The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Thursday, August 13, 2009 — 12:30 to 3:30 p.m., only

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

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

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

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

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

Notice. . .

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

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

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

Part A

Answer all questions in this part.

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

1 Which particle has the *least* mass?

(1) $_2^4He$ (3) $_0^1n$

(2) $_1^1H$ (4) $_{-1}^0e$

2 What information is necessary to determine the atomic mass of the element chlorine?

(1) the atomic mass of each artificially produced isotope of chlorine, only
(2) the relative abundance of each naturally occurring isotope of chlorine, only
(3) the atomic mass and the relative abundance of each naturally occurring isotope of chlorine
(4) the atomic mass and the relative abundance of each naturally occurring and artificially produced isotope of chlorine

3 In an atom of argon-40, the number of protons

(1) equals the number of electrons
(2) equals the number of neutrons
(3) is less than the number of electrons
(4) is greater than the number of electrons

4 An electron in a sodium atom moves from the third shell to the fourth shell. This change is a result of the atom

(1) absorbing energy   (3) gaining an electron
(2) releasing energy   (4) losing an electron

5 Which statement describes oxygen gas, $O_2(g)$, and ozone gas, $O_3(g)$?

(1) They have different molecular structures, only.
(2) They have different properties, only.
(3) They have different molecular structures and different properties.
(4) They have the same molecular structure and the same properties.

6 Which statement describes a chemical property of bromine?

(1) Bromine is soluble in water.
(2) Bromine has a reddish-brown color.
(3) Bromine combines with aluminum to produce $AlBr_3$.
(4) Bromine changes from a liquid to a gas at 332 K and 1 atm.

7 An atom of aluminum in the ground state and an atom of gallium in the ground state have the same

(1) mass
(2) electronegativity
(3) total number of protons
(4) total number of valence electrons

8 Which type of matter is composed of two or more elements that are chemically combined in a fixed proportion?

(1) solution
(2) compound
(3) homogeneous mixture
(4) heterogeneous mixture

9 Which type of substance can conduct electricity in the liquid phase but *not* in the solid phase?

(1) ionic compound
(2) molecular compound
(3) metallic element
(4) nonmetallic element

10 Why is a molecule of CO_2 nonpolar even though the bonds between the carbon atom and the oxygen atoms are polar?

(1) The shape of the CO_2 molecule is symmetrical.
(2) The shape of the CO_2 molecule is asymmetrical.
(3) The CO_2 molecule has a deficiency of electrons.
(4) The CO_2 molecule has an excess of electrons.

11 Which formula represents a molecular compound?

(1) HI   (3) KCl
(2) KI   (4) LiCl

12 Which element has the greatest density at STP?

(1) scandium   (3) silicon
(2) selenium   (4) sodium

13 Particles are arranged in a crystal structure in a sample of

(1) $H_2(g)$ (3) $Ar(g)$
(2) $Br_2(\ell)$ (4) $Ag(s)$

14 The relatively high boiling point of water is due to water having

(1) hydrogen bonding
(2) metallic bonding
(3) nonpolar covalent bonding
(4) strong ionic bonding

15 Matter is classified as a

(1) substance, only
(2) substance or as a mixture of substances
(3) homogenous mixture, only
(4) homogenous mixture or as a heterogeneous mixture

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

(1) ammonia   (3) propanol
(2) copper   (4) water

17 A beaker contains both alcohol and water. These liquids can be separated by distillation because the liquids have different

(1) boiling points   (3) particle sizes
(2) densities   (4) solubilities

18 Which term is defined as a measure of the average kinetic energy of the particles in a sample of matter?

(1) activation energy   (3) temperature
(2) potential energy   (4) entropy

19 How do the boiling point and freezing point of a solution of water and calcium chloride at standard pressure compare to the boiling point and freezing point of water at standard pressure?

(1) Both the freezing point and boiling point of the solution are higher.
(2) Both the freezing point and boiling point of the solution are lower.
(3) The freezing point of the solution is higher and the boiling point of the solution is lower.
(4) The freezing point of the solution is lower and the boiling point of the solution is higher.

20 Under which conditions of temperature and pressure does a sample of neon behave most like an ideal gas?

(1) 100 K and 0.25 atm
(2) 100 K and 25 atm
(3) 400 K and 0.25 atm
(4) 400 K and 25 atm

21 According to the kinetic molecular theory, which statement describes the particles in a sample of an ideal gas?

(1) The force of attraction between the gas particles is strong.
(2) The motion of the gas particles is random and straight-line.
(3) The collisions between the gas particles cannot result in a transfer of energy between the particles.
(4) The separation between the gas particles is smaller than the size of the gas particles themselves.

22 The activation energy of a chemical reaction can be *decreased* by the addition of

(1) a catalyst   (3) electrical energy
(2) an indicator   (4) thermal energy

23 A straight-chain hydrocarbon that has only one double bond in each molecule has the general formula

(1) C_nH_{2n-6} (3) C_nH_{2n}
(2) C_nH_{2n-2} (4) C_nH_{2n+2}

24 Why can an increase in temperature lead to more effective collisions between reactant particles and an increase in the rate of a chemical reaction?

(1) The activation energy of the reaction increases.
(2) The activation energy of the reaction decreases.
(3) The number of molecules with sufficient energy to react increases.
(4) The number of molecules with sufficient energy to react decreases.

25 Which reaction results in the production of soap?

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

26 Which substance is always a product when an Arrhenius acid in an aqueous solution reacts with an Arrhenius base in an aqueous solution?

(1) HBr
(2) H_2O
(3) KBr
(4) KOH

27 Which substance is an electrolyte?

(1) CCl_4
(2) C_2H_6
(3) HCl
(4) H_2O

28 One acid-base theory defines a base as an

(1) H^+ donor
(2) H^+ acceptor
(3) H donor
(4) H acceptor

29 A change in the nucleus of an atom that converts the atom from one element to another element is called

(1) combustion
(2) neutralization
(3) polymerization
(4) transmutation

30 Which particle is emitted from a hydrogen-3 nucleus when it undergoes radioactive decay?

(1) α
(2) β^-
(3) β^+
(4) γ

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 Which electron configuration represents an excited state for a potassium atom?

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

32 A sample of an element is malleable and can conduct electricity. This element could be

(1) H   (3) S
(2) He   (4) Sn

33 Which general trend is demonstrated by the Group 17 elements as they are considered in order from top to bottom on the Periodic Table?

(1) a decrease in atomic radius
(2) a decrease in electronegativity
(3) an increase in first ionization energy
(4) an increase in nonmetallic behavior

34 Which element is a liquid at 758 K and standard pressure?

(1) gold   (3) platinum
(2) silver   (4) thallium

35 Which equation represents a decomposition reaction?

(1) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
(2) $Cu(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + Cu(NO_3)_2(aq)$
(3) $2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$
(4) $KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(\ell)$

36 A compound has the empirical formula CH_2O and a gram-formula mass of 60. grams per mole. What is the molecular formula of this compound?

(1) CH_2O (3) C_3H_8O
(2) $C_2H_4O_2$ (4) $C_4H_8O_4$

37 Which formula represents strontium phosphate?

(1) $SrPO_4$ (3) $Sr_2(PO_4)_3$
(2) Sr_3PO_8 (4) $Sr_3(PO_4)_2$

38 Which Lewis electron-dot diagram represents calcium oxide?

39 Which statement describes the transfer of heat energy that occurs when an ice cube is added to an insulated container with 100 milliliters of water at 25°C?

(1) Both the ice cube and the water lose heat energy.
(2) Both the ice cube and the water gain heat energy.
(3) The ice cube gains heat energy and the water loses heat energy.
(4) The ice cube loses heat energy and the water gains heat energy.

40 What is the mass of NH_4Cl that must dissolve in 200. grams of water at 50.°C to make a saturated solution?

(1) 26 g   (3) 84 g
(2) 42 g   (4) 104 g

41 Given the bright-line spectra of three elements and the spectrum of a mixture formed from at least two of these elements:

Bright-Line Spectra

Element D

Element E

Element G

Mixture

750 nm   360 nm
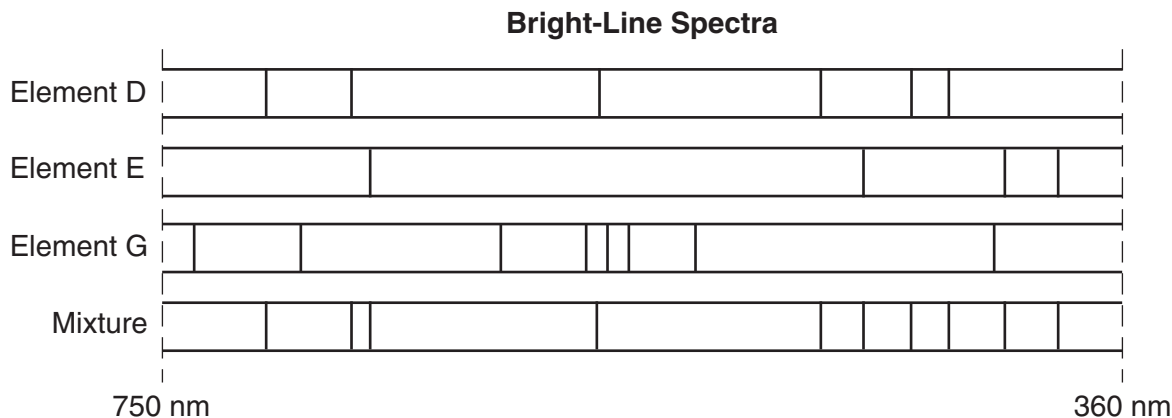
Which elements are present in this mixture?

(1) *E* and *D*, only
(2) *E* and *G*, only
(3) *D* and *G*, only
(4) *D*, *E*, and *G*

42 Given the balanced particle-diagram equation:

| Key |
| --- |
| ◯ = an atom of an element |
| ● = an atom of a different element |
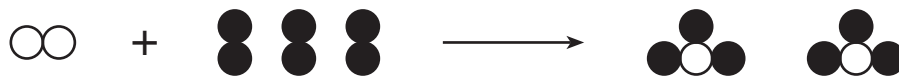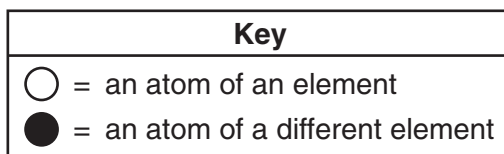
Which statement describes the type of change and the chemical properties of the product and reactants?

(1) The equation represents a physical change, with the product and reactants having different chemical properties.
(2) The equation represents a physical change, with the product and reactants having identical chemical properties.
(3) The equation represents a chemical change, with the product and reactants having different chemical properties.
(4) The equation represents a chemical change, with the product and reactants having identical chemical properties.
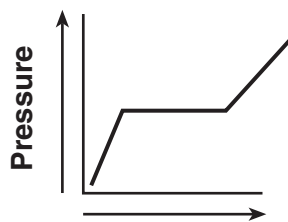
43 Which quantity of heat is equal to 200. joules?

(1) 20.0 kJ   (3) 0.200 kJ
(2) 2.00 kJ   (4) 0.0200 kJ

44 Which graph represents the relationship between pressure and volume for a sample of an ideal gas at constant temperature?
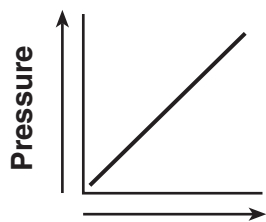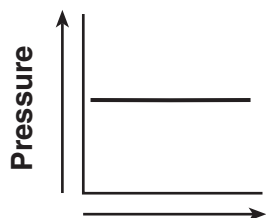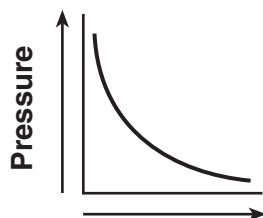
45 The entropy of a sample of H_2O increases as the sample changes from a

(1) gas to a liquid   (3) liquid to a gas
(2) gas to a solid   (4) liquid to a solid
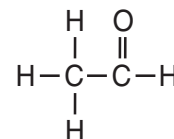
46 Ethanol and dimethyl ether have different chemical and physical properties because they have different

(1) functional groups
(2) molecular masses
(3) numbers of covalent bonds
(4) percent compositions by mass

47 Which formula represents an unsaturated hydrocarbon?
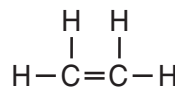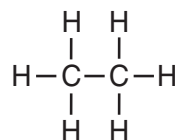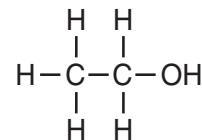
48 What is the oxidation state of nitrogen in the compound NH_4Br?

(1) –1   (3) –3
(2) +2   (4) +4

49 A student completes a titration by adding 12.0 milliliters of NaOH(aq) of unknown concentration to 16.0 milliliters of 0.15 M HCl(aq). What is the molar concentration of the NaOH(aq)?

(1) 0.11 M   (3) 1.1 M
(2) 0.20 M   (4) 5.0 M

50 What is the half-life of a radioisotope if 25.0 grams of an original 200.-gram sample of the isotope remains unchanged after 11.46 days?

(1) 2.87 d   (3) 11.46 d
(2) 3.82 d   (4) 34.38 d

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.*

51 Identify the element in Period 3 of the Periodic Table that reacts with oxygen to form an ionic compound represented by the formula X_2O. [1]

52 Given the balanced equation representing a reaction:

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

Determine the total number of moles of oxygen that react completely with 8.0 moles of C_2H_6. [1]

53 On the potential energy diagram *in your answer booklet*, draw an arrow to represent the activation energy of the forward reaction. [1]

54 Describe the electrons in an atom of carbon in the ground state. Your response must include:
  • the charge of an electron [1]
  • the location of electrons based on the wave-mechanical model [1]
  • the total number of electrons in a carbon atom [1]

55 Determine the mass of 5.20 moles of C_6H_{12} (gram-formula mass = 84.2 grams/mole). [1]

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

A 1.0-gram strip of zinc is reacted with hydrochloric acid in a test tube. The unbalanced equation below represents the reaction.

$$Zn(s) + HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$
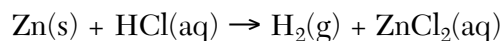
56 Balance the equation *in your answer booklet* for the reaction of zinc and hydrochloric acid, using the smallest whole-number coefficients. [1]

57 Explain, using information from Reference Table *F*, why the symbol (aq) is used to describe the product $ZnCl_2$. [1]

58 Explain, in terms of collision theory, why using 1.0 gram of powdered zinc, instead of the 1.0-gram strip of zinc, would have increased the rate of the reaction. [1]

Base your answers to questions 59 through 63 on the information below.

Bond energy is the amount of energy required to break a chemical bond. The table below gives a formula and the carbon-nitrogen bond energy for selected nitrogen compounds.

Selected Nitrogen Compounds

Compound	Formula	Carbon-Nitrogen Bond Energy (kJ/mol)
hydrogen cyanide	H—C≡N	890.
isocyanic acid	H—N=C=O	615
methanamine	H | H—C—N—H | | H H	293

59 Describe, in terms of electrons, the type of bonding between the carbon atom and the nitrogen atom in a molecule of methanamine.   [1]

60 Identify the noble gas that has atoms in the ground state with the same electron configuration as the nitrogen in a molecule of isocyanic acid.   [1]

61 State the relationship between the number of electrons in a carbon-nitrogen bond and carbon-nitrogen bond energy.   [1]

62 Explain, in terms of charge distribution, why a molecule of hydrogen cyanide is polar.   [1]

63 A 3.2-gram sample of air contains 0.000 74 gram of hydrogen cyanide. Determine the concentration, in parts per million, of the hydrogen cyanide in this sample.   [1]

Part C

Answer all questions in this part.

Directions (64–81): 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*.

64 Based on data collected during a laboratory investigation, a student determined an experimental value of 322 joules per gram for the heat of fusion of H_2O. Calculate the student's percent error. Your response must include a correct numerical setup and the calculated result. [2]

Base your answers to questions 65 through 67 on the information below.

A student used blue litmus paper and phenolphthalein paper as indicators to test the pH of distilled water and five aqueous household solutions. Then the student used a pH meter to measure the pH of the distilled water and each solution. The results of the student's work are recorded in the table below.

Testing Results

Liquid Tested	Color of Blue Litmus Paper	Color of Phenolphthalein Paper	Measured pH Value Using a pH Meter
2% milk	blue	colorless	6.4
distilled water	blue	colorless	7.0
household ammonia	blue	pink	11.5
lemon juice	red	colorless	2.3
tomato juice	red	colorless	4.3
vinegar	red	colorless	3.3

65 Identify the liquid tested that has the *lowest* hydronium ion concentration. [1]

66 Explain, in terms of the pH range for color change on Reference Table *M*, why litmus is *not* appropriate to differentiate the acidity levels of tomato juice and vinegar. [1]

67 Based on the measured pH values, identify the liquid tested that is 10 times more acidic than vinegar. [1]

Base your answers to questions 68 through 72 on the information below.

Biodiesel is an alternative fuel for vehicles that use petroleum diesel. Biodiesel is produced by reacting vegetable oil with CH_3OH. Methyl palmitate, $C_{15}H_{31}COOCH_3$, a compound found in biodiesel, is made from soybean oil. One reaction of methyl palmitate with oxygen is represented by the balanced equation below.

$$2C_{15}H_{31}COOCH_3 + 49O_2 \rightarrow 34CO_2 + 34H_2O + energy$$
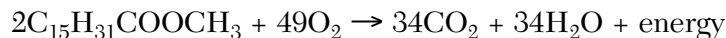
68 Write an IUPAC name for the compound that reacts with vegetable oil to produce biodiesel. [1]

69 Explain, in terms of *both* atoms and molecular structure, why there is no isomer of CH_3OH. [1]

70 Identify the class of organic compounds to which methyl palmitate belongs. [1]

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

72 State evidence from the balanced equation that indicates the reaction is exothermic. [1]

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

In a laboratory investigation, a student constructs a voltaic cell with iron and copper electrodes. Another student constructs a voltaic cell with zinc and iron electrodes. Testing the cells during operation enables the students to write the balanced ionic equations below.

Cell with iron and copper electrodes: $Cu^{2+}(aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+}(aq)$

Cell with zinc and iron electrodes: $Fe^{2+}(aq) + Zn(s) \rightarrow Fe(s) + Zn^{2+}(aq)$
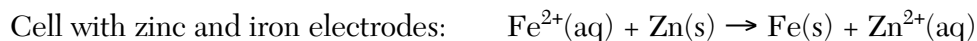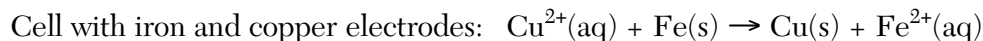
73 State evidence from the balanced equation for the cell with iron and copper electrodes that indicates the reaction in the cell is an oxidation-reduction reaction. [1]

74 Identify the particles transferred between Fe^{2+} and Zn during the reaction in the cell with zinc and iron electrodes. [1]

75 Write a balanced half-reaction equation for the reduction that takes place in the cell with zinc and iron electrodes. [1]

76 State the relative activity of the three metals used in these two voltaic cells. [1]

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

A method used by ancient Egyptians to obtain copper metal from copper(I) sulfide ore was heating the ore in the presence of air. Later, copper was mixed with tin to produce a useful alloy called bronze.

77 Calculate the density of a 129.5-gram sample of bronze that has a volume of 14.8 cubic centimeters. Your response must include a correct numerical setup and the calculated result. [2]

78 Convert the melting point of the metal obtained from copper(I) sulfide ore to degrees Celsius. [1]

79 A 133.8-gram sample of bronze was 10.3% tin by mass. Determine the total mass of tin in the sample. [1]

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

Scientists are investigating the production of energy using hydrogen-2 nuclei (deuterons) and hydrogen-3 nuclei (tritons). The balanced equation below represents one nuclear reaction between two deuterons.

$$_1^2H + _1^2H \rightarrow _2^3He + _0^1n + 5.23 \times 10^{-13} \text{ J}$$
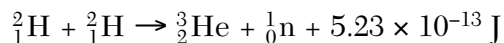
80 State, in terms of subatomic particles, how a deuteron differs from a triton. [1]

81 Identify the type of nuclear reaction represented by the equation. [1]

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Thursday, August 13, 2009 — 12:30 to 3:30 p.m., only

ANSWER SHEET

Student . . . . Sex: ☐ Male ☐ Female Grade . . . .

Teacher . . . . School . . . .

Record your answers to Part A and Part B–1 on this answer sheet.

Part A			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