4) Fe_2S_3

19 Compared to a 26-gram sample of NaCl(s) at STP, a 52-gram sample of NaCl(s) at STP has

(1) a different density
(2) a different gram-formula mass
(3) the same chemical properties
(4) the same volume

20 A gas changes directly to a solid during

(1) fusion
(2) deposition
(3) saponification
(4) decomposition

21 The phase of a sample of a molecular substance at STP is *not* determined by its

(1) arrangement of molecules
(2) intermolecular forces
(3) number of molecules
(4) molecular structure

22 Which atom has the *weakest* attraction for electrons in a chemical bond?

(1) a boron atom
(2) a calcium atom
(3) a fluorine atom
(4) a nitrogen atom

23 Which statement describes a chemical reaction at equilibrium?

(1) The products are completely consumed in the reaction.
(2) The reactants are completely consumed in the reaction.
(3) The concentrations of the products and reactants are equal.
(4) The concentrations of the products and reactants are constant.

24 Which element has atoms that can bond to each other in rings and networks?

(1) aluminum
(2) carbon
(3) hydrogen
(4) oxygen

25 In an oxidation-reduction reaction, the total number of electrons lost is

(1) equal to the total number of electrons gained
(2) equal to the total number of protons gained
(3) less than the total number of electrons gained
(4) less than the total number of protons gained

26 Which compounds are electrolytes?

(1) C_2H_5OH and H_2SO_4
(2) C_2H_5OH and CH_4
(3) KOH and H_2SO_4
(4) KOH and CH_4

27 Which compounds yield hydrogen ions as the only positive ions in an aqueous solution?

(1) H_2CO_3 and $HC_2H_3O_2$
(2) H_2CO_3 and $NaHCO_3$
(3) NH_3 and $HC_2H_3O_2$
(4) NH_3 and $NaHCO_3$

28 Nuclei of U-238 atoms are

(1) stable and spontaneously absorb alpha particles
(2) stable and spontaneously emit alpha particles
(3) unstable and spontaneously absorb alpha particles
(4) unstable and spontaneously emit alpha particles

29 Which nuclear emission has the greatest penetrating power?

(1) proton
(2) beta particle
(3) gamma radiation
(4) positron

30 The dating of geological formations is an example of a beneficial use of

(1) isomers
(2) electrolytes
(3) organic compounds
(4) radioactive nuclides

Part B–1

Answer all questions in this part.

Directions (31–50): For *each* statement or question, record on your separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

31 Which electron configuration represents a selenium atom in an excited state?

(1) 2-7-18-6
(2) 2-7-18-7
(3) 2-8-18-6
(4) 2-8-18-7

32 When the hydronium ion concentration of a solution is increased by a factor of 10, the pH value of the solution

(1) decreases 1 pH unit
(2) decreases 10 pH units
(3) increases 1 pH unit
(4) increases 10 pH units

33 In the formula XF_2, the element represented by *X* can be classified as a

(1) Group 1 metal
(2) Group 2 metal
(3) Group 1 nonmetal
(4) Group 2 nonmetal

34 Which compound has the *smallest* percent composition by mass of chlorine?

(1) HCl
(2) KCl
(3) LiCl
(4) NaCl

35 Given the incomplete equation representing a reaction:

$$2C_6H_{14} + \_\_\_\_\_\ O_2 \rightarrow 12CO_2 + 14H_2O$$

What is the coefficient of O_2 when the equation is completely balanced using the smallest whole-number coefficients?

(1) 13
(2) 14
(3) 19
(4) 26

36 What is the oxidation number of iodine in KIO_4?

(1) +1
(2) −1
(3) +7
(4) −7

37 What is the chemical formula for zinc carbonate?

(1) $ZnCO_3$
(2) $Zn(CO_3)_2$
(3) Zn_2CO_3
(4) Zn_3CO_2

38 Which statement explains why a molecule of CH_4 is nonpolar?

(1) The bonds between the atoms in a CH_4 molecule are polar.
(2) The bonds between the atoms in a CH_4 molecule are ionic.
(3) The geometric shape of a CH_4 molecule distributes the charges symmetrically.
(4) The geometric shape of a CH_4 molecule distributes the charges asymmetrically.

39 Which atom in the ground state has the same electron configuration as a calcium ion, Ca^{2+}, in the ground state?

(1) Ar
(2) K
(3) Mg
(4) Ne

40 In the compound $KHSO_4$, there is an ionic bond between the

(1) KH^+ and SO_4^{2-} ions
(2) $KHSO_3^+$ and O^{2-} ions
(3) K^+ and HS^- ions
(4) K^+ and HSO_4^- ions

41 Given the balanced equation representing a reaction:

$$^{27}_{13}\text{Al} + {}^{4}_{2}\text{He} \rightarrow {}^{30}_{15}\text{P} + {}^{1}_{0}\text{n}$$

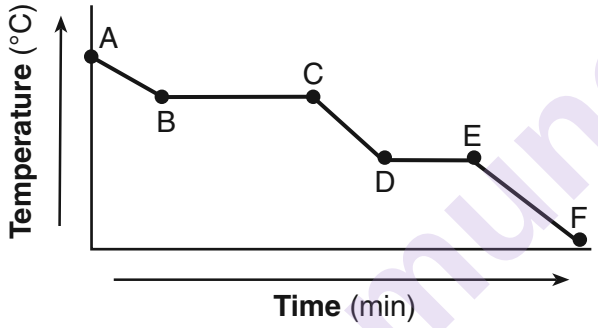
Which type of reaction is represented by this equation?

(1) combustion
(2) decomposition
(3) saponification
(4) transmutation

42 A 220.0-mL sample of helium gas is in a cylinder with a movable piston at 105 kPa and 275 K. The piston is pushed in until the sample has a volume of 95.0 mL. The new temperature of the gas is 310. K. What is the new pressure of the sample?

(1) 51.1 kPa
(2) 216 kPa
(3) 243 kPa
(4) 274 kPa

43 Given the cooling curve of a substance:



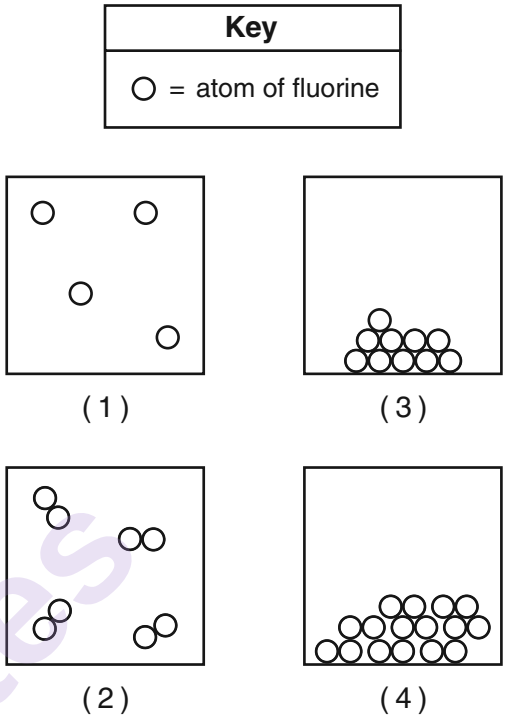
During which intervals is potential energy decreasing and average kinetic energy remaining constant?

(1) *AB* and *BC*
(2) *AB* and *CD*
(3) *DE* and *BC*
(4) *DE* and *EF*

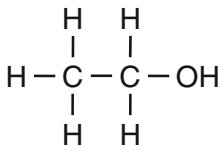
44 Which metal will spontaneously react with $Zn^{2+}(aq)$, but will *not* spontaneously react with $Mg^{2+}(aq)$?

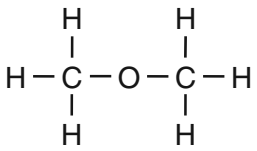
(1) Mn(s)
(2) Cu(s)
(3) Ni(s)
(4) Ba(s)

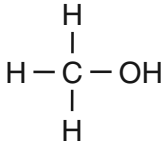
45 Which particle diagram represents the arrangement of F_2 molecules in a sample of fluorine at 95 K and standard pressure?

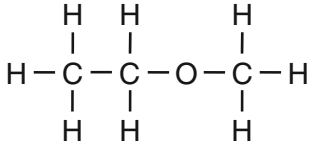


46 Given the formulas of four organic compounds:


(A)


(C)


(B)


(D)

Which compounds have the same molecular formula?

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

47 Given the incomplete equation representing a reaction:

$$2Na(s) + 2H_2O(\ell) \rightarrow 2Na^+(aq) + 2 \_\_\_\_\_ (aq) + H_2(g)$$

What is the formula of the missing product?

(1) O^{2-}
(2) O_2
(3) OH^-
(4) OH

48 Given the equation representing a reaction where the masses are expressed in atomic mass units:

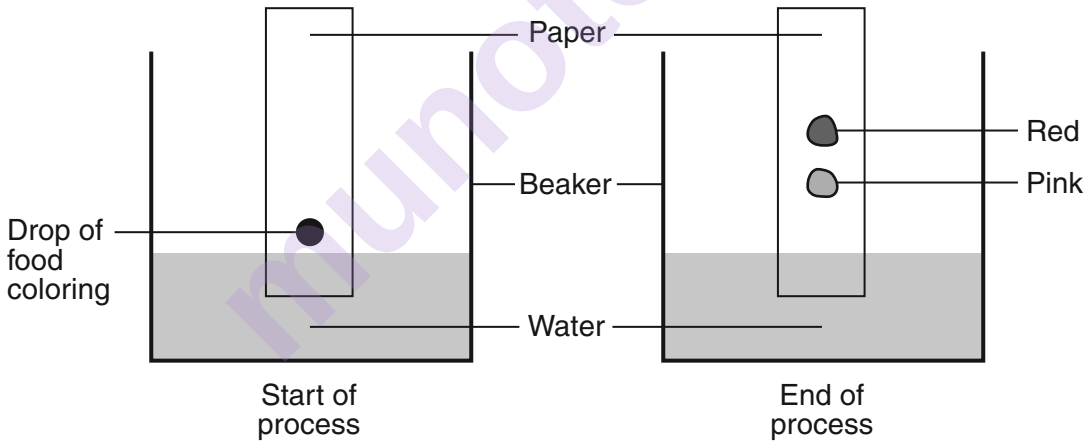
$$\text{hydrogen-2} + \text{hydrogen-1} \rightarrow \text{helium-3} + 8.814 \times 10^{-16}\ \text{kJ}$$

2.014 102 u 1.007 825 u 3.016 029 u

Which phrase describes this reaction?

(1) a chemical reaction and mass being converted to energy
(2) a chemical reaction and energy being converted to mass
(3) a nuclear reaction and mass being converted to energy
(4) a nuclear reaction and energy being converted to mass

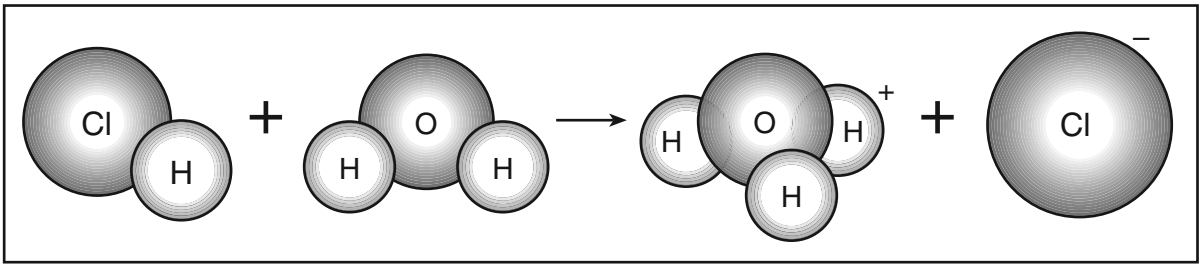
49 Given the diagram representing a process being used to separate the colored dyes in food coloring:



Which process is represented by this diagram?

(1) chromatography
(2) electrolysis
(3) distillation
(4) titration

50 Given the diagram representing a reaction:



According to one acid-base theory, the water acts as

(1) a base because it accepts an H^+
(2) a base because it donates an H^+
(3) an acid because it accepts an H^+
(4) an acid because it donates an H^+

Part B–2

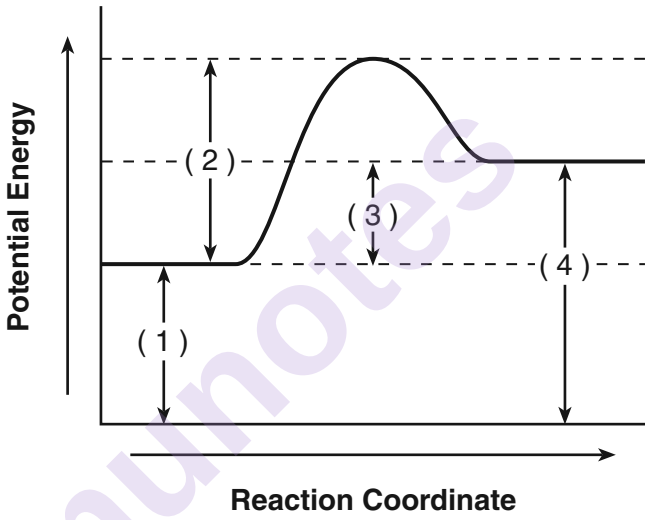
Answer all questions in this part.

Directions (51–65): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry.*

51 Draw a Lewis electron-dot diagram for an atom of silicon. [1]

Base your answers to questions 52 through 54 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.



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

52 State what interval 3 represents. [1]

53 Determine the net amount of energy absorbed when 2.00 moles of $C_2H_4(g)$ are produced. [1]

54 Identify *one* change in the reaction conditions, other than adding a catalyst, that can increase the rate of this reaction. [1]

Base your answers to questions 55 through 58 on the information below.

The atomic number and corresponding atomic radius of the Period 3 elements are shown in the data table below.

Data Table

Atomic Number	**Atomic Radius** (pm)
11	160.
12	140.
13	124
14	114
15	109
16	104
17	100.
18	101

55 On the grid *in your answer booklet*, mark an appropriate scale on the axis labeled "Atomic Radius (pm)." [1]

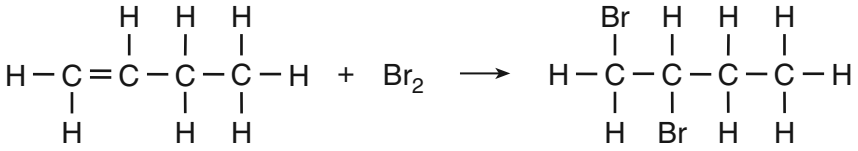
56 On the grid *in your answer booklet*, plot the data from the data table. Circle and connect the points. [1]

57 State the general relationship between the atomic number and the atomic radius for the Period 3 elements. [1]

58 Explain, in terms of electrons, the change in radius when a sodium atom becomes a sodium ion. [1]

Base your answers to questions 59 through 61 on the information below.

The equation below represents the reaction between 1-butene and bromine to form the compound 1,2-dibromobutane, $C_4H_8Br_2$.



59 Explain, in terms of bonding, why the hydrocarbon reactant is an unsaturated hydrocarbon. [1]

60 Determine the gram-formula mass of 1-butene. [1]

61 Write the empirical formula for the product. [1]

Base your answers to questions 62 through 65 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.

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

62 Determine the number of moles of $NH_4Cl(s)$ used to produce 2.0 liters of this solution. [1]

63 State evidence that indicates the dissolving of ammonium chloride is an endothermic process. [1]

64 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 $NH_4Cl(aq)$. [1]

65 Determine the minimum mass of $NH_4Cl(s)$ required to produce a saturated solution in 100. grams of water at 40.°C. [1]

Part C

Answer all questions in this part.

Directions (66–85): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 66 through 69 on the information below.

Nitrogen gas and oxygen gas make up about 99% of Earth's atmosphere. Other atmospheric gases include argon, carbon dioxide, methane, ozone, hydrogen, etc.

The amount of carbon dioxide in the atmosphere can vary. Data for the concentration of $CO_2(g)$ from 1960 to 2000 are shown in the table below.

Atmospheric Concentration of $CO_2(g)$

Year	**Concentration** (ppm)
1960	316.9
1980	338.7
2000	369.4

66 Identify *one* diatomic element found in the atmosphere. [1]

67 Explain, in terms of types of matter, why methane can be broken down by chemical means, but argon can *not* be broken down by chemical means. Your response must include *both* methane and argon. [1]

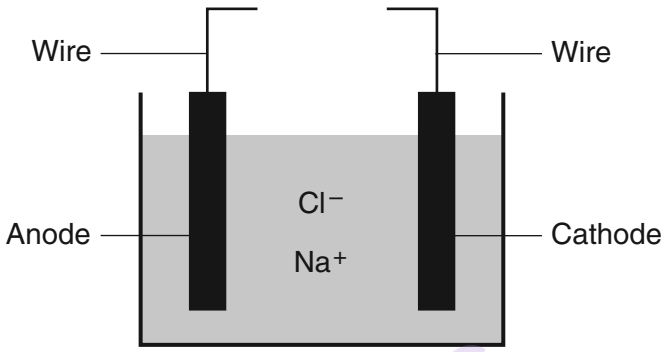
68 Show a numerical setup for calculating the mass of carbon dioxide in a 100.0-gram sample of air taken in 1980. [1]

69 Explain why the atmosphere is classified as a mixture. [1]

Base your answers to questions 70 through 72 on the information below.

Metallic elements are obtained from their ores by reduction. Some metals, such as zinc, lead, iron, and copper, can be obtained by heating their oxides with carbon.

More active metals, such as aluminum, magnesium, and sodium, can *not* be reduced by carbon. These metals can be obtained by the electrolysis of their molten (melted) ores. The diagram below represents an incomplete cell for the electrolysis of molten NaCl. The equation below represents the reaction that occurs when the completed cell operates.



$$2NaCl(\ell) \rightarrow 2Na(\ell) + Cl_2(g)$$

70 Identify the component required for the electrolysis of molten NaCl that is missing from the cell diagram. [1]

71 Identify *one* metal from the passage that is more active than carbon and *one* metal from the passage that is *less* active than carbon. [1]

72 Write a balanced half-reaction equation for the reduction of the iron ions in iron(III) oxide to iron atoms. [1]

Base your answers to questions 73 through 76 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.

73 Compare the abundance of the two naturally occurring isotopes of boron. [1]

74 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. [1]

75 State, in terms of subatomic particles, *one* difference between the nucleus of a carbon-11 atom and the nucleus of a boron-11 atom. [1]

76 One sample of a green vegetable contains 0.0035 gram of boron. Determine the total number of moles of boron in this sample. [1]

Base your answers to questions 77 through 79 on the information below.

The active ingredient in the pain reliever aspirin is acetylsalicylic acid. This compound can be produced by reacting salicylic acid with acetic acid. The label of one aspirin bottle indicates that the accepted mass of acetylsalicylic acid in each tablet is 325 milligrams.

In a laboratory, an aspirin tablet is crushed and mixed with water to dissolve all of the acetylsalicylic acid. The measured pH of the resulting solution is 3.0.

77 Write the chemical formula for the acetic acid. [1]

78 State the color of methyl orange indicator after the indicator is placed in the solution. [1]

79 The mass of acetylsalicylic acid in one aspirin tablet is determined to be 320. milligrams. Show a numerical setup for calculating the percent error for the mass of acetylsalicylic acid in this aspirin tablet. [1]

Base your answers to questions 80 through 82 on the information below.

A student investigated heat transfer using a bottle of water. The student placed the bottle in a room at 20.5°C. The student measured the temperature of the water in the bottle at 7 a.m. and again at 3 p.m. The data from the investigation are shown in the table below.

Water Bottle Investigation Data

7 a.m.		3 p.m.	
Mass of Water (g)	**Temperature** (°C)	**Mass of Water** (g)	**Temperature** (°C)
800.	12.5	800.	20.5

80 Compare the average kinetic energy of the water molecules in the bottle at 7 a.m. to the average kinetic energy of the water molecules in the bottle at 3 p.m. [1]

81 State the direction of heat transfer between the surroundings and the water in the bottle from 7 a.m. to 3 p.m. [1]

82 Show a numerical setup for calculating the change in the thermal energy of the water in the bottle from 7 a.m. to 3 p.m. [1]

Base your answers to questions 83 through 85 on the information below.

In one method of making bread, starch is broken down into glucose. Zymase, an enzyme present in yeast, acts as a catalyst for the reaction in which the glucose reacts to produce ethanol and carbon dioxide. The carbon dioxide gas causes the bread dough to rise. The balanced equation below represents the catalyzed reaction.

$$C_6H_{12}O_6(aq) \xrightarrow{\text{zymase}} 2CH_3CH_2OH(aq) + 2CO_2(g)$$

83 Identify the type of organic reaction represented by this equation. [1]

84 Identify the functional group in an ethanol molecule. [1]

85 State how the catalyst, zymase, increases the rate of this reaction. [1]

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