The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Thursday, January 25, 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 Which subatomic particles are located in the nucleus of a neon atom?

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

2 The total mass of the protons in an atom of gold-198 is approximately

(1) 79 atomic mass units
(2) 119 atomic mass units
(3) 198 atomic mass units
(4) 277 atomic mass units

3 In a calcium atom in the ground state, the electrons that possess the *least* amount of energy are located in the

(1) first electron shell
(2) second electron shell
(3) third electron shell
(4) fourth electron shell

4 Which group of atomic models is listed in historical order from the earliest to the most recent?

(1) hard-sphere model, wave-mechanical model, electron-shell model
(2) hard-sphere model, electron-shell model, wave-mechanical model
(3) electron-shell model, wave-mechanical model, hard-sphere model
(4) electron-shell model, hard-sphere model, wave-mechanical model

5 Which isotopic notation represents an atom of carbon-14?

(1) $^{6}_{8}C$
(3) $^{6}_{14}C$
(2) $^{8}_{6}C$
(4) $^{14}_{6}C$

6 An atom of argon rarely bonds to an atom of another element because an argon atom has

(1) 8 valence electrons
(2) 2 electrons in the first shell
(3) 3 electron shells
(4) 22 neutrons

7 The elements on the Periodic Table are arranged in order of increasing

(1) boiling point
(3) atomic number
(2) electronegativity
(4) atomic mass

8 Which element is classified as a nonmetal?

(1) Be
(3) Si
(2) Al
(4) Cl

9 Solid samples of the element phosphorus can be white, black, or red in color. The variations in color are due to different

(1) atomic masses
(2) molecular structures
(3) ionization energies
(4) nuclear charges

10 Given the balanced equation representing the reaction between propane and oxygen:

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

According to this equation, which ratio of oxygen to propane is correct?

(1) $\dfrac{5 \text{ grams } O_2}{1 \text{ gram } C_3H_8}$
(3) $\dfrac{10 \text{ grams } O_2}{11 \text{ grams } C_3H_8}$

(2) $\dfrac{5 \text{ moles } O_2}{1 \text{ mole } C_3H_8}$
(4) $\dfrac{10 \text{ moles } O_2}{11 \text{ moles } C_3H_8}$

11 Lithium and potassium have similar chemical properties because the atoms of both elements have the same

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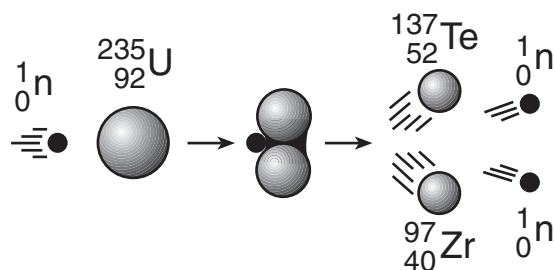(3) number of electron shells
(4) number of valence electrons

12 Which two substances are covalent compounds?

(1) $C_6H_{12}O_6(s)$ and $KI(s)$
(2) $C_6H_{12}O_6(s)$ and $HCl(g)$
(3) $KI(s)$ and $NaCl(s)$
(4) $NaCl(s)$ and $HCl(g)$

13 Which substance, when dissolved in water, forms a solution that conducts an electric current?

(1) C_2H_5OH (3) $C_{12}H_{22}O_{11}$
(2) $C_6H_{12}O_6$ (4) CH_3COOH

14 Given the diagram representing a reaction:

Which phrase best describes this type of reaction and the overall energy change that occurs?

(1) nuclear, and energy is released
(2) nuclear, and energy is absorbed
(3) chemical, and energy is released
(4) chemical, and energy is absorbed

15 Compared to a phosphorus atom, a P^{3-} ion has

(1) more electrons and a larger radius
(2) more electrons and a smaller radius
(3) fewer electrons and a larger radius
(4) fewer electrons and a smaller radius

16 The balanced equation below represents a molecule of bromine separating into two bromine atoms.

$$Br_2 \rightarrow Br + Br$$
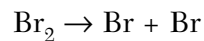
What occurs during this change?

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

17 Which substance can be decomposed by chemical means?

(1) tungsten   (3) krypton
(2) antimony   (4) methane

18 Bronze contains 90 to 95 percent copper and 5 to 10 percent tin. Because these percentages can vary, bronze is classified as

(1) a compound   (3) a mixture
(2) an element   (4) a substance

19 Compared to a 2.0 M aqueous solution of NaCl at 1 atmosphere, a 3.0 M aqueous solution of NaCl at 1 atmosphere has a

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

20 In which reaction are electrons transferred from one reactant to another reactant?

(1) $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$
(2) $AgNO_3(aq) + KCl(aq) \rightarrow$ $AgCl(s) + KNO_3(aq)$
(3) $HCl(aq) + NaOH(aq) \rightarrow$ $NaCl(aq) + H_2O(\ell)$
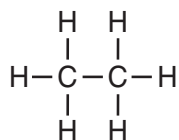(4) $H_3O^+(aq) + OH^-(aq) \rightarrow 2H_2O(\ell)$

21 Which statement must be true for any chemical reaction at equilibrium?

(1) The concentration of the products is greater than the concentration of the reactants.
(2) The concentration of the products is less than the concentration of the reactants.
(3) The concentration of the products and the concentration of the reactants are equal.
(4) The concentration of the products and the concentration of the reactants are constant.
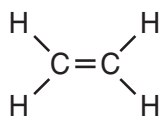
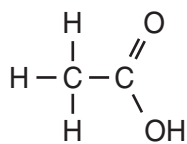22 Given the structural formula:

```
        H  H  H  H  O
        |  |  |  |  ‖
    H―C―C―C―C―C―OH
        |  |  |  |
        H  H  H  H
```
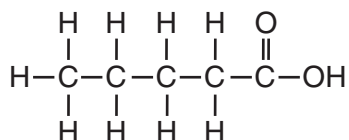
What is the IUPAC name of this compound?

(1) pentanal   (3) methyl pentanoate
(2) pentanol   (4) pentanoic acid

23 Which structural formula represents an unsaturated hydrocarbon?

```
    H  H
    |  |
H―C―C―H
    |  |
    H  H
   ( 1 )
```

```
  H         H
   \       /
    C = C
   /       \
  H         H
      ( 3 )
```

```
    H   O
    |   ‖
H―C―C
    |   \
    H   OH
   ( 2 )
```
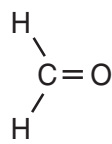
```
  H
   \
    C = O
   /
  H
   ( 4 )
```

24 Which group of nuclear emissions is listed in order of increasing charge?

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

25 Two substances have different physical and chemical properties. Both substances have molecules that contain two carbon atoms, one oxygen atom, and six hydrogen atoms. These two substances must be

(1) isomers of each other
(2) isotopes of each other
(3) the same compound
(4) the same hydrocarbon

26 Given the balanced equation representing a reaction:

$$CH_3CH_2CH_3 + Br_2 \rightarrow CH_3CH_2CH_2Br + HBr$$
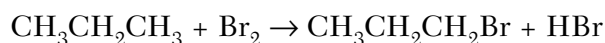
This organic reaction is best classified as

(1) an addition reaction
(2) an esterification reaction
(3) a polymerization reaction
(4) a substitution reaction

27 In terms of energy and entropy, systems in nature tend to undergo changes toward

(1) higher energy and higher entropy
(2) higher energy and lower entropy
(3) lower energy and higher entropy
(4) lower energy and lower entropy

28 Given the structural formula:

$$H―C\equiv C―H$$

What is the total number of electrons shared in the bond between the two carbon atoms?

(1) 6   (3) 3
(2) 2   (4) 4

29 Which compound has hydrogen bonding between its molecules?

(1) CH_4 (3) KH
(2) CaH_2 (4) NH_3

30 Which ion is the only negative ion produced by an Arrhenius base in water?

(1) NO_3^- (3) OH^-
(2) Cl^- (4) H^-

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 When the elements in Group 1 are considered in order from top to bottom, each successive element at standard pressure has
  (1) a higher melting point and a higher boiling point
  (2) a higher melting point and a lower boiling point
  (3) a lower melting point and a higher boiling point
  (4) a lower melting point and a lower boiling point

32 Which isotopic notation identifies a metalloid that is matched with the corresponding number of protons in each of its atoms?
  (1) ^{24}Mg and 12 protons
  (2) ^{28}Si and 14 protons
  (3) ^{75}As and 75 protons
  (4) ^{80}Br and 80 protons

33 At STP, which list of elements contains a solid, a liquid, and a gas?
  (1) Hf, Hg, He   (3) Ba, Br_2, B
  (2) Cr, Cl_2, C   (4) Se, Sn, Sr

34 Element *X* reacts with iron to form two different compounds with the formulas Fe*X* and Fe_2X_3. To which group on the Periodic Table does element *X* belong?
  (1) Group 8   (3) Group 13
  (2) Group 2   (4) Group 16

35 The molar mass of $Ba(OH)_2$ is
  (1) 154.3 g   (3) 171.3 g
  (2) 155.3 g   (4) 308.6 g

36 Given the balanced equation representing a reaction:

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$
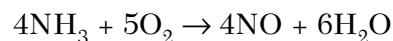
What is the *minimum* number of moles of O_2 that are needed to completely react with 16 moles of NH_3?
  (1) 16 mol   (3) 64 mol
  (2) 20. mol   (4) 80. mol

37 Which Lewis electron-dot diagram correctly represents a hydroxide ion?
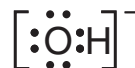
38 A 10.0-gram sample of which element has the *smallest* volume at STP?
  (1) aluminum   (3) titanium
  (2) magnesium   (4) zinc

39 At which temperature would atoms of a He(g) sample have the greatest average kinetic energy?
  (1) 25°C   (3) 273 K
  (2) 37°C   (4) 298 K

40 A student prepares four aqueous solutions, each with a different solute. The mass of each dissolved solute is shown in the table below.

**Mass of Dissolved Solute
for Four Aqueous Solutions**

Solution Number	Solute	Mass of Dissolved Solute (per 100. g of H_2O at 20.°C)
1	KI	120. g
2	$NaNO_3$	88 g
3	KCl	25 g
4	$KClO_3$	5 g

Which solution is saturated?
(1) 1   (3) 3
(2) 2   (4) 4

---

41 At room temperature, a mixture of sand and water can be separated by

(1) ionization   (3) filtration
(2) combustion   (4) sublimation

42 Given the balanced equation representing a reaction at 101.3 kPa and 298 K:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) + 91.8 \text{ kJ}$$

Which statement is true about this reaction?

(1) It is exothermic and ΔH equals –91.8 kJ.
(2) It is exothermic and ΔH equals +91.8 kJ.
(3) It is endothermic and ΔH equals –91.8 kJ.
(4) It is endothermic and ΔH equals +91.8 kJ.

43 Which balanced equation represents a phase equilibrium?

(1) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

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

(3) $Cl_2(g) \rightleftharpoons Cl_2(\ell)$

(4) $3O_2(g) \rightleftharpoons 2O_3(g)$

44 Given the system at equilibrium:

$$2POCl_3(g) + \text{energy} \rightleftharpoons 2PCl_3(g) + O_2(g)$$

Which changes occur when $O_2(g)$ is added to this system?

(1) The equilibrium shifts to the right and the concentration of $PCl_3(g)$ increases.
(2) The equilibrium shifts to the right and the concentration of $PCl_3(g)$ decreases.
(3) The equilibrium shifts to the left and the concentration of $PCl_3(g)$ increases.
(4) The equilibrium shifts to the left and the concentration of $PCl_3(g)$ decreases.

45 What is the oxidation number of chromium in the chromate ion, CrO_4^{2-}?
(1) +6   (3) +3
(2) +2   (4) +8

46 Given the balanced equation representing a reaction:

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

Which type of reaction is represented by this equation?

(1) decomposition   (3) single replacement
(2) neutralization   (4) synthesis

47 In which 0.01 M solution is phenolphthalein pink?

(1) $CH_3OH(aq)$ (3) $CH_3COOH(aq)$
(2) $Ca(OH)_2(aq)$ (4) $HNO_3(aq)$

48 As the pH of a solution is changed from 3 to 6, the concentration of hydronium ions

(1) increases by a factor of 3
(2) increases by a factor of 1000
(3) decreases by a factor of 3
(4) decreases by a factor of 1000

49 If $\frac{1}{8}$ of an original sample of krypton-74 remains unchanged after 34.5 minutes, what is the half-life of krypton-74?

(1) 11.5 min   (3) 34.5 min
(2) 23.0 min   (4) 46.0 min

50 Given the nuclear equation:

$$^{253}_{99}Es + X \rightarrow {}^{1}_{0}n + {}^{256}_{101}Md$$
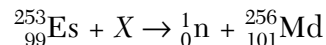
Which particle is represented by X?

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

Part B–2

Answer all questions in this part.

Directions (51–66): 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 Naturally occurring boron is composed of two isotopes. The percent abundance and the mass of each isotope are listed below.

- 19.9% of the boron atoms have a mass of 10.013 atomic mass units.

- 80.1% of the boron atoms have a mass of 11.009 atomic mass units.

In the space *in your answer booklet*, calculate the atomic mass of boron. Your response must include *both* a correct numerical setup and the calculated result. [2]

Base your answers to questions 52 and 53 on the information below.

During a laboratory activity, a student reacted a piece of zinc with 0.1 M HCl(aq).

52 Complete the equation *in your answer booklet* by writing the formula of the missing product. [1]

53 Based on Reference Table *J*, identify *one* metal that does *not* react spontaneously with HCl(aq). [1]

54 A hydrated compound contains water molecules within its crystal structure. The percent composition by mass of water in the hydrated compound $CaSO_4 \cdot 2H_2O$ has an accepted value of 20.9%. A student did an experiment and determined that the percent composition by mass of water in $CaSO_4 \cdot 2H_2O$ was 21.4%.

In the space *in your answer booklet*, calculate the percent error of the student's experimental result. Your response must include *both* a correct numerical setup and the calculated result. [2]

Base your answers to questions 55 through 57 on the information below.

The particle diagrams below represent the reaction between two nonmetals, A_2 and Q_2.

Reactants   Product

55 Using the symbols A and Q, write the chemical formula of the product. [1]

56 Identify the type of chemical bond between an atom of element A and an atom of element Q. [1]

57 Compare the total mass of the reactants to the total mass of the product. [1]

58 A potential energy diagram for a chemical reaction is shown *in your answer booklet*. On this diagram, draw a curve to show how the potential energy diagram will change when a catalyst is added to the reaction. [1]

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

60 An aqueous solution contains 300. parts per million of KOH. Determine the number of grams of KOH present in 1000. grams of this solution. [1]

Base your answers to questions 61 through 63 on the diagram below. The diagram shows a voltaic cell with copper and aluminum electrodes immediately after the external circuit is completed.
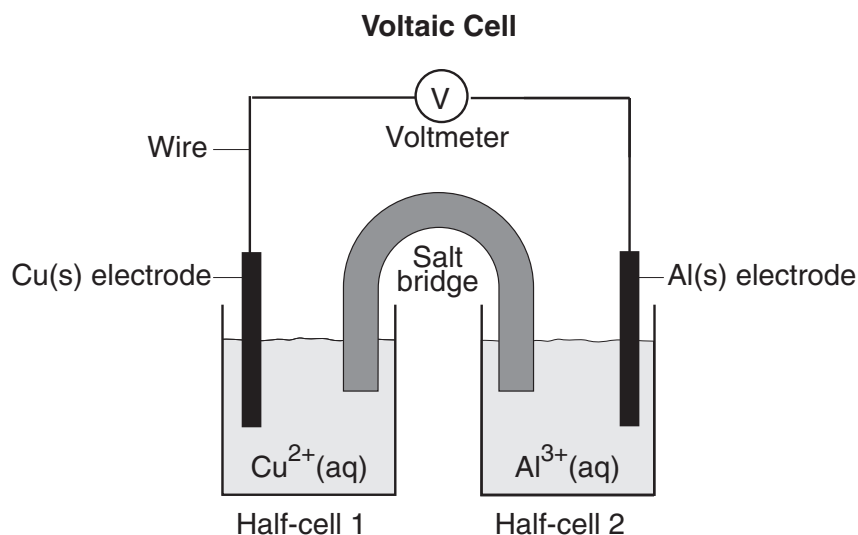
Voltaic Cell

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

62 As this voltaic cell operates, the mass of the Al(s) electrode decreases. Explain, in terms of particles, why this decrease in mass occurs. [1]

63 Explain the function of the salt bridge. [1]

64 Identify *two* indicators from Reference Table *M* that are yellow in solutions with a pH of 5.5. [1]

65 Explain, in terms of molecular structure or distribution of charge, why a molecule of methane is nonpolar. [1]

66 A liquid boils when the vapor pressure of the liquid equals the atmospheric pressure on the surface of the liquid. Using Reference Table *H*, determine the boiling point of water when the atmospheric pressure is 90. kPa. [1]

Part C

Answer all questions in this part.

Directions (67–83): 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 67 through 70 on the information below, which describes the proposed discovery of element 118.

> In 1999, a nuclear chemist and his team announced they had discovered a new element by crashing krypton atoms into lead. The new element, number 118, was assigned the name ununoctium and the symbol Uuo. One possible isotope of ununoctium could have been Uuo-291.
>
> However, the discovery of Uuo was not confirmed because other scientists could not reproduce the experimental results published by the nuclear chemist and his team. In 2006, another team of scientists claimed that they produced Uuo. This claim has yet to be confirmed.
>
> Adapted from *Discover* January 2002

67 Based on atomic number, in which group on the Periodic Table would element 118 be placed? [1]

68 What would be the total number of neutrons present in a theoretical atom of Uuo-291? [1]

69 What would be the total number of electrons present in a theoretical atom of Uuo-291? [1]

70 Explain why being able to reproduce scientific results is an important component of scientific research. [1]

Base your answers to questions 71 through 74 on the information below.

Have you ever seen an insect called a water strider "skating" across the surface of a calm pond? Have you ever "floated" a sewing needle on the water in a glass? If you have, then you've observed one of water's many amazing properties.

Water's surface tension keeps the water strider and the sewing needle from sinking into the water. Simply stated, the surface tension is due to the forces that hold the water molecules together. Without these intermolecular forces, the water strider and the sewing needle would sink below the surface of the water.

The surface tension of water at various temperatures is given in the data table below.

Surface Tension at Different Water Temperatures

| Water Temperature (°C)	Surface Tension (mN/m)
10.	74.2
25	72.0
50.	67.9
75	63.6
100.	58.9

71 On the grid *in your answer booklet*, plot the data from the data table. Circle and connect the five points. [1]

Example:

72 According to your graph, what is the surface tension of water at 60.°C? [1]

73 State the relationship between the surface tension and the temperature of water. [1]

74 The surface tension of liquid tetrachloromethane, CCl_4, at 25°C is 26.3 milli-newtons/meter (mN/m). Compare the intermolecular forces between molecules of CCl_4 to the intermolecular forces between molecules of water, H_2O, at 25°C. [1]

Base your answers to questions 75 through 77 on the information below.

A rigid cylinder is fitted with a movable piston. The cylinder contains a sample of helium gas, He(g), which has an initial volume of 125.0 milliliters and an initial pressure of 1.0 atmosphere, as shown below. The temperature of the helium gas sample is 20.0°C.
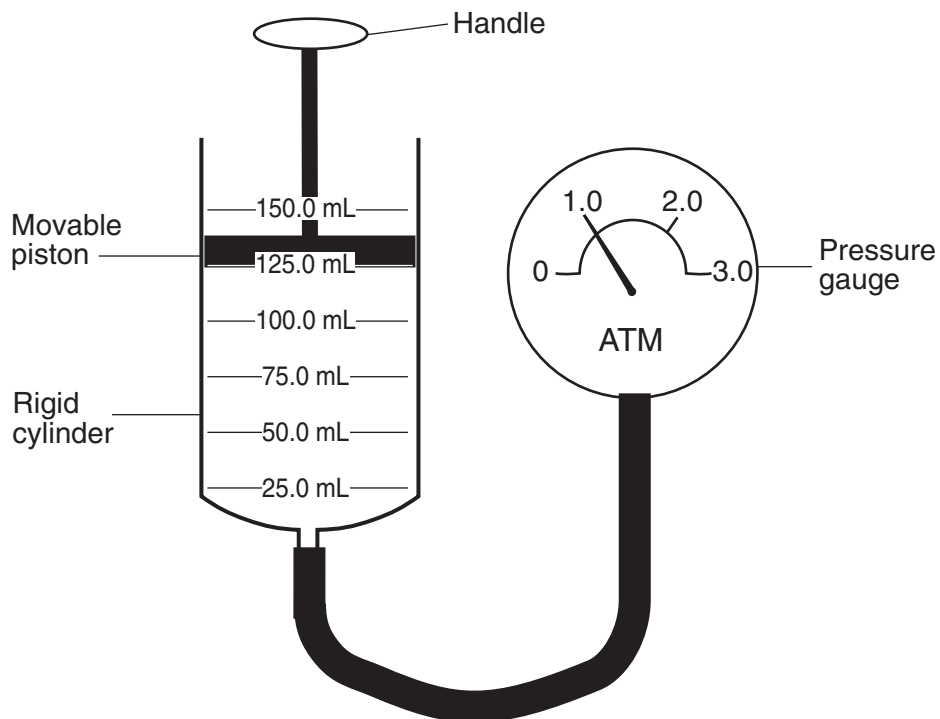
75 Express the initial volume of the helium gas sample, in liters. [1]

76 The piston is pushed further into the cylinder. In the space *in your answer booklet*, show a correct numerical setup for calculating the volume of the helium gas that is anticipated when the reading on the pressure gauge is 1.5 atmospheres. The temperature of the helium gas remains constant. [1]

77 Helium gas is removed from the cylinder and a sample of nitrogen gas, $N_2(g)$, is added to the cylinder. The nitrogen gas has a volume of 125.0 milliliters and a pressure of 1.0 atmosphere at 20.0°C. Compare the number of particles in this nitrogen gas sample to the number of particles in the original helium gas sample. [1]

Base your answers to questions 78 through 81 on the information below.

In preparing to titrate an acid with a base, a student puts on goggles and an apron. The student uses burets to dispense and measure the acid and the base in the titration. In each of two trials, a 0.500 M NaOH(aq) solution is added to a flask containing a volume of HCl(aq) solution of unknown concentration. Phenolphthalein is the indicator used in the titration. The calculated volumes used for the two trials are recorded in the table below.

Volumes of Base and Acid Used in Titration Trials

		Trial 1	Trial 2
Solution (aq)	Molarity (M)	Volume Used (mL)	Volume Used (mL)
NaOH	0.500	17.03	16.87
HCl	?	10.22	10.12

78 Write a chemical name for the acid used in the titration. [1]

79 Using the volumes from trial 1, determine the molarity of the HCl(aq) solution. [1]

80 Based on the information given in the table, how many significant figures should be shown in the calculated molarity of the HCl(aq) solution used in trial 2? [1]

81 Identify *one* additional safety precaution the student should have taken before performing the titration. [1]

Base your answers to questions 82 and 83 on the information below.

A gasoline engine burns gasoline in the presence of excess oxygen to form carbon dioxide and water. The main components of gasoline are isomers of octane. A structural formula of octane is shown below.

```
          H   H   H   H   H   H   H   H
          |   |   |   |   |   |   |   |
      H − C − C − C − C − C − C − C − C − H
          |   |   |   |   |   |   |   |
          H   H   H   H   H   H   H   H
```
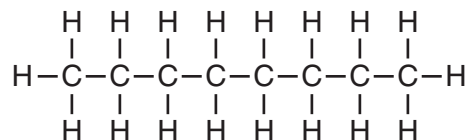
One isomer of octane is 2,2,4-trimethylpentane.

82 In the space *in your answer booklet*, draw a structural formula for 2,2,4-trimethylpentane. [1]

83 Explain, in terms of the arrangement of particles, why the entropy of gasoline vapor is greater than the entropy of liquid gasoline. [1]

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Thursday, January 25, 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				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

Tear Here

Tear Here

Tear Here

PS/CHEMISTRY

PS/CHEMISTRY