2018 U.S. NATIONAL CHEMISTRY OLYMPIAD

LOCAL SECTION EXAM

Prepared by the American Chemical Society Chemistry Olympiad Examinations Task Force

OLYMPIAD EXAMINATIONS TASK FORCE

Seth N. Brown, **Chair**, *University of Notre Dame,* Notre Dame, IN

James Ayers, *Colorado Mesa University*, Grand Junction, CO
Mark DeCamp, *University of Michigan*, Dearborn, MI (retired)
Marian DeWane, *Centennial High School*, Boise, ID
Xu Duan, *Holton-Arms School*, Bethesda, MD
Valerie Ferguson, *Moore HS*, Moore, OK
Julie Furstenau, *Thomas B. Doherty HS*, Colorado Springs, CO
Kimberly Gardner, *United States Air Force Academy*, CO
Paul Groves, *South Pasadena HS*, South Pasadena, CA
Nicolas Hamel, *Clackamas Community College*, Oregon City, OR
David W. Hostage, *Taft School*, Watertown, CT
John Kotz, *State University of New York*, Oneonta, NY (retired)
Jane Nagurney, *Scranton Preparatory School*, Scranton, PA
Sheila Nguyen, *Cypress College*, Cypress, CA
Ronald Ragsdale, *University of Utah*, Salt Lake City, UT (retired)

DIRECTIONS TO THE EXAMINER

This test is designed to be taken with an answer sheet on which the student records his or her responses. All answers are to be marked on that sheet, not written in the booklet. Each student should be provided with an answer sheet and scratch paper, both of which must be turned in with the test booklet at the end of the examination. Local Sections may use an answer sheet of their own choice.

The full examination consists of 60 multiple-choice questions representing a fairly wide range of difficulty. A periodic table and other useful information are provided on page two of this exam booklet for student reference.

Only non-programmable calculators are to be used on the ACS local section exam. The use of a programmable calculator, cell phone, or any other device that can access the internet or make copies or photographs during the exam is grounds for disqualification.

Suggested Time: 60 questions—110 minutes

DIRECTIONS TO THE EXAMINEE

DO NOT TURN THE PAGE UNTIL DIRECTED TO DO SO.

This is a multiple-choice examination with four choices for each question. There is only one correct or best answer to each question. When you select your choice, blacken the corresponding space on the answer sheet with your pencil. Make a heavy full mark, but no stray marks. If you decide to change your answer, be certain to erase your original answer completely.

ABBREVIATIONS AND SYMBOLS					
amount of substance	*n*	Faraday constant	*F*	molar mass	*M*
ampere	A	free energy	*G*	mole	mol
atmosphere	atm	frequency	ν	Planck's constant	*h*
atomic mass unit	u	gas constant	*R*	pressure	*P*
Avogadro constant	N_A	gram	g	rate constant	*k*
Celsius temperature	°C	hour	h	reaction quotient	*Q*
centi– prefix	c	joule	J	second	s
coulomb	C	kelvin	K	speed of light	*c*
density	d	kilo– prefix	k	temperature, K	*T*
electromotive force	*E*	liter	L	time	*t*
energy of activation	E_a	measure of pressure	mm Hg	vapor pressure	VP
enthalpy	*H*	milli– prefix	m	volt	V
entropy	*S*	molal	*m*	volume	*V*
equilibrium constant	*K*	molar	M		

CONSTANTS
$R = 8.314$ J mol^{-1} K^{-1}
$R = 0.08314$ L bar mol^{-1} K^{-1}
$F = 96{,}500$ C mol^{-1}
$F = 96{,}500$ J V^{-1} mol^{-1}
$N_A = 6.022 \times 10^{23}$ mol^{-1}
$h = 6.626 \times 10^{-34}$ J s
$c = 2.998 \times 10^{8}$ m s^{-1}
0 °C = 273.15 K
1 atm = 1.013 bar = 760 mm Hg
Specific heat capacity of H_2O = 4.184 J g^{-1} K^{-1}

EQUATIONS

$$E = E^{\circ} - \frac{RT}{nF}\ln Q \qquad \ln K = \left(\frac{-\Delta H^{\circ}}{R}\right)\left(\frac{1}{T}\right) + \text{constant} \qquad \ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

PERIODIC TABLE OF THE ELEMENTS

1 1A																	18 8A
1 **H** 1.008	2 **2A**											13 **3A**	14 **4A**	15 **5A**	16 **6A**	17 **7A**	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3 **3B**	4 **4B**	5 **5B**	6 **6B**	7 **7B**	8 **8B**	9 **8B**	10 **8B**	11 **1B**	12 **2B**	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.97	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.95	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (281)	111 **Rg** (272)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **Mc** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

DIRECTIONS

- When you have selected your answer to each question, blacken the corresponding space on the answer sheet using a soft, #2 pencil. Make a heavy, full mark, but no stray marks. If you decide to change an answer, erase the unwanted mark very carefully.
- There is only one correct answer to each question. Any questions for which more than one response has been blackened **will not be counted**.
- Your score is based solely on the number of questions you answer correctly. **It is to your advantage to answer every question.**

1. How many oxygen atoms are in 225 g O_2?

(A) 4.23×10^{24} **(B)** 6.84×10^{24}

(C) 8.47×10^{24} **(D)** 1.69×10^{25}

2. A 0.300 M solution of HCl is prepared by adding some 1.50 M HCl to a 500 mL volumetric flask and diluting to the mark with deionized water. What volume of 1.50 M HCl must be added?

(A) 100. mL **(B)** 150. mL

(C) 225. mL **(D)** 250. mL

3. Copper(I) oxide, Cu_2O, is reduced to metallic copper by heating in a stream of hydrogen gas. What mass of water is produced when 10.00 g copper is formed?

(A) 1.259 g **(B)** 1.417 g

(C) 2.835 g **(D)** 5.670 g

4. The mineral enargite is 48.41% Cu, 19.02% As, and 32.57% S by mass. What is the empirical formula of enargite?

(A) CuAsS **(B)** Cu_2AsS_2

(C) Cu_3AsS_4 **(D)** Cu_4AsS_3

5. A 5.0 g sample of calcium nitrate ($Ca(NO_3)_2$, M = 164) contaminated with silica (SiO_2, M = 60.1) is found to contain 1.0 g calcium. What is the mass percent purity of calcium nitrate in the sample?

(A) 20% **(B)** 24% **(C)** 73% **(D)** 82%

6. A solution of 20.0 g of which hydrated salt dissolved in 200 g H_2O will have the lowest freezing point?

(A) $CuSO_4 \cdot 5\ H_2O$ (M = 250)

(B) $NiSO_4 \cdot 6\ H_2O$ (M = 263)

(C) $MgSO_4 \cdot 7\ H_2O$ (M = 246)

(D) $Na_2SO_4 \cdot 10\ H_2O$ (M = 286)

7. Addition of 6 M HCl to which substance will NOT result in gas evolution?

(A) Al **(B)** Zn **(C)** K_2CO_3 **(D)** $NaNO_3$

8. A divalent metal ion dissolved in dilute hydrochloric acid forms a precipitate when H_2S is bubbled through the solution. Which ion is it?

(A) Ca^{2+} **(B)** Mn^{2+} **(C)** Zn^{2+} **(D)** Cd^{2+}

9. Which compound will form the most intensely colored 0.01 M aqueous solution?

(A) $KMnO_4$ **(B)** $KClO_4$

(C) $KAl(SO_4)_2$ **(D)** KI

10. A solution contains 0.1 M Sr^{2+} ions and 0.1 M Ag^+ ions. Addition of an equal volume of a 0.5 M solution of which reagent will cause precipitation of a strontium salt but not a silver salt?

(A) $NaNO_3$ **(B)** NaF

(C) NaOH **(D)** NaCl

11. Which would be most suitable for measuring 2.7 mL of ethanol for addition to a reaction with acidified dichromate?

(A) 10-mL graduated cylinder

(B) 10-mL volumetric flask

(C) 10-mL volumetric pipet

(D) 10-mL beaker

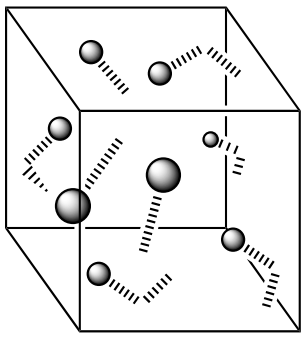
12. The molar mass of a solid carboxylic acid is determined by titrating a known mass of the acid with a standardized solution of NaOH to a phenolphthalein endpoint. Which errors will lead to a molar mass that is smaller than the actual molar mass?

I. Some of the acid is spilled when being transferred into the titration flask.
II. The endpoint is recorded when the solution is dark red in color rather than light pink.

(A) I only **(B)** II only

(C) Both I and II **(D)** Neither I nor II

13. What state of matter corresponds to the diagram below?



(A) Gas **(B)** Liquid

(C) Amorphous solid **(D)** Crystalline solid

14. The normal boiling point of 2-propanol, $(CH_3)_2CHOH$, is 83 ºC, while that of acetone, $(CH_3)_2C{=}O$, is 56 ºC. What is the principal reason for the greater boiling point of 2-propanol?

(A) The O–H bond in 2-propanol is stronger than the C–H bonds in acetone.

(B) 2-Propanol experiences greater London dispersion forces than acetone.

(C) 2-Propanol experiences stronger dipole-dipole interactions than acetone.

(D) 2-Propanol experiences stronger hydrogen bonding than acetone.

15. Consider the four gases CO_2, N_2, CCl_4, and He. Which is the correct order of increasing average molecular speed at 100 ºC?

(A) $He < N_2 < CO_2 < CCl_4$

(B) $CCl_4 < CO_2 < N_2 < He$

(C) $He < CO_2 < N_2 < CCl_4$

(D) $CCl_4 < N_2 < CO_2 < He$

16. Under what conditions will the behavior of a real gas best approximate the behavior of an ideal gas?

I. High temperature II. High pressure

(A) I only **(B)** II only

(C) Both I and II **(D)** Neither I nor II

17. A solid has a melting point of 1710 °C, is soluble in water, and does not conduct electricity in the solid state. What is the most likely nature of the bonding in this solid?

(A) Molecular covalent **(B)** Network covalent

(C) Ionic **(D)** Metallic

18. Toluene, C_7H_8, has both a higher vapor pressure than water at 25 ºC and a higher normal boiling point. Which statement best explains these observations?

(A) Liquids with higher vapor pressures typically have higher boiling points.

(B) Toluene has a higher molar mass than water.

(C) Toluene has a lower heat of vaporization than water.

(D) The density of toluene vapor is greater than that of water vapor.

19. To 100.0 g water at 25.00 ºC in a well-insulated container is added a block of aluminum initially at 100.0 ºC. The temperature of the water once the system reaches thermal equilibrium is 28.00 ºC. What is the mass of the aluminum block? (The specific heat capacity of Al is 0.900 J g^{-1} K^{-1}.)

(A) 4.17 g **(B)** 18.6 g **(C)** 19.4 g **(D)** 130. g

20. The standard enthalpy of formation, ΔH^o_f, of the compound MgO(*s*) is equal to the standard enthalpy change for which reaction?

(A) $Mg(s) + \frac{1}{2}\ O_2(g) \rightarrow MgO(s)$

(B) $2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$

(C) $Mg(g) + O(g) \rightarrow MgO(s)$

(D) $Mg^{2+}(aq) + O^{2-}(aq) \rightarrow MgO(s)$

21. The enthalpy of formation of $XeF_2(g)$ is –108 kJ mol^{-1} and the bond dissociation enthalpy of the F–F bond is 155 kJ mol^{-1}. What is the average bond dissociation enthalpy of a Xe–F bond?

(A) 47 kJ mol^{-1} **(B)** 54 kJ mol^{-1}

(C) 132 kJ mol^{-1} **(D)** 263 kJ mol^{-1}

22. What is the standard Gibbs free energy of formation, ΔG^o_f, of $NH_3(g)$ at 298 K?

Substance	ΔH^o_f, kJ mol^{-1}	S^o, J mol^{-1} K^{-1}
$H_2(g)$	0	131
$N_2(g)$	0	192
$NH_3(g)$	–46	193

(A) –104 kJ mol^{-1} **(B)** –16 kJ mol^{-1}

(C) –7 kJ mol^{-1} **(D)** 13 kJ mol^{-1}

23. The vaporization of a liquid at a certain temperature and pressure is spontaneous. For this process, which of the inequalities regarding the Gibbs free energy G and the internal energy E are correct?

I. $\Delta G < 0$ II. $\Delta E < \Delta H$

(A) I only **(B)** II only

(C) Both I and II **(D)** Neither I nor II

24. Which of the following reactions takes place with an increase in entropy under standard conditions?

(A) $NH_4^+(aq) + CH_3COO^-(aq) \rightarrow NH_3(aq) + CH_3COOH(aq)$

(B) $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

(C) $NH_3(g) + HCl(g) \rightarrow NH_4^+(aq) + Cl^-(aq)$

(D) $C_2H_4(g) + Br_2(l) \rightarrow C_2H_4Br_2(l)$

25. Carbon tetrachloride is produced from methyl chloride and chlorine according to the following equation:

$$CH_3Cl(g) + 3\ Cl_2(g) \rightarrow CCl_4(g) + 3\ HCl(g)$$

If the rate of formation of CCl_4 is measured to be 0.063 M min^{-1}, what is the rate of disappearance of Cl_2?

(A) 0.021 M min^{-1} **(B)** 0.063 M min^{-1}

(C) 0.13 M min^{-1} **(D)** 0.19 M min^{-1}

26. Iodine-131 decays with a half-life of 8.02 d. In a sample initially containing 5.00 mg of ^{131}I, what mass remains after 6.01 d?

(A) 1.13 mg **(B)** 1.87 mg

(C) 2.97 mg **(D)** 3.13 mg

27. For an irreversible reaction A → products, the graph of 1/[A] as a function of time is linear. What is the reaction order in A?

(A) Zeroth-order

(B) First-order

(C) Second-order

(D) The order in A cannot be determined based on the information given.

28. In comparing two reactions, the reaction with the greater activation energy always has

(A) the slower rate.

(B) the faster rate.

(C) the rate that varies less with temperature.

(D) the rate that varies more with temperature.

Questions 29 and 30 concern the reaction and mechanism below.

The formation of NOBr,

$$2\ NO(g) + Br_2(g) \rightarrow 2\ NOBr(g),$$

is studied, and the following mechanism is proposed:

$NO(g) + Br_2(g) \rightleftharpoons NOBr_2(g)$ fast, equilibrium

$NO(g) + NOBr_2(g) \rightarrow 2\ NOBr(g)$ slow

29. What rate law is predicted by this mechanism?

(A) Rate = $k[NO][Br_2]$ **(B)** Rate = $k[NO]^2[Br_2]$

(C) Rate = $k[NO][Br_2]^2$ **(D)** Rate = $k[NO]^2$

30. In this reaction, $NOBr_2(g)$ is best described as

(A) an intermediate**.**

(B) a product.

(C) a homogeneous catalyst.

(D) a heterogeneous catalyst.

31. What mass of silver chloride (M = 143.4) will dissolve in 1.00 L of water? The K_{sp} of AgCl is 1.8×10^{-10}.

(A) 1.4 mg **(B)** 1.9 mg **(C)** 2.9 mg **(D)** 3.8 mg

32. What is the pH of a 0.20 M solution of sodium benzoate, $Na(C_6H_5COO)$? The K_a of benzoic acid, C_6H_5COOH, is 6.5×10^{-5}.

(A) 5.26 **(B)** 8.74 **(C)** 9.09 **(D)** 11.56

33. Sulfur trioxide is formed from the reaction of sulfur dioxide and oxygen:

$$SO_2(g) + \tfrac{1}{2}\ O_2(g) \rightleftharpoons SO_3(g)$$

At 1000 K, an equilibrium mixture has partial pressures of 0.562 bar SO_2, 0.101 bar O_2, and 0.332 bar SO_3. What is the equilibrium constant K_p for the reaction at this temperature?

(A) 1.86 **(B)** 3.46 **(C)** 5.85 **(D)** 16.8

34. The following endothermic reaction is at equilibrium in a sealed container.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

Which of the following changes would result in an increase in the number of moles of $PCl_5(g)$ present at equilibrium?

I. Increasing the temperature II. Increasing the volume

(A) I only **(B)** II only

(C) Both I and II **(D)** Neither I nor II

35. A 0.12 M solution of a monoprotic acid is 2.3% ionized. What is the K_a of this acid?

(A) 2.8×10^{-3} **(B)** 3.3×10^{-4}

(C) 6.5×10^{-5} **(D)** 7.6×10^{-6}

36. Calcium fluoride, CaF_2, has a molar solubility of 2.1×10^{-4} mol L^{-1} at pH = 7.00. By what factor does its molar solubility increase in a solution with pH = 3.00? The pK_a of HF is 3.17.

(A) 1.48 **(B)** 1.83 **(C)** 2.48 **(D)** 4.96

37. The mineral crocidolite has the formula $Na_2Fe_5(Si_4O_{11})_2(OH)_2$. How many of the iron ions per formula unit are in the +2 oxidation state and how many are in the +3 oxidation state?

(A) All five are +2

(B) Three are +2, two are +3

(C) Two are +2, three are +3

(D) One is +2, four are +3

38. What products are formed in the electrolysis of 1.0 M aqueous HBr?

(A) H_2 at the cathode, Br_2 at the anode

(B) O_2 at the cathode, H_2 at the anode

(C) OH^- at the cathode, HOBr at the anode

(D) Br_3^- at the cathode, $HBrO_4$ at the anode

39. A 1.00 g sample of a hydrogen peroxide (H_2O_2) solution is placed in an Erlenmeyer flask and diluted with 20 mL of 1 M aqueous sulfuric acid. To this solution is added 0.0200 M $KMnO_4$ solution via a buret, until a pale purple color persists. This requires 22.50 mL of $KMnO_4$ solution. What is the percent by mass of hydrogen peroxide in the original solution?

(A) 0.613% **(B)** 1.53% **(C)** 3.83% **(D)** 7.65%

40. What is the standard cell potential of the following electrochemical cell?

$$Ni(s) \mid Ni^{2+}(aq),\ 1.0\ M \parallel Ag^{+}(aq),\ 1.0\ M \mid Ag(s)$$

Half-Reaction	E^o, V
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.23
$Ag^{+}(aq) + e^- \rightarrow Ag(s)$	+0.80

(A) –1.83 V **(B)** 0.57 V **(C)** 1.03 V **(D)** 1.83 V

41. Copper electrodes are placed into two aqueous solutions of copper(II) sulfate at 25 ºC. One compartment contains a 1.0 M solution while the other compartment contains a 0.10 M solution. The two compartments are connected with a salt bridge and the electrodes are connected by a wire passing through a voltmeter. In what direction do the electrons flow through the wire, and what is the cell potential read on the voltmeter?

	Direction of electron flow	Cell potential
(A)	From the electrode in the 1.0 M solution to the electrode in the 0.10 M solution	30 mV
(B)	From the electrode in the 1.0 M solution to the electrode in the 0.10 M solution	59 mV
(C)	From the electrode in the 0.10 M solution to the electrode in the 1.0 M solution	30 mV
(D)	From the electrode in the 0.10 M solution to the electrode in the 1.0 M solution	59 mV

42. A 1.00 g sample of a silver-containing ore is dissolved in dilute nitric acid. The solution is neutralized and then selectively electrolyzed to deposit the silver metal, requiring 670 s of 0.10 A current. What is the mass percentage of silver in the ore?

(A) 2.5% **(B)** 3.0% **(C)** 3.7% **(D)** 7.5%

43. What is the electron configuration of the Al^{3+} ion?

(A) $1s^2 2s^2 2p^6$ **(B)** $1s^2 2s^2 2p^6 3s^2 3p^1$

(C) $1s^2 2s^2 2p^6 3s^2 3p^4$ **(D)** $1s^2 2s^2 2p^6 3s^2 3p^6$

44. Which metal has the highest melting point?

(A) K **(B)** Ca **(C)** Fe **(D)** Zn

45. The wavelength of one line in the emission spectrum of C is 538 nm. What is the energy of one photon with this wavelength?

(A) 3.69×10^{-19} J **(B)** 3.69×10^{-26} J

(C) 3.56×10^{-40} J **(D)** 1.19×10^{-48} J

46. An orbital in a ground-state gas-phase As atom has $n = 3$, $l = 1$. How many electrons are in this orbital?

(A) 0 **(B)** 1 **(C)** 2 **(D)** 6

47. Atoms of which element have the smallest ionization energy?

(A) Na **(B)** F **(C)** K **(D)** Cl

48. The acidity of the group 16 hydrides increase going down the group ($H_2O << H_2S < H_2Se < H_2Te$). Which is the best explanation for this trend?

(A) The electronegativity of the group 16 elements increases going down the group.

(B) The polarizability of the group 16 elements increases going down the group.

(C) The polarity of the X–H bond increases going down the group.

(D) The H–X–H bond angle increases going down the group.

49. Which compound contains both ionic and covalent bonds?

(A) PF_3 **(B)** KF

(C) CH_3COOH **(D)** $MgSO_4$

50. Which gas-phase molecule is NOT linear?

(A) CS_2 **(B)** SO_2 **(C)** HCCH **(D)** BrCN

51. In the Lewis structure of the chlorate ion, ClO_3^-, how many lone pairs of electrons does the chlorine atom have?

(A) 0 **(B)** 1 **(C)** 2 **(D)** 3

52. A coordination complex $M(NH_3)_2Cl_2$ can be separated into a pair of geometric isomers. Is this observation consistent with a tetrahedral or a square planar geometry at the metal center?

(A) It is consistent only with a tetrahedral geometry.

(B) It is consistent only with a square planar geometry.

(C) It is consistent with either a square planar or a tetrahedral geometry.

(D) It is consistent with neither a square planar nor a tetrahedral geometry.

53. The bond in gas-phase O_2 (121 pm) is significantly longer than the bond in gas-phase O_2^+ (112 pm). What is the best explanation for this difference?

(A) O_2 has one more antibonding electron than O_2^+.

(B) O_2 has two unpaired electrons while O_2^+ has one.

(C) The bond in O_2 has less ionic character than the bond in O_2^+.

(D) It requires more energy to remove an electron from O_2 to form O_2^+ than it does to remove an electron from O to form O^+.

54. In the guanidinium ion, $[C(NH_2)_3]^+$, what is the best description of the hybridizations of the nitrogen atoms?

(A) All three sp^3 **(B)** Two sp^3, one sp^2

(C) One sp^3, two sp^2 **(D)** All three sp^2

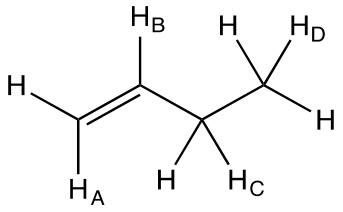
55. How many π bonds are in a molecule of propyne, C_3H_4?

(A) 0 **(B)** 1 **(C)** 2 **(D)** 3

56. How many isomers have the formula $C_2H_2Br_2$?

(A) 1 **(B)** 2 **(C)** 3 **(D)** 4

57. One hydrogen in 1-butene is replaced by bromine to give a chiral molecule. Which hydrogen is replaced?



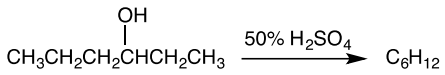
(A) H_A **(B)** H_B **(C)** H_C **(D)** H_D

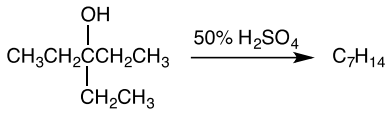
58. A compound with the formula C_6H_{12} does not decolorize bromine in $CHCl_3$ solution. Which compound could this be?

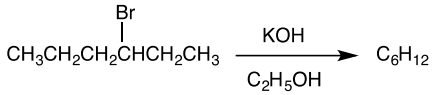
(A) Cyclohexane **(B)** 1-Hexene

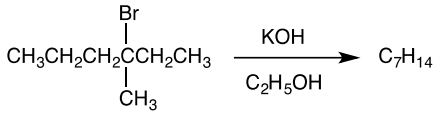
(C) *Trans*-3-hexene **(D)** *Cis*-3-hexene

59. Which reaction would yield a single alkene product?

(A) 

(B) 

(C) 

(D) 

60. The net chemical reaction of photosynthesis is best described as

(A) an endothermic reaction that forms sugars.

(B) an exothermic reaction that forms sugars.

(C) an endothermic reaction that breaks down sugars.

(D) an exothermic reaction that breaks down sugars.

END OF TEST

AMERICAN CHEMICAL SOCIETY

U.S. National Chemistry Olympiad

Olympiad 2018
USNCO Local Section Exam
KEY

Number	Answer
1.	C
2.	A
3.	B
4.	C
5.	D
6.	D
7.	D
8.	D
9.	A
10.	B
11.	A
12.	B
13.	A
14.	D
15.	B
16.	A
17.	C
18.	C
19.	C
20.	A
21.	C
22.	B
23.	C
24.	A
25.	D
26.	C
27.	C
28.	D
29.	B
30.	A

Number	Answer
31.	B
32.	B
33.	A
34.	A
35.	C
36.	B
37.	B
38.	A
39.	C
40.	C
41.	C
42.	D
43.	A
44.	C
45.	A
46.	C
47.	C
48.	B
49.	D
50.	B
51.	B
52.	B
53.	A
54.	D
55.	C
56.	C
57.	C
58.	A
59.	B
60.	A