The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, June 17, 2009 — 1:15 to 4:15 p.m., only

This is a test of your knowledge of chemistry. Use that knowledge to answer all questions in this examination. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry*. You are to answer *all* questions in all parts of this examination according to the directions provided in the examination booklet.

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

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

Record the number of your choice for each Part A and Part B–1 multiple-choice question on your separate answer sheet. Write your answers to the Part B–2 and Part C questions in your answer booklet. All work should be written in pen, except for graphs and drawings, which should be done in pencil. You may use scrap paper to work out the answers to the questions, but be sure to record all your answers on your separate answer sheet and in your answer booklet.

When you have completed the examination, you must sign the statement printed at the end of your separate answer sheet, indicating that you had no unlawful knowledge of the questions or answers prior to the examination and that you have neither given nor received assistance in answering any of the questions during the examination. Your answer sheet and answer booklet cannot be accepted if you fail to sign this declaration.

Notice. . .

A four-function or scientific calculator and a copy of the *Reference Tables for Physical Setting/Chemistry* must be available for you to use while taking this examination.

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

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

Part A

Answer all questions in this part.

Directions (1–30): For *each* statement or question, write on the separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry*.

1 Which subatomic particle is negatively charged?

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

2 Which element has the greatest density at STP?

(1) barium   (3) magnesium
(2) beryllium   (4) radium

3 What is the mass number of a carbon atom that contains six protons, eight neutrons, and six electrons?

(1) 6   (3) 14
(2) 8   (4) 20

4 Which element is a metalloid?

(1) Al   (3) As
(2) Ar   (4) Au

5 Which substance can be decomposed by chemical means?

(1) aluminum   (3) silicon
(2) octane   (4) xenon

6 An element that is malleable and a good conductor of heat and electricity could have an atomic number of

(1) 16   (3) 29
(2) 18   (4) 35

7 A 1.0-mole sample of krypton gas has a mass of

(1) 19 g   (3) 39 g
(2) 36 g   (4) 84 g

8 An atom in the ground state has a stable valence electron configuration. This atom could be an atom of

(1) Al   (3) Na
(2) Cl   (4) Ne

9 An atom of an element has a total of 12 electrons. An ion of the same element has a total of 10 electrons. Which statement describes the charge and radius of the ion?

(1) The ion is positively charged and its radius is smaller than the radius of the atom.
(2) The ion is positively charged and its radius is larger than the radius of the atom.
(3) The ion is negatively charged and its radius is smaller than the radius of the atom.
(4) The ion is negatively charged and its radius is larger than the radius of the atom.

10 Which formula represents a nonpolar molecule?

(1) CH_4 (3) H_2O
(2) HCl   (4) NH_3

11 The compound *X*Cl is classified as ionic if *X* represents the element

(1) H   (3) Rb
(2) I   (4) Br

12 The chemical bonding in sodium phosphate, Na_3PO_4, is classified as

(1) ionic, only
(2) metallic, only
(3) both covalent and ionic
(4) both covalent and metallic

13 Which element is composed of molecules that each contain a multiple covalent bond?

(1) chlorine   (3) hydrogen
(2) fluorine   (4) nitrogen

14 Which equation represents an exothermic reaction at 298 K?

(1) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

(2) $C(s) + O_2(g) \rightarrow CO_2(g)$

(3) $KNO_3(s) \xrightarrow{H_2O} K^+(aq) + NO_3^-(aq)$

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

15 Standard pressure is equal to

(1) 1 atm   (3) 273 atm
(2) 1 kPa   (4) 273 kPa

16 A large sample of solid calcium sulfate is crushed into smaller pieces for testing. Which two physical properties are the same for both the large sample and one of the smaller pieces?

(1) mass and density
(2) mass and volume
(3) solubility and density
(4) solubility and volume

17 According to the kinetic molecular theory, the molecules of an ideal gas

(1) have a strong attraction for each other
(2) have significant volume
(3) move in random, constant, straight-line motion
(4) are closely packed in a regular repeating pattern

18 At 65°C, which compound has a vapor pressure of 58 kilopascals?

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

19 At STP, which 2.0-gram sample of matter uniformly fills a 340-milliliter closed container?

(1) $Br_2(\ell)$ (3) $KCl(aq)$
(2) $Fe(NO_3)_2(s)$ (4) $Xe(g)$

20 Compared to the freezing point and boiling point of water at 1 atmosphere, a solution of a salt and water at 1 atmosphere has a

(1) lower freezing point and a lower boiling point
(2) lower freezing point and a higher boiling point
(3) higher freezing point and a lower boiling point
(4) higher freezing point and a higher boiling point

21 Changes in activation energy during a chemical reaction are represented by a

(1) cooling curve
(2) heating curve
(3) ionization energy diagram
(4) potential energy diagram

22 Under which conditions of temperature and pressure would a real gas behave most like an ideal gas?

(1) 200. K and 50.0 kPa
(2) 200. K and 200.0 kPa
(3) 600. K and 50.0 kPa
(4) 600. K and 200.0 kPa

23 Given the equation representing a reaction:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

Which statement describes this reaction at equilibrium?

(1) The concentration of $N_2O_4(g)$ must equal the concentration of $NO_2(g)$.
(2) The concentration of $N_2O_4(g)$ and the concentration of $NO_2(g)$ must be constant.
(3) The rate of the forward reaction is greater than the rate of the reverse reaction.
(4) The rate of the reverse reaction is greater than the rate of the forward reaction.

24 Which compound is a saturated hydrocarbon?

(1) propanal   (3) propene
(2) propane   (4) propyne

25 The isomers butane and methylpropane differ in their

    (1) molecular formulas
    (2) structural formulas
    (3) total number of atoms per molecule
    (4) total number of bonds per molecule

26 Which word equation represents a neutralization reaction?

    (1) base + acid → salt + water
    (2) base + salt → water + acid
    (3) salt + acid → base + water
    (4) salt + water → acid + base

27 An aqueous solution of lithium hydroxide contains hydroxide ions as the only negative ion in the solution. Lithium hydroxide is classified as an

    (1) aldehyde   (3) Arrhenius acid
    (2) alcohol   (4) Arrhenius base

28 One alternate acid-base theory states that an acid is an

    (1) H^+ donor   (3) OH^- donor
    (2) H^+ acceptor   (4) OH^- acceptor

29 Which particle has the greatest mass?

    (1) an alpha particle   (3) a neutron
    (2) a beta particle   (4) a positron

30 A beta particle may be spontaneously emitted from

    (1) a ground-state electron
    (2) a stable nucleus
    (3) an excited electron
   (4) an unstable nucleus

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 electron configuration represents an atom in an excited state?

(1) 2–7
(2) 2–6–2
(3) 2–8–1
(4) 2–8–8–2

32 Magnesium and calcium have similar chemical properties because a magnesium atom and a calcium atom have the same

(1) atomic number
(2) mass number
(3) total number of electron shells
(4) total number of valence electrons

33 What is the empirical formula for a compound with the molecular formula $C_6H_{12}Cl_2O_2$?

(1) CHClO
(2) CH_2ClO
(3) C_3H_6ClO
(4) $C_6H_{12}Cl_2O_2$

34 Given the balanced equation representing a reaction:

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

Which type of chemical reaction is represented by this equation?

(1) double replacement
(2) single replacement
(3) substitution
(4) synthesis

35 A person with a body temperature of 37°C holds an ice cube with a temperature of 0°C in a room where the air temperature is 20.°C. The direction of heat flow is

(1) from the person to the ice, only
(2) from the person to the ice and air, and from the air to the ice
(3) from the ice to the person, only
(4) from the ice to the person and air, and from the air to the person

36 What is the total mass of solute in 1000. grams of a solution having a concentration of 5 parts per million?

(1) 0.005 g
(2) 0.05 g
(3) 0.5 g
(4) 5 g

37 Which compound is *least* soluble in water at 60.°C?

(1) $KClO_3$
(2) KNO_3
(3) NaCl
(4) NH_4Cl

38 At standard pressure, which element has a freezing point *below* standard temperature?
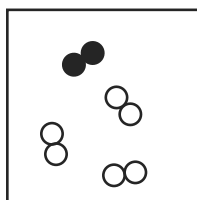
(1) In
(2) Ir
(3) Hf
(4) Hg

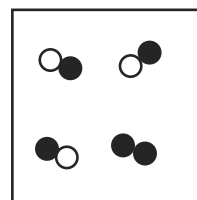39 Which two particle diagrams represent mixtures of diatomic elements?

Key
O = atom of one element
● = atom of another element
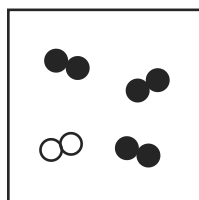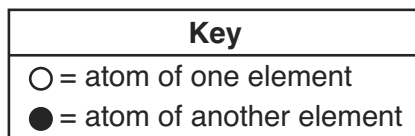
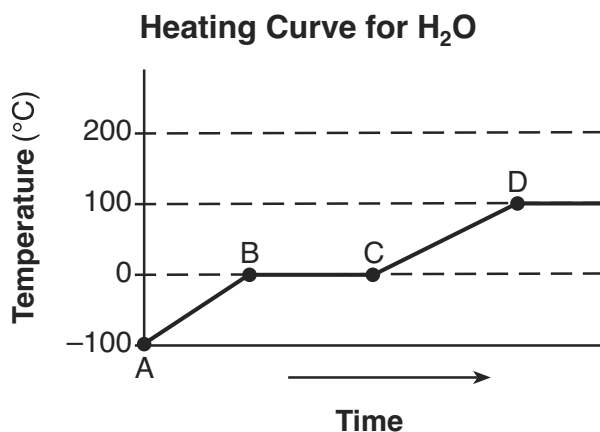A   B   C   D
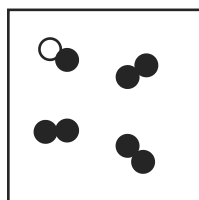
(1) A and B   (3) B and C
(2) A and C   (4) B and D

40 The graph below represents the relationship between temperature and time as heat is added to a sample of H_2O.

Heating Curve for H_2O

Which statement correctly describes the energy of the particles of the sample during interval BC?

(1) Potential energy decreases and average kinetic energy increases.
(2) Potential energy increases and average kinetic energy increases.
(3) Potential energy increases and average kinetic energy remains the same.
(4) Potential energy remains the same and average kinetic energy increases.

41 Given the balanced equation representing a reaction:

$$2HCl(aq) + Na_2S_2O_3(aq) \rightarrow S(s) + H_2SO_3(aq) + 2NaCl(aq)$$
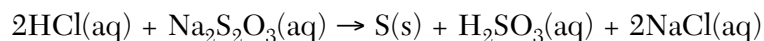
Decreasing the concentration of $Na_2S_2O_3(aq)$ *decreases* the rate of reaction because the

(1) activation energy decreases
(2) activation energy increases
(3) frequency of effective collisions decreases
(4) frequency of effective collisions increases

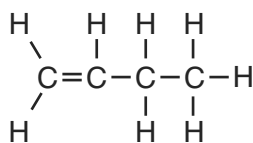42 Given the equation representing a reaction at equilibrium:

$$H_2(g) + I_2(g) + heat \rightleftharpoons 2HI(g)$$
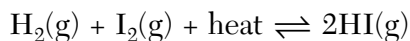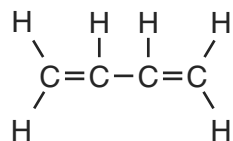
Which change favors the reverse reaction?

(1) decreasing the concentration of $HI(g)$
(2) decreasing the temperature
(3) increasing the concentration of $I_2(g)$
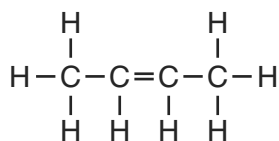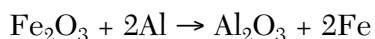(4) increasing the pressure

43 Which formula represents 2-butene?
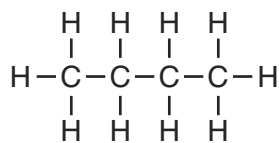
44 Given the balanced equation representing a reaction:

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$$

During this reaction, the oxidation number of Fe changes from

(1) +2 to 0 as electrons are transferred
(2) +2 to 0 as protons are transferred
(3) +3 to 0 as electrons are transferred
(4) +3 to 0 as protons are transferred

45 Which reaction occurs spontaneously?

(1) $Cl_2(g) + 2NaBr(aq) \rightarrow Br_2(\ell) + 2NaCl(aq)$
(2) $Cl_2(g) + 2NaF(aq) \rightarrow F_2(g) + 2NaCl(aq)$
(3) $I_2(s) + 2NaBr(aq) \rightarrow Br_2(\ell) + 2NaI(aq)$
(4) $I_2(s) + 2NaF(aq) \rightarrow F_2(g) + 2NaI(aq)$

46 Which sample of HCl(aq) contains the greatest number of moles of solute particles?

(1) 1.0 L of 2.0 M HCl(aq)
(2) 2.0 L of 2.0 M HCl(aq)
(3) 3.0 L of 0.50 M HCl(aq)
(4) 4.0 L of 0.50 M HCl(aq)

47 Which change in pH represents a hundredfold increase in the concentration of hydronium ions in a solution?

(1) pH 1 to pH 2   (3) pH 2 to pH 1
(2) pH 1 to pH 3   (4) pH 3 to pH 1

48 Which indicator would best distinguish between a solution with a pH of 3.5 and a solution with a pH of 5.5?

(1) bromthymol blue   (3) litmus
(2) bromcresol green   (4) thymol blue

49 Given the equation:

$$HCl(g) + H_2O(\ell) \rightarrow X(aq) + Cl^-(aq)$$
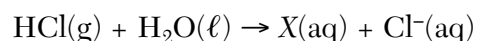
Which ion is represented by X?

(1) hydroxide   (3) hypochlorite
(2) hydronium   (4) perchlorate

50 Which nuclide is used to investigate human thyroid gland disorders?

(1) carbon-14   (3) cobalt-60
(2) potassium-37   (4) iodine-131

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 the information below.

A sample of helium gas is in a closed system with a movable piston. The volume of the gas sample is changed when both the temperature and the pressure of the sample are increased. The table below shows the initial temperature, pressure, and volume of the gas sample, as well as the final temperature and pressure of the sample.

Helium Gas in a Closed System

Condition	Temperature (K)	Pressure (atm)	Volume (mL)
initial	200.	2.0	500.
final	300.	7.0	?

51 In the space *in your answer booklet*, show a correct numerical setup for calculating the final volume of the helium gas sample.   [1]

52 Convert the final temperature of the helium gas sample to degrees Celsius.   [1]

53 Compare the total number of gas particles in the sample under the initial conditions to the total number of gas particles in the sample under the final conditions.   [1]

Base your answers to questions 54 through 57 on the information below.

Molar Mass and Boiling Point of Four Substances

Substance	Molar Mass (g/mol)	Boiling Point at 1 atm (K)
methane	16	112
ethane	30.	185
propane	44	231
butane	58	273

54 On the grid *in your answer booklet*, mark an appropriate scale on the axis labeled "Boiling Point (K)." [1]

55 On the same grid, plot the data from the data table. Circle and connect the points. [1]

56 Based on the data in the table, state the relationship between the boiling point at 1 atmosphere and molar mass for these four substances. [1]

57 State, in terms of intermolecular forces, why the boiling point of propane at 1 atmosphere is *lower* than the boiling point of butane at 1 atmosphere. [1]

Base your answers to questions 58 and 59 on the information below.

At a pressure of 101.3 kilopascals and a temperature of 373 K, heat is removed from a sample of water vapor, causing the sample to change from the gaseous phase to the liquid phase. This phase change is represented by the equation below.

$$H_2O(g) \rightarrow H_2O(\ell) + heat$$
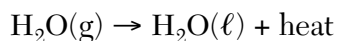
58 Explain, in terms of particle arrangement, why entropy *decreases* during this phase change. [1]

59 Determine the total amount of heat released by 5.00 grams of water vapor during this phase change. [1]

Base your answers to questions 60 through 62 on the information below.

A voltaic cell with magnesium and copper electrodes is shown in the diagram below. The copper electrode has a mass of 15.0 grams.

Voltaic Cell

$$Mg(s) + Cu^{2+}(aq) \longrightarrow Mg^{2+}(aq) + Cu(s)$$
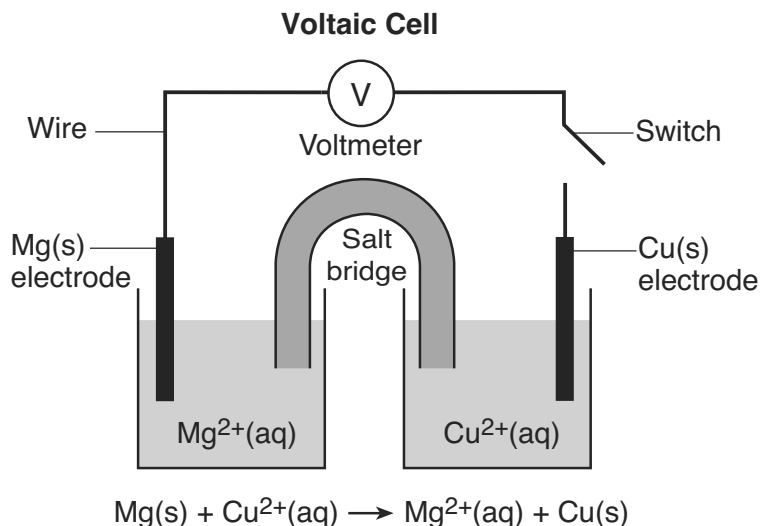
When the switch is closed, the reaction in the cell begins. The balanced ionic equation for the reaction in the cell is shown below the cell diagram. After several hours, the copper electrode is removed, rinsed with water, and dried. At this time, the mass of the copper electrode is greater than 15.0 grams.

60 State the direction of electron flow through the wire between the electrodes when the switch is closed. [1]

61 State the purpose of the salt bridge in this cell. [1]

62 Explain, in terms of copper ions and copper atoms, why the mass of the copper electrode increases as the cell operates. Your response must include information about *both* copper ions and copper atoms. [1]

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

Naturally Occurring Isotopes of Sulfur

Isotope	Atomic Mass (atomic mass units, u)	Natural Abundance (%)
^{32}S	31.97	94.93
^{33}S	32.97	0.76
^{34}S	33.97	4.29
^{36}S	35.97	0.02

63 State, in terms of the number of subatomic particles, *one* similarity and *one* difference between the atoms of these isotopes of sulfur.   [1]

64 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for an atom of sulfur-33.   [1]

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

Part C

Answer all questions in this part.

Directions (66–83): 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.

In 1897, J. J. Thomson demonstrated in an experiment that cathode rays were deflected by an electric field. This suggested that cathode rays were composed of negatively charged particles found in all atoms. Thomson concluded that the atom was a positively charged sphere of almost uniform density in which negatively charged particles were embedded. The total negative charge in the atom was balanced by the positive charge, making the atom electrically neutral.

In the early 1900s, Ernest Rutherford bombarded a very thin sheet of gold foil with alpha particles. After interpreting the results of the gold foil experiment, Rutherford proposed a more sophisticated model of the atom.

66 State *one* conclusion from Rutherford's experiment that contradicts one conclusion made by Thomson.   [1]

67 State *one* aspect of the modern model of the atom that agrees with a conclusion made by Thomson.   [1]

Base your answers to questions 68 through 70 on the information below.

Cobalt-60 is commonly used as a source of radiation for the prevention of food spoilage. Bombarding cobalt-59 nuclei with neutrons produces the nuclide cobalt-60. A food irradiation facility replaces the cobalt-60, a source of gamma rays, when the radioactivity level falls to $\frac{1}{8}$ of its initial level. The nuclide cesium-137 is also a source of radiation for the prevention of food spoilage.

68 Identify *one* emission spontaneously released by a cobalt-60 nucleus.   [1]

69 Determine the total number of years that elapse before an original cobalt-60 source in an irradiation facility must be replaced.   [1]

70 Complete the nuclear equation *in your answer booklet* for the decay of cesium-137. Your response must include the symbol, atomic number, and mass number of the missing particle.   [1]

Base your answers to questions 71 through 73 on the information below.

A soft-drink bottling plant makes a colorless, slightly acidic carbonated beverage called soda water. During production of the beverage, $CO_2(g)$ is dissolved in water at a pressure greater than 1 atmosphere. The bottle containing the solution is capped to maintain that pressure above the solution. As soon as the bottle is opened, fizzing occurs due to $CO_2(g)$ being released from the solution.

71 Explain why $CO_2(g)$ is released when a bottle of soda water is opened.   [1]

72 Write the chemical name of the acid in soda water.   [1]

73 State the relationship between the solubility of $CO_2(g)$ in water and the temperature of the aqueous solution. [1]

Base your answers to questions 74 through 76 on the information below.

During a bread-making process, glucose is converted to ethanol and carbon dioxide, causing the bread dough to rise. Zymase, an enzyme produced by yeast, is a catalyst needed for this reaction.

74 Balance the equation *in your answer booklet* for the reaction that causes bread dough to rise, using the smallest whole-number coefficients. [1]

75 In the space *in your answer booklet*, draw a structural formula for the alcohol formed in this reaction. [1]

76 State the effect of zymase on the activation energy for this reaction. [1]

Base your answers to questions 77 and 78 on the information below.

In performing a titration, a student adds three drops of phenolphthalein to a flask containing 25.00 milliliters of HCl(aq). Using a buret, the student slowly adds 0.150 M NaOH(aq) to the flask until one drop causes the indicator to turn light pink. The student determines that a total volume of 20.20 milliliters of NaOH(aq) was used in this titration.

77 The concentration of the NaOH(aq) used in the titration is expressed to what number of significant figures? [1]

78 Calculate the molarity of the HCl(aq) used in this titration. Your response must include *both* a correct numerical setup and the calculated result. [2]

Base your answers to questions 79 through 83 on the information below.

Arsenic is often obtained by heating the ore arsenopyrite, FeAsS. The decomposition of FeAsS is represented by the balanced equation below.

$$FeAsS(s) \xrightarrow{\text{heat}} FeS(s) + As(g)$$
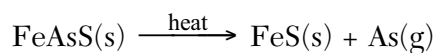
In the solid phase, arsenic occurs in two forms. One form, yellow arsenic, has a density of 1.97 g/cm^3 at STP. The other form, gray arsenic, has a density of 5.78 g/cm^3 at STP. When arsenic is heated rapidly in air, arsenic(III) oxide is formed.

Although arsenic is toxic, it is needed by the human body in very small amounts. The body of a healthy human adult contains approximately 5 milligrams of arsenic.

79 Convert the mass of arsenic found in the body of a healthy human adult to grams. [1]

80 When heated, a 125.0-kilogram sample of arsenopyrite yields 67.5 kilograms of FeS. Determine the total mass of arsenic produced in this reaction. [1]

81 Write the formula for the compound produced when arsenic is heated rapidly in air. [1]

82 Explain, in terms of the arrangement of atoms, why the two forms of arsenic have different densities at STP. [1]

83 Calculate the percent composition by mass of arsenic in arsenopyrite. Your response must include *both* a correct numerical setup and the calculated result. [2]

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, June 17, 2009 — 1:15 to 4:15 p.m., only

ANSWER SHEET

Student .... Sex: ☐ Male ☐ Female Grade ....

Teacher .... School ....

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

Part A			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