

Large-Type Edition

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING CHEMISTRY

Tuesday, June 25, 2019 — 9:15 a.m. to 12:15 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 START THIS EXAMINATION UNTIL THE SIGNAL IS GIVEN.

Part A

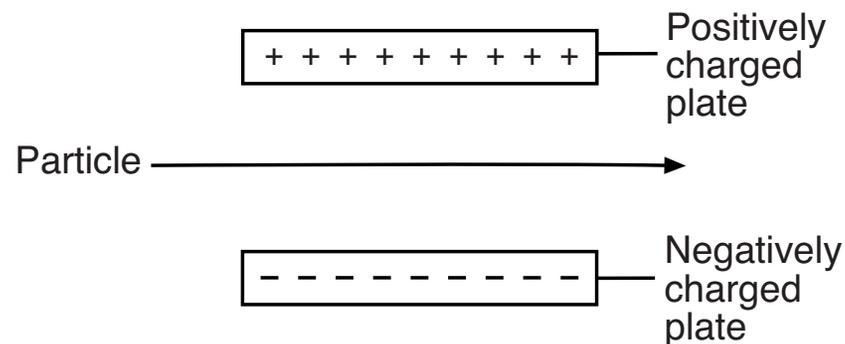
Answer all questions in this part.

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 are found in the nucleus of an argon atom?

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

2 The diagram below represents a particle traveling through an electric field.



An electric field exists between the two plates.

Which particle remains undeflected when passing through this electric field?

- (1) proton
- (2) electron
- (3) neutron
- (4) positron

- 3 The mass of an electron is
- (1) equal to the mass of a proton
 - (2) equal to the mass of a neutron
 - (3) greater than the mass of a proton
 - (4) less than the mass of a neutron
- 4 Compared to the energy of an electron in the second shell of an atom of sulfur, the energy of an electron in the
- (1) first shell is lower
 - (2) first shell is the same
 - (3) third shell is lower
 - (4) third shell is the same
- 5 In the ground state, an atom of which element has seven valence electrons?
- | | |
|----------------|--------------|
| (1) sodium | (3) nitrogen |
| (2) phosphorus | (4) fluorine |
- 6 Which information is sufficient to differentiate a sample of sodium from a sample of silver?
- (1) the mass of each sample
 - (2) the volume of each sample
 - (3) the reactivity of each sample with water
 - (4) the phase of each sample at room temperature
- 7 Graphite and diamond are two forms of solid carbon at STP. These forms have
- (1) different molecular structures and different properties
 - (2) different molecular structures and the same properties
 - (3) the same molecular structures and different properties
 - (4) the same molecular structures and the same properties
- 8 As the first five elements in Group 14 are considered in order from top to bottom, there are changes in both the
- (1) number of valence shell electrons and number of first shell electrons
 - (2) electronegativity values and number of first shell electrons
 - (3) number of valence shell electrons and atomic radii
 - (4) electronegativity values and atomic radii

- 9 Which statement explains why NaBr is classified as a compound?
- (1) Na and Br are chemically combined in a fixed proportion.
 - (2) Na and Br are both nonmetals.
 - (3) NaBr is a solid at 298 K and standard pressure.
 - (4) NaBr dissolves in H₂O at 298 K.
- 10 Which two terms represent types of chemical formulas?
- (1) fission and fusion
 - (2) oxidation and reduction
 - (3) empirical and structural
 - (4) endothermic and exothermic
- 11 During all chemical reactions, charge, mass and energy are
- (1) condensed
 - (2) conserved
 - (3) decayed
 - (4) decomposed
- 12 The degree of polarity of a covalent bond between two atoms is determined by calculating the difference in their
- (1) atomic radii
 - (2) melting points
 - (3) electronegativities
 - (4) ionization energies
- 13 Which substance can *not* be broken down by a chemical change?
- (1) ammonia
 - (2) magnesium
 - (3) methane
 - (4) water
- 14 Which statement describes the components of a mixture?
- (1) Each component gains new properties.
 - (2) Each component loses its original properties.
 - (3) The proportions of components can vary.
 - (4) The proportions of components cannot vary.
- 15 Table sugar can be separated from a mixture of table sugar and sand at STP by adding
- (1) sand, stirring, and distilling at 100.°C
 - (2) sand, stirring, and filtering
 - (3) water, stirring, and distilling at 100.°C
 - (4) water, stirring, and filtering

- 16 Which statement describes the particles of an ideal gas, based on the kinetic molecular theory?
- (1) The volume of the particles is considered negligible.
 - (2) The force of attraction between the particles is strong.
 - (3) The particles are closely packed in a regular, repeating pattern.
 - (4) The particles are separated by small distances, relative to their size.
- 17 During which two processes does a substance release energy?
- (1) freezing and condensation
 - (2) freezing and melting
 - (3) evaporation and condensation
 - (4) evaporation and melting
- 18 Based on Table *I*, which compound dissolves in water by an exothermic process?
- | | |
|----------|------------------------------|
| (1) NaCl | (3) NH_4Cl |
| (2) NaOH | (4) NH_4NO_3 |
- 19 At STP, which property of a molecular substance is determined by the arrangement of its molecules?
- (1) half-life
 - (2) molar mass
 - (3) physical state
 - (4) percent composition
- 20 Equilibrium can be reached by
- (1) physical changes, only
 - (2) nuclear changes, only
 - (3) both physical changes and chemical changes
 - (4) both nuclear changes and chemical changes
- 21 Which value is defined as the difference between the potential energy of the products and the potential energy of the reactants during a chemical change?
- (1) heat of fusion
 - (2) heat of reaction
 - (3) heat of deposition
 - (4) heat of vaporization

22 The effect of a catalyst on a chemical reaction is to provide a new reaction pathway that results in a different

- (1) potential energy of the products
- (2) heat of reaction
- (3) potential energy of the reactants
- (4) activation energy

23 Chemical systems in nature tend to undergo changes toward

- (1) lower energy and lower entropy
- (2) lower energy and higher entropy
- (3) higher energy and lower entropy
- (4) higher energy and higher entropy

24 The atoms of which element bond to one another in chains, rings, and networks?

- (1) barium
- (2) carbon
- (3) iodine
- (4) mercury

25 What is the general formula for the homologous series that includes ethene?

- (1) C_nH_{2n}
- (2) C_nH_{2n-6}
- (3) C_nH_{2n-2}
- (4) C_nH_{2n+2}

26 When an F atom becomes an F^- ion, the F atom

- (1) gains a proton
- (2) loses a proton
- (3) gains an electron
- (4) loses an electron

27 Which substance is an Arrhenius base?

- (1) HNO_3
- (2) H_2SO_3
- (3) $Ca(OH)_2$
- (4) CH_3COOH

28 In which type of nuclear reaction do two light nuclei combine to produce a heavier nucleus?

- (1) positron emission
- (2) gamma emission
- (3) fission
- (4) fusion

- 29 Using equal masses of reactants, which statement describes the relative amounts of energy released during a chemical reaction and a nuclear reaction?
- (1) The chemical and nuclear reactions release equal amounts of energy.
 - (2) The nuclear reaction releases half the amount of energy of the chemical reaction.
 - (3) The chemical reaction releases more energy than the nuclear reaction.
 - (4) The nuclear reaction releases more energy than the chemical reaction.

- 30 The ratio of the mass of U-238 to the mass of Pb-206 can be used to
- (1) diagnose thyroid disorders
 - (2) diagnose kidney function
 - (3) date geological formations
 - (4) date once-living things

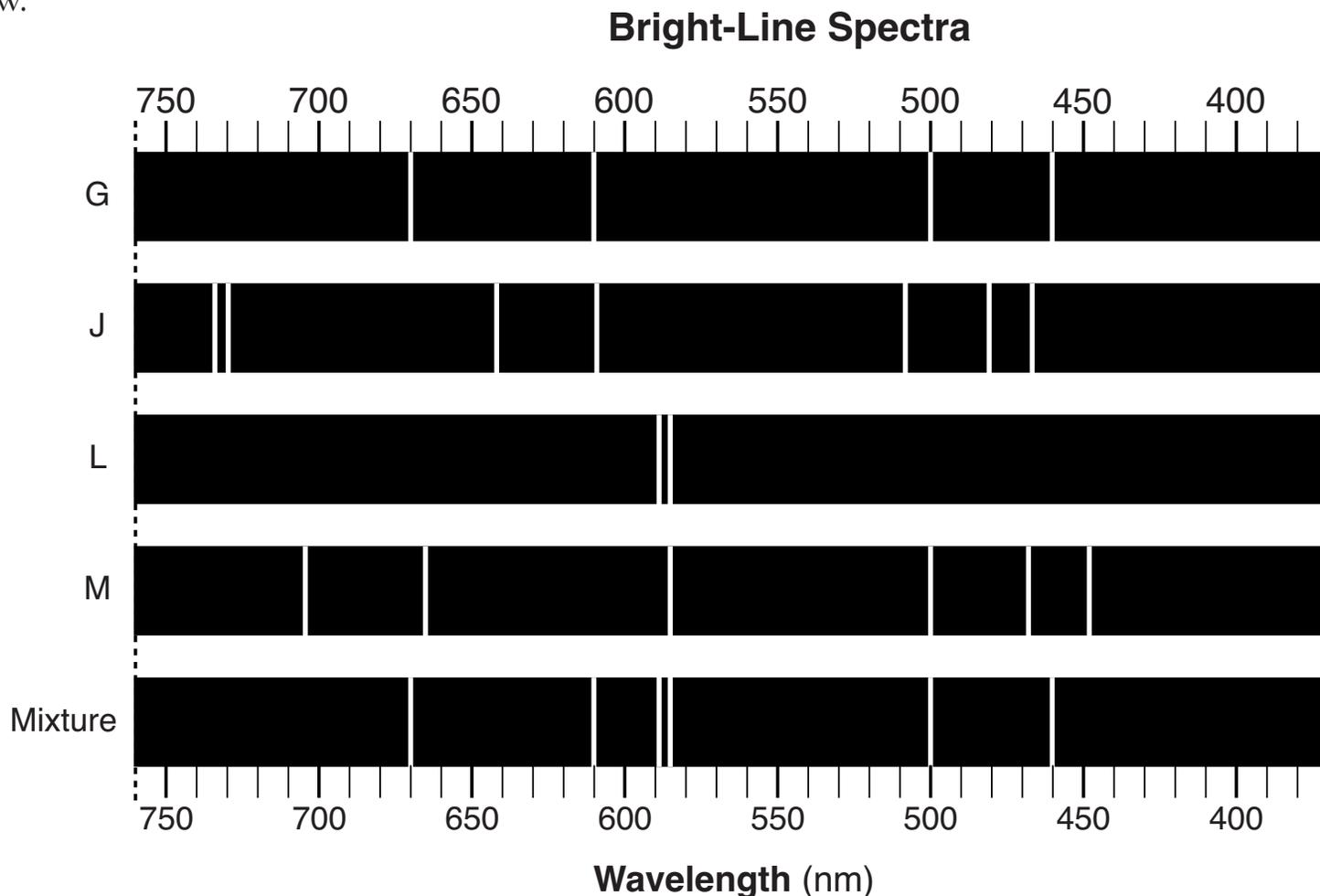
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Part B-1

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 The bright-line spectra of four elements, *G*, *J*, *L*, and *M*, and a mixture of *at least two* of these elements is given below.



Question 31 continued

Which elements are present in the mixture?

- (1) *G* and *J*
- (2) *G* and *L*
- (3) *M*, *J*, and *G*
- (4) *M*, *J*, and *L*

32 Which electron configuration represents an atom of chlorine in an excited state?

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

33 A student measures the mass and volume of a sample of aluminum at room temperature, and calculates the density of Al to be 2.85 grams per cubic centimeter. Based on Table S, what is the percent error for the student's calculated density of Al?

- (1) 2.7%
- (2) 5.3%
- (3) 5.6%
- (4) 95%

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34 Magnesium and calcium have similar chemical properties because their atoms in the ground state have

- (1) equal numbers of protons and electrons
- (2) equal numbers of protons and neutrons
- (3) two electrons in the first shell
- (4) two electrons in the outermost shell

35 As the elements in Period 2 of the Periodic Table are considered in order from left to right, which property generally *decreases*?

- (1) atomic radius
- (2) electronegativity
- (3) ionization energy
- (4) nuclear charge

36 Given the balanced equation for the reaction of butane and oxygen:



How many moles of carbon dioxide are produced when 5.0 moles of butane react completely?

- (1) 5.0 mol
- (2) 10. mol
- (3) 20. mol
- (4) 40. mol

37 What is the percent composition by mass of nitrogen in the compound N_2H_4 (gram-formula mass = 32 g/mol)?

- (1) 13%
- (2) 44%
- (3) 88%
- (4) 93%

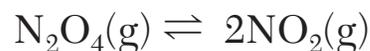
38 Which ion in the ground state has the same electron configuration as an atom of neon in the ground state?

- (1) Ca^{2+}
- (2) Cl^-
- (3) Li^+
- (4) O^{2-}

42 Which sample of HCl(aq) reacts at the fastest rate with a 1.0-gram sample of iron filings?

- (1) 10. mL of 1 M HCl(aq) at 10.°C
- (2) 10. mL of 1 M HCl(aq) at 25°C
- (3) 10. mL of 3 M HCl(aq) at 10.°C
- (4) 10. mL of 3 M HCl(aq) at 25°C

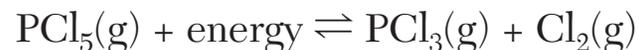
43 Given the equation representing a system at equilibrium:



Which statement describes the concentration of the two gases in this system?

- (1) The concentration of $\text{N}_2\text{O}_4(\text{g})$ must be less than the concentration of $\text{NO}_2(\text{g})$.
- (2) The concentration of $\text{N}_2\text{O}_4(\text{g})$ must be greater than the concentration of $\text{NO}_2(\text{g})$.
- (3) The concentration of $\text{N}_2\text{O}_4(\text{g})$ and the concentration of $\text{NO}_2(\text{g})$ must be equal.
- (4) The concentration of $\text{N}_2\text{O}_4(\text{g})$ and the concentration of $\text{NO}_2(\text{g})$ must be constant.

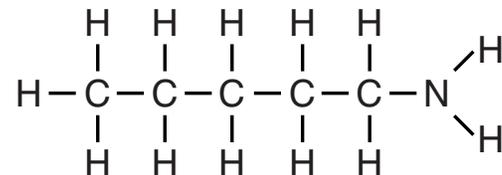
44 Given the equation representing a system at equilibrium:



Which change will cause the equilibrium to shift to the right?

- (1) adding a catalyst
- (2) adding more $\text{PCl}_3(\text{g})$
- (3) increasing the pressure
- (4) increasing the temperature

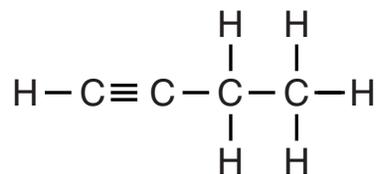
45 Given the formula representing a molecule:



A chemical name for this compound is

- (1) pentanone
- (2) 1-pentanol
- (3) 1-pentanamine
- (4) pentanamide

46 Given the formula of a compound:



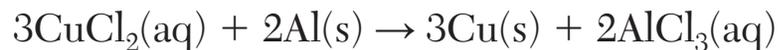
This compound is classified as an

- (1) aldehyde (3) alkyne
(2) alkene (4) alcohol

47 Which equation represents fermentation?

- (1) $\text{C}_2\text{H}_4 + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{OH}$
(2) $\text{C}_2\text{H}_4 + \text{HCl} \rightarrow \text{CH}_3\text{CH}_2\text{Cl}$
(3) $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{CH}_3\text{CH}_2\text{OH} + 2\text{CO}_2$
(4) $2\text{CH}_3\text{CHO} \rightarrow \text{C}_3\text{H}_5\text{CHO} + \text{H}_2\text{O}$

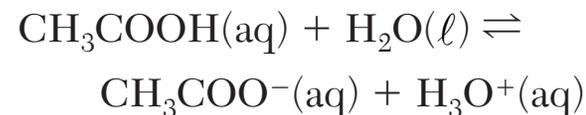
48 Given the equation representing a reaction:



The oxidation number of copper changes from

- (1) +1 to 0 (3) +2 to +1
(2) +2 to 0 (4) +6 to +3

49 Given the equation representing a reversible reaction:



According to one acid-base theory, the two H^+ donors in the equation are

- (1) CH_3COOH and H_2O
(2) CH_3COOH and H_3O^+
(3) CH_3COO^- and H_2O
(4) CH_3COO^- and H_3O^+

50 Which nuclear equation represents a spontaneous decay?

- (1) ${}_{86}^{222}\text{Rn} \rightarrow {}_{84}^{218}\text{Po} + {}_2^4\text{He}$
(2) ${}_{13}^{27}\text{Al} + {}_2^4\text{He} \rightarrow {}_{15}^{30}\text{P} + {}_0^1\text{n}$
(3) ${}_{92}^{235}\text{U} + {}_0^1\text{n} \rightarrow {}_{56}^{139}\text{Ba} + {}_{36}^{94}\text{Kr} + 3{}_0^1\text{n}$
(4) ${}_{3}^7\text{Li} + {}_1^1\text{H} \rightarrow {}_2^4\text{He} + {}_2^4\text{He}$

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 *2011 Edition Reference Tables for Physical Setting/Chemistry*.

51 Draw a structural formula for methanal. [1]

Base your answers to questions 52 through 54 on the information below and on the next page, and on your knowledge of chemistry.

The atomic mass and natural abundance of the naturally occurring isotopes of hydrogen are shown in the table below.

Naturally Occuring Isotopes of Hydrogen

Isotope	Common Name of Isotope	Atomic Mass (u)	Natural Abundance (%)
H-1	protium	1.0078	99.9885
H-2	deuterium	2.0141	0.0115
H-3	tritium	3.0160	negligible

The isotope H-2, also called deuterium, is usually represented by the symbol “D.” Heavy water forms when deuterium reacts with oxygen, producing molecules of D_2O .

52 Explain, in terms of subatomic particles, why atoms of H-1, H-2, and H-3 are each electrically neutral. [1]

53 Determine the formula mass of heavy water, D_2O . [1]

54 Based on Table *N*, identify the decay mode of tritium. [1]

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Base your answers to questions 55 through 57 on the information below and on your knowledge of chemistry.

At 23°C, 85.0 grams of $\text{NaNO}_3(\text{s})$ are dissolved in 100. grams of $\text{H}_2\text{O}(\ell)$.

- 55 Convert the temperature of the $\text{NaNO}_3(\text{s})$ to kelvins. [1]
- 56 Based on Table G, determine the additional mass of $\text{NaNO}_3(\text{s})$ that must be dissolved to saturate the solution at 23°C. [1]
- 57 State what happens to the boiling point and freezing point of the solution when the solution is diluted with an additional 100. grams of $\text{H}_2\text{O}(\ell)$. [1]
-

Base your answers to questions 58 through 61 on the information below and on your knowledge of chemistry.

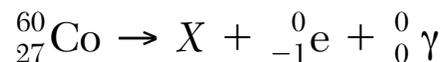
A 200.-milliliter sample of $\text{CO}_2(\text{g})$ is placed in a sealed, rigid cylinder with a movable piston at 296 K and 101.3 kPa.

- 58 State a change in temperature and a change in pressure of the $\text{CO}_2(\text{g})$ that would cause it to behave more like an ideal gas. [1]
- 59 Determine the volume of the sample of $\text{CO}_2(\text{g})$ if the temperature and pressure are changed to 336 K and 152.0 kPa. [1]
- 60 State, in terms of *both* the frequency and force of collisions, what would result from decreasing the temperature of the original sample of $\text{CO}_2(\text{g})$, at constant volume. [1]
- 61 Compare the mass of the original 200.-milliliter sample of $\text{CO}_2(\text{g})$ to the mass of the $\text{CO}_2(\text{g})$ sample when the cylinder is adjusted to a volume of 100. milliliters. [1]
-

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Base your answers to questions 62 through 65 on the information below and on your knowledge of chemistry.

Cobalt-60 is an artificial isotope of Co-59. The incomplete equation for the decay of cobalt-60, including beta and gamma emissions, is shown below.



- 62 Explain, in terms of *both* protons and neutrons, why Co-59 and Co-60 are isotopes of cobalt. [1]
- 63 Compare the penetrating power of the beta and gamma emissions. [1]
- 64 Complete the nuclear equation, *in your answer booklet*, for the decay of cobalt-60 by writing a notation for the missing product. [1]
- 65 Based on Table N, determine the total time required for an 80.00-gram sample of cobalt-60 to decay until only 10.00 grams of the sample remain unchanged. [1]
-

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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 and on your knowledge of chemistry.

During a laboratory activity, appropriate safety equipment was used and safety procedures were followed. A laboratory technician heated a sample of solid KClO_3 in a crucible to determine the percent composition by mass of oxygen in the compound. The unbalanced equation and the data for the decomposition of solid KClO_3 are shown below.



Lab Data and Calculated Results

Object or Material	Mass (g)
empty crucible and cover	22.14
empty crucible, cover, and KClO_3	24.21
KClO_3	2.07
crucible, cover, and KCl after heating	23.41
KCl	?
O_2	0.80

- 66 Write a chemical name for the compound that decomposed. [1]
- 67 Based on the lab data, show a numerical setup to determine the number of moles of O_2 produced. Use 32 g/mol as the gram-formula mass of O_2 . [1]
- 68 Based on the lab data, determine the mass of KCl produced in the reaction. [1]
- 69 Balance the equation *in your answer booklet* for the decomposition of $KClO_3$, using the smallest whole-number coefficients. [1]
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Base your answers to questions 70 through 73 on the information below and on your knowledge of chemistry.

A bottled water label lists the ions dissolved in the water. The table below lists the mass of some ions dissolved in a 500.-gram sample of the bottled water.

Ions in 500. g of Bottled Water

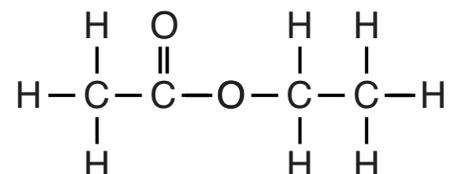
Ion Formula	Mass (g)
Ca^{2+}	0.040
Mg^{2+}	0.013
Na^{+}	0.0033
SO_4^{2-}	0.0063
HCO_3^{-}	0.180

- 70 State the number of significant figures used to express the mass of hydrogen carbonate ions in the table above. [1]
- 71 Based on Table *F*, write the formula of the ion in the bottled water table that would form the *least* soluble compound when combined with the sulfate ion. [1]
- 72 Show a numerical setup for calculating the parts per million of the Na^+ ions in the 500.-gram sample of the bottled water. [1]
- 73 Compare the radius of a Mg^{2+} ion to the radius of a Mg atom. [1]
-

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Base your answers to questions 74 through 77 on the information below and on your knowledge of chemistry.

Ethyl ethanoate is used as a solvent for varnishes and in the manufacture of artificial leather. The formula below represents a molecule of ethyl ethanoate.

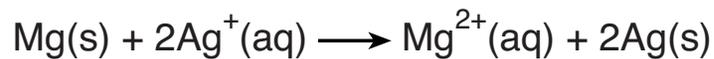
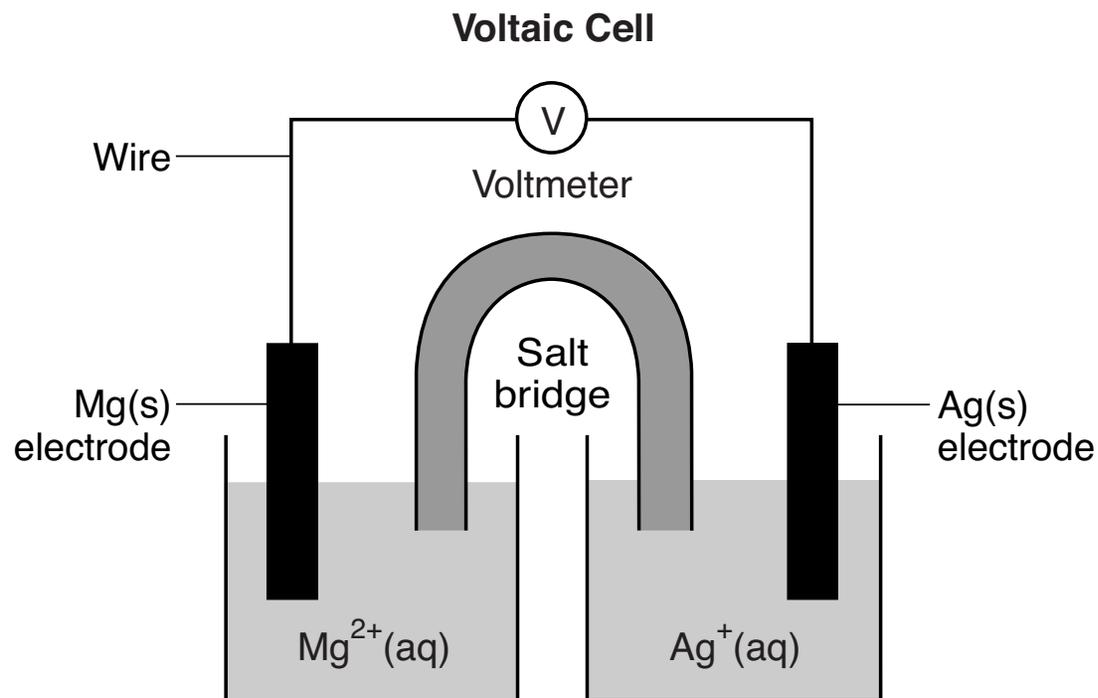


- 74 Identify the element in ethyl ethanoate that makes it an organic compound. [1]
- 75 Write the empirical formula for this compound. [1]
- 76 Write the name of the class of organic compounds to which this compound belongs. [1]
- 77 Determine the number of electrons shared in the bond between a hydrogen atom and a carbon atom in the molecule. [1]
-

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Base your answers to questions 78 through 80 on the information below and on your knowledge of chemistry.

An operating voltaic cell has magnesium and silver electrodes. The cell and the ionic equation representing the reaction that occurs in the cell are shown below.



- 78 State the purpose of the salt bridge in this cell. [1]
- 79 Write a balanced equation for the half-reaction that occurs at the magnesium electrode in this cell. [1]
- 80 Explain, in terms of electrical energy, how electrolysis reactions differ from voltaic cell reactions. [1]
-

Base your answers to questions 81 through 85 on the information below and on your knowledge of chemistry.

In a laboratory investigation, an $\text{HCl}(\text{aq})$ solution with a pH value of 2 is used to determine the molarity of a $\text{KOH}(\text{aq})$ solution. A 7.5-milliliter sample of the $\text{KOH}(\text{aq})$ is exactly neutralized by 15.0 milliliters of the 0.010 M $\text{HCl}(\text{aq})$. During this laboratory activity, appropriate safety equipment is used and safety procedures are followed.

- 81 Determine the pH value of a solution that is ten times *less* acidic than the $\text{HCl}(\text{aq})$ solution. [1]
- 82 State the color of the indicator bromcresol green if it is added to a sample of the $\text{KOH}(\text{aq})$ solution. [1]
- 83 Complete the equation *in your answer booklet* by writing the chemical formula for *each* product. [1]
- 84 Show a numerical setup for calculating the molarity of the KOH solution. [1]
- 85 Explain, in terms of aqueous ions, why 15.0 mL of a 1.0 M $\text{HCl}(\text{aq})$ solution is a better conductor of electricity than 15.0 mL of a 0.010 M $\text{HCl}(\text{aq})$ solution. [1]
-

