

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

PHYSICAL SETTING CHEMISTRY

Thursday, January 27, 2005 — 9:15 a.m. to 12:15 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.

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

Part A

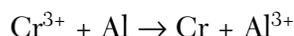
Answer all questions in this part.

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*.

- As an electron in an atom moves from the ground state to the excited state, the electron
 - gains energy as it moves to a higher energy level
 - gains energy as it moves to a lower energy level
 - loses energy as it moves to a higher energy level
 - loses energy as it moves to a lower energy level
- Which subatomic particle will be attracted by a positively charged object?
 - proton
 - neutron
 - electron
 - positron
- Which conclusion is based on the “gold foil experiment” and the resulting model of the atom?
 - An atom is mainly empty space, and the nucleus has a positive charge.
 - An atom is mainly empty space, and the nucleus has a negative charge.
 - An atom has hardly any empty space, and the nucleus has a positive charge.
 - An atom has hardly any empty space, and the nucleus has a negative charge.
- Which two particles have approximately the same mass?
 - proton and neutron
 - proton and electron
 - neutron and electron
 - neutron and positron
- Which element has chemical properties that are most similar to the chemical properties of sodium?
 - Mg
 - K
 - Se
 - Cl
- Germanium is classified as a
 - metal
 - metalloid
 - nonmetal
 - noble gas
- Which statement correctly describes diamond and graphite, which are different forms of solid carbon?
 - They differ in their molecular structure, only.
 - They differ in their properties, only.
 - They differ in their molecular structure and properties.
 - They do not differ in their molecular structure or properties.
- What is the chemical formula for copper(II) hydroxide?
 - CuOH
 - CuOH₂
 - Cu₂(OH)
 - Cu(OH)₂
- What is the percent composition by mass of aluminum in Al₂(SO₄)₃ (gram-formula mass = 342 grams/mole)?
 - 7.89%
 - 15.8%
 - 20.8%
 - 36.0%
- Which statement describes a chemical property that can be used to distinguish between compound A and compound B?
 - A is a blue solid, and B is a white solid.
 - A has a high melting point, and B has a low melting point.
 - A dissolves in water, and B does not dissolve in water.
 - A does not burn in air, and B does burn in air.

- 11 Which compound contains both ionic and covalent bonds?
 (1) CaCO_3 (3) MgF_2
 (2) PCl_3 (4) CH_2O
- 12 Which formula represents a nonpolar molecule?
 (1) HCl (3) NH_3
 (2) H_2O (4) CF_4
- 13 When a lithium atom forms an Li^+ ion, the lithium atom
 (1) gains a proton
 (2) gains an electron
 (3) loses a proton
 (4) loses an electron
- 14 Which Lewis electron-dot diagram represents a boron atom in the ground state?
 (1) $\cdot\text{B}$ (3) $:\ddot{\text{B}}\cdot$
 (2) $:\ddot{\text{B}}$ (4) $:\ddot{\text{B}}\cdot$
- 15 A sample is prepared by completely dissolving 10.0 grams of NaCl in 1.0 liter of H_2O . Which classification best describes this sample?
 (1) homogeneous compound
 (2) homogeneous mixture
 (3) heterogeneous compound
 (4) heterogeneous mixture
- 16 Which form of energy is converted to thermal energy when propane burns in air?
 (1) electromagnetic (3) electrical
 (2) nuclear (4) chemical
- 17 Which physical changes are endothermic?
 (1) melting and freezing
 (2) melting and evaporating
 (3) condensation and sublimation
 (4) condensation and deposition
- 18 Which transfer of energy occurs when ice cubes are placed in water that has a temperature of 45°C ?
 (1) Chemical energy is transferred from the ice to the water.
 (2) Chemical energy is transferred from the water to the ice.
 (3) Thermal energy is transferred from the ice to the water.
 (4) Thermal energy is transferred from the water to the ice.
- 19 At STP, 4 liters of O_2 contains the same total number of molecules as
 (1) 1 L of NH_3 (3) 8 L of He
 (2) 2 L of Cl_2 (4) 4 L of CO_2
- 20 What is the total number of electron pairs that are shared between the two carbon atoms in a molecule of ethyne?
 (1) 1 (3) 3
 (2) 2 (4) 4
- 21 Which pair of compounds are isomers?
 (1) NO_2 and N_2O_4
 (2) P_2O_5 and P_4O_{10}
 (3) HCOOH and CH_3COOH
 (4) CH_3OCH_3 and $\text{C}_2\text{H}_5\text{OH}$
- 22 Which organic compound is unsaturated?
 (1) 2-methylbutane (3) 2-hexanol
 (2) 2-chloropropane (4) 2-pentene
- 23 Which change in oxidation number indicates oxidation?
 (1) -1 to $+2$ (3) $+2$ to -3
 (2) -1 to -2 (4) $+3$ to $+2$

24 Given the redox reaction:



As the reaction takes place, there is a transfer of

- (1) electrons from Al to Cr^{3+}
- (2) electrons from Cr^{3+} to Al
- (3) protons from Al to Cr^{3+}
- (4) protons from Cr^{3+} to Al

25 The compound HNO_3 can be described as an

- (1) Arrhenius acid and an electrolyte
- (2) Arrhenius acid and a nonelectrolyte
- (3) Arrhenius base and an electrolyte
- (4) Arrhenius base and a nonelectrolyte

26 According to Reference Table *M*, what is the color of the indicator methyl orange in a solution that has a pH of 2?

- | | |
|------------|------------|
| (1) blue | (3) orange |
| (2) yellow | (4) red |

27 Given the reaction:



In this reaction, ammonia molecules (NH_3) act as a base because they

- (1) accept hydrogen ions (H^+)
- (2) accept hydroxide ions (OH^-)
- (3) donate hydrogen ions (H^+)
- (4) donate hydroxide ions (OH^-)

28 Which reaction is an example of natural transmutation?

- (1) ${}_{94}^{239}\text{Pu} \rightarrow {}_{92}^{235}\text{U} + {}_2^4\text{He}$
- (2) ${}_{13}^{27}\text{Al} + {}_2^4\text{He} \rightarrow {}_{15}^{30}\text{P} + {}_0^1\text{n}$
- (3) ${}_{92}^{238}\text{U} + {}_0^1\text{n} \rightarrow {}_{94}^{239}\text{Pu} + 2 {}_{-1}^0\text{e}$
- (4) ${}_{94}^{239}\text{Pu} + {}_0^1\text{n} \rightarrow {}_{56}^{147}\text{Ba} + {}_{38}^{90}\text{Sr} + 3 {}_0^1\text{n}$

29 Which statement best describes gamma radiation?

- (1) It has a mass of 1 and a charge of 1.
- (2) It has a mass of 0 and a charge of -1 .
- (3) It has a mass of 0 and a charge of 0.
- (4) It has a mass of 4 and a charge of $+2$.

30 Which change takes place in a nuclear fusion reaction?

- (1) Matter is converted to energy.
- (2) Energy is converted to matter.
- (3) Ionic bonds are converted to covalent bonds.
- (4) Covalent bonds are converted to ionic bonds.

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 total number of neutrons in the nucleus of a neutral atom that has 19 electrons and a mass number of 39?

- (1) 19 (3) 39
(2) 20 (4) 58

32 An unknown element X can form a compound with the formula XBr_3 . In which group on the Periodic Table would element X be found?

- (1) 1 (3) 13
(2) 2 (4) 14

33 As the elements in Group 17 on the Periodic Table are considered from top to bottom, what happens to the atomic radius and the metallic character of each successive element?

- (1) The atomic radius and the metallic character both increase.
(2) The atomic radius increases and the metallic character decreases.
(3) The atomic radius decreases and the metallic character increases.
(4) The atomic radius and the metallic character both decrease.

34 Which pair of compounds has the same empirical formula?

- (1) C_2H_2 and C_6H_6
(2) C_2H_6 and C_3H_8
(3) CH_3OH and C_2H_5OH
(4) CH_3CHO and CH_3COOH

35 Which equation shows a conservation of mass?

- (1) $Na + Cl_2 \rightarrow NaCl$
(2) $Al + Br_2 \rightarrow AlBr_3$
(3) $H_2O \rightarrow H_2 + O_2$
(4) $PCl_5 \rightarrow PCl_3 + Cl_2$

36 How many electrons are in an Fe^{2+} ion?

- (1) 24 (3) 28
(2) 26 (4) 56

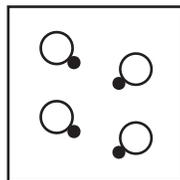
37 A substance that does not conduct electricity as a solid but does conduct electricity when melted is most likely classified as

- (1) an ionic compound
(2) a molecular compound
(3) a metal
(4) a nonmetal

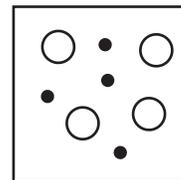
38 According to Reference Table H , what is the boiling point of ethanoic acid at 80 kPa?

- (1) $28^\circ C$ (3) $111^\circ C$
(2) $100^\circ C$ (4) $125^\circ C$

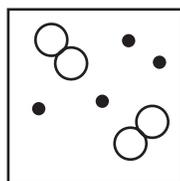
39 Which particle diagram represents one pure substance, only?



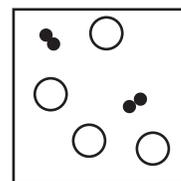
(1)



(3)



(2)



(4)

40 A sample of helium gas has a volume of 900. milliliters and a pressure of 2.50 atm at 298 K. What is the new pressure when the temperature is changed to 336 K and the volume is decreased to 450. milliliters?

- (1) 0.177 atm (3) 5.64 atm
 (2) 4.43 atm (4) 14.1 atm

41 Given the particle diagram:



At 101.3 kPa and 298 K, which element could this diagram represent?

- (1) Rn (3) Ag
 (2) Xe (4) Kr

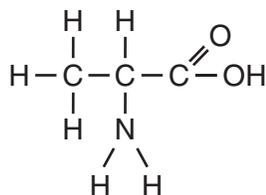
42 For most atoms with an atomic number less than 20, nuclear stability occurs when the ratio of neutrons to protons is 1:1. Which of the following atoms would be most likely to have an unstable nucleus?

- (1) ${}^4_2\text{He}$ (3) ${}^{16}_7\text{N}$
 (2) ${}^{12}_6\text{C}$ (4) ${}^{24}_{12}\text{Mg}$

43 Which of these changes produces the greatest increase in entropy?

- (1) $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
 (2) $2 \text{Mg}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2 \text{MgO}(\text{s})$
 (3) $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\ell)$
 (4) $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{s})$

44 Given the structural formula:



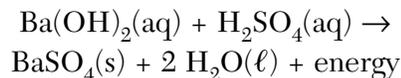
This structural formula represents a molecule of

- (1) an aldehyde (3) a ketone
 (2) an ester (4) an amino acid

45 Which half-reaction can occur at the anode in a voltaic cell?

- (1) $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$ (3) $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$
 (2) $\text{Sn} + 2\text{e}^- \rightarrow \text{Sn}^{2+}$ (4) $\text{Fe}^{3+} \rightarrow \text{Fe}^{2+} + \text{e}^-$

46 Given the reaction:



As the barium hydroxide solution is added to the solution of sulfuric acid, the electrical conductivity of the acid solution decreases because the

- (1) volume of the reaction mixture increases
 (2) temperature of the reaction mixture decreases
 (3) concentration of ions increases
 (4) concentration of ions decreases

47 Which chemical equation represents the reaction of an Arrhenius acid and an Arrhenius base?

- (1) $\text{HC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{H}_2\text{O}(\ell)$
 (2) $\text{C}_3\text{H}_8(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 3 \text{CO}_2(\text{g}) + 4 \text{H}_2\text{O}(\ell)$
 (3) $\text{Zn}(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2(\text{g})$
 (4) $\text{BaCl}_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2 \text{NaCl}(\text{aq})$

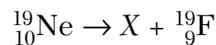
48 Based on Reference Table F, which of these saturated solutions has the *lowest* concentration of dissolved ions?

- (1) $\text{NaCl}(\text{aq})$ (3) $\text{NiCl}_2(\text{aq})$
 (2) $\text{MgCl}_2(\text{aq})$ (4) $\text{AgCl}(\text{aq})$

49 Based on Reference Table N, what fraction of a radioactive ${}^{90}\text{Sr}$ sample would remain unchanged after 56.2 years?

- (1) $\frac{1}{2}$ (3) $\frac{1}{8}$
 (2) $\frac{1}{4}$ (4) $\frac{1}{16}$

50 Given the nuclear equation:



Which particle is represented by X?

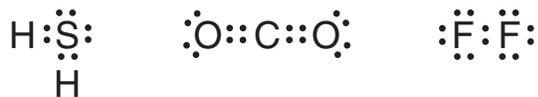
- (1) alpha (3) neutron
 (2) beta (4) positron

Part B-2

Answer all questions in this part.

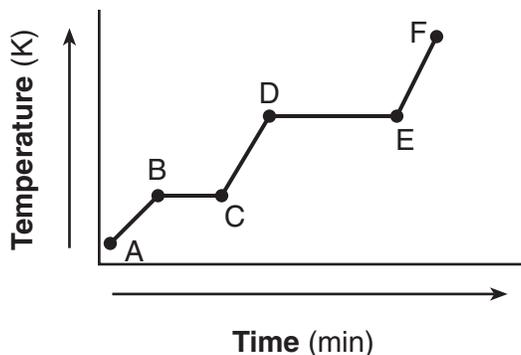
Directions (51–65): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 51 through 53 on your knowledge of chemical bonding and on the Lewis electron-dot diagrams of H_2S , CO_2 , and F_2 below.



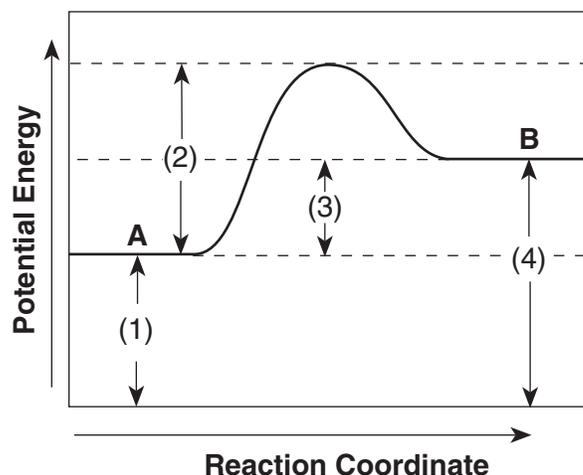
- 51 Which atom, when bonded as shown, has the same electron configuration as an atom of argon? [1]
- 52 Explain, in terms of *structure* and/or *distribution of charge*, why CO_2 is a nonpolar molecule. [1]
- 53 Explain, in terms of *electronegativity*, why a C=O bond in CO_2 is more polar than the F–F bond in F_2 . [1]
-

Base your answers to questions 54 and 55 on the heating curve below, which represents a substance starting as a solid below its melting point and being heated at a constant rate over a period of time.



- 54 What is happening to the average kinetic energy of the particles during segment \overline{BC} ? [1]
- 55 How does this heating curve illustrate that the heat of vaporization is greater than the heat of fusion? [1]
-

Base your answers to questions 56 through 58 on the potential energy diagram and the equation below.



56 The letter *B* represents which chemical formula or formulas in the equation? [1]

57 If 682.2 kilojoules are absorbed, how many moles of $\text{C}_2\text{H}_2\text{(g)}$ are produced? [1]

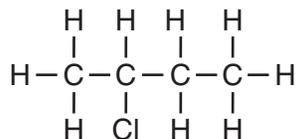
58 Describe how the potential energy diagram will change if a catalyst is added. [1]

Base your answers to questions 59 and 60 on the condensed structural formula below.



59 In the space provided in *your answer booklet*, draw the structural formula for this compound. [1]

60 The formula below represents a product formed when HCl reacts with $\text{CH}_3\text{CH}_2\text{CHCH}_2$.



What is an IUPAC name for this product? [1]

61 Given the equation:



To which class of organic compounds does product X belong? [1]

62 Identify the homologous series of hydrocarbons to which CH_3CHCH_2 belongs. [1]

Base your answers to questions 63 through 65 on the information below.

In a titration experiment, a student uses a 1.4 M HBr(aq) solution and the indicator phenolphthalein to determine the concentration of a KOH(aq) solution. The data for trial 1 is recorded in the table below.

Trial 1

Buret Readings	HBr(aq)	KOH(aq)
Initial volume (mL)	7.50	11.00
Final volume (mL)	22.90	33.10
Volume used (mL)	15.40	22.10

63 In the space provided *in your answer booklet*, show a correct numerical setup for calculating the molarity of the KOH(aq) solution for trial 1. [1]

64 Why is it better to use several trials of a titration rather than one trial to determine the molarity of a solution of an unknown concentration? [1]

65 In a second trial of this experiment, the molarity of KOH(aq) was determined to be 0.95 M. The actual molarity was 0.83 M. What is the percent error in the second trial? [1]

Part C

Answer all questions in this part.

Directions (66–84): 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 66 and 67 on the information below.

Naturally occurring elemental carbon is a mixture of isotopes. The percent composition of the two most abundant isotopes is listed below.

- 98.93% of the carbon atoms have a mass of 12.00 atomic mass units.
- 1.07% of the carbon atoms have a mass of 13.00 atomic mass units.

- 66 In the space provided *in your answer booklet*, show a correct numerical setup for calculating the average atomic mass of carbon. [1]
- 67 Describe, in terms of *subatomic particles found in the nucleus*, one difference between the nuclei of carbon-12 atoms and the nuclei of carbon-13 atoms. The response must include both isotopes. [1]
-

Base your answers to questions 68 and 69 on the information below.

A scientist in a chemistry laboratory determined the molecular formulas for two compounds containing nitrogen and oxygen to be NO_2 and N_2O_5 .

- 68 Write an IUPAC name for the compound N_2O_5 . [1]
- 69 In the space provided *in your answer booklet*, show a correct numerical setup for calculating the percent composition by mass of oxygen in NO_2 . [1]
-

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

In a laboratory experiment, 10.00 grams of an unknown solid is added to 100.0 milliliters of water and the temperature of the resulting solution is measured over several minutes, as recorded in the table below.

Data Table

Time (minutes)	Temperature (°C)
0	24.0
0.5	28.5
1.0	31.0
1.5	34.5
2.0	41.0
2.5	45.5
3.0	46.5

70 On the grid provided in *your answer booklet*, mark an appropriate scale on the axis labeled “Temperature (°C).” An appropriate scale is one that allows a trend to be seen. [1]

71 Plot the data from the data table. Circle and connect the points. [1]



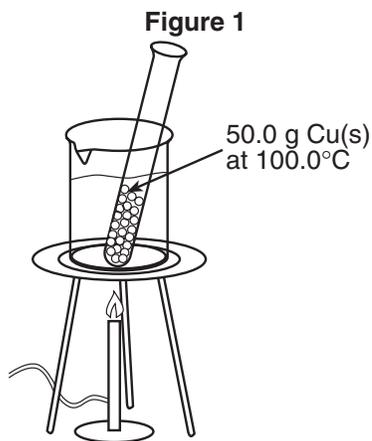
72 Given the statement:

The unknown solid is either sodium hydroxide or lithium bromide, and both of these compounds dissolve in water exothermically.

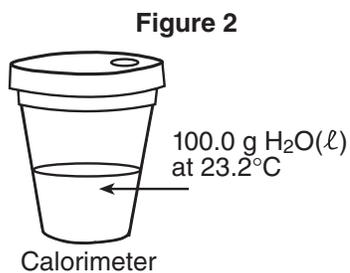
a Explain how the experimental data support the statement. [1]

b State specific information from Reference Table *I* to support the statement. [1]

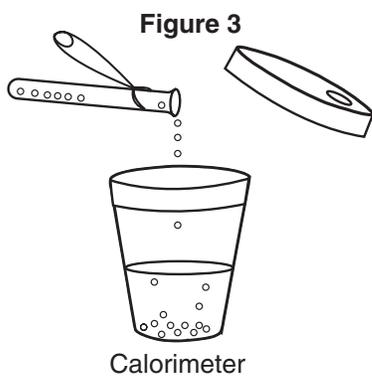
Base your answers to questions 73 through 76 on the information below.



In a laboratory investigation, a 50.0-gram sample of copper is at 100.0°C in a boiling water bath.



A Styrofoam cup with a lid is used as a calorimeter. The cup contains 100.0 grams of distilled water at 23.2°C.



The hot copper is poured into the cup of water, and the cup is quickly covered with the lid.



A thermometer is inserted through the lid. The copper and water are gently stirred in the cup. The temperature is checked periodically. The highest temperature noted is 26.3°C.

- 73 In terms of *energy flow*, explain why the temperature of the water in the calorimeter increases. [1]
- 74 Using the information given, complete the data table provided in *your answer booklet*. [1]
- 75 In the space provided in *your answer booklet*, show a correct numerical setup for calculating the number of joules of heat gained by the water. [1]
- 76 In this investigation, the change in heat of the copper is greater than the change in heat of the water. What error could account for this apparent violation of the Law of Conservation of Energy? Do *not* use human error as part of the answer. [1]
-

Base your answers to questions 77 through 79 on the information below.

Two alcohols that are used in our everyday lives are rubbing alcohol and ethylene glycol. Rubbing alcohol is used as an antiseptic. Ethylene glycol is the main ingredient in antifreeze, which is used in automobile cooling systems.

- 77 Explain, in terms of *molecular polarity*, why rubbing alcohol, 2-propanol, is soluble in water. [1]
- 78 What is the gram-formula mass of ethylene glycol, $C_2H_4(OH)_2$? [1]
- 79 In the space provided in *your answer booklet*, show a correct numerical setup for calculating the total number of moles of ethylene glycol needed to prepare 2.50 liters of a 10.0 M solution. [1]
-

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

The outer structure of the Statue of Liberty is made of copper metal. The framework is made of iron. Over time, a thin green layer (patina) forms on the copper surface.

- 80 When copper oxidized to form this patina layer, the copper atoms became copper(II) ions (Cu^{2+}). Write a balanced half-reaction for this oxidation of copper. [1]
- 81 Where the iron framework came in contact with the copper surface, a reaction occurred in which iron was oxidized. Using information from Reference Table J, explain why the iron was oxidized. [1]
-

Base your answers to questions 82 through 84 on the information below, the *Reference Tables for Physical Setting/Chemistry*, and your knowledge of chemistry.

Radioactivity and radioactive isotopes have the potential for both benefiting and harming living organisms. One use of radioactive isotopes is in radiation therapy as a treatment for cancer. Cesium-137 is sometimes used in radiation therapy.

A sample of cesium-137 was left in an abandoned clinic in Brazil in 1987. Cesium-137 gives off a blue glow because of its radioactivity. The people who discovered the sample were attracted by the blue glow and had no idea of any danger. Hundreds of people were treated for overexposure to radiation, and four people died.

- 82 Using Reference Table N, complete the equation provided *in your answer booklet* for the radioactive decay of $^{137}_{55}\text{Cs}$. Include *both* atomic number and mass number for *each* particle. [1]
- 83 If 12.5 grams of the original sample of cesium-137 remained after 90.69 years, what was the mass of the original sample? [1]
- 84 Suppose a 40-gram sample of iodine-131 and a 40-gram sample of cesium-137 were both abandoned in the clinic in 1987. Explain why the sample of iodine-131 would *not* pose as great a radiation risk to people today as the sample of cesium-137 would. [1]
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The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING CHEMISTRY

Thursday, January 27, 2005 — 9:15 a.m. to 12:15 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

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