The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, June 21, 2006 — 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*.

1 Which notation represents an atom of sodium with an atomic number of 11 and a mass number of 24?

(1) $^{24}_{11}Na$ (3) $^{13}_{11}Na$

(2) $^{11}_{24}Na$ (4) $^{35}_{11}Na$

2 Which element has chemical properties that are most similar to those of calcium?

(1) Co (3) N

(2) K (4) Sr

3 Which element is malleable and can conduct electricity in the solid phase?

(1) iodine (3) sulfur

(2) phosphorus (4) tin

4 Atoms of different isotopes of the same element differ in their total number of

(1) electrons (3) protons

(2) neutrons (4) valence electrons

5 Which statement correctly describes two forms of oxygen, O_2 and O_3?

(1) They have identical molecular structures and identical properties.

(2) They have identical molecular structures and different properties.

(3) They have different molecular structures and identical properties.

(4) They have different molecular structures and different properties.

6 What is the IUPAC name for the compound FeS?

(1) iron(II) sulfate (3) iron(II) sulfide

(2) iron(III) sulfate (4) iron(III) sulfide

7 Given the balanced equation representing a reaction:

$$F_2(g) + H_2(g) \rightarrow 2HF(g)$$

What is the mole ratio of $H_2(g)$ to HF(g) in this reaction?

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

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

8 Which list includes three types of chemical reactions?

(1) condensation, double replacement, and sublimation

(2) condensation, solidification, and synthesis

(3) decomposition, double replacement, and synthesis

(4) decomposition, solidification, and sublimation

9 Which type of bond results when one or more valence electrons are transferred from one atom to another?

(1) a hydrogen bond

(2) an ionic bond

(3) a nonpolar covalent bond

(4) a polar covalent bond

10 What is the total number of electrons shared in the bonds between the two carbon atoms in a molecule of H—C≡C—H?

(1) 6 (3) 3

(2) 2 (4) 8

11 Which formula represents a nonpolar molecule?

(1) CH_4 (3) H_2O

(2) HCl (4) NH_3

12 Which changes occur as a cadmium atom, Cd, becomes a cadmium ion, Cd^{2+}?

(1) The Cd atom gains two electrons and its radius decreases.
(2) The Cd atom gains two electrons and its radius increases.
(3) The Cd atom loses two electrons and its radius decreases.
(4) The Cd atom loses two electrons and its radius increases.

13 Which element has atoms with the greatest attraction for electrons in a chemical bond?

(1) beryllium
(2) fluorine
(3) lithium
(4) oxygen

14 Two substances, *A* and *Z*, are to be identified. Substance *A* can *not* be broken down by a chemical change. Substance *Z* can be broken down by a chemical change. What can be concluded about these substances?

(1) Both substances are elements.
(2) Both substances are compounds.
(3) Substance *A* is an element and substance *Z* is a compound.
(4) Substance *A* is a compound and substance *Z* is an element.

15 Which ion, when combined with chloride ions, Cl^-, forms an insoluble substance in water?

(1) Fe^{2+}
(2) Mg^{2+}
(3) Pb^{2+}
(4) Zn^{2+}

16 Molarity is defined as the

(1) moles of solute per kilogram of solvent
(2) moles of solute per liter of solution
(3) mass of a solution
(4) volume of a solvent

17 Which formula represents a hydrocarbon?

(1) $CH_3CH_2CH_2CHO$
(2) $CH_3CH_2CH_2CH_3$
(3) $CH_3CH_2CH_2COOH$
(4) $CH_3CH_2COOCH_3$

18 Which expression represents the ΔH for a chemical reaction in terms of the potential energy, *PE*, of its products and reactants?

(1) *PE* of products + *PE* of reactants
(2) *PE* of products – *PE* of reactants
(3) *PE* of products × *PE* of reactants
(4) *PE* of products ÷ *PE* of reactants

19 Which balanced equation represents an endothermic reaction?

(1) $C(s) + O_2(g) \rightarrow CO_2(g)$
(2) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell)$
(3) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
(4) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

20 Which formula represents propyne?

(1) C_3H_4
(2) C_3H_6
(3) C_5H_8
(4) C_5H_{10}

21 Which factors must be equal in a reversible chemical reaction at equilibrium?

(1) the activation energies of the forward and reverse reactions
(2) the rates of the forward and reverse reactions
(3) the concentrations of the reactants and products
(4) the potential energies of the reactants and products

22 The compounds CH_3OCH_3 and CH_3CH_2OH are isomers of each other. These two compounds must have the same

(1) density
(2) reactivity
(3) melting point
(4) molecular formula

23 Which balanced equation represents a redox reaction?

(1) $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
(2) $BaCl_2 + K_2CO_3 \rightarrow BaCO_3 + 2KCl$
(3) $CuO + CO \rightarrow Cu + CO_2$
(4) $HCl + KOH \rightarrow KCl + H_2O$

24 Which process occurs at the anode in an electrochemical cell?

(1) the loss of protons
(2) the loss of electrons
(3) the gain of protons
(4) the gain of electrons

25 Which substance is an electrolyte?

(1) CH_3OH
(2) $C_6H_{12}O_6$
(3) H_2O
(4) KOH

26 Which ion is the only negative ion present in an aqueous solution of an Arrhenius base?

(1) hydride ion
(2) hydrogen ion
(3) hydronium ion
(4) hydroxide ion

27 According to Reference Table *N*, which pair of isotopes spontaneously decays?

(1) C-12 and N-14
(2) C-12 and N-16
(3) C-14 and N-14
(4) C-14 and N-16

28 Which equation represents the radioactive decay of $^{226}_{88}Ra$?

(1) $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$
(2) $^{226}_{88}Ra \rightarrow {}^{226}_{89}Ac + {}^{0}_{-1}e$
(3) $^{226}_{88}Ra \rightarrow {}^{226}_{87}Fr + {}^{0}_{+1}e$
(4) $^{226}_{88}Ra \rightarrow {}^{225}_{88}Ra + {}^{1}_{0}n$

29 Which type of reaction converts one element to another element?

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

30 Which nuclear emission has the greatest mass?

(1) α
(2) γ
(3) β^-
(4) β^+

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 Which trends are observed as each of the elements within Group 15 on the Periodic Table is considered in order from top to bottom?

(1) Their metallic properties decrease and their atomic radii decrease.
(2) Their metallic properties decrease and their atomic radii increase.
(3) Their metallic properties increase and their atomic radii decrease.
(4) Their metallic properties increase and their atomic radii increase.

32 What is the total number of electrons in a S^{2-} ion?

(1) 10 (3) 16
(2) 14 (4) 18

33 A substance has an empirical formula of CH_2 and a molar mass of 56 grams per mole. The molecular formula for this compound is

(1) CH_2 (3) C_4H_8
(2) C_4H_6 (4) C_8H_4

34 Compared to an atom of phosphorus-31, an atom of sulfur-32 contains

(1) one less neutron (3) one more neutron
(2) one less proton (4) one more proton

35 In which compound is the percent composition by mass of chlorine equal to 42%?

(1) HClO (gram-formula mass = 52 g/mol)
(2) $HClO_2$ (gram-formula mass = 68 g/mol)
(3) $HClO_3$ (gram-formula mass = 84 g/mol)
(4) $HClO_4$ (gram-formula mass = 100. g/mol)

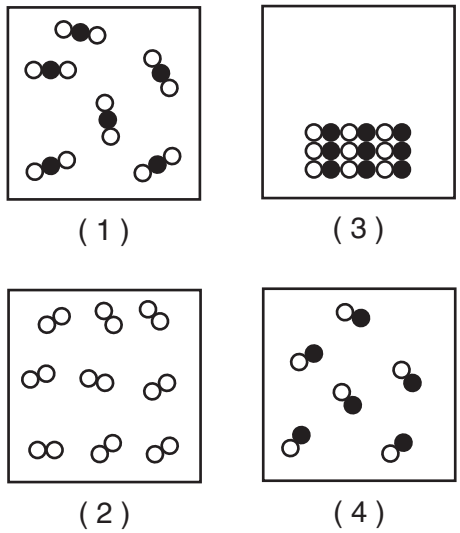
36 A metal, *M*, forms an oxide compound with the general formula M_2O. In which group on the Periodic Table could metal *M* be found?

(1) Group 1 (3) Group 16
(2) Group 2 (4) Group 17

37 Given the key:

Key
○ = Atom of oxygen
● = Atom of carbon

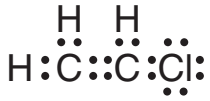
Which particle diagram represents a sample containing the compound CO(g)?



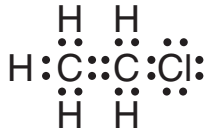
38 At standard pressure, which element has a melting point higher than standard temperature?

(1) F_2 (3) Fe
(2) Br_2 (4) Hg

39 Which Lewis electron-dot diagram represents chloroethene?

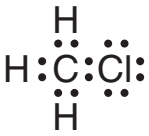


(1)



(3)

(2)



(4)

40 A saturated solution of $NaNO_3$ is prepared at 60.°C using 100. grams of water. As this solution is cooled to 10.°C, $NaNO_3$ precipitates (settles) out of the solution. The resulting solution is saturated. Approximately how many grams of $NaNO_3$ settled out of the original solution?

(1) 46 g
(2) 61 g
(3) 85 g
(4) 126 g

41 Which kelvin temperature is equivalent to –24°C?

(1) 226 K
(2) 249 K
(3) 273 K
(4) 297 K

42 Which substance has the *lowest* vapor pressure at 75°C?

(1) water
(2) ethanoic acid
(3) propanone
(4) ethanol

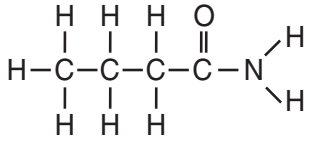
43 What is the IUPAC name for the compound that has the condensed structural formula $CH_3CH_2CH_2CHO$?

(1) butanal
(2) butanol
(3) propanal
(4) propanol

44 What volume of 0.500 M $HNO_3(aq)$ must completely react to neutralize 100.0 milliliters of 0.100 M KOH(aq)?

(1) 10.0 mL
(2) 20.0 mL
(3) 50.0 mL
(4) 500. mL

45 Given the formula:



This compound is classified as

(1) an aldehyde
(2) an amide
(3) an amine
(4) a ketone

46 Given the balanced equation with an unknown compound represented by *X*:

$$C_6H_{12}O_6(aq) \xrightarrow{\text{enzyme}} 2X + 2CO_2(g)$$

Which compound is represented by *X*?

(1) $CH_3OH(aq)$
(2) $CH_2(OH)_4(aq)$
(3) $CH_3CH_2OH(aq)$
(4) $CH_2OHCH_2OH(aq)$

47 Which reactants form the salt $CaSO_4(s)$ in a neutralization reaction?

(1) $H_2S(g)$ and $Ca(ClO_4)_2(s)$
(2) $H_2SO_3(aq)$ and $Ca(NO_3)_2(aq)$
(3) $H_2SO_4(aq)$ and $Ca(OH)_2(aq)$
(4) $SO_2(g)$ and CaO(s)

48 A student tested a 0.1 M aqueous solution and made the following observations:

- conducts electricity
- turns blue litmus to red
- reacts with Zn(s) to produce gas bubbles

Which compound could be the solute in this solution?

(1) CH_3OH
(2) LiBr
(3) HBr
(4) LiOH

49 What is the half-life of sodium-25 if 1.00 gram of a 16.00-gram sample of sodium-25 remains unchanged after 237 seconds?

(1) 47.4 s
(2) 59.3 s
(3) 79.0 s
(4) 118 s

50 Given the table below that shows students' examples of proposed models of the atom:

Proposed Models of the Atom

Model	Location of Protons	Location of Electrons
A	in the nucleus	specific shells
B	in the nucleus	regions of most probable location
C	dispersed throughout the atom	specific shells
D	dispersed throughout the atom	regions of most probable location

Which model correctly describes the locations of protons and electrons in the wave-mechanical model of the atom?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

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.*

Base your answers to questions 51 and 52 on the balanced equation below.

$$Fe(s) + 2HNO_3(aq) \rightarrow Fe(NO_3)_2(aq) + H_2(g)$$

51 What is the total number of oxygen atoms represented in the formula of the iron compound produced? [1]

52 Explain, using information from Reference Table *J*, why this reaction is spontaneous. [1]

Base your answers to questions 53 and 54 on the information below.

An atom has an atomic number of 9, a mass number of 19, and an electron configuration of 2–6–1.

53 What is the total number of neutrons in this atom? [1]

54 Explain why the number of electrons in the second and third shells shows that this atom is in an excited state. [1]

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55 To which homologous series does $CH_3CH_2CH_2CH_3$ belong? [1]

56 What is the mass of 4.76 moles of Na_3PO_4 (gram-formula mass = 164 grams/mole)? [1]

Base your answers to questions 57 and 58 on the information below.

Given the balanced equation for dissolving $NH_4Cl(s)$ in water:

$$NH_4Cl(s) \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$$

57 A student is holding a test tube containing 5.0 milliliters of water. When a sample of $NH_4Cl(s)$ is placed in the test tube, the test tube feels colder to the student's hand. Describe the direction of heat flow between the test tube and the hand. [1]

58 Using the key *in your answer booklet,* draw *at least two* water molecules in the box, showing the correct orientation of each water molecule when it is near the Cl^- ion in the aqueous solution. [1]

Base your answers to questions 59 and 60 on the information below.

Given the reaction at equilibrium:

$$2NO_2(g) \rightleftharpoons N_2O_4(g) + 55.3\ kJ$$

59 Explain, in terms of energy, why the forward reaction is exothermic. [1]

60 Explain, in terms of Le Chatelier's principle, why the equilibrium shifts to the right to relieve the stress when the pressure on the system is increased at constant temperature. [1]

Base your answers to questions 61 through 63 on the information below.

Given the balanced equation for an organic reaction between butane and chlorine that takes place at 300.°C and 101.3 kilopascals:

$$C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$$

61 Identify the type of organic reaction shown. [1]

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

63 Explain, in terms of collision theory, why the rate of the reaction would *decrease* if the temperature of the reaction mixture was lowered to 200.°C with pressure remaining unchanged. [1]

Base your answers to questions 64 through 66 on the information below.

Ethanol, C_2H_5OH, is a volatile and flammable liquid with a distinct odor at room temperature. Ethanol is soluble in water. The boiling point of ethanol is 78.2°C at 1 atmosphere. Ethanol can be used as a fuel to produce heat energy, as shown by the balanced equation below.

$$C_2H_5OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell) + 1367\ kJ$$

64 At 1 atmosphere, compare the boiling point of pure ethanol to the boiling point of a solution in which a nonvolatile substance is dissolved in ethanol. [1]

65 Determine the total amount of heat produced by the complete combustion of 2.00 moles of ethanol. [1]

66 Identify *one* physical property of ethanol, stated in the passage, that can be explained in terms of chemical bonds and intermolecular forces. [1]

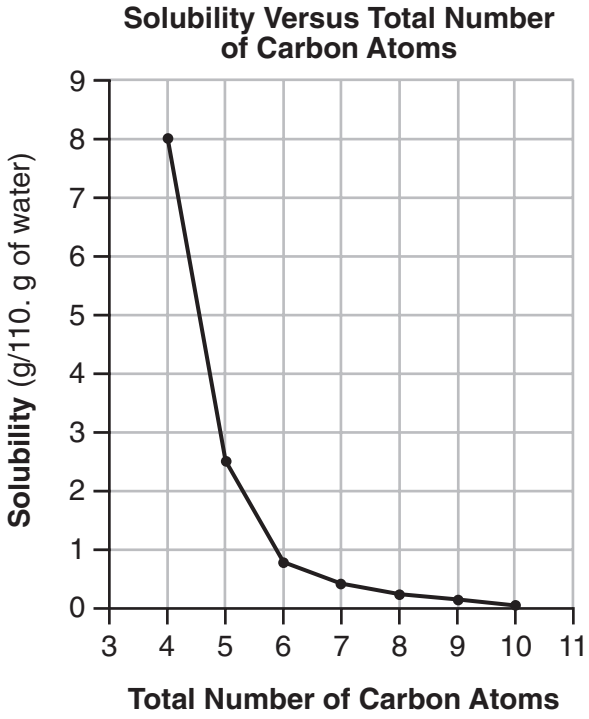
Part C

Answer all questions in this part.

Directions (67–84): 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.

The graph shows the relationship between the solubility of a sequence of primary alcohols in water and the total number of carbon atoms in a molecule of the corresponding alcohol at the same temperature and pressure. A primary alcohol has the —OH group located on an end carbon of the hydrocarbon chain.



Adapted from *Chemistry*, Collins Educational Publishing, pp. 227-231

67 Describe the relationship between the solubility of a primary alcohol in water and the total number of carbon atoms in the primary alcohol. [1]

68 Determine the total mass of 1-pentanol that will dissolve in 110. grams of water to produce a saturated solution. [1]

Base your answers to questions 69 and 70 on the information below.

Air bags are an important safety feature in modern automobiles. An air bag is inflated in milliseconds by the explosive decomposition of $NaN_3(s)$. The decomposition reaction produces $N_2(g)$, as well as Na(s), according to the unbalanced equation below.

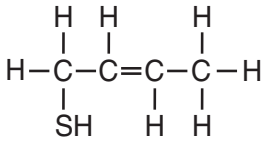
$$NaN_3(s) \rightarrow Na(s) + N_2(g)$$

69 Balance the equation *in your answer booklet* for the decomposition of NaN_3, using the smallest whole-number coefficients. [1]

70 When the air bag inflates, the nitrogen gas is at a pressure of 1.30 atmospheres, a temperature of 301 K, and has a volume of 40.0 liters. In the space *in your answer booklet,* calculate the volume of the nitrogen gas at STP. Your response must include *both* a correct numerical setup and the calculated volume. [2]

Base your answers to questions 71 and 72 on the information below.

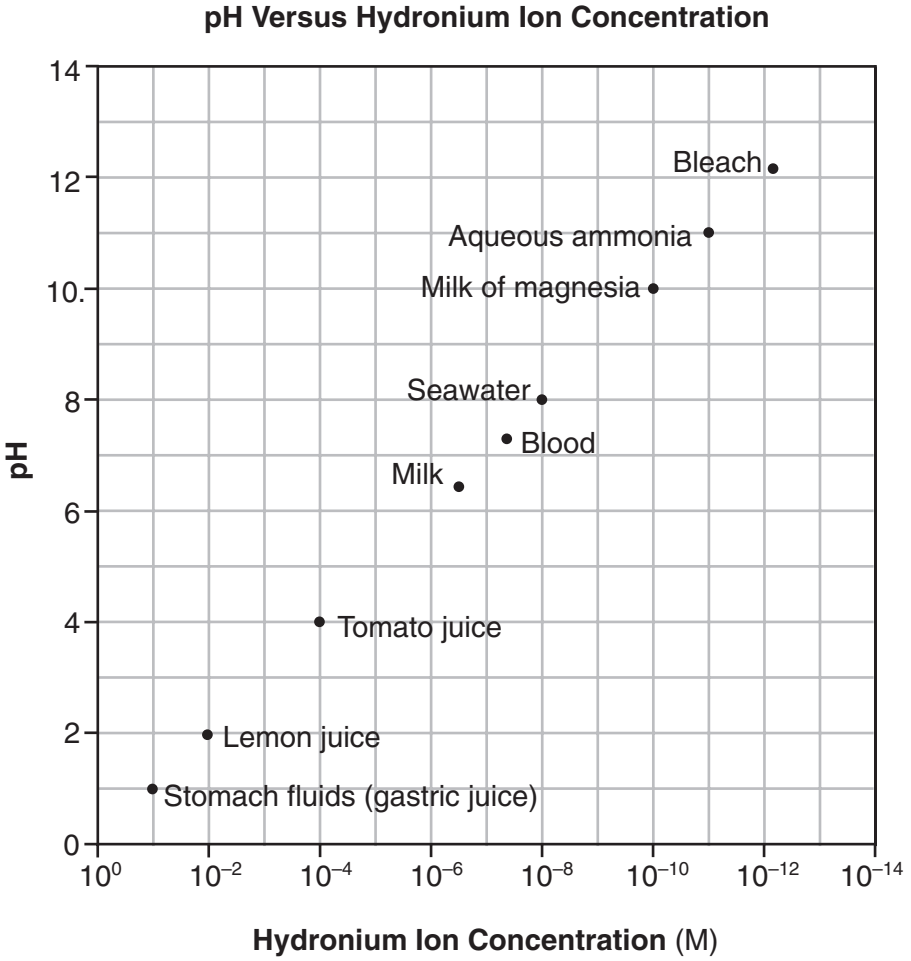
A thiol is very similar to an alcohol, but a thiol has a sulfur atom instead of an oxygen atom in the functional group. One of the compounds in a skunk's spray is 2-butene-1-thiol. The formula of this compound is shown below.



71 Explain, in terms of composition, why this compound is a thiol. [1]

72 Explain, in terms of electron configuration, why oxygen atoms and sulfur atoms form compounds with similar molecular structures. [1]

Base your answers to questions 73 through 75 on the graph below. The graph shows the relationship between pH value and hydronium ion concentration for common aqueous solutions and mixtures.



73 What is the hydronium ion concentration of tomato juice? [1]

74 What color is thymol blue when added to milk of magnesia? [1]

75 According to this graph, which mixture is approximately 100 times more acidic than milk of magnesia? [1]

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

Archimedes (287–212 BC), a Greek inventor and mathematician, made several discoveries important to science today. According to a legend, Hiero, the king of Syracuse, commanded Archimedes to find out if the royal crown was made of gold, only. The king suspected that the crown consisted of a mixture of gold, tin, and copper.

Archimedes measured the mass of the crown and the total amount of water displaced by the crown when it was completely submerged. He repeated the procedure using individual samples, one of gold, one of tin, and one of copper. Archimedes was able to determine that the crown was not made entirely of gold without damaging it.

76 Identify *one* physical property that Archimedes used in his comparison of the metal samples. [1]

77 Determine the volume of a 75-gram sample of gold at STP. [1]

Base your answers to questions 78 through 81 on the information below.

Aluminum is one of the most abundant metals in Earth's crust. The aluminum compound found in bauxite ore is Al_2O_3. Over one hundred years ago, it was difficult and expensive to isolate aluminum from bauxite ore. In 1886, a brother and sister team, Charles and Julia Hall, found that molten (melted) cryolite, Na_3AlF_6, would dissolve bauxite ore. Electrolysis of the resulting mixture caused the aluminum ions in the Al_2O_3 to be reduced to molten aluminum metal. This less expensive process is known as the Hall process.

78 Write the oxidation state for *each* of the elements in cryolite. [1]

79 Write the balanced half-reaction equation for the reduction of Al^{3+} to Al. [1]

80 Explain, in terms of ions, why molten cryolite conducts electricity. [1]

81 Explain, in terms of electrical energy, how the operation of a voltaic cell differs from the operation of an electrolytic cell used in the Hall process. Include *both* the voltaic cell and the electrolytic cell in your answer. [1]

Base your answers to questions 82 through 84 on the information below.

A glass tube is filled with hydrogen gas at low pressure. An electric current is passed through the gas, causing it to emit light. This light is passed through a prism to separate the light into the bright, colored lines of hydrogen's visible spectrum. Each colored line corresponds to a particular wavelength of light. One of hydrogen's spectral lines is red light with a wavelength of 656 nanometers.

Tubes filled with other gases produce different bright-line spectra that are characteristic of each kind of gas. These spectra have been observed and recorded.

82 Explain, in terms of electron energy states and energy changes, how hydrogen's bright-line spectrum is produced. [1]

83 Explain how the elements present on the surface of a star can be identified using bright-line spectra. [1]

84 A student measured the wavelength of hydrogen's visible red spectral line to be 647 nanometers. In the space *in your answer booklet,* show a correct numerical setup for calculating the student's percent error. [1]

Tear Here

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, June 21, 2006 — 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

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

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

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