**The University of the State of New York**

**REGENTS HIGH SCHOOL EXAMINATION**

# PHYSICAL SETTING
# CHEMISTRY

**Wednesday,** January 29, 2014 — 1:15 to 4:15 p.m., only

**The possession or use of any communications device is strictly prohibited when taking this examination. If you have or use any communications device, no matter how briefly, your examination will be invalidated and no score will be calculated for you.**

**This is a test of your knowledge of chemistry. Use that knowledge to answer all questions in this examination. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*. You are to answer *all* questions in all parts of this examination according to the directions provided in this examination booklet.**

**A separate answer sheet for Part A and Part B–1 has been provided to you. Follow the instructions from the proctor for completing the student information on your answer sheet. Record your answers to the Part A and Part B–1 multiple-choice questions on this separate answer sheet. Record your answers for the questions in Part B–2 and Part C in your separate answer booklet. Be sure to fill in the heading on the front of your answer booklet.**

**All answers in your answer booklet should be written in pen, except for graphs and drawings, which should be done in pencil. You may use scrap paper to work out the answers to the questions, but be sure to record all your answers on your separate answer sheet or in your answer booklet as directed.**

**When you have completed the examination, you must sign the statement printed on your separate answer sheet, indicating that you had no unlawful knowledge of the questions or answers prior to the examination and that you have neither given nor received assistance in answering any of the questions during the examination. Your answer sheet and answer booklet cannot be accepted if you fail to sign this declaration.**

**Notice. . .**

**A four-function or scientific calculator and a copy of the *2011 Edition Reference Tables for Physical Setting/Chemistry* must be available for you to use while taking this examination.**

**DO NOT 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 What is the approximate mass of a proton?

(1) 1 u
(2) 0.0005 u
(3) 1 g
(4) 0.0005 g

2 An electron in a sodium atom gains enough energy to move from the second shell to the third shell. The sodium atom becomes

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

3 Which particle has *no* charge?

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

4 Which quantity represents the number of protons in an atom?

(1) atomic number
(2) oxidation number
(3) number of neutrons
(4) number of valence electrons

5 The element sulfur is classified as a

(1) metal
(2) metalloid
(3) nonmetal
(4) noble gas

6 The elements in Group 2 have similar chemical properties because each atom of these elements has the same

(1) atomic number
(2) mass number
(3) number of electron shells
(4) number of valence electrons

7 What is formed when two atoms of bromine bond together?

(1) a monatomic molecule
(2) a diatomic molecule
(3) a heterogeneous mixture
(4) a homogeneous mixture

8 Gold can be flattened into an extremely thin sheet. The malleability of gold is due to the

(1) radioactive decay mode of the isotope Au-198
(2) proton-to-neutron ratio in an atom of gold
(3) nature of the bonds between gold atoms
(4) reactivity of gold atoms

9 Which term represents the attraction one atom has for the electrons in a bond with another atom?

(1) electronegativity
(2) electrical conductivity
(3) first ionization energy
(4) mechanical energy

10 Salt water is classified as a

(1) compound because the proportion of its atoms is fixed
(2) compound because the proportion of its atoms can vary
(3) mixture because the proportion of its components is fixed
(4) mixture because the proportion of its components can vary

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

(1) ammonia
(2) arsenic
(3) ethane
(4) propanal

12 Some physical properties of two samples of iodine-127 at two different temperatures are shown in the table below.

**Selected Physical Properties of Iodine-127 Samples at 1 atm**

| Sample | Sample Temperature (K) | Description | Density ($g/cm^3$) |
|---|---|---|---|
| 1 | 298 | dark-gray crystals | 4.933 |
| 2 | 525 | dark-purple gas | 0.006 |

These two samples are two different

(1) mixtures
(2) substances
(3) phases of matter
(4) isotopes of iodine

13 Powdered iron is magnetic, but powdered sulfur is *not*. What occurs when they form a mixture in a beaker at room temperature?

(1) The iron retains its magnetic properties.
(2) The iron loses its metallic properties.
(3) The sulfur gains magnetic properties.
(4) The sulfur gains metallic properties.

14 Which property is a measure of the average kinetic energy of the particles in a sample of matter?

(1) mass
(2) density
(3) pressure
(4) temperature

15 According to the kinetic molecular theory, which statement describes the particles of an ideal gas?

(1) The gas particles are arranged in a regular pattern.
(2) The force of attraction between the gas particles is strong.
(3) The gas particles are hard spheres in continuous circular motion.
(4) The collisions of the gas particles may result in the transfer of energy.

16 The concentration of a solution can be expressed in

(1) milliliters per minute
(2) parts per million
(3) grams per kelvin
(4) joules per gram

17 Two hydrogen atoms form a hydrogen molecule when

(1) one atom loses a valence electron to the other atom
(2) one atom shares four electrons with the other atom
(3) the two atoms collide and both atoms gain energy
(4) the two atoms collide with sufficient energy to form a bond

18 Which type of formula represents the simplest whole-number ratio of atoms of the elements in a compound?

(1) molecular formula
(2) condensed formula
(3) empirical formula
(4) structural formula

19 The coefficients in a balanced chemical equation represent

(1) the mass ratios of the substances in the reaction
(2) the mole ratios of the substances in the reaction
(3) the total number of electrons in the reaction
(4) the total number of elements in the reaction

20 Systems in nature tend to undergo changes toward

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

21 Which formula represents an organic compound?

(1) $CaH_2$ (3) $H_2O_2$
(2) $C_4H_8$ (4) $P_2O_5$

22 Which class of organic compounds contains nitrogen?

(1) aldehyde (3) amine
(2) alcohol (4) ether

23 Which term identifies a type of organic reaction?

(1) deposition (3) esterification
(2) distillation (4) sublimation

24 Which compound is classified as a hydrocarbon?

(1) butanal (3) 2-butanol
(2) butyne (4) 2-butanone

25 In an oxidation-reduction reaction, the number of electrons lost is

(1) equal to the number of electrons gained
(2) equal to the number of protons gained
(3) less than the number of electrons gained
(4) less than the number of protons gained

26 Which substance is an electrolyte?

(1) $C_6H_{12}O_6(s)$ (3) NaOH(s)
(2) $C_2H_5OH(\ell)$ (4) $H_2(g)$

27 Which energy conversion must occur in an operating electrolytic cell?

(1) electrical energy to chemical energy
(2) electrical energy to nuclear energy
(3) chemical energy to electrical energy
(4) chemical energy to nuclear energy

28 Which compound yields $H^+$ ions as the only positive ions in an aqueous solution?

(1) KOH (3) $CH_3OH$
(2) NaOH (4) $CH_3COOH$

29 Which statement describes the relative masses of two different particles?

(1) A neutron has less mass than a positron.
(2) A beta particle has less mass than a neutron.
(3) An alpha particle has less mass than a positron.
(4) An alpha particle has less mass than a beta particle.

30 Which term represents a type of nuclear reaction?

(1) condensation
(2) vaporization
(3) single replacement
(4) natural transmutation

## 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 ion has the *smallest* radius?

(1) $O^{2-}$
(2) $S^{2-}$
(3) $Se^{2-}$
(4) $Te^{2-}$

32 Equal amounts of ethanol and water are mixed at room temperature and at 101.3 kPa. Which process is used to separate ethanol from the mixture?

(1) distillation
(2) reduction
(3) filtration
(4) ionization

33 A sample of a substance has these characteristics:

- melting point of 984 K
- hard, brittle solid at room temperature
- poor conductor of heat and electricity as a solid
- good conductor of electricity as a liquid or in an aqueous solution

This sample is classified as

(1) a metallic element
(2) a radioactive element
(3) a molecular compound
(4) an ionic compound

34 Given the balanced equation representing a reaction:

$$N_2 + \text{energy} \rightarrow N + N$$

Which statement describes this reaction?

(1) Bonds are broken, and the reaction is endothermic.
(2) Bonds are broken, and the reaction is exothermic.
(3) Bonds are formed, and the reaction is endothermic.
(4) Bonds are formed, and the reaction is exothermic.

35 When lithium reacts with bromine to form the compound LiBr, each lithium atom

(1) gains one electron and becomes a negatively charged ion
(2) gains three electrons and becomes a negatively charged ion
(3) loses one electron and becomes a positively charged ion
(4) loses three electrons and becomes a positively charged ion

36 A beaker with water and the surrounding air are all at 24°C. After ice cubes are placed in the water, heat is transferred from

(1) the ice cubes to the air
(2) the beaker to the air
(3) the water to the ice cubes
(4) the water to the beaker

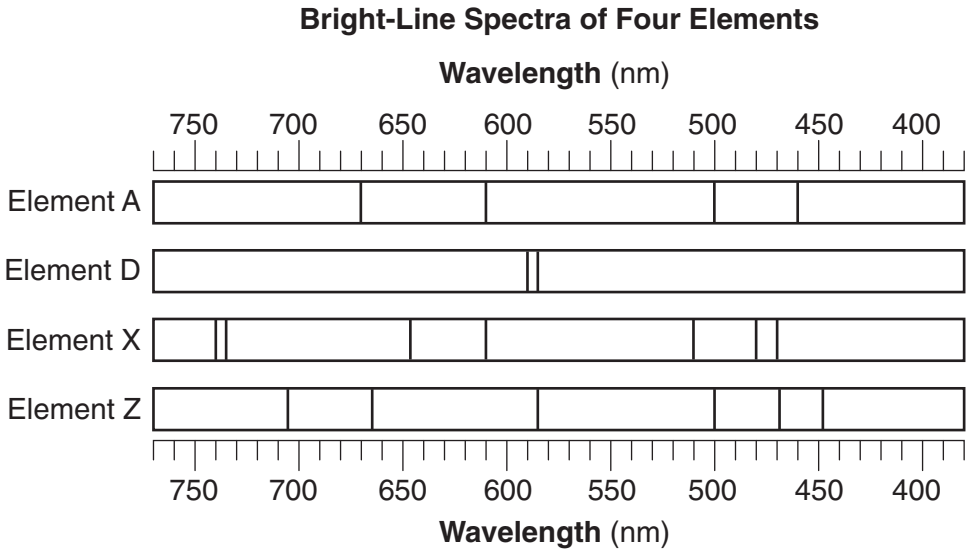
37 A sample of chlorine gas is at 300. K and 1.00 atmosphere. At which temperature and pressure would the sample behave more like an ideal gas?

(1) 0 K and 1.00 atm
(2) 150. K and 0.50 atm
(3) 273 K and 1.00 atm
(4) 600. K and 0.50 atm

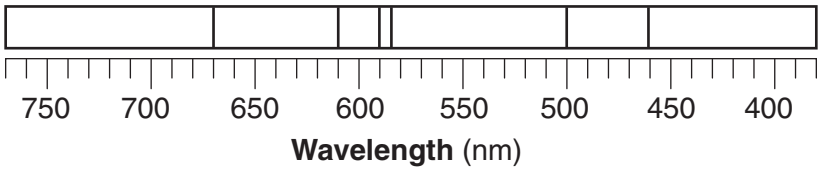
38 When a sample of a gas is heated in a sealed, rigid container from 200. K to 400. K, the pressure exerted by the gas is

(1) decreased by a factor of 2
(2) increased by a factor of 2
(3) decreased by a factor of 200.
(4) increased by a factor of 200.

39 The bright-line spectra produced by four elements are represented in the diagram below.



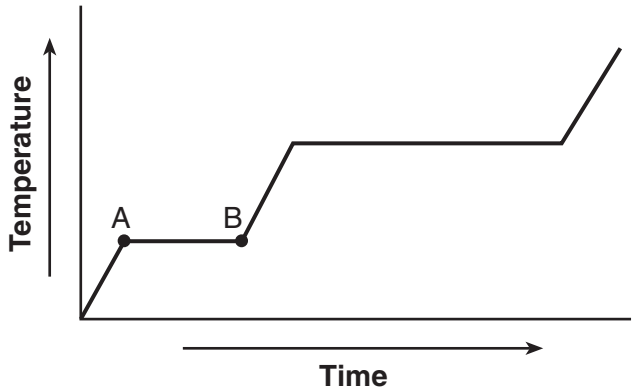

Given the bright-line spectrum of a mixture formed from two of these elements:




Which elements are present in this mixture?

(1) *A* and *D*
(2) *A* and *X*
(3) *Z* and *D*
(4) *Z* and *X*

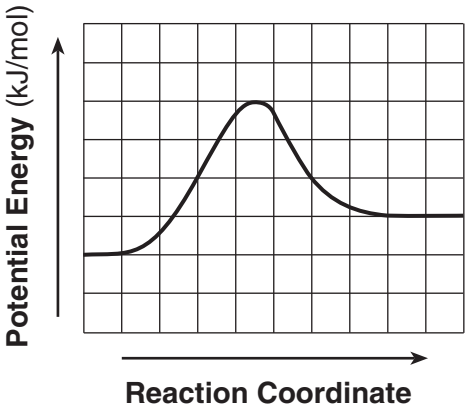
40 The graph below represents the relationship between time and temperature as heat is added at a constant rate to a sample of a substance.




During interval *AB*, which energy change occurs for the particles in this sample?

(1) The potential energy of the particles increases.
(2) The potential energy of the particles decreases.
(3) The average kinetic energy of the particles increases.
(4) The average kinetic energy of the particles decreases.

41 Given the potential energy diagram for a reversible chemical reaction:




Each interval on the axis labeled "Potential Energy (kJ/mol)" represents 10. kilojoules per mole. What is the activation energy of the forward reaction?

(1) 10. kJ/mol
(2) 30. kJ/mol
(3) 40. kJ/mol
(4) 60. kJ/mol

42 Which condensed structural formula represents an unsaturated compound?

(1) $CH_3CHCHCH_3$
(2) $CH_3CH_2CH_3$
(3) $CH_3CH_3$
(4) $CH_4$

43 Which element reacts spontaneously with 1.0 M HCl(aq) at room temperature?

(1) copper
(2) gold
(3) silver
(4) zinc

44 Given the balanced ionic equation:

$$3Pb^{2+}(aq) + 2Cr(s) \rightarrow 3Pb(s) + 2Cr^{3+}(aq)$$

What is the number of moles of electrons gained by 3.0 moles of lead ions?

(1) 5.0 mol
(2) 2.0 mol
(3) 3.0 mol
(4) 6.0 mol

45 What is the amount of heat energy released when 50.0 grams of water is cooled from 20.0°C to 10.0°C?

(1) $5.00 \times 10^2$ J
(2) $2.09 \times 10^3$ J
(3) $1.67 \times 10^5$ J
(4) $1.13 \times 10^6$ J

46 What occurs at one of the electrodes in both an electrolytic cell and a voltaic cell?

(1) Oxidation occurs as electrons are gained at the cathode.
(2) Oxidation occurs as electrons are lost at the anode.
(3) Reduction occurs as electrons are gained at the anode.
(4) Reduction occurs as electrons are lost at the cathode.

47 Given the balanced equation representing a reaction:

$$H_2O(\ell) + HCl(g) \rightarrow H_3O^+(aq) + Cl^-(aq)$$

According to one acid-base theory, the $H_2O(\ell)$ molecules

(1) accept $H^+$ ions
(2) accept $OH^-$ ions
(3) donate $H^+$ ions
(4) donate $OH^-$ ions

48 When an atom of the unstable isotope Na-24 decays, it becomes an atom of Mg-24 because the Na-24 atom spontaneously releases

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

49 Which balanced equation represents nuclear fusion?

(1) ${}^{3}_{1}H \rightarrow {}^{3}_{2}He + {}^{0}_{-1}e$
(2) ${}^{235}_{92}U \rightarrow {}^{231}_{90}Th + {}^{4}_{2}He$
(3) ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He$
(4) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{90}_{38}Sr + {}^{143}_{54}Xe + 3{}^{1}_{0}n$

50 Which reaction releases the greatest amount of energy per kilogram of reactants?

(1) ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$
(2) $2C + H_2 \rightarrow C_2H_2$
(3) $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$
(4) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(\ell)$

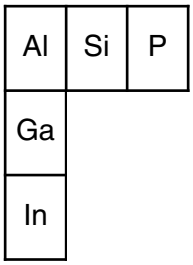
## Part B–2

**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 54 on the information below and on your knowledge of chemistry.

The diagram below represents three elements in Group 13 and three elements in Period 3 and their relative positions on the Periodic Table.




Some elements in the solid phase exist in different forms that vary in their physical properties. For example, at room temperature, red phosphorus has a density of 2.16 g/cm$^3$ and white phosphorus has a density of 1.823 g/cm$^3$.

51 Identify the element from the diagram that will react with chlorine to form a compound with the general formula $XCl_4$. [1]

52 Consider the Period 3 elements in the diagram in order of increasing atomic number. State the trend in electronegativity for these elements. [1]

53 Compare the number of atoms per cubic centimeter in red phosphorus with the number of atoms per cubic centimeter in white phosphorus. [1]

54 Identify *one* element from the diagram that will combine with phosphorus in the same ratio of atoms as the ratio in aluminum phosphide. [1]

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

The compounds $KNO_3$ and $NaNO_3$ are soluble in water.

55 Compare the entropy of 30. grams of solid $KNO_3$ at 20.°C with the entropy of 30. grams of $KNO_3$ dissolved in 100. grams of water at 20.°C. [1]

56 Explain why the total thermal energy of a sample containing 22.2 grams of $NaNO_3$ dissolved in 200. grams of water at 20.°C is greater than the total thermal energy of a sample containing 11.1 grams of $NaNO_3$ dissolved in 100. grams of water at 20.°C. [1]

57 Compare the boiling point of a $NaNO_3$ solution at standard pressure to the boiling point of water at standard pressure. [1]

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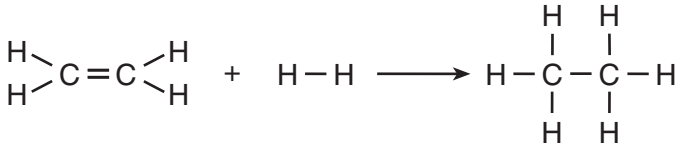
Base your answers to questions 58 through 61 on the information below and on your knowledge of chemistry.

Ethene and hydrogen can react at a faster rate in the presence of the catalyst platinum. The equation below represents a reaction between ethene and hydrogen.



58 Determine the molar mass of the product. [1]

59 State the number of electrons shared between the carbon atoms in one molecule of the reactant ethene. [1]

60 Explain, in terms of activation energy, why the catalyzed reaction occurs at a faster rate. [1]

61 Explain why the reaction is classified as an addition reaction. [1]

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Base your answers to questions 62 and 63 on the information below and on your knowledge of chemistry.

In a titration, 50.0 milliliters of 0.026 M HCl(aq) is neutralized by 38.5 milliliters of KOH(aq).

62 In the space *in your answer booklet*, show a numerical setup for calculating the molarity of the KOH(aq). [1]

63 Complete the equation *in your answer booklet* for the neutralization by writing the formula of the missing product. [1]

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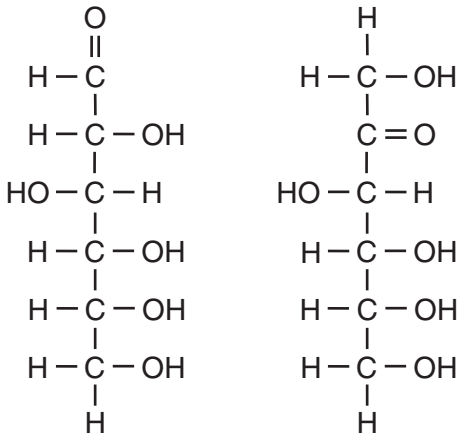
Base your answers to questions 64 and 65 on the information below and on your knowledge of chemistry.

Table sugar, sucrose, is a combination of two simple sugars, glucose and fructose. The formulas below represent these simple sugars.




64 Identify the functional group that appears more than once in the fructose molecule. [1]

65 Explain, in terms of atoms and molecular structure, why glucose and fructose are isomers of each other. [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 70 on the information below and on your knowledge of chemistry.

Baking soda, $NaHCO_3$, can be commercially produced during a series of chemical reactions called the Solvay process. In this process, $NH_3(aq)$, NaCl(aq), and other chemicals are used to produce $NaHCO_3(s)$ and $NH_4Cl(aq)$.

To reduce production costs, $NH_3(aq)$ is recovered from $NH_4Cl(aq)$ through a different series of reactions. This series of reactions can be summarized by the overall reaction represented by the unbalanced equation below.

$$NH_4Cl(aq) + CaO(s) \rightarrow NH_3(aq) + H_2O(\ell) + CaCl_2(aq)$$

66 Write a chemical name for baking soda. [1]

67 Determine the percent composition by mass of carbon in baking soda (gram-formula mass = 84 grams per mole). [1]

68 State the color of bromcresol green in a sample of $NH_3(aq)$. [1]

69 Determine the mass of $NH_4Cl$ that must be dissolved in 100. grams of $H_2O$ to produce a saturated solution at 70.°C. [1]

70 Balance the equation *in your answer booklet* for the overall reaction used to recover $NH_3(aq)$, using the smallest whole-number coefficients. [1]

Base your answers to questions 71 through 75 on the information below and on your knowledge of chemistry.

Rubbing alcohol is a product available at most pharmacies and supermarkets. One rubbing alcohol solution contains 2-propanol and water. The boiling point of 2-propanol is 82.3°C at standard pressure.

71 Explain, in terms of electronegativity differences, why a C — O bond is more polar than a C — H bond. [1]

72 Identify a strong intermolecular force of attraction between an alcohol molecule and a water molecule in the solution. [1]

73 Determine the vapor pressure of water at a temperature equal to the boiling point of the 2-propanol. [1]

74 Explain, in terms of charge distribution, why a molecule of the 2-propanol is a polar molecule. [1]

75 In the space *in your answer booklet*, draw a structural formula for the 2-propanol. [1]

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Base your answers to questions 76 and 77 on the information below and on your knowledge of chemistry.

Silver-plated utensils were popular before stainless steel became widely used to make eating utensils. Silver tarnishes when it comes in contact with hydrogen sulfide, $H_2S$, which is found in the air and in some foods. However, stainless steel does *not* tarnish when it comes in contact with hydrogen sulfide.

76 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for the compound that tarnishes silver. [1]

77 In the ground state, an atom of which noble gas has the same electron configuration as the sulfide ion in $Ag_2S$? [1]

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

Common household bleach is an aqueous solution containing hypochlorite ions. A closed container of bleach is an equilibrium system represented by the equation below.

$$Cl_2(g) + 2OH^-(aq) \rightleftharpoons ClO^-(aq) + Cl^-(aq) + H_2O(\ell)$$

78 Compare the rate of the forward reaction to the rate of the reverse reaction for this system. [1]

79 State the change in oxidation number for chlorine when the $Cl_2(g)$ changes to $Cl^-(aq)$ during the forward reaction. [1]

80 Explain why the container must be closed to maintain equilibrium. [1]

81 State the effect on the concentration of the $ClO^-$ ion when there is a *decrease* in the concentration of the $OH^-$ ion. [1]

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

Iodine has many isotopes, but only iodine-127 is stable and is found in nature. One radioactive iodine isotope, I-108, decays by alpha particle emission. Iodine-131 is also radioactive and has many important medical uses.

82 Determine the number of neutrons in an atom of I-127. [1]

83 Explain, in terms of protons and neutrons, why I-127 and I-131 are different isotopes of iodine. [1]

84 Complete the equation *in your answer booklet* for the nuclear decay of I-108. [1]

85 Determine the total time required for an 80.0-gram sample of I-131 to decay until only 1.25 grams of the sample remains unchanged. [1]

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