

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

**PHYSICAL SETTING  
CHEMISTRY**

**Thursday, January 26, 2012 — 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 *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 the examination booklet.

The answers to *all* questions in this examination are to be written in your separate answer booklet. Be sure to fill in the heading on the front of 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 in your answer booklet.

When you have completed the examination, you must sign the statement printed on the first page of your answer booklet, 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 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.

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 in your answer booklet 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*.

- What is the number of electrons in a completely filled second shell of an atom?  
(1) 32 (2) 2 (3) 18 (4) 8
- What is the number of electrons in an atom that has 3 protons and 4 neutrons?  
(1) 1 (2) 7 (3) 3 (4) 4
- As a result of the gold foil experiment, it was concluded that an atom  
(1) contains protons, neutrons, and electrons  
(2) contains a small, dense nucleus  
(3) has positrons and orbitals  
(4) is a hard, indivisible sphere
- Which statement describes the distribution of charge in an atom?  
(1) A neutral nucleus is surrounded by one or more negatively charged electrons.  
(2) A neutral nucleus is surrounded by one or more positively charged electrons.  
(3) A positively charged nucleus is surrounded by one or more negatively charged electrons.  
(4) A positively charged nucleus is surrounded by one or more positively charged electrons.
- Which atom in the ground state has an outermost electron with the most energy?  
(1) Cs (2) K (3) Li (4) Na
- Which particle has the *least* mass?  
(1) alpha particle (2) beta particle (3) neutron (4) proton
- The elements in Group 2 are classified as  
(1) metals (2) metalloids (3) nonmetals (4) noble gases
- Which list includes elements with the most similar chemical properties?  
(1) Br, Ga, Hg (2) Cr, Pb, Xe (3) O, S, Se (4) N, O, F
- The notation for the nuclide  $^{137}_{55}\text{Cs}$  gives information about  
(1) mass number, only  
(2) atomic number, only  
(3) both mass number and atomic number  
(4) neither mass number nor atomic number
- Which pair represents two forms of an element in the same phase at STP but with different structures and different properties?  
(1)  $\text{I}_2(\text{s})$  and  $\text{I}_2(\text{g})$  (2)  $\text{O}_2(\text{g})$  and  $\text{O}_3(\text{g})$  (3)  $\text{H}_2(\text{g})$  and  $\text{Hg}(\text{g})$  (4)  $\text{H}_2\text{O}(\text{s})$  and  $\text{H}_2\text{O}(\ell)$
- The elements on the Periodic Table are arranged in order of increasing  
(1) atomic mass (2) atomic number (3) molar mass (4) oxidation number
- What is the IUPAC name for the compound  $\text{ZnO}$ ?  
(1) zinc oxide (2) zinc oxalate (3) zinc peroxide (4) zinc hydroxide
- Which atom attains a stable valence electron configuration by bonding with another atom?  
(1) neon (2) radon (3) helium (4) hydrogen

- 14 An ionic bond can be formed when one or more electrons are
- (1) equally shared by two atoms
  - (2) unequally shared by two atoms
  - (3) transferred from the nucleus of one atom to the nucleus of another atom
  - (4) transferred from the valence shell of one atom to the valence shell of another atom
- 15 Which sample of  $\text{CO}_2$  has a definite shape and a definite volume?
- (1)  $\text{CO}_2(\text{aq})$
  - (2)  $\text{CO}_2(\text{g})$
  - (3)  $\text{CO}_2(\ell)$
  - (4)  $\text{CO}_2(\text{s})$
- 16 What occurs in order to break the bond in a  $\text{Cl}_2$  molecule?
- (1) Energy is absorbed.
  - (2) Energy is released.
  - (3) The molecule creates energy.
  - (4) The molecule destroys energy.
- 17 A sealed, rigid 1.0-liter cylinder contains He gas at STP. An identical sealed cylinder contains Ne gas at STP. These two cylinders contain the same number of
- (1) atoms
  - (2) electrons
  - (3) ions
  - (4) protons
- 18 Which statement describes a chemical change?
- (1) Alcohol evaporates.
  - (2) Water vapor forms snowflakes.
  - (3) Table salt ( $\text{NaCl}$ ) is crushed into powder.
  - (4) Glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) and oxygen produce  $\text{CO}_2$  and  $\text{H}_2\text{O}$ .
- 19 Which statement describes the particles of an ideal gas according to the kinetic molecular theory?
- (1) The gas particles are arranged in a regular geometric pattern.
  - (2) The gas particles are in random, constant, straight-line motion.
  - (3) The gas particles are separated by very small distances, relative to their sizes.
  - (4) The gas particles are strongly attracted to each other.
- 20 Which sample of matter is classified as a substance?
- (1) air
  - (2) ammonia
  - (3) milk
  - (4) seawater
- 21 Which element has the *lowest* electronegativity value?
- (1) F
  - (2) Fr
  - (3) Cl
  - (4) Cr
- 22 At standard pressure,  $\text{CH}_4$  boils at 112 K and  $\text{H}_2\text{O}$  boils at 373 K. What accounts for the higher boiling point of  $\text{H}_2\text{O}$  at standard pressure?
- (1) covalent bonding
  - (2) ionic bonding
  - (3) hydrogen bonding
  - (4) metallic bonding
- 23 A mixture of sand and table salt can be separated by filtration because the substances in the mixture differ in
- (1) boiling point
  - (2) density at STP
  - (3) freezing point
  - (4) solubility in water
- 24 Systems in nature tend to undergo changes toward
- (1) lower energy and lower entropy
  - (2) lower energy and higher entropy
  - (3) higher energy and lower entropy
  - (4) higher energy and higher entropy
- 25 In the wave-mechanical model of the atom, an orbital is the most probable location of
- (1) a proton
  - (2) a positron
  - (3) a neutron
  - (4) an electron
- 26 Functional groups are used to classify
- (1) organic compounds
  - (2) inorganic compounds
  - (3) heterogeneous mixtures
  - (4) homogeneous mixtures

- 27 Which class of compounds contains *at least one* element from Group 17 of the Periodic Table?
- (1) aldehyde                      (3) ester  
(2) amine                          (4) halide
- 28 In a propanal molecule, an oxygen atom is bonded with a carbon atom. What is the total number of pairs of electrons shared between these atoms?
- (1) 1                                  (3) 3  
(2) 2                                  (4) 4
- 29 When a voltaic cell operates, ions move through the
- (1) anode                          (3) salt bridge  
(2) cathode                        (4) external circuit
- 30 When dissolved in water, an Arrhenius base yields
- (1) hydrogen ions                (3) hydroxide ions  
(2) hydronium ions               (4) oxide ions
-

Part B-1

Answer all questions in this part.

Directions (31–50): For each statement or question, write in your answer booklet 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.

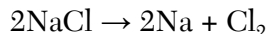
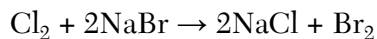
31 What is the total number of valence electrons in a germanium atom in the ground state?

- (1) 22 (3) 32  
(2) 2 (4) 4

32 Which element is paired with an excited-state electron configuration for an atom of the element?

- (1) Ca: 2-8-8-2 (3) K: 2-6-8-3  
(2) Na: 2-8-2 (4) F: 2-8

33 Given the balanced equations representing two chemical reactions:



Which types of chemical reactions are represented by these equations?

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

34 An ion that consists of 7 protons, 6 neutrons, and 10 electrons has a net charge of

- (1) 4- (3) 3+  
(2) 3- (4) 4+

35 Which Lewis electron-dot diagram represents a molecule having a nonpolar covalent bond?



(1)



(3)



(2)



H

(4)

36 Which quantity is equal to 50 kilojoules?

- (1) 0.05 J (3)  $5 \times 10^3$  J  
(2) 500 J (4)  $5 \times 10^4$  J

37 Which compound is formed from its elements by an exothermic reaction at 298 K and 101.3 kPa?

- (1)  $\text{C}_2\text{H}_4(\text{g})$  (3)  $\text{H}_2\text{O}(\text{g})$   
(2)  $\text{HI}(\text{g})$  (4)  $\text{NO}_2(\text{g})$

38 At which temperature is the vapor pressure of ethanol equal to 80. kPa?

- (1) 48°C (3) 80°C  
(2) 73°C (4) 101°C

39 At 25°C, gas in a rigid cylinder with a movable piston has a volume of 145 mL and a pressure of 125 kPa. Then the gas is compressed to a volume of 80. mL. What is the new pressure of the gas if the temperature is held at 25°C?

- (1) 69 kPa (3) 160 kPa  
(2) 93 kPa (4) 230 kPa

40 A 2400.-gram sample of an aqueous solution contains 0.012 gram of  $\text{NH}_3$ . What is the concentration of  $\text{NH}_3$  in the solution, expressed as parts per million?

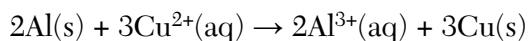
- (1) 5.0 ppm (3) 20. ppm  
(2) 15 ppm (4) 50. ppm

41 Which equation represents a change that results in an increase in disorder?

- (1)  $\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g})$   
(2)  $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{s})$   
(3)  $2\text{Na}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{NaCl}(\text{s})$   
(4)  $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\ell)$

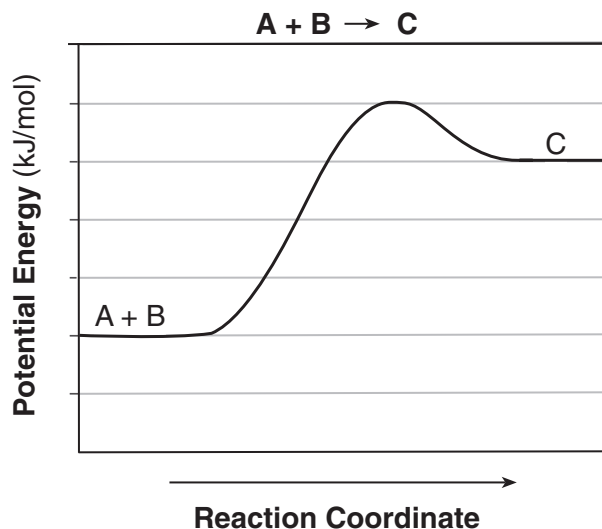
- 42 A solution consists of 0.50 mole of  $\text{CaCl}_2$  dissolved in 100. grams of  $\text{H}_2\text{O}$  at  $25^\circ\text{C}$ . Compared to the boiling point and freezing point of 100. grams of  $\text{H}_2\text{O}$  at standard pressure, the solution at standard pressure has
- (1) a lower boiling point and a lower freezing point
  - (2) a lower boiling point and a higher freezing point
  - (3) a higher boiling point and a lower freezing point
  - (4) a higher boiling point and a higher freezing point

- 43 Given the balanced ionic equation representing a reaction:



Which half-reaction represents the reduction that occurs?

- (1)  $\text{Al} \rightarrow \text{Al}^{3+} + 3e$
  - (2)  $\text{Al}^{3+} + 3e \rightarrow \text{Al}$
  - (3)  $\text{Cu} \rightarrow \text{Cu}^{2+} + 2e$
  - (4)  $\text{Cu}^{2+} + 2e \rightarrow \text{Cu}$
- 44 Given the equation and potential energy diagram representing a reaction:



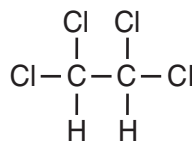
If each interval on the axis labeled “Potential Energy (kJ/mol)” represents 10. kJ/mol, what is the heat of reaction?

- (1) +60. kJ/mol
- (2) +20. kJ/mol
- (3) +30. kJ/mol
- (4) +40. kJ/mol

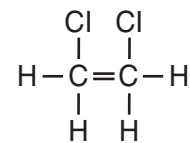
- 45 Some solid  $\text{KNO}_3$  remains at the bottom of a stoppered flask containing a saturated  $\text{KNO}_3(\text{aq})$  solution at  $22^\circ\text{C}$ . Which statement explains why the contents of the flask are at equilibrium?

- (1) The rate of dissolving is equal to the rate of crystallization.
- (2) The rate of dissolving is greater than the rate of crystallization.
- (3) The concentration of the solid is equal to the concentration of the solution.
- (4) The concentration of the solid is greater than the concentration of the solution.

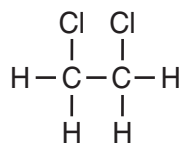
- 46 Which formula represents the product of the addition reaction between ethene and chlorine,  $\text{Cl}_2$ ?



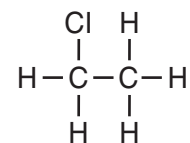
(1)



(3)



(2)



(4)

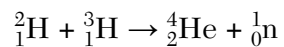
- 47 Based on Reference Table J, which two reactants react spontaneously?

- (1)  $\text{Mg}(s) + \text{ZnCl}_2(\text{aq})$
- (2)  $\text{Cu}(s) + \text{FeSO}_4(\text{aq})$
- (3)  $\text{Pb}(s) + \text{ZnCl}_2(\text{aq})$
- (4)  $\text{Co}(s) + \text{NaCl}(\text{aq})$

- 48 When the pH value of a solution is changed from 2 to 1, the concentration of hydronium ions

- (1) decreases by a factor of 2
- (2) increases by a factor of 2
- (3) decreases by a factor of 10
- (4) increases by a factor of 10

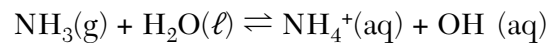
49 Given the balanced equation representing a nuclear reaction:



Which phrase identifies and describes this reaction?

- (1) fission, mass converted to energy
- (2) fission, energy converted to mass
- (3) fusion, mass converted to energy
- (4) fusion, energy converted to mass

50 Given the equation representing a reversible reaction:



According to one acid-base theory, the reactant that donates an  $\text{H}^+$  ion in the forward reaction is

- (1)  $\text{NH}_3(\text{g})$
- (2)  $\text{H}_2\text{O}(\ell)$
- (3)  $\text{NH}_4^+(\text{aq})$
- (4)  $\text{OH}^-(\text{aq})$

## 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 *Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 51 through 54 on the information below.

The atomic radius and the ionic radius for some Group 1 and some Group 17 elements are given in the tables below.

#### Atomic and Ionic Radii of Some Elements

##### Group 1

Particle	Radius (pm)
Li atom	130.
Li <sup>+</sup> ion	78
Na atom	160.
Na <sup>+</sup> ion	98
K atom	200.
K <sup>+</sup> ion	133
Rb atom	215
Rb <sup>+</sup> ion	148

##### Group 17

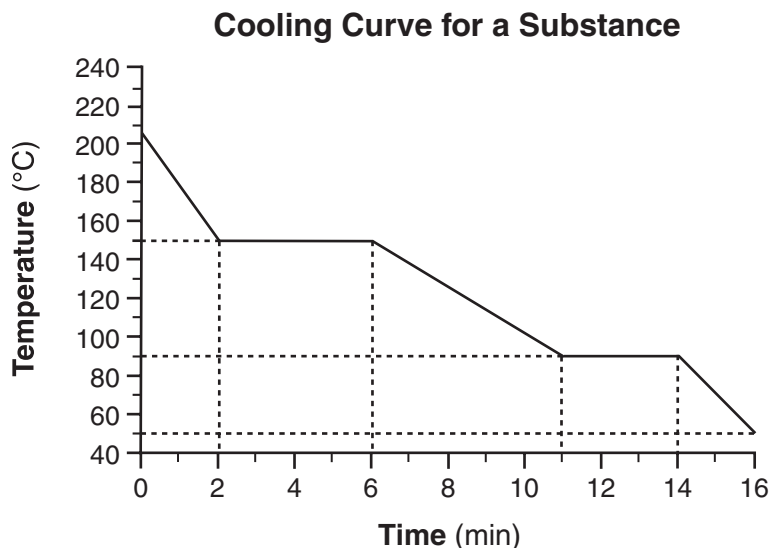
Particle	Radius (pm)
F atom	60.
F <sup>-</sup> ion	133
Cl atom	100.
Cl <sup>-</sup> ion	181
Br atom	117
Br <sup>-</sup> ion	?
I atom	136
I <sup>-</sup> ion	220.

- 51 Estimate the radius of a Br<sup>-</sup> ion. [1]
- 52 Explain, in terms of electron shells, why the radius of a K<sup>+</sup> ion is greater than the radius of an Na<sup>+</sup> ion. [1]
- 53 Write *both* the name and the charge of the particle that is gained by an F atom when the atom becomes an F<sup>-</sup> ion. [1]
- 54 State the relationship between atomic number and first ionization energy as the elements in Group 1 are considered in order of increasing atomic number. [1]
-



Base your answers to questions 55 through 57 on the information below.

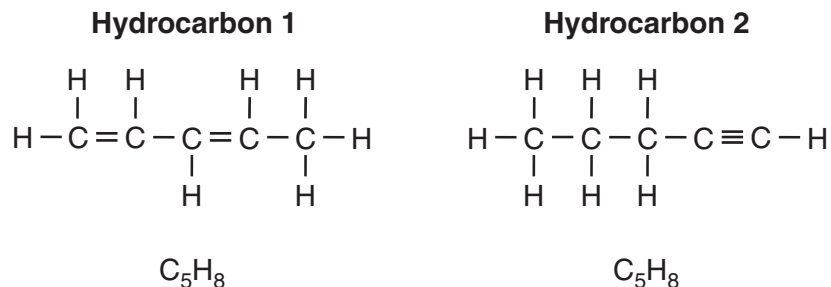
Starting as a gas at 206°C, a sample of a substance is allowed to cool for 16 minutes. This process is represented by the cooling curve below.



- 55 What is the melting point of this substance? [1]
- 56 At what time do the particles of this sample have the *lowest* average kinetic energy? [1]
- 57 Using the key in your answer booklet, draw *two* particle diagrams to represent the *two* phases of the sample at minute 4. Your response must include *at least six* particles for *each* diagram. [1]
- 

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

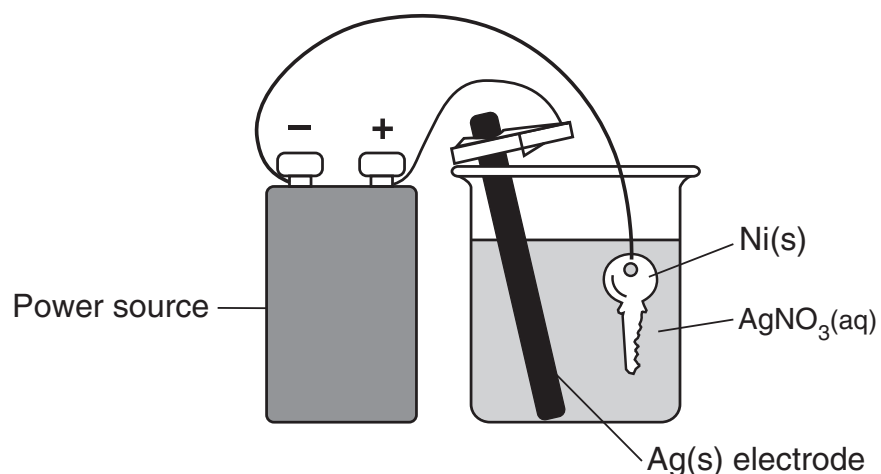
Two hydrocarbons that are isomers of each other are represented by the structural formulas and molecular formulas below.



- 58 Explain, in terms of bonds, why these hydrocarbons are unsaturated. [1]
- 59 Explain, in terms of structural formulas and molecular formulas, why these hydrocarbons are isomers of each other. [1]
-

Base your answers to questions 60 through 62 on the information below.

The diagram below represents an operating electrolytic cell used to plate silver onto a nickel key. As the cell operates, oxidation occurs at the silver electrode and the mass of the silver electrode decreases.



- 60 Identify the cathode in the cell. [1]
- 61 State the purpose of the power source in the cell. [1]
- 62 Explain, in terms of Ag atoms and Ag<sup>+</sup>(aq) ions, why the mass of the silver electrode *decreases* as the cell operates. [1]
- 

Base your answers to questions 63 through 65 on the information below.

In a titration, a few drops of an indicator are added to a flask containing 35.0 milliliters of HNO<sub>3</sub>(aq) of unknown concentration. After 30.0 milliliters of 0.15 M NaOH(aq) solution is slowly added to the flask, the indicator changes color, showing the acid is neutralized.

- 63 The volume of the NaOH(aq) solution is expressed to what number of significant figures? [1]
- 64 Complete the equation *in your answer booklet* for this neutralization reaction by writing the formula of *each* product. [1]
- 65 In the space *in your answer booklet*, show a numerical setup for calculating the concentration of the HNO<sub>3</sub>(aq) solution. [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 *Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 66 through 69 on the information below.

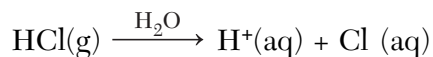
During a fireworks display, salts are heated to very high temperatures. Ions in the salts absorb energy and become excited. Spectacular colors are produced as energy is emitted from the ions in the form of light.

The color of the emitted light is characteristic of the metal ion in each salt. For example, the lithium ion in lithium carbonate,  $\text{Li}_2\text{CO}_3$ , produces a deep-red color. The strontium ion in strontium carbonate,  $\text{SrCO}_3$ , produces a bright-red color. Similarly, calcium chloride is used for orange light, sodium chloride for yellow light, and barium chloride for green light.

- 66 Write the formula for the salt used to produce green light in a fireworks display. [1]
- 67 Identify the *two* types of chemical bonds found in the salt used to produce a deep-red color. [1]
- 68 Determine the oxidation state of carbon in the salt used to produce a bright-red color. [1]
- 69 Explain, in terms of subatomic particles and energy states, how the colors in a fireworks display are produced. [1]
- 

Base your answers to questions 70 and 71 on the information below.

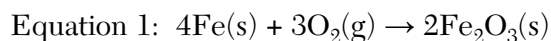
A scientist makes a solution that contains 44.0 grams of hydrogen chloride gas,  $\text{HCl}(\text{g})$ , in 200. grams of water,  $\text{H}_2\text{O}(\ell)$ , at  $20.^\circ\text{C}$ . This process is represented by the balanced equation below.



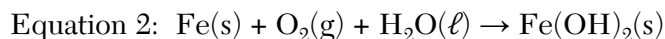
- 70 Based on Reference Table G, identify, in terms of saturation, the type of solution made by the scientist. [1]
- 71 Explain, in terms of the distribution of particles, why the solution is a homogeneous mixture. [1]
-

Base your answers to questions 72 through 74 on the information below.

Iron has been used for thousands of years. In the air, iron corrodes. One reaction for the corrosion of iron is represented by the balanced equation below.



In the presence of water, iron corrodes more quickly. This corrosion is represented by the unbalanced equation below.



- 72 Identify *one* substance in the passage that can *not* be broken down by a chemical change. [1]
- 73 Using equation 1, describe *one* chemical property of iron. [1]
- 74 Balance the equation *in your answer booklet*, using the smallest whole-number coefficients. [1]
- 

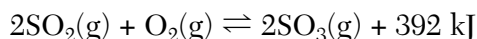
Base your answers to questions 75 through 78 on the information below.

Vitamin C, also known as ascorbic acid, is water soluble and cannot be produced by the human body. Each day, a person's diet should include a source of vitamin C, such as orange juice. Ascorbic acid has a molecular formula of  $\text{C}_6\text{H}_8\text{O}_6$  and a gram-formula mass of 176 grams per mole.

- 75 What is the color of the indicator thymol blue after it is added to an aqueous solution of vitamin C? [1]
- 76 Determine the number of moles of vitamin C in an orange that contains 0.071 gram of vitamin C. [1]
- 77 In the space *in your answer booklet*, show a numerical setup for calculating the percent composition by mass of oxygen in ascorbic acid. [1]
- 78 Write the empirical formula for ascorbic acid. [1]
-

Base your answers to questions 79 through 81 on the information below.

Several steps are involved in the industrial production of sulfuric acid. One step involves the oxidation of sulfur dioxide gas to form sulfur trioxide gas. A catalyst is used to increase the rate of production of sulfur trioxide gas. In a rigid cylinder with a movable piston, this reaction reaches equilibrium, as represented by the equation below.



- 79 Explain, in terms of collision theory, why increasing the pressure of the gases in the cylinder increases the rate of the forward reaction. [1]
- 80 Determine the amount of heat released by the production of 1.0 mole of  $\text{SO}_3(\text{g})$ . [1]
- 81 State, in terms of the concentration of  $\text{SO}_3(\text{g})$ , what occurs when more  $\text{O}_2(\text{g})$  is added to the reaction at equilibrium. [1]
- 

Base your answers to questions 82 through 85 on the information below.

Nuclear radiation is harmful to living cells, particularly to fast-growing cells, such as cancer cells and blood cells. An external beam of the radiation emitted from a radioisotope can be directed on a small area of a person to destroy cancer cells within the body.

Cobalt-60 is an artificially produced radioisotope that emits gamma rays and beta particles. One hospital keeps a 100.0-gram sample of cobalt-60 in an appropriate, secure storage container for future cancer treatment.

- 82 State *one* risk to human tissue associated with the use of radioisotopes to treat cancer. [1]
- 83 Compare the penetrating power of the two emissions from the Co-60. [1]
- 84 Complete the nuclear equation *in your answer booklet* for the beta decay of the Co-60 by writing an isotopic notation for the missing product. [1]
- 85 Determine the total time that will have elapsed when 12.5 grams of the original Co-60 sample at the hospital remains unchanged. [1]
-





