

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

# PHYSICAL SETTING CHEMISTRY

Thursday, January 27, 2011 — 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 *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 *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*.

- An orbital is a region of space where there is a high probability of finding
  - a proton
  - a positron
  - a neutron
  - an electron
- Which statement matches a subatomic particle with its charge?
  - A neutron has a negative charge.
  - A proton has a negative charge.
  - A neutron has no charge.
  - A proton has no charge.
- An atom of any element must contain
  - an equal number of protons and neutrons
  - an equal number of protons and electrons
  - more electrons than neutrons
  - more electrons than protons
- Which statement compares the masses of two subatomic particles?
  - The mass of an electron is greater than the mass of a proton.
  - The mass of an electron is greater than the mass of a neutron.
  - The mass of a proton is greater than the mass of an electron.
  - The mass of a proton is greater than the mass of a neutron.
- The bright-line spectrum of sodium is produced when energy is
  - absorbed as electrons move from higher to lower electron shells
  - absorbed as electrons move from lower to higher electron shells
  - released as electrons move from higher to lower electron shells
  - released as electrons move from lower to higher electron shells
- The valence electrons of a germanium atom in the ground state are located in the
  - first shell
  - second shell
  - third shell
  - fourth shell
- The elements on the Periodic Table are arranged in order of increasing
  - atomic mass
  - atomic number
  - first ionization energy
  - selected oxidation state
- Which list of elements contains a metal, a metalloid, a nonmetal, and a noble gas?
  - Be, Si, Cl, Kr
  - C, N, Ne, Ar
  - K, Fe, B, F
  - Na, Zn, As, Sb
- The two forms of oxygen,  $O_2(g)$  and  $O_3(g)$ , have
  - different molecular structures and identical properties
  - different molecular structures and different properties
  - identical molecular structures and identical properties
  - identical molecular structures and different properties
- The sum of the atomic masses of the atoms in one molecule of  $C_3H_6Br_2$  is called the
  - formula mass
  - isotopic mass
  - percent abundance
  - percent composition
- What is the total number of electron pairs shared between the two atoms in an  $O_2$  molecule?
  - 1
  - 2
  - 6
  - 4

- 12 When an atom of lithium loses an electron, the atom becomes a
- (1) negative ion with a radius smaller than the radius of the atom
  - (2) negative ion with a radius larger than the radius of the atom
  - (3) positive ion with a radius smaller than the radius of the atom
  - (4) positive ion with a radius larger than the radius of the atom
- 13 Given the balanced equation representing a reaction:
- $$2\text{NaCl} \rightarrow 2\text{Na} + \text{Cl}_2$$
- To break the bonds in NaCl, the reactant must
- (1) absorb energy
  - (2) create energy
  - (3) destroy energy
  - (4) release energy
- 14 A molecular compound is formed when a chemical reaction occurs between atoms of
- (1) chlorine and sodium
  - (2) chlorine and yttrium
  - (3) oxygen and hydrogen
  - (4) oxygen and magnesium
- 15 Which substance can *not* be broken down by chemical means?
- (1) ammonia
  - (2) antimony
  - (3) methane
  - (4) water
- 16 Which two physical properties allow a mixture to be separated by chromatography?
- (1) hardness and boiling point
  - (2) density and specific heat capacity
  - (3) malleability and thermal conductivity
  - (4) solubility and molecular polarity
- 17 The solubility of KCl(s) in water depends on the
- (1) pressure on the solution
  - (2) rate of stirring
  - (3) size of the KCl sample
  - (4) temperature of the water
- 18 Which sample of water contains particles having the highest average kinetic energy?
- (1) 25 mL of water at 95°C
  - (2) 45 mL of water at 75°C
  - (3) 75 mL of water at 75°C
  - (4) 95 mL of water at 25°C
- 19 Under which conditions of temperature and pressure does carbon dioxide gas behave most like an ideal gas?
- (1) low temperature and low pressure
  - (2) low temperature and high pressure
  - (3) high temperature and low pressure
  - (4) high temperature and high pressure
- 20 Which process results in a chemical change?
- (1) tearing tin foil
  - (2) melting an iron bar
  - (3) crushing an aluminum can
  - (4) burning magnesium ribbon
- 21 For a chemical reaction, the heat of reaction is equal to the
- (1) potential energy of the reactants, only
  - (2) potential energy of the products, only
  - (3) potential energy of the products plus the potential energy of the reactants
  - (4) potential energy of the products minus the potential energy of the reactants
- 22 Given the equation representing a system at equilibrium:
- $$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$$
- At equilibrium, the concentration of
- (1) SO<sub>2</sub>(g) must equal the concentration of SO<sub>3</sub>(g)
  - (2) SO<sub>2</sub>(g) must be constant
  - (3) O<sub>2</sub>(g) must equal the concentration of SO<sub>2</sub>(g)
  - (4) O<sub>2</sub>(g) must be decreasing

- 23 The two isomers of butane have different  
(1) formula masses      (3) molecular formulas  
(2) empirical formulas    (4) structural formulas
- 24 An oxidation-reduction reaction involves the  
(1) sharing of electrons  
(2) sharing of protons  
(3) transfer of electrons  
(4) transfer of protons
- 25 Which energy change occurs in an operating voltaic cell?  
(1) chemical to electrical  
(2) electrical to chemical  
(3) chemical to nuclear  
(4) nuclear to chemical
- 26 Which compound is an electrolyte?  
(1) butene                      (3) dimethyl ether  
(2) propane                    (4) methanoic acid
- 27 According to the Arrhenius theory, a base reacts with an acid to produce  
(1) ammonia and methane  
(2) ammonia and a salt  
(3) water and methane  
(4) water and a salt
- 28 What is one benefit associated with a nuclear fission reaction?  
(1) The products are not radioactive.  
(2) Stable isotopes are used as reactants.  
(3) There is no chance of biological exposure.  
(4) A large amount of energy is produced.
- 29 Which balanced equation represents a fusion reaction?  
(1)  ${}_{92}^{235}\text{U} + {}_0^1\text{n} \rightarrow {}_{36}^{93}\text{Kr} + {}_{56}^{140}\text{Ba} + 3{}_0^1\text{n}$   
(2)  ${}_1^2\text{H} + {}_1^3\text{H} \rightarrow {}_2^4\text{He} + {}_0^1\text{n}$   
(3)  ${}_{7}^{14}\text{N} + {}_2^4\text{He} \rightarrow {}_8^{17}\text{O} + {}_1^1\text{H}$   
(4)  ${}_{88}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Rn} + {}_2^4\text{He}$
- 30 Which radioisotope emits alpha particles?  
(1) Fe-53                              (3) Au-198  
(2) Sr-90                              (4) Pu-239

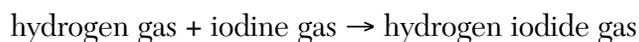
## Part B-1

### 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 Which electron configuration represents the electrons of an atom in an excited state?  
(1) 2-1 (3) 2-8-7  
(2) 2-7-4 (4) 2-4
- 32 What is the total number of neutrons in an atom of O-18?  
(1) 18 (3) 10  
(2) 16 (4) 8
- 33 What is the net charge of an ion that has 8 protons, 9 neutrons, and 10 electrons?  
(1) 1+ (3) 1-  
(2) 2+ (4) 2-
- 34 Which element is malleable and a good conductor of electricity at STP?  
(1) argon (3) iodine  
(2) carbon (4) silver
- 35 Which element has chemical properties that are most similar to the chemical properties of sodium?  
(1) beryllium (3) lithium  
(2) calcium (4) magnesium
- 36 If an element, X, can form an oxide that has the formula  $X_2O_3$ , then element X would most likely be located on the Periodic Table in the same group as  
(1) Ba (3) In  
(2) Cd (4) Na
- 37 What is the total mass of  $KNO_3$  that must be dissolved in 50. grams of  $H_2O$  at  $60.^{\circ}C$  to make a saturated solution?  
(1) 32 g (3) 64 g  
(2) 53 g (4) 106 g
- 38 Which statement describes the general trends in electronegativity and metallic properties as the elements in Period 2 are considered in order of increasing atomic number?  
(1) Both electronegativity and metallic properties decrease.  
(2) Both electronegativity and metallic properties increase.  
(3) Electronegativity decreases and metallic properties increase.  
(4) Electronegativity increases and metallic properties decrease.
- 39 Which balanced equation represents a single-replacement reaction?  
(1)  $Mg + 2AgNO_3 \rightarrow Mg(NO_3)_2 + 2Ag$   
(2)  $2Mg + O_2 \rightarrow 2MgO$   
(3)  $MgCO_3 \rightarrow MgO + CO_2$   
(4)  $MgCl_2 + 2AgNO_3 \rightarrow 2AgCl + Mg(NO_3)_2$
- 40 Given the balanced equation representing a reaction:  
$$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$$
  
This reaction occurs more quickly when powdered iron is used instead of a single piece of iron of the same mass because the powdered iron  
(1) acts as a better catalyst than the single piece of iron  
(2) absorbs less energy than the single piece of iron  
(3) has a greater surface area than the single piece of iron  
(4) is more metallic than the single piece of iron
- 41 The temperature of a sample of water changes from  $10^{\circ}C$  to  $20^{\circ}C$  when the sample absorbs 418 joules of heat. What is the mass of the sample?  
(1) 1 g (3) 100 g  
(2) 10 g (4) 1000 g

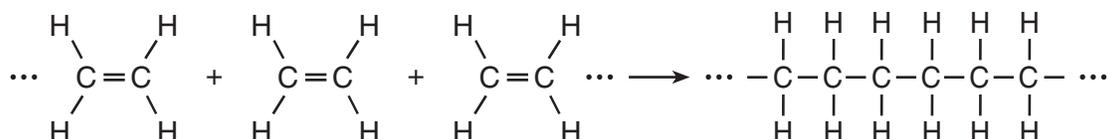
42 Given the reaction at 101.3 kilopascals and 298 K:



This reaction is classified as

- (1) endothermic, because heat is absorbed
- (2) endothermic, because heat is released
- (3) exothermic, because heat is absorbed
- (4) exothermic, because heat is released

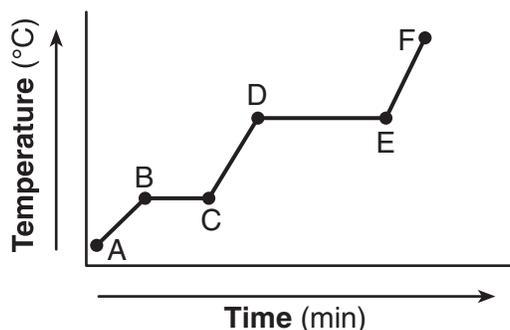
43 Given the equation:



Which type of reaction is represented by this equation?

- |                    |                    |
|--------------------|--------------------|
| (1) combustion     | (3) polymerization |
| (2) esterification | (4) substitution   |

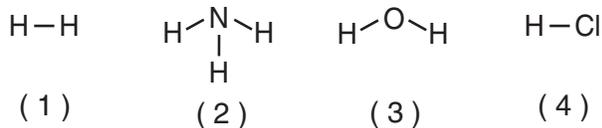
44 The graph below represents the uniform heating of a sample of a substance starting as a solid below its melting point.



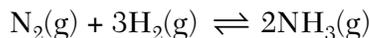
Which statement describes what happens to the energy of the particles of the sample during time interval *DE*?

- (1) Average kinetic energy increases, and potential energy remains the same.
- (2) Average kinetic energy decreases, and potential energy remains the same.
- (3) Average kinetic energy remains the same, and potential energy increases.
- (4) Average kinetic energy remains the same, and potential energy decreases.

45 Which molecule has a nonpolar covalent bond?



46 Given the equation representing a reaction at equilibrium:



What occurs when the concentration of  $\text{H}_2(\text{g})$  is increased?

- (1) The equilibrium shifts to the left, and the concentration of  $\text{N}_2(\text{g})$  decreases.
- (2) The equilibrium shifts to the left, and the concentration of  $\text{N}_2(\text{g})$  increases.
- (3) The equilibrium shifts to the right, and the concentration of  $\text{N}_2(\text{g})$  decreases.
- (4) The equilibrium shifts to the right, and the concentration of  $\text{N}_2(\text{g})$  increases.

47 Which ionic equation is balanced?

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

48 The table below gives information about four aqueous solutions at standard pressure.

**Four Aqueous Solutions**

Aqueous Solution	Concentration (M)	Solute
A	2.0	$\text{BaCl}_2$
B	2.0	$\text{NaNO}_3$
C	1.0	$\text{C}_6\text{H}_{12}\text{O}_6$
D	1.0	$\text{K}_2\text{SO}_3$

Which list of solutions is arranged in order from highest boiling point to lowest boiling point?

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

49 What is the total number of years that must pass before only 25.00 grams of an original 100.0-gram sample of C-14 remains unchanged?

- (1) 2865 y
- (2) 5730 y
- (3) 11 460 y
- (4) 17 190 y

50 Which radioisotope is used for diagnosing thyroid disorders?

- (1) U-238
- (2) Pb-206
- (3) I-131
- (4) Co-60

## 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*.

- 51 Explain, in terms of electronegativity difference, why the bond in a molecule of HF is more polar than the bond in a molecule of HI. [1]
- 52 Explain, in terms of activity, why HCl(aq) reacts with Zn(s), but HCl(aq) does *not* react with Cu(s). [1]
- 53 Copper has two naturally occurring isotopes. Information about the two isotopes is shown in the table below.

**Naturally Occurring Isotopes of Copper**

Isotope	Atomic Mass (atomic mass units, u)	Percent Natural Abundance (%)
Cu-63	62.93	69.17
Cu-65	64.93	30.83

In the space *in your answer booklet*, show a numerical setup for calculating the atomic mass of copper. [1]

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Base your answers to questions 54 and 55 on the information below.

In an experiment, 2.54 grams of copper completely reacts with sulfur, producing 3.18 grams of copper(I) sulfide.

- 54 Determine the total mass of sulfur consumed. [1]
- 55 Write the chemical formula of the compound produced. [1]
-

Base your answers to questions 56 and 57 on the information below.

**Physical Properties of CF<sub>4</sub> and NH<sub>3</sub>  
at Standard Pressure**

<b>Compound</b>	<b>Melting Point (°C)</b>	<b>Boiling Point (°C)</b>	<b>Solubility in Water at 20.0°C</b>
CF <sub>4</sub>	-183.6	-127.8	insoluble
NH <sub>3</sub>	-77.7	-33.3	soluble

56 State evidence that indicates NH<sub>3</sub> has stronger intermolecular forces than CF<sub>4</sub>. [1]

57 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for CF<sub>4</sub>. [1]

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

A 2.0-liter aqueous solution contains a total of 3.0 moles of dissolved NH<sub>4</sub>Cl at 25°C and standard pressure.

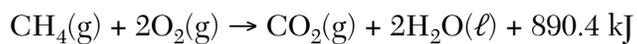
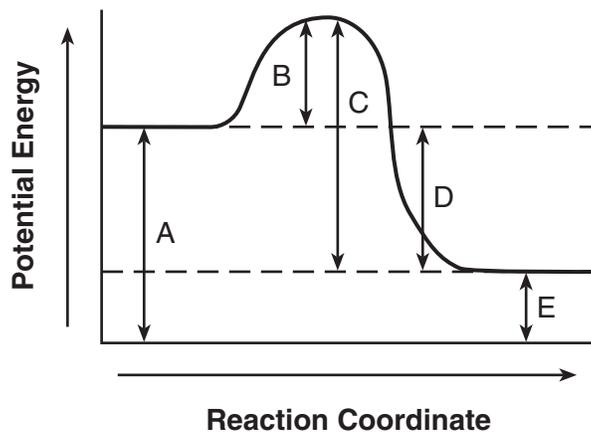
58 Determine the molarity of the solution. [1]

59 Identify the *two* ions present in the solute. [1]

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Base your answers to questions 60 and 61 on the information below.

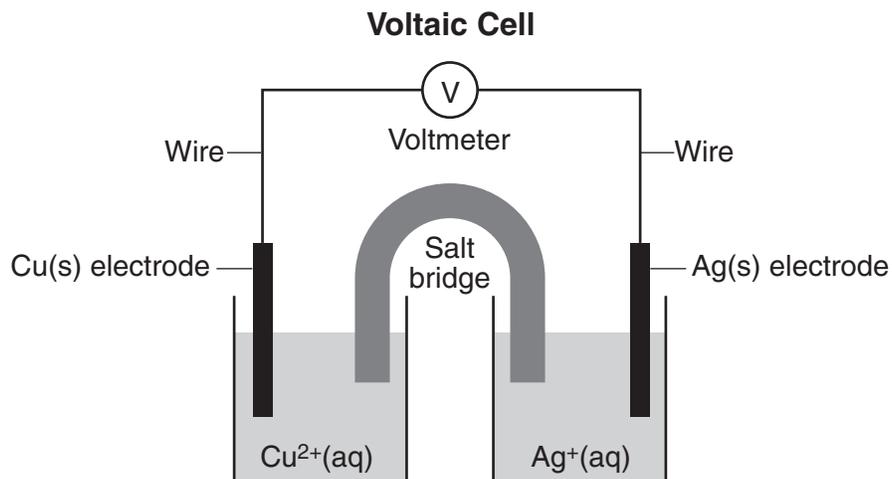
The chemical reaction between methane and oxygen is represented by the potential energy diagram and balanced equation below.



- 60 Which potential energy interval in the diagram represents the activation energy of the forward reaction? [1]
- 61 Explain, in terms of collision theory, why a lower concentration of oxygen gas *decreases* the rate of this reaction. [1]
-

Base your answers to questions 62 and 63 on the information below.

The diagram and balanced ionic equation below represent a voltaic cell with copper and silver electrodes and the reaction that occurs when the cell is operating.



62 Describe the direction of electron flow in the external circuit in this operating cell. [1]

63 State the purpose of the salt bridge in this voltaic cell. [1]

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

A 20.0-milliliter sample of HCl(aq) is completely neutralized by 32.0 milliliters of 0.50 M KOH(aq).

64 Calculate the molarity of the HCl(aq). Your response must include *both* a numerical setup and the calculated result. [2]

65 According to the data, to what number of significant figures should the calculated molarity of the HCl(aq) be expressed? [1]

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## Part C

### Answer all questions in this part.

*Directions (66–83):* 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 68 on the information below.

In the early 1800s, John Dalton proposed an atomic theory that was based on experimental observations made by several scientists. Three concepts of Dalton's atomic theory are stated below.

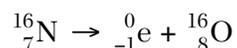
Statement A: Atoms are indivisible and cannot be destroyed or broken down into smaller parts.

Statement B: Atoms of one element cannot be changed into atoms of another element.

Statement C: All atoms of one element have the same mass.

66 Explain, in terms of particles, why statement A is no longer accepted. [1]

67 The decay of N-16 is represented by the balanced equation below.



State evidence that indicates statement B is *not* always true. [1]

68 Explain, in terms of particles in the atoms of an element, why statement C is *false*. [1]

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

A tablet of one antacid contains citric acid,  $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$ , and sodium hydrogen carbonate,  $\text{NaHCO}_3$ . When the tablet dissolves in water, bubbles of  $\text{CO}_2$  are produced. This reaction is represented by the incomplete equation below.



69 Complete the equation *in your answer booklet* by writing the formula of the missing product. [1]

70 State evidence that a chemical reaction occurred when the tablet was placed in the water. [1]

71 Determine the total number of moles of sodium hydrogen carbonate that will completely react with 0.010 mole of citric acid. [1]

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

Cold packs are used to treat minor injuries. Some cold packs contain  $\text{NH}_4\text{NO}_3(\text{s})$  and a small packet of water at room temperature before activation. To activate this type of cold pack, the small packet must be broken to mix the water and  $\text{NH}_4\text{NO}_3(\text{s})$ . The temperature of this mixture decreases to approximately  $2^\circ\text{C}$  and remains at this temperature for 10 to 15 minutes.

72 State the direction of heat flow that occurs when the activated cold pack is applied to the body. [1]

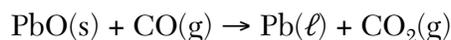
73 Identify *both* types of bonds in the  $\text{NH}_4\text{NO}_3(\text{s})$ . [1]

74 Identify the type of mixture formed when the  $\text{NH}_4\text{NO}_3(\text{s})$  is completely dissolved in the water. [1]

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Base your answers to questions 75 through 77 on the information below.

Litharge,  $\text{PbO}$ , is an ore that can be roasted (heated) in the presence of carbon monoxide,  $\text{CO}$ , to produce elemental lead. The reaction that takes place during this roasting process is represented by the balanced equation below.



75 Write the balanced equation for the reduction half-reaction that occurs during this roasting process. [1]

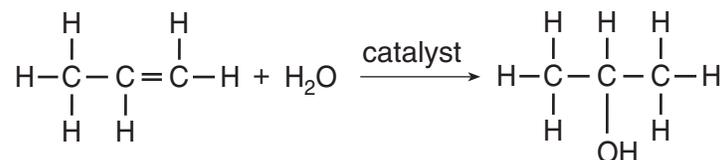
76 Determine the oxidation number of carbon in carbon monoxide. [1]

77 Calculate the percent composition by mass of oxygen in litharge (gram-formula mass = 223.2 grams per mole). Your response must include *both* a numerical setup and the calculated result. [2]

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Base your answers to questions 78 through 80 on the information below.

In one industrial organic reaction,  $C_3H_6$  reacts with water in the presence of a catalyst. This reaction is represented by the balanced equation below.



78 Explain, in terms of bonding, why  $C_3H_6$  is classified as an unsaturated hydrocarbon. [1]

79 Write the IUPAC name for the organic reactant. [1]

80 Identify the class of compound to which the product of the reaction belongs. [1]

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Base your answers to questions 81 through 83 on the information below.

A student, wearing chemical safety goggles and a lab apron, is to perform a laboratory test to determine the pH value of two different solutions. The student is given one bottle containing a solution with a pH of 2.0 and another bottle containing a solution with a pH of 5.0. The student is also given six dropping bottles, each containing a different indicator listed in Reference Table M.

81 State *one* safety precaution, *not* mentioned in the passage, that the student should take while performing tests on the samples from the bottles. [1]

82 Identify an indicator in Reference Table M that would differentiate the two solutions. [1]

83 Compare the hydronium ion concentration of the solution having a pH of 2.0 to the hydronium ion concentration of the other solution given to the student. [1]

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