

The University of the State of New York
REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING CHEMISTRY

Wednesday, January 28, 2004 — 9:15 a.m. to 12:15 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 your use while taking this examination.

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

Part A

Answer all questions in this part.

Directions (1–31): 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*.

- A neutral atom contains 12 neutrons and 11 electrons. The number of protons in this atom is
 - 1
 - 11
 - 12
 - 23
- Isotopes of an element must have different
 - atomic numbers
 - mass numbers
 - numbers of protons
 - numbers of electrons
- Which element is a noble gas?
 - krypton
 - chlorine
 - antimony
 - manganese
- On the present Periodic Table of the Elements, the elements are arranged according to increasing
 - number of oxidation states
 - number of neutrons
 - atomic mass
 - atomic number
- What is a property of most metals?
 - They tend to gain electrons easily when bonding.
 - They tend to lose electrons easily when bonding.
 - They are poor conductors of heat.
 - They are poor conductors of electricity.
- What is the correct formula for iron (III) phosphate?
 - FeP
 - Fe₃P₂
 - FePO₄
 - Fe₃(PO₄)₂
- The bond between Br atoms in a Br₂ molecule is
 - ionic and is formed by the sharing of two valence electrons
 - ionic and is formed by the transfer of two valence electrons
 - covalent and is formed by the sharing of two valence electrons
 - covalent and is formed by the transfer of two valence electrons
- The amount of energy required to remove the outermost electron from a gaseous atom in the ground state is known as
 - first ionization energy
 - activation energy
 - conductivity
 - electronegativity
- What occurs when an atom of chlorine and an atom of hydrogen become a molecule of hydrogen chloride?
 - A chemical bond is broken and energy is released.
 - A chemical bond is broken and energy is absorbed.
 - A chemical bond is formed and energy is released.
 - A chemical bond is formed and energy is absorbed.
- Which molecule is nonpolar?
 - H₂O
 - NH₃
 - CO
 - CO₂
- Which must be a mixture of substances?
 - solid
 - liquid
 - gas
 - solution

12 A bottle of rubbing alcohol contains both 2-propanol and water. These liquids can be separated by the process of distillation because the 2-propanol and water

- (1) have combined chemically and retain their different boiling points
- (2) have combined chemically and have the same boiling point
- (3) have combined physically and retain their different boiling points
- (4) have combined physically and have the same boiling point

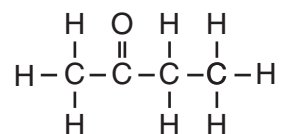
13 Compared to pure water, an aqueous solution of calcium chloride has a

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

14 Under which conditions does a real gas behave most like an ideal gas?

- (1) at low temperatures and high pressures
- (2) at low temperatures and low pressures
- (3) at high temperatures and high pressures
- (4) at high temperatures and low pressures

15 What is the IUPAC name of the compound with the following structural formula?

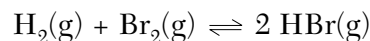


- (1) propanone
- (2) propanal
- (3) butanone
- (4) butanal

16 Which statement best explains the role of a catalyst in a chemical reaction?

- (1) A catalyst is added as an additional reactant and is consumed but not regenerated.
- (2) A catalyst limits the amount of reactants used.
- (3) A catalyst changes the kinds of products produced.
- (4) A catalyst provides an alternate reaction pathway that requires less activation energy.

17 Given the reaction at equilibrium:



The rate of the forward reaction is

- (1) greater than the rate of the reverse reaction
- (2) less than the rate of the reverse reaction
- (3) equal to the rate of the reverse reaction
- (4) independent of the rate of the reverse reaction

18 Which statement best explains why most atomic masses on the Periodic Table are decimal numbers?

- (1) Atomic masses are determined relative to an H-1 standard.
- (2) Atomic masses are determined relative to an O-16 standard.
- (3) Atomic masses are a weighted average of the naturally occurring isotopes.
- (4) Atomic masses are an estimated average of the artificially produced isotopes.

19 All organic compounds must contain the element

- (1) phosphorus
- (2) oxygen
- (3) carbon
- (4) nitrogen

20 Which of the following compounds has the highest boiling point?

- (1) H_2O
- (2) H_2S
- (3) H_2Se
- (4) H_2Te

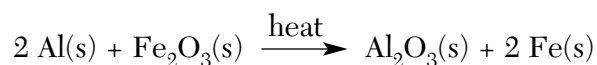
21 The functional group $-\text{COOH}$ is found in

- (1) esters
- (2) aldehydes
- (3) alcohols
- (4) organic acids

22 Which of these elements is the best conductor of electricity?

- (1) S
- (2) N
- (3) Br
- (4) Ni

23 Given the reaction:



Which species undergoes reduction?

- (1) Al (3) Al^{3+}
(2) Fe (4) Fe^{3+}

24 Which energy transformation occurs when an electrolytic cell is in operation?

- (1) chemical energy \rightarrow electrical energy
(2) electrical energy \rightarrow chemical energy
(3) light energy \rightarrow heat energy
(4) light energy \rightarrow chemical energy

25 Which of these pH numbers indicates the highest level of acidity?

- (1) 5 (3) 10
(2) 8 (4) 12

26 According to the Arrhenius theory, when a base dissolves in water it produces

- (1) CO_3^{2-} as the only negative ion in solution
(2) OH^- as the only negative ion in solution
(3) NH_4^+ as the only positive ion in solution
(4) H^+ as the only positive ion in solution

27 Which compound is an electrolyte?

- (1) $\text{C}_6\text{H}_{12}\text{O}_6$ (3) CaCl_2
(2) CH_3OH (4) CCl_4

28 Which equation represents a spontaneous nuclear decay?

- (1) $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
(2) $\text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
(3) ${}_{13}^{27}\text{Al} + {}_2^4\text{He} \rightarrow {}_{15}^{30}\text{P} + {}_0^1\text{n}$
(4) ${}_{38}^{90}\text{Sr} \rightarrow {}_{-1}^0\text{e} + {}_{39}^{90}\text{Y}$

29 The stability of an isotope is based on its

- (1) number of neutrons, only
(2) number of protons, only
(3) ratio of neutrons to protons
(4) ratio of electrons to protons

Note that questions 30 and 31 have only three choices.

30 As the temperature of a substance *decreases*, the average kinetic energy of its particles

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

31 When an atom of phosphorus becomes a phosphide ion (P^{3-}), the radius

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

Part B-1

Answer all questions in this part.

Directions (32–50): 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.

32 The data table below represents the properties determined by the analysis of substances A, B, C, and D.

Substance	Melting Point (°C)	Boiling Point (°C)	Conductivity
A	−80	−20	none
B	20	190	none
C	320	770	as solid
D	800	1250	in solution

Which substance is an ionic compound?

- | | |
|-------|-------|
| (1) A | (3) C |
| (2) B | (4) D |

33 What is the total number of electrons in a Cr^{3+} ion?

- | | |
|--------|--------|
| (1) 18 | (3) 24 |
| (2) 21 | (4) 27 |

34 As the atoms of the Group 17 elements in the ground state are considered from top to bottom, each successive element has

- (1) the same number of valence electrons and similar chemical properties
- (2) the same number of valence electrons and identical chemical properties
- (3) an increasing number of valence electrons and similar chemical properties
- (4) an increasing number of valence electrons and identical chemical properties

35 Which solution when mixed with a drop of bromthymol blue will cause the indicator to change from blue to yellow?

- | | |
|-------------------------|----------------------------------|
| (1) 0.1 M HCl | (3) 0.1 M CH_3OH |
| (2) 0.1 M NH_3 | (4) 0.1 M NaOH |

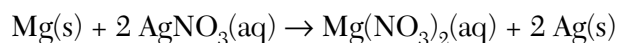
36 What is the empirical formula of a compound with the molecular formula N_2O_4 ?

- | | |
|-------------------|----------------------------|
| (1) NO | (3) N_2O |
| (2) NO_2 | (4) N_2O_3 |

37 What is the correct Lewis electron-dot structure for the compound magnesium fluoride?

- | | |
|--|---|
| $\text{Mg} \begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array} \text{F} \begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array}$ | $\left[\begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array} \text{F} \right]^- \text{Mg}^{2+} \left[\begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array} \text{F} \right]^-$ |
| (1) | (3) |
| $\text{Mg}^+ \left[\begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array} \text{F} \right]^-$ | $\begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array} \text{F} \begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array} \text{Mg} \begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array} \text{F} \begin{array}{c} \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \\ \cdot\cdot \end{array}$ |
| (2) | (4) |

38 Given the reaction:



Which type of reaction is represented?

- | | |
|------------------------|-------------------|
| (1) single replacement | (3) synthesis |
| (2) double replacement | (4) decomposition |

39 Which equation shows conservation of both mass and charge?

- (1) $\text{Cl}_2 + \text{Br}^- \rightarrow \text{Cl}^- + \text{Br}_2$
- (2) $\text{Cu} + 2 \text{Ag}^+ \rightarrow \text{Cu}^{2+} + \text{Ag}$
- (3) $\text{Zn} + \text{Cr}^{3+} \rightarrow \text{Zn}^{2+} + \text{Cr}$
- (4) $\text{Ni} + \text{Pb}^{2+} \rightarrow \text{Ni}^{2+} + \text{Pb}$

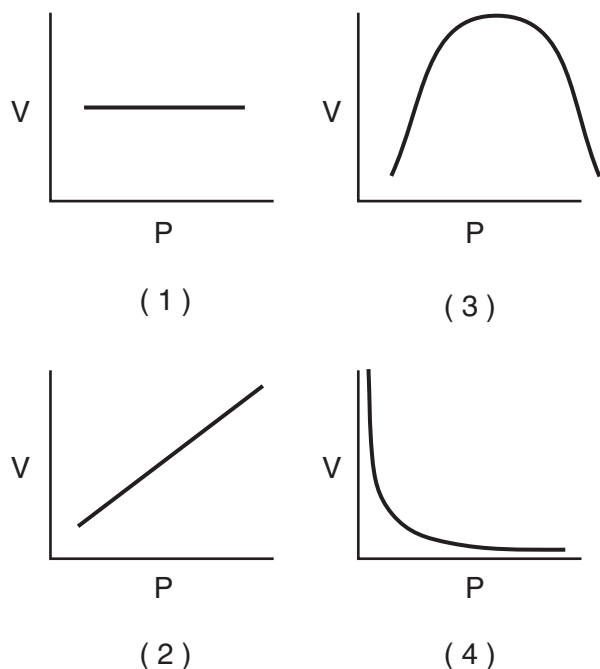
40 The volume of a gas is 4.00 liters at 293 K and constant pressure. For the volume of the gas to become 3.00 liters, the Kelvin temperature must be equal to

- (1) $\frac{3.00 \times 293}{4.00}$
- (2) $\frac{4.00 \times 293}{3.00}$
- (3) $\frac{3.00 \times 4.00}{293}$
- (4) $\frac{293}{3.00 \times 4.00}$

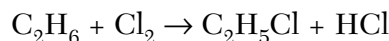
41 What is the molarity of a solution containing 20 grams of NaOH in 500 milliliters of solution?

- (1) 1 M
- (2) 2 M
- (3) 0.04 M
- (4) 0.5 M

42 Which graph best represents the pressure-volume relationship for an ideal gas at constant temperature?



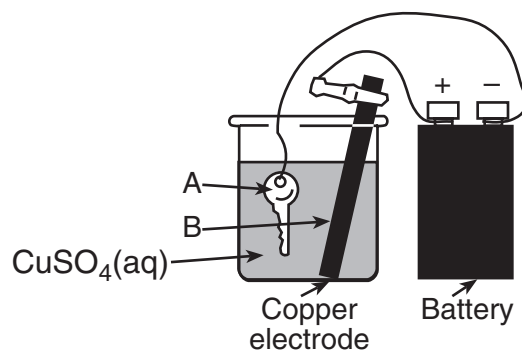
43 Given the equation:



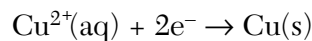
This reaction is best described as

- (1) addition involving a saturated hydrocarbon
- (2) addition involving an unsaturated hydrocarbon
- (3) substitution involving a saturated hydrocarbon
- (4) substitution involving an unsaturated hydrocarbon

44 The diagram below shows a key being plated with copper in an electrolytic cell.



Given the reduction reaction for this cell:



This reduction occurs at

- (1) A, which is the anode
- (2) A, which is the cathode
- (3) B, which is the anode
- (4) B, which is the cathode

45 A student neutralized 16.4 milliliters of HCl by adding 12.7 milliliters of 0.620 M KOH. What was the molarity of the HCl acid?

- (1) 0.168 M
- (2) 0.480 M
- (3) 0.620 M
- (4) 0.801 M

46 Nuclear fusion *differs* from nuclear fission because nuclear fusion reactions

- (1) form heavier isotopes from lighter isotopes
- (2) form lighter isotopes from heavier isotopes
- (3) convert mass to energy
- (4) convert energy to mass

47 After 32 days, 5 milligrams of an 80-milligram sample of a radioactive isotope remains unchanged. What is the half-life of this element?

- (1) 8 days (3) 16 days
(2) 2 days (4) 4 days

48 Which electron configuration represents an atom of chlorine in an excited state?

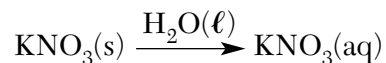
- (1) 2-8-7 (3) 2-8-6-1
(2) 2-8-8 (4) 2-8-7-1

Note that questions 49 and 50 have only three choices.

49 As each successive element in Group 15 of the Periodic Table is considered in order of increasing atomic number, the atomic radius

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

50 Given the equation:



As $\text{H}_2\text{O}(\ell)$ is added to $\text{KNO}_3(\text{s})$ to form $\text{KNO}_3(\text{aq})$, the entropy of the system

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

Part B–2

Answer all questions in this part.

Directions (51–62): 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 unbalanced equation provided *in your answer booklet*.

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

52 *a* Using your balanced equation, show a correct numerical setup for calculating the total number of moles of $\text{H}_2\text{O}(\text{g})$ produced when 5.0 moles of $\text{O}_2(\text{g})$ are completely consumed. Use the space provided *in your answer booklet*. [1]

b Record your answer. [1]

Base your answers to questions 53 through 55 on the data table provided *in your answer booklet*.

53 *In your answer booklet*, record the electronegativity for the elements with atomic numbers 11 through 17. [1]

54 On the grid provided *in your answer booklet*, mark an appropriate scale on the axis labeled “Electronegativity.” [1]

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

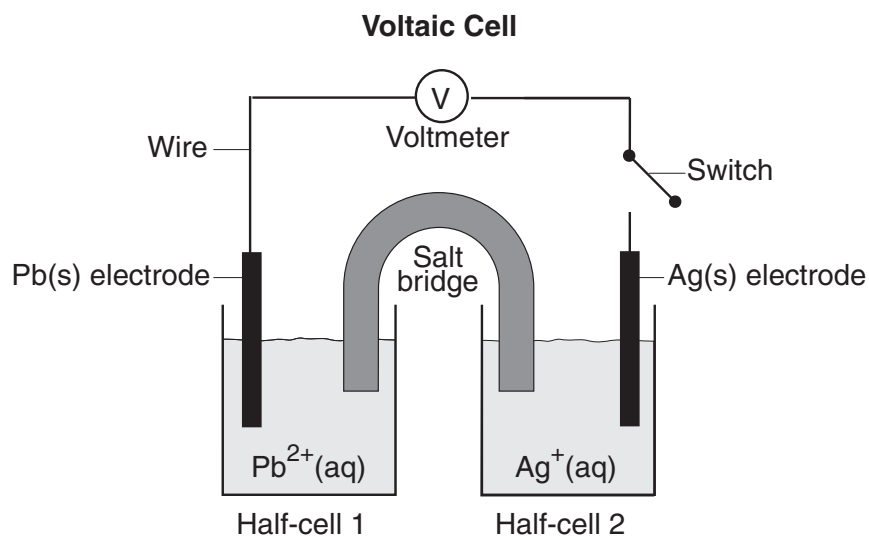
Example: 

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

A student uses 200 grams of water at a temperature of 60°C to prepare a saturated solution of potassium chloride, KCl.

- 56 Identify the solute in this solution. [1]
- 57 According to Reference Table G, how many grams of KCl must be used to create this saturated solution? [1]
- 58 This solution is cooled to 10°C and the excess KCl precipitates (settles out). The resulting solution is saturated at 10°C. How many grams of KCl precipitated out of the original solution? [1]
-

Base your answers to questions 59 through 61 on the diagram of the voltaic cell below.



- 59 When the switch is closed, in which half-cell does oxidation occur? [1]
- 60 When the switch is closed, state the direction that electrons will flow through the wire. [1]
- 61 *Based on the given equation*, write the balanced half-reaction that occurs in half-cell 1. [1]
-
- 62 In the space provided *in your answer booklet*, draw a Lewis electron-dot structure for an atom of phosphorus. [1]
-

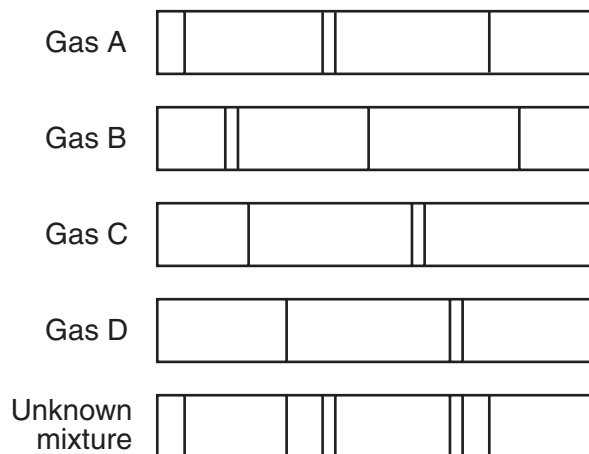
Part C

Answer all questions in this part.

Directions (63–81): 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 63 and 64 on the information and the bright-line spectra represented below.

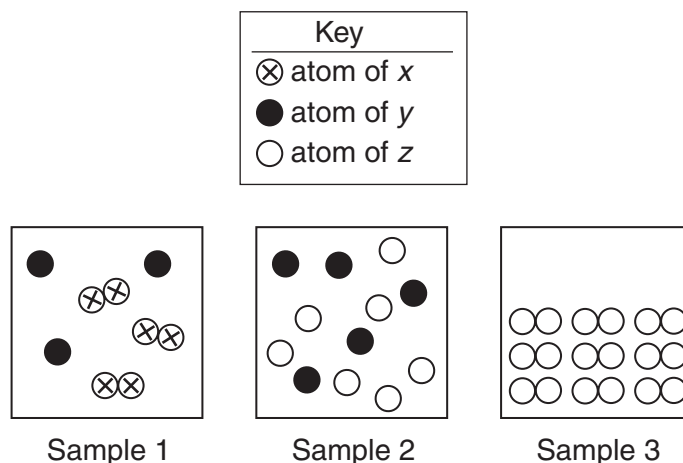
Many advertising signs depend on the production of light emissions from gas-filled glass tubes that are subjected to a high-voltage source. When light emissions are passed through a spectroscope, bright-line spectra are produced.



63 Identify the *two* gases in the unknown mixture. [2]

64 Explain the production of an emission spectrum in terms of the *energy states of an electron*. [1]

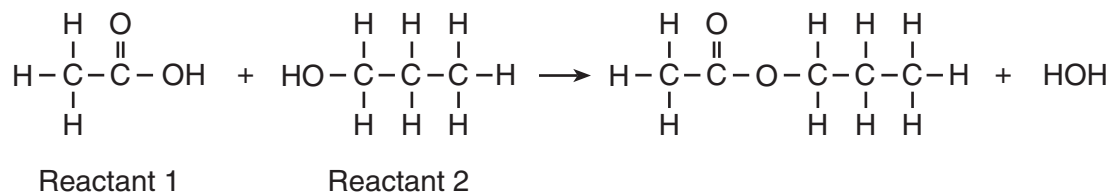
Base your answers to questions 65 through 67 on the particle diagrams below, which show atoms and/or molecules in three different samples of matter at STP.



- 65 Which sample represents a pure substance? [1]
- 66 When two atoms of *y* react with one atom of *z*, a compound forms. Using the number of atoms shown in sample 2, what is the maximum number of molecules of this compound that can be formed? [1]
- 67 Explain why ⊗⊗ does *not* represent a compound. [1]
-

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

Many artificial flavorings are prepared using the type of organic reaction shown below.



- 68 What is the name of this organic reaction? [1]
- 69 To what class of organic compounds does reactant 2 belong? [1]
- 70 In the space provided *in your answer booklet*, draw the structural formula of an isomer of reactant 2. [1]
-

Base your answers to questions 71 through 74 on the article below, the *Reference Tables for Physical Setting/Chemistry*, and your knowledge of chemistry.

Radioactivity at home

You may be surprised to learn that you do not need to visit a nuclear power plant or a hospital X-ray laboratory to find sources of radioactivity. They are all around us. In fact, it is likely that you'll find a few at home. Your front porch may incorporate cinder blocks or granite blocks. Both contain uranium. Walk through the front door, look up, and you'll see a smoke detector that owes its effectiveness to the constant source of alpha particle emissions from Americium-241. As long as the gases remain ionized within the shielded container, electricity flows, and all is calm. When smoke enters the chamber, it neutralizes the charges on these ions. In the absence of these ions, the circuit breaks and the alarm goes off.

Indicator lights on your appliances may use Krypton-85; electric blankets, promethium-147; and fluorescent lights, thorium-229. Even the food we eat is radioactive. The more potassium-rich the food source, the more potassium-40—a radioactive isotope that makes up about 0.01% of the natural supply of this mineral—is present. Thus, brazil nuts, peanuts, bananas, potatoes, and flour, all rich in potassium, are radiation sources.

—*Chem Matters*
April 2000

- 71 Write the equation for the alpha decay that occurs in a smoke detector containing Americium-241 (Am-241). [2]
- 72 How is the radioactive decay of Krypton-85 different from the radioactive decay of Americium-241? [1]
- 73 State one benefit or useful application of radioactivity *not* mentioned in this article. [1]
- 74 State one risk or danger associated with radioactivity. [1]
-

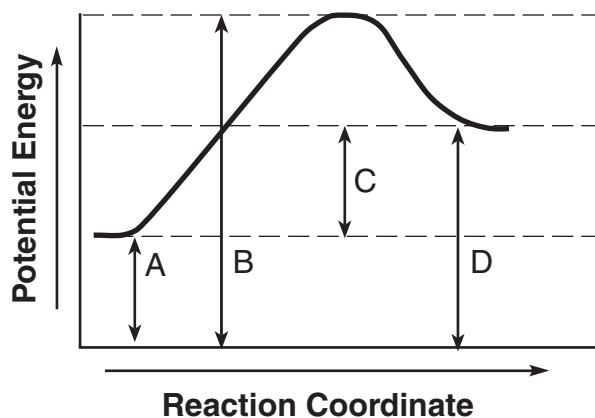
Base your answers to questions 75 and 76 on the information below.

Gypsum is a mineral that is used in the construction industry to make drywall (sheetrock). The chemical formula for this hydrated compound is $\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$. A hydrated compound contains water molecules within its crystalline structure. Gypsum contains 2 moles of water for each 1 mole of calcium sulfate.

- 75 What is the gram formula mass of $\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$? [1]
- 76 *a* In the space provided in *your answer booklet*, show a correct numerical setup for calculating the percent composition by mass of water in this compound. [1]
- b* Record your answer. [1]
-

Base your answers to questions 77 through 79 on the information and potential energy diagram below.

Chemical cold packs are often used to reduce swelling after an athletic injury. The diagram represents the potential energy changes when a cold pack is activated.



77 Which lettered interval on the diagram represents the potential energy of the products? [1]

78 Which lettered interval on the diagram represents the heat of reaction? [1]

79 Identify a reactant listed in Reference Table I that could be mixed with water for use in a chemical cold pack. [1]

Base your answers to questions 80 and 81 on the information below.

Calcium hydroxide is commonly known as agricultural lime and is used to adjust the soil pH. Before the lime was added to a field, the soil pH was 5. After the lime was added, the soil underwent a 100-fold decrease in hydronium ion concentration.

80 What is the new pH of the soil in the field? [1]

81 According to Reference Table F, calcium hydroxide is soluble in water. Identify another hydroxide compound that contains a Group 2 element and is also soluble in water. [1]

Tear Here

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING CHEMISTRY

Wednesday, January 28, 2004 — 9:15 a.m. to 12:15 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 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 Part A Score []

Part B-1

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