

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

**PHYSICAL SETTING
CHEMISTRY**

Tuesday, June 18, 2013 — 9:15 a.m. to 12:15 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*.

- According to the wave-mechanical model of the atom, an orbital is a region of the most probable location of
 - an alpha particle
 - a gamma ray
 - an electron
 - a proton
- Which particles have approximately the same mass?
 - an electron and an alpha particle
 - an electron and a proton
 - a neutron and an alpha particle
 - a neutron and a proton
- During a flame test, a lithium salt produces a characteristic red flame. This red color is produced when electrons in excited lithium atoms
 - are lost by the atoms
 - are gained by the atoms
 - return to lower energy states within the atoms
 - move to higher energy states within the atoms
- Compared to the energy and charge of the electrons in the first shell of a Be atom, the electrons in the second shell of this atom have
 - less energy and the same charge
 - less energy and a different charge
 - more energy and the same charge
 - more energy and a different charge
- Which quantity can vary among atoms of the same element?
 - mass number
 - atomic number
 - number of protons
 - number of electrons
- Which substances have atoms of the same element but different molecular structures?
 - He(g) and Ne(g)
 - O₂(g) and O₃(g)
 - K(s) and Na(s)
 - P₄(s) and S₈(s)
- An atom that has 13 protons and 15 neutrons is an isotope of the element
 - nickel
 - silicon
 - aluminum
 - phosphorus
- Which elements have the most similar chemical properties?
 - Si, As, and Te
 - N₂, O₂, and F₂
 - Mg, Sr, and Ba
 - Ca, Cs, and Cu
- Which list includes three types of chemical formulas for organic compounds?
 - covalent, metallic, isotopic
 - covalent, metallic, molecular
 - empirical, structural, isotopic
 - empirical, structural, molecular
- In a bond between an atom of carbon and an atom of fluorine, the fluorine atom has a
 - weaker attraction for electrons
 - stronger attraction for electrons
 - smaller number of first-shell electrons
 - larger number of first-shell electrons
- A sample of CO₂(s) and a sample of CO₂(g) differ in their
 - chemical compositions
 - empirical formulas
 - molecular structures
 - physical properties

- 12 Which statement defines the temperature of a sample of matter?
- (1) Temperature is a measure of the total electromagnetic energy of the particles.
 - (2) Temperature is a measure of the total thermal energy of the particles.
 - (3) Temperature is a measure of the average potential energy of the particles.
 - (4) Temperature is a measure of the average kinetic energy of the particles.
- 13 For a chemical reaction, the difference between the potential energy of the products and the potential energy of the reactants is equal to the
- (1) heat of fusion
 - (2) heat of reaction
 - (3) activation energy of the forward reaction
 - (4) activation energy of the reverse reaction
- 14 Which equation represents sublimation?
- (1) $\text{Hg}(\ell) \rightarrow \text{Hg}(s)$
 - (2) $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(g)$
 - (3) $\text{NH}_3(g) \rightarrow \text{NH}_3(\ell)$
 - (4) $\text{CH}_4(\ell) \rightarrow \text{CH}_4(g)$
- 15 Which statement describes the particles of an ideal gas, based on the kinetic molecular theory?
- (1) The motion of the gas particles is orderly and circular.
 - (2) The gas particles have no attractive forces between them.
 - (3) The gas particles are larger than the distances separating them.
 - (4) As the gas particles collide, the total energy of the system decreases.
- 16 Two grams of potassium chloride are completely dissolved in a sample of water in a beaker. This solution is classified as
- (1) an element
 - (2) a compound
 - (3) a homogeneous mixture
 - (4) a heterogeneous mixture
- 17 Which compound has the strongest hydrogen bonding between its molecules?
- (1) HBr
 - (2) HCl
 - (3) HF
 - (4) HI
- 18 Powdered sulfur is yellow, and powdered iron is gray. When powdered sulfur and powdered iron are mixed at 20°C , the powdered iron
- (1) becomes yellow
 - (2) becomes a liquid
 - (3) remains ionic
 - (4) remains magnetic
- 19 An effective collision between reactant particles requires the particles to have the proper
- (1) charge and mass
 - (2) charge and orientation
 - (3) energy and mass
 - (4) energy and orientation
- 20 Which term is defined as a measure of the disorder of a system?
- (1) heat
 - (2) entropy
 - (3) kinetic energy
 - (4) activation energy
- 21 Which process is used to determine the concentration of an acid?
- (1) chromatography
 - (2) distillation
 - (3) electrolysis
 - (4) titration
- 22 The compounds CH_3OCH_3 and $\text{CH}_3\text{CH}_2\text{OH}$ have different functional groups. Therefore, these compounds have different
- (1) chemical properties
 - (2) gram-formula masses
 - (3) percent compositions by mass
 - (4) numbers of atoms per molecule
- 23 Which term identifies the half-reaction that occurs at the anode of an operating electrochemical cell?
- (1) oxidation
 - (2) reduction
 - (3) neutralization
 - (4) transmutation
- 24 During the operation of a voltaic cell, the cell produces
- (1) electrical energy spontaneously
 - (2) chemical energy spontaneously
 - (3) electrical energy nonspontaneously
 - (4) chemical energy nonspontaneously

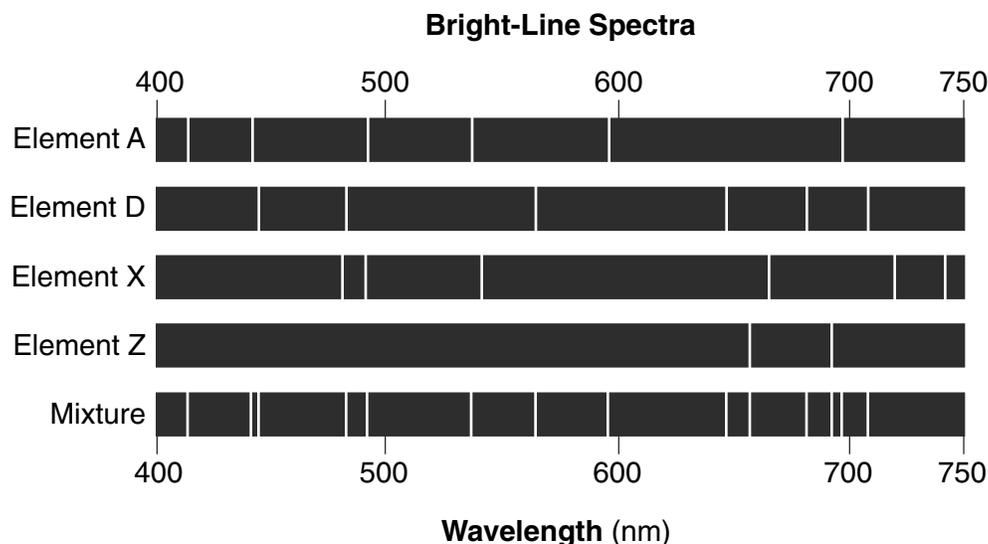
- 25 In which type of chemical reaction are electrons transferred?
- (1) organic addition
 - (2) oxidation-reduction
 - (3) double replacement
 - (4) acid-base neutralization
- 26 A substance that dissolves in water and produces hydronium ions as the only positive ions in the solution is classified as
- (1) an alcohol
 - (2) an acid
 - (3) a base
 - (4) a salt
- 27 According to one acid-base theory, a base is an
- (1) H^+ acceptor
 - (2) H^+ donor
 - (3) Na^+ acceptor
 - (4) Na^+ donor
- 28 Which compound is an electrolyte?
- (1) CCl_4
 - (2) CH_3OH
 - (3) $C_6H_{12}O_6$
 - (4) $Ca(OH)_2$
- 29 Which term identifies a type of nuclear reaction?
- (1) fermentation
 - (2) deposition
 - (3) reduction
 - (4) fission
- 30 Which radioisotopes have the same decay mode and have half-lives greater than 1 hour?
- (1) Au-198 and N-16
 - (2) Ca-37 and Fe-53
 - (3) I-131 and P-32
 - (4) Tc-99 and U-233
-

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 The diagram below represents the bright-line spectra of four elements and a bright-line spectrum produced by a mixture of three of these elements.



Which element is *not* present in the mixture?

- (1) A (3) X
(2) D (4) Z

- 32 What is the overall charge of an ion that has 12 protons, 10 electrons, and 14 neutrons?

- (1) 2- (3) 4-
(2) 2+ (4) 4+

- 33 As the elements in Period 3 are considered in order of increasing atomic number, there is a general *decrease* in

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

- 34 Which electron configuration represents the electrons of a sulfur atom in an excited state?

- (1) 2-6-6 (3) 2-8-4
(2) 2-7-7 (4) 2-8-6

- 35 Given the word equation:

sodium chlorate \rightarrow sodium chloride + oxygen

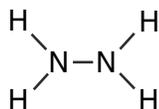
Which type of chemical reaction is represented by this equation?

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

36 Which compound has the highest percent composition by mass of strontium?

- (1) SrCl_2 (3) SrO
 (2) SrI_2 (4) SrS

37 Given the formula for hydrazine:



How many pairs of electrons are shared between the two nitrogen atoms?

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

38 Which formulas represent one ionic compound and one molecular compound?

- (1) N_2 and SO_2 (3) BaCl_2 and N_2O_4
 (2) Cl_2 and H_2S (4) NaOH and BaSO_4

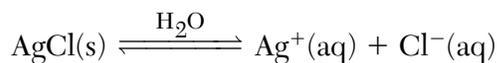
39 Which Kelvin temperature is equal to $200.^\circ\text{C}$?

- (1) -73 K (3) $200.\text{ K}$
 (2) 73 K (4) 473 K

40 A 10.0-gram sample of $\text{H}_2\text{O}(\ell)$ at 23.0°C absorbs 209 joules of heat. What is the final temperature of the $\text{H}_2\text{O}(\ell)$ sample?

- (1) 5.0°C (3) 28.0°C
 (2) 18.0°C (4) 50.0°C

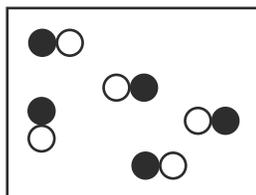
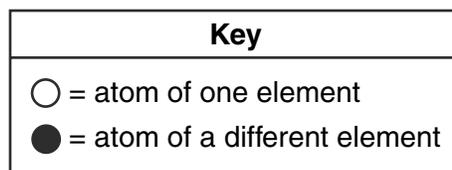
41 Given the equation representing a system at equilibrium:



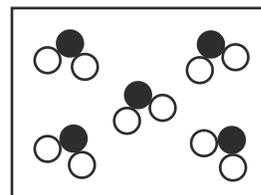
When the concentration of $\text{Cl}^-(\text{aq})$ is increased, the concentration of $\text{Ag}^+(\text{aq})$

- (1) decreases, and the amount of $\text{AgCl}(\text{s})$ increases
 (2) decreases, and the amount of $\text{AgCl}(\text{s})$ decreases
 (3) increases, and the amount of $\text{AgCl}(\text{s})$ increases
 (4) increases, and the amount of $\text{AgCl}(\text{s})$ decreases

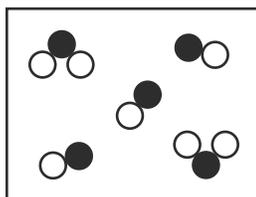
42 Which particle diagram represents a sample of matter that can *not* be broken down by chemical means?



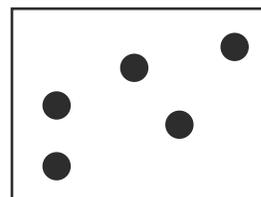
(1)



(3)

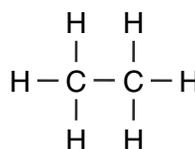


(2)

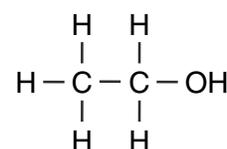


(4)

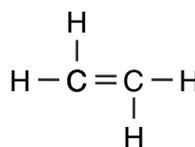
43 Which formula represents an unsaturated hydrocarbon?



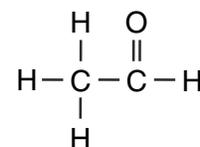
(1)



(3)



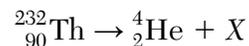
(2)



(4)

- 44 When the pH of a solution is changed from 4 to 3, the hydronium ion concentration of the solution
- (1) decreases by a factor of 10
 - (2) increases by a factor of 10
 - (3) decreases by a factor of 100
 - (4) increases by a factor of 100
- 45 Three samples of the same solution are tested, each with a different indicator. All three indicators, bromthymol blue, bromcresol green, and thymol blue, appear blue if the pH of the solution is
- (1) 4.7
 - (2) 6.0
 - (3) 7.8
 - (4) 9.9
- 46 A 10.0-milliliter sample of NaOH(aq) is neutralized by 40.0 milliliters of 0.50 M HCl. What is the molarity of the NaOH(aq)?
- (1) 1.0 M
 - (2) 2.0 M
 - (3) 0.25 M
 - (4) 0.50 M
- 47 Radiation is spontaneously emitted from hydrogen-3 nuclei, but radiation is *not* spontaneously emitted from hydrogen-1 nuclei or hydrogen-2 nuclei. Which hydrogen nuclei are stable?
- (1) nuclei of H-1 and H-2, only
 - (2) nuclei of H-1 and H-3, only
 - (3) nuclei of H-2 and H-3, only
 - (4) nuclei of H-1, H-2, and H-3

- 48 Given the equation representing a nuclear reaction in which X represents a nuclide:



Which nuclide is represented by X?

- (1) ${}_{92}^{236}\text{Ra}$
 - (2) ${}_{88}^{228}\text{Ra}$
 - (3) ${}_{92}^{236}\text{U}$
 - (4) ${}_{88}^{228}\text{U}$
- 49 After decaying for 48 hours, $\frac{1}{16}$ of the original mass of a radioisotope sample remains unchanged. What is the half-life of this radioisotope?
- (1) 3.0 h
 - (2) 9.6 h
 - (3) 12 h
 - (4) 24 h
- 50 Which balanced equation represents nuclear fusion?
- (1) ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^4_2\text{He}$
 - (2) $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
 - (3) ${}^6_3\text{Li} + {}^1_0\text{n} \rightarrow {}^3_1\text{H} + {}^4_2\text{He}$
 - (4) $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$

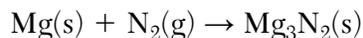
Part B-2

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.

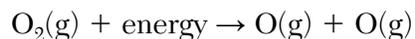
When magnesium is ignited in air, the magnesium reacts with oxygen and nitrogen. The reaction between magnesium and nitrogen is represented by the unbalanced equation below.



- 51 Balance the equation *in your answer booklet* for the reaction between magnesium and nitrogen, using the smallest whole-number coefficients. [1]
- 52 In the ground state, which noble gas has atoms with the same electron configuration as a magnesium ion? [1]
- 53 Explain, in terms of electrons, why an atom of the metal in this reaction forms an ion that has a smaller radius than its atom. [1]
-

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

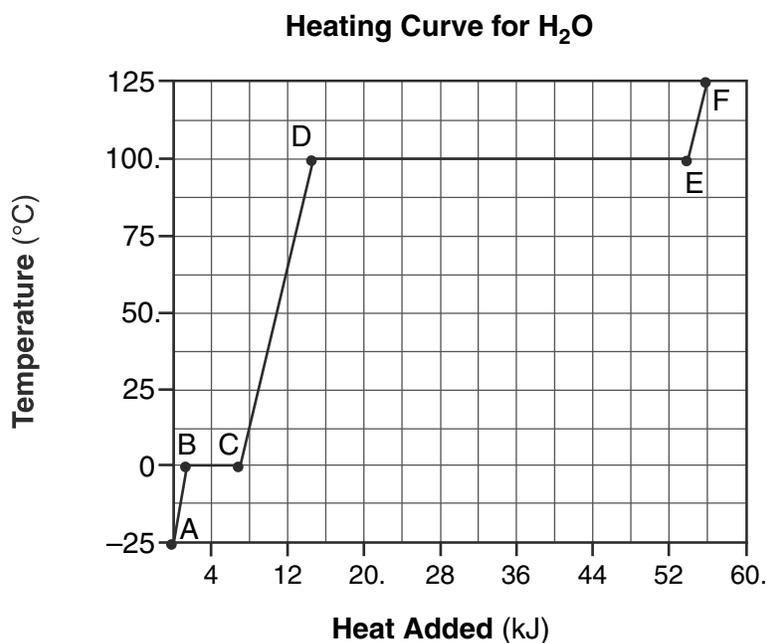
The balanced equation below represents a reaction.



- 54 Identify the type of chemical bond in a molecule of the reactant. [1]
- 55 In the space *in your answer booklet*, draw a Lewis electron-dot diagram of one oxygen atom. [1]
- 56 Explain, in terms of bonds, why energy is absorbed during this reaction. [1]
-

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

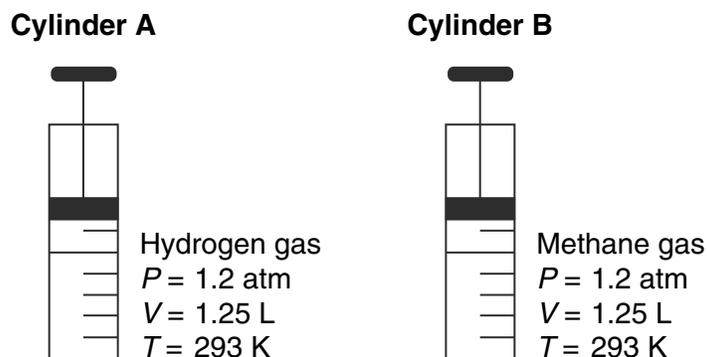
Starting as a solid at -25°C , a sample of H_2O is heated at a constant rate until the sample is at 125°C . This heating occurs at standard pressure. The graph below represents the relationship between temperature and heat added to the sample.



- 57 Describe what happens to *both* the potential energy and the average kinetic energy of the molecules in the H_2O sample during interval *AB*. [1]
- 58 Using the graph, determine the total amount of heat added to the sample during interval *CD*. [1]
- 59 Explain, in terms of heat of fusion and heat of vaporization, why the heat added during interval *DE* is greater than the heat added during interval *BC* for this sample of water. [1]
-

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

Cylinder A has a movable piston and contains hydrogen gas. An identical cylinder, B, contains methane gas. The diagram below represents these cylinders and the conditions of pressure, volume, and temperature of the gas in each cylinder.



- 60 Compare the total number of gas molecules in cylinder A to the total number of gas molecules in cylinder B. [1]
- 61 State a change in temperature and a change in pressure that will cause the gas in cylinder A to behave more like an ideal gas. [1]
- 62 In the space *in your answer booklet*, show a numerical setup for calculating the volume of the gas in cylinder B at STP. [1]
-

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

There are several isomers of C_6H_{14} . The formulas and boiling points for two of these isomers are given in the table below.

Isomer	Formula	Boiling Point at 1 atm ($^{\circ}C$)
1	<pre> H H H H H H H-C-C-C-C-C-C-H H H H H H H</pre>	68.7
2	<pre> H H-C-H H-C---C---C---C-H H H H H H-C-H H</pre>	49.7

63 Identify the homologous series to which these isomers belong. [1]

64 Write the empirical formula for isomer 1. [1]

65 Explain, in terms of intermolecular forces, why isomer 2 boils at a lower temperature than isomer 1. [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.

Before atomic numbers were known, Mendeleev developed a classification system for the 63 elements known in 1872, using oxide formulas and atomic masses. He used an R in the oxide formulas to represent any element in each group. The atomic mass was listed in parentheses after the symbol of each element. A modified version of Mendeleev's classification system is shown in the table below.

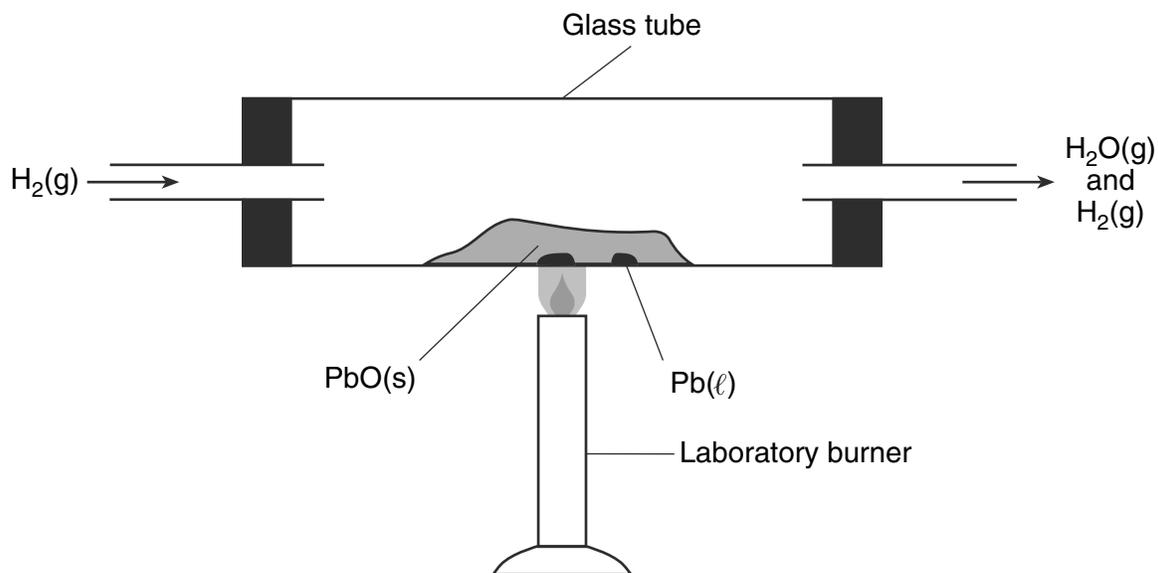
Modified Version of Mendeleev's Table

Group →	I	II	III	IV	V	VI	VII	
Oxide formulas	R_2O	RO	R_2O_3	RO_2	R_2O_5	RO_3	R_2O_7	
Series	1	H(1)						
	2	Li(7)	Be(9.4)	B(11)	C(12)	N(14)	O(16)	F(19)
	3	Na(23)	Mg(24)	Al(27.3)	Si(28)	P(31)	S(32)	Cl(35.5)
	4	K(39)	Ca(40)		Ti(48)	V(51)	Cr(52)	Mn(55)
	5	Cu(63)	Zn(65)			As(75)	Se(78)	Br(80)
	6	Rb(85)	Sr(87)	Yt(88)	Zr(90)	Nb(94)	Mo(96)	
	7	Ag(108)	Cd(112)	In(113)	Sn(118)	Sb(122)	Te(125)	I(127)
	8	Cs(133)	Ba(137)	Di(138)	Ce(140)			

- 66 Identify *one* characteristic used by Mendeleev to develop his classification system of the elements. [1]
- 67 Based on Mendeleev's oxide formula, what is the number of electrons lost by each atom of the elements in Group III? [1]
- 68 Based on Table J, identify the *least* active metal listed in Group I on Mendeleev's table. [1]
- 69 Explain, in terms of chemical reactivity, why the elements in Group 18 on the modern Periodic Table were *not* identified by Mendeleev at that time. [1]
-

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

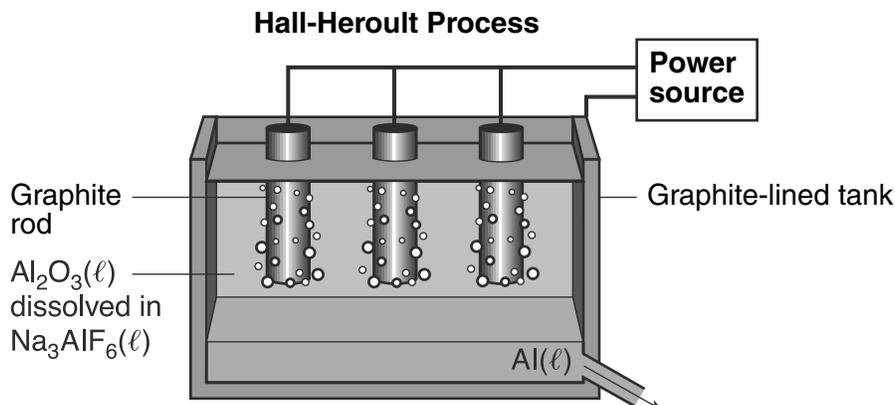
In a laboratory apparatus, a sample of lead(II) oxide reacts with hydrogen gas at high temperature. The products of this reaction are liquid lead and water vapor. As the reaction proceeds, water vapor and excess hydrogen gas leave the glass tube. The diagram and balanced equation below represent this reaction.



- 70 Determine the change in oxidation number for the hydrogen that reacts. [1]
- 71 Write a balanced half-reaction equation for the reduction of the Pb^{2+} ions in this reaction. [1]
- 72 Explain why the reaction that occurs in this glass tube can *not* reach equilibrium. [1]
- 73 State *one* change in reaction conditions, other than adding a catalyst, that would cause the rate of this reaction to increase. [1]
-

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

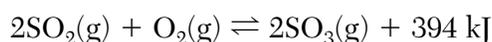
In the late 19th century, the Hall-Heroult process was invented as an inexpensive way to produce aluminum. In this process, $\text{Al}_2\text{O}_3(\ell)$ extracted from bauxite is dissolved in $\text{Na}_3\text{AlF}_6(\ell)$ in a graphite-lined tank, as shown in the diagram below. The products are carbon dioxide and molten aluminum metal.



- 74 Compare the chemical properties of a 300.-kilogram sample of $\text{Al}_2\text{O}_3(\ell)$ with the chemical properties of a 600.-kilogram sample of $\text{Al}_2\text{O}_3(\ell)$. [1]
- 75 Write the chemical name for the liquid compound dissolved in the $\text{Na}_3\text{AlF}_6(\ell)$. [1]
- 76 What is the melting point of the substance that collects at the bottom of the tank? [1]
- 77 Compare the density of the $\text{Al}(\ell)$ with the density of the mixture of $\text{Al}_2\text{O}_3(\ell)$ and $\text{Na}_3\text{AlF}_6(\ell)$. [1]
-

Base your answers to questions 78 through 80 on the information below and on your knowledge of chemistry.

One process used to manufacture sulfuric acid is called the contact process. One step in this process, the reaction between sulfur dioxide and oxygen, is represented by the forward reaction in the system at equilibrium shown below.



A mixture of platinum and vanadium(V) oxide may be used as a catalyst for this reaction. The sulfur trioxide produced is then used to make sulfuric acid.

- 78 Determine the amount of energy released when 1.00 mole of sulfur trioxide is produced. [1]
- 79 Write the chemical formula for vanadium(V) oxide. [1]
- 80 On the labeled axes *in your answer booklet*, complete the potential energy diagram for the forward reaction represented by this equation. [1]
-

Base your answers to questions 81 and 82 on the information below and on your knowledge of chemistry.

Two very stable compounds, Freon-12 and Freon-14, are used as liquid refrigerants. A Freon-12 molecule consists of one carbon atom, two chlorine atoms, and two fluorine atoms. A Freon-14 molecule consists of one carbon atom and four fluorine atoms.

81 In the space *in your answer booklet*, draw a structural formula for Freon-12. [1]

82 To which class of organic compounds do Freon-12 and Freon-14 belong? [1]

Base your answers to questions 83 through 85 on the information below and on your knowledge of chemistry.

Chemical concepts are applied in candy making. A recipe for making lollipops is shown below.

Hard-Candy Lollipops Recipe

Ingredients:

414 grams of sugar

177 grams of water

158 milliliters of light corn syrup

Step 1: In a saucepan, mix the sugar and water. Heat this mixture, while stirring, until all of the sugar dissolves.

Step 2: Add the corn syrup and heat the mixture until it boils.

Step 3: Continue boiling the mixture until the temperature reaches 143°C at standard pressure.

Step 4: Remove the pan from the heat and allow it to stand until the bubbling stops. Pour the mixture into lollipop molds that have been coated with cooking oil spray.

83 Explain, in terms of the polarity of sugar molecules, why the sugar dissolves in water. [1]

84 Determine the concentration, expressed as percent by mass, of the sugar dissolved in the mixture produced in step 1. [1]

85 Explain, in terms of the concentration of sugar molecules, why the boiling point of the mixture in step 3 increases as water evaporates from the mixture. [1]
