Large-Type Edition

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING

CHEMISTRY

Tuesday, June 24, 2025 — 9:15 a.m. to 12:15 p.m., only

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

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 *2011 Edition Reference Tables for Physical Setting/Chemistry*. You are to answer *all* questions in all parts of this examination according to the directions provided in this examination booklet.

A separate answer sheet for Part A and Part B–1 has been provided to you. Follow the instructions from the proctor for completing the student information on your answer sheet. Record your answers to the Part A and Part B–1 multiple-choice questions on this separate answer sheet. Record your answers for the questions in Part B–2 and Part C in your separate answer booklet. Be sure to fill in the heading on the front of your answer booklet.

All answers in your answer booklet 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 or in your answer booklet as directed.

When you have completed the examination, you must sign the statement printed on 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 *2011 Edition Reference Tables for Physical Setting/Chemistry* must be available for you to use while taking this examination.

DO NOT START THIS EXAMINATION UNTIL THE SIGNAL IS GIVEN.

Part A

Answer all questions in this part.

Directions (1–30): For *each* statement or question, record on your 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 *2011 Edition Reference Tables for Physical Setting/Chemistry*.

1 Which sequence of historic developments led to the modern model of the atom?

(1) electrons in shells outside a nucleus, hard sphere, mostly empty space
(2) electrons in shells outside a nucleus, mostly empty space, hard sphere
(3) hard sphere, electrons in shells outside a nucleus, mostly empty space
(4) hard sphere, mostly empty space, electrons in shells outside a nucleus

2 Which statement compares the energy of an electron in the third shell of a rubidium atom to the energy of an electron in a different shell of the same atom?

(1) An electron in the third shell has less energy than an electron in the second shell.
(2) An electron in the third shell has less energy than an electron in the first shell.
(3) An electron in the third shell has more energy than an electron in the first shell.
(4) An electron in the third shell has more energy than an electron in the fifth shell.

3 When an electron in an atom returns from a higher energy state to a lower energy state

(1) the atom becomes a negative ion
(2) the atom becomes a positive ion
(3) a specific amount of energy is emitted
(4) a specific amount of energy is absorbed

4 The atomic mass of chlorine is the weighted average of the atomic masses of the

(1) radioactive isotopes of chlorine
(2) naturally occurring isotopes of chlorine
(3) artificially produced isotopes of chlorine
(4) radioactive and artificial isotopes of chlorine

5 The elements on the Periodic Table are arranged in order of increasing

(1) atomic mass
(2) atomic number
(3) ionization energy
(4) electronegativity

6 Which element symbol represents a metalloid?

(1) Ba
(2) Cs
(3) Te
(4) Xe

7 Which term identifies a chemical property that can be used to differentiate a sample of sodium from a sample of gold?

(1) density
(2) mass
(3) reactivity
(4) temperature

8 Which term identifies the type of matter that is composed of two or more different elements chemically combined in a fixed ratio?

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

9 The coefficients in a balanced equation represent the

(1) atomic numbers of each element in the reaction
(2) mass numbers of the reactants and products
(3) mass ratio of substances in the reaction
(4) mole ratio of substances in the reaction

10 Given the equation representing a reaction:

$$Br + Br \rightarrow Br_2$$

Which statement describes what occurs during this reaction?

(1) Energy is released as bonds are formed.
(2) Energy is released as bonds are broken.
(3) Energy is absorbed as bonds are formed.
(4) Energy is absorbed as bonds are broken.

11 Which term represents a property used to determine the degree of polarity in the bond between two atoms?

(1) conductivity
(2) electronegativity
(3) joule
(4) pascal

12 Which sample of matter has proportions of components that can be varied?

(1) solid iodine
(2) gaseous iodine
(3) liquid ammonia
(4) aqueous ammonia

13 Which term identifies a form of energy?

(1) pascal
(2) molarity
(3) temperature
(4) electromagnetic

14 According to the kinetic molecular theory, which statement describes the particles of an ideal gas?

(1) The force of attraction between the particles is strong.
(2) The particles are arranged in a regular, geometric pattern.
(3) The particles move in random, constant, straight-line motion.
(4) The collisions between particles result in a net loss of energy.

15 A reaction most likely occurs when particles collide with proper energy and

(1) mass
(2) density
(3) volume
(4) orientation

16 At STP, 2.0 liters of $N_2(g)$ and 2.0 liters of $O_2(g)$ have the same

(1) density
(2) boiling point
(3) melting point
(4) number of molecules

17 Which phrase describes a factor that determines the physical state of a molecular substance?

(1) arrangement of the molecules
(2) decay mode of the molecules
(3) conductivity of the molecules
(4) solubility of the molecules

18 Which combination of reactants will result in the fastest rate of reaction of a 1.0-gram sample of Zn(s) and 30. milliliters of HCl(aq) at 25°C?

(1) 1.0-g cube of Zn(s) with 1.0 M HCl(aq)
(2) 1.0-g cube of Zn(s) with 2.0 M HCl(aq)
(3) 1.0-g powdered Zn(s) with 1.0 M HCl(aq)
(4) 1.0-g powdered Zn(s) with 2.0 M HCl(aq)

19 Which term represents the energy absorbed or released during a chemical change?

(1) heat of fusion
(2) heat of reaction
(3) heat of vaporization
(4) heat capacity

20 In terms of energy and disorder, systems in nature have a tendency to undergo changes toward

(1) lower energy and greater disorder
(2) lower energy and less disorder
(3) higher energy and greater disorder
(4) higher energy and less disorder

21 A molecule of which straight chain hydrocarbon contains nine carbon atoms?

(1) butane
(2) hexane
(3) nonane
(4) propane

22 Which compound is an unsaturated hydrocarbon?

(1) 1-heptanol
(2) 2-butyne
(3) octane
(4) ethanal

23 What is the number of electrons shared between the carbon atoms in an ethene molecule?

(1) 6
(2) 2
(3) 3
(4) 4

24 Which two terms represent types of organic reactions?

(1) solidification and polymerization
(2) solidification and vaporization
(3) substitution and polymerization
(4) substitution and vaporization

25 In an operating electrolytic cell, oxidation occurs at the

(1) anode
(2) cathode
(3) salt bridge
(4) switch

26 An Arrhenius base yields which negative ions in an aqueous solution?

(1) hydronium ions
(2) hydroxide ions
(3) ammonium ions
(4) peroxide ions

27 Which change in the concentration of H_3O^+ ions results in a *decrease* of one unit in the pH value for an aqueous solution?

(1) a decrease in the concentration of H_3O^+ by a factor of 10
(2) a decrease in the concentration of H_3O^+ by a factor of 1
(3) an increase in the concentration of H_3O^+ by a factor of 10
(4) an increase in the concentration of H_3O^+ by a factor of 1

28 Based on Table *N*, which phrase describes the half-lives and the decay modes of uranium-235 and uranium-238?

(1) the same half-life but different decay modes
(2) the same half-life and the same decay mode
(3) different half-lives and different decay modes
(4) different half-lives but the same decay mode

29 Nuclear fission reactions result in the net conversion of

(1) mass to energy
(2) energy to mass
(3) beta particles to alpha particles
(4) alpha particles to beta particles

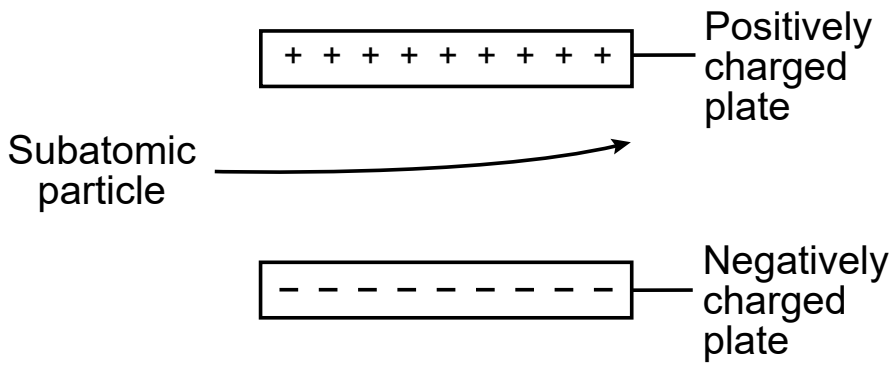
30 What is a risk associated with the production of energy in a nuclear power plant?

(1) chemical tracing
(2) radioactive dating
(3) detection of disease
(4) long-term storage of waste

Part B–1
Answer all questions in this part.

Directions (31–50): For *each* statement or question, record on your 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 *2011 Edition Reference Tables for Physical Setting/Chemistry*.

31 The diagram below represents the path of a subatomic particle as it travels through an electric field between two charged plates.



Which subatomic particle is traveling between the charged plates?

(1) electron
(2) neutron
(3) positron
(4) proton

32 Which electron configuration represents the electrons in a neon atom in an excited state?

(1) 2–7
(2) 2–8
(3) 2–6–1
(4) 2–7–1

33 Element *X* reacts with chlorine to form the compound XCl_3. In which group on the Periodic Table of the Elements is element *X* located?

(1) Group 1
(2) Group 2
(3) Group 13
(4) Group 18

34 What is the number of moles of calcium oxide in a 238-gram sample of CaO? (gram-formula mass of CaO = 56.1 g/mol)

(1) 0.236 mol
(2) 4.24 mol
(3) 182 mol
(4) 294 mol

35 What is the molarity of an aqueous solution that contains 0.60 mole of KCl dissolved in 3.5 liters of solution?

(1) 0.17 M
(2) 0.60 M
(3) 2.1 M
(4) 5.8 M

36 Which statement describes the freezing point of a solution prepared by dissolving $NH_4Cl(s)$ in water at 25°C?

(1) The solution has a freezing point lower than 0°C.
(2) The solution has a freezing point equal to 0°C.
(3) The solution has a freezing point equal to 25°C.
(4) The solution has a freezing point higher than 25°C.

37 At which temperature and pressure will a sample of a real gas behave most like an ideal gas?

(1) 250. K and 100. atm
(2) 500. K and 10. atm
(3) 750. K and 1 atm
(4) 1000. K and 0.1 atm

38 In a sealed, rigid cylinder with a movable piston, a sample of H_2 gas occupies 30.0 L at 50.0 kPa and 200. K. What is the pressure of the gas if the volume is changed to 60.0 L and the gas is heated to 300. K?

(1) 16.7 kPa
(2) 37.5 kPa
(3) 66.7 kPa
(4) 150. kPa

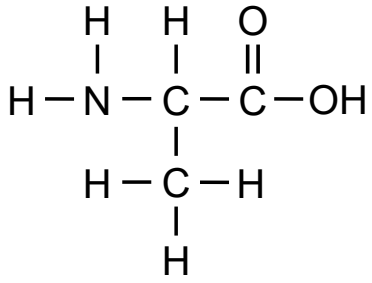
39 Which statement explains why a catalyzed reaction occurs at a faster rate than the same reaction when uncatalyzed?

(1) The catalyst provides a different reaction pathway for the reaction with a lower activation energy.
(2) The catalyst provides a different reaction pathway for the reaction with a higher activation energy.
(3) The catalyst uses the same reaction pathway for the reaction with a lower activation energy.
(4) The catalyst uses the same reaction pathway for the reaction with a higher activation energy.

40 At standard pressure, which 10.0-gram sample of nitrogen has the greatest entropy?

(1) nitrogen at 30. K
(2) nitrogen at 50. K
(3) nitrogen at 70. K
(4) nitrogen at 90. K

41 Given the structural formula for an organic compound:



Which two functional groups are present in molecules of this compound?

(1) amine and aldehyde
(2) amine and organic acid
(3) amide and aldehyde
(4) amide and organic acid

42 Given the equation representing a reaction:

$$Fe + CuCl_2 \rightarrow FeCl_2 + Cu$$

When the iron atoms lose 2 moles of electrons, the copper ions in $CuCl_2$

(1) lose 1 mole of electrons
(2) lose 2 moles of electrons
(3) gain 1 mole of electrons
(4) gain 2 moles of electrons

43 Given the equation representing a reaction:

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

What is the change in oxidation state for aluminum in this reaction?

(1) 0 to +3
(2) 0 to +6
(3) +3 to 0
(4) +6 to 0

44 Sulfuric acid, $H_2SO_4(aq)$, can neutralize an aqueous solution of calcium hydroxide, $Ca(OH)_2(aq)$. What is the formula for the salt produced by this neutralization reaction?

(1) Ca_2SO_4
(2) $Ca(SO_2)_2$
(3) $CaSO_3$
(4) $CaSO_4$

45 Given the equation representing a reaction:

$$^{15}_{8}O \rightarrow {}^{0}_{+1}e + {}^{15}_{7}N$$

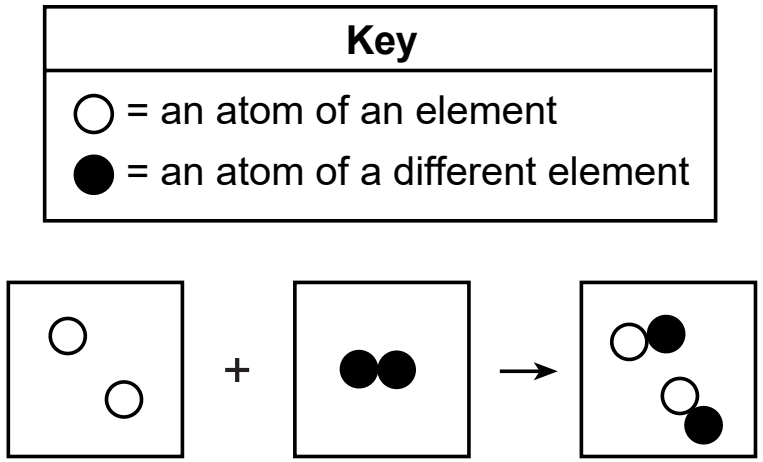
Which type of reaction is represented by this equation?

(1) synthesis
(2) esterification
(3) substitution
(4) transmutation

46 Which equation represents nuclear fission?

(1) $UO_2 + 4HCl \rightarrow UCl_4 + 2H_2O$
(2) $U + 2Br_2 \rightarrow UBr_4$
(3) $^{235}_{92}U \rightarrow {}^{4}_{2}He + {}^{231}_{90}Th$
(4) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$

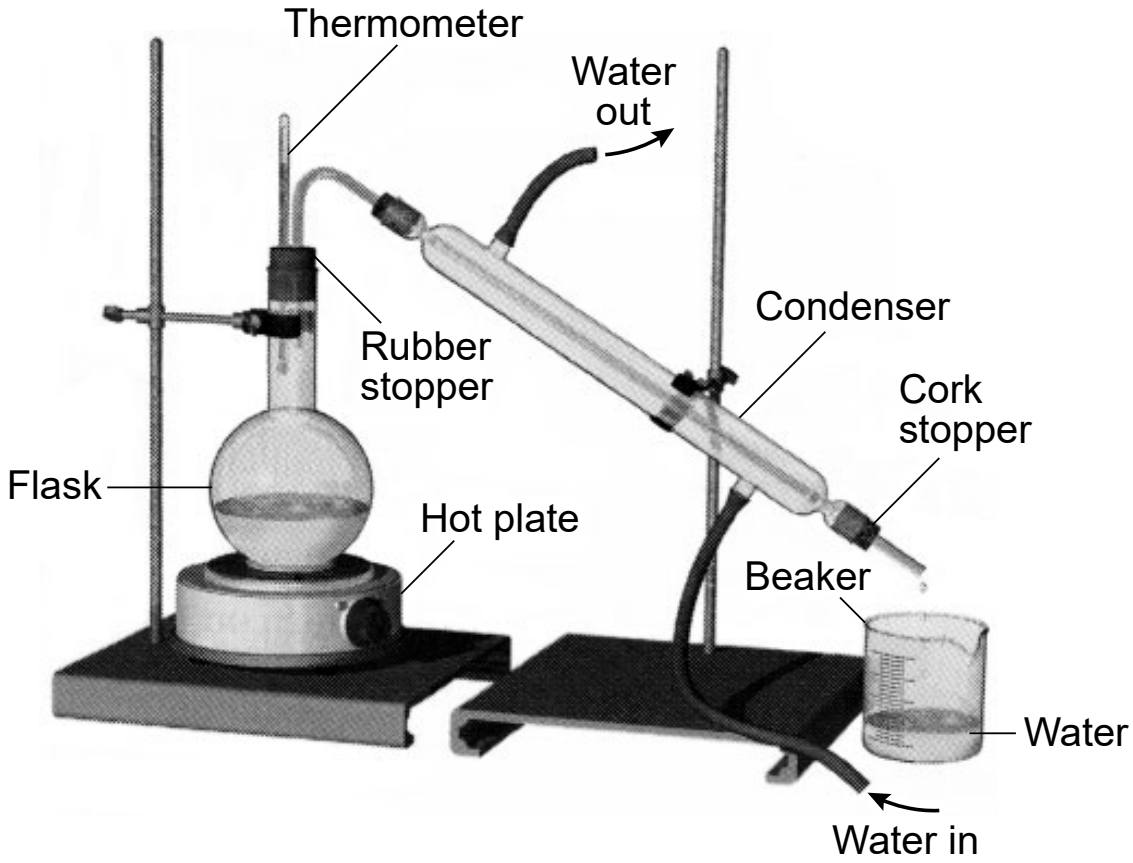
47 Given the particle-diagram equation:



Which type of reaction is represented by the equation?

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

48 The diagram below represents a laboratory process that is used to separate a mixture of two different liquids.



Which process is shown in this diagram?

(1) crystallization
(2) distillation
(3) filtration
(4) titration

49 Given the equation representing a system at equilibrium:

$$CO_3^{2-}(aq) + H_2O(\ell) \rightleftharpoons HCO_3^{-}(aq) + OH^{-}(aq)$$

Which statement describes the base in the forward reaction?

(1) The $H_2O(\ell)$ is the base because it accepts an H^+ ion.
(2) The $H_2O(\ell)$ is the base because it donates an H^+ ion.
(3) The $CO_3^{2-}(aq)$ is the base because it accepts an H^+ ion.
(4) The $CO_3^{2-}(aq)$ is the base because it donates an H^+ ion.

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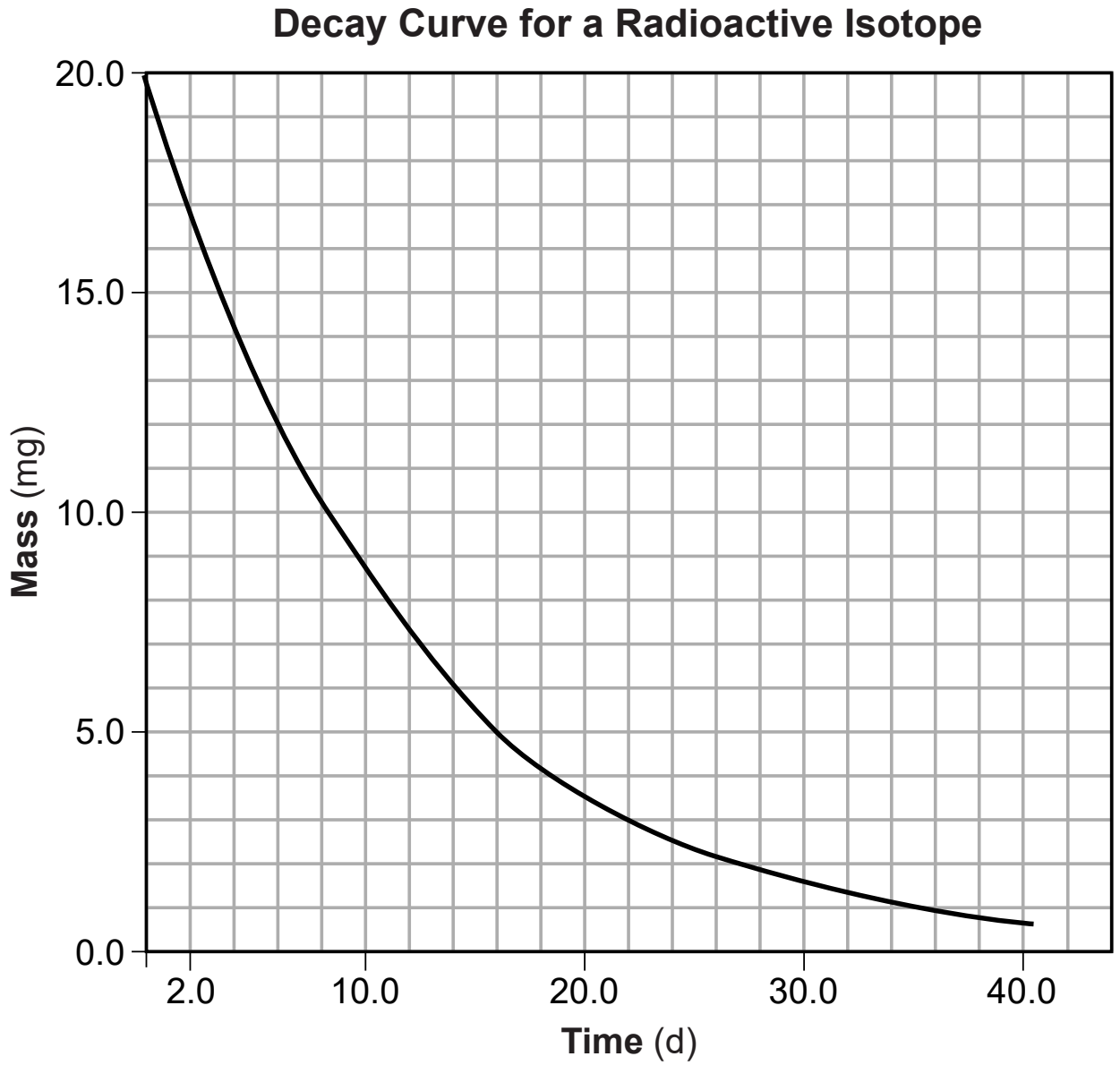
50 The graph below shows the decay curve for a 20.0-milligram sample of a radioactive isotope.



What is the half-life of this isotope?

(1) 5.0 d
(2) 8.0 d
(3) 8.7 d
(4) 10.0 d

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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 *2011 Edition Reference Tables for Physical Setting/Chemistry*.

51 Based on Table *F*, identify *one* positive ion that forms an insoluble compound with iodide ions in an aqueous solution. [1]

Base your answers to questions 52 through 54 on the information below and on your knowledge of chemistry.

The number of subatomic particles in four different atoms, represented by the letters *L*, *M*, *Q*, and *R*, are shown in the table below.

Subatomic Particles in Four Different Atoms

Atom	Number of Protons	Number of Neutrons	Number of Electrons
L	32	32	32
M	33	32	33
Q	33	34	33
R	34	34	34

52 State the number of valence electrons in an atom of *M* in the ground state. [1]

53 Compare the mass of a proton in atom *R* to the mass of an electron in atom *R*. [1]

54 Write the two letters, from this table, that represent atoms that are isotopes of the same element. [1]

Base your answers to questions 55 through 58 on the information below and on your knowledge of chemistry.

Potassium and bromine react to form the ionic compound potassium bromide.

55 Compare the radius of a potassium ion in the ground state to the radius of a potassium atom in the ground state. [1]

56 Identify the noble gas that has atoms in the ground state with the same electron configuration as a potassium ion, K^+, in the ground state. [1]

57 In the space *in your answer booklet*, draw a Lewis electron-dot diagram of a bromide ion, Br^-. [1]

58 Identify the type of bonding in a sample of solid potassium. [1]

Base your answers to questions 59 and 60 on the information below and on your knowledge of chemistry.

Hydrogen sulfide, H_2S, and water, H_2O, are both molecular compounds.

59 State, in terms of valence electrons, why the bonds in a molecule of hydrogen sulfide are covalent. [1]

60 Explain, in terms of charge distribution, why a molecule of H_2S is a polar molecule. [1]

Base your answers to questions 61 through 63 on the information below and on your knowledge of chemistry.

An equilibrium system in a sealed, rigid container is represented by the equation below.

$$H_2(g) + I_2(g) + \text{heat} \rightleftharpoons 2HI(g)$$

61 Compare the rate of the forward reaction to the rate of the reverse reaction in this system. [1]

62 State the effect on the concentration of iodine gas when hydrogen gas is added to this equilibrium system. [1]

63 Draw a potential energy diagram on the labeled axes *in your answer booklet* for the forward reaction. [1]

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

Radon-222 and radon-223 are two radioactive isotopes of radon. Radon-222 emits alpha particles when it decays and radon-223 emits beta particles when it decays.

64 Complete the nuclear equation *in your answer booklet* for the decay of radon-222 by writing a notation for the missing product. [1]

65 Determine the time required for a sample of radon-222 to decay until only $\frac{1}{4}$ of the original sample remains unchanged. [1]

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Part C

Answer all questions in this part.

Directions (66-85): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 66 through 69 on the information below and on your knowledge of chemistry.

Chlorine, phosphorus, and sulfur are three elements located in Period 3 on the Periodic Table that have been used to produce important compounds for agriculture.

66 Identify the element classification of these three elements. [1]

67 Determine the mass number of an atom of sulfur that contains 18 neutrons. [1]

68 State the trend in atomic radius as these three Period 3 elements on the Periodic Table are considered in order of increasing atomic number. [1]

69 Identify which of these three elements is a gas at STP. [1]

Base your answers to questions 70 through 72 on the information below and on your knowledge of chemistry.

Silicon carbide, SiC, is a compound used for making sandpaper and for cutting and polishing metals and glass. The balanced equation below represents the production of silicon carbide.

$$SiO_2 + 3C + \text{heat} \rightarrow SiC + 2CO$$

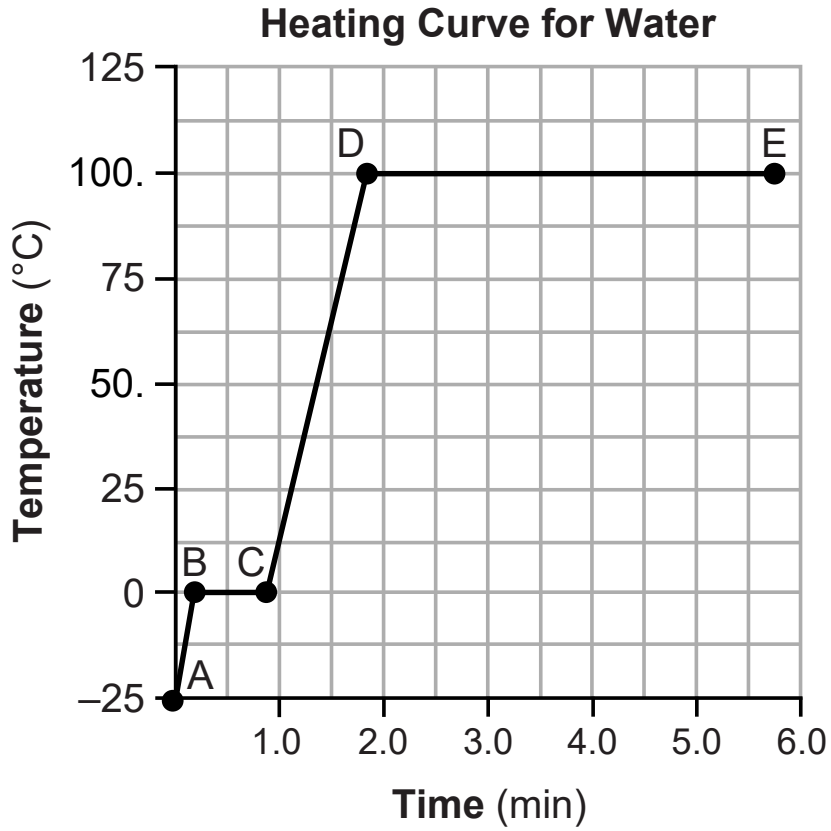
70 Show a numerical setup for calculating the gram-formula mass of silicon dioxide. [1]

71 Write a chemical name for the product, CO, in the equation. [1]

72 Determine the number of moles of carbon that are required to produce 4.0 moles of silicon carbide, SiC. [1]

Base your answers to questions 73 through 75 on the information below and on your knowledge of chemistry.

At standard pressure, a student heated a 120.-gram sample of $H_2O(s)$ at $-25^{\circ}C$ until the entire sample boiled for four minutes. This process is represented by the heating curve below. During this laboratory activity appropriate safety equipment was used and safety procedures were followed.



73 Identify the physical change that takes place during interval *BC* of the heating curve. [1]

74 State what happens to the average kinetic energy of the molecules in the H_2O sample during interval *CD*. [1]

75 Determine the quantity of heat absorbed when the 120.-gram sample of water boils away completely at its boiling point. [1]

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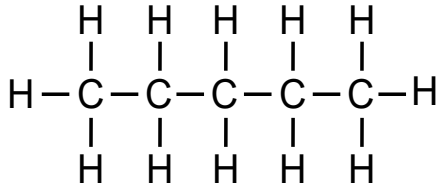
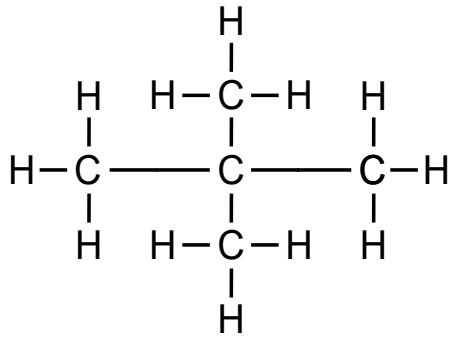
Base your answers to questions 76 through 78 on the information below and on your knowledge of chemistry.

The structural formulas of two of the three isomers of pentane and their boiling points at standard pressure are shown below.

Compound	Structural Formula	Boiling Point (°C)
pentane		36.1
dimethylpropane		9.5

76 Write the general formula of the homologous series to which these compounds belong. [1]

77 State, in terms of strength of intermolecular forces, why the boiling point of dimethylpropane is lower than the boiling point of pentane. [1]

78 In the space *in your answer booklet*, draw a structural formula of the third pentane isomer, 2-methylbutane. [1]

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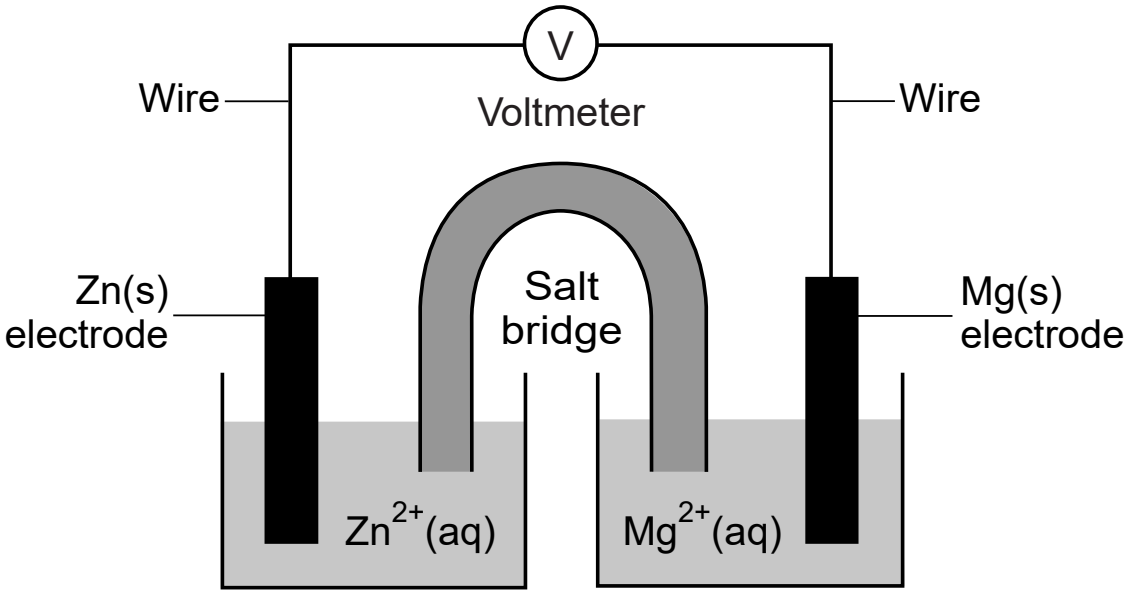
Base your answers to questions 79 through 81 on the information below and on your knowledge of chemistry.

In a laboratory activity, a student constructs an electrochemical cell. The diagram and the ionic equation below represent this cell and the reaction that occurs. During this laboratory activity appropriate safety equipment is used and safety procedures are followed.

Voltaic Cell



$$Zn^{2+}(aq) + Mg(s) \longrightarrow Zn(s) + Mg^{2+}(aq)$$

79 State the form of energy that is converted to electrical energy in this type of cell. [1]

80 State, in terms of the electrodes, the direction of electron flow in the external circuit when the cell is operating. [1]

81 Write a balanced equation for the reduction half-reaction that occurs in this cell. [1]

Base your answers to questions 82 through 85 on the information below and on your knowledge of chemistry.

During a titration, 11.1 mL of hydrochloric acid, HCl(aq), is exactly neutralized by 33.3 mL of 0.10 M sodium hydroxide, NaOH(aq). During this laboratory activity, appropriate safety equipment is used and safety procedures are followed.

82 Identify the positive ion present in the HCl(aq). [1]

83 Determine the concentration of the HCl(aq) using the titration data. [1]

84 State the color of bromcresol green if it is added to a sample of the sodium hydroxide solution. [1]

85 State, in terms of ions, why a sample of the 0.10 M NaOH is a good conductor of electricity. [1]

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