

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

**PHYSICAL SETTING  
CHEMISTRY**

**Wednesday, June 20, 2018 — 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.**

## Part A

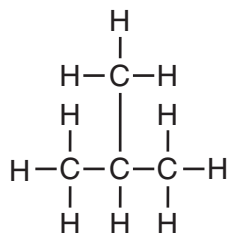
Answer all questions in this part.

*Directions (1–30):* For *each* statement or question, record on your separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

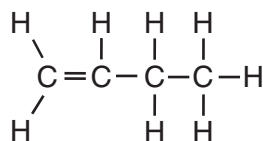
- 1 Which statement describes the charge and location of an electron in an atom?
  - (1) An electron has a positive charge and is located outside the nucleus.
  - (2) An electron has a positive charge and is located in the nucleus.
  - (3) An electron has a negative charge and is located outside the nucleus.
  - (4) An electron has a negative charge and is located in the nucleus.
- 2 Which statement explains why a xenon atom is electrically neutral?
  - (1) The atom has fewer neutrons than electrons.
  - (2) The atom has more protons than electrons.
  - (3) The atom has the same number of neutrons and electrons.
  - (4) The atom has the same number of protons and electrons.
- 3 If two atoms are isotopes of the same element, the atoms must have
  - (1) the same number of protons and the same number of neutrons
  - (2) the same number of protons and a different number of neutrons
  - (3) a different number of protons and the same number of neutrons
  - (4) a different number of protons and a different number of neutrons
- 4 Which electrons in a calcium atom in the ground state have the greatest effect on the chemical properties of calcium?
  - (1) the two electrons in the first shell
  - (2) the two electrons in the fourth shell
  - (3) the eight electrons in the second shell
  - (4) the eight electrons in the third shell
- 5 The weighted average of the atomic masses of the naturally occurring isotopes of an element is the
  - (1) atomic mass of the element
  - (2) atomic number of the element
  - (3) mass number of each isotope
  - (4) formula mass of each isotope
- 6 Which element is classified as a metalloid?
  - (1) Cr
  - (2) Cs
  - (3) Sc
  - (4) Si
- 7 Which statement describes a chemical property of iron?
  - (1) Iron oxidizes.
  - (2) Iron is a solid at STP.
  - (3) Iron melts.
  - (4) Iron is attracted to a magnet.
- 8 Graphite and diamond are two forms of the same element in the solid phase that differ in their
  - (1) atomic numbers
  - (2) crystal structures
  - (3) electronegativities
  - (4) empirical formulas
- 9 Which ion has the largest radius?
  - (1)  $\text{Br}^-$
  - (2)  $\text{Cl}^-$
  - (3)  $\text{F}^-$
  - (4)  $\text{I}^-$
- 10 Carbon monoxide and carbon dioxide have
  - (1) the same chemical properties and the same physical properties
  - (2) the same chemical properties and different physical properties
  - (3) different chemical properties and the same physical properties
  - (4) different chemical properties and different physical properties

- 11 Based on Table S, which group on the Periodic Table has the element with the highest electronegativity?
- (1) Group 1                      (3) Group 17  
(2) Group 2                      (4) Group 18
- 12 What is represented by the chemical formula  $\text{PbCl}_2(\text{s})$ ?
- (1) a substance  
(2) a solution  
(3) a homogeneous mixture  
(4) a heterogeneous mixture
- 13 What is the vapor pressure of propanone at  $50.^\circ\text{C}$ ?
- (1) 37 kPa                      (3) 83 kPa  
(2) 50. kPa                      (4) 101 kPa
- 14 Which statement describes the charge distribution and the polarity of a  $\text{CH}_4$  molecule?
- (1) The charge distribution is symmetrical and the molecule is nonpolar.  
(2) The charge distribution is asymmetrical and the molecule is nonpolar.  
(3) The charge distribution is symmetrical and the molecule is polar.  
(4) The charge distribution is asymmetrical and the molecule is polar.
- 15 In a laboratory investigation, a student separates colored compounds obtained from a mixture of crushed spinach leaves and water by using paper chromatography. The colored compounds separate because of differences in
- (1) molecular polarity  
(2) malleability  
(3) boiling point  
(4) electrical conductivity
- 16 Which phrase describes the motion and attractive forces of ideal gas particles?
- (1) random straight-line motion and no attractive forces  
(2) random straight-line motion and strong attractive forces  
(3) random curved-line motion and no attractive forces  
(4) random curved-line motion and strong attractive forces
- 17 At which temperature will  $\text{Hg}(\ell)$  and  $\text{Hg}(\text{s})$  reach equilibrium in a closed system at 1.0 atmosphere?
- (1) 234 K                      (3) 373 K  
(2) 273 K                      (4) 630. K
- 18 A molecule of any organic compound has at least one
- (1) ionic bond                      (3) oxygen atom  
(2) double bond                      (4) carbon atom
- 19 A chemical reaction occurs when reactant particles
- (1) are separated by great distances  
(2) have no attractive forces between them  
(3) collide with proper energy and proper orientation  
(4) convert chemical energy into nuclear energy
- 20 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
- 21 Which formula can represent an alkyne?
- (1)  $\text{C}_2\text{H}_4$                       (3)  $\text{C}_3\text{H}_4$   
(2)  $\text{C}_2\text{H}_6$                       (4)  $\text{C}_3\text{H}_6$

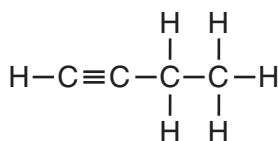
22 Given the formula representing a compound:



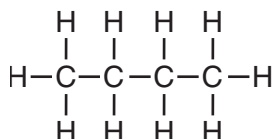
Which formula represents an isomer of this compound?



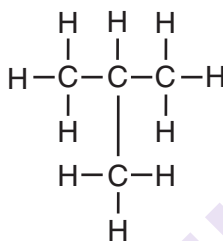
(1)



(3)



(2)



(4)

23 Which energy conversion occurs in an operating voltaic cell?

- (1) chemical energy to electrical energy
- (2) chemical energy to nuclear energy
- (3) electrical energy to chemical energy
- (4) electrical energy to nuclear energy

24 Which process requires energy to decompose a substance?

- (1) electrolysis
- (2) neutralization
- (3) sublimation
- (4) synthesis

25 The concentration of which ion is increased when LiOH is dissolved in water?

- (1) hydroxide ion
- (2) hydrogen ion
- (3) hydronium ion
- (4) halide ion

26 Which equation represents neutralization?

- (1)  $6\text{Li(s)} + \text{N}_2\text{(g)} \rightarrow 2\text{Li}_3\text{N(s)}$
- (2)  $2\text{Mg(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{MgO(s)}$
- (3)  $2\text{KOH(aq)} + \text{H}_2\text{SO}_4\text{(aq)} \rightarrow \text{K}_2\text{SO}_4\text{(aq)} + 2\text{H}_2\text{O(l)}$
- (4)  $\text{Pb(NO}_3)_2\text{(aq)} + \text{K}_2\text{CrO}_4\text{(aq)} \rightarrow 2\text{KNO}_3\text{(aq)} + \text{PbCrO}_4\text{(s)}$

27 The stability of an isotope is related to its ratio of

- (1) neutrons to positrons
- (2) neutrons to protons
- (3) electrons to positrons
- (4) electrons to protons

28 Which particle has the *least* mass?

- (1) alpha particle
- (2) beta particle
- (3) neutron
- (4) proton

29 The energy released during a nuclear reaction is a result of

- (1) breaking chemical bonds
- (2) forming chemical bonds
- (3) mass being converted to energy
- (4) energy being converted to mass

30 The use of uranium-238 to determine the age of a geological formation is a beneficial use of

- (1) nuclear fusion
- (2) nuclear fission
- (3) radioactive isomers
- (4) radioactive isotopes

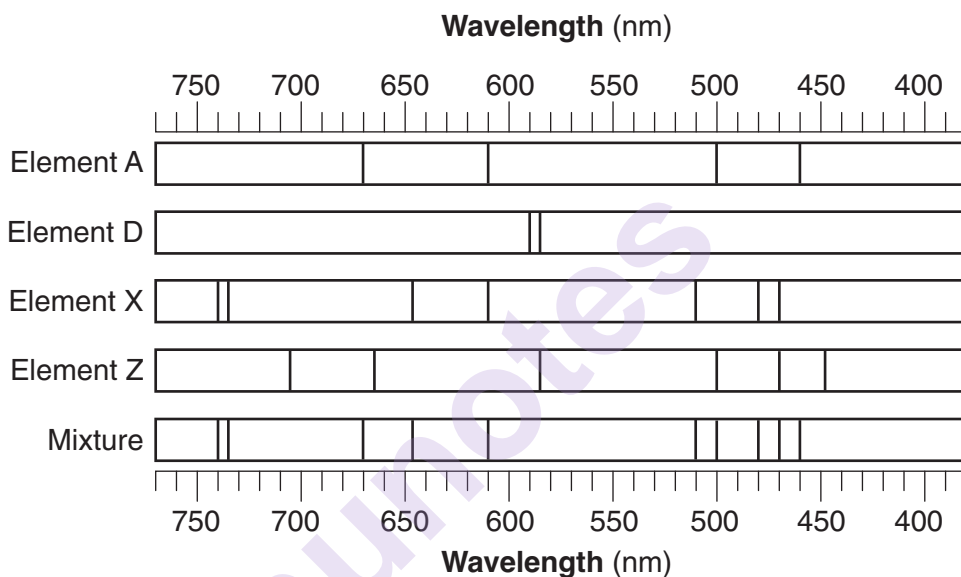
## Part B-1

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*.

Base your answers to questions 31 and 32 on your knowledge of chemistry and the bright-line spectra produced by four elements and the spectrum of a mixture of elements represented in the diagram below.

### Bright-Line Spectra



31 Which elements are present in this mixture?

- |             |             |
|-------------|-------------|
| (1) D and A | (3) X and A |
| (2) D and Z | (4) X and Z |

32 Each line in the spectra represents the energy

- (1) absorbed as an atom loses an electron
  - (2) absorbed as an atom gains an electron
  - (3) released as an electron moves from a lower energy state to a higher energy state
  - (4) released as an electron moves from a higher energy state to a lower energy state
-

- 33 The table below shows the number of protons, neutrons, and electrons in four ions.

**Four Ions**

<b>Ion</b>	<b>Number of Protons</b>	<b>Number of Neutrons</b>	<b>Number of Electrons</b>
A	8	10	10
E	9	10	10
G	11	12	10
J	12	12	10

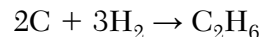
Which ion has a charge of 2-?

- (1) A (3) G  
(2) E (4) J
- 34 What is the approximate mass of an atom that contains 26 protons, 26 electrons and 19 neutrons?
- (1) 26 u (3) 52 u  
(2) 45 u (4) 71 u
- 35 Which electron configuration represents a potassium atom in an excited state?
- (1) 2-7-6 (3) 2-8-8-1  
(2) 2-8-5 (4) 2-8-7-2

- 36 What is the total number of neutrons in an atom of K-42?

- (1) 19 (3) 23  
(2) 20 (4) 42

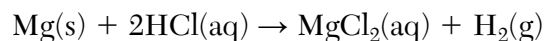
- 37 Given the equation representing a reaction:



What is the number of moles of C that must completely react to produce 2.0 moles of C<sub>2</sub>H<sub>6</sub>?

- (1) 1.0 mol (3) 3.0 mol  
(2) 2.0 mol (4) 4.0 mol

- 38 Given the equation representing a reaction:



Which type of chemical reaction is represented by the equation?

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

39 The table below lists properties of selected elements at room temperature.

**Properties of Selected Elements at Room Temperature**

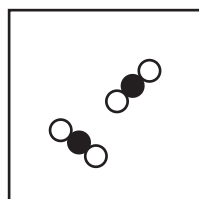
Element	Density (g/cm <sup>3</sup> )	Malleability	Conductivity
sodium	0.97	yes	good
gold	19.3	yes	good
iodine	4.933	no	poor
tungsten	19.3	yes	good

Based on this table, which statement describes how two of these elements can be differentiated from each other?

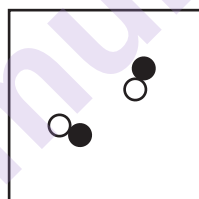
- (1) Gold can be differentiated from tungsten based on density.
- (2) Gold can be differentiated from sodium based on malleability.
- (3) Sodium can be differentiated from tungsten based on conductivity.
- (4) Sodium can be differentiated from iodine based on malleability.

40 Which particle diagram represents a mixture?

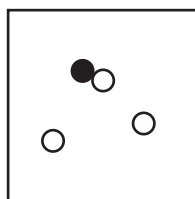
Key
● = an atom of an element
○ = an atom of a different element



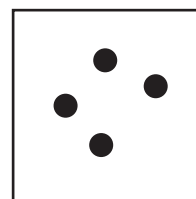
( 1 )



( 2 )



( 3 )



( 4 )

41 An atom of which element reacts with an atom of hydrogen to form a bond with the greatest degree of polarity?

- (1) carbon (3) nitrogen  
(2) fluorine (4) oxygen

42 What is the concentration of an aqueous solution that contains 1.5 moles of NaCl in 500. milliliters of this solution?

- (1) 0.30 M (3) 3.0 M  
(2) 0.75 M (4) 7.5 M

43 The table below shows data for the temperature, pressure, and volume of four gas samples.

**Data for Four Gases**

Gas Sample	Temperature (K)	Pressure (atm)	Volume (L)
I	600.	2.0	5.0
II	300.	1.0	10.0
III	600.	3.0	5.0
IV	300.	1.0	10.0

Which two gas samples contain the same number of molecules?

- (1) I and II (3) II and III  
(2) I and III (4) II and IV

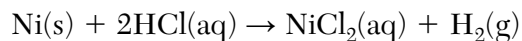
44 Based on Table I, what is the  $\Delta H$  value for the production of 1.00 mole of  $\text{NO}_2(\text{g})$  from its elements at 101.3 kPa and 298 K?

- (1) +33.2 kJ (3) +132.8 kJ  
(2) -33.2 kJ (4) -132.8 kJ

45 Which equation represents an addition reaction?

- (1)  $\text{C}_3\text{H}_8 + \text{Cl}_2 \rightarrow \text{C}_3\text{H}_7\text{Cl} + \text{HCl}$   
(2)  $\text{C}_3\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_3\text{H}_6\text{Cl}_2$   
(3)  $\text{CaCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{NaCl}$   
(4)  $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

46 Given the balanced equation representing a reaction:



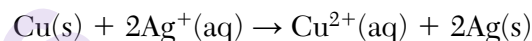
In this reaction, each Ni atom

- (1) loses 1 electron (3) gains 1 electron  
(2) loses 2 electrons (4) gains 2 electrons

47 Which equation represents a reduction half-reaction?

- (1)  $\text{Fe} \rightarrow \text{Fe}^{3+} + 3\text{e}^-$  (3)  $\text{Fe}^{3+} \rightarrow \text{Fe} + 3\text{e}^-$   
(2)  $\text{Fe} + 3\text{e}^- \rightarrow \text{Fe}^{3+}$  (4)  $\text{Fe}^{3+} + 3\text{e}^- \rightarrow \text{Fe}$

48 Given the balanced ionic equation representing a reaction:



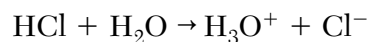
During this reaction, electrons are transferred from

- (1) Cu(s) to  $\text{Ag}^+(\text{aq})$   
(2)  $\text{Cu}^{2+}(\text{aq})$  to Ag(s)  
(3) Ag(s) to  $\text{Cu}^{2+}(\text{aq})$   
(4)  $\text{Ag}^+(\text{aq})$  to Cu(s)

49 Which metal reacts spontaneously with  $\text{Sr}^{2+}$  ions?

- (1) Ca(s) (3) Cs(s)  
(2) Co(s) (4) Cu(s)

50 Given the balanced equation representing a reaction:



The water molecule acts as a base because it

- (1) donates an  $\text{H}^+$  (3) donates an  $\text{OH}^-$   
(2) accepts an  $\text{H}^+$  (4) accepts an  $\text{OH}^-$



**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 State the general trend in first ionization energy as the elements in Period 3 are considered from left to right. [1]
- 52 Identify a type of strong intermolecular force that exists between water molecules, but does *not* exist between carbon dioxide molecules. [1]
- 53 Draw a structural formula for 2-butanol. [1]
- 

Base your answers to questions 54 through 56 on the information below and on your knowledge of chemistry.

Some compounds of silver are listed with their chemical formulas in the table below.

**Silver Compounds**

Name	Chemical Formula
silver carbonate	$\text{Ag}_2\text{CO}_3$
silver chlorate	$\text{AgClO}_3$
silver chloride	$\text{AgCl}$
silver sulfate	$\text{Ag}_2\text{SO}_4$

- 54 Explain, in terms of element classification, why silver chloride is an ionic compound. [1]
- 55 Show a numerical setup for calculating the percent composition by mass of silver in silver carbonate (gram-formula mass = 276 g/mol). [1]
- 56 Identify the silver compound in the table that is most soluble in water. [1]
- 

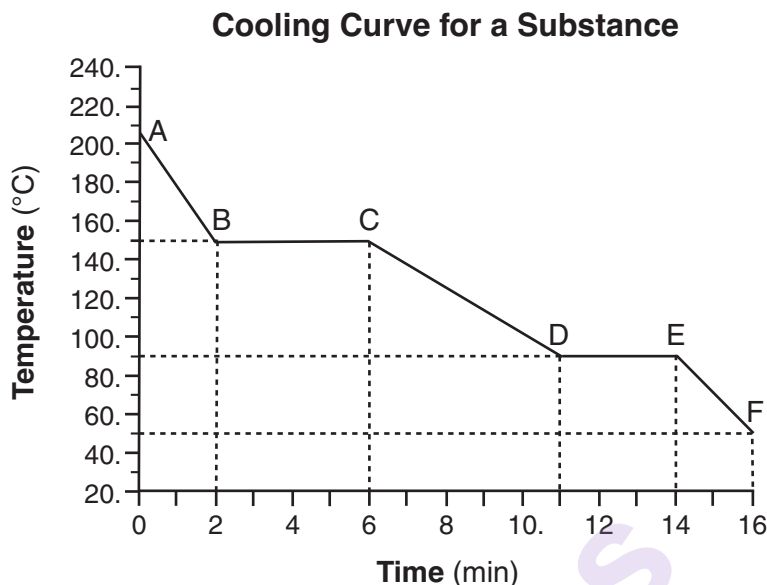
Base your answers to questions 57 through 59 on the information below and on your knowledge of chemistry.

When a cobalt-59 atom is bombarded by a subatomic particle, a radioactive cobalt-60 atom is produced. After 21.084 years, 1.20 grams of an original sample of cobalt-60 produced remains unchanged.

- 57 Complete the nuclear equation by writing a notation for the missing particle. [1]
- 58 Based on Table N, identify the decay mode of cobalt-60. [1]
- 59 Determine the mass of the original sample of cobalt-60 produced. [1]
-

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

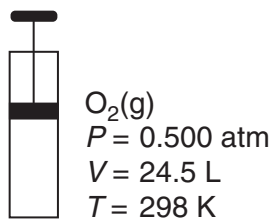
A sample of a molecular substance starting as a gas at 206°C and 1 atm is allowed to cool for 16 minutes. This process is represented by the cooling curve below.



- 60 Determine the number of minutes that the substance was in the liquid phase, only. [1]
- 61 Compare the strength of the intermolecular forces within this substance at 180.°C to the strength of the intermolecular forces within this substance at 120.°C. [1]
- 62 Describe what happens to the potential energy and the average kinetic energy of the molecules in the sample during interval *DE*. [1]
- 

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

The diagram below represents a cylinder with a moveable piston containing 16.0 g of  $O_2(g)$ . At 298 K and 0.500 atm, the  $O_2(g)$  has a volume of 24.5 liters.



- 63 Determine the number of moles of  $O_2(g)$  in the cylinder. The gram-formula mass of  $O_2(g)$  is 32.0 g/mol. [1]
- 64 State the changes in *both* pressure and temperature of the gas in the cylinder that would increase the frequency of collisions between the  $O_2(g)$  molecules. [1]
- 65 Show a numerical setup for calculating the volume of  $O_2(g)$  in the cylinder at 265 K and 1.00 atm. [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 69 on the information below and on your knowledge of chemistry.

In the late 1800s, Dmitri Mendeleev developed a periodic table of the elements known at that time. Based on the pattern in his periodic table, he was able to predict properties of some elements that had not yet been discovered. Information about two of these elements is shown in the table below.

**Some Element Properties Predicted by Mendeleev**

Predicted Elements	Property	Predicted Value	Actual Value
eka-aluminum (Ea)	density at STP	5.9 g/cm <sup>3</sup>	5.91 g/cm <sup>3</sup>
	melting point	low	30.°C
	oxide formula	Ea <sub>2</sub> O <sub>3</sub>	
	approximate molar mass	68 g/mol	
eka-silicon (Es)	density at STP	5.5 g/cm <sup>3</sup>	5.3234 g/cm <sup>3</sup>
	melting point	high	938°C
	oxide formula	EsO <sub>2</sub>	
	approximate molar mass	72 g/mol	

66 Identify the phase of Ea at 310. K. [1]

67 Write a chemical formula for the compound formed between Ea and Cl. [1]

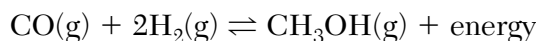
68 Identify the element that Mendeleev called eka-silicon, Es. [1]

69 Show a numerical setup for calculating the percent error of Mendeleev's predicted density of Es. [1]

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

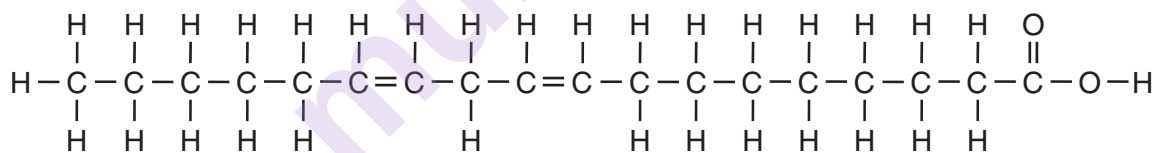
Methanol can be manufactured by a reaction that is reversible. In the reaction, carbon monoxide gas and hydrogen gas react using a catalyst. The equation below represents this system at equilibrium.



- 70 State the class of organic compounds to which the product of the forward reaction belongs. [1]
- 71 Compare the rate of the forward reaction to the rate of the reverse reaction in this equilibrium system. [1]
- 72 Explain, in terms of collision theory, why increasing the concentration of  $\text{H}_2\text{(g)}$  in this system will increase the concentration of  $\text{CH}_3\text{OH(g)}$ . [1]
- 73 State the effect on the rates of both the forward and reverse reactions if no catalyst is used in the system. [1]
- 

Base your answers to questions 74 through 76 on the information below and on your knowledge of chemistry.

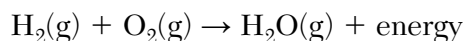
Fatty acids, a class of compounds found in living things, are organic acids with long hydrocarbon chains. Linoleic acid, an unsaturated fatty acid, is essential for human skin flexibility and smoothness. The formula below represents a molecule of linoleic acid.



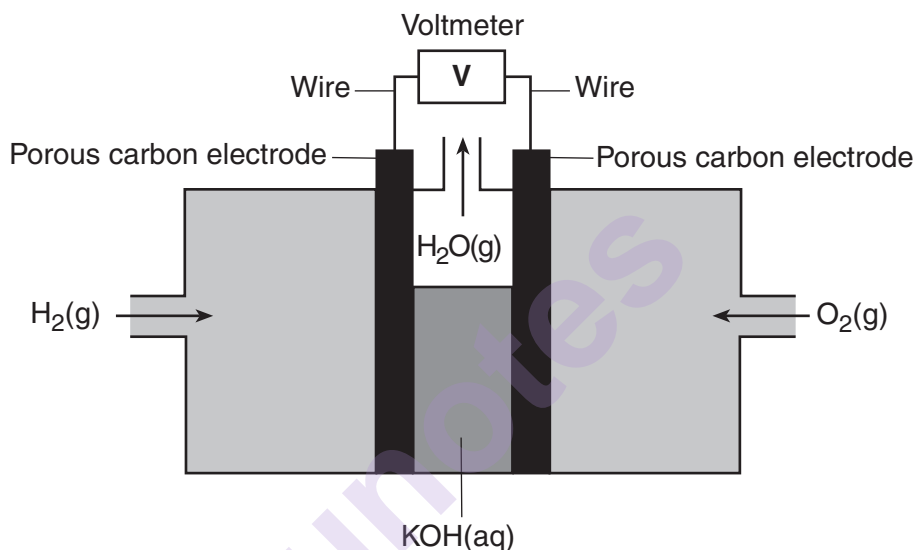
- 74 Write the molecular formula of linoleic acid. [1]
- 75 Identify the type of chemical bond between the oxygen atom and the hydrogen atom in the linoleic acid molecule. [1]
- 76 On the diagram *in your answer booklet*, circle the organic acid functional group. [1]
-

Base your answers to questions 77 through 79 on the information below and on your knowledge of chemistry.

Fuel cells are voltaic cells. In one type of fuel cell, oxygen gas,  $\text{O}_2(\text{g})$ , reacts with hydrogen gas,  $\text{H}_2(\text{g})$ , producing water vapor,  $\text{H}_2\text{O}(\text{g})$ , and electrical energy. The unbalanced equation for this redox reaction is shown below.



A diagram of the fuel cell is shown below. During operation of the fuel cell, hydrogen gas is pumped into one compartment and oxygen gas is pumped into the other compartment. Each compartment has an inner wall that is a porous carbon electrode through which ions flow. Aqueous potassium hydroxide,  $\text{KOH}(\text{aq})$ , and the porous electrodes serve as the salt bridge.



- 77 Balance the equation *in your answer booklet* for the reaction in this fuel cell, using the smallest whole-number coefficients. [1]
- 78 Determine the change in oxidation number for oxygen in this operating fuel cell. [1]
- 79 State the number of moles of electrons that are gained when 5.0 moles of electrons are lost in this reaction. [1]
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Base your answers to questions 80 through 82 on the information below and on your knowledge of chemistry.

In a laboratory investigation, a student compares the concentration and pH value of each of four different solutions of hydrochloric acid,  $\text{HCl(aq)}$ , as shown in the table below.

**Data for  $\text{HCl(aq)}$  Solutions**

<b>Solution</b>	<b>Concentration of <math>\text{HCl(aq)}</math> (M)</b>	<b>pH Value</b>
W	1.0	0
X	0.10	1
Y	0.010	2
Z	0.0010	3

80 State the number of significant figures used to express the concentration of solution Z. [1]

81 Determine the concentration of an  $\text{HCl(aq)}$  solution that has a pH value of 4. [1]

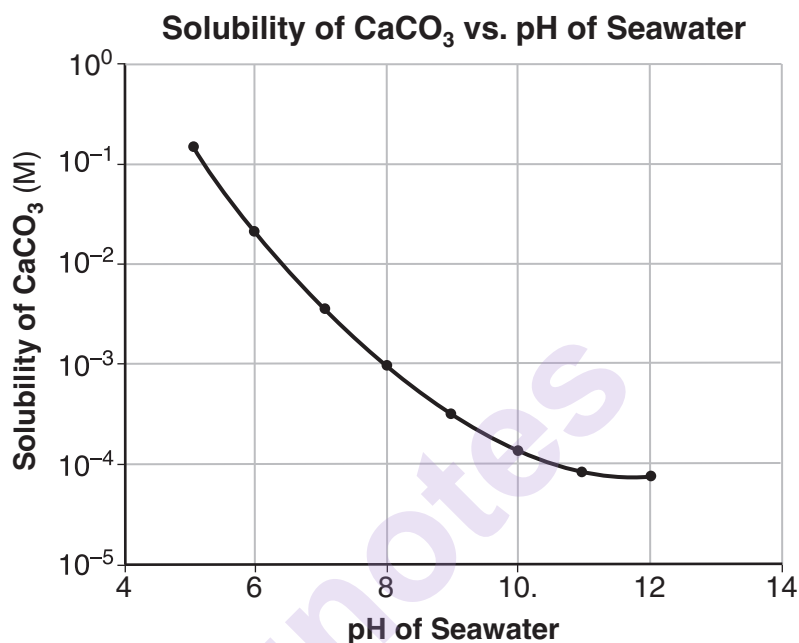
82 Determine the volume of 0.25 M  $\text{NaOH(aq)}$  that would exactly neutralize 75.0 milliliters of solution X. [1]

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

Carbon dioxide is slightly soluble in seawater. As carbon dioxide levels in the atmosphere increase, more  $\text{CO}_2$  dissolves in seawater, making the seawater more acidic because carbonic acid,  $\text{H}_2\text{CO}_3(\text{aq})$ , is formed.

Seawater also contains aqueous calcium carbonate,  $\text{CaCO}_3(\text{aq})$ , which is used by some marine organisms to make their hard exoskeletons. As the acidity of the sea water changes, the solubility of  $\text{CaCO}_3$  also changes, as shown in the graph below.



- 83 State the trend in the solubility of  $\text{CaCO}_3$  as seawater becomes more acidic. [1]
- 84 State the color of bromcresol green in a sample of seawater in which the  $\text{CaCO}_3$  solubility is  $10^{-2}$  M. [1]
- 85 A sample of seawater has a pH of 8. Determine the new pH of the sample if the hydrogen ion concentration is increased by a factor of 100. [1]
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