

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

# PHYSICAL SETTING CHEMISTRY

Wednesday, June 20, 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 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.

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, 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 The mass of a proton is approximately equal to the mass of

- (1) an alpha particle      (3) a positron  
(2) a beta particle      (4) a neutron

2 An orbital of an atom is defined as the most probable location of

- (1) an electron      (3) a positron  
(2) a neutron      (4) a proton

3 What must occur when an electron in an atom returns from a higher energy state to a lower energy state?

- (1) A specific amount of energy is released.  
(2) A random amount of energy is released.  
(3) The atom undergoes transmutation.  
(4) The atom spontaneously decays.

4 Which element is a liquid at 305 K and 1.0 atmosphere?

- (1) magnesium      (3) gallium  
(2) fluorine      (4) iodine

5 Which list of elements consists of a metal, a metalloid, and a nonmetal?

- (1) Li, Na, Rb      (3) Sn, Si, C  
(2) Cr, Mo, W      (4) O, S, Te

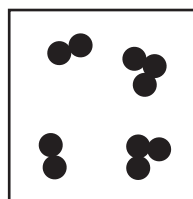
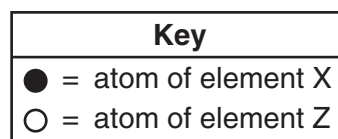
6 At STP, which physical property of aluminum always remains the same from sample to sample?

- (1) mass      (3) length  
(2) density      (4) volume

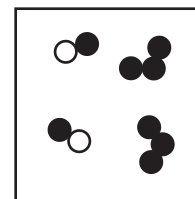
7 Which statement describes a chemical property of silicon?

- (1) Silicon has a blue-gray color.  
(2) Silicon is a brittle solid at 20.°C.  
(3) Silicon melts at 1414°C.  
(4) Silicon reacts with fluorine.

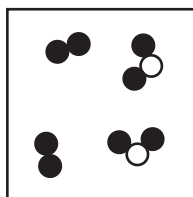
8 Which diagram represents a mixture of two different molecular forms of the same element?



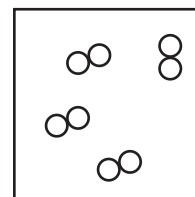
(1)



(3)



(2)



(4)

9 A compound is broken down by chemical means during

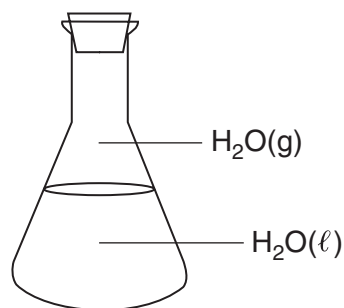
- (1) chromatography      (3) electrolysis  
(2) distillation      (4) filtration

- 10 Which quantities must be conserved in all chemical reactions?  
 (1) mass, charge, density  
 (2) mass, charge, energy  
 (3) charge, volume, density  
 (4) charge, volume, energy
- 11 Which phrase describes the distribution of charge and the polarity of a  $\text{CH}_4$  molecule?  
 (1) symmetrical and polar  
 (2) symmetrical and nonpolar  
 (3) asymmetrical and polar  
 (4) asymmetrical and nonpolar
- 12 What is the charge of the nucleus of an oxygen atom?  
 (1) 0  
 (2)  $-2$   
 (3)  $+8$   
 (4)  $+16$
- 13 Which ion has *no* electrons?  
 (1)  $\text{H}^+$   
 (2)  $\text{Li}^+$   
 (3)  $\text{Na}^+$   
 (4)  $\text{Rb}^+$
- 14 To break a chemical bond, energy must be  
 (1) absorbed  
 (2) destroyed  
 (3) produced  
 (4) released
- 15 Which Lewis electron-dot diagram represents a nitrogen atom in the ground state?  
 (1)  $\overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{N}}}$   
 (2)  $\cdot\underset{\cdot}{\text{N}}\cdot$   
 (3)  $\cdot\overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{N}}}\cdot$   
 (4)  $:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{N}}}:$
- 16 What is the most likely electronegativity value for a metallic element?  
 (1) 1.3  
 (2) 2.7  
 (3) 3.4  
 (4) 4.0
- 17 Which polyatomic ion has a charge of  $3-$ ?  
 (1) chromate ion  
 (2) oxalate ion  
 (3) phosphate ion  
 (4) thiocyanate ion
- 18 Every chlorine atom has  
 (1) 7 electrons  
 (2) 17 neutrons  
 (3) a mass number of 35  
 (4) an atomic number of 17
- 19 Which substance can *not* be broken down by a chemical change?  
 (1) ammonia  
 (2) methanol  
 (3) propane  
 (4) phosphorus
- 20 At standard pressure, which substance becomes *less* soluble in water as temperature increases from  $10.^{\circ}\text{C}$  to  $80.^{\circ}\text{C}$ ?  
 (1)  $\text{HCl}$   
 (2)  $\text{KCl}$   
 (3)  $\text{NaCl}$   
 (4)  $\text{NH}_4\text{Cl}$
- 21 Which type of concentration is calculated when the grams of solute is divided by the grams of the solution, and the result is multiplied by 1 000 000?  
 (1) molarity  
 (2) parts per million  
 (3) percent by mass  
 (4) percent by volume
- 22 Which type of energy is associated with the random motion of atoms and molecules in a sample of air?  
 (1) chemical energy  
 (2) electrical energy  
 (3) nuclear energy  
 (4) thermal energy
- 23 The temperature of a sample of matter is a measure of the  
 (1) total kinetic energy of the particles in the sample  
 (2) total potential energy of the particles in the sample  
 (3) average potential energy of the particles in the sample  
 (4) average kinetic energy of the particles in the sample
- 24 Which unit is used to express the pressure of a gas?  
 (1) mole  
 (2) joule  
 (3) kelvin  
 (4) pascal

25 Which sample of matter sublimates at room temperature and standard pressure?

- (1)  $\text{Br}_2(\ell)$                       (3)  $\text{CO}_2(\text{s})$   
(2)  $\text{Cl}_2(\text{g})$                       (4)  $\text{SO}_2(\text{aq})$

26 Given the diagram representing a closed system at constant temperature:



**Stoppered Flask**

Which statement describes this system at equilibrium?

- (1) The mass of  $\text{H}_2\text{O}(\ell)$  equals the mass of  $\text{H}_2\text{O}(\text{g})$ .  
(2) The volume of  $\text{H}_2\text{O}(\ell)$  equals the volume of  $\text{H}_2\text{O}(\text{g})$ .  
(3) The number of moles of  $\text{H}_2\text{O}(\ell)$  equals the number of moles of  $\text{H}_2\text{O}(\text{g})$ .  
(4) The rate of evaporation of  $\text{H}_2\text{O}(\ell)$  equals the rate of condensation of  $\text{H}_2\text{O}(\text{g})$ .

27 Which reaction occurs at the cathode in an electrochemical cell?

- (1) combustion                      (3) oxidation  
(2) neutralization                      (4) reduction

28 Which substance yields  $\text{H}^+(\text{aq})$  as the only positive ion in an aqueous solution?

- (1)  $\text{CH}_3\text{CHO}$                       (3)  $\text{CH}_3\text{COOH}$   
(2)  $\text{CH}_3\text{CH}_2\text{OH}$                       (4)  $\text{CH}_3\text{OCH}_3$

29 Compared to the mass and the penetrating power of an alpha particle, a beta particle has

- (1) less mass and greater penetrating power  
(2) less mass and less penetrating power  
(3) more mass and greater penetrating power  
(4) more mass and less penetrating power

30 During a nuclear reaction, mass is converted into

- (1) charge                      (3) isomers  
(2) energy                      (4) volume

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 An atom in the ground state has two electrons in its first shell and six electrons in its second shell. What is the total number of protons in the nucleus of this atom?

(1) 5 (3) 7  
(2) 2 (4) 8

- 32 A bromine atom in an excited state could have an electron configuration of

(1) 2-8-18-6 (3) 2-8-17-7  
(2) 2-8-18-7 (4) 2-8-17-8

- 33 The atomic masses and the natural abundances of the two naturally occurring isotopes of lithium are shown in the table below.

Lithium Isotopes

Isotope	Atomic Mass (u)	Natural Abundance (%)
Li-6	6.02	7.5
Li-7	7.02	92.5

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

(1)  $(0.075)(6.02 \text{ u}) + (0.925)(7.02 \text{ u})$   
(2)  $(0.925)(6.02 \text{ u}) + (0.075)(7.02 \text{ u})$   
(3)  $(7.5)(6.02 \text{ u}) + (92.5)(7.02 \text{ u})$   
(4)  $(92.5)(6.02 \text{ u}) + (7.5)(7.02 \text{ u})$

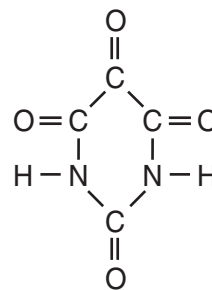
- 34 Element X reacts with chlorine to form an ionic compound that has the formula  $XCl_2$ . To which group on the Periodic Table could element X belong?

(1) Group 1 (3) Group 13  
(2) Group 2 (4) Group 15

- 35 Which general trend is found in Period 3 as the elements are considered in order of increasing atomic number?

(1) increasing atomic radius  
(2) increasing electronegativity  
(3) decreasing atomic mass  
(4) decreasing first ionization energy

- 36 Given the formula for a compound:



Which molecular formula and empirical formula represent this compound?

(1)  $C_2HNO_2$  and  $CHNO$   
(2)  $C_2HNO_2$  and  $C_2HNO_2$   
(3)  $C_4H_2N_2O_4$  and  $CHNO$   
(4)  $C_4H_2N_2O_4$  and  $C_2HNO_2$

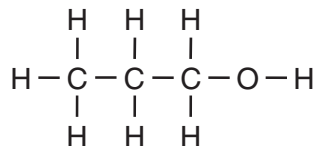
- 37 What is the gram-formula mass of  $(NH_4)_3PO_4$ ?

(1) 112 g/mol (3) 149 g/mol  
(2) 121 g/mol (4) 242 g/mol

- 38 In the ground state, which atom has a completely filled valence electron shell?

(1) C (3) Ne  
(2) V (4) Sb

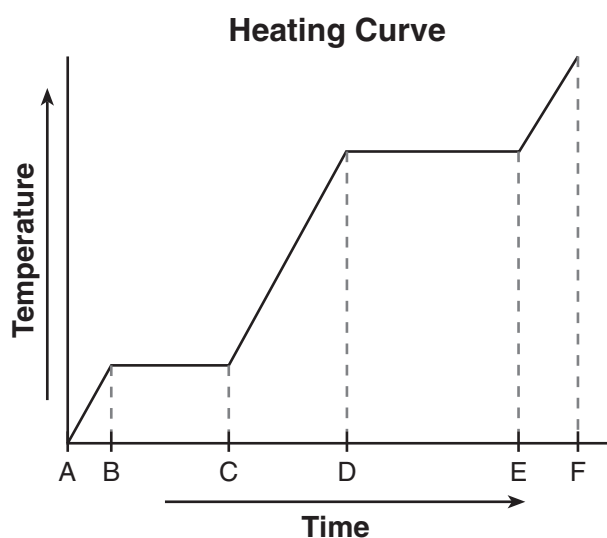
39 Given the formula:



The bond between which two atoms has the greatest degree of polarity?

- (1) C and C                      (3) H and C  
 (2) C and O                      (4) H and O

40 Given the diagram representing a heating curve for a substance:



During which time interval is the average kinetic energy of the particles of the substance constant while the potential energy of the particles increases?

- (1) AC                              (3) CD  
 (2) BC                              (4) DF

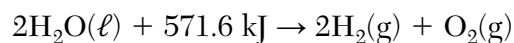
41 At 50.°C and standard pressure, intermolecular forces of attraction are strongest in a sample of

- (1) ethanoic acid                (3) propanone  
 (2) ethanol                        (4) water

42 At 101.3 kPa and 298 K, what is the total amount of heat released when one mole of aluminum oxide,  $\text{Al}_2\text{O}_3(\text{s})$ , is formed from its elements?

- (1) 393.5 kJ                      (3) 1676 kJ  
 (2) 837.8 kJ                      (4) 3351 kJ

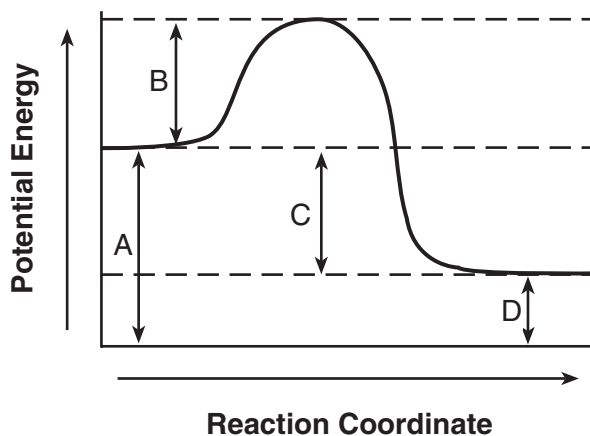
43 Given the balanced equation representing a reaction:



What occurred as a result of this reaction?

- (1) Energy was absorbed, and entropy increased.  
 (2) Energy was absorbed, and entropy decreased.  
 (3) Energy was released, and entropy increased.  
 (4) Energy was released, and entropy decreased.

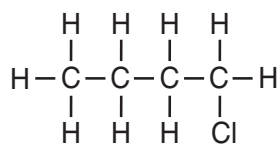
44 Given the potential energy diagram representing a reversible reaction:



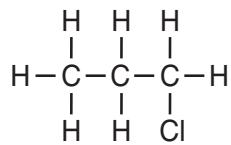
The activation energy for the reverse reaction is represented by

- (1) A + B                      (3) B + D  
 (2) B + C                      (4) C + D

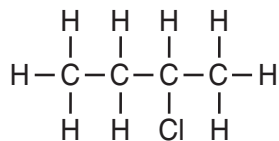
45 Which formula represents a molecule of 2-chlorobutane?



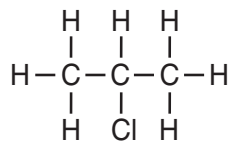
(1)



(3)

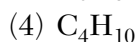
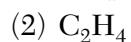


(2)

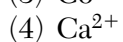
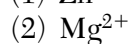
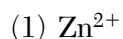


(4)

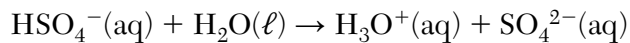
46 Which formula represents an unsaturated hydrocarbon?



47 Which ion is most easily reduced?



48 Given the balanced equation representing a reaction:



According to one acid-base theory, the  $\text{H}_2\text{O}(\ell)$  molecules act as

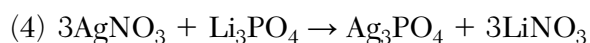
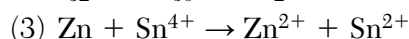
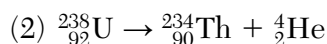
(1) a base because they accept  $\text{H}^+$  ions

(2) a base because they donate  $\text{H}^+$  ions

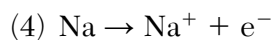
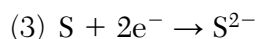
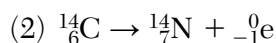
(3) an acid because they accept  $\text{H}^+$  ions

(4) an acid because they donate  $\text{H}^+$  ions

49 Which equation represents an oxidation-reduction reaction?



50 Which equation represents natural transmutation?



## Part B–2

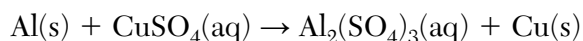
### Answer all questions in this part.

*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 What is the mass of  $\text{KNO}_3(\text{s})$  that must dissolve in 100. grams of water to form a saturated solution at  $50.^\circ\text{C}$ ? [1]

Base your answers to questions 52 through 55 on the information below.

The reaction between aluminum and an aqueous solution of copper(II) sulfate is represented by the unbalanced equation below.



- 52 Identify the type of chemical reaction represented by the equation. [1]
- 53 Balance the equation *in your answer booklet*, using the smallest whole-number coefficients. [1]
- 54 Explain why the equation represents a chemical change. [1]
- 55 Determine the total mass of Cu produced when 1.08 grams of Al reacts completely with 9.58 grams of  $\text{CuSO}_4$  to produce 6.85 grams of  $\text{Al}_2(\text{SO}_4)_3$ . [1]
- 

Base your answers to questions 56 through 59 on the information below.

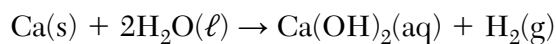
A total of 1.4 moles of sodium nitrate is dissolved in enough water to make 2.0 liters of an aqueous solution. The gram-formula mass of sodium nitrate is 85 grams per mole.

- 56 Write the chemical formula for the solute in the solution. [1]
- 57 Show a numerical setup for calculating the mass of the solute used to make the solution. [1]
- 58 Compare the boiling point of the solution at standard pressure to the boiling point of  $\text{H}_2\text{O}$  at standard pressure. [1]
- 59 Determine the molarity of the solution. [1]
-



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

Calcium reacts with water. This reaction is represented by the balanced equation below. The aqueous product of this reaction can be heated to evaporate the water, leaving a white solid,  $\text{Ca}(\text{OH})_2(\text{s})$ .



- 60 Compare the electrical conductivity of the aqueous product in the reaction to the electrical conductivity of the white solid that remains after the water is evaporated from the solution. [1]
- 61 Write the chemical name of the base produced in the reaction. [1]
- 62 State *one* change in reaction conditions that will increase the rate of the reaction. [1]
- 

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

In a titration, 20.0 milliliters of 0.15 M  $\text{HCl}(\text{aq})$  is exactly neutralized by 18.0 milliliters of  $\text{KOH}(\text{aq})$ .

- 63 Complete the equation *in your answer booklet* for the neutralization reaction by writing the formula of *each* product. [1]
- 64 Compare the number of moles of  $\text{H}^+(\text{aq})$  ions to the number of moles of  $\text{OH}^-(\text{aq})$  ions in the titration mixture when the  $\text{HCl}(\text{aq})$  is exactly neutralized by the  $\text{KOH}(\text{aq})$ . [1]
- 65 Determine the concentration of the  $\text{KOH}(\text{aq})$ . [1]
-

## Part C

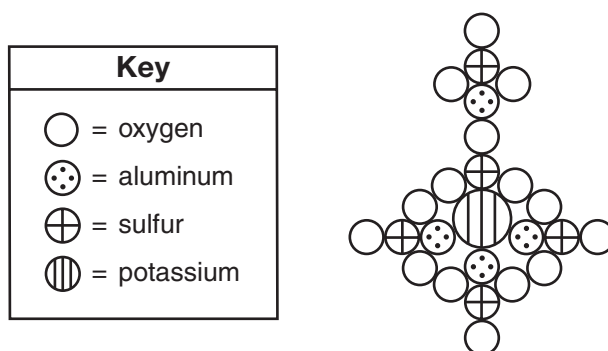
### Answer all questions in this part.

*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.

John Dalton, an early scientist, sketched the structure of compounds using his own symbols for the elements known at the time. Dalton's symbols for four elements and his drawing of potassium aluminum sulfate are represented by the diagram below.

#### Dalton's Drawing for Potassium Aluminum Sulfate

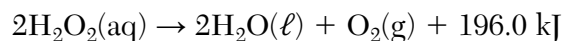


Today, it is known that the chemical formula for potassium aluminum sulfate is  $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ . It is a hydrated compound because water molecules are included within its crystal structure. There are 12 moles of  $\text{H}_2\text{O}$  for every 1 mole of  $\text{KAl}(\text{SO}_4)_2$ . The compound contains two different positive ions. The gram-formula mass of  $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$  is 474 grams per mole.

- 66 Identify *one* positive ion in the hydrated compound. Your response must include *both* the chemical symbol and charge of the ion. [1]
- 67 Describe, in terms of composition, *one* way in which Dalton's perception of potassium aluminum sulfate differs from what is known today about the compound. [1]
- 68 Show a numerical setup for calculating the percent composition by mass of water in  $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ . [1]
-

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

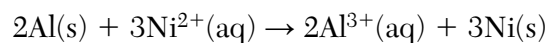
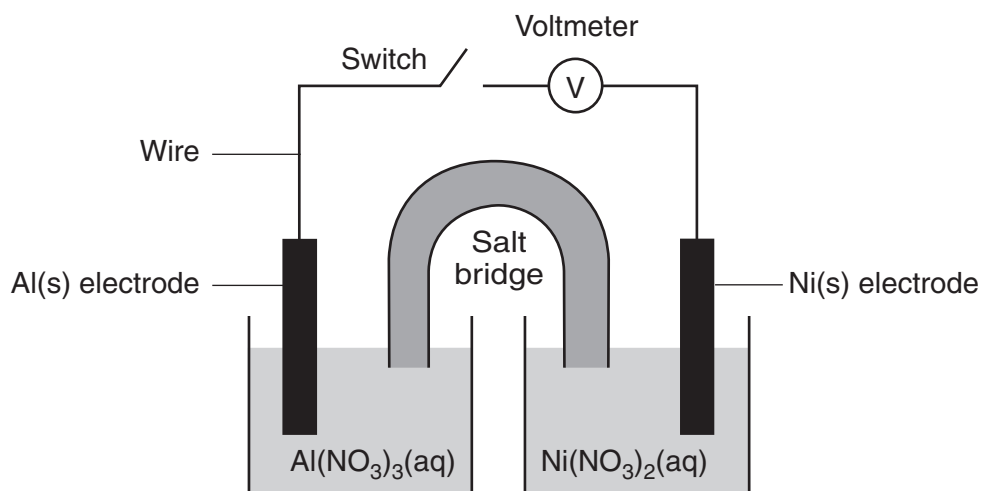
At standard pressure, hydrogen peroxide,  $\text{H}_2\text{O}_2$ , melts at  $-0.4^\circ\text{C}$ , boils at  $151^\circ\text{C}$ , and is very soluble in water. A bottle of aqueous hydrogen peroxide,  $\text{H}_2\text{O}_2(\text{aq})$ , purchased from a pharmacy has a pressure-releasing cap. Aqueous hydrogen peroxide decomposes at room temperature, as represented by the balanced equation below.



- 69 State, in terms of *both* melting point and boiling point, why  $\text{H}_2\text{O}_2$  is a liquid at room temperature. [1]
- 70 State evidence that indicates the decomposition of  $\text{H}_2\text{O}_2(\text{aq})$  is exothermic. [1]
- 71 Explain why a hydrogen peroxide bottle needs a pressure-releasing cap. [1]
- 

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

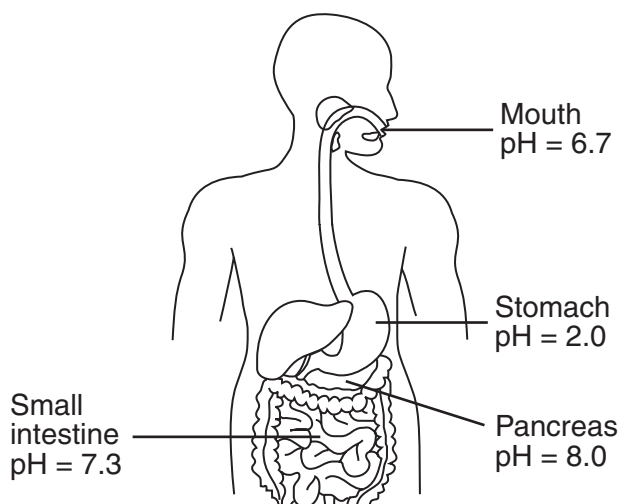
A student constructs an electrochemical cell during a laboratory investigation. When the switch is closed, electrons flow through the external circuit. The diagram and equation below represent this cell and the reaction that occurs.



- 72 State the direction of electron flow through the wire when the switch is closed. [1]
- 73 Write a balanced half-reaction equation for the oxidation that occurs when the switch is closed. [1]
- 74 Determine the number of moles of  $\text{Al}(\text{s})$  needed to completely react with 9.0 moles of  $\text{Ni}^{2+}(\text{aq})$  ions. [1]
- 75 State, in terms of energy, why this cell is a voltaic cell. [1]
-

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

The diagram below shows typical pH values found in four parts of the human digestive system. In the small intestine, the enzyme lipase acts as a catalyst, increasing the rate of fat digestion.



76 Which labeled part of the digestive system has the most acidic environment? [1]

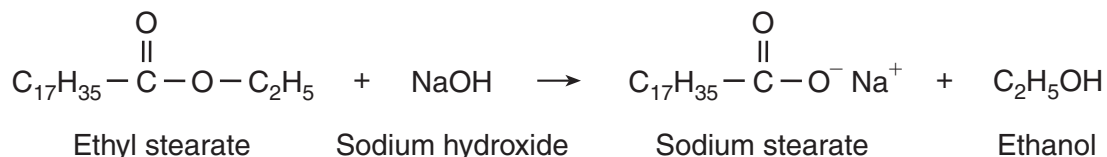
77 What is the color of thymol blue at the pH of the small intestine? [1]

78 State how the catalyst lipase increases the rate of the fat digestion. [1]

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

One type of soap is produced when ethyl stearate and sodium hydroxide react. The soap produced by this reaction is called sodium stearate. The other product of the reaction is ethanol. This reaction is represented by the balanced equation below.



79 Identify the type of organic reaction used to make soap. [1]

80 To which class of organic compounds does ethyl stearate belong? [1]

81 Identify the *two* types of bonds in the compound sodium stearate. [1]

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

Nuclear fission has been used to produce electricity. However, nuclear fusion for electricity production is still under development. The notations of some nuclides used in nuclear reactions are shown in the table below.

**Some Nuclides Used in Nuclear Reactions**

Reaction	Nuclides
nuclear fission	${}_{92}^{233}\text{U}$ , ${}_{92}^{235}\text{U}$
nuclear fusion	${}_1^1\text{H}$ , ${}_1^3\text{H}$

- 82 Compare the atomic masses of nuclides used in fusion to the atomic masses of nuclides used in fission. [1]
- 83 Complete the table *in your answer booklet* that compares the total number of protons and the total number of neutrons for the hydrogen nuclides used for fusion. [1]
- 84 Complete the nuclear equation *in your answer booklet* for the fission of  ${}_{92}^{235}\text{U}$  by writing the notation of the missing product. [1]
- 85 State *one* potential benefit of using nuclear fusion instead of the current use of nuclear fission to produce electricity. [1]
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