Large-Type Edition

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING

CHEMISTRY

Wednesday, August 17, 2022 — 8:30 to 11:30 a.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 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, 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 What is the number of protons in an atom with the electron configuration of 2−5?

(1) 5
(2) 2
(3) 3
(4) 7

2 In the wave-mechanical model of an atom, an orbital is defined as

(1) a region of the most probable neutron location
(2) a region of the most probable electron location
(3) the straight-line path of a neutron
(4) the straight-line path of an electron

3 In the ground state, which shell of a potassium atom has an electron with the greatest amount of energy?

(1) first
(2) second
(3) third
(4) fourth

4 Which phrase describes two atoms that contain the same number of protons but a different number of neutrons?

(1) ions of the same element
(2) isotopes of the same element
(3) a mixture of different elements
(4) nuclides of different elements

5 All atoms of an element have the same

(1) mass number
(2) atomic mass
(3) number of neutrons
(4) number of protons

6 Which Group 15 element is classified as a metal?

(1) N
(2) P
(3) As
(4) Bi

7 Compared to the number of electron shells and radius of an aluminum atom in the ground state, a boron atom in the ground state has

(1) fewer electron shells and a smaller radius
(2) fewer electron shells and a larger radius
(3) more electron shells and a smaller radius
(4) more electron shells and a larger radius

8 Hydrogen sulfide, H_2S, is classified as a

(1) compound with atoms in a fixed proportion
(2) compound with atoms in a proportion that can vary
(3) mixture with atoms in a fixed proportion
(4) mixture with atoms in a proportion that can vary

9 A structural formula differs from a molecular formula in that a structural formula shows the

(1) arrangement of atoms
(2) number of atoms
(3) ratio of atoms
(4) types of atoms

10 Which type of reaction occurs when a compound is separated into its elements?

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

11 Which terms represent two categories of compounds?

(1) chemical and physical
(2) chemical and molecular
(3) ionic and physical
(4) ionic and molecular

12 When an atom of hydrogen and an atom of chlorine combine to form a molecule of hydrogen chloride, a bond is

(1) formed as energy is absorbed
(2) formed as energy is released
(3) broken as energy is absorbed
(4) broken as energy is released

13 All atoms of the element vanadium must have the same

(1) atomic number
(2) mass number
(3) number of neutrons plus electrons
(4) number of protons plus neutrons

14 Which sample of matter can be separated into two different substances by physical means?

(1) liquid bromine
(2) gaseous propane
(3) solid sodium acetate
(4) aqueous magnesium sulfate

15 Two liquids can be separated by distillation due to a difference in

(1) concentration
(2) conductivity
(3) boiling point
(4) heat of fusion

16 Which unit can be used to express the concentration of a $PbCl_2(aq)$ solution?

(1) kelvins
(2) kilojoules per gram
(3) pascals
(4) parts per million

17 Compared to the freezing point and boiling point of water at 1.0 atm, a 0.5 M aqueous solution of NaCl at 1.0 atm has

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

18 Which form of energy is converted to thermal energy when propane burns in air?

(1) chemical
(2) electrical
(3) mechanical
(4) nuclear

19 According to the kinetic molecular theory, which statement explains why an ideal gas can be compressed to a smaller volume?

(1) The motion of the gas particles is circular and orderly.
(2) The force of attraction between the gas particles is strong.
(3) As the gas particles collide, the total energy of the system decreases.
(4) The gas particles are separated by great distances relative to their size.

20 Under which conditions of temperature and pressure does a sample of propane behave *least* like an ideal gas?

(1) 250. K and 1.0 atm
(2) 250. K and 5.0 atm
(3) 500. K and 1.0 atm
(4) 500. K and 5.0 atm

21 Compared to a 1.0-L sample of $CO_2(g)$ in a sealed, rigid container at STP, a 1.0-L sample of $CH_4(g)$ in a sealed, rigid container at STP has the same

(1) density
(2) molar mass
(3) chemical properties
(4) number of molecules

22 A chemical reaction occurs when

(1) $H_2O(g)$ forms $H_2O(\ell)$
(2) $H_2O(\ell)$ forms $H_2O(s)$
(3) $O_2(\ell)$ forms $O_2(s)$
(4) $O_2(g)$ forms $O_3(g)$

23 What is the purpose of adding a catalyst to a chemical reaction?

(1) to decrease the potential energy of the products
(2) to increase the potential energy of the reactants
(3) to convert solid reactants to liquid reactants
(4) to provide an alternate reaction pathway

24 Systems in nature tend to undergo changes toward

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

25 Which reaction occurs at the anode in an electrochemical cell?

(1) neutralization
(2) oxidation
(3) reduction
(4) substitution

26 As more NaCl(s) is dissolved in a dilute, unsaturated NaCl(aq) solution, the conductivity of the solution

(1) decreases as the ion concentration decreases
(2) decreases as the ion concentration increases
(3) increases as the ion concentration decreases
(4) increases as the ion concentration increases

27 Which substance always forms when an Arrhenius acid reacts with an Arrhenius base?

(1) CO_2
(2) H_2
(3) CH_3OH
(4) H_2O

28 Which symbol represents a nuclear emission with the greatest mass and the greatest ionizing power?

(1) α
(2) β^+
(3) β^-
(4) γ

29 One potential benefit of nuclear fusion reactions is

(1) reactor meltdown
(2) uncontrolled chain reaction
(3) production of large amounts of energy
(4) production of radioactive waste materials

30 Determining the age of a wooden beam from a sunken ship is an example of a beneficial use of

(1) Lewis structures
(2) polyatomic ions
(3) radioactive nuclides
(4) homogeneous mixture

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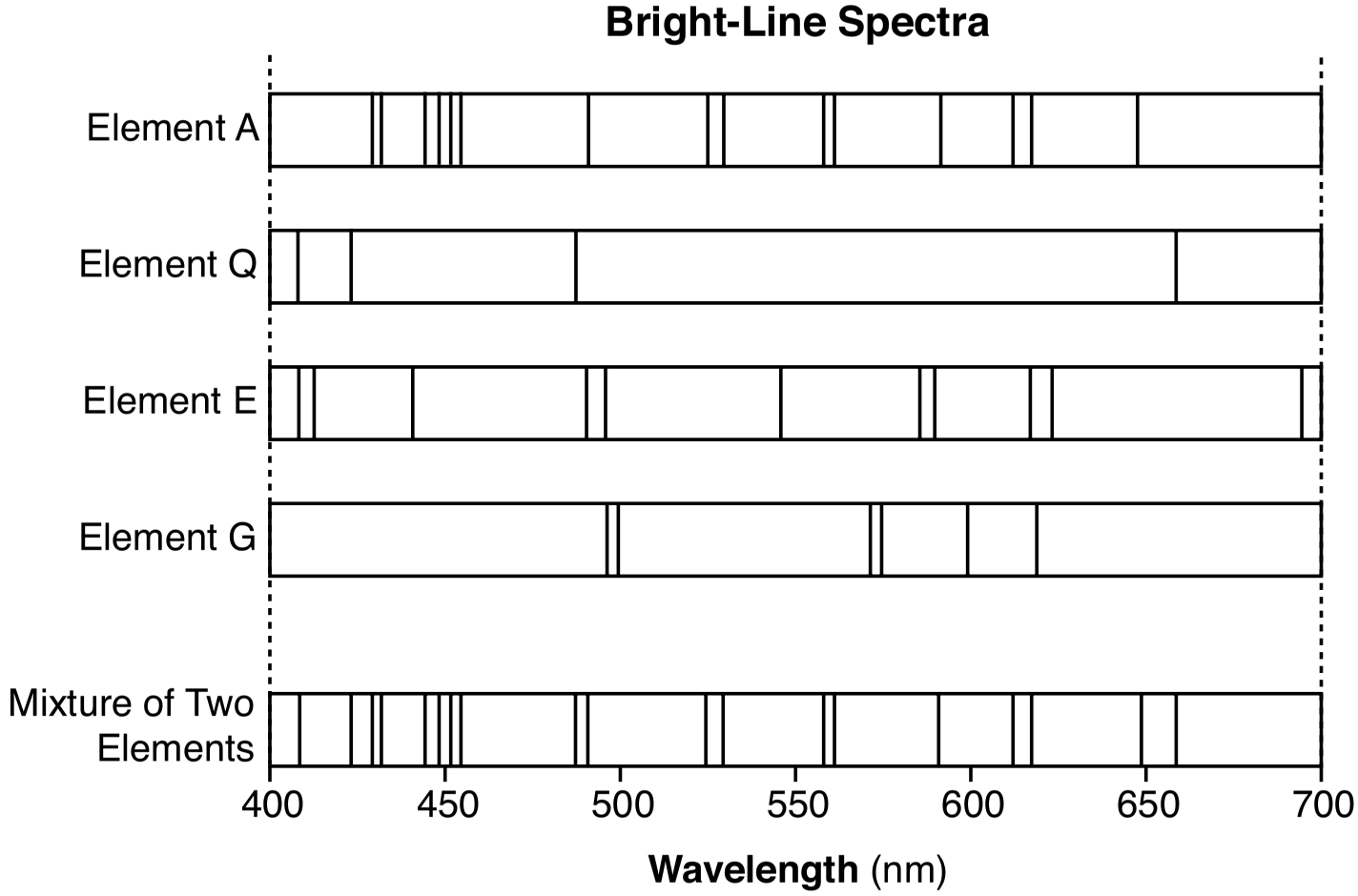
Part B–1

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 Given the bright-line spectra of four elements and the spectrum of a mixture formed from two of these elements:



Question 31 is continued on the next page.

Question 31 continued

Which two elements are present in this mixture?

(1) *A* and *Q*
(2) *A* and *E*
(3) *G* and *Q*
(4) *G* and *E*

32 What is the approximate mass of an atom that has 10 electrons, 10 protons, and 9 neutrons?

(1) 10. u
(2) 19 u
(3) 20. u
(4) 29 u

33 Which electron configuration represents the electrons of an atom in an excited state?

(1) 2-7-3
(2) 2-8-2
(3) 2-8-8-1
(4) 2-8-9-2

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34 Given information about the naturally occurring isotopes of bromine:

Naturally Occurring Isotopes of Bromine

Isotope Notation	Atomic Mass (u)	Natural Abundance (%)
Br-79	78.92	50.69
Br-81	80.92	49.31

Which numerical setup can be used to determine the atomic mass of bromine?

(1) (78.92 u)(50.69) + (80.92 u)(49.31)
(2) (80.92 u)(50.69) + (78.92 u)(49.31)
(3) (78.92 u)(0.5069) + (80.92 u)(0.4931)
(4) (80.92 u)(0.5069) + (78.92 u)(0.4931)

35 What is a chemical name of the compound CuS?

(1) copper(I) sulfide
(2) copper(I) sulfate
(3) copper(II) sulfide
(4) copper(II) sulfate

36 Given the equation representing a reaction:

$$2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$$

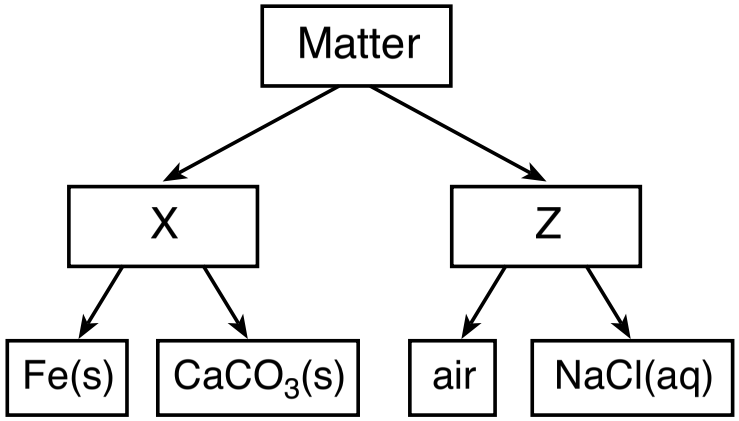
What is the mass of $N_2(g)$ produced when 1.0 gram of $H_2(g)$ completely reacts with 15.0 grams of NO(g) to produce 9.0 grams of $H_2O(g)$?

(1) 7.0 g
(2) 14.0 g
(3) 25.0 g
(4) 28.0 g

37 An atom of which element bonds with an atom of hydrogen to form the most polar bond?

(1) bromine
(2) chlorine
(3) fluorine
(4) iodine

38 Given the diagram representing a classification of matter:



Which types of matter are represented by *X* and *Z* in the diagram?

(1) *X* is mixture, and *Z* is substance.
(2) *X* is substance, and *Z* is mixture.
(3) *X* is element, and *Z* is compound.
(4) *X* is compound, and *Z* is element.

39 Based on Table *G*, which sample, when added to 100. grams of water and thoroughly stirred, produces a heterogeneous mixture at 20.°C?

(1) 20. g of KCl
(2) 20. g of KI
(3) 80. g of KCl
(4) 80. g of KI

40 How many milliliters of 1 M HCl(aq) must be diluted with water to make exactly 500 mL of 0.1 M HCl(aq)?

(1) 10 mL
(2) 50 mL
(3) 100 mL
(4) 5000 mL

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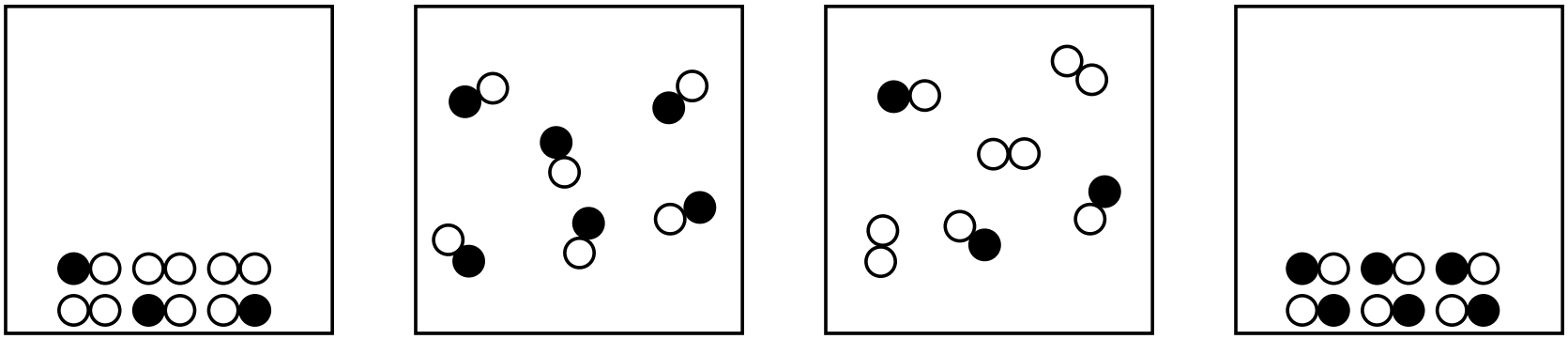
41 Which two particle diagrams represent two different phases of the same compound, only?

Key
○ = atom of one element
● = atom of a different element



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

42 A sample of KCl(s) is dissolved in water to form KCl(aq). When the water in the KCl(aq) is completely evaporated, KCl(s) remains. Which statement describes a property of the KCl(s) after the water evaporated?

(1) The KCl(s) becomes a molecular compound.
(2) The molar mass of the KCl(s) decreases.
(3) The melting point of the KCl(s) is unchanged.
(4) The KCl(s) conducts an electric current.

43 Which statement describes ice and liquid water in a stoppered flask at 0°C at equilibrium?

(1) The rate of melting must equal the rate of freezing.
(2) The rate of freezing must be greater than the rate of melting.
(3) The mass of the ice must equal the mass of the liquid water.
(4) The mass of the ice must be greater than the mass of the liquid water.

44 Given the equation representing a system at equilibrium in a sealed, rigid container:

$$N_2(g) + O_2(g) + 182.6\ kJ \rightleftharpoons 2NO(g)$$

When heat is added to the system, the concentration of $N_2(g)$

(1) decreases and the concentration of NO(g) decreases
(2) decreases and the concentration of NO(g) increases
(3) increases and the concentration of NO(g) increases
(4) increases and the concentration of NO(g) decreases

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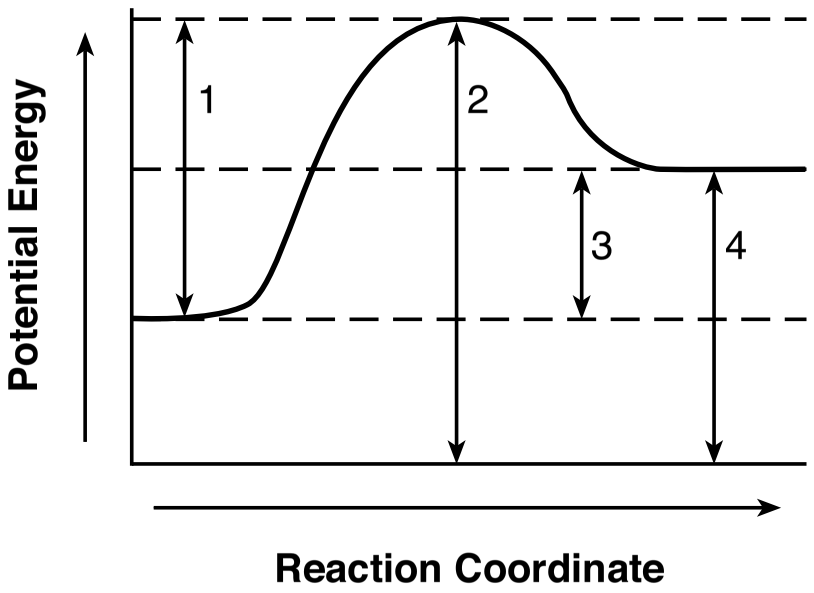
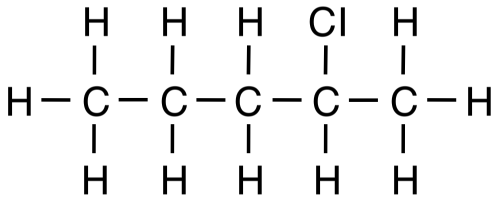
45 Given the potential energy diagram for a reaction:



Which numbered interval represents the activation energy of the reaction?

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

46 Given the formula representing a compound:



What is a chemical name for the compound?

(1) 2-chloropentene
(2) 2-chloropentane
(3) 4-chloropentene
(4) 4-chloropentane

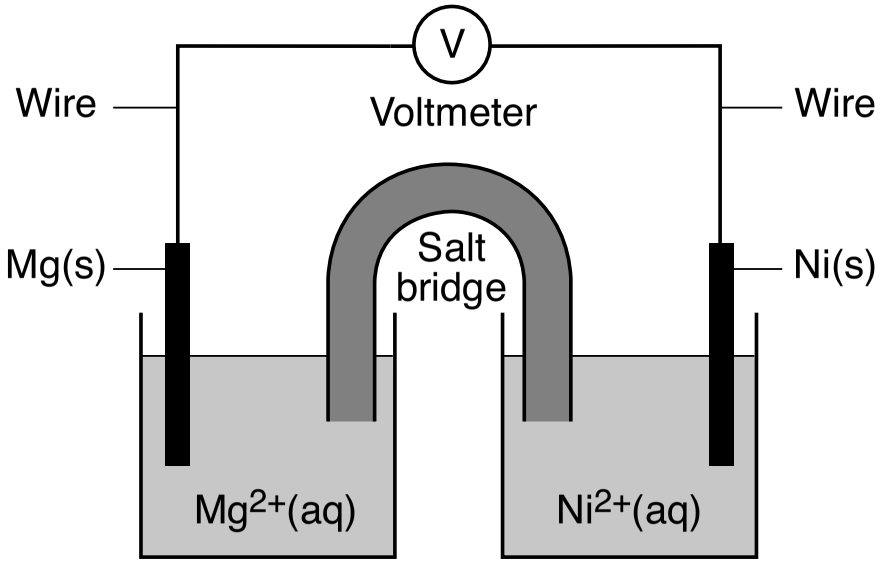
47 Which formula represents a saturated organic compound?

(1) C_2H_2
(2) C_2H_4
(3) C_3H_4
(4) C_3H_8

48 The compounds $CH_3CH_2CH_2OH$ and $CH_3OCH_2CH_3$ have different

(1) numbers of carbon atoms per mole
(2) numbers of hydrogen atoms per mole
(3) functional groups
(4) molecular masses

49 The diagram and ionic equation below represent an operating voltaic cell.



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

Which phrase describes the direction of electron flow in this cell?

(1) from Ni(s) through the wire to Mg(s)
(2) from Mg(s) through the wire to Ni(s)
(3) from $Ni^{2+}(aq)$ ions through the salt bridge to $Mg^{2+}(aq)$ ions
(4) from $Mg^{2+}(aq)$ ions through the salt bridge to $Ni^{2+}(aq)$ ions

50 Given the equation representing a reaction at equilibrium:

$$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

According to one acid-base theory, which pair are the H^+ donors?

(1) $NH_3(aq)$ and $H_2O(\ell)$
(2) $NH_3(aq)$ and $OH^-(aq)$
(3) $NH_4^+(aq)$ and $H_2O(\ell)$
(4) $NH_4^+(aq)$ and $OH^-(aq)$

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 Identify a metal from Table *J* that is *less* active than silver. [1]

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

Fluorine, chlorine, bromine, and iodine are located in Group 17 and are called halogens.

52 State, in terms of electrons, why these halogens have similar chemical properties. [1]

53 Compare the radius of a chlorine atom to the radius of a Cl^- ion. [1]

54 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for an atom of fluorine in the ground state. [1]

Base your answers to questions 55 through 57 on the information below and on your knowledge of chemistry.

A sample of helium gas in a sealed, rigid container is at 240. K and 120. kPa. The temperature is increased to 360. K.

55 State the number of significant figures to which the given pressure is expressed. [1]

56 Determine the pressure of the helium at 360. K. [1]

57 Show a numerical setup for converting 120. kPa to atmospheres. [1]

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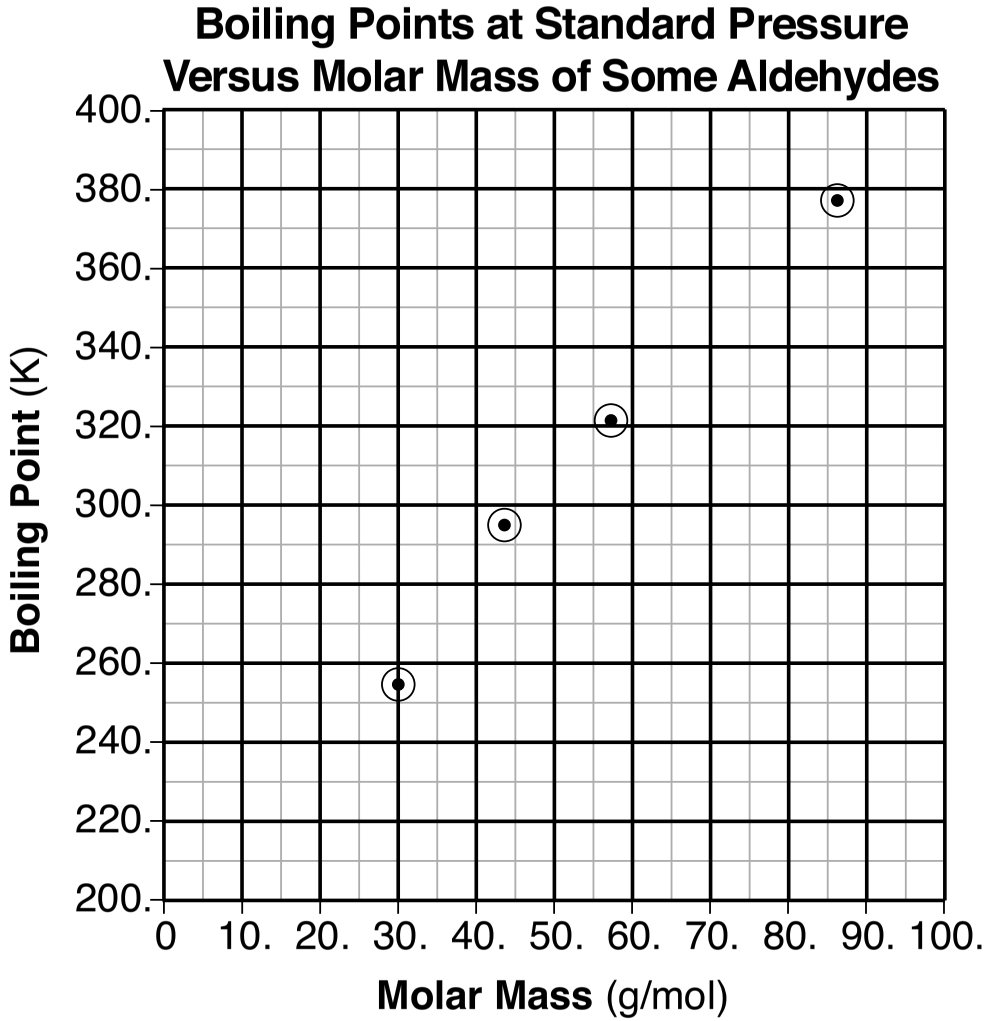
Base your answers to questions 58 and 59 on the information below and on your knowledge of chemistry.

The table and graph below show information about five aldehydes.

Names and Molar Masses of Selected Aldehydes

Name	**Molar Mass** (g/mol)
methanal	30.0
ethanal	44.1
propanal	58.1
butanal	72.1
pentanal	86.1

Questions 58 and 59 are continued on the next page.



58 Based on the graph, determine the boiling point of butanal at standard pressure. [1]

59 Determine the mass of 3.00 moles of propanal using the molar mass given in the table. [1]

Base your answers to questions 60 through 62 on the information below and on your knowledge of chemistry.

A 100.-mL sample of liquid water is heated in a flask to boiling at 1 atm. As the water boils, some liquid water changes phase to water vapor. The equation below represents this change.

$$H_2O(\ell) + \text{heat} \rightarrow H_2O(g)$$

60 Describe the change in potential energy of the water molecules that vaporize during boiling. [1]

61 Compare the entropy of the $H_2O(\ell)$ to the $H_2O(g)$ that is formed. [1]

62 Determine the mass of liquid water that vaporizes if 7700 joules of energy is absorbed by the $H_2O(\ell)$ at 100.°C. [1]

Base your answers to questions 63 through 65 on the information below and on your knowledge of chemistry.

Tritium, hydrogen-3, is a radioisotope.

63 State the number of neutrons in an atom of tritium. [1]

64 Complete the nuclear equation *in your answer booklet* for the decay of tritium by writing a notation for the missing nuclide. [1]

65 Based on Table *N*, identify a nuclide that has the same decay mode as tritium, but has a longer half-life. [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.

Phosphorus combines with oxygen to form an oxide that reacts with water to produce phosphoric acid, which is an important industrial compound used to produce fertilizers. An unbalanced equation for the production of phosphoric acid is shown below.

$$P_4O_{10}(s) + H_2O(\ell) \rightarrow H_3PO_4(aq) + \text{energy}$$

66 Balance the equation *in your answer booklet* for the production of phosphoric acid, using the *smallest* whole-number coefficients. [1]

67 Write the empirical formula of the solid reactant in the equation. [1]

68 Show a numerical setup for calculating the percent composition by mass of phosphorus in P_4O_{10} (formula mass = 283.89 u). [1]

69 Determine the oxidation state of phosphorus in the phosphoric acid. [1]

Base your answers to questions 70 through 73 on the information below and on your knowledge of chemistry.

Calcium oxide, CaO, also known as lime, is an important industrial chemical. Lime can be obtained by the heating of limestone, which is mainly calcium carbonate, $CaCO_3$. An equation representing the reaction for the production of lime is shown below.

$$CaCO_3(s) + \text{heat} \rightarrow CaO(s) + CO_2(g)$$

70 State the solubility of limestone in water. [1]

71 State evidence from the equation that the reaction to form lime is endothermic. [1]

72 Identify the noble gas that has atoms in the ground state with the same electron configuration as the calcium ion, in the ground state, in the $CaCO_3$. [1]

73 State the type of chemical bonding in a sample of CaO. [1]

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Base your answers to questions 74 and 75 on the information below and on your knowledge of chemistry.

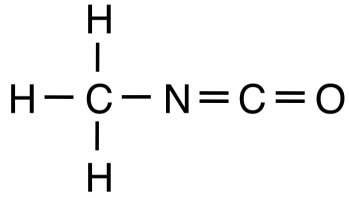
During a laboratory activity, a student places 20.0 mL of HCl(aq) of unknown concentration into a flask. The solution is titrated with 0.10 M KOH(aq) until the HCl(aq) is exactly neutralized. At the end of the titration, the volume of KOH(aq) added is 42.0 mL. During the laboratory activity appropriate safety equipment was used and safety procedures were followed.

74 Compare the number of moles of $H^+(aq)$ ions to the number of moles of $OH^-(aq)$ ions in the titration mixture when the HCl(aq) is exactly neutralized by the KOH(aq). [1]

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

Base your answers to questions 76 and 77 on the information below and on your knowledge of chemistry.

A scientific sampling instrument landed on a comet. Four of the organic compounds detected on the comet are methyl isocyanate, propanone, propanal, and ethanamide. The structural formula for methyl isocyanate is shown below:



76 Identify the element in these four compounds that makes them organic compounds. [1]

77 Write the names of the two organic compounds detected on the comet that are isomers of each other. [1]

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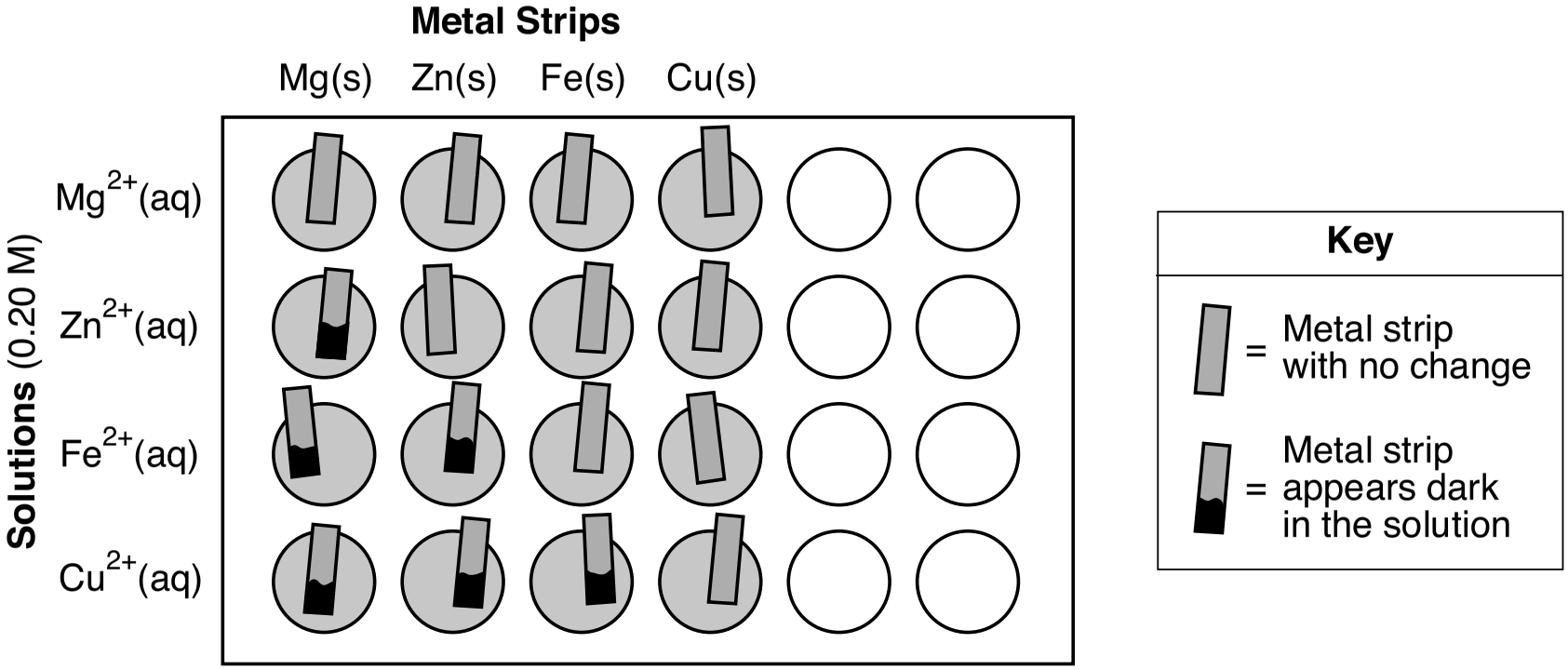
Base your answers to questions 78 through 81 on the information below and on your knowledge of chemistry.

During a laboratory activity appropriate safety equipment is used and safety procedures are followed. A student tests samples of four different metals using 0.20 M aqueous metal ion solutions of the same four metals. The student uses a 24-well plate as the reaction container for the different metal and solution combinations.

Before placing a metal strip in each solution, the student cleans the surface of the metal strip with sandpaper. The 24-well plate diagram below shows the setup and results of the investigation. In each vertical column, the metal strips are all the same metal. For each horizontal row, all of the solutions contain the same type of metal ion.

24-Well Plate with Metal Strips and Aqueous Metal Ion Solutions



Questions 78-81 are continued on the next page.

78 Using the results of the student's investigation, state evidence that zinc metal is more active than copper metal. [1]

79 Compare the number of electrons lost by the Mg(s) placed in the $Zn^{2+}(aq)$ solution to the number of electrons gained by the $Zn^{2+}(aq)$. [1]

80 Write a balanced, half-reaction equation for the reduction of the copper ions. [1]

81 State why the student was instructed to clean the surface of the metal strips with sandpaper before placing each strip into an aqueous metal ion solution. [1]

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Base your answers to questions 82 and 83 on the information below and on your knowledge of chemistry.

Tetrachloromethane, CCl_4, was used as a dry cleaning solvent until it was banned for this use in the U.S. in 1970 due to its toxicity. This solvent was replaced in many dry cleaning processes by tetrachloroethene, C_2Cl_4. Another currently available alternative dry cleaning solvent is 1-bromopropane. The table below shows the boiling points of these solvents.

Boiling Points of Three Compounds at 1 atm

Name	**Boiling Point** (°C)
tetrachloromethane	76.8
tetrachloroethene	121.3
1-bromopropane	71.1

82 Explain, in terms of intermolecular forces, why tetrachloroethene has a higher boiling point than tetrachloromethane. [1]

83 Draw a structural formula for 1-bromopropane. [1]

Base your answers to questions 84 and 85 on the information below and on your knowledge of chemistry.

When a neutron is absorbed by a uranium-235 nucleus, the nucleus can split. One possible nuclear reaction is represented by the balanced equation below.

$$ {}^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{90}_{38}\mathrm{Sr} + {}^{142}_{54}\mathrm{Xe} + 4\,{}^{1}_{0}\mathrm{n} + \text{energy} $$

In this reaction, the products have a mass that is 0.180 u less than the mass of the reactants.

84 Compare the energy released per gram of reactant during this reaction to the energy released per gram of reactant in a chemical reaction. [1]

85 Determine the time required for an 8.00-mg sample of Sr-90 to decay until only 2.00 mg of the sample remains unchanged. [1]

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