

The University of the State of New York
REGENTS HIGH SCHOOL EXAMINATION

**PHYSICAL SETTING
CHEMISTRY**

Wednesday, August 16, 2017 — 8:30 to 11:30 a.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*.

- Which phrase describes an Al atom?
 - a negatively charged nucleus, surrounded by negatively charged electrons
 - a negatively charged nucleus, surrounded by positively charged electrons
 - a positively charged nucleus, surrounded by negatively charged electrons
 - a positively charged nucleus, surrounded by positively charged electrons
- What is the number of electrons in an atom that has 20 protons and 17 neutrons?
 - 37
 - 20
 - 3
 - 17
- The mass of a proton is approximately equal to the mass of
 - an electron
 - a neutron
 - an alpha particle
 - a beta particle
- When a sample of $\text{CO}_2(\text{s})$ becomes $\text{CO}_2(\text{g})$, there is a change in
 - bond type
 - gram-formula mass
 - molecular polarity
 - particle arrangement
- Which properties are characteristic of Group 2 elements at STP?
 - good electrical conductivity and electronegativities less than 1.7
 - good electrical conductivity and electronegativities greater than 1.7
 - poor electrical conductivity and electronegativities less than 1.7
 - poor electrical conductivity and electronegativities greater than 1.7
- Compared to an atom of C-12, an atom of C-14 has a greater
 - number of electrons
 - number of protons
 - atomic number
 - mass number
- Elements that have atoms with stable valence electron configurations in the ground state are found in
 - Group 1
 - Group 8
 - Group 11
 - Group 18
- A magnesium atom that loses two electrons becomes a
 - positive ion with a smaller radius
 - negative ion with a smaller radius
 - positive ion with a larger radius
 - negative ion with a larger radius
- An atom of which element has the strongest attraction for the electrons in a bond?
 - aluminum
 - carbon
 - chlorine
 - lithium
- Which type of matter can *not* be broken down into simpler substances by a chemical change?
 - an element
 - a solution
 - a mixture
 - a compound
- According to Table *F*, which substance is most soluble in water?
 - AgCl
 - CaCO₃
 - Na₂CO₃
 - SrSO₄

12 Given the equation representing a reaction:



Which statement describes the energy change in 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.

13 Which sample of matter is a mixture?

- | | |
|-------------|---------------|
| (1) air | (3) manganese |
| (2) ammonia | (4) water |

14 Paper chromatography can separate the components of a mixture of colored dyes because the components have differences in

- (1) decay mode
- (2) thermal conductivity
- (3) ionization energy
- (4) molecular polarity

15 At standard pressure, the boiling point of an unsaturated $\text{NaNO}_3(\text{aq})$ solution increases when

- (1) the solution is diluted with water
- (2) some of the $\text{NaNO}_3(\text{aq})$ solution is removed
- (3) the solution is stirred
- (4) more $\text{NaNO}_3(\text{s})$ is dissolved in the solution

16 Which term identifies a form of energy?

- | | |
|----------------|------------------|
| (1) combustion | (3) thermal |
| (2) exothermic | (4) electrolytic |

17 According to kinetic molecular theory, which statement describes one characteristic of an ideal gas system?

- (1) The distance between gas molecules is smaller than the diameter of one gas molecule.
- (2) The attractive force between two gas molecules is strong.
- (3) The energy of the system decreases as gas molecules collide.
- (4) The straight-line motion of the gas molecules is constant and random.

18 The temperature of a substance is a measure of the

- (1) average kinetic energy of its particles
- (2) average potential energy of its particles
- (3) ionization energy of its particles
- (4) activation energy of its particles

19 A real gas behaves most like an ideal gas at

- (1) low pressure and high temperature
- (2) low pressure and low temperature
- (3) high pressure and high temperature
- (4) high pressure and low temperature

20 A reaction is most likely to occur when the colliding particles have proper orientation and

- | | |
|------------|---------------|
| (1) mass | (3) half-life |
| (2) volume | (4) energy |

21 At STP, a 12.0-liter sample of $\text{CH}_4(\text{g})$ has the same total number of molecules as

- (1) 6.0 L of $\text{H}_2(\text{g})$ at STP
- (2) 12.0 L of $\text{CO}_2(\text{g})$ at STP
- (3) 18.0 L of $\text{HCl}(\text{g})$ at STP
- (4) 24.0 L of $\text{O}_2(\text{g})$ at STP

22 At standard pressure, during which physical change does the potential energy decrease?

- | | |
|---------------------|---------------------|
| (1) liquid to gas | (3) solid to gas |
| (2) liquid to solid | (4) solid to liquid |

23 Which equation represents a chemical equilibrium?

- (1) $\text{N}_2(\ell) \rightleftharpoons \text{N}_2(\text{g})$
- (2) $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$
- (3) $\text{CO}_2(\text{s}) \rightleftharpoons \text{CO}_2(\text{g})$
- (4) $\text{NH}_3(\ell) \rightleftharpoons \text{NH}_3(\text{g})$

24 The amount of randomness of the atoms in a system is an indication of the

- (1) entropy of the system
- (2) polarity of the system
- (3) excited state of the atoms
- (4) ground state of the atoms

- 25 When a sample of Ca(s) loses 1 mole of electrons in a reaction with a sample of $\text{O}_2(\text{g})$, the oxygen
- (1) loses 1 mole of electrons
 - (2) loses 2 moles of electrons
 - (3) gains 1 mole of electrons
 - (4) gains 2 moles of electrons
- 26 Which reaction occurs at the anode of an electrochemical cell?
- (1) oxidation
 - (2) reduction
 - (3) neutralization
 - (4) transmutation
- 27 Which substance is an electrolyte?
- (1) CCl_4
 - (2) $\text{C}_6\text{H}_{12}\text{O}_6$
 - (3) SiO_2
 - (4) H_2SO_4
- 28 In which process does a heavy nucleus split into two lighter nuclei?
- (1) titration
 - (2) fission
 - (3) electrolysis
 - (4) neutralization
- 29 Which process converts mass into energy?
- (1) distillation of ethanol
 - (2) filtration of a mixture
 - (3) fusion of hydrogen atoms
 - (4) ionization of cesium atoms
- 30 Which radioisotope is used to determine the age of once-living organisms?
- (1) carbon-14
 - (2) cobalt-60
 - (3) iodine-131
 - (4) uranium-238
-

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 the electrons in an atom of calcium in an excited state?

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

32 The table below gives the atomic mass and the abundance of the two naturally occurring isotopes of bromine.

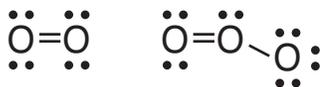
Naturally Occurring Isotopes of Bromine

Isotopes	Atomic Mass (u)	Natural Abundance (%)
Br-79	78.92	50.69
Br-81	80.92	49.31

Which numerical setup can be used to calculate the atomic mass of the element bromine?

- (1) $(78.92 \text{ u})(50.69) + (80.92 \text{ u})(49.31)$
 (2) $(78.92 \text{ u})(49.31) + (80.92 \text{ u})(50.69)$
 (3) $(78.92 \text{ u})(0.5069) + (80.92 \text{ u})(0.4931)$
 (4) $(78.92 \text{ u})(0.4931) + (80.92 \text{ u})(0.5069)$

33 Given the formulas of two substances:



These diagrams represent substances that have

- (1) the same molecular structure and the same physical properties
 (2) the same molecular structure and different physical properties
 (3) different molecular structures and the same physical properties
 (4) different molecular structures and different physical properties

34 What is the chemical formula of titanium(II) oxide?

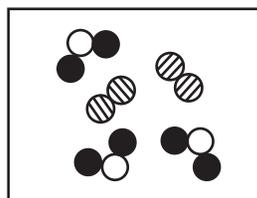
- (1) TiO (3) TiO₂
 (2) Ti₂O (4) Ti₂O₃

35 Which equation shows conservation of mass and energy for a reaction at 101.3 kPa and 298 K?

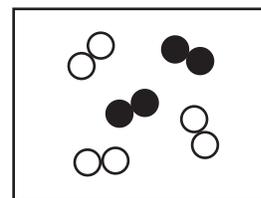
- (1) $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g}) + 483.6 \text{ kJ}$
 (2) $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\ell) + 285.8 \text{ kJ}$
 (3) $\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) + 483.6 \text{ kJ}$
 (4) $\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\ell) + 285.8 \text{ kJ}$

36 Which two particle diagrams each represent a sample of one substance?

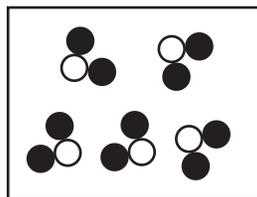
Key
○ = atom of oxygen
● = atom of hydrogen
⊖ = atom of chlorine



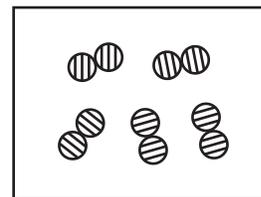
I



III



II



IV

- (1) I and II (3) II and III
 (2) I and III (4) II and IV

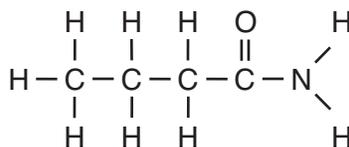
Part B-2

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*.

Base your answers to questions 51 and 52 on the information below and on your knowledge of chemistry.

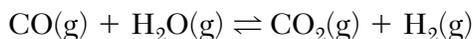
The formula below represents a molecule of butanamide.



- 51 State the type of chemical bond between a hydrogen atom and the nitrogen atom in the molecule. [1]
- 52 Explain, in terms of charge distribution, why a molecule of butanamide is polar. [1]
-

Base your answers to questions 53 and 54 on the information below and on your knowledge of chemistry.

An equilibrium system in a sealed, rigid container is represented by the equation below.



- 53 Compare the rate of the forward reaction to the rate of the reverse reaction at equilibrium. [1]
- 54 State the effect on the concentrations of $\text{H}_2\text{O(g)}$ and $\text{CO}_2\text{(g)}$ when more $\text{H}_2\text{(g)}$ is added to the system. [1]
-

Base your answers to questions 55 through 58 on the information below and on your knowledge of chemistry.

The table below contains selected information about chlorine and two compounds containing chlorine. One piece of information is missing for each of the substances in the table.

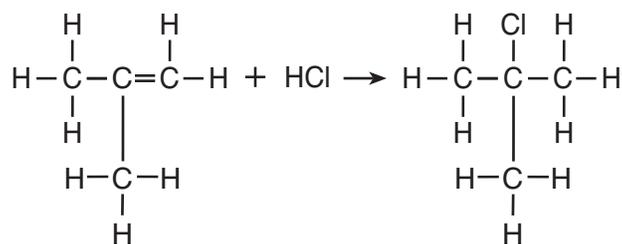
Chlorine and Two Compounds Containing Chlorine

Name	Formula	Molar Mass (g/mol)	Phase at STP
chlorine	Cl ₂	71	?
calcium chloride	CaCl ₂	?	solid
1,2-dichloroethene	?	97	liquid

- 55 Identify the phase of the chlorine at STP. [1]
- 56 Determine the molar mass for calcium chloride. [1]
- 57 The liquid compound has an empirical formula of CHCl. Write the molecular formula for this compound. [1]
- 58 Explain, in terms of electrons, why the compound containing calcium and chlorine is classified as an ionic compound. [1]
-

Base your answers to questions 59 and 60 on the information below and on your knowledge of chemistry.

The equation below represents the reaction between 2-methylpropene and hydrogen chloride gas.



- 59 Explain, in terms of chemical bonds, why the hydrocarbon is unsaturated. [1]
- 60 Identify the class of organic compounds to which the product belongs. [1]
-

Base your answers to questions 61 through 65 on the information below and on your knowledge of chemistry.

Many scientists made observations of the elements that led to the modern Periodic Table. In 1829, Dobereiner found groups of three elements that have similar properties and called each of these groups a triad. Dobereiner noticed a relationship between the atomic masses of the elements in each triad. Triad 1, shown in the table below, consists of sulfur, selenium, and tellurium. The middle element, selenium, has an atomic mass that is close to the sum of the atomic masses of sulfur and tellurium, divided by 2.

For example: $\frac{32 \text{ u} + 128 \text{ u}}{2} = 80. \text{ u}$, which is close to the 79 u value in the table.

The other triads shown in the table below demonstrate the same mathematical relationship.

Dobereiner's Triads

Triad	Triad	Dobereiner's Atomic Masses (u)
1	sulfur selenium tellurium	32 79 128
2	calcium strontium barium	40. 88 137
3	chlorine bromine iodine	35.5 80. 127
4	lithium sodium potassium	7 23 39

- 61 Identify the triad that contains a metalloid. [1]
- 62 Explain, in terms of electrons, why the elements in triad 2 have similar chemical properties. [1]
- 63 State the trend in first ionization energy as the elements in triad 3 are considered in order of increasing atomic number. [1]
- 64 Compare the volume of a 100.-gram sample of the first element in triad 4 to the volume of a 100.-gram sample of the third element in triad 4 when both samples are at room temperature. [1]
- 65 Show a numerical setup that demonstrates Dobereiner's mathematical relationship for triad 2. [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 68 on the information below and on your knowledge of chemistry.

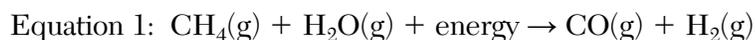
Wood is mainly cellulose, a polymer produced by plants. One use of wood is as a fuel in campfires, fireplaces, and wood furnaces. The molecules of cellulose are long chains of repeating units. Each unit of the chain can be represented as $C_6H_{10}O_5$. The balanced equation below represents a reaction that occurs when $C_6H_{10}O_5$ is burned in air.



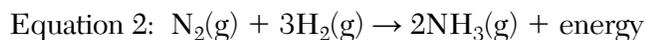
- 66 State evidence from the equation that this reaction is exothermic. [1]
- 67 Explain, in terms of substances in the reaction, why the equation represents a chemical change. [1]
- 68 Show a numerical setup for calculating the percent composition by mass of carbon in $C_6H_{10}O_5$ (gram-formula mass = 162.1 g/mol). [1]
-

Base your answers to questions 69 through 72 on the information below and on your knowledge of chemistry.

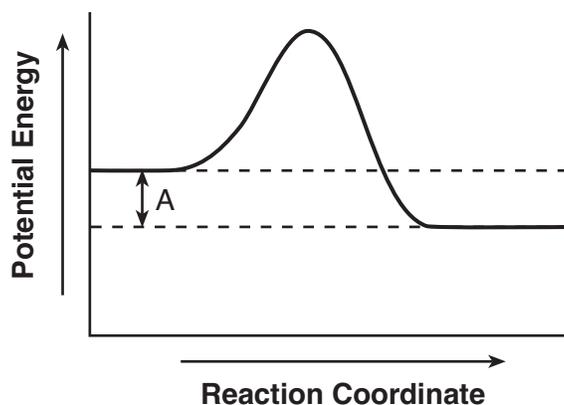
Millions of tons of ammonia are produced each year for use as fertilizer to increase food production. Most of the hydrogen needed to produce ammonia comes from methane gas reacting with steam. This reaction, which occurs in a container under controlled conditions, is shown below in unbalanced equation 1.



The reaction that produces ammonia is represented by balanced equation 2, shown below. A catalyst can be used to increase the rate of the reaction.



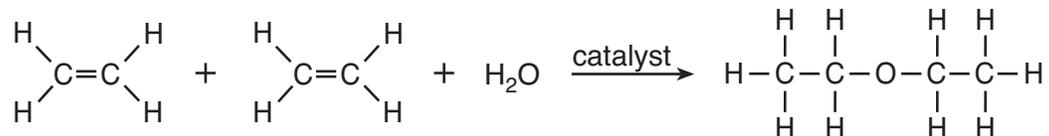
A potential energy diagram for equation 2 is shown below.



- 69 Balance equation 1 *in your answer booklet*, using the smallest whole-number coefficients. [1]
- 70 Explain, in terms of collision theory, why an increase in temperature increases the rate of reaction between methane gas and steam. [1]
- 71 State what is represented by interval A on the potential energy diagram. [1]
- 72 Determine the number of moles of hydrogen gas required to react completely with 50.0 moles of nitrogen gas in the production of ammonia. [1]
-

Base your answers to questions 73 through 77 on the information below and on your knowledge of chemistry.

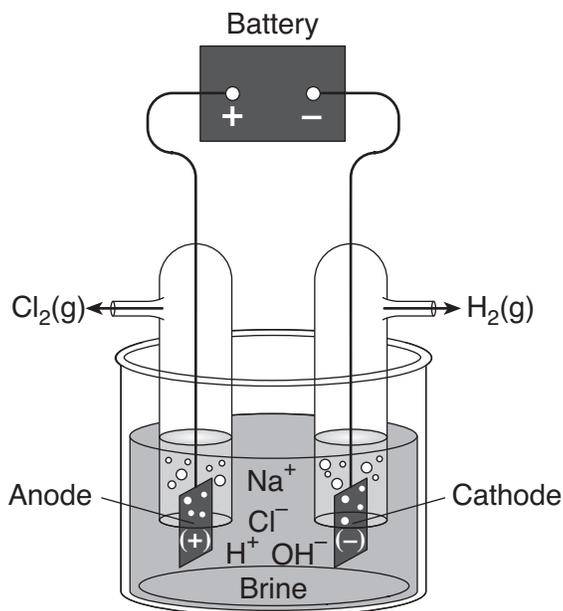
Diethyl ether is used as a laboratory and industrial solvent. The boiling point of diethyl ether at standard pressure is 34.6°C. The equation below represents a reaction that produces diethyl ether.



- 73 Identify the element in diethyl ether that allows it to be classified as an organic compound. [1]
- 74 State the number of electrons shared between the carbon atoms in one molecule of the organic reactant. [1]
- 75 State why the reaction is classified as a synthesis reaction. [1]
- 76 Explain, in terms of the strength of intermolecular forces, why the boiling point of diethyl ether at standard pressure is *lower* than the boiling point of water at standard pressure. [1]
- 77 Draw a structural formula for an isomer of the product that has the same functional group. [1]
-

Base your answers to questions 78 through 81 on the information below and on your knowledge of chemistry.

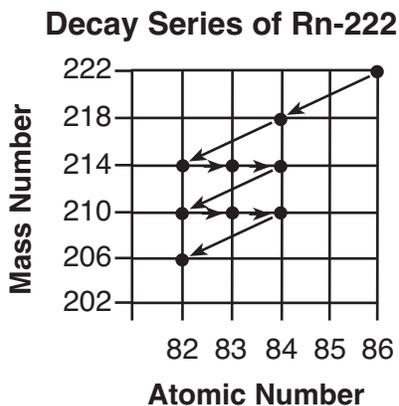
The electrolysis of brine, a concentrated aqueous sodium chloride solution, produces three important industrial chemicals: chlorine gas, hydrogen gas, and sodium hydroxide. The diagram and equation below represent a brine electrolysis cell. Before the battery is connected, the pH value of the brine solution is 7.0.



- 78 Explain, in terms of energy, why this cell is an electrolytic cell. [1]
- 79 Explain, in terms of ions, why the aqueous solution in the cell conducts an electric current. [1]
- 80 State the oxidation number of oxygen in the aqueous product. [1]
- 81 Compare the pH value of the solution before the battery is connected to the pH value of the solution after the cell operates for 20 minutes. [1]
-

Base your answers to questions 82 through 85 on the information below and on your knowledge of chemistry.

The isotope Rn-222 is produced by the decay of uranium in Earth's crust. Some of this isotope leaks into basements of homes in areas where the ground is more porous. An atom of Rn-222 decays to an atom of Pb-206 through a series of steps as shown on the graph below.



- 82 Determine the number of neutrons in an atom of Pb-214. [1]
- 83 Complete the nuclear equation *in your answer booklet* for the decay of Po-218 by writing a notation for the missing product. [1]
- 84 Determine the fraction of an original sample of Rn-222 that remains unchanged after 7.646 days. [1]
- 85 Explain, in terms of elements, why the decay of Bi-210 is considered a transmutation. [1]
-

