The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING

CHEMISTRY

Thursday, August 16, 2007 — 12:30 to 3:30 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 What was concluded about the structure of the atom as the result of the gold foil experiment?

(1) A positively charged nucleus is surrounded by positively charged particles.
(2) A positively charged nucleus is surrounded by mostly empty space.
(3) A negatively charged nucleus is surrounded by positively charged particles.
(4) A negatively charged nucleus is surrounded by mostly empty space.

2 An atom is electrically neutral because the

(1) number of protons equals the number of electrons
(2) number of protons equals the number of neutrons
(3) ratio of the number of neutrons to the number of electrons is 1:1
(4) ratio of the number of neutrons to the number of protons is 2:1

3 How do the energy and the most probable location of an electron in the third shell of an atom compare to the energy and the most probable location of an electron in the first shell of the same atom?

(1) In the third shell, an electron has more energy and is closer to the nucleus.
(2) In the third shell, an electron has more energy and is farther from the nucleus.
(3) In the third shell, an electron has less energy and is closer to the nucleus.
(4) In the third shell, an electron has less energy and is farther from the nucleus.

4 Which element is a solid at STP and a good conductor of electricity?

(1) iodine   (3) nickel
(2) mercury   (4) sulfur

5 Which element has both metallic and nonmetallic properties?

(1) Rb   (3) Si
(2) Rn   (4) Sr

6 The carbon atoms in graphite and the carbon atoms in diamond have different

(1) atomic numbers
(2) atomic masses
(3) electronegativities
(4) structural arrangements

7 Atoms of which element have the greatest tendency to gain electrons?

(1) bromine   (3) fluorine
(2) chlorine   (4) iodine

8 Which statement describes a chemical property of the element magnesium?

(1) Magnesium is malleable.
(2) Magnesium conducts electricity.
(3) Magnesium reacts with an acid.
(4) Magnesium has a high boiling point.

9 Matter that is composed of two or more different elements chemically combined in a fixed proportion is classified as

(1) a compound   (3) a mixture
(2) an isotope   (4) a solution

10 Given the balanced equation representing a reaction:

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

What is the mole ratio of $CO(g)$ to $CO_2(g)$ in this reaction?

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

11 Given the balanced equation representing a reaction:

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell) + 55.8 \text{ kJ}$$
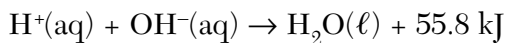
In this reaction there is conservation of

(1) mass, only
(2) mass and charge, only
(3) mass and energy, only
(4) mass, charge, and energy

12 Which polyatomic ion contains the greatest number of oxygen atoms?

(1) acetate
(2) carbonate
(3) hydroxide
(4) peroxide

13 Which formula represents an ionic compound?

(1) H_2
(2) CH_4
(3) CH_3OH
(4) NH_4Cl

14 An ion of which element has a larger radius than an atom of the same element?

(1) aluminum
(2) chlorine
(3) magnesium
(4) sodium

15 Which statement must be true when solution equilibrium occurs?

(1) The solution is at STP.
(2) The solution is supersaturated.
(3) The concentration of the solution remains constant.
(4) The masses of the dissolved solute and the undissolved solute are equal.

16 Which liquid has the highest vapor pressure at 75°C?

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

17 What is the total number of different elements present in NH_4NO_3?

(1) 7
(2) 9
(3) 3
(4) 4

18 Which sample of matter is a single substance?

(1) air
(2) ammonia gas
(3) hydrochloric acid
(4) salt water

19 At STP, which sample contains the same number of molecules as 11.2 liters of $CO_2(g)$ at STP?

(1) 5.6 L of $NO_2(g)$
(2) 7.5 L of $H_2(g)$
(3) 11.2 L of $N_2(g)$
(4) 22.4 L of $CO(g)$

20 A sample of gas is held at constant pressure. Increasing the kelvin temperature of this gas sample causes the average kinetic energy of its molecules to

(1) decrease and the volume of the gas sample to decrease
(2) decrease and the volume of the gas sample to increase
(3) increase and the volume of the gas sample to decrease
(4) increase and the volume of the gas sample to increase

21 Given the balanced equation representing a reaction:

$$Cl_2(g) \rightarrow Cl(g) + Cl(g)$$

What occurs during this change?

(1) Energy is absorbed and a bond is broken.
(2) Energy is absorbed and a bond is formed.
(3) Energy is released and a bond is broken.
(4) Energy is released and a bond is formed.

22 A molecule of butane and a molecule of 2-butene both have the same total number of
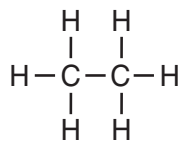
(1) carbon atoms
(2) hydrogen atoms
(3) single bonds
(4) double bonds

23 Which general formula represents the homologous series of hydrocarbons that includes the compound l-heptyne?

(1) C_nH_{2n-6}
(2) C_nH_{2n-2}
(3) C_nH_{2n}
(4) C_nH_{2n+2}

24 Which two compounds are isomers of each other?

(1) CH_3CH_2COOH and $CH_3COOCH_2CH_3$
(2) CH_3CH_2CHO and CH_3COCH_3
(3) $CH_3CHBrCH_3$ and $CH_2BrCHBrCH_3$
(4) $CH_3CHOHCH_3$ and $CH_3CHOHCH_2OH$

25 Which formula represents an unsaturated hydrocarbon?

H H
| |
H−C−C−H
| |
H H

(1)

H H
| |
H−C−C−H
| |
H Cl

(3)

$$\overset{H}{\underset{H}{\diagdown}}C=C\overset{H}{\underset{H}{\diagup}}$$

(2)

$$\overset{H}{\underset{H}{\diagdown}}C=C\overset{H}{\underset{Cl}{\diagup}}$$
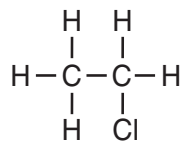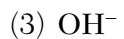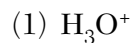
(4)
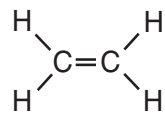
26 Which formula represents a hydronium ion?

(1) H_3O^+

(3) OH^-

(2) NH_4^+

(4) HCO_3^-
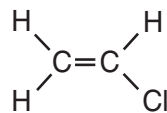
27 Which compound is an Arrhenius acid?

(1) H_2SO_4

(3) NaOH

(2) KCl

(4) NH_3
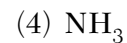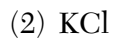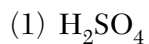
28 What is the decay mode of ^{37}K?

(1) β^-

(3) γ

(2) β^+

(4) α

29 Which nuclear emission has the greatest penetrating power?

(1) alpha particle

(3) gamma radiation

(2) beta particle

(4) positron
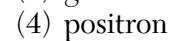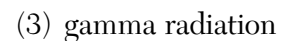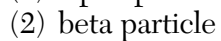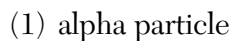
30 What is the mass number of an alpha particle?

(1) 1

(3) 0

(2) 2

(4) 4

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 What is the net charge on an ion that has 9 protons, 11 neutrons, and 10 electrons?

(1) 1+   (3) 1–
(2) 2+   (4) 2–

32 Which two particles make up most of the mass of a hydrogen-2 atom?

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

33 Which statement explains why sulfur is classified as a Group 16 element?

(1) A sulfur atom has 6 valence electrons.
(2) A sulfur atom has 16 neutrons.
(3) Sulfur is a yellow solid at STP.
(4) Sulfur reacts with most metals.

34 How do the atomic radius and metallic properties of sodium compare to the atomic radius and metallic properties of phosphorus?

(1) Sodium has a larger atomic radius and is more metallic.
(2) Sodium has a larger atomic radius and is less metallic.
(3) Sodium has a smaller atomic radius and is more metallic.
(4) Sodium has a smaller atomic radius and is less metallic.

35 A compound has a molar mass of 90. grams per mole and the empirical formula CH_2O. What is the molecular formula of this compound?

(1) CH_2O (3) $C_3H_6O_3$
(2) $C_2H_4O_2$ (4) $C_4H_8O_4$

36 At standard pressure, a certain compound has a low boiling point and is insoluble in water. At STP, this compound most likely exists as

(1) ionic crystals
(2) metallic crystals
(3) nonpolar molecules
(4) polar molecules

37 The table below shows mass and volume data for four samples of substances at 298 K and 1 atmosphere.

Masses and Volumes of Four Samples

Sample	Mass (g)	Volume (mL)
A	30.	60.
B	40.	50.
C	45	90.
D	90.	120.

Which two samples could consist of the same substance?

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

38 Which group on the Periodic Table of the Elements contains elements that react with oxygen to form compounds with the general formula X_2O?

(1) Group 1   (3) Group 14
(2) Group 2   (4) Group 18

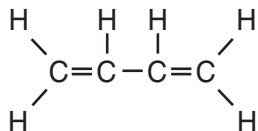39 An unsaturated solution is formed when 80. grams of a salt is dissolved in 100. grams of water at 40.°C. This salt could be

(1) KCl   (3) NaCl
(2) KNO_3 (4) $NaNO_3$

40 Which kelvin temperature is equal to 56°C?

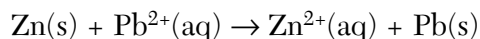(1) –329 K   (3) 217 K
(2) –217 K   (4) 329 K

41 Given the formula of a substance:

$$
\begin{array}{c}
\text{H} \qquad \text{H } \text{H} \qquad \text{H} \\
\diagdown \qquad | \quad | \qquad \diagup \\
\text{C=C}-\text{C=C} \\
\diagup \qquad\qquad\qquad \diagdown \\
\text{H} \qquad\qquad\qquad \text{H}
\end{array}
$$

What is the total number of shared electrons in a molecule of this substance?

(1) 22   (3) 9
(2) 11   (4) 6

42 Given the balanced equation representing the reaction occurring in a voltaic cell:

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

In the completed external circuit, the electrons flow from

(1) $Pb(s)$ to $Zn(s)$

(2) $Pb^{2+}(aq)$ to $Zn^{2+}(aq)$

(3) $Zn(s)$ to $Pb(s)$

(4) $Zn^{2+}(aq)$ to $Pb^{2+}(aq)$

43 Which balanced equation represents a redox reaction?

(1) $CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$

(2) $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

(3) $AgNO_3(aq) + KCl(aq) \rightarrow$
$\quad AgCl(s) + KNO_3(aq)$

(4) $H_2SO_4(aq) + 2KOH(aq) \rightarrow$
$\quad K_2SO_4(aq) + 2H_2O(\ell)$

44 Given the unbalanced ionic equation:

$$3Mg + \underline{\quad} Fe^{3+} \rightarrow 3Mg^{2+} + \underline{\quad} Fe$$
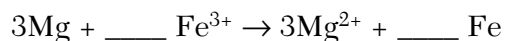
When this equation is balanced, both Fe^{3+} and Fe have a coefficient of

(1) 1, because a total of 6 electrons is transferred
(2) 2, because a total of 6 electrons is transferred
(3) 1, because a total of 3 electrons is transferred
(4) 2, because a total of 3 electrons is transferred

45 A student collects the materials and equipment below to construct a voltaic cell.

- two 250-mL beakers
- wire and a switch
- one strip of magnesium
- one strip of copper
- 125 mL of 0.20 M $Mg(NO_3)_2(aq)$
- 125 mL of 0.20 M $Cu(NO_3)_2(aq)$

Which additional item is required for the construction of the voltaic cell?

(1) an anode   (3) a cathode
(2) a battery   (4) a salt bridge

46 Given the balanced equation representing a reaction:

$$Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$
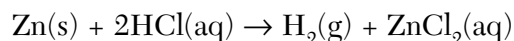
Which set of reaction conditions produces $H_2(g)$ at the fastest rate?

(1) a 1.0-g lump of $Zn(s)$ in 50. mL of
0.5 M $HCl(aq)$ at 20.°C

(2) a 1.0-g lump of $Zn(s)$ in 50. mL of
0.5 M $HCl(aq)$ at 30.°C

(3) 1.0 g of powdered $Zn(s)$ in 50. mL of
1.0 M $HCl(aq)$ at 20.°C

(4) 1.0 g of powdered $Zn(s)$ in 50. mL of
1.0 M $HCl(aq)$ at 30.°C

47 The table below shows the color of the indicators methyl orange and litmus in two samples of the same solution.

Results of Acid-Base Indicator Tests

Indicator	Color Result from the Indicator Test
methyl orange	yellow
litmus	red

Which pH value is consistent with the indicator results?

(1) 1
(2) 5
(3) 3
(4) 10

48 What is the pH of a solution that has a hydronium ion concentration 100 times greater than a solution with a pH of 4?

(1) 5
(2) 2
(3) 3
(4) 6

49 Which nuclear equation represents a natural transmutation?

(1) $^{9}_{4}Be + ^{1}_{1}H \rightarrow ^{6}_{3}Li + ^{4}_{2}He$
(2) $^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n$
(3) $^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$
(4) $^{235}_{92}U \rightarrow ^{231}_{90}Th + ^{4}_{2}He$

50 A nuclear fission reaction and a nuclear fusion reaction are similar because both reactions

(1) form heavy nuclides from light nuclides
(2) form light nuclides from heavy nuclides
(3) release a large amount of energy
(4) absorb a large amount of energy

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 What is the oxidation number of nitrogen in $NO(g)$? [1]

52 Write an electron configuration for an atom of aluminum-27 in an excited state. [1]

53 What color is bromcresol green after it is added to a sample of $NaOH(aq)$? [1]

Base your answers to questions 54 through 56 on the information below.

The accepted values for the atomic mass and percent natural abundance of each naturally occurring isotope of silicon are given in the data table below.

Naturally Occurring Isotopes of Silicon

Isotope	Atomic Mass (atomic mass units)	Percent Natural Abundance (%)
Si-28	27.98	92.22
Si-29	28.98	4.69
Si-30	29.97	3.09

54 Determine the total number of neutrons in an atom of Si-29. [1]

55 In the space *in your answer booklet*, show a correct numerical setup for calculating the atomic mass of Si. [1]

56 A scientist calculated the percent natural abundance of Si-30 in a sample to be 3.29%. Determine the percent error for this value. [1]

Base your answers to questions 57 through 60 on the information below.

The temperature of a sample of a substance is increased from 20.°C to 160.°C as the sample absorbs heat at a constant rate of 15 kilojoules per minute at standard pressure. The graph below represents the relationship between temperature and time as the sample is heated.

Temperature Versus Time
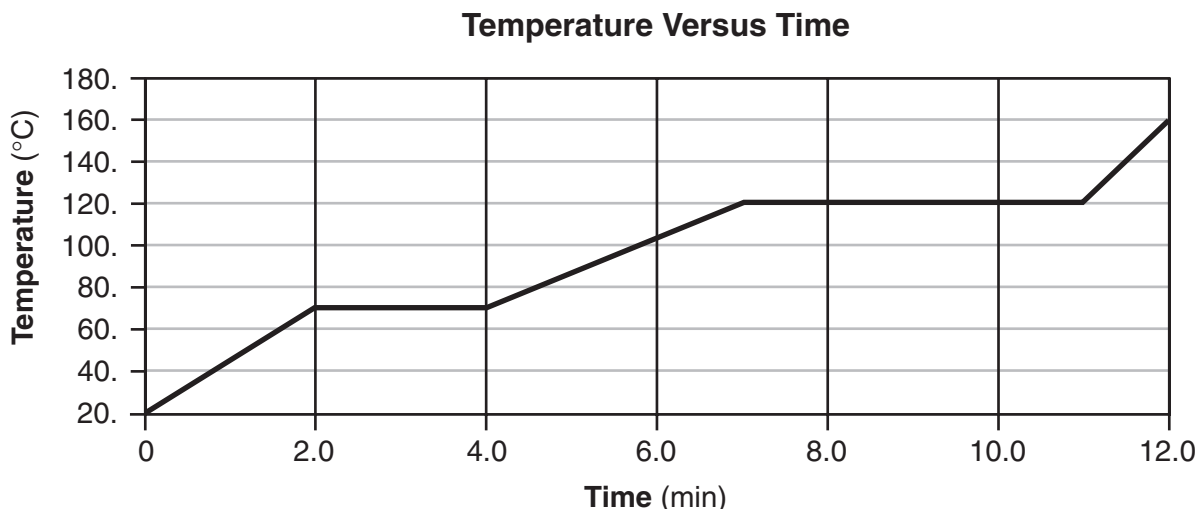
57 What is the boiling point of this sample? [1]

58 *In your answer booklet*, use the key to draw *at least nine* particles in the box, showing the correct particle arrangement of this sample during the first minute of heating. [1]

59 What is the total time this sample is in the liquid phase, only? [1]

60 Determine the total amount of heat required to completely melt this sample at its melting point. [1]

_____

Base your answers to questions 61 through 63 on the reaction represented by the balanced equation below.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell) + 571.6 \text{ kJ}$$
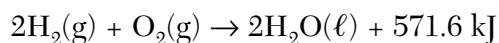
61 Identify the information in this equation that indicates the reaction is exothermic. [1]

62 On the axes *in your answer booklet*, draw a potential energy diagram for the reaction represented by this equation. [1]

63 Explain why the entropy of the system *decreases* as the reaction proceeds. [1]

_____

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

The incomplete equation below represents an esterification reaction. The alcohol reactant is represented by **X**.

$$\begin{matrix} & H & O \\ & | & \| \\ H- & C-C & -OH \\ & | \\ & H \end{matrix} + \textbf{X} \xrightarrow{\text{catalyst}} \begin{matrix} & H & O & & H & H & H \\ & | & \| & & | & | & | \\ H- & C-C & -O- & C-C-C & -H \\ & | & & & | & | & | \\ & H & & & H & H & H \end{matrix} + H_2O$$
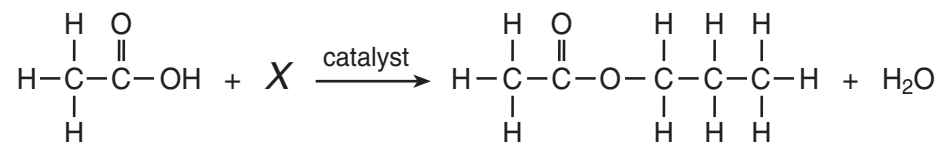
64 On the structural formula *in your answer booklet*, circle the acid functional group, only. [1]

65 Write an IUPAC name for the reactant represented by its structural formula in this equation. [1]

66 In the space *in your answer booklet*, draw the structural formula for the alcohol represented by **X**. [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.*
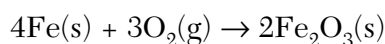
Base your answers to questions 67 through 69 on the information below.

> Elements with atomic numbers 112 and 114 have been produced and their IUPAC names are pending approval. However, an element that would be put between these two elements on the Periodic Table has not yet been produced. If produced, this element will be identified by the symbol Uut until an IUPAC name is approved.

67 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for an atom of Uut. [1]

68 Determine the charge of an Uut nucleus. Your response must include *both* the numerical value and the sign of the charge. [1]

69 Identify *one* element that would be chemically similar to Uut. [1]

Base your answers to questions 70 through 72 on the information below.

> Rust on an automobile door contains $Fe_2O_3(s)$. The balanced equation representing one of the reactions between iron in the door of the automobile and oxygen in the atmosphere is given below.

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

70 Identify the type of chemical reaction represented by this equation. [1]

71 Determine the gram-formula mass of the product of this reaction. [1]

72 Write the IUPAC name for Fe_2O_3. [1]

Base your answers to questions 73 through 75 on the information below.

A hydrate is a compound that has water molecules within its crystal structure. The formula for the hydrate $CuSO_4•5H_2O(s)$ shows that there are five moles of water for every one mole of $CuSO_4(s)$. When $CuSO_4•5H_2O(s)$ is heated, the water within the crystals is released, as represented by the balanced equation below.

$$CuSO_4•5H_2O(s) \rightarrow CuSO_4(s) + 5H_2O(g)$$
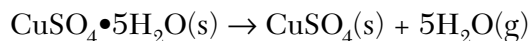
A student first masses an empty crucible (a heat-resistant container). The student then masses the crucible containing a sample of $CuSO_4•5H_2O(s)$. The student repeatedly heats and masses the crucible and its contents until the mass is constant. The student's recorded experimental data and calculations are shown below.

Data and calculation before heating:

mass of $CuSO_4•5H_2O(s)$ and crucible	21.37 g
– mass of crucible	19.24 g
mass of $CuSO_4•5H_2O(s)$	2.13 g

Data and calculation after heating to a constant mass:

mass of $CuSO_4(s)$ and crucible	20.61 g
– mass of crucible	19.24 g
mass of $CuSO_4(s)$	1.37 g

Calculation to determine the mass of water:

mass of $CuSO_4•5H_2O(s)$	2.13 g
– mass of $CuSO_4(s)$	1.37 g
mass of $H_2O(g)$	0.76 g

73 Identify the total number of significant figures recorded in the calculated mass of $CuSO_4•5H_2O(s)$. [1]

74 In the space *in your answer booklet*, use the student's data to show a correct numerical setup for calculating the percent composition by mass of water in the hydrate. [1]

75 Explain why the sample in the crucible must be heated until the constant mass is reached. [1]

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

The equilibrium equation below is related to the manufacture of a bleaching solution. In this equation, Cl⁻(aq) means that chloride ions are surrounded by water molecules.

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

76 *In your answer booklet*, use the key to draw *two* water molecules in the box, showing the correct orientation of each water molecule toward the chloride ion. [1]

77 Explain, in terms of collision theory, why increasing the concentration of $Cl_2(g)$ increases the concentration of $OCl^-(aq)$ in this equilibrium system. [1]

Base your answers to questions 78 through 80 on the information below.

In a laboratory activity, 0.500 mole of NaOH(s) is completely dissolved in distilled water to form 400. milliliters of NaOH(aq). This solution is then used to titrate a solution of $HNO_3(aq)$.

78 Identify the negative ion produced when the NaOH(s) is dissolved in distilled water. [1]

79 In the space *in your answer booklet*, calculate the molarity of the NaOH(aq). Your response must include *both* a correct numerical setup and the calculated result. [2]

80 *In your answer booklet*, complete the equation representing this titration reaction by writing the formulas of the products. [1]

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

The fossilized remains of a plant were found at a construction site. The fossilized remains contain $\frac{1}{16}$ the amount of carbon-14 that is present in a living plant.

81 Determine the approximate age of these fossilized remains. [1]

82 Complete the nuclear equation *in your answer booklet* for the decay of C-14. Your response must include the atomic number, the mass number, and the symbol of the missing particle. [1]

Base your answers to questions 83 and 84 on the information below.

Electroplating is an electrolytic process used to coat metal objects with a more expensive and less reactive metal. The diagram below shows an electroplating cell that includes a battery connected to a silver bar and a metal spoon. The bar and spoon are submerged in $AgNO_3(aq)$.

An Electroplating Cell
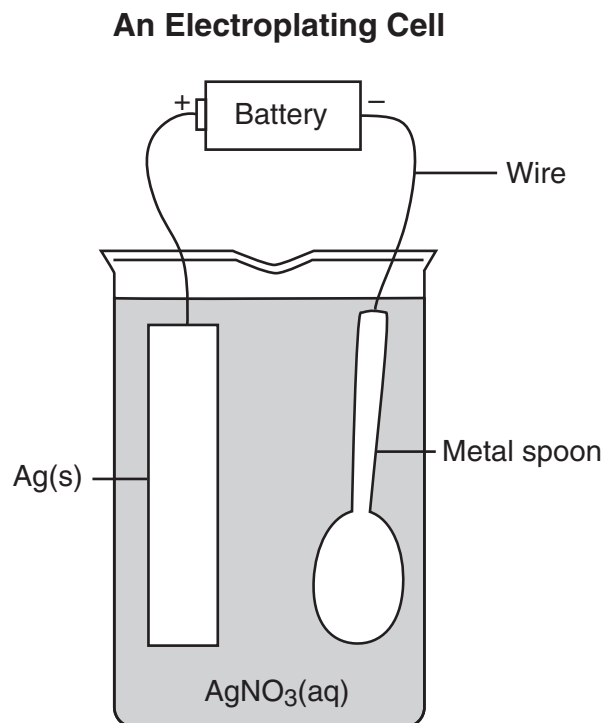
83 Explain why $AgNO_3$ is a better choice than AgCl for use in this electrolytic process. [1]

84 Explain the purpose of the battery in this cell. [1]

The University of the State of New York

PHYSICAL SETTING
CHEMISTRY

Thursday, August 16, 2007 — 12:30 to 3:30 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			**Part B–1**	
1	11	21	31	41 . . . .
2	12	22	32	42 . . . .
3	13	23	33	43 . . . .
4	14	24	34	44 . . . .
5	15	25	35	45 . . . .
6	16	26	36	46 . . . .
7	17	27	37	47 . . . .
8	18	28	38	48 . . . .
9	19	29	39	49 . . . .
10	20	30	40	50 . . . .

Part A Score

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

PS/CHEMISTRY