The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Tuesday, June 20, 2017 — 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 OPEN THIS EXAMINATION BOOKLET UNTIL THE SIGNAL IS GIVEN.

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 statement describes the structure of an atom?
   (1) The nucleus contains positively charged electrons.
   (2) The nucleus contains negatively charged protons.
   (3) The nucleus has a positive charge and is surrounded by negatively charged electrons.
   (4) The nucleus has a negative charge and is surrounded by positively charged electrons.

2 Which term is defined as the region in an atom where an electron is most likely to be located?
   (1) nucleus   (3) quanta
   (2) orbital   (4) spectra

3 What is the number of electrons in an atom of scandium?
   (1) 21   (3) 45
   (2) 24   (4) 66

4 Which particle has the *least* mass?
   (1) a proton   (3) a helium atom
   (2) an electron   (4) a hydrogen atom

5 Which electron transition in an excited atom results in a release of energy?
   (1) first shell to the third shell
   (2) second shell to the fourth shell
   (3) third shell to the fourth shell
   (4) fourth shell to the second shell

6 On the Periodic Table, the number of protons in an atom of an element is indicated by its
   (1) atomic mass
   (2) atomic number
   (3) selected oxidation states
   (4) number of valence electrons

7 Which type of formula shows an element symbol for each atom and a line for each bond between atoms?
   (1) ionic   (3) empirical
   (2) structural   (4) molecular

8 What is conserved during all chemical reactions?
   (1) charge   (3) vapor pressure
   (2) density   (4) melting point

9 In which type of reaction can two compounds exchange ions to form two different compounds?
   (1) synthesis
   (2) decomposition
   (3) single replacement
   (4) double replacement

10 At STP, two 5.0-gram solid samples of different ionic compounds have the same density. These solid samples could be differentiated by their
   (1) mass   (3) temperature
   (2) volume   (4) solubility in water

11 What is the number of electrons shared between the atoms in an I_2 molecule?
   (1) 7   (3) 8
   (2) 2   (4) 4

12 Which substance has nonpolar covalent bonds?
   (1) Cl_2 (3) SiO_2
   (2) SO_3 (4) CCl_4

13 Compared to a potassium atom, a potassium ion has
   (1) a smaller radius   (3) fewer protons
   (2) a larger radius   (4) more protons

14 Which form of energy is associated with the random motion of particles in a gas?

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

15 The average kinetic energy of water molecules *decreases* when

(1) $H_2O(\ell)$ at 337 K changes to $H_2O(\ell)$ at 300. K
(2) $H_2O(\ell)$ at 373 K changes to $H_2O(g)$ at 373 K
(3) $H_2O(s)$ at 200. K changes to $H_2O(s)$ at 237 K
(4) $H_2O(s)$ at 273 K changes to $H_2O(\ell)$ at 273 K

16 The joule is a unit of

(1) concentration (3) pressure
(2) energy (4) volume

17 Compared to a sample of helium at STP, the same sample of helium at a higher temperature and a lower pressure

(1) condenses to a liquid
(2) is more soluble in water
(3) forms diatomic molecules
(4) behaves more like an ideal gas

18 A sample of a gas is in a sealed, rigid container that maintains a constant volume. Which changes occur between the gas particles when the sample is heated?

(1) The frequency of collisions increases, and the force of collisions decreases.
(2) The frequency of collisions increases, and the force of collisions increases.
(3) The frequency of collisions decreases, and the force of collisions decreases.
(4) The frequency of collisions decreases, and the force of collisions increases.

19 At STP, which gaseous sample has the same number of molecules as 3.0 liters of $N_2(g)$?

(1) 6.0 L of $F_2(g)$ (3) 3.0 L of $H_2(g)$
(2) 4.5 L of $N_2(g)$ (4) 1.5 L of $Cl_2(g)$

20 Distillation of crude oil from various parts of the world yields different percentages of hydrocarbons. Which statement explains these different percentages?

(1) Each component in a mixture has a different solubility in water.
(2) Hydrocarbons are organic compounds.
(3) The carbons in hydrocarbons may be bonded in chains or rings.
(4) The proportions of components in a mixture can vary.

21 In which 1.0-gram sample are the particles arranged in a crystal structure?

(1) $CaCl_2(s)$ (3) $CH_3OH(\ell)$
(2) $C_2H_6(g)$ (4) $CaI_2(aq)$

22 When a reversible reaction is at equilibrium, the concentration of products and the concentration of reactants must be

(1) decreasing (3) constant
(2) increasing (4) equal

23 In chemical reactions, the difference between the potential energy of the products and the potential energy of the reactants is equal to the

(1) activation energy
(2) ionization energy
(3) heat of reaction
(4) heat of vaporization

24 What occurs when a catalyst is added to a chemical reaction?

(1) an alternate reaction pathway with a lower activation energy
(2) an alternate reaction pathway with a higher activation energy
(3) the same reaction pathway with a lower activation energy
(4) the same reaction pathway with a higher activation energy

25 What is the name of the compound with the formula $CH_3CH_2CH_2NH_2$?

(1) 1-propanol (3) propanal
(2) 1-propanamine (4) propanamide

26 Which compound is an isomer of $C_2H_5OC_2H_5$?

   (1) CH_3COOH (3) $C_3H_7COCH_3$

   (2) $C_2H_5COOCH_3$ (4) C_4H_9OH

27 Ethanoic acid and 1-butanol can react to produce water and a compound classified as an

   (1) aldehyde   (3) ester

   (2) amide   (4) ether

28 During an oxidation-reduction reaction, the number of electrons gained is

   (1) equal to the number of electrons lost
   (2) equal to the number of protons gained
   (3) less than the number of electrons lost
   (4) less than the number of protons gained

29 Which process requires energy for a nonspontaneous redox reaction to occur?

   (1) deposition   (3) alpha decay

   (2) electrolysis   (4) chromatography

30 Which pair of compounds represents one Arrhenius acid and one Arrhenius base?

   (1) CH_3OH and NaOH   (3) HNO_3 and NaOH

   (2) CH_3OH and HCl   (4) HNO_3 and HCl

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

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

32 Some information about the two naturally occurring isotopes of gallium is given in the table below.

Natural Abundance of Two Gallium Isotopes

Isotope	Natural Abundance (%)	Atomic Mass (u)
Ga-69	60.11	68.926
Ga-71	39.89	70.925

Which numerical setup can be used to calculate the atomic mass of gallium?

(1) (0.6011)(68.926 u) + (0.3989)(70.925 u)
(2) (60.11)(68.926 u) + (39.89)(70.925 u)
(3) (0.6011)(70.925 u) + (0.3989)(68.926 u)
(4) (60.11)(70.925 u) + (39.89)(68.926 u)

33 A student measures the mass and volume of a sample of copper at room temperature and 101.3 kPa. The mass is 48.9 grams and the volume is 5.00 cubic centimeters. The student calculates the density of the sample. What is the percent error of the student's calculated density?

(1) 7.4%   (3) 9.2%
(2) 8.4%   (4) 10.2%

34 What is the chemical formula for sodium sulfate?

(1) Na_2SO_4 (3) $NaSO_4$
(2) Na_2SO_3 (4) $NaSO_3$

35 Given the balanced equation representing a reaction:

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s) + energy$$
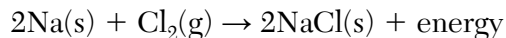
If 46 grams of Na and 71 grams of Cl_2 react completely, what is the total mass of NaCl produced?

(1) 58.5 g   (3) 163 g
(2) 117 g   (4) 234 g
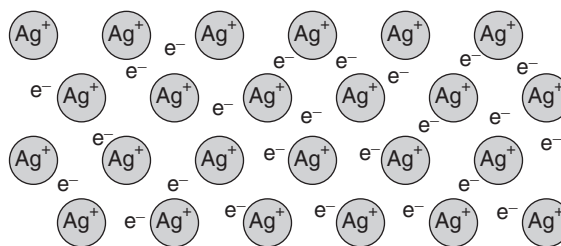
36 Given the balanced equation representing a reaction:

$$2NO + O_2 \rightarrow 2NO_2 + energy$$
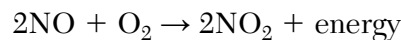
The mole ratio of NO to NO_2 is

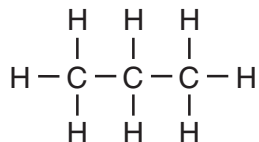(1) 1 to 1   (3) 3 to 2
(2) 2 to 1   (4) 5 to 2

37 The particle diagram below represents a solid sample of silver.

Which type of bonding is present when valence electrons move within the sample?

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

38 Given the formula representing a molecule:

$$H-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-H$$

Which statement explains why the molecule is nonpolar?

(1) Electrons are shared between the carbon atoms and the hydrogen atoms.
(2) Electrons are transferred from the carbon atoms to the hydrogen atoms.
(3) The distribution of charge in the molecule is symmetrical.
(4) The distribution of charge in the molecule is asymmetrical.

39 A solid sample of a compound and a liquid sample of the same compound are each tested for electrical conductivity. Which test conclusion indicates that the compound is ionic?

(1) Both the solid and the liquid are good conductors.
(2) Both the solid and the liquid are poor conductors.
(3) The solid is a good conductor, and the liquid is a poor conductor.
(4) The solid is a poor conductor, and the liquid is a good conductor.

40 Which statement explains why 10.0 mL of a 0.50 M H_2SO_4(aq) solution exactly neutralizes 5.0 mL of a 2.0 M NaOH(aq) solution?

(1) The moles of H^+(aq) equal the moles of OH^-(aq).
(2) The moles of H_2SO_4(aq) equal the moles of NaOH(aq).
(3) The moles of H_2SO_4(aq) are greater than the moles of NaOH(aq).
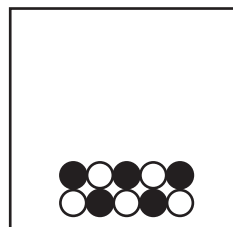(4) The moles of H^+(aq) are greater than the moles of OH^-(aq).

41 Which particle diagram represents *one* substance in the gas phase?

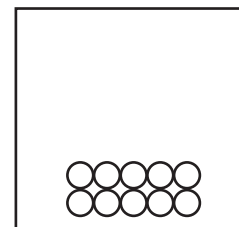| Key |
|---|
| ◯ = atom of one element |
| ● = atom of another element |
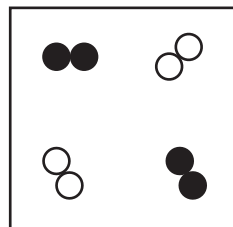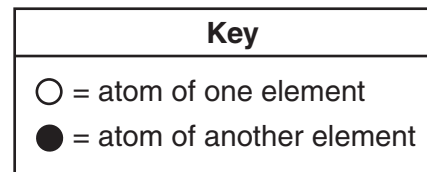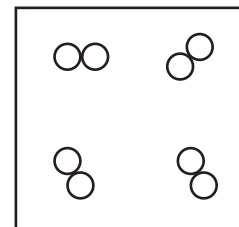
(1)   (3)
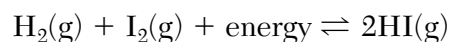

(2)   (4)

42 Given the equation representing a chemical reaction at equilibrium in a sealed, rigid container:

$$H_2(g) + I_2(g) + energy \rightleftharpoons 2HI(g)$$

When the concentration of H_2(g) is increased by adding more hydrogen gas to the container at constant temperature, the equilibrium shifts

(1) to the right, and the concentration of HI(g) decreases
(2) to the right, and the concentration of HI(g) increases
(3) to the left, and the concentration of HI(g) decreases
(4) to the left, and the concentration of HI(g) increases
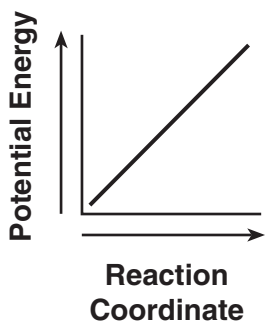
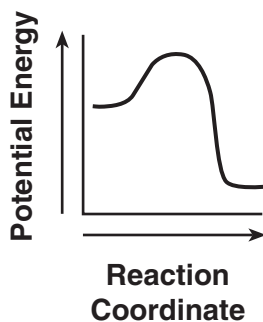43 Which diagram represents the potential energy changes during an exothermic reaction?
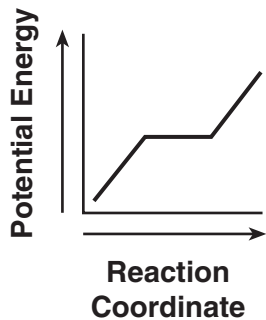
(1)
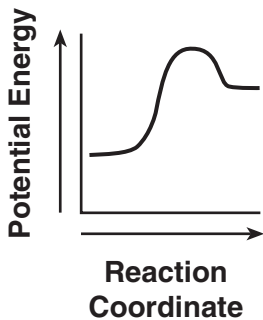
(3)

(2)

(4)

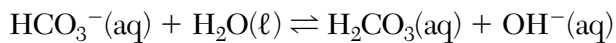44 Which compound is classified as an ether?

(1) CH_3CHO (3) CH_3COCH_3
(2) CH_3OCH_3 (4) CH_3COOCH_3

45 Given the equation representing a reversible reaction:

$$HCO_3^-(aq) + H_2O(\ell) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$$

Which formula represents the H^+ acceptor in the forward reaction?

(1) $HCO_3^-(aq)$ (3) $H_2CO_3(aq)$
(2) $H_2O(\ell)$ (4) $OH^-(aq)$

46 What is the mass of an original 5.60-gram sample of iron-53 that remains unchanged after 25.53 minutes?

(1) 0.35 g   (3) 1.40 g
(2) 0.70 g   (4) 2.80 g
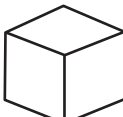
47 Given the equation representing a nuclear reaction:

$$^1_1H + X \rightarrow {}^6_3Li + {}^4_2He$$
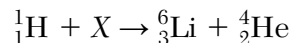
The particle represented by X is

(1) ^9_4Li (3) $^{10}_5Be$
(2) ^9_4Be (4) $^{10}_6C$

48 Fission and fusion reactions both release energy. However, only fusion reactions

(1) require elements with large atomic numbers
(2) create radioactive products
(3) use radioactive reactants
(4) combine light nuclei

49 The chart below shows the crystal shapes and melting points of two forms of solid phosphorus.

Two Forms of Phosphorus

Form of Phosphorus	Crystal Shape	Melting Point (°C)
white	cubic	44
black	orthorhombic	610

Which phrase describes the two forms of phosphorus?

(1) same crystal structure and same properties
(2) same crystal structure and different properties
(3) different crystal structures and different properties
(4) different crystal structures and same properties

50 Which graph shows the relationship between pressure and Kelvin temperature for an ideal gas at constant volume?

Pressure

Temperature

(1)

Pressure

Temperature

(3)

Pressure

Temperature

(2)

Pressure

Temperature

(4)
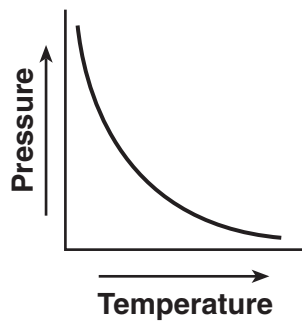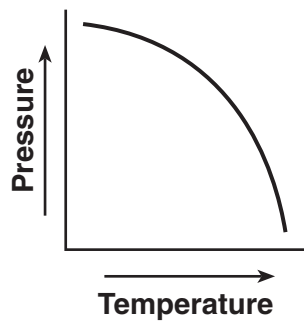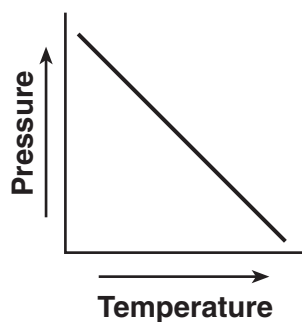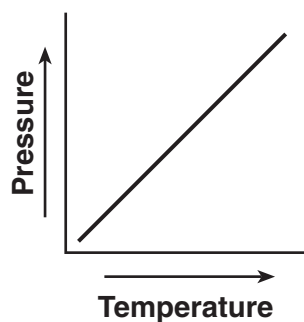
Part B–2

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.*

Base your answers to questions 51 through 53 on the information below and on your knowledge of chemistry.

The elements in Group 17 are called halogens. The word "halogen" is derived from Greek and means "salt former."

51 State the trend in electronegativity for the halogens as these elements are considered in order of increasing atomic number.   [1]

52 Identify the type of chemical bond that forms when potassium reacts with bromine to form a salt.   [1]

53 Based on Table *F*, identify *one* ion that reacts with iodide ions in an aqueous solution to form an insoluble compound.   [1]

Base your answers to questions 54 through 57 on the information below and on your knowledge of chemistry.

The diagrams below represent four different atomic nuclei.

Four Atomic Nuclei
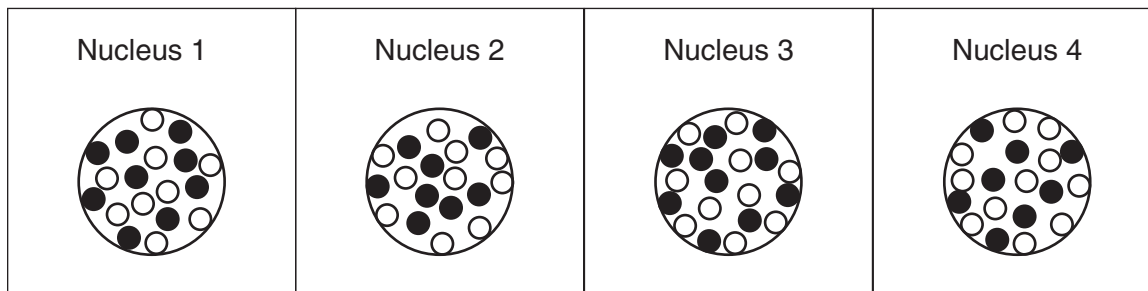
Key

● = proton
○ = neutron

54 Identify the element that has atomic nuclei represented by nucleus 1.   [1]

55 Determine the mass number of the nuclide represented by nucleus 2.   [1]

56 Explain why nucleus 2 and nucleus 4 represent the nuclei of two different isotopes of the same element.   [1]

57 Identify the nucleus above that is found in an atom that has a stable valence electron configuration.   [1]

Base your answers to questions 58 through 60 on the information below and on your knowledge of chemistry.

The equation below represents a chemical reaction at 1 atm and 298 K.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$
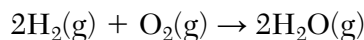
58 State the change in energy that occurs in order to break the bonds in the hydrogen molecules.   [1]

59 In the space *in your answer booklet,* draw a Lewis electron-dot diagram for a water molecule.   [1]

60 Compare the strength of attraction for electrons by a hydrogen atom to the strength of attraction for electrons by an oxygen atom within a water molecule.   [1]

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

- A test tube contains a sample of solid stearic acid, an organic acid.
- Both the sample and the test tube have a temperature of 22.0°C.
- The stearic acid melts after the test tube is placed in a beaker with 320. grams of water at 98.0°C.
- The temperature of the liquid stearic acid and water in the beaker reaches 74.0°C.

61 Identify the element in stearic acid that makes it an organic compound.   [1]

62 State the direction of heat transfer between the test tube and the water when the test tube was placed in the water.   [1]

63 Show a numerical setup for calculating the amount of thermal energy change for the water in the beaker.   [1]

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

A nuclear reaction is represented by the equation below.

$$^{3}_{1}H \rightarrow {}^{3}_{2}He + {}^{0}_{-1}e$$
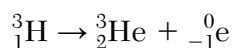
64 Identify the decay mode of hydrogen-3.   [1]

65 Explain why the equation represents a transmutation.   [1]

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 68 on the information below and on your knowledge of chemistry.

A technician recorded data for two properties of Period 3 elements. The data are shown in the table below.

Two Properties of Period 3 Elements

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Ionic Radius (pm)	95	66	51	41	212	184	181	—
Reaction with Cold Water	reacts vigorously	reacts very slowly	no observable reaction	no observable reaction	no observable reaction	no observable reaction	reacts slowly	no observable reaction

66 Identify the element in this table that is classified as a metalloid. [1]

67 State the phase of chlorine at 281 K and 101.3 kPa. [1]

68 State evidence from the technician's data which indicates that sodium is more active than aluminum. [1]

Base your answers to questions 69 through 71 on the information below and on your knowledge of chemistry.

Ammonia, $NH_3(g)$, can be used as a substitute for fossil fuels in some internal combustion engines. The reaction between ammonia and oxygen in an engine is represented by the unbalanced equation below.

$$NH_3(g) + O_2(g) \rightarrow N_2(g) + H_2O(g) + energy$$
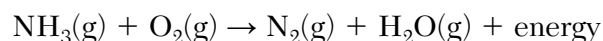
69 Balance the equation *in your answer booklet* for the reaction of ammonia and oxygen, using the smallest whole-number coefficients. [1]

70 Show a numerical setup for calculating the mass, in grams, of a 4.2-mole sample of O_2. Use 32 g/mol as the gram-formula mass of O_2. [1]

71 Determine the new pressure of a 6.40-L sample of oxygen gas at 300. K and 100. kPa after the gas is compressed to 2.40 L at 900. K. [1]

Base your answers to questions 72 through 76 on the information below and on your knowledge of chemistry.

Fruit growers in Florida protect oranges when the temperature is near freezing by spraying water on them. It is the freezing of the water that protects the oranges from frost damage. When $H_2O(\ell)$ at 0°C changes to $H_2O(s)$ at 0°C, heat energy is released. This energy helps to prevent the temperature inside the orange from dropping below freezing, which could damage the fruit. After harvesting, oranges can be exposed to ethene gas, C_2H_4, to improve their color.

72 Write the empirical formula for ethene.   [1]

73 Explain, in terms of bonding, why the hydrocarbon ethene is classified as unsaturated.   [1]

74 Determine the gram-formula mass of ethene.   [1]

75 Explain, in terms of particle arrangement, why the entropy of the water *decreases* when the water freezes.   [1]

76 Determine the quantity of heat released when 2.00 grams of $H_2O(\ell)$ freezes at 0°C.   [1]

Base your answers to questions 77 through 80 on the information below and on your knowledge of chemistry.

A student constructs an electrochemical cell during a laboratory investigation. When the switch is closed, electrons flow through the external circuit. The diagram and ionic equation below represent this cell and the reaction that occurs.

$$Cu^{2+}(aq) + Zn(s) \longrightarrow Cu(s) + Zn^{2+}(aq)$$
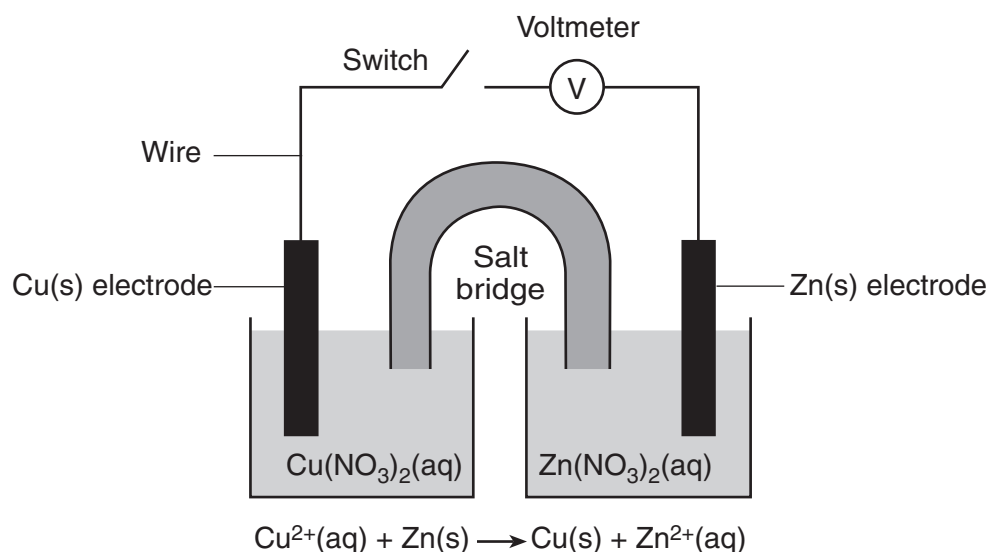
77 State the form of energy that is converted to electrical energy in the operating cell. [1]

78 State, in terms of the Cu(s) electrode and the Zn(s) electrode, the direction of electron flow in the external circuit when the cell operates. [1]

79 Write a balanced equation for the half-reaction that occurs in the Cu half-cell when the cell operates. [1]

80 State what happens to the mass of the Cu electrode and the mass of the Zn electrode in the operating cell. [1]

Base your answers to questions 81 and 82 on the information below and on your knowledge of chemistry.

A solution is made by dissolving 70.0 grams of $KNO_3(s)$ in 100. grams of water at 50.°C and standard pressure.

81 Show a numerical setup for calculating the percent by mass of KNO_3 in the solution. [1]

82 Determine the number of additional grams of KNO_3 that must dissolve to make this solution saturated. [1]

Base your answers to questions 83 through 85 on the information below and on your knowledge of chemistry.

Vinegar is a commercial form of acetic acid, $HC_2H_3O_2(aq)$. One sample of vinegar has a pH value of 2.4.

83 Explain, in terms of particles, why $HC_2H_3O_2(aq)$ can conduct an electric current. [1]

84 State the color of bromthymol blue indicator in a sample of the commercial vinegar. [1]

85 State the pH value of a sample that has ten times *fewer* hydronium ions than an equal volume of a vinegar sample with a pH value of 2.4. [1]