The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, June 22, 2005 — 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 (1–33): 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 modern wave-mechanical model of the atom, the orbitals are regions of the most probable location of

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

2 Compared to a proton, an electron has

  (1) a greater quantity of charge and the same sign
  (2) a greater quantity of charge and the opposite sign
  (3) the same quantity of charge and the same sign
  (4) the same quantity of charge and the opposite sign

3 Which two notations represent atoms that are isotopes of the same element?

  (1) $^{121}_{50}$Sn and $^{119}_{50}$Sn   (3) $^{19}_{8}$O and $^{19}_{9}$F

  (2) $^{121}_{50}$Sn and $^{121}_{50}$Sn   (4) $^{39}_{17}$Cl and $^{39}_{19}$K

4 The elements in Period 5 on the Periodic Table are arranged from left to right in order of

  (1) decreasing atomic mass
  (2) decreasing atomic number
  (3) increasing atomic mass
  (4) increasing atomic number

5 Which list of elements contains a metal, a metalloid, and a nonmetal?

  (1) Zn, Ga, Ge   (3) Cd, Sb, I
  (2) Si, Ge, Sn   (4) F, Cl, Br

6 An example of a physical property of an element is the element's ability to

  (1) react with an acid
  (2) react with oxygen
  (3) form a compound with chlorine
  (4) form an aqueous solution

7 Which element is malleable and conducts electricity?

  (1) iron   (3) sulfur
  (2) iodine   (4) phosphorus

8 At STP, solid carbon can exist as graphite or as diamond. These two forms of carbon have

  (1) the same properties and the same crystal structures
  (2) the same properties and different crystal structures
  (3) different properties and the same crystal structures
  (4) different properties and different crystal structures

9 What is the formula of titanium(II) oxide?

  (1) TiO   (3) Ti_2O
  (2) TiO_2 (4) Ti_2O_3

10 Which substance can be decomposed by a chemical change?

  (1) calcium   (3) copper
  (2) potassium   (4) ammonia

11 As a chlorine atom becomes a negative ion, the atom

  (1) gains an electron and its radius increases
  (2) gains an electron and its radius decreases
  (3) loses an electron and its radius increases
  (4) loses an electron and its radius decreases

12 Based on Reference Table *S*, the atoms of which of these elements have the strongest attraction for electrons in a chemical bond?

  (1) N   (3) P
  (2) Na   (4) Pt

13 Which terms are used to identify pure substances?

(1) an element and a mixture
(2) an element and a compound
(3) a solution and a mixture
(4) a solution and a compound

14 The solubility of $KClO_3(s)$ in water increases as the

(1) temperature of the solution increases
(2) temperature of the solution decreases
(3) pressure on the solution increases
(4) pressure on the solution decreases

15 Compared to a 0.1 M aqueous solution of NaCl, a 0.8 M aqueous solution of NaCl has a

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

16 The kinetic molecular theory assumes that the particles of an ideal gas

(1) are in random, constant, straight-line motion
(2) are arranged in a regular geometric pattern
(3) have strong attractive forces between them
(4) have collisions that result in the system losing energy

17 In which process does a solid change directly into a vapor?

(1) condensation   (3) deposition
(2) sublimation   (4) solidification

18 Which statement must be true about a chemical system at equilibrium?

(1) The forward and reverse reactions stop.
(2) The concentration of reactants and products are equal.
(3) The rate of the forward reaction is equal to the rate of the reverse reaction.
(4) The number of moles of reactants is equal to the number of moles of product.

19 Adding a catalyst to a chemical reaction results in

(1) a decrease in activation energy and a decrease in the reaction rate
(2) a decrease in activation energy and an increase in the reaction rate
(3) an increase in activation energy and a decrease in the reaction rate
(4) an increase in activation energy and an increase in the reaction rate

20 Systems in nature tend to undergo changes toward

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

21 Which element has atoms that can bond with each other to form long chains or rings?

(1) carbon   (3) oxygen
(2) nitrogen   (4) fluorine

22 Which formula represents an unsaturated hydrocarbon?

(1) C_2H_6 (3) C_5H_8
(2) C_3H_8 (4) C_6H_{14}

23 Given the structural formula:

What is the IUPAC name of this compound?

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

24 What is the oxidation state of nitrogen in $NaNO_2$?

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

25 The three isomers of pentane have different

    (1) formula masses
    (2) molecular formulas
    (3) empirical formulas
    (4) structural formulas

26 Where does oxidation occur in an electro-chemical cell?

    (1) at the cathode in both an electrolytic cell and a voltaic cell
    (2) at the cathode in an electrolytic cell and at the anode in a voltaic cell
    (3) at the anode in both an electrolytic cell and a voltaic cell
    (4) at the anode in an electrolytic cell and at the cathode in a voltaic cell

27 Which formula represents an electrolyte?

    (1) CH_3OCH_3 (3) CH_3COOH
    (2) CH_3OH (4) C_2H_5CHO

28 When an Arrhenius acid dissolves in water, the only positive ion in the solution is

    (1) H^+ (3) Na^+
    (2) Li^+ (4) K^+

29 What is the half-life and decay mode of Rn-222?

    (1) 1.91 days and alpha decay
    (2) 1.91 days and beta decay
    (3) 3.82 days and alpha decay
    (4) 3.82 days and beta decay

30 Which equation represents a transmutation reaction?

    (1) $^{239}_{92}U \rightarrow {}^{239}_{92}U + {}^{0}_{0}\gamma$
    (2) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$
    (3) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
    (4) $nC_2H_4 \xrightarrow{\text{catalyst}} (-C_2H_4-)_n$

31 Which equation represents positron decay?

    (1) $^{87}_{37}Rb \rightarrow {}^{0}_{-1}e + {}^{87}_{38}Sr$
    (2) $^{227}_{92}U \rightarrow {}^{223}_{90}Th + {}^{4}_{2}He$
    (3) $^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$
    (4) $^{11}_{6}C \rightarrow {}^{0}_{+1}e + {}^{11}_{5}B$

32 Which equation represents a fusion reaction?

    (1) $H_2O(g) \rightarrow H_2O(\ell)$
    (2) $C(s) + O_2(g) \rightarrow CO_2(g)$
    (3) $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$
    (4) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3{}^{1}_{0}n$

Note that question 33 has only three choices.

33 An electron in an atom moves from the ground state to an excited state when the energy of the electron

    (1) decreases
    (2) increases
    (3) remains the same

Part B–1

Answer all questions in this part.

Directions (34–50): 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*.

34 Which symbol represents a particle that has the same total number of electrons as S^{2-}?

(1) O^{2-} (3) Se^{2-}
(2) Si   (4) Ar

35 The data table below shows elements *Xx, Yy,* and *Zz* from the same group on the Periodic Table.

Element	Atomic Mass (atomic mass unit)	Atomic Radius (pm)
Xx	69.7	141
Yy	114.8	?
Zz	204.4	171

What is the most likely atomic radius of element *Yy*?

(1) 103 pm   (3) 166 pm
(2) 127 pm   (4) 185 pm

36 Which substance has a chemical formula with the same ratio of metal ions to nonmetal ions as in potassium sulfide?

(1) sodium oxide
(2) sodium chloride
(3) magnesium oxide
(4) magnesium chloride

37 The molecular formula of glucose is $C_6H_{12}O_6$. What is the empirical formula of glucose?

(1) CHO   (3) $C_6H_{12}O_6$
(2) CH_2O (4) $C_{12}H_{24}O_{12}$

38 According to Reference Table *F*, which of these compounds is the *least* soluble in water?

(1) K_2CO_3 (3) $Ca_3(PO_4)_2$
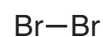(2) $KC_2H_3O_2$ (4) $Ca(NO_3)_2$

39 A sample of a substance containing only magnesium and chlorine was tested in the laboratory and was found to be composed of 74.5% chlorine by mass. If the total mass of the sample was 190.2 grams, what was the mass of the magnesium?

(1) 24.3 g   (3) 70.9 g
(2) 48.5 g   (4) 142 g
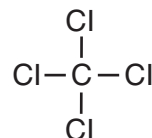
40 Which molecule contains a nonpolar covalent bond?

O=C=O   Br—Br

(1)   (3)

C≡O

(2)

```
     Cl
     |
Cl — C — Cl
     |
     Cl
```
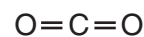
(4)

41 According to Reference Table *G*, which substance forms an unsaturated solution when 80 grams of the substance is dissolved in 100 grams of H_2O at 10°C?

(1) KI   (3) $NaNO_3$
(2) KNO_3 (4) NaCl

42 What is the concentration of a solution, in parts per million, if 0.02 gram of Na_3PO_4 is dissolved in 1000 grams of water?

(1) 20 ppm   (3) 0.2 ppm
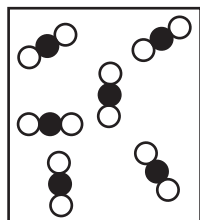(2) 2 ppm   (4) 0.02 ppm

43 Given the simple representations for atoms of two elements:

$\bigcirc$ = an atom of an element

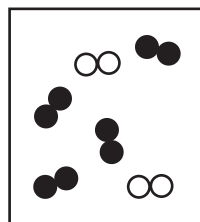● = an atom of a different element

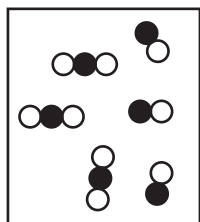Which particle diagram represents molecules of only one compound in the gaseous phase?
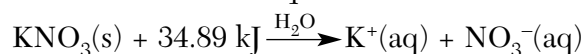

(1)   (3)

(2)   (4)

44 Given the balanced equation:

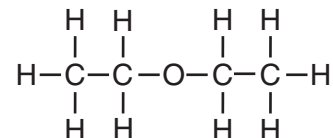$$KNO_3(s) + 34.89 \text{ kJ} \xrightarrow{H_2O} K^+(aq) + NO_3^-(aq)$$
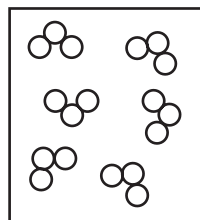
Which statement best describes this process?

(1) It is endothermic and entropy increases.
(2) It is endothermic and entropy decreases.
(3) It is exothermic and entropy increases.
(4) It is exothermic and entropy decreases.

45 A 1.0-gram piece of zinc reacts with 5 milliliters of HCl(aq). Which of these conditions of concentration and temperature would produce the greatest rate of reaction?

(1) 1.0 M HCl(aq) at 20.°C
(2) 1.0 M HCl(aq) at 40.°C
(3) 2.0 M HCl(aq) at 20.°C
(4) 2.0 M HCl(aq) at 40.°C

46 At STP, fluorine is a gas and iodine is a solid. This observation can be explained by the fact that fluorine has

(1) weaker intermolecular forces of attraction than iodine
(2) stronger intermolecular forces of attraction than iodine
(3) lower average kinetic energy than iodine
(4) higher average kinetic energy than iodine

47 Given the structural formula:

$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-O-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$

The compound represented by this formula can be classified as an

(1) organic acid   (3) ester
(2) ether   (4) aldehyde

48 Sulfuric acid, H_2SO_4(aq), can be used to neutralize barium hydroxide, $Ba(OH)_2$(aq). What is the formula for the salt produced by this neutralization?

(1) BaS   (3) $BaSO_3$
(2) $BaSO_2$ (4) $BaSO_4$

49 Given the balanced ionic equation:

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$
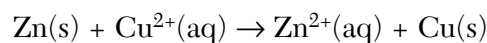
Which equation represents the oxidation half-reaction?

(1) $Zn(s) + 2e^- \rightarrow Zn^{2+}(aq)$
(2) $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$
(3) $Cu^{2+}(aq) \rightarrow Cu(s) + 2e^-$
(4) $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

50 In which solution will thymol blue indicator appear blue?

(1) 0.1 M CH_3COOH (3) 0.1 M HCl
(2) 0.1 M KOH   (4) 0.1 M H_2SO_4

Part B–2

## Answer all questions in this part.

Directions (51–64): 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 and 52 on the diagram below, which represents an atom of magnesium-26 in the ground state.

Mg-26 nucleus
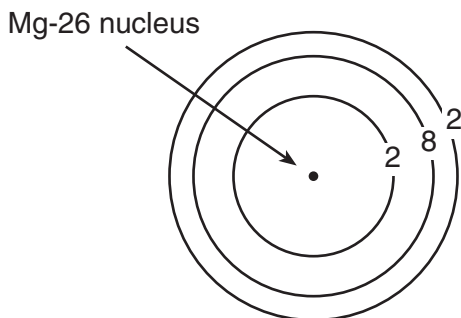
51 What is the total number of valence electrons in an atom of Mg-26 in the ground state? [1]

52 On the diagram *in your answer booklet,* write an appropriate number of electrons in *each* shell to represent a Mg-26 atom in an excited state. Your answer may include additional shells. [1]

53 Explain, in terms of atomic structure, why germanium is chemically similar to silicon. [1]

54 Given the balanced equation:

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$
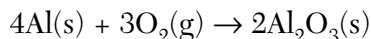
What is the total number of moles of $O_2(g)$ that must react completely with 8.0 moles of Al(s) in order to form $Al_2O_3(s)$? [1]

Base your answers to questions 55 and 56 on the balanced equation below.

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$
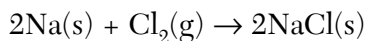
55 In the box *in your answer booklet,* draw a Lewis electron-dot diagram for a molecule of chlorine, Cl_2. [1]

56 Explain, in terms of electrons, why the bonding in NaCl is ionic. [1]

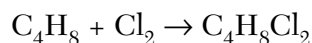Base your answers to questions 57 and 58 on the information below.

Given the reaction at equilibrium:

$$2NO_2(g) + 7H_2(g) \rightleftharpoons 2NH_3(g) + 4H_2O(g) + 1127 \text{ kJ}$$
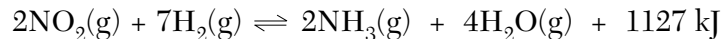
57 On the diagram *in your answer booklet,* complete the potential energy diagram for the forward reaction. Be sure your drawing shows the activation energy and the potential energy of the products. [2]

58 Explain, in terms of Le Chatelier's principle, why the concentration of $NH_3(g)$ *decreases* when the temperature of the equilibrium system increases. [1]
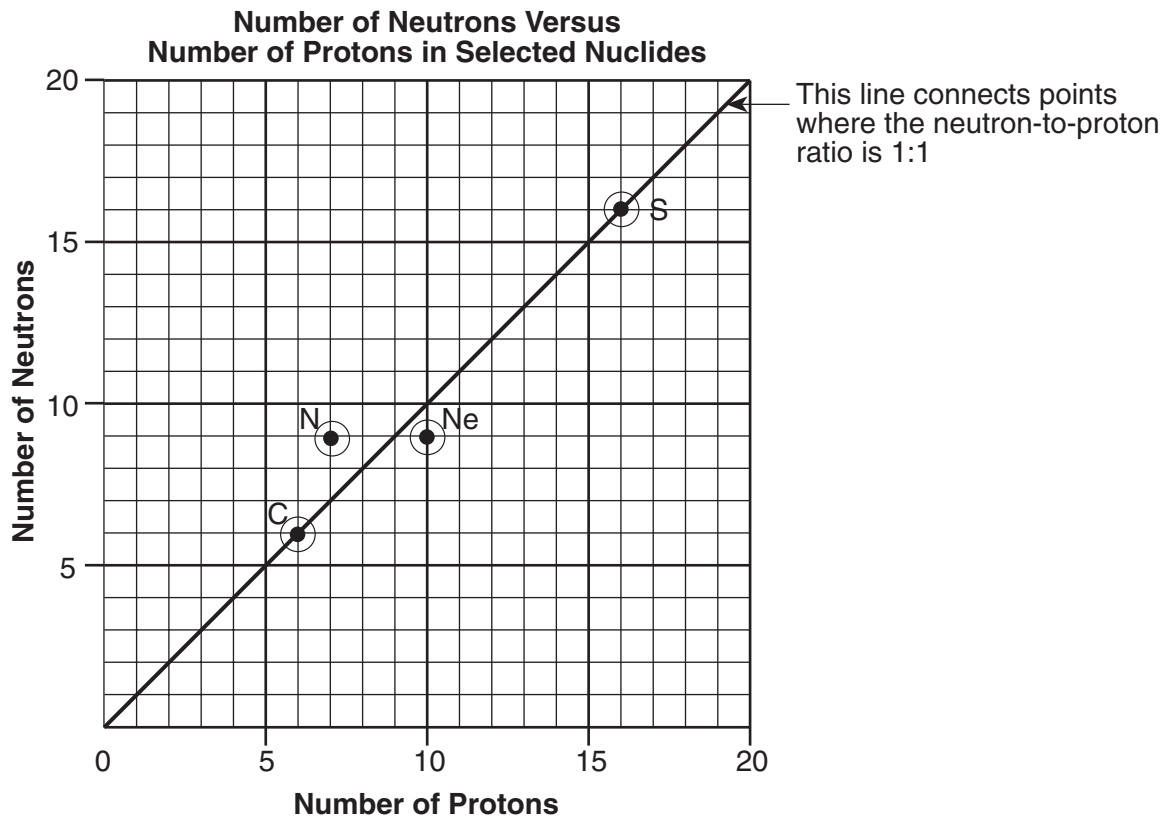
Base your answers to questions 59 and 60 on the information below.

Given the reaction between 1-butene and chlorine gas:

$$C_4H_8 + Cl_2 \rightarrow C_4H_8Cl_2$$

59 Which type of chemical reaction is represented by this equation? [1]

60 In the space *in your answer booklet,* draw the structural formula of the product 1,2-dichlorobutane. [1]

Base your answers to questions 61 through 64 on the information below, which relates the numbers of neutrons and protons for specific nuclides of C, N, Ne, and S.

**Number of Neutrons Versus
Number of Protons in Selected Nuclides**

This line connects points where the neutron-to-proton ratio is 1:1

61 Using the point plotted on the graph for neon, complete the table *in your answer booklet*. [1]

62 Explain, in terms of atomic particles, why S-32 is a stable nuclide. [1]

63 Using the point plotted on the graph for nitrogen, what is the neutron-to-proton ratio of this nuclide? [1]

64 Based on Reference Table *N*, complete the decay equation for N-16 *in your answer booklet*. [1]

Part C

Answer all questions in this part.

Directions (65–83): 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.*

65 In the early 1900s, experiments were conducted to determine the structure of the atom. One of these experiments involved bombarding gold foil with alpha particles. Most alpha particles passed directly through the foil. Some, however, were deflected at various angles. Based on this alpha particle experiment, state *two* conclusions that were made concerning the structure of an atom.   [2]

Base your answers to questions 66 through 70 on the information below.

A substance is a solid at 15°C. A student heated a sample of the solid substance and recorded the temperature at one-minute intervals in the data table below.

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12
Temperature (°C)	15	32	46	53	53	53	53	53	53	53	53	60	65

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

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

Example:

68 Based on the data table, what is the melting point of this substance?   [1]

69 What is the evidence that the average kinetic energy of the particles of this substance is increasing during the first three minutes?   [1]

70 The heat of fusion for this substance is 122 joules per gram. How many joules of heat are needed to melt 7.50 grams of this substance at its melting point?   [1]

Base your answers to questions 71 through 73 on the diagram of a voltaic cell and the balanced ionic equation below.

Mg(s) + Ni^{2+}(aq) $\longrightarrow$ Mg^{2+}(aq) + Ni(s)
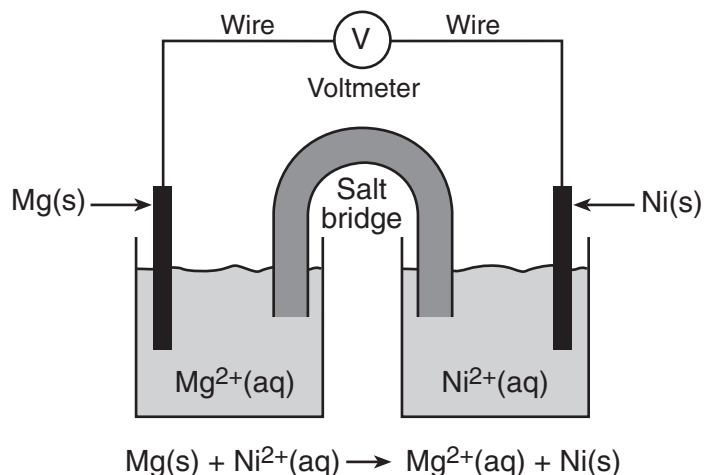
71 What is the total number of moles of electrons needed to completely reduce 6.0 moles of Ni^{2+}(aq) ions? [1]

72 Identify *one* metal from Reference Table *J* that is more easily oxidized than Mg(s). [1]

73 Explain the function of the salt bridge in the voltaic cell. [1]

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

Acid rain is a problem in industrialized countries around the world. Oxides of sulfur and nitrogen are formed when various fuels are burned. These oxides dissolve in atmospheric water droplets that fall to earth as acid rain or acid snow.

While normal rain has a pH between 5.0 and 6.0 due to the presence of dissolved carbon dioxide, acid rain often has a pH of 4.0 or lower. This level of acidity can damage trees and plants, leach minerals from the soil, and cause the death of aquatic animals and plants.

If the pH of the soil is too low, then quicklime, CaO, can be added to the soil to increase the pH. Quicklime produces calcium hydroxide when it dissolves in water.

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

75 A sample of wet soil has a pH of 4.0. After the addition of quicklime, the H$^+$ ion concentration of the soil is $\frac{1}{100}$ of the original H$^+$ ion concentration of the soil. What is the new pH of the soil sample? [1]

76 Samples of acid rain are brought to a laboratory for analysis. Several titrations are performed and it is determined that a 20.0-milliliter sample of acid rain is neutralized with 6.50 milliliters of 0.010 M NaOH. What is the molarity of the H$^+$ ions in the acid rain? [1]

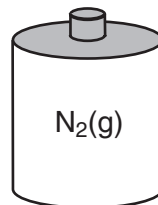Base your answers to questions 77 through 79 on the information and diagrams below.

Cylinder A contains 22.0 grams of $CO_2(g)$ and cylinder B contains $N_2(g)$. The volumes, pressures, and temperatures of the two gases are indicated under each cylinder.

Cylinder A   **Cylinder B**

$CO_2(g)$ $N_2(g)$
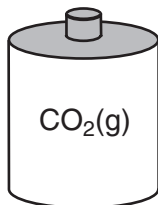
V = 12.3 L   V = 12.3 L
P = 1.0 atm   P = 1.0 atm
T = 300. K   T = 300. K

77 What is the total number of moles of $CO_2(g)$ in cylinder A?   [1]

78 Explain why the number of molecules of $N_2(g)$ in cylinder B is the same as the number of molecules of $CO_2(g)$ in cylinder A.   [1]

79 The temperature of the $CO_2(g)$ is increased to 450. K and the volume of cylinder A remains constant. In the space *in your answer booklet,* show a correct numerical setup for calculating the new pressure of the $CO_2(g)$ in cylinder A.   [1]

_____

Base your answers to questions 80 through 83 on the information and diagram below and on your knowledge of chemistry.

Crude oil is a mixture of many hydrocarbons that have different numbers of carbon atoms. The use of a fractionating tower allows the separation of this mixture based on the boiling points of the hydrocarbons.

To begin the separation process, the crude oil is heated to about 400°C in a furnace, causing many of the hydrocarbons of the crude oil to vaporize. The vaporized mixture is pumped into a fractionating tower that is usually more than 30 meters tall. The temperature of the tower is highest at the bottom. As vaporized samples of hydrocarbons travel up the tower, they cool and condense. The liquid hydrocarbons are collected on trays and removed from the tower. The diagram below illustrates the fractional distillation of the crude oil and the temperature ranges in which the different hydrocarbons condense.

Distillation of Crude Oil
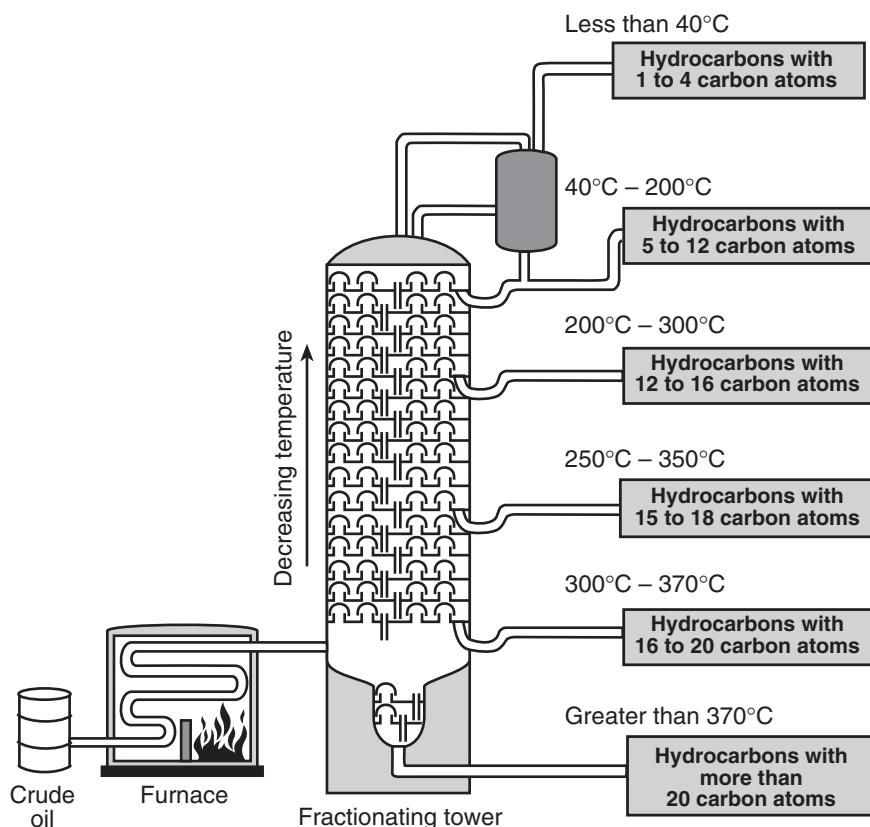
80 State the trend between the boiling point of the hydrocarbons contained in the crude oil and the number of carbon atoms in these molecules.   [1]

81 Describe the relationship between the strength of the intermolecular forces and the number of carbon atoms in the different hydrocarbon molecules.   [1]

82 Write an IUPAC name of *one* saturated hydrocarbon that leaves the fractionating tower at *less than* 40°C.   [1]

83 How many hydrogen atoms are present in one molecule of octane?   [1]

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Wednesday, June 22, 2005 — 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	12	23	34	43 ....
2	13	24	35	44 ....
3	14	25	36	45 ....
4	15	26	37	46 ....
5	16	27	38	47 ....
6	17	28	39	48 ....
7	18	29	40	49 ....
8	19	30	41	50 ....
9	20	31	42	
10	21	32		
11	22	33		

Part B–1 Score

Part A 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

PS/CHEMISTRY