The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Tuesday, June 24, 2003 — 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 (1–35): 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 The atomic number of an atom is always equal to the number of its

(1) protons, only
(2) neutrons, only
(3) protons plus neutrons
(4) protons plus electrons

2 Which subatomic particle has no charge?

(1) alpha particle
(2) beta particle
(3) neutron
(4) electron

3 When the electrons of an excited atom return to a lower energy state, the energy emitted can result in the production of

(1) alpha particles
(2) isotopes
(3) protons
(4) spectra

4 The atomic mass of an element is calculated using the

(1) atomic number and the ratios of its naturally occurring isotopes
(2) atomic number and the half-lives of each of its isotopes
(3) masses and the ratios of its naturally occurring isotopes
(4) masses and the half-lives of each of its isotopes

5 The region that is the most probable location of an electron in an atom is

(1) the nucleus
(2) an orbital
(3) the excited state
(4) an ion

6 Which is a property of most nonmetallic solids?

(1) high thermal conductivity
(2) high electrical conductivity
(3) brittleness
(4) malleability

7 Alpha particles are emitted during the radioactive decay of

(1) carbon-14
(2) neon-19
(3) calcium-37
(4) radon-222

8 Which is an empirical formula?

(1) P_2O_5
(2) P_4O_6
(3) C_2H_4
(4) C_3H_6

9 Which substance can be decomposed by a chemical change?

(1) Co
(2) CO
(3) Cr
(4) Cu

10 The percent by mass of calcium in the compound calcium sulfate ($CaSO_4$) is approximately

(1) 15%
(2) 29%
(3) 34%
(4) 47%

11 What is represented by the dots in a Lewis electron-dot diagram of an atom of an element in Period 2 of the Periodic Table?

(1) the number of neutrons in the atom
(2) the number of protons in the atom
(3) the number of valence electrons in the atom
(4) the total number of electrons in the atom

12 Which type of chemical bond is formed between two atoms of bromine?

(1) metallic
(2) hydrogen
(3) ionic
(4) covalent

13 Which of these formulas contains the most polar bond?

(1) H–Br
(2) H–Cl
(3) H–F
(4) H–I

14 According to Table *F*, which of these salts is *least* soluble in water?

(1) LiCl
(2) RbCl
(3) $FeCl_2$
(4) $PbCl_2$

15 Which of these terms refers to matter that could be heterogeneous?

(1) element
(2) mixture
(3) compound
(4) solution

16 In which material are the particles arranged in a regular geometric pattern?

(1) $CO_2(g)$
(2) NaCl(aq)
(3) $H_2O(\ell)$
(4) $C_{12}H_{22}O_{11}(s)$

17 Which change is exothermic?

(1) freezing of water
(2) melting of iron
(3) vaporization of ethanol
(4) sublimation of iodine

18 Which type of change must occur to form a compound?

(1) chemical
(2) physical
(3) nuclear
(4) phase

19 Which formula correctly represents the composition of iron (III) oxide?

(1) FeO_3
(2) Fe_2O_3
(3) Fe_3O
(4) Fe_3O_2

20 Given the reaction:

$$PbCl_2(aq) + Na_2CrO_4(aq) \rightarrow$$

$$PbCrO_4(s) + 2\ NaCl(aq)$$

What is the total number of moles of NaCl formed when 2 moles of Na_2CrO_4 react completely?

(1) 1 mole
(2) 2 moles
(3) 3 moles
(4) 4 moles

21 Which hydrocarbon is saturated?

(1) propene
(2) ethyne
(3) butene
(4) heptane

22 Which statement correctly describes an endothermic chemical reaction?

(1) The products have higher potential energy than the reactants, and the ΔH is negative.
(2) The products have higher potential energy than the reactants, and the ΔH is positive.
(3) The products have lower potential energy than the reactants, and the ΔH is negative.
(4) The products have lower potential energy than the reactants, and the ΔH is positive.

23 At standard pressure when NaCl is added to water, the solution will have a

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

24 Which element has atoms that can form single, double, and triple covalent bonds with other atoms of the same element?

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

25 Which compound is an isomer of pentane?

(1) butane
(2) propane
(3) methyl butane
(4) methyl propane

26 In which substance does chlorine have an oxidation number of +1?

(1) Cl_2
(2) HCl
(3) HClO
(4) $HClO_2$

27 Which statement is true for any electrochemical cell?

(1) Oxidation occurs at the anode, only.
(2) Reduction occurs at the anode, only.
(3) Oxidation occurs at both the anode and the cathode.
(4) Reduction occurs at both the anode and the cathode.

28 Given the equation:

$$2\ Al + 3\ Cu^{2+} \rightarrow 2\ Al^{3+} + 3\ Cu$$

The reduction half-reaction is

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

29 Which 0.1 M solution contains an electrolyte?

(1) $C_6H_{12}O_6(aq)$
(2) $CH_3COOH(aq)$
(3) $CH_3OH(aq)$
(4) $CH_3OCH_3(aq)$

30 Which equation represents a neutralization reaction?

(1) $Na_2CO_3 + CaCl_2 \rightarrow 2\ NaCl + CaCO_3$
(2) $Ni(NO_3)_2 + H_2S \rightarrow NiS + 2\ HNO_3$
(3) $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$
(4) $H_2SO_4 + Mg(OH)_2 \rightarrow MgSO_4 + 2\ H_2O$

31 An Arrhenius acid has

(1) only hydroxide ions in solution
(2) only hydrogen ions in solution
(3) hydrogen ions as the only positive ions in solution
(4) hydrogen ions as the only negative ions in solution

32 Which type of radioactive emission has a positive charge and weak penetrating power?

(1) alpha particle
(2) beta particle
(3) gamma ray
(4) neutron

33 Which substance contains metallic bonds?

(1) $Hg(\ell)$
(2) $H_2O(\ell)$
(3) NaCl(s)
(4) $C_6H_{12}O_6(s)$

34 What is the name of the process in which the nucleus of an atom of one element is changed into the nucleus of an atom of a different element?

(1) decomposition
(2) transmutation
(3) substitution
(4) reduction

Note that question 35 has only three choices.

35 A catalyst is added to a system at equilibrium. If the temperature remains constant, the activation energy of the forward reaction

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

Part B–1

Answer all questions in this part.

Directions (36–50): 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*.

36 The nucleus of an atom of K-42 contains

(1) 19 protons and 23 neutrons
(2) 19 protons and 42 neutrons
(3) 20 protons and 19 neutrons
(4) 23 protons and 19 neutrons

37 What is the total number of electrons in a Cu^+ ion?

(1) 28
(2) 29
(3) 30
(4) 36

38 Which list of elements is arranged in order of increasing atomic radii?

(1) Li, Be, B, C
(2) Sr, Ca, Mg, Be
(3) Sc, Ti, V, Cr
(4) F, Cl, Br, I

39 Which isotope is most commonly used in the radioactive dating of the remains of organic materials?

(1) ^{14}C
(2) ^{16}N
(3) ^{32}P
(4) ^{37}K

40 According to Reference Table *H*, what is the vapor pressure of propanone at 45°C?

(1) 22 kPa
(2) 33 kPa
(3) 70. kPa
(4) 98 kPa

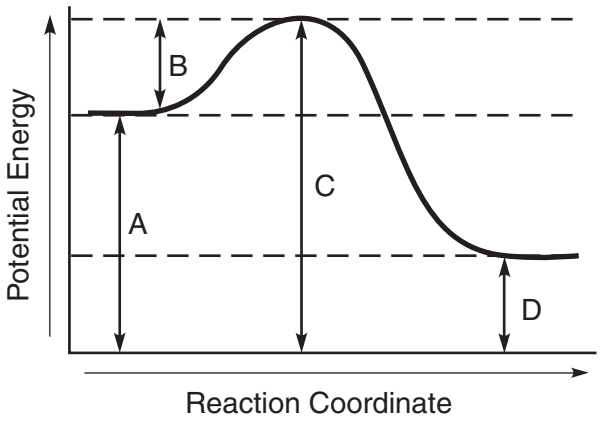
41 The freezing point of bromine is

(1) 539°C
(2) –539°C
(3) 7°C
(4) –7°C

42 Hexane (C_6H_{14}) and water do *not* form a solution. Which statement explains this phenomenon?

(1) Hexane is polar and water is nonpolar.
(2) Hexane is ionic and water is polar.
(3) Hexane is nonpolar and water is polar.
(4) Hexane is nonpolar and water is ionic.

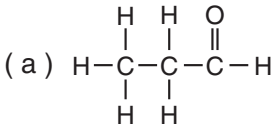
43 The potential energy diagram below represents a reaction.

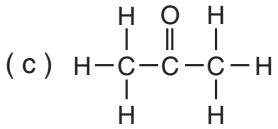


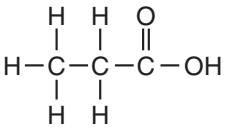
Which arrow represents the activation energy of the forward reaction?

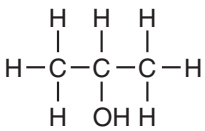
(1) *A*
(2) *B*
(3) *C*
(4) *D*

44 Given the formulas of four organic compounds:

(a)


(c)


(b)


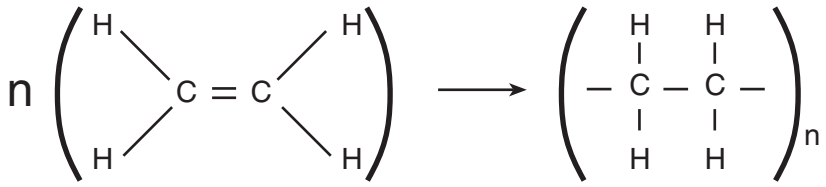
(d)


Which pair below contains an alcohol and an acid?

(1) *a* and *b*
(2) *a* and *c*
(3) *b* and *d*
(4) *c* and *d*

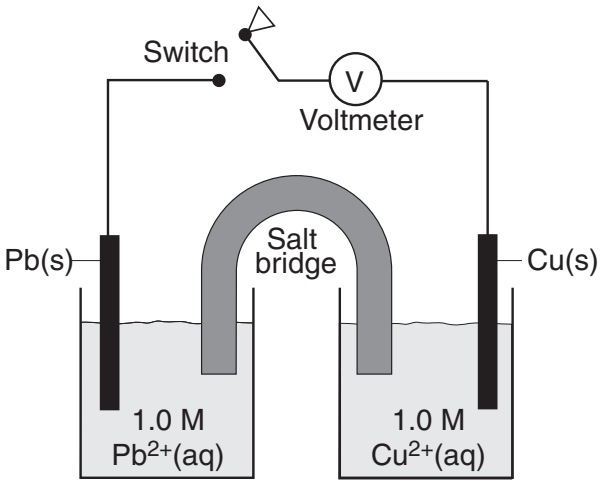
45 Which type of reaction is represented by the equation below?

Note: n and n are very large numbers equal to about 2000.



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

46 A diagram of a chemical cell and an equation are shown below.



$Pb(s) + Cu^{2+}(aq) \longrightarrow Pb^{2+}(aq) + Cu(s)$

When the switch is closed, electrons will flow from

(1) the Pb(s) to the Cu(s)
(2) the Cu(s) to the Pb(s)
(3) the $Pb^{2+}(aq)$ to the Pb(s)
(4) the $Cu^{2+}(aq)$ to the Cu(s)

47 Which ion has the same electron configuration as an atom of He?

(1) H^-
(2) O^{2-}
(3) Na^+
(4) Ca^{2+}

48 A student was given four unknown solutions. Each solution was checked for conductivity and tested with phenolphthalein. The results are shown in the data table below.

Solution	Conductivity	Color with Phenolphthalein
A	Good	Colorless
B	Poor	Colorless
C	Good	Pink
D	Poor	Pink

Based on the data table, which unknown solution could be 0.1 M NaOH?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

49 In the reaction $^{239}_{93}Np \rightarrow {}^{239}_{94}Pu + X$, what does *X* represent?

(1) a neutron
(2) a proton
(3) an alpha particle
(4) a beta particle

Note that question 50 has only three choices.

50 As carbon dioxide sublimes, its entropy

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

Part B–2

Answer all questions in this part.

Directions (51–63): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry.*

Base your answers to questions 51 and 52 on the electron configuration table shown below.

Element	Electron Configuration
X	2–8–8–2
Y	2–8–7–3
Z	2–8–8

51 What is the total number of valence electrons in an atom of electron configuration *X*? [1]

52 Which electron configuration represents the excited state of a calcium atom? [1]

Base your answers to questions 53 and 54 on the information below.

Given: Samples of Na, Ar, As, Rb

53 Which *two* of the given elements have the most similar chemical properties? [1]

54 Explain your answer in terms of the Periodic Table of the Elements. [1]

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

Diethyl ether is widely used as a solvent.

55 In the space provided *in your answer booklet,* draw the structural formula for diethyl ether. [1]

56 In the space provided *in your answer booklet,* draw the structural formula for an alcohol that is an isomer of diethyl ether. [1]

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

Two chemistry students each combine a different metal with hydrochloric acid. Student *A* uses zinc, and hydrogen gas is readily produced. Student *B* uses copper, and no hydrogen gas is produced.

57 State one chemical reason for the different results of students *A* and *B*. [1]

58 Using Reference Table *J*, identify another metal that will react with hydrochloric acid to yield hydrogen gas. [1]

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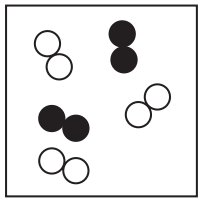
59 Given the reaction between two different elements in the gaseous state:

Box *A* below represents a mixture of the two reactants before the reaction occurs. The product of this reaction is a gas. In Box *B* provided *in your answer booklet*, draw the system after the reaction has gone to completion, based on the Law of Conservation of Matter. [2]



Box A

System Before Reaction

60 As a neutral sulfur atom gains two electrons, what happens to the radius of the atom? [1]

61 After a neutral sulfur atom gains two electrons, what is the resulting charge of the ion? [1]

62 *a* In the space provided *in your answer booklet*, calculate the heat released when 25.0 grams of water freezes at 0°C. Show all work. [1]

b Record your answer with an appropriate unit. [1]

63 State one difference between voltaic cells and electrolytic cells. Include information about *both* types of cells in your answer. [1]

Part C

Answer all questions in this part.

Directions (64–79): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry.*

Base your answers to questions 64 and 65 on the diagram below, which shows a piston confining a gas in a cylinder.

64 Using the set of axes provided *in your answer booklet,* sketch the general relationship between the pressure and the volume of an ideal gas at constant temperature. [1]

65 The gas volume in the cylinder is 6.2 milliliters and its pressure is 1.4 atmospheres. The piston is then pushed in until the gas volume is 3.1 milliliters while the temperature remains constant.

a In the space provided *in your answer booklet,* calculate the pressure, in atmospheres, after the change in volume. Show all work. [1]

b Record your answer. [1]

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66 A student recorded the following buret readings during a titration of a base with an acid:

	Standard 0.100 M HCl	Unknown KOH
Initial reading	9.08 mL	0.55 mL
Final reading	19.09 mL	5.56 mL

a In the space provided *in your answer booklet,* calculate the molarity of the KOH. Show all work. [1]

b Record your answer to the correct number of significant figures. [1]

67 John Dalton was an English scientist who proposed that atoms were hard, indivisible spheres. In the modern model, the atom has a different internal structure.

a Identify one experiment that led scientists to develop the modern model of the atom. [1]

b Describe this experiment. [1]

c State one conclusion about the internal structure of the atom, based on this experiment. [1]

Base your answers to questions 68 through 73 on the information below and on your knowledge of chemistry.

Nuclear Waste Storage Plan for Yucca Mountain

In 1978, the U.S. Department of Energy began a study of Yucca Mountain which is located 90 miles from Las Vegas, Nevada. The study was to determine if Yucca Mountain would be suitable for a long-term burial site for high-level radioactive waste. A three-dimensional (3-D) computer scale model of the site was used to simulate the Yucca Mountain area. The computer model study for Yucca Mountain included such variables as: the possibility of earthquakes, predicted water flow through the mountain, increased rainfall due to climate changes, radioactive leakage from the waste containers, and increased temperatures from the buried waste within the containers.

The containers that will be used to store the radioactive waste are designed to last 10,000 years. Within the 10,000-year time period, cesium and strontium, the most powerful radioactive emitters, would have decayed. Other isotopes found in the waste would decay more slowly, but are not powerful radioactive emitters.

In 1998, scientists discovered that the compressed volcanic ash making up Yucca Mountain was full of cracks. Because of the arid climate, scientists assumed that rainwater would move through the cracks at a slow rate. However, when radioactive chlorine-36 was found in rock samples at levels halfway through the mountain, it was clear that rainwater had moved quickly down through Yucca Mountain. It was only 50 years earlier when this chlorine-36 isotope had contaminated rainwater during atmospheric testing of the atom bomb.

Some opponents of the Yucca Mountain plan believe that the uncertainties related to the many variables of the computer model result in limited reliability of its predictions. However, advocates of the plan believe it is safer to replace the numerous existing radioactive burial sites around the United States with the one site at Yucca Mountain. Other opponents of the plan believe that transporting the radioactive waste to Yucca Mountain from the existing 131 burial sites creates too much danger to the United States. In 2002, after years of political debate, a final legislative vote approved the development of Yucca Mountain to replace the existing 131 burial sites.

68 State one uncertainty in the computer model that limits the reliability of this computer model. [1]

69 Scientists assume that a manufacturing defect would cause at least one of the waste containers stored in the Yucca Mountain repository to leak within the first 1,000 years. State one possible effect such a leak could have on the environment near Yucca Mountain. [1]

70 State one risk associated with leaving radioactive waste in the 131 sites around the country where it is presently stored. [1]

71 If a sample of cesium-137 is stored in a waste container in Yucca Mountain, how much time must elapse until only $\frac{1}{32}$ of the original sample remains unchanged? [1]

72 The information states "Within the 10,000-year time period, cesium and strontium, the most powerful radioactive emitters, would have decayed." Use information from Reference Table *N* to support this statement. [1]

73 Why is water flow a crucial factor in deciding whether Yucca Mountain is a suitable burial site? [1]

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

A student wishes to investigate how the reaction rate changes with a change in concentration of HCl(aq).

Given the reaction: $Zn(s) + HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$

74 Identify the independent variable in this investigation. [1]

75 Identify one other variable that might affect the rate and should be held constant during this investigation. [1]

76 Describe the effect of increasing the concentration of HCl(aq) on the reaction rate and justify your response in terms of *collision theory.* [1]

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

A truck carrying concentrated nitric acid overturns and spills its contents. The acid drains into a nearby pond. The pH of the pond water was 8.0 before the spill. After the spill, the pond water is 1,000 times more acidic.

77 Name an ion in the pond water that has increased in concentration due to this spill. [1]

78 What is the new pH of the pond water after the spill? [1]

79 What color would bromthymol blue be at this new pH? [1]

Tear Here

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Tuesday, June 24, 2003 — 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	13	25 .....
2	14	26 .....
3	15	27 .....
4	16	28 .....
5	17	29 .....
6	18	30 .....
7	19	31 .....
8	20	32 .....
9	21	33 .....
10	22	34 .....
11	23	35 .....
12	24	

Part A Score

Part B–1

36	44 .....
37	45 .....
38	46 .....
39	47 .....
40	48 .....
41	49 .....
42	50 .....
43	

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