**The University of the State of New York**

**REGENTS HIGH SCHOOL EXAMINATION**

# PHYSICAL SETTING
# CHEMISTRY

**Wednesday,** August 13, 2008 — 12:30 to 3:30 p.m., only

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

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

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

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

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

**Notice. . .**

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

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

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

## Part A

**Answer all questions in this part.**

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

1 In the wave-mechanical model of the atom, orbitals are regions of the most probable locations of

(1) protons
(2) positrons
(3) neutrons
(4) electrons

2 Which phrase describes an atom?

(1) a positively charged electron cloud surrounding a positively charged nucleus
(2) a positively charged electron cloud surrounding a negatively charged nucleus
(3) a negatively charged electron cloud surrounding a positively charged nucleus
(4) a negatively charged electron cloud surrounding a negatively charged nucleus

3 Which total mass is the *smallest*?

(1) the mass of 2 electrons
(2) the mass of 2 neutrons
(3) the mass of 1 electron plus the mass of 1 proton
(4) the mass of 1 neutron plus the mass of 1 electron

4 Elements on the modern Periodic Table are arranged in order of increasing

(1) atomic mass
(2) atomic number
(3) number of neutrons
(4) number of valence electrons

5 As the elements of Group 17 are considered in order of increasing atomic number, there is an increase in

(1) atomic radius
(2) electronegativity
(3) first ionization energy
(4) number of electrons in the first shell

6 Chlorine-37 can be represented as

(1) $^{17}_{35}Cl$
(2) $^{20}_{37}Cl$
(3) $^{35}_{20}Cl$
(4) $^{37}_{17}Cl$

7 Which element is a metal that is in the liquid phase at STP?

(1) bromine
(2) cobalt
(3) hydrogen
(4) mercury

8 Which list of formulas represents compounds, only?

(1) $CO_2$, $H_2O$, $NH_3$
(2) $H_2$, $N_2$, $O_2$
(3) $H_2$, Ne, NaCl
(4) MgO, NaCl, $O_2$

9 What is the chemical formula for iron(III) oxide?

(1) FeO
(2) $Fe_2O_3$
(3) $Fe_3O$
(4) $Fe_3O_2$

10 An atom of which element has the greatest attraction for the electrons in a bond with a hydrogen atom?

(1) chlorine
(2) phosphorus
(3) silicon
(4) sulfur

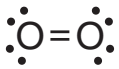
11 Which property could be used to identify a compound in the laboratory?

(1) mass
(2) melting point
(3) temperature
(4) volume

12 Which statement describes what occurs as two atoms of bromine combine to become a molecule of bromine?

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

13 Given a formula for oxygen:



What is the total number of electrons shared between the atoms represented in this formula?

(1) 1
(2) 2
(3) 8
(4) 4

14 Solid $ZnCl_2$ and liquid $ZnCl_2$ have different

(1) empirical formulas
(2) formula masses
(3) ion ratios
(4) physical properties

15 Which phrase describes the molarity of a solution?

(1) liters of solute per mole of solution
(2) liters of solution per mole of solution
(3) moles of solute per liter of solution
(4) moles of solution per liter of solution

16 Which substance can *not* be decomposed by a chemical change?

(1) $AlCl_3$
(2) $H_2O$
(3) HI
(4) Cu

17 Tetrachloromethane, $CCl_4$, is classified as a

(1) compound because the atoms of the elements are combined in a fixed proportion
(2) compound because the atoms of the elements are combined in a proportion that varies
(3) mixture because the atoms of the elements are combined in a fixed proportion
(4) mixture because the atoms of the elements are combined in a proportion that varies

18 Which formulas represent two polar molecules?

(1) $CO_2$ and HCl
(2) $CO_2$ and $CH_4$
(3) $H_2O$ and HCl
(4) $H_2O$ and $CH_4$

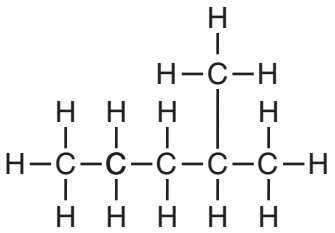
19 Hydrocarbons are compounds that contain

(1) carbon, only
(2) carbon and hydrogen, only
(3) carbon, hydrogen, and oxygen, only
(4) carbon, hydrogen, oxygen, and nitrogen, only

20 The reaction that joins thousands of small, identical molecules to form one very long molecule is called

(1) esterification
(2) fermentation
(3) polymerization
(4) substitution

21 What is the IUPAC name of the organic compound that has the formula shown below?



(1) 1,1-dimethylbutane
(2) 2-methylpentane
(3) hexane
(4) 4-methylpentane

22 A voltaic cell spontaneously converts chemical energy to

(1) electrical energy
(2) geothermal energy
(3) mechanical energy
(4) nuclear energy

23 Given the balanced equation representing a reaction:

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

What is the total number of moles of electrons lost by Mg(s) when 2.0 moles of electrons are gained by $Ni^{2+}(aq)$?

(1) 1.0 mol
(2) 2.0 mol
(3) 3.0 mol
(4) 4.0 mol

24 Which half-reaction correctly represents reduction?

(1) $Mn^{4+} \rightarrow Mn^{3+} + e^-$
(2) $Mn^{4+} \rightarrow Mn^{7+} + 3e^-$
(3) $Mn^{4+} + e^- \rightarrow Mn^{3+}$
(4) $Mn^{4+} + 3e^- \rightarrow Mn^{7+}$

25 Which indicator is blue in a solution that has a pH of 5.6?

(1) bromcresol green
(2) bromthymol blue
(3) methyl orange
(4) thymol blue

26 The Arrhenius theory explains the behavior of

(1) acids and bases
(2) alcohols and amines
(3) isomers and isotopes
(4) metals and nonmetals

27 In which laboratory process could a student use 0.10 M NaOH(aq) to determine the concentration of an aqueous solution of HBr?

(1) chromatography
(2) decomposition of the solute
(3) evaporation of the solvent
(4) titration

28 A nuclear reaction in which two light nuclei combine to form a more massive nucleus is called

(1) addition
(2) fission
(3) fusion
(4) substitution

29 The nucleus of a radium-226 atom is unstable, which causes the nucleus to spontaneously

(1) absorb electrons
(2) absorb protons
(3) decay
(4) oxidize

30 A serious risk factor associated with the operation of a nuclear power plant is the production of

(1) acid rain
(2) helium gas
(3) greenhouse gases, such as $CO_2$
(4) radioisotopes with long half-lives

## 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 protons in an atom with the electron configuration 2-8-18-32-18-1?

(1) 69 (3) 118
(2) 79 (4) 197

32 Which two elements have the most similar chemical properties?

(1) Be and Mg (3) Cl and Ar
(2) Ca and Br (4) Na and P

33 In the ground state, each atom of an element has two valence electrons. This element has a lower first ionization energy than calcium. Where is this element located on the Periodic Table?

(1) Group 1, Period 4 (3) Group 2, Period 3
(2) Group 2, Period 5 (4) Group 3, Period 4

34 Which equation shows conservation of mass and charge?

(1) $NH_4Br \rightarrow NH_3 + Br_2$
(2) $2Mg + Fe^{3+} \rightarrow Mg^{2+} + 3Fe$
(3) $H_2SO_4 + LiOH \rightarrow Li_2SO_4 + H_2O$
(4) $Cu + 2Ag^{+} \rightarrow Cu^{2+} + 2Ag$

35 What is the percent composition by mass of hydrogen in $NH_4HCO_3$ (gram-formula mass = 79 grams/mole)?

(1) 5.1% (3) 10.%
(2) 6.3% (4) 50.%

36 What is the total number of valence electrons in a sulfide ion in the ground state?

(1) 8 (3) 16
(2) 2 (4) 18

37 A temperature of 37°C is equivalent to a temperature of

(1) 98.6 K (3) 310. K
(2) 236 K (4) 371 K

38 Which balanced equation represents a chemical change?

(1) $H_2O(\ell) + \text{energy} \rightarrow H_2O(g)$
(2) $2H_2O(\ell) + \text{energy} \rightarrow 2H_2(g) + O_2(g)$
(3) $H_2O(\ell) \rightarrow H_2O(s) + \text{energy}$
(4) $H_2O(g) \rightarrow H_2O(\ell) + \text{energy}$

39 When 5 grams of KCl are dissolved in 50. grams of water at 25°C, the resulting mixture can be described as

(1) heterogeneous and unsaturated
(2) heterogeneous and supersaturated
(3) homogeneous and unsaturated
(4) homogeneous and supersaturated

40 Which aqueous solution of KI freezes at the *lowest* temperature?

(1) 1 mol of KI in 500. g of water
(2) 2 mol of KI in 500. g of water
(3) 1 mol of KI in 1000. g of water
(4) 2 mol of KI in 1000. g of water

41 Which compound is a member of the same homologous series as $C_3H_8$?

(1) $CH_4$ (3) $C_5H_8$
(2) $C_4H_8$ (4) $C_5H_{10}$

42 Which equation represents an oxidation-reduction reaction?

(1) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
(2) $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$
(3) $MgCrO_4 + BaCl_2 \rightarrow MgCl_2 + BaCrO_4$
(4) $Zn(NO_3)_2 + Na_2CO_3 \rightarrow 2NaNO_3 + ZnCO_3$

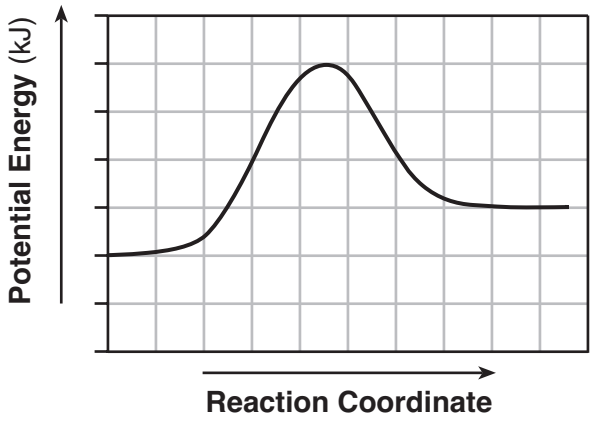
43 Given the balanced equation representing a reaction:

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

The oxidation state of chlorine in this reaction changes from

(1) –1 to +1
(2) –1 to +5
(3) +1 to –1
(4) +5 to –1

44 The potential energy diagram for a chemical reaction is shown below.




Each interval on the axis labeled "Potential Energy (kJ)" represents 40 kilojoules. What is the heat of reaction?

(1) –120 kJ
(2) –40 kJ
(3) +40 kJ
(4) +160 kJ

45 Given the balanced equation representing a reaction occurring in an electrolytic cell:

$$2NaCl(\ell) \rightarrow 2Na(\ell) + Cl_2(g)$$

Where is $Na(\ell)$ produced in the cell?

(1) at the anode, where oxidation occurs
(2) at the anode, where reduction occurs
(3) at the cathode, where oxidation occurs
(4) at the cathode, where reduction occurs

46 Given the balanced equation representing a reaction:

$$NH_3(g) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$$

According to one acid-base theory, the $NH_3(g)$ molecules act as

(1) an acid because they accept $H^+$ ions
(2) an acid because they donate $H^+$ ions
(3) a base because they accept $H^+$ ions
(4) a base because they donate $H^+$ ions

47 What volume of 0.120 M $HNO_3(aq)$ is needed to completely neutralize 150.0 milliliters of 0.100 M NaOH(aq)?

(1) 62.5 mL
(2) 125 mL
(3) 180. mL
(4) 360. mL

48 Given the balanced equation representing a nuclear reaction:

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3X + \text{energy}$$

Which particle is represented by *X*?

(1) $^{0}_{-1}e$
(2) $^{1}_{1}H$
(3) $^{4}_{2}He$
(4) $^{1}_{0}n$

49 An original sample of the radioisotope fluorine-21 had a mass of 80.0 milligrams. Only 20.0 milligrams of this original sample remain unchanged after 8.32 seconds. What is the half-life of fluorine-21?

(1) 1.04 s
(2) 2.08 s
(3) 4.16 s
(4) 8.32 s

50 Which nuclide is paired with a specific use of that nuclide?

(1) carbon-14, treatment of cancer
(2) cobalt-60, dating of rock formations
(3) iodine-131, treatment of thyroid disorders
(4) uranium-238, dating of once-living organisms

## 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 Identify *one* ion from Table *F* that can combine with $Pb^{2+}(aq)$ to produce an insoluble compound. [1]

52 Describe *one* appropriate laboratory test that can be used to determine the malleability of a solid sample of an element at room temperature. [1]

53 State *two* methods to increase the rate of a chemical reaction and explain, in terms of particle behavior, how *each* method increases the reaction rate. [2]

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

**Naturally Occurring Isotopes of Copper**

| **Isotope Notation** | **Percent Natural Abundance** (%) | **Atomic Mass** (atomic mass units, u) |
|---|---|---|
| Cu-63 | 69.17 | 62.930 |
| Cu-65 | 30.83 | 64.928 |

54 State, in terms of subatomic particles, how an atom of Cu-63 differs from an atom of Cu-65. [1]

55 What is the total number of electrons in an atom of Cu-65? [1]

56 The atomic mass of Cu-63 is expressed to what number of significant figures? [1]

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

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

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. The heat of vaporization of ethanol is 838 joules per gram. A sample of ethanol has a mass of 65.0 grams and is boiling at 1.00 atmosphere.

58 Based on Table *H*, what is the temperature of this sample of ethanol? [1]

59 Calculate the minimum amount of heat required to completely vaporize this sample of ethanol. Your response must include *both* a correct numerical setup and the calculated result. [2]

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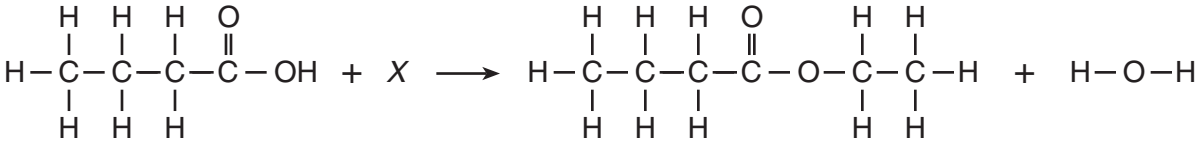
Base your answers to questions 60 through 62 on the information below.

The equation below represents the reaction between butanoic acid and an unidentified reactant, *X*.



60 Identify the type of organic reaction represented by the equation. [1]

61 Write the molecular formula of the organic product in the equation. [1]

62 In the space *in your answer booklet*, draw a structural formula for the unidentified reactant, *X*, in the equation. [1]

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

A piece of magnesium ribbon is reacted with excess hydrochloric acid to produce aqueous magnesium chloride and hydrogen gas. The volume of the dry hydrogen gas produced is 45.6 milliliters. The temperature of the gas is 293 K, and the pressure is 99.5 kilopascals.

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

64 Identify the type of bond between the atoms in a molecule of the gas produced in this laboratory investigation. [1]

65 Calculate the volume this dry hydrogen gas would occupy at STP. Your response must include *both* a correct numerical setup and the calculated result. [2]

## Part C

**Answer all questions in this part.**

*Directions* (66–80): 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.

In a laboratory, a glass tube is filled with hydrogen gas at a very low pressure. When a scientist applies a high voltage between metal electrodes in the tube, light is emitted. The scientist analyzes the light with a spectroscope and observes four distinct spectral lines. The table below gives the color, frequency, and energy for each of the four spectral lines. The unit for frequency is hertz, Hz.

**Visible Spectrum of Hydrogen**

| Color | Frequency ($\times 10^{14}$ Hz) | Energy ($\times 10^{-19}$ J) |
|---|---|---|
| red | 4.6 | 3.0 |
| blue green | 6.2 | 4.1 |
| blue | 6.9 | 4.6 |
| violet | 7.3 | 4.8 |

66 On the grid *in your answer booklet*, plot the data from the data table for frequency and energy. Circle and connect the points, including the point (0,0) that has already been plotted and circled for you. [1]

67 A spectral line in the infrared region of the spectrum of hydrogen has a frequency of $2.3 \times 10^{14}$ hertz. Using your graph, estimate the energy associated with this spectral line. [1]

68 Explain, in terms of subatomic particles and energy states, why light is emitted by the hydrogen gas. [1]

69 Identify *one* condition *not* mentioned in the passage, under which hydrogen gas behaves most like an ideal gas. [1]

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

Carbon and oxygen are examples of elements that exist in more than one form in the same phase.

Graphite and diamond are two crystalline arrangements for carbon. The crystal structure of graphite is organized in layers. The bonds between carbon atoms within each layer of graphite are strong. The bonds between carbon atoms that connect different layers of graphite are weak because the shared electrons in these bonds are loosely held by the carbon atoms. The crystal structure of diamond is a strong network of atoms in which all the shared electrons are strongly held by the carbon atoms. Graphite is an electrical conductor, but diamond is not. At 25°C, graphite has a density of 2.2 g/cm$^3$ and diamond has a density of 3.51 g/cm$^3$.

The element oxygen can exist as diatomic molecules, $O_2$, and as ozone, $O_3$. At standard pressure the boiling point of ozone is 161 K.

70 Explain, in terms of electrons, why graphite is an electrical conductor and diamond is *not*. Your response must include information about *both* graphite and diamond. [1]

71 Calculate the volume, in cm$^3$, of a diamond at 25°C that has a mass of 0.200 gram. Your response must include *both* a correct numerical setup and the calculated result. [2]

72 Explain, in terms of intermolecular forces, the difference in the boiling points of $O_2$ and $O_3$ at standard pressure. Your response must include information about *both* $O_2$ and $O_3$. [1]

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

A portable propane-fueled lantern contains a mesh silk bag coated with metal hydroxides. The primary metal hydroxide is yttrium hydroxide. When the silk bag is installed, it is ignited and burned away, leaving the metal hydroxide coating. The coating forms metal oxides that glow brightly when heated to a high temperature.

During a test, a propane lantern is operated for three hours and consumes 5.0 moles of propane from the lantern's tank. The balanced equation below represents the combustion of propane.

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O + \text{energy}$$

73 At standard pressure, the boiling point of propane is 231 K. In the box *in your answer booklet*, draw a particle diagram to represent the phase of the propane as it leaves the tank at 294 K. Your response must include *at least six* molecules. [1]

74 Calculate the total mass of propane consumed during the lantern test. Your response must include *both* a correct numerical setup and the calculated result. [2]

75 Determine the total number of moles of $CO_2$ produced during the lantern test. [1]

76 Write the formula for the primary metal hydroxide used in the lantern. [1]

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Base your answers to questions 77 through 80 on the information below.

When a person perspires (sweats), the body loses many sodium ions and potassium ions. The evaporation of sweat cools the skin.

After a strenuous workout, people often quench their thirst with sports drinks that contain NaCl and KCl. A single 250.-gram serving of one sports drink contains 0.055 gram of sodium ions.

77 In the space *in your answer booklet*, show a correct numerical setup for calculating the concentration of sodium ions in this sports drink, expressed as percent by mass. [1]

78 Describe the transfer of energy between the skin and the surroundings as a person perspires and the sweat evaporates. [1]

79 State why the salts in sports drinks are classified as electrolytes. [1]

80 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for *one* of the positive ions lost by the body as a person perspires. [1]

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Tear Here

**The University of the State of New York**

REGENTS HIGH SCHOOL EXAMINATION

# PHYSICAL SETTING
# CHEMISTRY

**Wednesday,** August 13, 2008 — 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 ..... | 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