The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING

CHEMISTRY

Wednesday, June 22, 2011 — 1:15 to 4:15 p.m., only

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 *Reference Tables for Physical Setting/Chemistry*. You are to answer *all* questions in all parts of this examination according to the directions provided in the examination booklet.

The answers to *all* questions in this examination are to be written in your separate answer booklet. Be sure to fill in the heading on the front of your answer booklet.

All work 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 in your answer booklet.

When you have completed the examination, you must sign the statement printed on the first page of your answer booklet, 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 booklet cannot be accepted if you fail to sign this declaration.

Notice. . .

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

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

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, write in your answer booklet 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 *Reference Tables for Physical Setting/Chemistry*.

1 A neutron has a charge of

(1) +1
(2) +2
(3) 0
(4) −1

2 Which particle has the *least* mass?

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

3 A sample of matter must be copper if

(1) each atom in the sample has 29 protons
(2) atoms in the sample react with oxygen
(3) the sample melts at 1768 K
(4) the sample can conduct electricity

4 In the electron cloud model of the atom, an orbital is defined as the most probable

(1) charge of an electron
(2) conductivity of an electron
(3) location of an electron
(4) mass of an electron

5 The elements on the Periodic Table are arranged in order of increasing

(1) atomic number
(2) mass number
(3) number of isotopes
(4) number of moles

6 Which element has the highest melting point?

(1) tantalum
(2) rhenium
(3) osmium
(4) hafnium

7 In a chemical reaction, there is conservation of

(1) energy, volume, and mass
(2) energy, volume, and charge
(3) mass, charge, and energy
(4) mass, charge, and volume

8 At STP, both diamond and graphite are solids composed of carbon atoms. These solids have

(1) the same crystal structure and the same properties
(2) the same crystal structure and different properties
(3) different crystal structures and the same properties
(4) different crystal structures and different properties

9 The gram-formula mass of a compound is 48 grams. The mass of 1.0 mole of this compound is

(1) 1.0 g
(2) 4.8 g
(3) 48 g
(4) 480 g

10 Given the balanced equation representing a reaction:

$$Cl_2 \rightarrow Cl + Cl$$

What occurs during this reaction?

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

11 Which atom has the *weakest* attraction for the electrons in a bond with an H atom?

(1) Cl atom
(2) F atom
(3) O atom
(4) S atom

12 Which substance can *not* be broken down by a chemical change?

(1) ammonia
(2) mercury
(3) propane
(4) water

13 At standard pressure, how do the boiling point and the freezing point of NaCl(aq) compare to the boiling point and the freezing point of $H_2O(\ell)$?

(1) Both the boiling point and the freezing point of NaCl(aq) are lower.
(2) Both the boiling point and the freezing point of NaCl(aq) are higher.
(3) The boiling point of NaCl(aq) is lower, and the freezing point of NaCl(aq) is higher.
(4) The boiling point of NaCl(aq) is higher, and the freezing point of NaCl(aq) is lower.

14 The temperature of a sample of matter is a measure of the

(1) average kinetic energy of its particles
(2) average potential energy of its particles
(3) total kinetic energy of its particles
(4) total potential energy of its particles

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

(1) have no potential energy
(2) have strong intermolecular forces
(3) are arranged in a regular, repeated geometric pattern
(4) are separated by great distances, compared to their size

16 Given the equation representing a closed system:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

Which statement describes this system at equilibrium?

(1) The volume of the $NO_2(g)$ is greater than the volume of the $N_2O_4(g)$.
(2) The volume of the $NO_2(g)$ is less than the volume of the $N_2O_4(g)$.
(3) The rate of the forward reaction and the rate of the reverse reaction are equal.
(4) The rate of the forward reaction and the rate of the reverse reaction are unequal.

17 In a chemical reaction, the difference between the potential energy of the products and the potential energy of the reactants is equal to the

(1) activation energy
(2) kinetic energy
(3) heat of reaction
(4) rate of reaction

18 For a given chemical reaction, the addition of a catalyst provides a different reaction pathway that

(1) decreases the reaction rate and has a higher activation energy
(2) decreases the reaction rate and has a lower activation energy
(3) increases the reaction rate and has a higher activation energy
(4) increases the reaction rate and has a lower activation energy

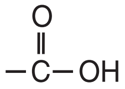
19 Which atoms can bond with each other to form chains, rings, or networks?

(1) carbon atoms
(2) hydrogen atoms
(3) oxygen atoms
(4) nitrogen atoms

20 A molecule of an unsaturated hydrocarbon must have

(1) at least one single carbon-carbon bond
(2) at least one multiple carbon-carbon bond
(3) two or more single carbon-carbon bonds
(4) two or more multiple carbon-carbon bonds

21 Given a formula of a functional group:



$$-\overset{\overset{\displaystyle O}{\|}}{C}-OH$$

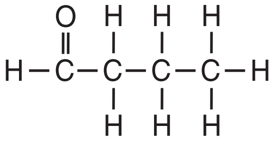
An organic compound that has this functional group is classified as

(1) an acid
(2) an aldehyde
(3) an ester
(4) a ketone

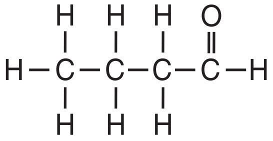
22 Which statement describes where the oxidation and reduction half-reactions occur in an operating electrochemical cell?

(1) Oxidation and reduction both occur at the anode.
(2) Oxidation and reduction both occur at the cathode.
(3) Oxidation occurs at the anode, and reduction occurs at the cathode.
(4) Oxidation occurs at the cathode, and reduction occurs at the anode.

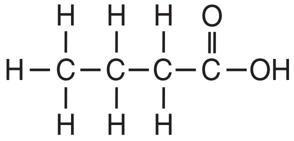
23 Given a formula representing a compound:



Which formula represents an isomer of this compound?



(1)



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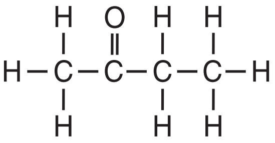

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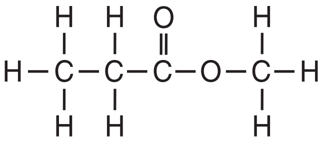


(4)

24 Which energy conversion occurs in an operating electrolytic cell?

(1) chemical energy to electrical energy
(2) electrical energy to chemical energy
(3) nuclear energy to thermal energy
(4) thermal energy to nuclear energy

25 Which compounds can be classified as electrolytes?

(1) alcohols
(2) alkynes
(3) organic acids
(4) saturated hydrocarbons

26 Potassium hydroxide is classified as an Arrhenius base because KOH contains

(1) OH^- ions
(2) O^{2-} ions
(3) K^+ ions
(4) H^+ ions

27 In which laboratory process is a volume of solution of known concentration used to determine the concentration of another solution?

(1) deposition
(2) distillation
(3) filtration
(4) titration

28 According to one acid-base theory, an acid is an

(1) H^+ acceptor
(2) H^+ donor
(3) OH^- acceptor
(4) OH^- donor

29 Energy is released during the fission of Pu-239 atoms as a result of the

(1) formation of covalent bonds
(2) formation of ionic bonds
(3) conversion of matter to energy
(4) conversion of energy to matter

30 Atoms of I-131 spontaneously decay when the

(1) stable nuclei emit alpha particles
(2) stable nuclei emit beta particles
(3) unstable nuclei emit alpha particles
(4) unstable nuclei emit beta particles

Part B–1

Answer all questions in this part.

Directions (31–50): For *each* statement or question, write in your answer booklet 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 *Reference Tables for Physical Setting/Chemistry*.

31 Compared to the atoms of nonmetals in Period 3, the atoms of metals in Period 3 have

(1) fewer valence electrons
(2) more valence electrons
(3) fewer electron shells
(4) more electron shells

32 Which elements are malleable and good conductors of electricity?

(1) iodine and silver
(2) iodine and xenon
(3) tin and silver
(4) tin and xenon

33 Which atom in the ground state requires the *least* amount of energy to remove its valence electron?

(1) lithium atom
(2) potassium atom
(3) rubidium atom
(4) sodium atom

34 What is the chemical formula of iron(III) sulfide?

(1) FeS
(2) Fe_2S_3
(3) $FeSO_3$
(4) $Fe_2(SO_3)_3$

35 What is the percent composition by mass of sulfur in the compound $MgSO_4$ (gram-formula mass = 120. grams per mole)?

(1) 20.%
(2) 27%
(3) 46%
(4) 53%

36 Which compound becomes *less* soluble in water as the temperature of the solution is increased?

(1) HCl
(2) KCl
(3) NaCl
(4) NH_4Cl

37 Given the balanced equation representing a reaction:

$$2H_2 + O_2 \rightarrow 2H_2O$$

What is the mass of H_2O produced when 10.0 grams of H_2 reacts completely with 80.0 grams of O_2?

(1) 70.0 g
(2) 90.0 g
(3) 180. g
(4) 800. g

38 Given two formulas representing the same compound:

Formula A	**Formula B**
CH_3	C_2H_6

Which statement describes these formulas?

(1) Formulas *A* and *B* are both empirical.
(2) Formulas *A* and *B* are both molecular.
(3) Formula *A* is empirical, and formula *B* is molecular.
(4) Formula *A* is molecular, and formula *B* is empirical.

39 Given the balanced equation representing a reaction:

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

Which type of reaction is represented by this equation?

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

40 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

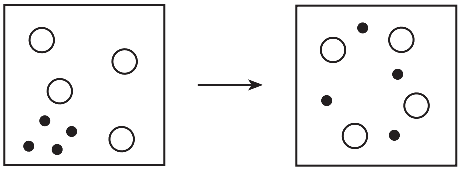
(1) both the air and the water to the cylinder
(2) both the cylinder and the air to the water
(3) the air to the water and from the water to the cylinder
(4) the cylinder to the water and from the water to the air

41 Which diagram represents a physical change, only?

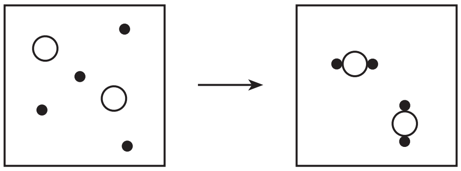
Key

● = an atom of an element

○ = an atom of a different element



(1)



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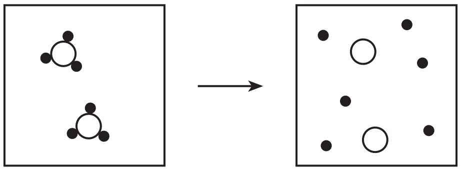

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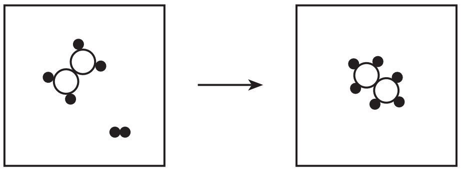


(4)

42 During a laboratory activity to investigate reaction rate, a student reacts 1.0-gram samples of solid zinc with 10.0-milliliter samples of HCl(aq). The table below shows information about the variables in five experiments the student performed.

Reaction of Zn(s) with HCl(aq)

Experiment	**Description of Zinc Sample**	**HCl(aq) Concentration** (M)	**Temperature** (K)
1	lumps	0.10	270.
2	powder	0.10	270.
3	lumps	0.10	290.
4	lumps	1.0	290.
5	powder	1.0	280.

Which two experiments can be used to investigate the effect of the concentration of HCl(aq) on the reaction rate?

(1) 1 and 3
(2) 1 and 5
(3) 4 and 2
(4) 4 and 3

43 Which temperature change would cause a sample of an ideal gas to double in volume while the pressure is held constant?

(1) from 400. K to 200. K
(2) from 200. K to 400. K
(3) from 400.°C to 200.°C
(4) from 200.°C to 400.°C

44 A 36-gram sample of water has an initial temperature of 22°C. After the sample absorbs 1200 joules of heat energy, the final temperature of the sample is

(1) 8.0°C
(2) 14°C
(3) 30.°C
(4) 55°C

45 Which statement explains why Br_2 is a liquid at STP and I_2 is a solid at STP?

(1) Molecules of Br_2 are polar, and molecules of I_2 are nonpolar.
(2) Molecules of I_2 are polar, and molecules of Br_2 are nonpolar.
(3) Molecules of Br_2 have stronger intermolecular forces than molecules of I_2.
(4) Molecules of I_2 have stronger intermolecular forces than molecules of Br_2.

46 Which balanced equation represents an oxidation-reduction reaction?

(1) $Ba(NO_3)_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaNO_3$
(2) $H_3PO_4 + 3KOH \rightarrow K_3PO_4 + 3H_2O$
(3) $Fe(s) + S(s) \rightarrow FeS(s)$
(4) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

47 Which solution reacts with LiOH(aq) to produce a salt and water?

(1) KCl(aq)
(2) CaO(aq)
(3) NaOH(aq)
(4) $H_2SO_4(aq)$

48 Which volume of 2.0 M NaOH(aq) is needed to completely neutralize 24 milliliters of 1.0 M HCl(aq)?

(1) 6.0 mL
(2) 12 mL
(3) 24 mL
(4) 48 mL

49 Which type of reaction releases the greatest amount of energy per mole of reactant?

(1) combustion
(2) decomposition
(3) nuclear fusion
(4) oxidation-reduction

50 Which balanced equation represents natural transmutation?

(1) ${}^{9}_{4}\text{Be} + {}^{1}_{1}\text{H} \rightarrow {}^{6}_{3}\text{Li} + {}^{4}_{2}\text{He}$
(2) ${}^{14}_{7}\text{N} + {}^{4}_{2}\text{He} \rightarrow {}^{17}_{8}\text{O} + {}^{1}_{1}\text{H}$
(3) ${}^{239}_{94}\text{Pu} + {}^{1}_{0}\text{n} \rightarrow {}^{144}_{58}\text{Ce} + {}^{94}_{36}\text{Kr} + 2{}^{1}_{0}\text{n}$
(4) ${}^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$

Part B–2

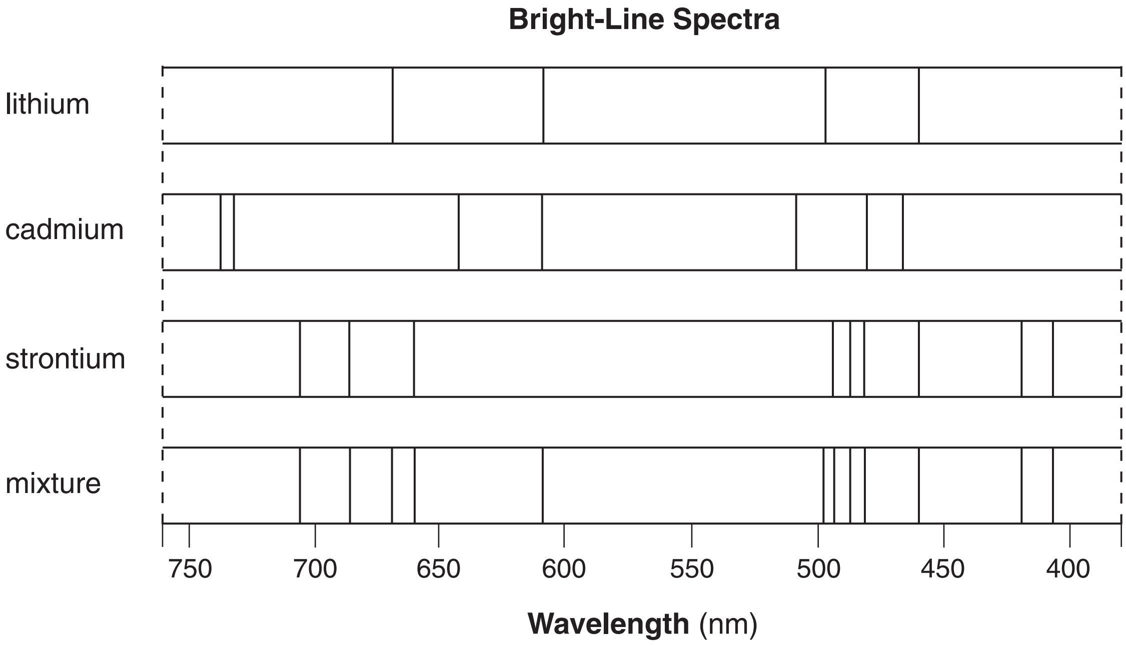
Answer all questions in this part.

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

51 Explain, in terms of protons and neutrons, why U-235 and U-238 are different isotopes of uranium. [1]

Base your answers to questions 52 through 54 on the information below.

The bright-line spectra for three elements and a mixture of elements are shown below.



52 Explain, in terms of *both* electrons and energy, how the bright-line spectrum of an element is produced. [1]

53 Identify *all* the elements in the mixture. [1]

54 State the total number of valence electrons in a cadmium atom in the ground state. [1]

Base your answers to questions 55 through 59 on the information below.

The ionic radii of some Group 2 elements are given in the table below.

Ionic Radii of Some Group 2 Elements

Symbol	**Atomic Number**	**Ionic Radius** (pm)
Be	4	44
Mg	12	66
Ca	20	99
Ba	56	134

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

56 On the same grid, plot the data from the data table. Circle and connect the points. [1]

57 Estimate the ionic radius of strontium. [1]

58 State the trend in ionic radius as the elements in Group 2 are considered in order of increasing atomic number. [1]

59 Explain, in terms of electrons, why the ionic radius of a Group 2 element is smaller than its atomic radius. [1]

Base your answers to questions 60 and 61 on the information below.

The balanced equation below represents the decomposition of potassium chlorate.

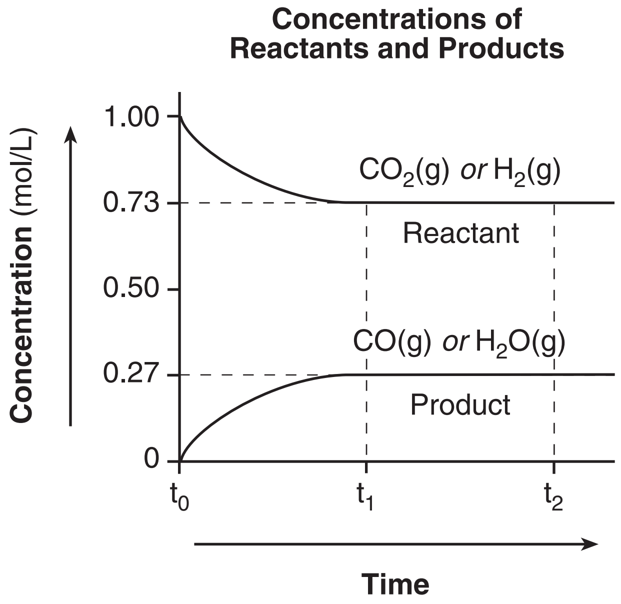
$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

60 Determine the oxidation number of chlorine in the reactant in the equation. [1]

61 State why the entropy of the reactant is less than the entropy of the products. [1]

Base your answers to questions 62 and 63 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.

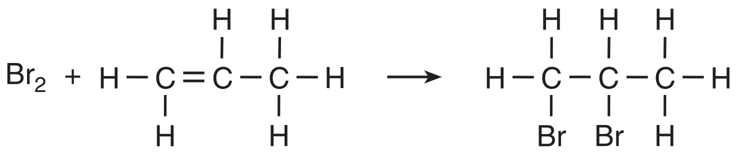


62 Determine the change in the concentration of $CO_2(g)$ between time t_0 and time t_1. [1]

63 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? [1]

Base your answers to questions 64 and 65 on the information below.

A reaction between bromine and a hydrocarbon is represented by the balanced equation below.



$$Br_2 + H{-}CH{=}CH{-}CH_2{-}H \longrightarrow H{-}CHBr{-}CHBr{-}CH_2{-}H$$

64 Identify the type of organic reaction. [1]

65 Write the name of the homologous series to which the hydrocarbon belongs. [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 *Reference Tables for Physical Setting/Chemistry*.

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

Ozone, $O_3(g)$, is produced from oxygen, $O_2(g)$, by electrical discharge during thunderstorms. The unbalanced equation below represents the reaction that forms ozone.

$$O_2(g) \xrightarrow{\text{electricity}} O_3(g)$$

66 Balance the equation *in your answer booklet* for the production of ozone, using the smallest whole-number coefficients. [1]

67 Identify the type of bonding between the atoms in an oxygen molecule. [1]

68 Explain, in terms of electron configuration, why an oxygen molecule is more stable than an oxygen atom. [1]

Base your answers to questions 69 and 70 on the information below.

Natural gas is a mixture that includes butane, ethane, methane, and propane. Differences in boiling points can be used to separate the components of natural gas. The boiling points at standard pressure for these components are listed in the table below.

Data Table

Component of Natural Gas	Boiling Point at Standard Pressure (°C)
butane	–0.5
ethane	–88.6
methane	–161.6
propane	–42.1

69 Identify a process used to separate the components of natural gas. [1]

70 List the *four* components of natural gas in order of increasing strength of intermolecular forces. [1]

Base your answers to questions 71 through 73 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.

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

71 Write the chemical formula for *one* compound in the equation that contains *both* ionic bonds and covalent bonds. [1]

72 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. [1]

73 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for the reactant containing nitrogen in the equation. [1]

Base your answers to questions 74 through 76 on the information below.

A student prepared two mixtures, each in a labeled beaker. Enough water at 20.°C was used to make 100 milliliters of each mixture.

Information about Two Mixtures at 20.°C

	Mixture 1	**Mixture 2**
Composition	NaCl in H_2O	Fe filings in H_2O
Student Observations	• colorless liquid • no visible solid on bottom of beaker	• colorless liquid • black solid on bottom of beaker
Other Data	• mass of NaCl(s) dissolved = 2.9 g	• mass of Fe(s) = 15.9 g • density of Fe(s) = 7.87 g/cm^3

74 Classify *each* mixture using the term “homogeneous” or the term “heterogeneous.” [1]

75 Determine the volume of the Fe filings used to produce mixture 2. [1]

76 Describe a procedure to physically remove the water from mixture 1. [1]

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

A student performed a laboratory activity to observe the reaction between aluminum foil and an aqueous copper(II) chloride solution. The reaction is represented by the balanced equation below.

$$2Al(s) + 3CuCl_2(aq) \rightarrow 3Cu(s) + 2AlCl_3(aq) + \text{energy}$$

The procedures and corresponding observations for the activities are given below.

Procedure	**Observation**
In a beaker, completely dissolve 5.00 g of $CuCl_2$ in 80.0 mL of H_2O.	• The solution is blue green.
Cut 1.5 g of Al(s) foil into small pieces. Add all the foil to the mixture in the beaker. Stir the contents for 1 minute.	• The surface of Al(s) foil appears partially black. • The beaker feels warm to the touch.
Observe the beaker and contents after 10 minutes.	• The liquid in the beaker appears colorless. • A reddish-brown solid is seen at the bottom of the beaker. • Some pieces of Al(s) with a partially black coating remain in the beaker.

77 State *one* observation that indicates Cu^{2+} ions became Cu atoms. [1]

78 Describe *one* change in the procedure that would cause the reaction to occur at a faster rate. [1]

79 State *one* safety procedure the student should perform after completing the laboratory activity. [1]

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

Some carbonated beverages are made by forcing carbon dioxide gas into a beverage solution. When a bottle of one kind of carbonated beverage is first opened, the beverage has a pH value of 3.

80 State, in terms of the pH scale, why this beverage is classified as acidic. [1]

81 Using Table *M*, identify *one* indicator that is yellow in a solution that has the same pH value as this beverage. [1]

82 After the beverage bottle is left open for several hours, the hydronium ion concentration in the beverage solution decreases to $\frac{1}{1000}$ of the original concentration. Determine the new pH of the beverage solution. [1]

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

Polonium-210 occurs naturally, but is scarce. Polonium-210 is primarily used in devices designed to eliminate static electricity in machinery. It is also used in brushes to remove dust from camera lenses.

Polonium-210 can be created in the laboratory by bombarding bismuth-209 with neutrons to create bismuth-210. The bismuth-210 undergoes beta decay to produce polonium-210. Polonium-210 has a half-life of 138 days and undergoes alpha decay.

83 State *one* beneficial use of Po-210. [1]

84 Complete the nuclear equation *in your answer booklet* for the decay of Po-210, by writing a notation for the missing product. [1]

85 Determine the total mass of an original 28.0-milligram sample of Po-210 that remains unchanged after 414 days. [1]

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