The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, June 20, 2007 — 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 According to the wave-mechanical model of the atom, electrons in an atom

(1) travel in defined circles
(2) are most likely found in an excited state
(3) have a positive charge
(4) are located in orbitals outside the nucleus

2 What is the total charge of the nucleus of a carbon atom?

(1) –6
(2) 0
(3) +6
(4) +12

3 A sample composed only of atoms having the same atomic number is classified as

(1) a compound
(2) a solution
(3) an element
(4) an isomer

4 Which two particles each have a mass approximately equal to one atomic mass unit?

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

5 Which two characteristics are associated with metals?

(1) low first ionization energy and low electronegativity
(2) low first ionization energy and high electronegativity
(3) high first ionization energy and low electronegativity
(4) high first ionization energy and high electronegativity

6 Which element is most chemically similar to chlorine?

(1) Ar
(2) F
(3) Fr
(4) S

7 Which substance can be decomposed by chemical means?

(1) ammonia
(2) oxygen
(3) phosphorus
(4) silicon

8 When an atom loses one or more electrons, this atom becomes a

(1) positive ion with a radius smaller than the radius of this atom
(2) positive ion with a radius larger than the radius of this atom
(3) negative ion with a radius smaller than the radius of this atom
(4) negative ion with a radius larger than the radius of this atom

9 What is the name of the polyatomic ion in the compound Na_2O_2?

(1) hydroxide
(2) oxalate
(3) oxide
(4) peroxide

10 Given the balanced equation:

$$I + I \rightarrow I_2$$

Which statement describes the process represented by this equation?

(1) A bond is formed as energy is absorbed.
(2) A bond is formed and energy is released.
(3) A bond is broken as energy is absorbed.
(4) A bond is broken and energy is released.

11 An oxygen molecule contains a double bond because the two atoms of oxygen share a total of

(1) 1 electron
(2) 2 electrons
(3) 3 electrons
(4) 4 electrons

12 Which term is defined as a measure of the average kinetic energy of the particles in a sample?

(1) temperature
(2) pressure
(3) thermal energy
(4) chemical energy

13 A 3.0 M HCl(aq) solution contains a total of

(1) 3.0 grams of HCl per liter of water
(2) 3.0 grams of HCl per mole of solution
(3) 3.0 moles of HCl per liter of solution
(4) 3.0 moles of HCl per mole of water

14 A dilute, aqueous potassium nitrate solution is best classified as a

(1) homogeneous compound
(2) homogeneous mixture
(3) heterogeneous compound
(4) heterogeneous mixture

15 Given the equation representing a phase change at equilibrium:

$$C_2H_5OH(\ell) \rightleftharpoons C_2H_5OH(g)$$

Which statement is true?

(1) The forward process proceeds faster than the reverse process.
(2) The reverse process proceeds faster than the forward process.
(3) The forward and reverse processes proceed at the same rate.
(4) The forward and reverse processes both stop.

16 A 5.0-gram sample of zinc and a 50.-milliliter sample of hydrochloric acid are used in a chemical reaction. Which combination of these samples has the fastest reaction rate?

(1) a zinc strip and 1.0 M HCl(aq)
(2) a zinc strip and 3.0 M HCl(aq)
(3) zinc powder and 1.0 M HCl(aq)
(4) zinc powder and 3.0 M HCl(aq)

17 For a given reaction, adding a catalyst increases the rate of the reaction by

(1) providing an alternate reaction pathway that has a higher activation energy
(2) providing an alternate reaction pathway that has a lower activation energy
(3) using the same reaction pathway and increasing the activation energy
(4) using the same reaction pathway and decreasing the activation energy

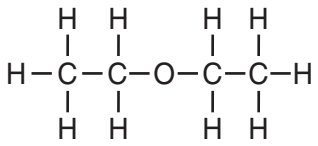
18 Which reaction releases the greatest amount of energy per 2 moles of product?

(1) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$
(2) $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$
(3) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
(4) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

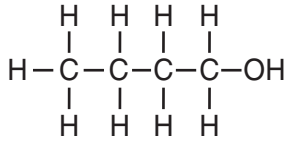
19 What is the total number of carbon atoms in a molecule of ethanoic acid?

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

20 Given the formulas for two compounds:



and



These compounds differ in

(1) gram-formula mass
(2) molecular formula
(3) percent composition by mass
(4) physical properties at STP

21 A double carbon-carbon bond is found in a molecule of

(1) pentane
(2) pentene
(3) pentyne
(4) pentanol

22 Which changes occur when Pt^{2+} is reduced?

(1) The Pt^{2+} gains electrons and its oxidation number increases.
(2) The Pt^{2+} gains electrons and its oxidation number decreases.
(3) The Pt^{2+} loses electrons and its oxidation number increases.
(4) The Pt^{2+} loses electrons and its oxidation number decreases.

23 Which balanced equation represents an oxidation-reduction reaction?

(1) $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$
(2) $C + H_2O \rightarrow CO + H_2$
(3) $CaCO_3 \rightarrow CaO + CO_2$
(4) $Mg(OH)_2 + 2HNO_3 \rightarrow Mg(NO_3)_2 + 2H_2O$

24 Which energy conversion occurs during the operation of a voltaic cell?

(1) Chemical energy is spontaneously converted to electrical energy.
(2) Chemical energy is converted to electrical energy only when an external power source is provided.
(3) Electrical energy is spontaneously converted to chemical energy.
(4) Electrical energy is converted to chemical energy only when an external power source is provided.

25 An Arrhenius base yields which ion as the only negative ion in an aqueous solution?

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

26 According to one acid-base theory, a water molecule acts as an acid when the water molecule

(1) accepts an H^+
(2) accepts an OH^-
(3) donates an H^+
(4) donates an OH^-

27 Which list of radioisotopes contains an alpha emitter, a beta emitter, and a positron emitter?

(1) C-14, N-16, P-32
(2) Cs-137, Fr-220, Tc-99
(3) Kr-85, Ne-19, Rn-222
(4) Pu-239, Th-232, U-238

28 Which nuclear decay emission consists of energy, only?

(1) alpha particle
(2) beta particle
(3) gamma radiation
(4) positron

29 Which balanced equation represents nuclear fusion?

(1) ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3{}^{1}_{0}n$
(2) ${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$
(3) ${}^{6}_{3}Li + {}^{1}_{0}n \rightarrow {}^{3}_{1}H + {}^{4}_{2}He$
(4) ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$

30 The energy released by a nuclear reaction results primarily from the

(1) breaking of bonds between atoms
(2) formation of bonds between atoms
(3) conversion of mass into energy
(4) conversion of energy into mass

Part B–1

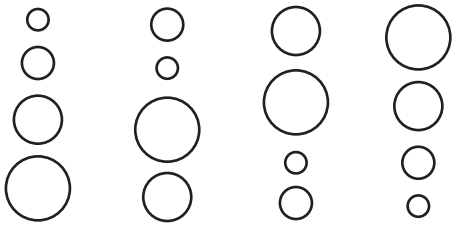
Answer all questions in this part.

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 could represent a strontium atom in an excited state?

(1) 2–8–18–7–1
(2) 2–8–18–7–3
(3) 2–8–18–8–1
(4) 2–8–18–8–2

32 Which grouping of circles, when considered in order from the top to the bottom, best represents the relative size of the atoms of Li, Na, K, and Rb, respectively?



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

33 What is the total number of neutrons in an atom of $^{57}_{26}Fe$?

(1) 26
(2) 31
(3) 57
(4) 83

34 At STP, which element is brittle and *not* a conductor of electricity?

(1) S
(2) K
(3) Na
(4) Ar

35 What is the total number of electrons in a Mg^{2+} ion?

(1) 10
(2) 12
(3) 14
(4) 24

36 Which formula represents lead(II) chromate?

(1) $PbCrO_4$
(2) $Pb(CrO_4)_2$
(3) Pb_2CrO_4
(4) $Pb_2(CrO_4)_3$

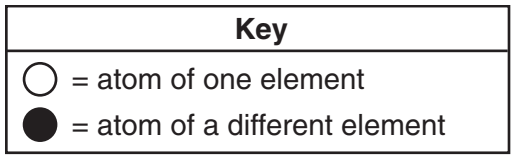
37 Compared to an electron in the first electron shell of an atom, an electron in the third shell of the same atom has

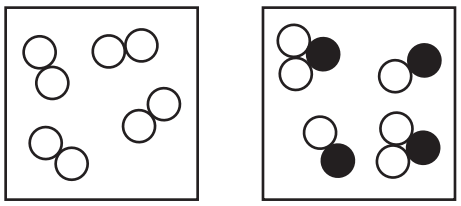
(1) less mass
(2) less energy
(3) more mass
(4) more energy

38 Which pair consists of a molecular formula and its corresponding empirical formula?

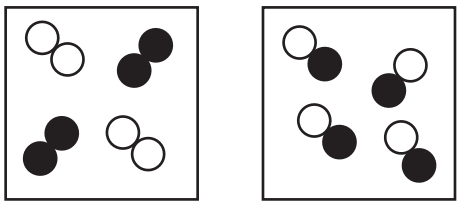
(1) C_2H_2 and CH_3CH_3
(2) C_6H_6 and C_2H_2
(3) P_4O_{10} and P_2O_5
(4) SO_2 and SO_3

39 Which particle diagram represents a sample of one compound, only?





(1) (3)



(2) (4)

40 An atom in the ground state contains a total of 5 electrons, 5 protons, and 5 neutrons. Which Lewis electron-dot diagram represents this atom?

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

41 At STP, fluorine is a gas and bromine is a liquid because, compared to fluorine, bromine has

(1) stronger covalent bonds
(2) stronger intermolecular forces
(3) weaker covalent bonds
(4) weaker intermolecular forces

42 The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. What is the boiling point of propanone if the pressure on its surface is 48 kilopascals?

(1) 25°C
(2) 30.°C
(3) 35°C
(4) 40.°C

43 At which Celsius temperature does lead change from a solid to a liquid?

(1) 874°C
(2) 601°C
(3) 328°C
(4) 0°C

44 Given the equation representing a reaction at equilibrium:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{energy}$$

Which change causes the equilibrium to shift to the right?

(1) decreasing the concentration of $H_2(g)$
(2) decreasing the pressure
(3) increasing the concentration of $N_2(g)$
(4) increasing the temperature

45 Which compound is an unsaturated hydrocarbon?

(1) hexanal
(2) hexane
(3) hexanoic acid
(4) hexyne

46 The organic compound represented by the condensed structural formula $CH_3CH_2CH_2CHO$ is classified as an

(1) alcohol
(2) aldehyde
(3) ester
(4) ether

47 Given the balanced ionic equation representing a reaction:

$$2Al^{3+}(aq) + 3Mg(s) \rightarrow 3Mg^{2+}(aq) + 2Al(s)$$

In this reaction, electrons are transferred from

(1) Al to Mg^{2+}
(2) Al^{3+} to Mg
(3) Mg to Al^{3+}
(4) Mg^{2+} to Al

48 Which two formulas represent Arrhenius acids?

(1) CH_3COOH and CH_3CH_2OH
(2) $HC_2H_3O_2$ and H_3PO_4
(3) $KHCO_3$ and $KHSO_4$
(4) NaSCN and $Na_2S_2O_3$

49 Information related to a titration experiment is given in the balanced equation and table below.

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

Titration Experiment Results

volume of $H_2SO_4(aq)$ used	12.0 mL
concentration of $H_2SO_4(aq)$	?
volume of KOH(aq) used	36.0 mL
concentration of KOH(aq)	0.16 M

Based on the equation and the titration results, what is the concentration of the $H_2SO_4(aq)$?

(1) 0.12 M
(2) 0.16 M
(3) 0.24 M
(4) 0.96 M

50 Which radioisotope is used in medicine to treat thyroid disorders?

(1) cobalt-60
(2) iodine-131
(3) phosphorus-32
(4) uranium-238

Part B–2

Answer all questions in this part.

Directions (51–63): 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.

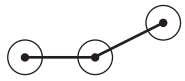
A gas sample is held at constant temperature in a closed system. The volume of the gas is changed, which causes the pressure of the gas to change. Volume and pressure data are shown in the table below.

Volume and Pressure of a Gas Sample

Volume (mL)	**Pressure** (atm)
1200	0.5
600	1.0
300	2.0
150	4.0
100	6.0

51 On the grid *in your answer booklet*, mark an appropriate scale on the axis labeled "Volume (mL)." [1]

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

Example: 

53 Based on your graph, what is the pressure of the gas when the volume of the gas is 200. milliliters? [1]

_____

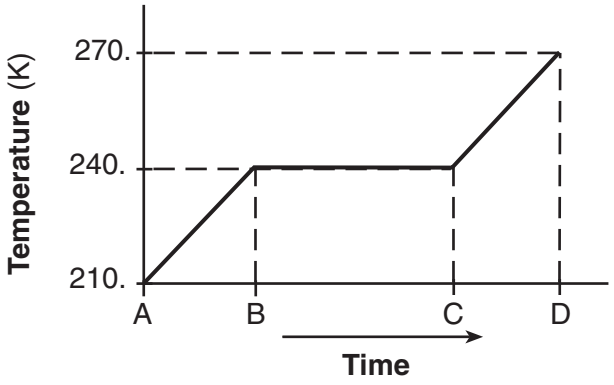
54 Explain, in terms of collision theory, why the rate of a chemical reaction increases with an increase in temperature. [1]

55 Determine the percent composition by mass of oxygen in the compound $C_6H_{12}O_6$. [1]

Base your answers to questions 56 through 58 on the information below.

A 5.00-gram sample of liquid ammonia is originally at 210. K. The diagram of the partial heating curve below represents the vaporization of the sample of ammonia at standard pressure due to the addition of heat. The heat is *not* added at a constant rate.

Partial Heating Curve for Ammonia



Some physical constants for ammonia are shown in the data table below.

Some Physical Constants for Ammonia

specific heat capacity of $NH_3(\ell)$	4.71 J/g•K
heat of fusion	332 J/g
heat of vaporization	1370 J/g

56 In the space *in your answer booklet*, calculate the total heat absorbed by the 5.00-gram sample of ammonia during time interval *AB*. Your response must include *both* a correct numerical setup and the calculated result. [2]

57 Describe what is happening to *both* the potential energy and the average kinetic energy of the molecules in the ammonia sample during time interval *BC*. Your response must include *both* potential energy and average kinetic energy. [1]

58 Determine the total amount of heat required to vaporize this 5.00-gram sample of ammonia at its boiling point. [1]

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

The unbalanced equation below represents the decomposition of potassium chlorate.

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

59 Balance the equation *in your answer booklet*, using the smallest whole-number coefficients. [1]

60 Determine the oxidation number of chlorine in the reactant. [1]

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61 Complete the nuclear equation *in your answer booklet*. Include the symbol, atomic number, and mass number for the missing particle. [1]

62 Explain, in terms of electronegativity, why a P–Cl bond in a molecule of PCl_5 is more polar than a P–S bond in a molecule of P_2S_5. [1]

63 A 1.00-mole sample of neon gas occupies a volume of 24.4 liters at 298 K and 101.3 kilopascals. In the space *in your answer booklet*, calculate the density of this sample. Your response must include *both* a correct numerical setup and the calculated result. [2]

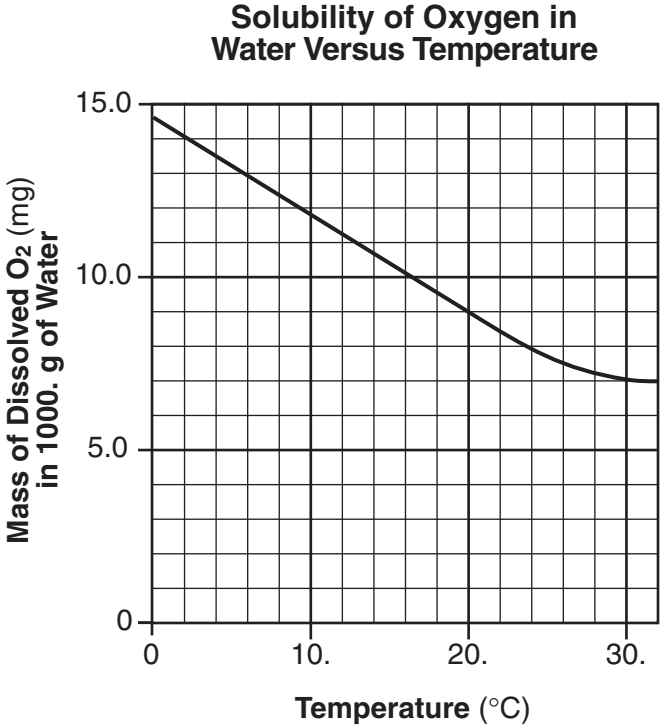
Part C

Answer all questions in this part.

Directions (64–82): 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 64 through 66 on the information below.

Scientists who study aquatic ecosystems are often interested in the concentration of dissolved oxygen in water. Oxygen, O_2, has a very low solubility in water, and therefore its solubility is usually expressed in units of milligrams per 1000. grams of water at 1.0 atmosphere. The graph below shows a solubility curve of oxygen in water.



64 A student determines that 8.2 milligrams of oxygen is dissolved in a 1000.-gram sample of water at 15°C and 1.0 atmosphere. In terms of saturation, what type of solution is this sample? [1]

65 Explain, in terms of molecular polarity, why oxygen gas has low solubility in water. Your response must include *both* oxygen and water. [1]

66 An aqueous solution has 0.0070 gram of oxygen dissolved in 1000. grams of water. In the space *in your answer booklet*, calculate the dissolved oxygen concentration of this solution in parts per million. Your response must include *both* a correct numerical setup and the calculated result. [2]

Base your answers to questions 67 and 68 on the information below.

Sulfur dioxide, SO_2, is one gas produced when fossil fuels are burned. When this gas reacts with water in the atmosphere, an acid is produced forming acid rain. The pH of the water in a lake changes when acid rain collects in the lake.

Two samples of the same rainwater are tested using two indicators. Methyl orange is yellow in one sample of this rainwater. Litmus is red in the other sample of this rainwater.

67 Identify a possible pH value for the rainwater that was tested. [1]

68 Write the formula for *one* substance that can neutralize the lake water affected by acid rain. [1]

Base your answers to questions 69 through 72 on the information below.

Propane is a fuel that is sold in rigid, pressurized cylinders. Most of the propane in a cylinder is liquid, with gas in the space above the liquid level. When propane is released from the cylinder, the propane leaves the cylinder as a gas. Propane gas is used as a fuel by mixing it with oxygen in the air and igniting the mixture, as represented by the balanced equation below.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell) + 2219.2\ kJ$$

A small amount of methanethiol, which has a distinct odor, is added to the propane to help consumers detect a propane leak. In methanethiol, the odor is caused by the thiol functional group (–SH). Methanethiol, CH_3SH, has a structure that is very similar to the structure of methanol.

69 In the box *in your answer booklet*, draw a particle diagram to represent propane in a pressurized cylinder using the key in your answer booklet. Your response must include *at least six* molecules of propane in the gas phase and *at least six* molecules of propane in the liquid phase. [1]

70 On the diagram *in your answer booklet*, draw a potential energy diagram for this reaction. [1]

71 Determine the total amount of energy released when 2.50 moles of propane is completely reacted with oxygen. [1]

72 In the space *in your answer booklet*, draw a structural formula for a molecule of methanethiol. [1]

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

The table below lists physical and chemical properties of six elements at standard pressure that correspond to known elements on the Periodic Table. The elements are identified by the code letters, *D*, *E*, *G*, *J*, *L*, and *Q*.

Properties of Six Elements at Standard Pressure

Element D Density 0.00018 g/cm^3 Melting point –272°C Boiling point –269°C Oxide formula (none)	Element E Density 1.82 g/cm^3 Melting point 44°C Boiling point 280°C Oxide formula E_2O_5	Element G Density 0.53 g/cm^3 Melting point 181°C Boiling point 1347°C Oxide formula G_2O
Element J Density 0.0013 g/cm^3 Melting point –210°C Boiling point –196°C Oxide formula J_2O_5	Element L Density 0.86 g/cm^3 Melting point 64°C Boiling point 774°C Oxide formula L_2O	Element Q Density 0.97 g/cm^3 Melting point 98°C Boiling point 883°C Oxide formula Q_2O

73 What is the total number of elements in the "Properties of Six Elements at Standard Pressure" table that are solids at STP? [1]

74 An atom of element *G* is in the ground state. What is the total number of valence electrons in this atom? [1]

75 Letter *Z* corresponds to an element on the Periodic Table other than the six listed elements. Elements *G*, *Q*, *L*, and *Z* are in the same group on the Periodic Table, as shown in the diagram below.

Based on the trend in the melting points for elements *G*, *Q*, and *L* listed in the "Properties of Six Elements at Standard Pressure" table, estimate the melting point of element *Z*, in degrees Celsius. [1]

76 Identify, by code letter, the element that is a noble gas in the "Properties of Six Elements at Standard Pressure" table. [1]

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

Ozone gas, O_3, can be used to kill adult insects in storage bins for grain without damaging the grain. The ozone is produced from oxygen gas, O_2, in portable ozone generators located near the storage bins. The concentrations of ozone used are so low that they do not cause any environmental damage. This use of ozone is safer and more environmentally friendly than a method that used bromomethane, CH_3Br. However, bromomethane was more effective than ozone because CH_3Br killed immature insects as well as adult insects.

Adapted From: *The Sunday Gazette* (Schenectady, NY) 3/9/03

77 Determine the total number of moles of CH_3Br in 19 grams of CH_3Br (gram-formula mass = 95 grams/mol). [1]

78 Given the balanced equation for producing bromomethane:

$$Br_2 + CH_4 \rightarrow CH_3Br + HBr$$

Identify the type of organic reaction shown. [1]

79 Based on the information in the passage, state *one* advantage of using ozone instead of bromomethane for insect control in grain storage bins. [1]

Base your answers to questions 80 through 82 on the information below.

In living organisms, the ratio of the naturally occurring isotopes of carbon, C-12 to C-13 to C-14, is fairly consistent. When an organism such as a woolly mammoth died, it stopped taking in carbon, and the amount of C-14 present in the mammoth began to decrease. For example, one fossil of a woolly mammoth is found to have $\frac{1}{32}$ of the amount of C-14 found in a living organism.

80 Identify the type of nuclear reaction that caused the amount of C-14 in the woolly mammoth to *decrease* after the organism died. [1]

81 Determine the total time that has elapsed since this woolly mammoth died. [1]

82 State, in terms of subatomic particles, how an atom of C-13 is different from an atom of C-12. [1]

Tear Here

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, June 20, 2007 — 1:15 to 4:15 p.m., only

ANSWER SHEET

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

Teacher ..... School .....

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

Part A

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

Part A Score

Part B–1

31	41 .....
32	42 .....
33	43 .....
34	44 .....
35	45 .....
36	46 .....
37	47 .....
38	48 .....
39	49 .....
40	50 .....

Part B–1 Score

Write your answers to Part B–2 and Part C in your answer booklet.

The declaration below should be signed when you have completed the examination.

I do hereby affirm, at the close of this examination, that I had no unlawful knowledge of the questions or answers prior to the examination and that I have neither given nor received assistance in answering any of the questions during the examination.

Signature

Tear Here

Tear Here

Tear Here

PS/CHEMISTRY