

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

PHYSICAL SETTING CHEMISTRY

Thursday, January 29, 2009 — 1:15 to 4:15 p.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 *Reference Tables for Physical Setting/Chemistry*. You are to answer *all* questions in all parts of this examination according to the directions provided in the examination booklet.

Your answer sheet for Part A and Part B–1 is the last page of this examination booklet. Turn to the last page and fold it along the perforations. Then, slowly and carefully, tear off your answer sheet and fill in the heading.

The answers to the questions in Part B–2 and Part C are to be written in your separate answer booklet. Be sure to fill in the heading on the front of your answer booklet.

Record the number of your choice for each Part A and Part B–1 multiple-choice question on your separate answer sheet. Write your answers to the Part B–2 and Part C questions in your answer booklet. All work 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 and in your answer booklet.

When you have completed the examination, you must sign the statement printed at the end of 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 *Reference Tables for Physical Setting/Chemistry* must be available for you to use while taking this examination.

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

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, write on the 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 *Reference Tables for Physical Setting/Chemistry*.

- On the modern Periodic Table, the elements are arranged in order of increasing
 - atomic mass
 - atomic number
 - mass number
 - oxidation number
- Which particle has a mass that is approximately the same as the mass of a proton?
 - an alpha particle
 - a beta particle
 - a neutron
 - a positron
- An atom of an element forms a 2^+ ion. In which group on the Periodic Table could this element be located?
 - 1
 - 2
 - 13
 - 17
- Which statement describes the relative energy of the electrons in the shells of a calcium atom?
 - An electron in the first shell has more energy than an electron in the second shell.
 - An electron in the first shell has the same amount of energy as an electron in the second shell.
 - An electron in the third shell has more energy than an electron in the second shell.
 - An electron in the third shell has less energy than an electron in the second shell.
- According to the electron-cloud model of the atom, an orbital is a
 - circular path traveled by an electron around the nucleus
 - spiral path traveled by an electron toward the nucleus
 - region of the most probable proton location
 - region of the most probable electron location
- What can be determined if only the atomic number of an atom is known?
 - the total number of neutrons in the atom, only
 - the total number of protons in the atom, only
 - the total number of protons and the total number of neutrons in the atom
 - the total number of protons and the total number of electrons in the atom
- The most common isotope of chromium has a mass number of 52. Which notation represents a different isotope of chromium?
 - ${}_{24}^{52}\text{Cr}$
 - ${}_{24}^{54}\text{Cr}$
 - ${}_{52}^{24}\text{Cr}$
 - ${}_{54}^{24}\text{Cr}$
- Which Group 14 element is a metalloid?
 - tin
 - silicon
 - lead
 - carbon
- Samples of four Group 15 elements, antimony, arsenic, bismuth, and phosphorus, are in the gaseous phase. An atom in the ground state of which element requires the *least* amount of energy to remove its most loosely held electron?
 - As
 - Bi
 - P
 - Sb
- Which substance can be broken down by chemical means?
 - CO
 - Ce
 - Ca
 - Cu
- During all chemical reactions, mass, energy, and charge are
 - absorbed
 - conserved
 - formed
 - released

- 12 Which formula represents a molecular compound?
(1) Kr (3) N₂O₄
(2) LiOH (4) NaI
- 13 The bonds in BaO are best described as
(1) covalent, because valence electrons are shared
(2) covalent, because valence electrons are transferred
(3) ionic, because valence electrons are shared
(4) ionic, because valence electrons are transferred
- 14 In which sample of water do the molecules have the highest average kinetic energy?
(1) 20. mL at 100.°C (3) 60. mL at 60.°C
(2) 40. mL at 80.°C (4) 80. mL at 40.°C
- 15 Which compound is insoluble in water?
(1) calcium bromide (3) silver bromide
(2) potassium bromide (4) sodium bromide
- 16 Which element is a brittle solid with low conductivity at STP?
(1) sulfur (3) argon
(2) sodium (4) aluminum
- 17 Which two samples of gas at STP contain the same total number of molecules?
(1) 1 L of CO(g) and 0.5 L of N₂(g)
(2) 2 L of CO(g) and 0.5 L of NH₃(g)
(3) 1 L of H₂(g) and 2 L of Cl₂(g)
(4) 2 L of H₂(g) and 2 L of Cl₂(g)
- 18 A reaction is most likely to occur when reactant particles collide with
(1) proper energy, only
(2) proper orientation, only
(3) both proper energy and proper orientation
(4) neither proper energy nor proper orientation
- 19 The net energy released or absorbed during a reversible chemical reaction is equal to
(1) the activation energy of the endothermic reaction
(2) the activation energy of the exothermic reaction
(3) the difference between the potential energy of the products and the potential energy of the reactants
(4) the sum of the potential energy of the products and the potential energy of the reactants
- 20 A catalyst lowers the activation energy of a reaction by
(1) providing an alternate reaction pathway
(2) decreasing the heat of reaction
(3) increasing the mass of the reactants
(4) changing the mole ratio of the reactants
- 21 Which element is present in every organic compound?
(1) carbon (3) nitrogen
(2) fluorine (4) oxygen
- 22 Given the balanced equation representing a reaction:
$$2\text{Fe} + 3\text{Cu}^{2+} \rightarrow 2\text{Fe}^{3+} + 3\text{Cu}$$

When the iron atoms lose six moles of electrons, how many moles of electrons are gained by the copper ions?
(1) 12 moles (3) 3 moles
(2) 2 moles (4) 6 moles
- 23 Which statement describes electrolysis?
(1) Chemical energy is used to produce an electrical change.
(2) Chemical energy is used to produce a thermal change.
(3) Electrical energy is used to produce a chemical change.
(4) Thermal energy is used to produce a chemical change.

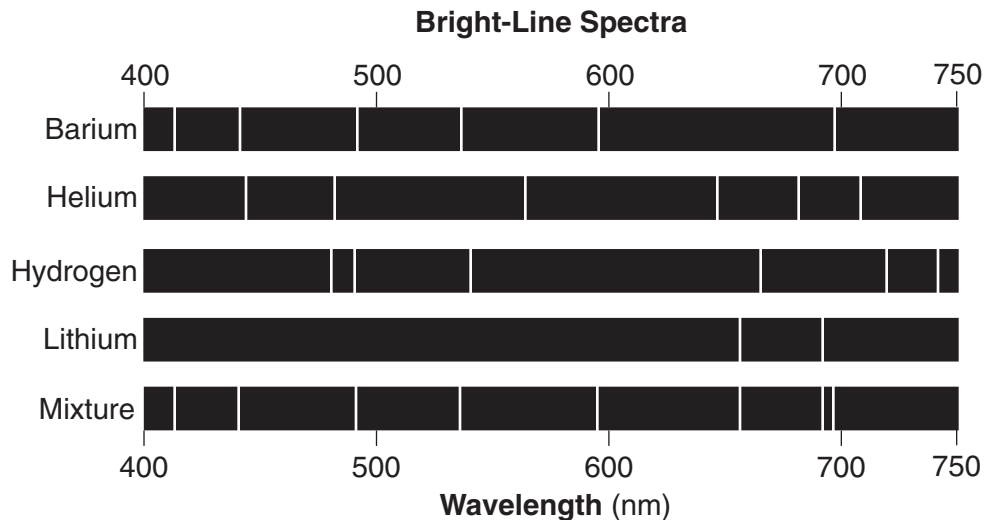
- 24 During which process does an atom gain one or more electrons?
(1) transmutation (3) oxidation
(2) reduction (4) neutralization
- 25 Which substance is an Arrhenius base?
(1) CH_3OH (3) LiOH
(2) CH_3Cl (4) LiCl
- 26 Which statement describes an alternate theory of acids and bases?
(1) Acids and bases are both H^+ acceptors.
(2) Acids and bases are both H^+ donors.
(3) Acids are H^+ acceptors, and bases are H^+ donors.
(4) Acids are H^+ donors, and bases are H^+ acceptors.
- 27 Which two compounds are electrolytes?
(1) $\text{C}_6\text{H}_{12}\text{O}_6$ and $\text{CH}_3\text{CH}_2\text{OH}$
(2) $\text{C}_6\text{H}_{12}\text{O}_6$ and HCl
(3) NaOH and HCl
(4) NaOH and $\text{CH}_3\text{CH}_2\text{OH}$
- 28 The only positive ion found in $\text{H}_2\text{SO}_4(\text{aq})$ is the
(1) ammonium ion (3) hydroxide ion
(2) hydronium ion (4) sulfate ion
- 29 Which risk is associated with using nuclear fission to produce energy in a power plant?
(1) depletion of hydrocarbons
(2) depletion of atmospheric oxygen
(3) exposure of workers to radiation
(4) exposure of workers to sulfur dioxide
- 30 An unstable nucleus loses the most mass if the nucleus emits
(1) an alpha particle (3) a positron
(2) a beta particle (4) a gamma ray
-

Part B-1

Answer all questions in this part.

Directions (31–50): For each statement or question, write on the 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 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 two of these elements.



Which two elements are in this mixture?

- (1) barium and hydrogen (3) helium and hydrogen
(2) barium and lithium (4) helium and lithium
-

- 32 The table below gives information about the nucleus of each of four atoms.

Nuclei of Four Atoms

Atom	Number of Protons	Number of Neutrons
A	6	6
D	6	7
E	7	7
G	7	8

How many different elements are represented by the nuclei in the table?

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

- 33 What is the total number of valence electrons in an atom of germanium in the ground state?

- (1) 8 (3) 14
(2) 2 (4) 4

- 34 In the formula X_2O_5 , the symbol X could represent an element in Group

- (1) 1 (3) 15
(2) 2 (4) 18

35 A 50.0-gram block of copper at 10.0°C is carefully lowered into 100.0 grams of water at 90.0°C in an insulated container. Which statement describes the transfer of heat in this system?

- (1) The water loses heat to the block until both are at 10.0°C.
- (2) The block gains heat from the water until both are at 90.0°C.
- (3) The water loses heat and the block gains heat until both are at the same temperature that is between 10.0°C and 90.0°C.
- (4) The water gains heat and the block loses heat until both are at the same temperature that is between 10.0°C and 90.0°C.

36 The compounds C_2H_4 and C_4H_8 have the same

- (1) freezing point at standard pressure
- (2) boiling point at standard pressure
- (3) molecular formula
- (4) empirical formula

37 The chemical bond between which two atoms is most polar?

- (1) C–N
- (2) H–H
- (3) S–Cl
- (4) Si–O

38 What is the total amount of heat absorbed by 100.0 grams of water when the temperature of the water is increased from 30.0°C to 45.0°C?

- (1) 418 J
- (2) 6270 J
- (3) 12 500 J
- (4) 18 800 J

39 Which process is exothermic?

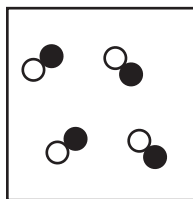
- (1) boiling of water
- (2) melting of copper
- (3) condensation of ethanol vapor
- (4) sublimation of iodine

40 Which sample, when dissolved in 1.0 liter of water, produces a solution with the *lowest* freezing point?

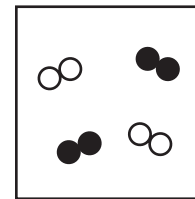
- (1) 0.1 mol of C_2H_5OH
- (2) 0.1 mol of LiBr
- (3) 0.2 mol of $C_6H_{12}O_6$
- (4) 0.2 mol of $CaCl_2$

41 Which particle diagram represents a mixture of an element and a compound?

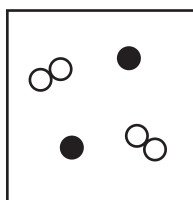
Key	
○	= an atom of an element
●	= an atom of a different element



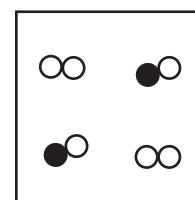
(1)



(3)

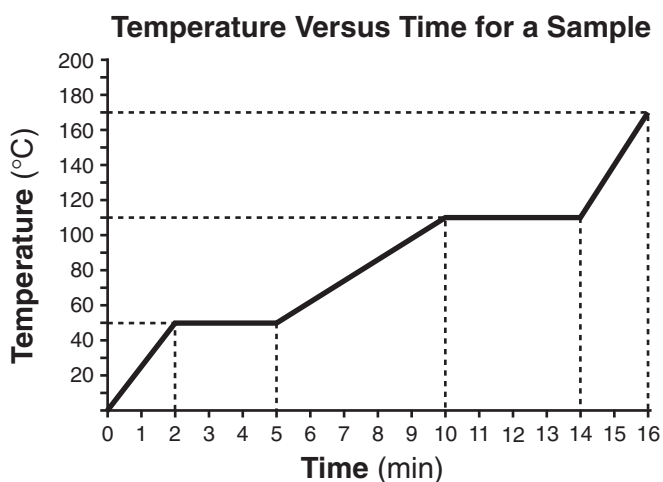


(2)



(4)

42 Starting as a solid, a sample of a substance is heated at a constant rate. The graph below shows the changes in temperature of this sample.

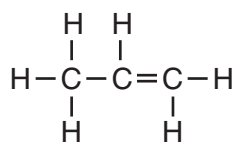


What is the melting point of the sample and the total time required to completely melt the sample after it has reached its melting point?

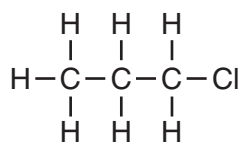
- (1) 50°C and 3 min
- (2) 50°C and 5 min
- (3) 110°C and 4 min
- (4) 110°C and 14 min

- 43 Which compound is an alkyne?
 (1) C_2H_2 (3) C_4H_8
 (2) C_2H_4 (4) C_4H_{10}
- 44 What is the oxidation number of sulfur in $Na_2S_2O_3$?
 (1) -1 (3) +6
 (2) +2 (4) +4

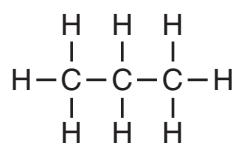
- 45 Which formula represents an unsaturated hydrocarbon?



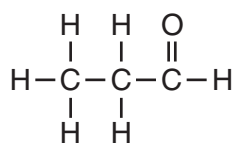
(1)



(3)



(2)



(4)

- 46 Which balanced equation represents a redox reaction?
 (1) $PCl_5 \rightarrow PCl_3 + Cl_2$
 (2) $KOH + HCl \rightarrow KCl + H_2O$
 (3) $LiBr \rightarrow Li^+ + Br^-$
 (4) $Ca^{2+} + SO_4^{2-} \rightarrow CaSO_4$
- 47 A 25.0-milliliter sample of $HNO_3(aq)$ is neutralized by 32.1 milliliters of 0.150 M $KOH(aq)$. What is the molarity of the $HNO_3(aq)$?
 (1) 0.117 M (3) 0.193 M
 (2) 0.150 M (4) 0.300 M

- 48 Which nuclide has a half-life that is *less* than one minute?
 (1) cesium-137 (3) phosphorus-32
 (2) francium-220 (4) strontium-90
- 49 The table below indicates the stability of six nuclides.

Stability of Six Nuclides

Nuclide	Stability
C-12	stable
C-14	unstable
N-14	stable
N-16	unstable
O-16	stable
O-19	unstable

All atoms of the unstable nuclides listed in this table have

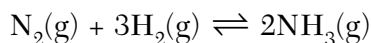
- (1) an odd number of neutrons
 (2) an odd number of protons
 (3) more neutrons than protons
 (4) more protons than neutrons
- 50 Cobalt-60 and iodine-131 are radioactive isotopes that are used in
 (1) dating geologic formations
 (2) industrial measurements
 (3) medical procedures
 (4) nuclear power

Part B-2

Answer all questions in this part.

Directions (51–66): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry*.

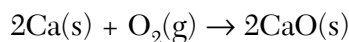
- 51 In the box *in your answer booklet*, draw a Lewis electron-dot diagram for an atom of boron. [1]
- 52 Explain, in terms of atomic structure, why the noble gas neon is an unreactive element. [1]
- 53 Given the equation representing a reaction at equilibrium:



Explain, in terms of collision theory, why the rate of the forward reaction *decreases* when the concentration of $\text{N}_2(\text{g})$ is decreased. [1]

Base your answers to questions 54 and 55 on the information below.

A 4.86-gram sample of calcium reacted completely with oxygen to form 6.80 grams of calcium oxide. This reaction is represented by the balanced equation below.



- 54 Determine the total mass of oxygen that reacted. [1]
- 55 Explain, in terms of electrons, why the radius of a calcium ion is smaller than the radius of a calcium atom. [1]
-

Base your answers to questions 56 through 58 on the information below.

The compounds $\text{NH}_4\text{Br(s)}$ and $\text{NH}_3\text{(g)}$ are soluble in water. Solubility data for $\text{NH}_4\text{Br(s)}$ in water are listed in the table below.

Solubility of NH_4Br in H_2O

Temperature (°C)	Mass of NH_4Br per 100. g of H_2O (g)
0	60.
20.	75
40.	90.
60.	105
80.	120.
100.	135

- 56 On the grid *in your answer booklet*, plot the data from the data table. Circle and connect the points. [1]
- 57 Determine the total mass of $\text{NH}_4\text{Br(s)}$ that must be dissolved in 200. grams of H_2O at 60.°C to produce a saturated solution. [1]
- 58 Compare the solubilities of $\text{NH}_4\text{Br(s)}$ and $\text{NH}_3\text{(g)}$, each in 100. grams of H_2O , as temperature increases at standard pressure. Your response must include *both* $\text{NH}_4\text{Br(s)}$ and $\text{NH}_3\text{(g)}$. [1]
-

Base your answers to questions 59 through 61 on the information below.

Carbon forms molecular compounds with some elements from Group 16. Two of these compounds are carbon dioxide, CO_2 , and carbon disulfide, CS_2 .

Carbon dioxide is a colorless, odorless gas at room temperature. At standard temperature and pressure, $\text{CO}_2\text{(s)}$ changes directly to $\text{CO}_2\text{(g)}$.

Carbon disulfide is formed by a direct reaction of carbon and sulfur. At room temperature, CS_2 is a colorless liquid with an offensive odor. Carbon disulfide vapors are flammable.

- 59 Identify *one* physical property and *one* chemical property of CS_2 . [1]
- 60 State what happens to the potential energy of CO_2 molecules during this phase change of CO_2 . [1]
- 61 Compare the intermolecular forces in CO_2 and CS_2 at room temperature. [1]
-

Base your answers to questions 62 through 64 on the data table below.

**Formulas and Boiling Points
of Selected Alkanes**

Name	Formula	Boiling Point at 1 Atm (°C)
methane	CH ₄	-162
ethane	C ₂ H ₆	-89
propane	C ₃ H ₈	-42
butane	C ₄ H ₁₀	-0.5
pentane	C ₅ H ₁₂	36

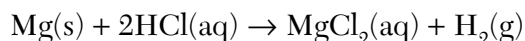
62 In the space *in your answer booklet*, draw a structural formula for butane. [1]

63 At standard pressure and 298 K, which alkane is a liquid? [1]

64 What is the boiling point of propane at 1 atmosphere, in kelvins? [1]

Base your answers to questions 65 and 66 on the information below.

The balanced equation below represents the reaction between magnesium metal and hydrochloric acid to produce aqueous magnesium chloride and hydrogen gas.



A piece of Mg(s) has a volume of 0.0640 cubic centimeters. This piece of Mg(s) reacts completely with HCl(aq) to produce H₂(g). The H₂(g) produced has a volume of 112 milliliters and a pressure of 1.00 atmosphere at 298 K.

65 The volume of the piece of Mg(s) is expressed to what number of significant figures? [1]

66 In the space *in your answer booklet*, show a correct numerical setup for calculating the volume of the H₂(g) produced if the conditions are changed to STP. [1]

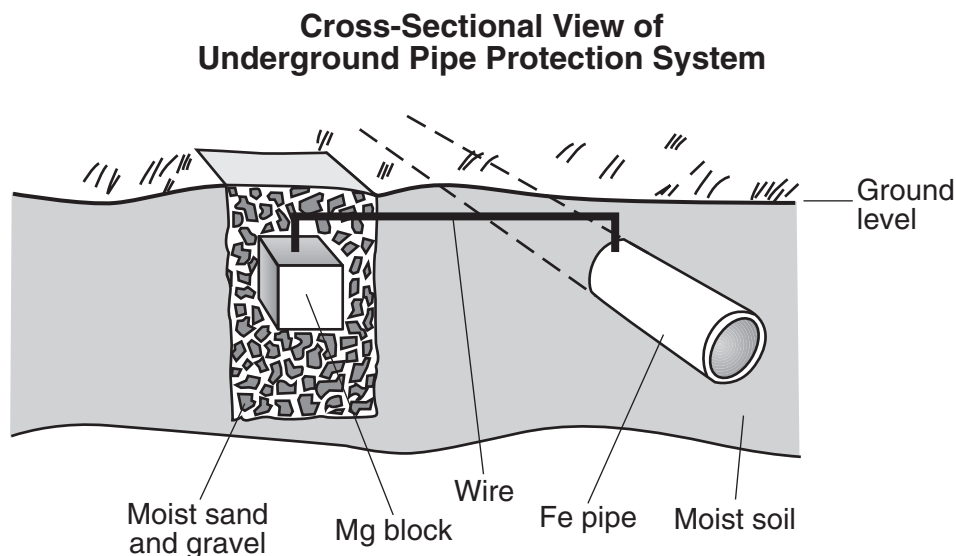
Part C

Answer all questions in this part.

Directions (67–81): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 67 and 68 on the information below.

Underground iron pipes in contact with moist soil are likely to corrode. This corrosion can be prevented by applying the principles of electrochemistry. Connecting an iron pipe to a magnesium block with a wire creates an electrochemical cell. The magnesium block acts as the anode and the iron pipe acts as the cathode. A diagram of this system is shown below.

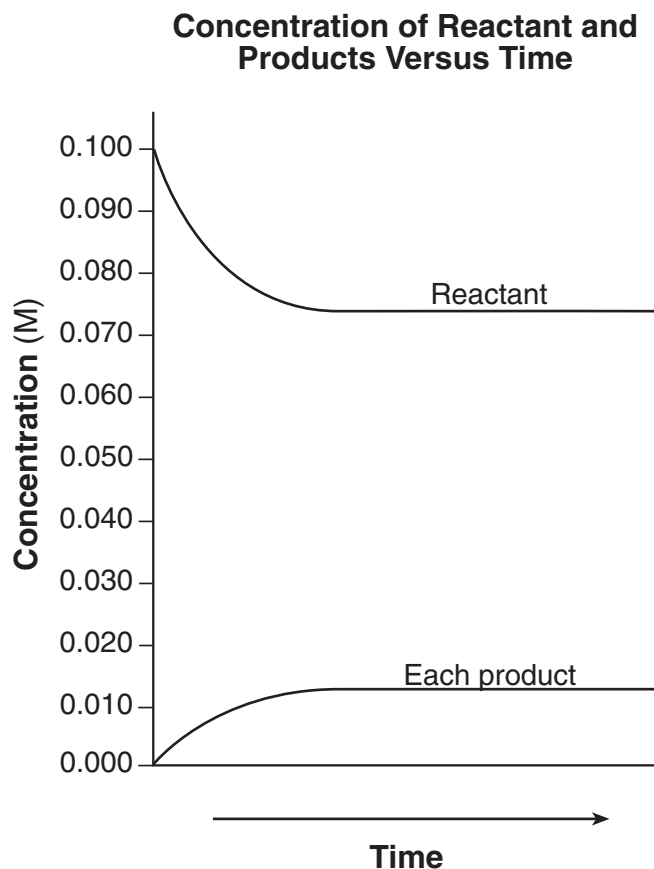


- 67 State the direction of the flow of electrons between the electrodes in this cell. [1]
- 68 Explain, in terms of reactivity, why magnesium is preferred over zinc to protect underground iron pipes. Your response must include *both* magnesium and zinc. [1]
-

Base your answers to questions 69 through 71 on the information below.

In a laboratory, 0.100 mole of colorless hydrogen iodide gas at room temperature is placed in a 1.00-liter flask. The flask is sealed and warmed, causing the $\text{HI}(\text{g})$ to start decomposing to $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$. Then the temperature of the contents of the flask is kept constant.

During this reaction, the contents of the flask change to a pale purple-colored mixture of $\text{HI}(\text{g})$, $\text{H}_2(\text{g})$, and $\text{I}_2(\text{g})$. When the color of the mixture in the flask stops changing, the concentration of $\text{I}_2(\text{g})$ is determined to be 0.013 mole per liter. The relationship between concentration and time for the reactant and products is shown in the graph below.



- 69 Write a balanced equation to represent the decomposition reaction occurring in the flask. [1]
- 70 State, in terms of concentration, evidence that indicates the system in the flask has reached equilibrium. [1]
- 71 Calculate the mass of $\text{I}_2(\text{g})$ in the flask at equilibrium. Your response must include *both* a correct numerical setup and the calculated result. [2]
-

Base your answers to questions 72 through 74 on the information below.

Soil pH can affect the development of plants. For example, a hydrangea plant produces blue flowers when grown in acidic soil but pink flowers when grown in basic soil. Evergreen plants can show a yellowing of foliage, called chlorosis, when grown in soil that is too basic.

Acidic soil can be neutralized by treating it with calcium hydroxide, $\text{Ca}(\text{OH})_2$, commonly called slaked lime. Slaked lime is slightly soluble in water.

- 72 Compare the hydrogen ion concentration to the hydroxide ion concentration in soil when a hydrangea plant produces pink flowers. [1]
- 73 An evergreen plant has yellowing foliage. The soil surrounding the plant is tested with methyl orange and bromthymol blue. Both indicators turn yellow in the soil tests. State, in terms of pH value, why the yellowing of the plant is *not* due to chlorosis. [1]
- 74 Write an equation, using symbols *or* words, for the neutralization of the ions in acidic soil by the ions released by slaked lime in water. [1]
-

Base your answers to questions 75 through 77 on the information below.

A fluorescent light tube contains a noble gas and a drop of mercury. When the fluorescent light operates, the Hg is a vapor and there are free-flowing Hg ions and electrons in the tube. The electrons collide with Hg atoms that then emit ultraviolet (UV) radiation.

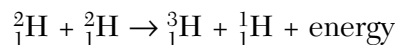
The inside of the tube is coated with a mixture of several compounds that absorb UV radiation. Ions in the coating emit a blend of red, green, and blue light that together appears as white light. The compound that produces red light is Y_2O_3 . The compound that produces green light is $\text{CeMgAl}_{11}\text{O}_{19}$. The compound that produces blue light is $\text{BaMgAl}_{10}\text{O}_{17}$.

- 75 Write the chemical name of the compound that produces red light. [1]
- 76 Calculate the percent composition by mass of aluminum in the compound that produces green light. Your response must include *both* a correct numerical setup and the calculated result. [2]
- 77 Explain, in terms of *both* electrons and energy, how ions in the coating emit light. [1]
-

Base your answers to questions 78 and 79 on the information below.

A substance known as heavy water can be obtained from ordinary water and could be a significant source of energy in the future. Heavy water contains deuterium, H-2. Instead of the two hydrogen atoms in a typical water molecule, a heavy water molecule has two deuterium atoms. In 3.78 kilograms of ordinary water, the percent composition by mass of heavy water is approximately 0.0156%.

Deuterium atoms completely ionize at approximately 10^8 K. The result is an ionized gas consisting of electrons and deuterons (the nuclei of deuterium). A triton is the nucleus of a tritium atom, H-3. These particles react according to the equations below. In the second equation, X represents an unidentified product.



- 78 Calculate the mass of heavy water in a 3.78-kilogram sample of ordinary water. Your response must include *both* a correct numerical setup and the calculated result. [2]
- 79 Identify particle X in the second nuclear equation. Your response must include the symbol, atomic number, and mass number of the particle. [1]
-

Base your answers to questions 80 and 81 on the information below.

Ethyl butanoate is an organic compound that contributes to the odor of pineapple. Ethyl butanoate is one of the products formed by the reaction of butanoic acid with ethanol.

- 80 Identify *two* differences in the structures between a molecule of butanoic acid and a molecule of ethanol. *Each* of your responses must include *both* compounds. [2]
- 81 Identify the type of organic reaction that produces the compound that contributes to the odor of pineapple. [1]
-

Tear Here

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING CHEMISTRY

Thursday, January 29, 2009 — 1:15 to 4:15 p.m., only

ANSWER SHEET

Student Sex: Male Female Grade

Teacher School

Record your answers to Part A and Part B-1 on this answer sheet.

Part A

- 1 11 21
2 12 22
3 13 23
4 14 24
5 15 25
6 16 26
7 17 27
8 18 28
9 19 29
10 20 30

Part A Score

[Box for Part A Score]

Part B-1

- 31 41
32 42
33 43
34 44
35 45
36 46
37 47
38 48
39 49
40 50

Part B-1 Score

[Box for Part B-1 Score]

Write your answers to Part B-2 and Part C in your answer booklet.

The declaration below should be signed when you have completed the examination.

I do hereby affirm, at the close of this examination, that I had no unlawful knowledge of the questions or answers prior to the examination and that I have neither given nor received assistance in answering any of the questions during the examination.

Signature

Tear Here

Tear Here

Tear Here