The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Thursday, August 16, 2018 — 8:30 to 11:30 a.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 *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 According to the wave-mechanical model, an orbital is defined as the most probable location of
(1) a proton
(2) a neutron
(3) a positron
(4) an electron

2 The part of an atom that has an overall positive charge is called
(1) an electron
(2) the nucleus
(3) the first shell
(4) the valence shell

3 Which subatomic particles each have a mass of approximately 1 u?
(1) proton and electron
(2) proton and neutron
(3) neutron and electron
(4) neutron and positron

4 The discovery of the electron as a subatomic particle was a result of
(1) collision theory
(2) kinetic molecular theory
(3) the gold-foil experiment
(4) experiments with cathode ray tubes

5 The elements on the Periodic Table of the Elements are arranged in order of increasing
(1) atomic mass
(2) formula mass
(3) atomic number
(4) oxidation number

6 Which element is classified as a metalloid?
(1) Te
(2) S
(3) Hg
(4) I

7 At STP, $O_2(g)$ and $O_3(g)$ are two forms of the same element that 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

8 Which substance can be broken down by chemical means?

(1) ammonia   (3) antimony
(2) aluminum   (4) argon

9 Which statement describes $H_2O(\ell)$ and $H_2O_2(\ell)$?

(1) Both are compounds that have the same properties.
(2) Both are compounds that have different properties.
(3) Both are mixtures that have the same properties.
(4) Both are mixtures that have different properties.

10 Which two terms represent major categories of compounds?

(1) ionic and nuclear
(2) ionic and molecular
(3) empirical and nuclear
(4) empirical and molecular

11 Which formula represents an asymmetrical molecule?

(1) CH_4 (3) N_2
(2) CO_2 (4) NH_3

12 Which statement describes the energy changes that occur as bonds are broken and formed during a chemical reaction?

(1) Energy is absorbed when bonds are both broken and formed.
(2) Energy is released when bonds are both broken and formed.
(3) Energy is absorbed when bonds are broken, and energy is released when bonds are formed.
(4) Energy is released when bonds are broken, and energy is absorbed when bonds are formed.

13 A solid sample of copper is an excellent conductor of electric current. Which type of chemical bonds are in the sample?

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

14 Which list includes three forms of energy?

(1) thermal, nuclear, electronegativity
(2) thermal, chemical, electromagnetic
(3) temperature, nuclear, electromagnetic
(4) temperature, chemical, electronegativity

15 Based on Table S, an atom of which element has the strongest attraction for electrons in a chemical bond?

(1) chlorine   (3) oxygen
(2) nitrogen   (4) selenium

16 At which temperature and pressure would a sample of helium behave most like an ideal gas?

(1) 75 K and 500. kPa
(2) 150. K and 500. kPa
(3) 300. K and 50. kPa
(4) 600. K and 50. kPa

17 A cube of iron at 20.°C is placed in contact with a cube of copper at 60.°C. Which statement describes the initial flow of heat between the cubes?

(1) Heat flows from the copper cube to the iron cube.
(2) Heat flows from the iron cube to the copper cube.
(3) Heat flows in both directions between the cubes.
(4) Heat does not flow between the cubes.

18 Which sample at STP has the same number of atoms as 18 liters of $Ne(g)$ at STP?

(1) 18 moles of $Ar(g)$
(2) 18 liters of $Ar(g)$
(3) 18 grams of $H_2O(g)$
(4) 18 milliliters of $H_2O(g)$

19 Compared to H_2S, the higher boiling point of H_2O is due to the

(1) greater molecular size of water
(2) stronger hydrogen bonding in water
(3) higher molarity of water
(4) larger gram-formula mass of water

20 In terms of entropy and energy, systems in nature tend to undergo changes toward

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

21 Amines, amides, and amino acids are categories of

(1) isomers
(2) isotopes
(3) organic compounds
(4) inorganic compounds

22 A molecule of which compound has a multiple covalent bond?

(1) CH_4 (3) C_3H_8
(2) C_2H_4 (4) C_4H_{10}

23 Which type of reaction produces soap?

(1) polymerization   (3) fermentation
(2) combustion   (4) saponification

24 For a reaction system at equilibrium, LeChatelier's principle can be used to predict the

(1) activation energy for the system
(2) type of bonds in the reactants
(3) effect of a stress on the system
(4) polarity of the product molecules

25 Which value changes when a Cu atom becomes a Cu^{2+} ion?

(1) mass number
(2) oxidation number
(3) number of protons
(4) number of neutrons

26 Which reaction occurs at the anode in an electrochemical cell?

(1) oxidation   (3) combustion
(2) reduction   (4) substitution

27 What evidence indicates that the nuclei of strontium-90 atoms are unstable?

(1) Strontium-90 electrons are in the excited state.
(2) Strontium-90 electrons are in the ground state.
(3) Strontium-90 atoms spontaneously absorb beta particles.
(4) Strontium-90 atoms spontaneously emit beta particles.

28 Which nuclear emission is listed with its notation?

(1) gamma radiation, $_0^0\gamma$
(2) proton, $_2^4He$
(3) neutron, $_{-1}^0\beta$
(4) alpha particle, $_1^1H$

29 The energy released by a nuclear fusion reaction is produced when

(1) energy is converted to mass
(2) mass is converted to energy
(3) heat is converted to temperature
(4) temperature is converted to heat

30 Dating once-living organisms is an example of a beneficial use of

(1) redox reactions
(2) organic isomers
(3) radioactive isotopes
(4) neutralization reactions

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 What is the net charge of an ion that has 11 protons, 10 electrons, and 12 neutrons?

(1) 1+　　　　　　　　(3) 1−
(2) 2+　　　　　　　　(4) 2−

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

(1) 2-5　　　　　　　　(3) 2-5-1
(2) 2-8-5　　　　　　　(4) 2-6

33 Which element is a liquid at 1000. K?

(1) Ag　　　　　　　　(3) Ca
(2) Al　　　　　　　　(4) Ni

34 Which formula represents ammonium nitrate?

(1) NH_4NO_3　　　　　(3) $NH_4(NO_3)_2$
(2) NH_4NO_2　　　　　(4) $NH_4(NO_2)_2$

35 The empirical formula for butene is

(1) CH_2　　　　　　　(3) C_4H_6
(2) C_2H_4　　　　　　(4) C_4H_8

36 Which equation represents a conservation of charge?

(1) $2Fe^{3+} + Al \rightarrow 2Fe^{2+} + Al^{3+}$
(2) $2Fe^{3+} + 2Al \rightarrow 3Fe^{2+} + 2Al^{3+}$
(3) $3Fe^{3+} + 2Al \rightarrow 2Fe^{2+} + 2Al^{3+}$
(4) $3Fe^{3+} + Al \rightarrow 3Fe^{2+} + Al^{3+}$

37 Given the balanced equation representing a reaction:

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

Which type of reaction is represented by this equation?

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

38 When a Mg^{2+} ion becomes a Mg atom, the radius increases because the Mg^{2+} ion

(1) gains 2 protons　　　(3) loses 2 protons
(2) gains 2 electrons　　(4) loses 2 electrons

39 The *least* polar bond is found in a molecule of

(1) HI　　　　　　(3) HCl
(2) HF　　　　　　(4) HBr

40 A solution is prepared using 0.125 g of glucose, $C_6H_{12}O_6$, in enough water to make 250. g of total solution. The concentration of this solution, expressed in parts per million, is

(1) 5.00×10^1 ppm　　(3) 5.00×10^3 ppm
(2) 5.00×10^2 ppm　　(4) 5.00×10^4 ppm

41 What is the amount of heat, in joules, required to increase the temperature of a 49.5-gram sample of water from 22°C to 66°C?

(1) 2.2×10^3 J　　　(3) 9.1×10^3 J
(2) 4.6×10^3 J　　　(4) 1.4×10^4 J

42 A sample of a gas in a rigid cylinder with a movable piston has a volume of 11.2 liters at STP. What is the volume of this gas at 202.6 kPa and 300. K?

(1) 5.10 L　　　　(3) 22.4 L
(2) 6.15 L　　　　(4) 24.6 L

43 The equation below represents a reaction between two molecules, X_2 and Z_2. These molecules form an "activated complex," which then forms molecules of the product.

Key
●● = a molecule of X_2
◯◯ = a molecule of Z_2

●● + ◯◯ ⟶ [activated complex] ⟶ ●◯ + ●◯

Reactants   Activated   Product
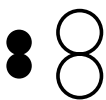   complex
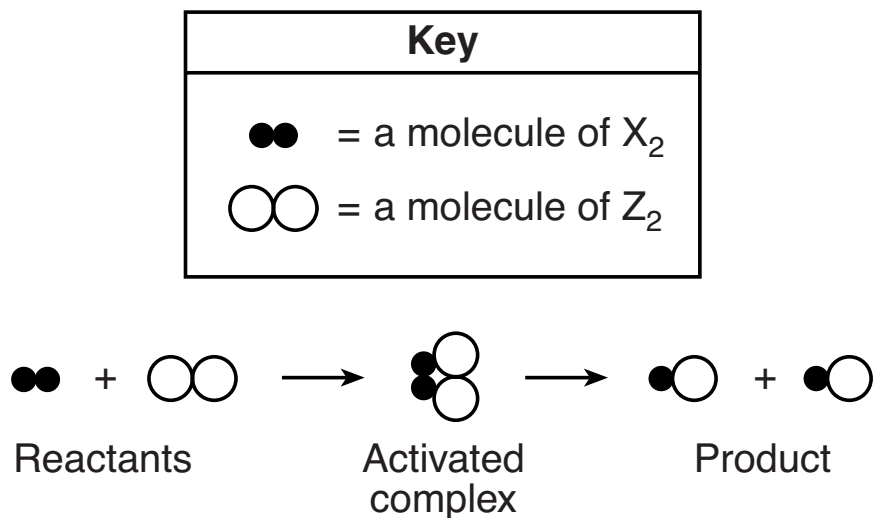
Which diagram represents the most likely orientation of X_2 and Z_2 when the molecules collide with proper energy, producing an activated complex?
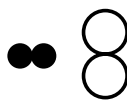
(1)

(3)

(2)

(4)

44 What is the chemical name for the compound $CH_3CH_2CH_2CH_3$?

(1) butane   (3) decane
(2) butene   (4) decene

45 In a laboratory activity, the density of a sample of vanadium is determined to be 6.9 g/cm³ at room temperature. What is the percent error for the determined value?

(1) 0.15%   (3) 13%
(2) 0.87%   (4) 15%

46 Given the equation representing a reaction:

$$Cd + NiO_2 + 2H_2O \rightarrow Cd(OH)_2 + Ni(OH)_2$$
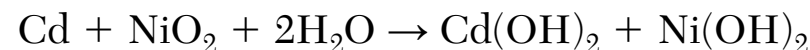
Which half-reaction equation represents the oxidation in the reaction?

(1) $Ni^{4+} + 2e^- \rightarrow Ni^{2+}$
(2) $Ni^{4+} \rightarrow Ni^{2+} + 2e^-$
(3) $Cd \rightarrow Cd^{2+} + 2e^-$
(4) $Cd + 2e^- \rightarrow Cd^{2+}$

47 Which metal reacts spontaneously with $NiCl_2(aq)$?

(1) Au(s) (3) Sn(s)
(2) Cu(s) (4) Zn(s)

48 Which solution is the best conductor of an electric current?

(1) 0.001 mole of NaCl dissolved in 1000. mL of water
(2) 0.005 mole of NaCl dissolved in 1000. mL of water
(3) 0.1 mole of NaCl dissolved in 1000. mL of water
(4) 0.05 mole of NaCl dissolved in 1000. mL of water

49 Compared to a 1.0-liter aqueous solution with a pH of 7.0, a 1.0-liter aqueous solution with a pH of 5.0 contains

(1) 10 times more hydronium ions
(2) 100 times more hydronium ions
(3) 10 times more hydroxide ions
(4) 100 times more hydroxide ions

50 Given the equation representing a reaction:

$$^{208}_{82}Pb + ^{70}_{30}Zn \rightarrow ^{277}_{112}Cn + ^{1}_{0}n$$
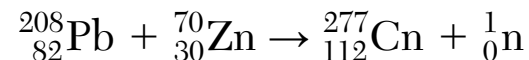
Which type of reaction is represented by this equation?

(1) neutralization (3) substitution
(2) polymerization (4) transmutation

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 Show a numerical setup for calculating the percent composition by mass of oxygen in Al_2O_3 (gram-formula mass = 102 g/mol). [1]

52 Identify a laboratory process that can be used to separate a liquid mixture of methanol and water, based on the differences in their boiling points. [1]

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Base your answers to questions 53 through 55 on the information below and on your knowledge of chemistry.

The table below shows data for three isotopes of the same element.

Data for Three Isotopes of an Element

Isotopes	Number of Protons	Number of Neutrons	Atomic Mass (u)	Natural Abundance (%)
Atom D	12	12	23.99	78.99
Atom E	12	13	24.99	10.00
Atom G	12	14	25.98	11.01

53 Explain, in terms of subatomic particles, why these three isotopes represent the same element. [1]

54 State the number of valence electrons in an atom of isotope D in the ground state. [1]

55 Compare the energy of an electron in the first electron shell to the energy of an electron in the second electron shell in an atom of isotope E. [1]

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Base your answers to questions 56 through 58 on the information below and on your knowledge of chemistry.

The elements in Group 2 on the Periodic Table can be compared in terms of first ionization energy, electronegativity, and other general properties.

56 Describe the general trend in electronegativity as the metals in Group 2 on the Periodic Table are considered in order of increasing atomic number. [1]

57 Explain, in terms of electron configuration, why the elements in Group 2 have similar chemical properties. [1]

58 Explain, in terms of atomic structure, why barium has a lower first ionization energy than magnesium. [1]

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Base your answers to questions 59 through 61 on the information below and on your knowledge of chemistry.

A saturated solution of sulfur dioxide is prepared by dissolving $SO_2(g)$ in 100. g of water at 10.°C and standard pressure.

59 Determine the mass of SO_2 in this solution. [1]

60 Based on Table G, state the general relationship between solubility and temperature of an aqueous SO_2 solution at standard pressure. [1]

61 Describe what happens to the solubility of $SO_2(g)$ when the pressure is increased at constant temperature. [1]

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

Starting as a solid, a sample of a molecular substance is heated, until the entire sample of the substance is a gas. The graph below represents the relationship between the temperature of the sample and the elapsed time.

Heating Curve
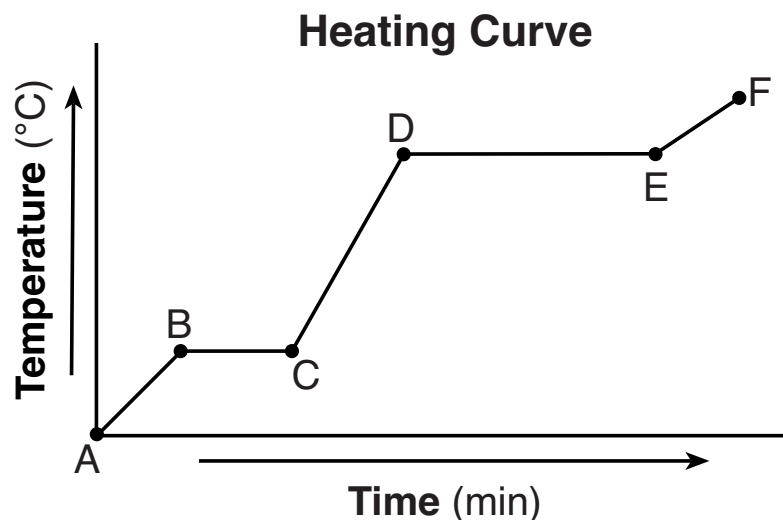
62 Using the key *in your answer booklet*, draw a particle diagram to represent the sample during interval *AB*. Your response must include *at least six* molecules. [1]

63 Compare the average kinetic energy of the molecules of the sample during interval *BC* to the average kinetic energy of the molecules of the sample during interval *DE*. [1]

64 On the graph *in your answer booklet*, mark an **X** on the axis labeled "Temperature (°C)" to indicate the boiling point of the substance. [1]

65 State evidence that indicates the sample undergoes only physical changes during this heating. [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.

"Water gas," a mixture of hydrogen and carbon monoxide, is an industrial fuel and source of commercial hydrogen. Water gas is produced by passing steam over hot carbon obtained from coal. The equation below represents this system at equilibrium:

$$C(s) + H_2O(g) + heat \rightleftharpoons CO(g) + H_2(g)$$

66 State, in terms of the rates of the forward and reverse reactions, what occurs when dynamic equilibrium is reached in this system. [1]

67 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for a molecule of H_2O. [1]

68 Explain, in terms of collisions, why increasing the surface area of the hot carbon increases the rate of the forward reaction. [1]

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Base your answers to questions 69 through 71 on the information below and on your knowledge of chemistry.

In a laboratory activity, each of four different masses of $KNO_3(s)$ is placed in a separate test tube that contains 10.0 grams of H_2O at 25°C.

When each sample is first placed in the water, the temperature of the mixture decreases. The mixture in each test tube is then stirred while it is heated in a hot water bath until all of the $KNO_3(s)$ is dissolved. The contents of each test tube are then cooled to the temperature at which KNO_3 crystals first reappear. The procedure is repeated until the recrystallization temperatures for each mixture are consistent, as shown in the table below.

Data Table for the Laboratory Activity

| Mixture	Mass of KNO₃ (g)	Mass of H₂O (g)	Temperature of Recrystallization (°C)
1	4.0	10.0	24
2	5.0	10.0	32
3	7.5	10.0	45
4	10.0	10.0	58

69 Based on Table *I*, explain why there is a *decrease* in temperature when the $KNO_3(s)$ was first dissolved in the water.   [1]

70 Determine the percent by mass concentration of KNO_3 in mixture 2 after heating.   [1]

71 Compare the freezing point of mixture 4 at 1.0 atm to the freezing point of water at 1.0 atm.   [1]

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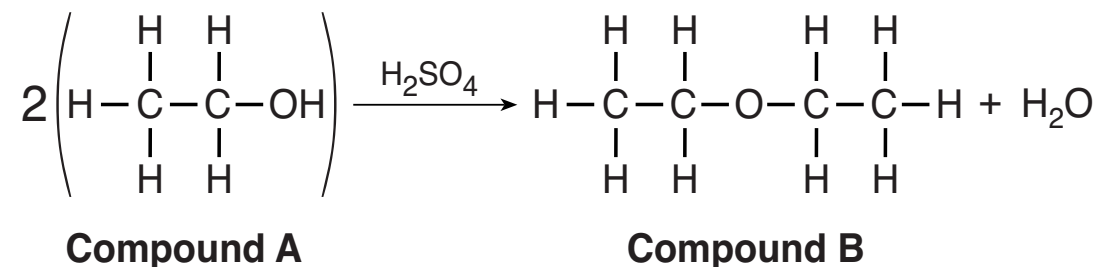Base your answers to questions 72 through 74 on the information below and on your knowledge of chemistry.

The balanced equation below represents the reaction between carbon monoxide and oxygen to produce carbon dioxide.

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g) + energy$$
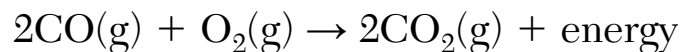
72 On the potential energy diagram *in your answer booklet*, draw a double-headed arrow ($\updownarrow$) to indicate the interval that represents the heat of reaction. [1]

73 Determine the number of moles of $O_2(g)$ needed to completely react with 8.0 moles of $CO(g)$. [1]

74 On the potential energy diagram *in your answer booklet*, draw a dashed line to show how the potential energy diagram changes when the reaction is catalyzed. [1]

Base your answers to questions 75 through 77 on the information below and on your knowledge of chemistry.

The equation below represents an industrial preparation of diethyl ether.

$$2\left(\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ | \quad | \\ \text{H} \quad \text{H} \end{array}\right) \xrightarrow{\text{H}_2\text{SO}_4} \begin{array}{c} \text{H} \quad \text{H} \quad\quad \text{H} \quad \text{H} \\ | \quad | \quad\quad\quad | \quad | \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{C}-\text{C}-\text{H} + \text{H}_2\text{O} \\ | \quad | \quad\quad\quad | \quad | \\ \text{H} \quad \text{H} \quad\quad \text{H} \quad \text{H} \end{array}$$

Compound A   **Compound B**

75 Write the name of the class of organic compounds to which compound *A* belongs. [1]

76 Identify the element in compound *B* that makes it an organic compound. [1]

77 Explain, in terms of elements, why compound *B* is *not* a hydrocarbon. [1]

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

A student is to determine the concentration of an NaOH(aq) solution by performing two different titrations. In a first titration, the student titrates 25.0 mL of 0.100 M H_2SO_4(aq) with NaOH(aq) of unknown concentration.

In a second titration, the student titrates 25.0 mL of 0.100 M HCl(aq) with a sample of the NaOH(aq). During this second titration, the volume of the NaOH(aq) added and the corresponding pH value of the reaction mixture is measured. The graph below represents the relationship between pH and the volume of the NaOH(aq) added for this second titration.

**pH versus Volume of NaOH(aq)
Added to HCl(aq)**

Volume of NaOH(aq) Added
(mL)
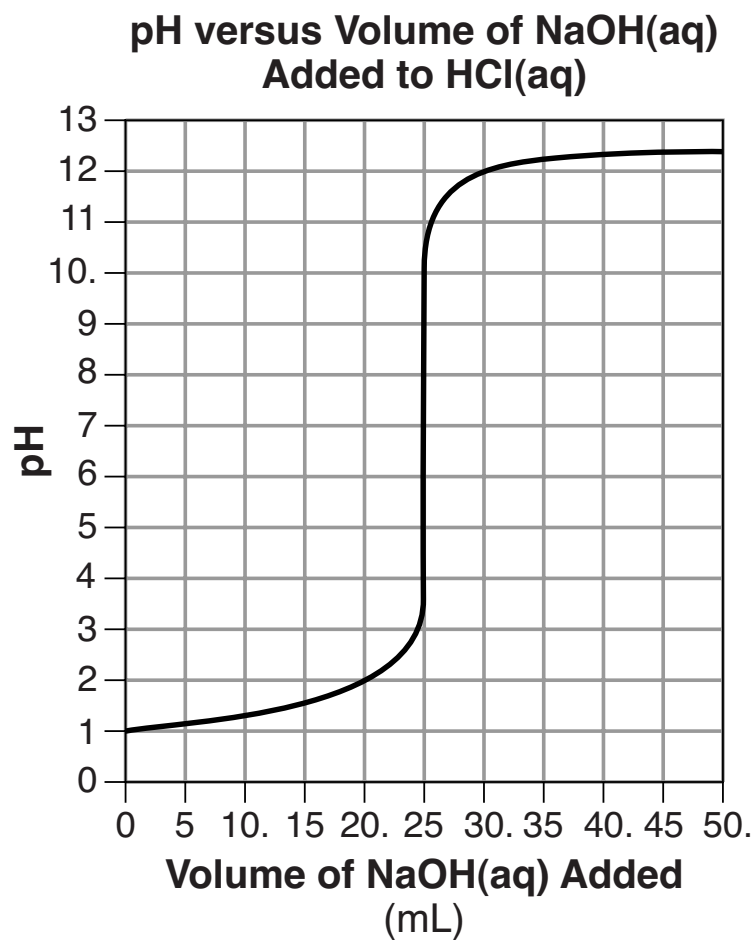
78 Identify the positive ion present in the H_2SO_4(aq) solution before the titration. [1]

79 Complete the equation *in your answer booklet* for the neutralization that occurs in the first titration by writing a formula of the missing product. [1]

80 Based on the graph, determine the volume of NaOH(aq) used to exactly neutralize the HCl(aq). [1]

81 State the color of phenolphthalein indicator if it were added after the HCl(aq) was titrated with 50. mL of NaOH(aq). [1]

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

When uranium-235 nuclei are bombarded with neutrons, many different combinations of smaller nuclei can be produced. The production of neodymium-150 and germanium-81 in one of these reactions is represented by the equation below.

$$_0^1n + _{92}^{235}U \rightarrow _{60}^{150}Nd + _{32}^{81}Ge + 5_0^1n$$
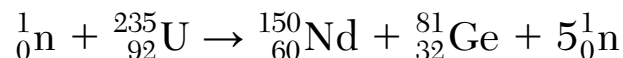
Germanium-81 and uranium-235 have different decay modes. Ge-81 emits beta particles and has a half-life of 7.6 seconds.

82 Explain, in terms of nuclides, why the reaction represented by the nuclear equation is a fission reaction.   [1]

83 State the number of protons and number of neutrons in a neodymium-150 atom.   [1]

84 Complete the equation *in your answer booklet* for the decay of Ge-81 by writing a notation for the missing nuclide.   [1]

85 Determine the time required for a 16.00-gram sample of Ge-81 to decay until only 1.00 gram of the sample remains unchanged.   [1]

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