

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

PHYSICAL SETTING CHEMISTRY

Thursday, January 28, 2010 — 1:15 to 4:15 p.m., only

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

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

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

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

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

Notice . . .

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

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

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

Part A

Answer all questions in this part.

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

- Which two particles have opposite charges?
 - an electron and a neutron
 - an electron and a proton
 - a proton and a neutron
 - a proton and a positron
- Which statement describes how an atom in the ground state becomes excited?
 - The atom absorbs energy, and one or more electrons move to a higher electron shell.
 - The atom absorbs energy, and one or more electrons move to a lower electron shell.
 - The atom releases energy, and one or more electrons move to a higher electron shell.
 - The atom releases energy, and one or more electrons move to a lower electron shell.
- An element that has a low first ionization energy and good conductivity of heat and electricity is classified as a
 - metal
 - metalloid
 - nonmetal
 - noble gas
- The chemical properties of calcium are most similar to the chemical properties of
 - Ar
 - K
 - Mg
 - Sc
- Which element is a liquid at STP?
 - argon
 - bromine
 - chlorine
 - sulfur
- Which statement describes a chemical property of aluminum?
 - Aluminum is malleable.
 - Aluminum reacts with sulfuric acid.
 - Aluminum conducts an electric current.
 - Aluminum has a density of 2.698 g/cm^3 at STP.
- Which element has an atom in the ground state with a total of three valence electrons?
 - aluminum
 - lithium
 - phosphorus
 - scandium
- Which substance can be broken down by chemical means?
 - magnesium
 - manganese
 - mercury
 - methanol
- The gram-formula mass of NO_2 is defined as the mass of
 - one mole of NO_2
 - one molecule of NO_2
 - two moles of NO
 - two molecules of NO
- In which type of reaction do two or more substances combine to produce a single substance?
 - synthesis
 - decomposition
 - single replacement
 - double replacement
- Which formula represents a nonpolar molecule?
 - HCl
 - H_2O
 - NH_3
 - CH_4
- Which symbol represents an atom in the ground state with the most stable valence electron configuration?
 - B
 - O
 - Li
 - Ne
- Which element has an atom with the greatest tendency to attract electrons in a chemical bond?
 - carbon
 - chlorine
 - silicon
 - sulfur

- 14 The nitrogen atoms in a molecule of N_2 share a total of
- (1) one pair of electrons
 - (2) one pair of protons
 - (3) three pairs of electrons
 - (4) three pairs of protons
- 15 An ionic compound is formed when there is a reaction between the elements
- (1) strontium and chlorine
 - (2) hydrogen and chlorine
 - (3) nitrogen and oxygen
 - (4) sulfur and oxygen
- 16 Which compound has both ionic and covalent bonding?
- | | |
|----------------|--------------------|
| (1) $CaCO_3$ | (3) CH_3OH |
| (2) CH_2Cl_2 | (4) $C_6H_{12}O_6$ |
- 17 The liquids hexane and water are placed in a test tube. The test tube is stoppered, shaken, and placed in a test tube rack. The liquids separate into two distinct layers because hexane and water have different
- (1) formula masses
 - (2) molecular polarities
 - (3) pH values
 - (4) specific heats
- 18 Which statement describes the particles of an ideal gas based on the kinetic molecular theory?
- (1) The gas particles are relatively far apart and have negligible volume.
 - (2) The gas particles are in constant, nonlinear motion.
 - (3) The gas particles have attractive forces between them.
 - (4) The gas particles have collisions without transferring energy.
- 19 Under which conditions of temperature and pressure would a 1-liter sample of a real gas behave most like an ideal gas?
- (1) 100 K and 0.1 atm
 - (2) 100 K and 10 atm
 - (3) 500 K and 0.1 atm
 - (4) 500 K and 10 atm
- 20 Which type of energy is associated with the random motion of the particles in a sample of gas?
- (1) chemical energy
 - (2) electromagnetic energy
 - (3) nuclear energy
 - (4) thermal energy
- 21 The particles in which sample of $LiCl(s)$ have the same average kinetic energy as the particles in a 2.0-mole sample of $H_2O(\ell)$ at $25^\circ C$?
- (1) 1.0 mol at $75^\circ C$
 - (2) 2.0 mol at $50^\circ C$
 - (3) 3.0 mol at $25^\circ C$
 - (4) 4.0 mol at $0^\circ C$
- 22 Which rigid cylinder contains the same number of gas molecules at STP as a 2.0-liter rigid cylinder containing $H_2(g)$ at STP?
- (1) 1.0-L cylinder of $O_2(g)$
 - (2) 2.0-L cylinder of $CH_4(g)$
 - (3) 1.5-L cylinder of $NH_3(g)$
 - (4) 4.0-L cylinder of $He(g)$
- 23 Hydrogen bonding is a type of
- (1) strong covalent bond
 - (2) weak ionic bond
 - (3) strong intermolecular force
 - (4) weak intermolecular force
- 24 The data collected from a laboratory titration are used to calculate the
- (1) rate of a chemical reaction
 - (2) heat of a chemical reaction
 - (3) concentration of a solution
 - (4) boiling point of a solution
- 25 When one compound dissolves in water, the only positive ion produced in the solution is $H_3O^+(aq)$. This compound is classified as
- (1) a salt
 - (2) a hydrocarbon
 - (3) an Arrhenius acid
 - (4) an Arrhenius base

- 26 Which nuclear emission has the greatest mass and the *least* penetrating power?
- (1) an alpha particle (3) a neutron
(2) a beta particle (4) a positron
- 27 Which radioisotope has an atom that emits a particle with a mass number of 0 and a charge of +1?
- (1) ${}^3\text{H}$ (3) ${}^{19}\text{Ne}$
(2) ${}^{16}\text{N}$ (4) ${}^{239}\text{Pu}$
- 28 In which type of reaction do two lighter nuclei combine to form one heavier nucleus?
- (1) combustion (3) nuclear fission
(2) reduction (4) nuclear fusion
- 29 For which compound is the process of dissolving in water exothermic?
- (1) NaCl (3) NH_4Cl
(2) NaOH (4) NH_4NO_3
- 30 Which quantities must be equal for a chemical reaction at equilibrium?
- (1) the activation energies of the forward and reverse reactions
(2) the rates of the forward and reverse reactions
(3) the concentrations of the reactants and products
(4) the potential energies of the reactants and products
-

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 formula represents copper(I) oxide?

- (1) CuO (3) Cu₂O
(2) CuO₂ (4) Cu₂O₂

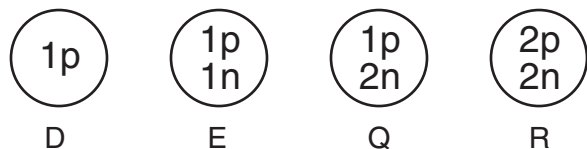
32 At STP, a 7.49-gram sample of an element has a volume of 1.65 cubic centimeters. The sample is most likely

- (1) Ta (3) Te
(2) Tc (4) Ti

33 Which element, represented by X, reacts with fluorine to produce the compound XF₂?

- (1) aluminum (3) magnesium
(2) argon (4) sodium

34 Each diagram below represents the nucleus of a different atom.



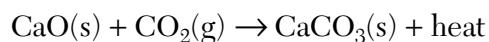
Which diagrams represent nuclei of the same element?

- (1) D and E, only (3) Q and R, only
(2) D, E, and Q (4) Q, R, and E

35 As atomic number increases within Group 15 on the Periodic Table, atomic radius

- (1) decreases, only
(2) increases, only
(3) decreases, then increases
(4) increases, then decreases

36 Given the balanced equation representing a reaction:



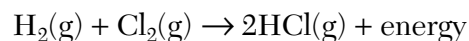
What is the total mass of CaO(s) that reacts completely with 88 grams of CO₂(g) to produce 200. grams of CaCO₃(s)?

- (1) 56 g (3) 112 g
(2) 88 g (4) 288 g

37 What is the empirical formula of a compound that has a carbon-to-hydrogen ratio of 2 to 6?

- (1) CH₃ (3) C₃H
(2) C₂H₆ (4) C₆H₂

38 Given the balanced equation representing a reaction:



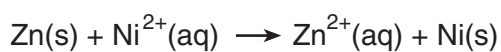
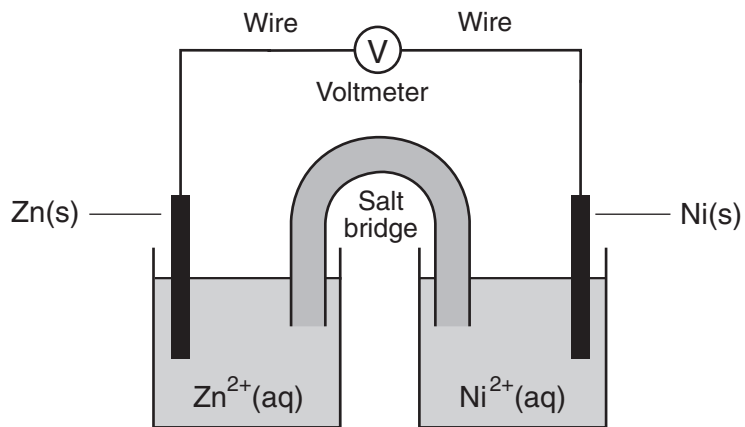
Which statement describes the energy changes in this reaction?

- (1) Energy is absorbed as bonds are formed, only.
(2) Energy is released as bonds are broken, only.
(3) Energy is absorbed as bonds are broken, and energy is released as bonds are formed.
(4) Energy is absorbed as bonds are formed, and energy is released as bonds are broken.

39 Which solution has the highest boiling point at standard pressure?

- (1) 0.10 M KCl(aq)
(2) 0.10 M K₂SO₄(aq)
(3) 0.10 M K₃PO₄(aq)
(4) 0.10 M KNO₃(aq)

50 The diagram below represents an operating electrochemical cell and the balanced ionic equation for the reaction occurring in the cell.



Which statement identifies the part of the cell that conducts electrons and describes the direction of electron flow as the cell operates?

- (1) Electrons flow through the salt bridge from the Ni(s) to the Zn(s).
 - (2) Electrons flow through the salt bridge from the Zn(s) to the Ni(s).
 - (3) Electrons flow through the wire from the Ni(s) to the Zn(s).
 - (4) Electrons flow through the wire from the Zn(s) to the Ni(s).
-

Part B–2

Answer all questions in this part.

Directions (51–65): 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 Based on Table G, determine the total mass of NH_3 that must be dissolved in 200. grams of water to produce a saturated solution at $20.^\circ\text{C}$. [1]
- 52 Determine the total time that must elapse until only $\frac{1}{4}$ of an original sample of the radioisotope Rn-222 remains unchanged. [1]

Base your answers to questions 53 through 55 on the information below.

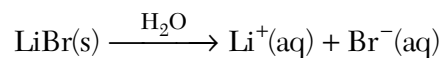
A phase change for carbon dioxide that occurs spontaneously at $20.^\circ\text{C}$ and 1.0 atmosphere is represented by the balanced equation below.



- 53 Write the name of this phase change. [1]
- 54 Describe what happens to the potential energy of the CO_2 molecules as this phase change occurs. [1]
- 55 *In your answer booklet*, use the key to draw *at least five* molecules in the box to represent CO_2 after this phase change is completed. [1]
-

Base your answers to questions 56 and 57 on the information below.

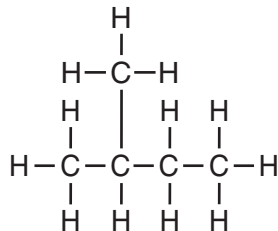
The dissolving of solid lithium bromide in water is represented by the balanced equation below.



- 56 Calculate the total mass of $\text{LiBr}(\text{s})$ required to make 500.0 grams of an aqueous solution of LiBr that has a concentration of 388 parts per million. Your response must include *both* a correct numerical setup and the calculated result. [2]
- 57 Based on Table F, identify *one* ion that reacts with Br^- ions in an aqueous solution to form an insoluble compound. [1]
-

Base your answers to questions 58 through 60 on the information below.

The formula below represents a hydrocarbon.



- 58 Identify the homologous series to which this hydrocarbon belongs. [1]
- 59 Explain, in terms of carbon-carbon bonds, why this hydrocarbon is saturated. [1]
- 60 In the space *in your answer booklet*, draw a structural formula for *one* isomer of this hydrocarbon. [1]
-

Base your answers to questions 61 through 63 on the information below.

The atomic and ionic radii for sodium and chlorine are shown in the table below.

Atomic and Ionic Radii

Particle	Radius (pm)
Na atom	190.
Na ⁺ ion	102
Cl atom	97
Cl ⁻ ion	181

- 61 Write the ground state electron configuration for the ion that has a radius of 181 picometers. [1]
- 62 Convert the radius of an Na⁺ ion to meters. [1]
- 63 Explain, in terms of atomic structure, why the radius of an Na atom is larger than the radius of an Na⁺ ion. [1]
-

Base your answers to questions 64 and 65 on the information below.

The nucleus of one boron atom has five protons and four neutrons.

64 Determine the total number of electrons in the boron atom. [1]

65 Determine the total charge of the boron nucleus. [1]

Part C

Answer all questions in this part.

Directions (66–84): 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*.

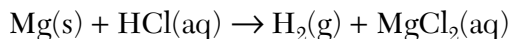
Base your answers to questions 66 through 68 on the information below.

At STP, iodine, I_2 , is a crystal, and fluorine, F_2 , is a gas. Iodine is soluble in ethanol, forming a tincture of iodine. A typical tincture of iodine is 2% iodine by mass.

- 66 Compare the strength of the intermolecular forces in a sample of I_2 at STP to the strength of the intermolecular forces in a sample of F_2 at STP. [1]
- 67 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for a molecule of I_2 . [1]
- 68 Determine the total mass of I_2 in 25 grams of this typical tincture of iodine. [1]
-

Base your answers to questions 69 through 71 on the information below.

In a laboratory investigation, magnesium reacts with hydrochloric acid to produce hydrogen gas and magnesium chloride. This reaction is represented by the unbalanced equation below.



- 69 State, in terms of the relative activity of elements, why this reaction is spontaneous. [1]
- 70 Balance the equation *in your answer booklet*, using the smallest whole-number coefficients. [1]
- 71 Write a balanced half-reaction equation for the oxidation that occurs. [1]
-

Base your answers to questions 72 through 75 on the information below.

An experiment is performed to determine how concentration affects the rate of reaction. In each of four trials, equal volumes of solution A and solution B are mixed while temperature and pressure are held constant. The concentration of solution B is held constant, but the concentration of solution A is varied. The concentration of solution A and the time for the reaction to go to completion for each trial are recorded in the data table below.

Data Table

Trial	Concentration of Solution A (M)	Reaction Time (s)
1	0.0200	4.5
2	0.0150	7.0
3	0.0100	12.0
4	0.0050	20.0

- 72 Describe the relationship between the concentration of solution A and the time for the reaction to go to completion. [1]
- 73 On the grid *in your answer booklet*, mark an appropriate scale on the axis labeled "Reaction Time (s)." [1]
- 74 On the same grid, plot the data from the data table. Circle and connect the points. [1]
- 75 Identify *one* factor, other than the concentration of the solutions, that can affect the rate of this reaction. [1]
-

Base your answers to questions 76 through 78 on the information below.

Carbon has three naturally occurring isotopes, C-12, C-13, and C-14. Diamond and graphite are familiar forms of solid carbon. Diamond is one of the hardest substances known, while graphite is a very soft substance. Diamond has a rigid network of bonded atoms. Graphite has atoms bonded in thin layers that are held together by weak forces.

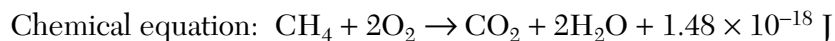
Recent experiments have produced new forms of solid carbon called fullerenes. One fullerene, C₆₀, is a spherical, cagelike molecule of carbon.

- 76 Determine *both* the total number of protons and the total number of neutrons in an atom of the naturally occurring carbon isotope with the largest mass number. [1]
- 77 Identify the type of bonding in a fullerene molecule. [1]
- 78 State, in terms of the arrangement of atoms, the difference in hardness between diamond and graphite. [1]
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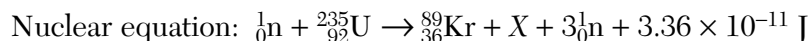
Base your answers to questions 79 through 81 on the information below.

Hydrocarbons and fissionable nuclei are among the sources used for the production of energy in the United States. A chemical reaction produces much less energy than a nuclear reaction per mole of reactant.

The balanced chemical equation below represents the reaction of one molecule of a hydrocarbon with two molecules of oxygen.



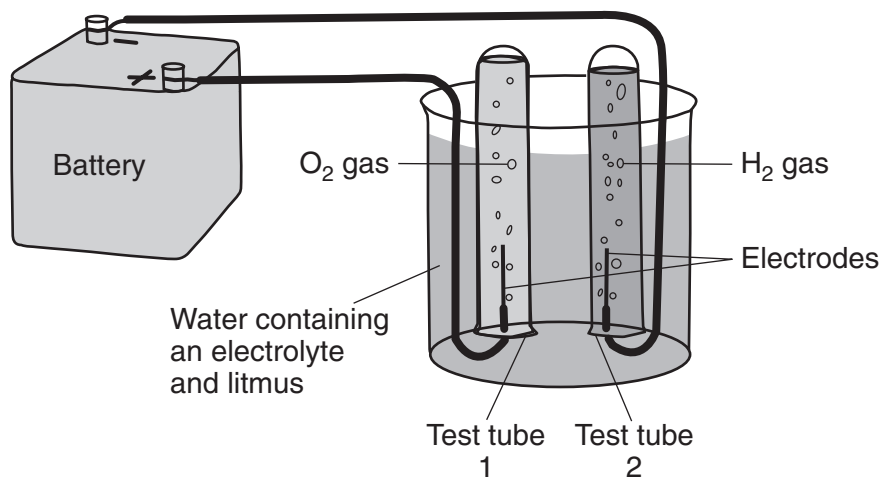
The nuclear equation below represents one of the many possible reactions for one fissionable nucleus. In this equation, X represents a missing product.



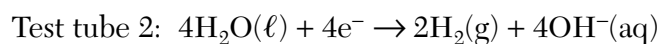
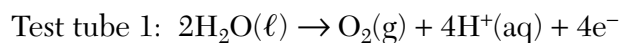
- 79 Identify the type of organic reaction represented by the chemical equation. [1]
- 80 On the labeled axes *in your answer booklet*, draw a potential energy diagram for the reaction of the hydrocarbon with oxygen. [1]
- 81 Write an isotopic notation for the missing product represented by X in the nuclear equation. [1]
-

Base your answers to questions 82 through 84 on the information below.

The diagram below shows a system in which water is being decomposed into oxygen gas and hydrogen gas. Litmus is used as an indicator in the water. The litmus turns red in test tube 1 and blue in test tube 2.



The oxidation and reduction occurring in the test tubes are represented by the balanced equations below.



- 82 Identify the information in the diagram that indicates this system is an electrolytic cell. [1]
- 83 Determine the change in oxidation number of oxygen during the reaction in test tube 1. [1]
- 84 Explain, in terms of the products formed in test tube 2, why litmus turns blue in test tube 2. [1]
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The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING CHEMISTRY

Thursday, January 28, 2010 — 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

- 1 11 21
2 12 22
3 13 23
4 14 24
5 15 25
6 16 26
7 17 27
8 18 28
9 19 29
10 20 30

Part A Score

[Box for Part A Score]

Part B-1

- 31 41
32 42
33 43
34 44
35 45
36 46
37 47
38 48
39 49
40 50

Part B-1 Score

[Box for Part B-1 Score]

Write your answers to Part B-2 and Part C in your answer booklet.

The declaration below must 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

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