The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, August 20, 2025 — 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*.

1 Which statement describes the modern model of the atom?

(1) The atom has a small, negatively charged nucleus.
(2) The atom is a hard, indivisible sphere.
(3) Electrons are positive particles in the atom.
(4) Electrons in the atom have wave-like properties.

2 Which subatomic particles are found in the nucleus of a beryllium atom?

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

3 According to the electron cloud model of the atom, the region of space with the highest probability of locating an electron is

(1) a fixed circular path
(2) the nucleus
(3) an excited state
(4) an orbital

4 Which element has atoms that each contain 14 protons?

(1) Al
(2) C
(3) N
(4) Si

5 Which statement describes a chemical property of an element?

(1) Aluminum melts at 933 K.
(2) Copper is reddish in color.
(3) Silver reacts with hydrogen sulfide.
(4) Potassium has a density of 0.89 g/cm^3 at room temperature.

6 At 298 K and 101.3 kPa, oxygen exists in two gaseous forms: $O_2(g)$ and $O_3(g)$. These two forms of oxygen have

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

7 Which two terms represent types of chemical formulas?

(1) spectral and covalent
(2) spectral and molecular
(3) structural and empirical
(4) structural and nuclear

8 In all chemical reactions, there is a conservation of

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

9 A sample of solid tungsten has mobile valence electrons throughout the sample. Which type of bonding is present in the sample?

(1) nonpolar covalent
(2) polar covalent
(3) metallic
(4) ionic

10 Which formula represents a polar molecule?

(1) F_2
(2) CH_4
(3) CO_2
(4) NH_3

11 What occurs when two fluorine atoms react to produce a fluorine molecule?

(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.

12 A sample of NaCl(s) and a sample of NaCl(ℓ) have

(1) the same phase and the same physical properties
(2) the same phase and different physical properties
(3) different phases and the same physical properties
(4) different phases and different physical properties

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

(1) manganese
(2) ethene
(3) propanal
(4) water

14 All aqueous solutions of glucose are classified as

(1) mixtures with a fixed proportion
(2) compounds with a fixed proportion
(3) mixtures with proportions that may vary
(4) compounds with proportions that may vary

15 At which pressure and temperature does a sample of He(g) behave most like an ideal gas?

(1) 0.5 atm and 137 K
(2) 0.5 atm and 546 K
(3) 2.0 atm and 137 K
(4) 2.0 atm and 546 K

16 The kinetic molecular theory states that the particles of an ideal gas

(1) constantly move in circular paths
(2) have no attractive forces between them
(3) create energy when gas particles collide with each other
(4) are separated by very small distances relative to their sizes

17 A reaction is most likely to occur when reactant particles collide with proper

(1) energy and orientation
(2) mass and volume
(3) phase and charge
(4) pressure and density

18 A sample of gas is in a sealed, rigid cylinder at constant volume. Which changes occur in the force of collisions of the gas particles and frequency of their collisions when the sample is cooled?

(1) Force of collisions decreases and frequency of collisions increases.
(2) Force of collisions decreases and frequency of collisions decreases.
(3) Force of collisions increases and frequency of collisions increases.
(4) Force of collisions increases and frequency of collisions decreases.

19 At STP, 2.0 liters of Ar(g) contains 5.4×10^{22} atoms. How many atoms are contained in 2.0 liters of Ne(g) at STP?

(1) 2.7×10^{11}
(2) 2.7×10^{22}
(3) 5.4×10^{11}
(4) 5.4×10^{22}

20 When a system is at equilibrium, the concentrations of the reactants and the products must be

(1) equal
(2) constant
(3) decreasing
(4) increasing

21 Which expression represents the heat of reaction for a chemical change?

(1) (potential energy of the products) − (potential energy of the reactants)
(2) (potential energy of the products) + (potential energy of the reactants)
(3) (kinetic energy of the products) − (kinetic energy of the reactants)
(4) (kinetic energy of the products) + (kinetic energy of the reactants)

22 When a catalyst is added to a chemical reaction it produces

(1) a greater heat of reaction
(2) a greater activation energy for the reactants
(3) an alternate reaction pathway
(4) an alternate potential energy for the products

23 Naturally occurring chemical systems tend to undergo changes toward

(1) lower energy and lower disorder
(2) lower energy and greater disorder
(3) higher energy and lower disorder
(4) higher energy and greater disorder

24 Which formula represents an organic compound?

(1) PCl_3
(2) BrCl
(3) CH_3Cl
(4) NH_4Cl

25 Where do oxidation and reduction occur in an electrochemical cell?

(1) Oxidation occurs at the anode and reduction occurs at the cathode.
(2) Oxidation occurs at the anode and reduction occurs in the salt bridge.
(3) Oxidation occurs at the cathode and reduction occurs at the anode.
(4) Oxidation occurs at the cathode and reduction occurs in the salt bridge.

26 Which element is the most active nonmetal?

(1) bromine
(2) chlorine
(3) fluorine
(4) iodine

27 When a sample of solid $Ca(OH)_2$ dissolves in water, the only negative ions in the solution are

(1) hydronium ions
(2) hydroxide ions
(3) oxide ions
(4) calcium ions

28 Which products are formed when an Arrhenius acid and an Arrhenius base react?

(1) an alcohol and an ester
(2) an alcohol and water
(3) a salt and an ester
(4) a salt and water

29 The stability of an isotope is related to the ratio of which subatomic particles?

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

30 Which nuclear emission has the greatest mass?

(1) an alpha particle
(2) a beta particle
(3) a neutron
(4) a positron

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 element is listed with the number of valence electrons and the number of non-valence electrons in one of its atoms in the ground state?

(1) Sodium has two valence electrons and 11 non-valence electrons.
(2) Phosphorus has five valence electrons and 10 non-valence electrons.
(3) Chlorine has seven valence electrons and 17 non-valence electrons.
(4) Argon has 10 valence electrons and 18 non-valence electrons.

32 An atom has a mass number of 112 and contains 48 protons. How many neutrons does this atom contain?

(1) 48
(2) 54
(3) 64
(4) 160

33 There is a *decrease* in value of which property as the elements in Period 2 are considered in order from lithium to fluorine?

(1) atomic radius
(2) electronegativity
(3) first ionization energy
(4) atomic mass

34 What is a chemical name for $NaClO_3$?

(1) sodium chlorate
(2) sodium chlorite
(3) sodium hypochlorite
(4) sodium perchlorate

35 Which formula represents a molecule that has four electrons shared between the two atoms?

(1) Br_2
(2) Cl_2
(3) H_2
(4) O_2

36 Given the balanced equation representing a reaction:

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s) + 3351\ kJ$$

What is the number of moles of $Al_2O_3(s)$ formed when 12 moles of $O_2(g)$ react completely?

(1) 8 mol
(2) 2 mol
(3) 3 mol
(4) 12 mol

37 A substance has an empirical formula of CH_2 and a molar mass of 112 g/mol. What is the molecular formula for this compound?

(1) CH_2
(2) C_4H_8
(3) C_8H_{16}
(4) $C_{12}H_{24}$

38 Compared to the vapor pressure of ethanol at 1.0 atm and 25°C, the vapor pressure of water at 1.0 atm and 25°C is

(1) lower because water has weaker intermolecular forces
(2) lower because water has stronger intermolecular forces
(3) higher because water has weaker intermolecular forces
(4) higher because water has stronger intermolecular forces

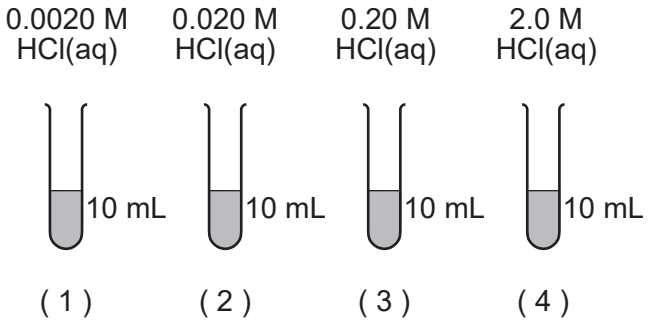
39 Based on Table *S*, a molecule of which substance contains the most polar bond?

(1) HBr
(2) HF
(3) IBr
(4) IF

40 Based on Table *F*, which compound is most soluble in water?

(1) CaS
(2) $CaCO_3$
(3) $CaSO_4$
(4) $CaCrO_4$

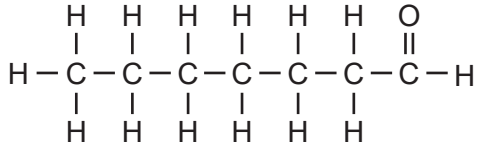
41 Each of four test tubes contains a different concentration of HCl(aq) at 298 K. A 1.0-gram sample of iron filings is added to each test tube. In which test tube is the reaction occurring at the fastest rate?



42 Which equation represents an increase in entropy?

(1) $CO_2(g) \rightarrow CO_2(s)$
(2) $H_2O(\ell) \rightarrow H_2O(s)$
(3) $Br_2(g) \rightarrow Br_2(\ell)$
(4) $I_2(s) \rightarrow I_2(g)$

43 Given the formula representing a compound:



What is a chemical name for this compound?

(1) 1-heptanone
(2) 7-heptanol
(3) heptanal
(4) heptanoic acid

44 Given the incomplete equation with *X* representing a missing product:

$$CH_4 + Cl_2 \rightarrow X + HCl$$

Which formula represents the missing product, *X*?

(1) CH_4Cl
(2) CH_4Cl_2
(3) CH_3Cl
(4) CH_3Cl_2

45 Which type of reaction produces ethanol and carbon dioxide from glucose, $C_6H_{12}O_6$?

(1) addition
(2) fermentation
(3) substitution
(4) polymerization

46 Given the balanced ionic equation:

$$2Fe^{3+}(aq) + Sn^{2+}(aq) \rightarrow 2Fe^{2+}(aq) + Sn^{4+}(aq)$$

How many moles of electrons are gained by $Fe^{3+}(aq)$ when $Sn^{2+}(aq)$ loses 2 moles of electrons?

(1) 1 mol
(2) 2 mol
(3) 3 mol
(4) 4 mol

47 Which aqueous solution of LiCl is the best conductor of an electric current?

(1) 0.1 M LiCl(aq)
(2) 0.01 M LiCl(aq)
(3) 0.001 M LiCl(aq)
(4) 0.0001 M LiCl(aq)

48 Given the equation representing a reaction:

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

According to one acid-base theory, the H_2O acts as an acid because it is an

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

49 Based on Table *N*, which statement compares the half-lives and decay modes of krypton-85 and potassium-42?

(1) They have the same half-life and the same decay mode.
(2) They have the same half-life but different decay modes.
(3) They have different half-lives but the same decay mode.
(4) They have different half-lives and different decay modes.

50 Which statement explains the energy released by a fission reaction?

(1) Thermal energy is converted to chemical energy.
(2) Chemical energy is converted to thermal energy.
(3) Mass is converted to energy.
(4) Energy is converted to mass.

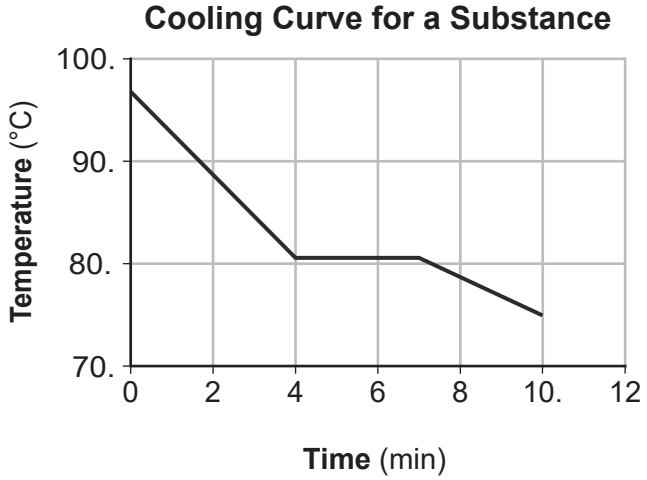
Part B–2

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 through 53 on the information below and on your knowledge of chemistry.

A sample of a molecular substance starting as a liquid at 97.0°C and 1 atm is cooled for 10. minutes. The heat of fusion for this substance is 148 joules per gram. This cooling process is represented on the graph below.



51 State what happens to the average kinetic energy of the molecules in the sample during the first 3 minutes. [1]

52 Determine the freezing point of the substance in degrees Celsius. [1]

53 Determine the amount of heat, in joules, released when a 64.0-gram sample of this liquid substance solidifies at its freezing point. [1]

Base your answers to questions 54 through 56 on the information below and on your knowledge of chemistry.

At standard pressure, the boiling points of four hydrocarbons and the boiling points of four alcohols are shown in the table below.

Boiling Points of Selected Hydrocarbons and Alcohols at Standard Pressure

Hydrocarbon	Boiling Point (°C)	Alcohol	Boiling Point (°C)
methane	−161.5	methanol	64.6
ethane	−88.6	ethanol	78.3
propane	−42.1	1-propanol	97.2
butane	−0.5	1-butanol	117.1

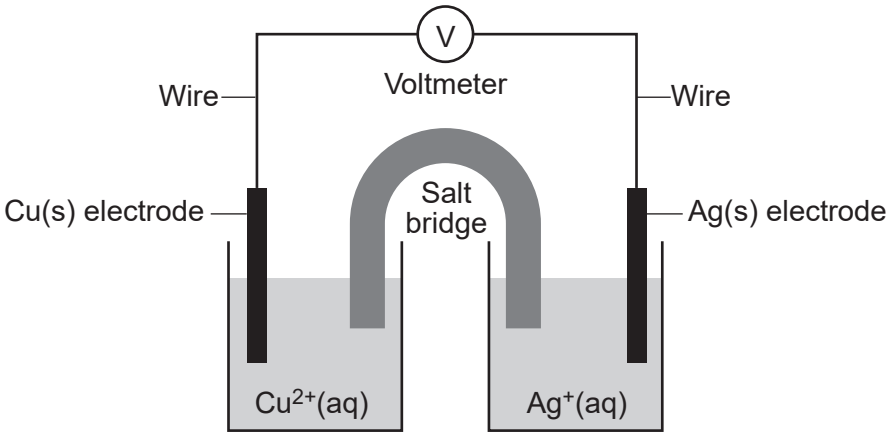
54 State, in terms of carbon-carbon bonds, why ethane is saturated. [1]

55 Draw a structural formula for 1-butanol. [1]

56 Describe what happens to the boiling points of the alcohols as the number of carbon atoms per molecule increases. [1]

Base your answers to questions 57 through 59 on the information below and on your knowledge of chemistry.

The diagram and ionic equation below represent an operating electrochemical cell.



$$Cu(s) + 2Ag^{+}(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$$

57 State the oxidation number of the silver atoms in the Ag(s) electrode. [1]

58 State the form of energy that is converted to electrical energy in this operating cell. [1]

59 Write a balanced half-reaction equation for the oxidation reaction that occurs when the cell operates. [1]

Base your answers to questions 60 through 63 on the information below and on your knowledge of chemistry.

During a titration, 10.0 mL of HCl(aq) is exactly neutralized by adding 20.0 mL of 0.10 M NaOH(aq). The NaOH(aq) has a pH value of 13.0. During this laboratory activity appropriate safety equipment is used and safety procedures are followed.

60 State the color of bromthymol blue after it is added to a sample of the NaOH(aq) solution. [1]

61 State, in terms of ions, why the HCl(aq) solution can conduct electricity. [1]

62 Show a numerical setup for calculating the molarity of the HCl(aq), using the titration data. [1]

63 State the pH value when the H^+ ion concentration in the original NaOH(aq) has increased by a factor of 10 compared to its original value. [1]

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

A phosphorus radioisotope decays by positron emission and has a half-life of 2.50 minutes. This reaction is represented by the equation below.

$$^{30}_{15}\mathrm{P} \rightarrow {}^{0}_{+1}\beta + {}^{30}_{14}\mathrm{Si}$$

64 State, in terms of elements, why the equation represents a transmutation reaction. [1]

65 Determine the time required for an original 200.0-milligram sample of phosphorus–30 to decay until only 12.5 milligrams of the sample remains unchanged. [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 and on your knowledge of chemistry.

Compounds of gallium are used in lasers and light-emitting diodes, also known as LEDs. The atomic mass and natural abundance of the two naturally occurring isotopes of gallium are given in the table below.

Naturally Occurring Isotopes of Gallium

Isotope	Atomic Mass (u)	Natural Abundance (%)
Ga-69	68.926	60.11
Ga-71	70.925	39.89

66 Compare the energy of an electron in the fourth shell of a gallium atom to the energy of an electron in the first shell of the same atom. [1]

67 State how a bright-line spectrum from a sample of an element viewed through a spectroscope can be used to identify the element as gallium. [1]

68 Show a numerical setup for calculating the atomic mass of gallium. [1]

69 Explain, in terms of *both* protons and neutrons, why an atom of Ga-69 and an atom of Ga-71 are classified as different isotopes of the same element. [1]

Base your answers to questions 70 through 73 on the information below and on your knowledge of chemistry.

Ammonium sulfate is a fertilizer produced by the reaction between ammonia and sulfuric acid. The unbalanced equation for this reaction is shown below.

$$NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

70 State why the equation represents a synthesis reaction. [1]

71 Determine the percent composition by mass of nitrogen in NH_3 (gram-formula mass of NH_3 = 17.0 g/mol). [1]

72 Determine the gram-formula mass of H_2SO_4. [1]

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

Base your answers to questions 74 through 78 on the information below and on your knowledge of chemistry.

Seawater is also called salt water because it contains many dissolved ions. When the water is evaporated from a sample of seawater, solid salts such as NaCl form. The table below shows the percent of some of the ions in the sample of seawater.

Some Ions in the Sample of Seawater

Ion	Percent of Total Ions (%)
Cl^-	55.3
Na^+	30.7
Mg^{2+}	3.7

74 State, in terms of element classification, why the bonding in a sample of sodium chloride is ionic. [1]

75 Identify the noble gas that has atoms with the same electron configuration as a chloride ion when both the atoms and the ions are in the ground state. [1]

76 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for the ion in this table that has the greatest percentage of ions in seawater. [1]

77 State, in terms of electrons, why the radius of a Mg^{2+} ion is smaller than the radius of a Mg atom. [1]

78 Using the key *in your answer booklet*, draw *at least two* water molecules in the box, showing the orientation of *each* water molecule toward the Na^+ ion. [1]

Base your answers to questions 79 through 81 on the information below and on your knowledge of chemistry.

A student investigating the properties of solutions dissolved 44.0 grams of KCl(s) in 200. grams of water at 30.°C. During this laboratory activity appropriate safety equipment was used and safety procedures were followed.

79 Classify, in terms of saturation, the type of solution produced by the student. [1]

80 Based on Table *G*, state what happens to the solubility of KCl in water as temperature increases from 30.°C to 70.°C. [1]

81 Compare the boiling point of the solution at standard pressure to the boiling point of water at standard pressure. [1]

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

In a process used for centuries, limestone containing calcium carbonate is heated to produce calcium oxide and carbon dioxide gas. When placed in a sealed, rigid container, the reaction is reversible, allowing CaO and CO_2 to react to produce $CaCO_3$. These reactions produce an equilibrium system as represented by the equation below.

$$CaCO_3(s) + 177.8\ kJ \rightleftharpoons CaO(s) + CO_2(g)$$

82 Compare the rate of the forward reaction to the rate of the reverse reaction in this equilibrium system. [1]

83 Convert the energy term in the equation, 177.8 kJ, to joules. [1]

84 Explain, in terms of collisions between CaO and CO_2, why adding more $CO_2(g)$ to this equilibrium increases the amount of $CaCO_3(s)$ in the system. [1]

85 On the labeled axes *in your answer booklet*, draw a potential energy diagram for the forward reaction in this system. [1]

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