The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Tuesday, August 20, 2024 — 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 two particles each have a mass approximately equal to one atomic mass unit?

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

2 As the electron in a hydrogen atom gains energy and moves from the first shell to the third shell, the hydrogen atom becomes an

(1) atom in an excited state
(2) atom in the ground state
(3) ion in an excited state
(4) ion in the ground state

3 Which phrase describes the protons and neutrons in atoms of two different isotopes of the same element?

(1) the same number of protons and the same number of neutrons
(2) the same number of protons and a different number of neutrons
(3) a different number of protons and the same number of neutrons
(4) a different number of protons and a different number of neutrons

4 Which phrase compares the properties and molecular structure of oxygen, $O_2(g)$, and ozone, $O_3(g)$?

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

5 Which phrase describes the composition of a compound?

(1) different elements physically combined
(2) different elements chemically combined
(3) the same element physically combined
(4) the same element chemically combined

6 Which quantity is conserved during all chemical reactions?

(1) density   (3) charge
(2) molecules   (4) temperature

7 At STP, a 5.0-gram sample of which substance contains metallic bonds?

(1) CO   (3) KI
(2) Fe   (4) Ne

8 When a cesium atom becomes a positive ion, there is a change in electron configuration and radius. Which statement describes this change?

(1) The atom gains an electron, and the radius increases.
(2) The atom gains an electron, and the radius decreases.
(3) The atom loses an electron, and the radius increases.
(4) The atom loses an electron, and the radius decreases.

9 Given the equation representing a reaction:

$$F + F \rightarrow F_2$$

Which statement describes the changes that occur during this reaction?

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

10 Which atom, in the ground state, has a stable valence electron configuration?

(1) Bi   (3) Pb
(2) Cs   (4) Rn

11 Which term represents the strength of attraction that an atom has for the electrons in a chemical bond?

(1) entropy
(2) electronegativity
(3) first ionization energy
(4) heat of reaction

12 Which phrase describes a sample of $NaCl(s)$?

(1) a mixture that has constant composition and properties throughout
(2) a mixture that varies in both composition and properties
(3) a substance that has constant composition and properties throughout
(4) a substance that varies in both composition and properties

13 Which substance contains only atoms with the same atomic number?

(1) ammonia   (3) methane
(2) selenium   (4) water

14 Differences in which property allow the separation of a mixture of 2-propanol and water by distillation at 1.0 atm?

(1) boiling point   (3) solubility
(2) freezing point   (4) electronegativity

15 At standard pressure, how do the freezing point and the boiling point of $H_2O(\ell)$ compare to the freezing point and the boiling point of 1.0 M $KCl(aq)$?

(1) Both the freezing point and boiling point of $H_2O(\ell)$ are lower.
(2) Both the freezing point and boiling point of $H_2O(\ell)$ are higher.
(3) The freezing point of $H_2O(\ell)$ is lower, and the boiling point of $H_2O(\ell)$ is higher.
(4) The freezing point of $H_2O(\ell)$ is higher, and the boiling point of $H_2O(\ell)$ is lower.

16 Which term represents a form of energy?

(1) molarity   (3) thermal
(2) temperature   (4) volume

17 Which sample of zinc has atoms with the highest average kinetic energy?

(1) 5.0 g of Zn at 40.°C
(2) 10. g of Zn at 30.°C
(3) 15 g of Zn at 20.°C
(4) 20. g of Zn at 10.°C

18 Under which conditions will a real gas behave more like an ideal gas?

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

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

(1) constantly move in circular paths
(2) have no attractive forces between them
(3) do not transfer energy when the particles collide
(4) are separated by small distances relative to their sizes

20 A reaction between two different gases is most likely to occur when the colliding molecules have the proper orientation and sufficient

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

21 Which statement describes a chemical reaction that has reached equilibrium?

(1) The reactants have been completely consumed.
(2) The reverse reaction has stopped.
(3) The concentrations of the products and reactants remain constant.
(4) The rate of the forward reaction is greater than the rate of the reverse reaction.

22 An enzyme acts as a catalyst to speed up a reaction by providing an alternate reaction pathway that has a

(1) higher activation energy
(2) lower activation energy
(3) higher heat of reaction
(4) lower heat of reaction

23 Which element has atoms that can bond together to form chains, rings, or networks?

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

24 A molecule of which compound contains an atom of nitrogen?

(1) 2-chloropropane   (3) 2-pentanone
(2) 1-propanol   (4) 1-propanamine

25 How many electrons are shared between the carbon atoms in a molecule of ethyne?

(1) 6   (3) 3
(2) 2   (4) 4

26 Which change takes place in the process of reduction?

(1) A neutron is lost.
(2) A neutron is gained.
(3) An electron is lost.
(4) An electron is gained.

27 The indicator methyl orange is red in an aqueous solution that has a pH value of

(1) 9.2   (3) 4.5
(2) 7.0   (4) 2.7

28 Which radioactive emissions are listed in order from greatest penetrating power to least penetrating power?

(1) alpha particle, beta particle, gamma radiation
(2) beta particle, gamma radiation, alpha particle
(3) gamma radiation, beta particle, alpha particle
(4) gamma radiation, alpha particle, beta particle

29 What is one benefit of a nuclear fission reaction?

(1) Fission reactants are hydrogen isotopes.
(2) Fission products must be stored indefinitely.
(3) Electrical energy can be produced using fission reactions.
(4) Workers in nuclear power plants can be exposed to radiation from fission reactions.

30 Which statement compares the relative amounts of energy released during a chemical reaction and a nuclear reaction when both reactions consume 1.0 mole of reactant?

(1) The chemical and nuclear reactions release equal amounts of energy.
(2) The nuclear reaction releases one half the amount of energy of the chemical reaction.
(3) The chemical reaction releases much more energy than the nuclear reaction.
(4) The nuclear reaction releases much more energy than the chemical reaction.

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 A student calculates the density of a sample of Fe to be 7.57 grams per cubic centimeter. Based on Table *S*, what is the percent error for the student's calculated density of Fe?

(1) −0.038%   (3) −3.8%
(2) −0.040%   (4) −4.0%

32 Based on Table *S*, which general trend is observed as the elements in Group 17 are considered in order of increasing atomic number from fluorine to iodine?

(1) increase in first ionization energy
(2) increase in boiling point
(3) decrease in melting point
(4) decrease in density

33 Given the equation representing a reaction:

$$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$$
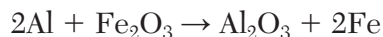
Which type of chemical reaction is represented by this equation?

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

34 At STP, which property can be used to differentiate a 2.0-gram sample of NaCl(s) from a 2.0-gram sample of AgCl(s)?
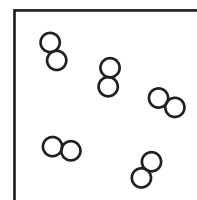
(1) mass   (3) phase
(2) solubility (4) temperature

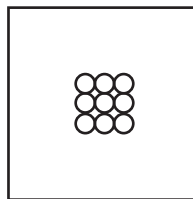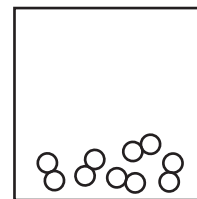35 Which particle model diagram represents a sample of neon at 35 K and 1.0 atmosphere?
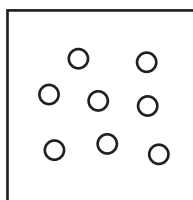
36 Which formula represents a molecule with the most polar bond?

(1) F_2 (3) HCl
(2) H_2 (4) HBr

37 What is the amount of heat that must be absorbed to increase the temperature of a 130.-gram sample of water from 20.0°C to 50.0°C?

(1) 3.90×10^3 J   (3) 4.34×10^4 J
(2) 1.63×10^4 J   (4) 2.94×10^5 J

38 A sealed, rigid cylinder contains 50. milliliters of argon gas, $Ar(g)$, at 1.0 atmosphere and 273 K. A second sealed, rigid cylinder contains helium gas, $He(g)$. Which conditions of volume, pressure, and temperature in the second cylinder would result in the number of helium atoms being equal to the number of argon atoms in the first cylinder?

(1) 50. mL, 0.5 atm, 546 K
(2) 50. mL, 1.0 atm, 273 K
(3) 100. mL, 0.5 atm, 546 K
(4) 100. mL, 1.0 atm, 273 K

39 Which equation represents a physical equilibrium?

(1) $CO_2(g) \rightleftharpoons CO_2(s)$
(2) $C(s) + O_2(g) \rightarrow CO_2(g)$
(3) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
(4) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

40 Given an equation representing a system at equilibrium:
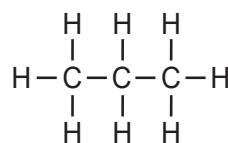
$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + energy$$
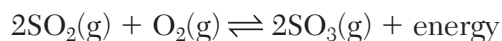
Which change occurs when the temperature is increased?

(1) The equilibrium shifts to the left and the concentration of $SO_3(g)$ decreases.
(2) The equilibrium shifts to the left and the concentration of $SO_3(g)$ increases.
(3) The equilibrium shifts to the right and the concentration of $SO_3(g)$ decreases.
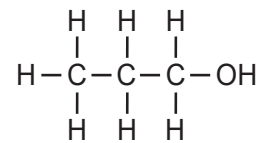(4) The equilibrium shifts to the right and the concentration of $SO_3(g)$ increases.

41 Which phase change results in an increase in disorder?

(1) $I_2(g) \rightarrow I_2(s)$
(2) $Cl_2(\ell) \rightarrow Cl_2(g)$
(3) $N_2O_4(g) \rightarrow N_2O_4(\ell)$
(4) $H_2O(\ell) \rightarrow H_2O(s)$

42 Which formula represents an unsaturated hydrocarbon?
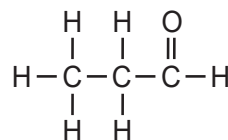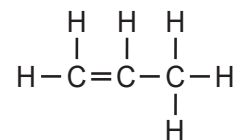
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   H  H  H                H  H  H
   |  |  |                |  |  |
H—C—C—C—H            H—C—C—C—OH
   |  |  |                |  |  |
   H  H  H                H  H  H
     (1)                    (3)

   H  H  O                H  H  H
   |  |  ||               |  |  |
H—C—C—C—H            H—C=C—C—H
   |  |                          |
   H  H                          H
     (2)                    (4)
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43 Given the incomplete equation for a fermentation reaction:

$$X \rightarrow 2CH_3CH_2OH + 2CO_2$$

Which formula represents the missing reactant, X, in this equation?

(1) $C_5H_6O_5$ (3) $C_6H_6O_6$
(2) $C_5H_{12}O_5$ (4) $C_6H_{12}O_6$

44 Which equation represents a combustion reaction?

(1) $Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$
(2) $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$
(3) $2K + 2H_2O \rightarrow 2KOH + H_2$
(4) $BaS + 2H_2O \rightarrow Ba(OH)_2 + H_2S$

45 Given the equation representing a reaction:

$$Cl_2(g) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(s)$$
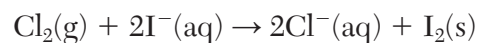
What is the number of moles of electrons gained by $Cl_2(g)$ when 2.0 moles of electrons are lost by $I^-(aq)$?

(1) 1.0 mol   (3) 3.0 mol
(2) 2.0 mol   (4) 4.0 mol

46 Which statement describes a 0.1 M NaOH(aq) solution?

    (1) The solution contains an Arrhenius acid and conducts electricity.
    (2) The solution contains an Arrhenius acid and does not conduct electricity.
    (3) The solution contains an Arrhenius base and conducts electricity.
    (4) The solution contains an Arrhenius base and does not conduct electricity.

47 A sample of LiOH(aq) has a concentration of 0.020 M. How many significant figures are used to express the concentration of this solution?

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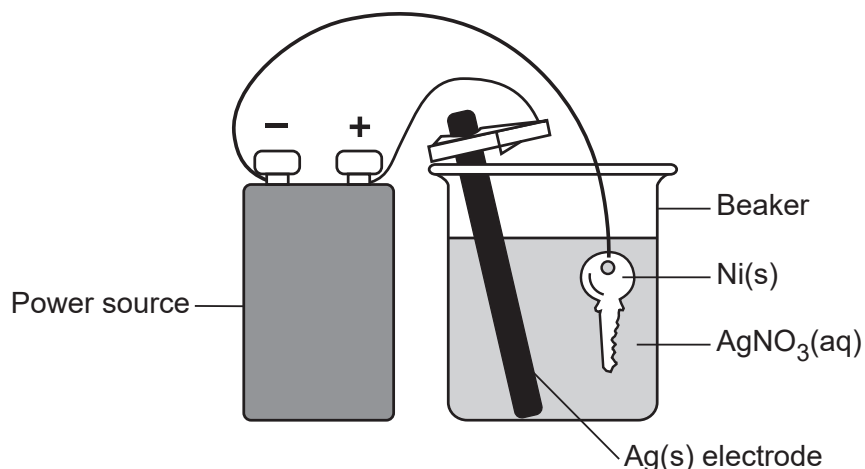   (2) 2   (4) 4

48 Given the balanced equation representing a reaction:

$$C_2H_5OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell) + energy$$

The mole ratio of oxygen molecules to carbon dioxide molecules is

    (1) 1:2   (3) 3:2
   (2) 1:3   (4) 3:3

49 The diagram below represents an operating cell that is used to plate silver onto a nickel key.

Which statement describes the reaction that occurs inside the beaker?

    (1) A spontaneous reaction converts electrical energy to chemical energy.
    (2) A spontaneous reaction converts chemical energy to electrical energy.
    (3) A nonspontaneous reaction uses electrical energy to produce a chemical change.
    (4) A nonspontaneous reaction uses chemical change to produce electrical energy.

50 Given the equation representing an equilibrium:

$$HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$$
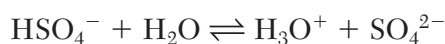
Which two formulas represent the H^+ acceptors in this equilibrium?

    (1) HSO_4^- and H_3O^+ (3) H_2O and H_3O^+
    (2) H_2O and SO_4^{2-} (4) HSO_4^- and SO_4^{2-}

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 Lewis electron-dot diagram for a molecule of ammonia. [1]

Base your answers to questions 52 and 53 on the information below and on your knowledge of chemistry.

The table below gives the atomic mass and the natural abundance of the two naturally occurring isotopes of copper.

Naturally Occurring Isotopes of Copper

Isotope	Atomic Mass (u)	Natural Abundance (%)
Cu-63	62.93	69.15
Cu-65	64.93	30.85

52 Compare the energy of an electron in the first shell of a copper atom in the ground state to the energy of an electron in the second shell of the same atom in the ground state. [1]

53 Show a numerical setup for calculating the atomic mass of copper. [1]

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

The elements on the Periodic Table vary in their properties. The placement or locations of elements in Period 2 give an indication of the physical and chemical properties of these elements.

54 Identify the element in Period 2 that is classified as a metalloid. [1]

55 Identify the element in Period 2 that requires the *least* amount of energy to remove the most loosely held electrons from a mole of gaseous atoms of the element in the ground state. [1]

56 State the general trend in atomic radius as the elements in Period 2 are considered in order of increasing atomic number. [1]

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

An aqueous solution of lead(II) nitrate reacts with an aqueous solution of potassium iodide in a test tube. The reaction produces a yellow solid that settles to the bottom of the test tube. The unbalanced equation for this reaction is shown below.

$$Pb(NO_3)_2(aq) + KI(aq) \rightarrow PbI_2(s) + KNO_3(aq)$$
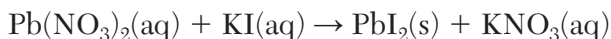
57 Balance the equation *in your answer booklet* for this reaction, using the *smallest* whole-number coefficients. [1]

58 Write a chemical name for the aqueous product. [1]

59 Determine the gram-formula mass of the yellow solid compound produced by the reaction. [1]

_____

Base your answers to questions 60 through 62 on the information below and on your knowledge of chemistry.

The vapor pressures of four liquids at various temperatures are given in Table *H*.

60 Identify the substance on Table *H* with the *weakest* intermolecular forces at 40.°C. [1]

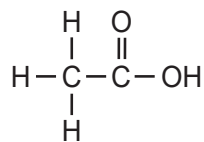61 Determine the vapor pressure of ethanoic acid at standard pressure and 50.°C. [1]

62 Explain, in terms of charge distribution, why water is a polar molecule. [1]

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Base your answers to questions 63 through 65 on the information below and on your knowledge of chemistry.

Molecule *A* and molecule *B* are represented by the formulas below.
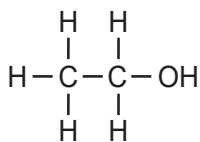
Molecule A   Molecule B

63 Identify the class of organic compound to which molecule *A* belongs. [1]

64 Draw a structural formula for dimethyl ether, the isomer of molecule *A*. [1]

65 Write a chemical name for the compound represented by molecule *B*. [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 student investigated the relative chemical activity of four metals by placing one piece of each metal in aqueous nitrate solutions of each of the four metals. The observations from the investigation are shown in the table below.

Observations of Four Metals

| Metal | Color of Metal | Compound in Aqueous Solution | | | |
		$Cu(NO_3)_2(aq)$	$Mg(NO_3)_2(aq)$	$Zn(NO_3)_2(aq)$	$AgNO_3(aq)$
Cu	red	no reaction	no reaction	no reaction	black solid appears
Mg	silver-white	gray solid appears	no reaction	gray solid appears	black solid appears
Zn	blue-white	black solid appears	no reaction	no reaction	black solid appears
Ag	silver	no reaction	no reaction	no reaction	no reaction

The student wanted to use information from this investigation to make an operating voltaic cell using a zinc electrode and a $Zn(NO_3)_2(aq)$ solution in one of the half-cells.

66 Identify the most active metal and the least active metal used in this investigation. [1]

67 Determine the oxidation state of nitrogen in the $AgNO_3(aq)$ solution. [1]

68 Write a balanced half-reaction equation for the oxidation of the zinc during this investigation. [1]

69 Identify a metal, in this investigation, that could be used as the cathode in the other half-cell in the student's voltaic cell. [1]

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

A student investigated the properties of solutions by dissolving 46.0 grams of $NH_4Cl(s)$ in 200. grams of water at 20.°C. The gram-formula mass of $NH_4Cl(s)$ is 53.5 grams per mole. The temperature of the solution decreased as the $NH_4Cl(s)$ dissolved. During this laboratory activity, appropriate safety equipment was used and safety procedures were followed.

70 State, in terms of temperature, why the dissolving of the $NH_4Cl(s)$ is classified as an endothermic process.   [1]

71 Classify, in terms of saturation, the type of solution produced in this investigation.   [1]

72 Based on Table *G*, identify the solute that has a solubility at 20.°C that is closest to the solubility of $NH_4Cl(s)$ at 20.°C.   [1]

73 Determine the number of moles of $NH_4Cl(s)$ dissolved in the 200. grams of water in this investigation.   [1]

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

The process of evaporation affects the concentration of ions in a sample of seawater. The table below shows the name and concentration of four different ions in a seawater sample. The concentrations are expressed in grams per 1000. grams of seawater.

**Concentration of Four Ions
in a Seawater Sample**

Ion	Concentration (g/1000. g of seawater)
bromide	0.067
chloride	19.33
potassium	0.394
sodium	10.53

74 Determine the concentration of potassium ions, in parts per million, in the sample of seawater. [1]

75 State what happens to the potential energy of the water molecules as they evaporate from a sample of the seawater. [1]

76 State how the concentration of ions in a sample of the seawater changes as some of the water evaporates from the seawater sample. [1]

77 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 bromide ion. [1]

Base your answers to questions 78 through 81 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 student performed three trials of a titration using 0.16 M KOH(aq) to determine the unknown concentration of a solution of hydrochloric acid, HCl(aq). The volumes of the solutions used are shown in the table below.

Titration Data

Trial	Volume of HCl(aq) (mL)	Volume of 0.16 M KOH(aq) (mL)
1	10.0	15.3
2	10.0	15.0
3	10.0	15.1

78 Identify the positive ion in the solution of hydrochloric acid. [1]

79 Complete the equation *in your answer booklet* for the reaction that occurs during this titration by writing a formula for *each* product. [1]

80 Show a numerical setup for calculating the molarity of the HCl(aq) solution using the titration data from trial 2. [1]

81 Explain, in terms of experimental design, why it is better to use data from multiple trials of a titration to determine the molarity of the acid than to use the data from only one trial of the titration. [1]

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

Scientists can produce useful radioisotopes of the lighter elements by bombarding atoms with neutrons. Tritium, $^{3}_{1}H$, can be produced by bombarding a nuclide represented by X as shown by the incomplete equation below.

$$X + {}^{1}_{0}n \rightarrow {}^{3}_{1}H + {}^{4}_{2}He$$
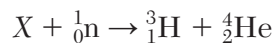
82 State the neutron to proton ratio in the $^{4}_{2}He$ product of the reaction.   [1]

83 Based on Table N, state the decay mode of tritium.   [1]

84 Determine the time required for a 1.00-gram sample of the $^{3}_{1}H$ produced to decay until 0.25 gram of the sample remains unchanged.   [1]

85 Complete the nuclear equation *in your answer booklet* for this reaction by writing a notation for the missing reactant.   [1]

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