

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

PHYSICAL SETTING CHEMISTRY

Tuesday, August 17, 2004 — 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.

DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL THE SIGNAL IS GIVEN.

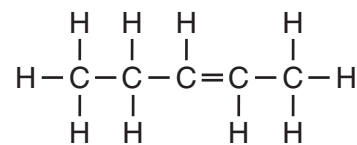
Part A

Answer all questions in this part.

Directions (1–33): 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 of these phrases best describes an atom?
- (1) a positive nucleus surrounded by a hard negative shell
 - (2) a positive nucleus surrounded by a cloud of negative charges
 - (3) a hard sphere with positive particles uniformly embedded
 - (4) a hard sphere with negative particles uniformly embedded
- 2 Which statement is true about a proton and an electron?
- (1) They have the same masses and the same charges.
 - (2) They have the same masses and different charges.
 - (3) They have different masses and the same charges.
 - (4) They have different masses and different charges.
- 3 The atomic mass of an element is the weighted average of the masses of
- (1) its two most abundant isotopes
 - (2) its two least abundant isotopes
 - (3) all of its naturally occurring isotopes
 - (4) all of its radioactive isotopes
- 4 What determines the order of placement of the elements on the modern Periodic Table?
- (1) atomic number
 - (2) atomic mass
 - (3) the number of neutrons, only
 - (4) the number of neutrons and protons
- 5 Which compound contains only covalent bonds?
- (1) NaOH
 - (2) Ba(OH)₂
 - (3) Ca(OH)₂
 - (4) CH₃OH
- 6 At 298 K, oxygen (O₂) and ozone (O₃) have different properties because their
- (1) atoms have different atomic numbers
 - (2) atoms have different atomic masses
 - (3) molecules have different molecular structures
 - (4) molecules have different average kinetic energies
- 7 Which substance represents a compound?
- (1) C(s)
 - (2) Co(s)
 - (3) CO(g)
 - (4) O₂(g)
- 8 All chemical reactions have a conservation of
- (1) mass, only
 - (2) mass and charge, only
 - (3) charge and energy, only
 - (4) mass, charge, and energy
- 9 Which characteristic is a property of molecular substances?
- (1) good heat conductivity
 - (2) good electrical conductivity
 - (3) low melting point
 - (4) high melting point
- 10 Given the Lewis electron-dot diagram:
- $$\begin{array}{c} \text{H} \\ \vdots \\ \text{H} : \text{C} : \text{H} \\ \vdots \\ \text{H} \end{array}$$
- Which electrons are represented by all of the dots?
- (1) the carbon valence electrons, only
 - (2) the hydrogen valence electrons, only
 - (3) the carbon and hydrogen valence electrons
 - (4) all of the carbon and hydrogen electrons

- 11 Which grouping of the three phases of bromine is listed in order from left to right for increasing distance between bromine molecules?
 (1) gas, liquid, solid (3) solid, gas, liquid
 (2) liquid, solid, gas (4) solid, liquid, gas
- 12 Which statement concerning elements is true?
 (1) Different elements must have different numbers of isotopes.
 (2) Different elements must have different numbers of neutrons.
 (3) All atoms of a given element must have the same mass number.
 (4) All atoms of a given element must have the same atomic number.
- 13 At room temperature, the solubility of which solute in water would be most affected by a change in pressure?
 (1) methanol (3) carbon dioxide
 (2) sugar (4) sodium nitrate
- 14 Based on Reference Table I, which change occurs when pellets of solid NaOH are added to water and stirred?
 (1) The water temperature increases as chemical energy is converted to heat energy.
 (2) The water temperature increases as heat energy is stored as chemical energy.
 (3) The water temperature decreases as chemical energy is converted to heat energy.
 (4) The water temperature decreases as heat energy is stored as chemical energy.
- 15 The concept of an ideal gas is used to explain
 (1) the mass of a gas sample
 (2) the behavior of a gas sample
 (3) why some gases are monatomic
 (4) why some gases are diatomic
- 16 Molecules in a sample of $\text{NH}_3(\ell)$ are held closely together by intermolecular forces
 (1) existing between ions
 (2) existing between electrons
 (3) caused by different numbers of neutrons
 (4) caused by unequal charge distribution
- 17 Which process represents a chemical change?
 (1) melting of ice
 (2) corrosion of copper
 (3) evaporation of water
 (4) crystallization of sugar
- 18 At STP, which 4.0-gram zinc sample will react fastest with dilute hydrochloric acid?
 (1) lump (3) powdered
 (2) bar (4) sheet metal
- 19 Which information about a chemical reaction is provided by a potential energy diagram?
 (1) the oxidation states of the reactants and products
 (2) the average kinetic energy of the reactants and products
 (3) the change in solubility of the reacting substances
 (4) the energy released or absorbed during the reaction
- 20 A catalyst works by
 (1) increasing the potential energy of the reactants
 (2) increasing the energy released during a reaction
 (3) decreasing the potential energy of the products
 (4) decreasing the activation energy required for a reaction
- 21 Even though the process is endothermic, snow can sublime. Which tendency in nature accounts for this phase change?
 (1) a tendency toward greater entropy
 (2) a tendency toward greater energy
 (3) a tendency toward less entropy
 (4) a tendency toward less energy
- 22 What is the IUPAC name of the compound with the structural formula shown below?



- (1) 2-pentene (3) 2-pentyne
 (2) 3-pentene (4) 3-pentyne

- 23 Molecules of 1-bromopropane and 2-bromopropane differ in
- (1) molecular formula
 - (2) structural formula
 - (3) number of carbon atoms per molecule
 - (4) number of bromine atoms per molecule
- 24 Which half-reaction correctly represents reduction?
- (1) $\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$
 - (2) $\text{F}_2 \rightarrow 2 \text{F}^- + 2\text{e}^-$
 - (3) $\text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au}$
 - (4) $\text{Fe}^{2+} + \text{e}^- \rightarrow \text{Fe}^{3+}$
- 25 In a redox reaction, how does the total number of electrons lost by the oxidized substance compare to the total number of electrons gained by the reduced substance?
- (1) The number lost is always greater than the number gained.
 - (2) The number lost is always equal to the number gained.
 - (3) The number lost is sometimes equal to the number gained.
 - (4) The number lost is sometimes less than the number gained.
- 26 Which reaction is an example of an oxidation-reduction reaction?
- (1) $\text{AgNO}_3 + \text{KI} \rightarrow \text{AgI} + \text{KNO}_3$
 - (2) $\text{Cu} + 2 \text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2 \text{Ag}$
 - (3) $2 \text{KOH} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2 \text{H}_2\text{O}$
 - (4) $\text{Ba}(\text{OH})_2 + 2 \text{HCl} \rightarrow \text{BaCl}_2 + 2 \text{H}_2\text{O}$
- 27 Which compound is an Arrhenius base?
- (1) CH_3OH
 - (2) CO_2
 - (3) LiOH
 - (4) NO_2
- 28 The only positive ion found in an aqueous solution of sulfuric acid is the
- (1) hydroxide ion
 - (2) hydronium ion
 - (3) sulfite ion
 - (4) sulfate ion
- 29 Which process uses a volume of solution of known concentration to determine the concentration of another solution?
- (1) distillation
 - (2) substitution
 - (3) transmutation
 - (4) titration
- 30 Which pH change represents a hundredfold increase in the concentration of H_3O^+ ?
- (1) pH 5 to pH 7
 - (2) pH 13 to pH 14
 - (3) pH 3 to pH 1
 - (4) pH 4 to pH 3
- 31 Which radioisotope undergoes beta decay and has a half-life of less than 1 minute?
- (1) Fr-220
 - (2) K-42
 - (3) N-16
 - (4) P-32
- 32 Which set of symbols represents atoms with valence electrons in the same electron shell?
- (1) Ba, Br, Bi
 - (2) Sr, Sn, I
 - (3) O, S, Te
 - (4) Mn, Hg, Cu
- Note that question 33 has only three choices.**
- 33 When compared with the energy of an electron in the first shell of a carbon atom, the energy of an electron in the second shell of a carbon atom is
- (1) less
 - (2) greater
 - (3) the same

Part B-1

Answer all questions in this part.

Directions (34–50): 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*.

34 What is the total number of electrons found in an atom of sulfur?

- (1) 6 (3) 16
(2) 8 (4) 32

35 Which electron configuration represents the electrons of an atom in an excited state?

- (1) 2–8–1 (3) 2–8–17–6
(2) 2–8–6 (4) 2–8–18–5

36 The nucleus of an atom of cobalt-58 contains

- (1) 27 protons and 31 neutrons
(2) 27 protons and 32 neutrons
(3) 59 protons and 60 neutrons
(4) 60 protons and 60 neutrons

37 Which pair of formulas correctly represents a molecular formula and its corresponding empirical formula?

- (1) C₂H₂ and CH (3) C₄H₆ and CH
(2) C₃H₄ and CH₂ (4) C₅H₈ and C₂H₂

38 Which substance is correctly paired with its type of bonding?

- (1) NaBr—nonpolar covalent
(2) HCl—nonpolar covalent
(3) NH₃—polar covalent
(4) Br₂—polar covalent

39 A gas occupies a volume of 444 mL at 273 K and 79.0 kPa. What is the final kelvin temperature when the volume of the gas is changed to 1880 mL and the pressure is changed to 38.7 kPa?

- (1) 31.5 K (3) 566 K
(2) 292 K (4) 2360 K

40 At STP, which of these substances is most soluble in H₂O?

- (1) CCl₄ (3) HCl
(2) CO₂ (4) N₂

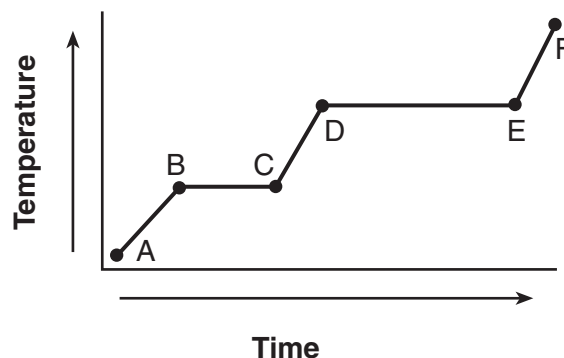
41 Based on intermolecular forces, which of these substances would have the highest boiling point?

- (1) He (3) CH₄
(2) O₂ (4) NH₃

42 How much heat energy must be absorbed to completely melt 35.0 grams of H₂O(s) at 0°C?

- (1) 9.54 J (3) 11 700 J
(2) 146 J (4) 79 100 J

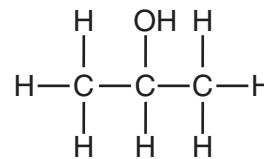
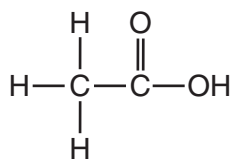
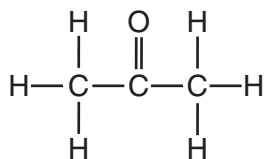
43 The graph below represents the uniform heating of a substance, starting below its melting point, when the substance is solid.



Which line segments represent an increase in average kinetic energy?

- (1) \overline{AB} and \overline{BC} (3) \overline{BC} and \overline{DE}
(2) \overline{AB} and \overline{CD} (4) \overline{DE} and \overline{EF}

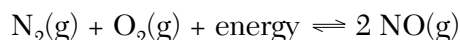
44 Given the three organic structural formulas shown below:



Which organic-compound classes are represented by these structural formulas, as shown from left to right?

- (1) ester, organic acid, ketone
(2) ester, aldehyde, organic acid
(3) ketone, aldehyde, alcohol
(4) ketone, organic acid, alcohol

45 Given the reaction at equilibrium:



Which change will result in a *decrease* in the amount of NO(g) formed?

- (1) decreasing the pressure
(2) decreasing the concentration of $\text{N}_2(\text{g})$
(3) increasing the concentration of $\text{O}_2(\text{g})$
(4) increasing the temperature

46 Given the equation:



Which molecule is represented by X?

- (1) C_2H_4 (3) C_3H_6
(2) C_2H_6 (4) C_3H_8

47 Which metal reacts spontaneously with a solution containing zinc ions?

- (1) magnesium (3) copper
(2) nickel (4) silver

48 Which statement correctly describes a solution with a pH of 9?

- (1) It has a higher concentration of H_3O^+ than OH^- and causes litmus to turn blue.
(2) It has a higher concentration of OH^- than H_3O^+ and causes litmus to turn blue.
(3) It has a higher concentration of H_3O^+ than OH^- and causes methyl orange to turn yellow.
(4) It has a higher concentration of OH^- than H_3O^+ and causes methyl orange to turn red.

49 How many days are required for 200. grams of radon-222 to decay to 50.0 grams?

- (1) 1.91 days (3) 7.64 days
(2) 3.82 days (4) 11.5 days

50 A student calculates the density of an unknown solid. The mass is 10.04 grams, and the volume is 8.21 cubic centimeters. How many significant figures should appear in the final answer?

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

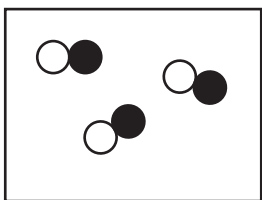
Part B-2

Answer all questions in this part.

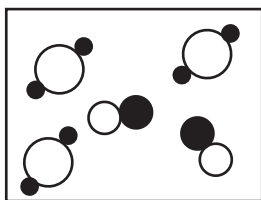
Directions (51–65): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry*.

- 51 In the 19th century, Dmitri Mendeleev predicted the existence of a then unknown element X with a mass of 68. He also predicted that an oxide of X would have the formula X_2O_3 . On the modern Periodic Table, what is the group number and period number of element X ? [1]
- 52 Given the equation: $2 H_2(g) + O_2(g) \rightarrow 2 H_2O(g)$
If 8.0 moles of O_2 are completely consumed, what is the total number of moles of H_2O produced? [1]
- 53 In the space provided *in your answer booklet*, show a correct numerical setup for determining how many liters of a 1.2 M solution can be prepared with 0.50 mole of $C_6H_{12}O_6$. [1]

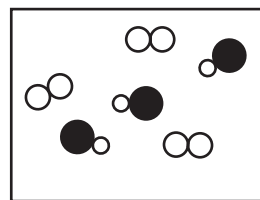
Base your answers to questions 54 through 57 on the particle diagrams below. Samples A, B, and C contain molecules at STP.



A



B



C

- 54 Explain why the average kinetic energy of sample B is equal to the average kinetic energy of sample C. [1]
- 55 Explain, in terms of the *composition*, why sample A represents a pure substance. [1]
- 56 Explain why sample C could represent a mixture of fluorine and hydrogen chloride. [1]
- 57 Contrast sample A and sample B, in terms of *compounds and mixtures*. Include both sample A and sample B in your answer. [1]
-

Base your answers to questions 58 through 60 on the electronegativity values and atomic numbers of fluorine, chlorine, bromine, and iodine that are listed on Reference Table S.

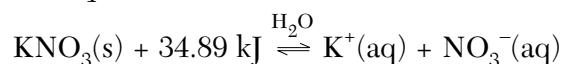
- 58 On the grid provided in *your answer booklet*, mark an appropriate scale on the axis labeled "Electronegativity." An appropriate scale is one that allows a trend to be seen. [1]
- 59 On the same grid, plot the electronegativity and atomic number data from Reference Table S. Circle and connect the points. [1]

Example: 

- 60 Explain, in terms of *electronegativity*, why the H–F bond is expected to be more polar than the H–I bond. [1]
-
- 61 What is the gram-formula mass of $(\text{NH}_4)_2\text{CO}_3$? Use atomic masses rounded to the nearest whole number. [1]
- 62 In the space provided in *your answer booklet*, show a correct numerical setup for calculating the number of moles of CO_2 (gram-formula mass = 44 g/mol) present in 11 grams of CO_2 . [1]

Base your answers to questions 63 and 64 on the information below.

Given the equilibrium equation at 298 K:



- 63 Describe, in terms of *LeChatelier's principle*, why an increase in temperature increases the solubility of KNO_3 . [1]
- 64 The equation indicates that KNO_3 has formed a saturated solution. Explain, in terms of *equilibrium*, why the solution is saturated. [1]
-
- 65 In the space provided in *your answer booklet*, draw the structural formula for butanoic acid. [1]
-

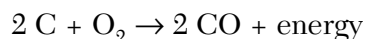
Part C

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 *Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 66 through 69 on the information below, which describes the smelting of iron ore, and on your knowledge of chemistry.

In the smelting of iron ore, Fe_2O_3 is reduced in a blast furnace at high temperature by a reaction with carbon monoxide. Crushed limestone, CaCO_3 , is also added to the mixture to remove impurities in the ore. The carbon monoxide is formed by the oxidation of carbon (coke), as shown in the reaction below:



Liquid iron flows from the bottom of the blast furnace and is processed into different alloys of iron.

- 66 Balance the equation for the reaction of Fe_2O_3 and CO in *your answer booklet*, using the smallest whole-number coefficients. [1]
- 67 Using the set of axes provided in *your answer booklet*, sketch a potential energy diagram for the reaction of carbon and oxygen that produces carbon monoxide. [1]
- 68 What is the oxidation number of carbon in CaCO_3 ? [1]
- 69 Convert the melting point of iron metal to degrees Celsius. [1]
-

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

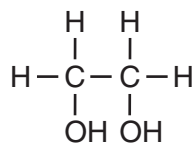
Potassium ions are essential to human health. The movement of dissolved potassium ions, $\text{K}^+(\text{aq})$, in and out of a nerve cell allows that cell to transmit an electrical impulse.

- 70 What is the total number of electrons in a potassium ion? [1]
- 71 Explain, in terms of *atomic structure*, why a potassium ion is smaller than a potassium atom. [1]
- 72 What property of potassium ions allows them to transmit an electrical impulse? [1]
-

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

Ethene (common name ethylene) is a commercially important organic compound. Millions of tons of ethene are produced by the chemical industry each year. Ethene is used in the manufacture of synthetic fibers for carpeting and clothing, and it is widely used in making polyethylene. Low-density polyethylene can be stretched into a clear, thin film that is used for wrapping food products and consumer goods. High-density polyethylene is molded into bottles for milk and other liquids.

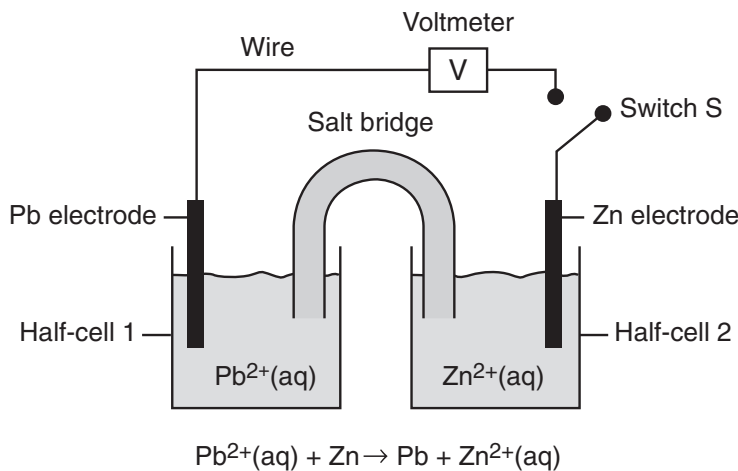
Ethene can also be oxidized to produce ethylene glycol, which is used in antifreeze for automobiles. The structural formula for ethylene glycol is:



At standard atmospheric pressure, the boiling point of ethylene glycol is 198°C, compared to ethene that boils at -104°C.

- 73 Identify the type of organic reaction by which ethene (ethylene) is made into polyethylene. [1]
- 74 According to the information in the reading passage, state *two* consumer products manufactured from ethene. [1]
- 75 Explain, in terms of *bonding*, why ethene is an unsaturated hydrocarbon. [1]
-

Base your answers to questions 76 through 78 on the diagram below, which represents a voltaic cell at 298 K and 1 atm.



- 76 In which half-cell will oxidation occur when switch S is closed? [1]
- 77 Write the balanced half-reaction equation that will occur in half-cell 1 when switch S is closed. [1]
- 78 Describe the direction of electron flow between the electrodes when switch S is closed. [1]
-

Base your answers to questions 79 through 81 on the information and data table below.

Indigestion may be caused by excess stomach acid (hydrochloric acid). Some products used to treat indigestion contain magnesium hydroxide. The magnesium hydroxide neutralizes some of the stomach acid.

The amount of acid that can be neutralized by three different brands of antacids is shown in the data table below.

Antacid Brand	Mass of Antacid Tablet (g)	Volume of HCl(aq) Neutralized (mL)
X	2.00	25.20
Y	1.20	18.65
Z	1.75	22.50

79 Based on Reference Table *F*, describe the solubility of magnesium hydroxide in water. [1]

80 In the space provided *in your answer booklet*, show a correct numerical setup for calculating the milliliters of HCl(aq) neutralized per gram of antacid tablet for *each* brand of antacid. [1]

81 Which antacid brand neutralizes the most acid per gram of antacid tablet? [1]

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

A Glow in the Dark, and Scientific Peril

The [Marie and Pierre] Curies set out to study radioactivity in 1898. Their first accomplishment was to show that radioactivity was a property of atoms themselves. Scientifically, that was the most important of their findings, because it helped other researchers refine their understanding of atomic structure.

More famous was their discovery of polonium and radium. Radium was the most radioactive substance the Curies had encountered. Its radioactivity is due to the large size of the atom, which makes the nucleus unstable and prone to decay, usually to radon and then lead, by emitting particles and energy as it seeks a more stable configuration.

Marie Curie struggled to purify radium for medical uses, including early radiation treatment for tumors. But radium's bluish glow caught people's fancy, and companies in the United States began mining it and selling it as a novelty: for glow-in-the-dark light pulls, for instance, and bogus cure-all patent medicines that actually killed people.

What makes radium so dangerous is that it forms chemical bonds in the same way as calcium, and the body can mistake it for calcium and absorb it into the bones. Then, it can bombard cells with radiation at close range, which may cause bone tumors or bone-marrow damage that can give rise to anemia or leukemia.

— Denise Grady, *The New York Times*, October 6, 1998

- 82 State one risk associated with the use of radium. [1]
- 83 Using Reference Table N, complete the equation provided *in your answer booklet* for the nuclear decay of $^{226}_{88}\text{Ra}$. Include *both* atomic number and mass number for *each* particle. [1]
- 84 Using information from the Periodic Table, explain why radium forms chemical bonds in the same way as calcium does. [1]
- 85 If a scientist purifies 1.0 gram of radium-226, how many years must pass before only 0.50 gram of the original radium-226 sample remains unchanged? [1]
-

Tear Here

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING CHEMISTRY

Tuesday, August 17, 2004 — 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

- 1 12 23
2 13 24
3 14 25
4 15 26
5 16 27
6 17 28
7 18 29
8 19 30
9 20 31
10 21 32
11 22 33

Part A Score

[Box for Part A Score]

Part B-1

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

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

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