2016 U.S. NATIONAL CHEMISTRY OLYMPIAD

LOCAL SECTION EXAM

Prepared by the American Chemical Society Chemistry Olympiad Examinations Task Force

OLYMPIAD EXAMINATIONS TASK FORCE

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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
$R = 8.314\ \text{J•mol}^{-1}\text{•K}^{-1}$
$R = 0.0821\ \text{L•atm•mol}^{-1}\text{•K}^{-1}$
$F = 96{,}500\ \text{C•mol}^{-1}$
$F = 96{,}500\ \text{J•V}^{-1}\text{•mol}^{-1}$
$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$
$h = 6.626 \times 10^{-34}\ \text{J•s}$
$c = 2.998 \times 10^{8}\ \text{m•s}^{-1}$
0 °C = 273.15 K
1 atm = 760 mm Hg
Specific heat capacity of H_2O = $4.184\ \text{J•g}^{-1}\text{•K}^{-1}$

EQUATIONS

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

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** 78.96	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** 95.94	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 (Uut) (284)	114 **Fl** (289)	115 (Uup) (288)	116 **Lv** (293)	117 (Uus) (294)	118 (Uuo) (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. A 20.0 g sample of mercury(II) oxide (HgO, $M = 216.6$) is heated strongly, causing it to decompose to metallic Hg and O_2 gas. What volume of O_2 gas is produced (measured at STP)?

(A) 1.03 L **(B)** 2.07 L **(C)** 4.14 L **(D)** 14.0 L

2. When 30.0 mL of 0.10 M $AgNO_3$ is added to 30.0 mL of 0.10 M NaCl, aqueous $NaNO_3$ and solid AgCl are formed. How much solid AgCl is produced?

(A) 0.0030 mol **(B)** 0.0060 mol

(C) 0.030 mol **(D)** 0.060 mol

3. How much $Sr(OH)_2 \cdot 8\ H_2O$ ($M = 265.76$) is needed to prepare 250.0 mL of solution in which $[OH^-] = 0.100$ M?

(A) 3.32 g **(B)** 6.64 g **(C)** 9.97 g **(D)** 13.3 g

4. A 10.00 g sample of a compound containing only carbon, hydrogen, and oxygen forms 23.98 g CO_2 and 4.91 g H_2O upon complete combustion. What is the empirical formula of the compound?

(A) C_2HO **(B)** C_3H_3O **(C)** $C_6H_3O_2$ **(D)** C_6H_6O

5. Which of the following is a nonelectrolyte in aqueous solution?

(A) H_2SO_4 **(B)** $NaC_2H_3O_2$

(C) K_2CO_3 **(D)** CH_2O

6. An aqueous solution of potassium sulfate (K_2SO_4) has a freezing point of –2.24 ºC. What is its molality? ($K_f = 1.86$ ºC•m^{-1})

(A) 0.401 *m* **(B)** 0.602 *m*

(C) 1.20 *m* **(D)** 4.17 *m*

7. Dissolution of which salt in water results in a decrease in the temperature of the solution?

(A) $KHSO_4$ **(B)** NaOH

(C) $AlCl_3$ **(D)** NH_4NO_3

8. What is observed when equal volumes of 0.1 M aqueous HCl and 0.01 M aqueous Na_2SO_3 are mixed?

(A) Colorless solution and a white precipitate

(B) Colored solution and a white precipitate

(C) Colorless solution and a colored precipitate

(D) Colorless solution, no precipitate, and gas evolution

9. Which combination of dilute aqueous reagents will not produce a precipitate?

(A) $AgNO_3 + HCl$ **(B)** $NaOH + HClO_4$

(C) $BaBr_2 + Na_2SO_4$ **(D)** $ZnI_2 + KOH$

10. A solution of a salt of which metal produces a bright red color in a flame test?

(A) Lithium **(B)** Sodium

(C) Potassium **(D)** Copper

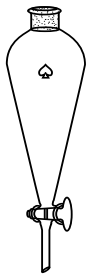
11. Which cation forms a colorless aqueous solution?

(A) Co^{2+} **(B)** Ni^{2+} **(C)** Cu^{2+} **(D)** Zn^{2+}

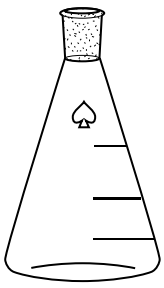
12. Which 50-mL container would be most suitable for measuring and dispensing 37 mL of an aqueous solution?

(A)

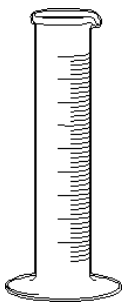
(B)



(C)



(D)



13. A sample of O_2 gas at a given temperature and pressure has a density of 1.30 g L^{-1}. What is the density of gaseous propane (C_3H_8) under the same conditions?

(A) 1.30 g L^{-1} **(B)** 1.79 g L^{-1}

(C) 1.96 g L^{-1} **(D)** 2.60 g L^{-1}

14. Which statements about the behavior of gaseous H_2 molecules in a container at 1 atm and 298 K are correct?

I. All H_2 molecules are moving at the same speed.

II. The H_2 molecules are colliding more frequently with the walls of the container than they would in the same container at 398 K.

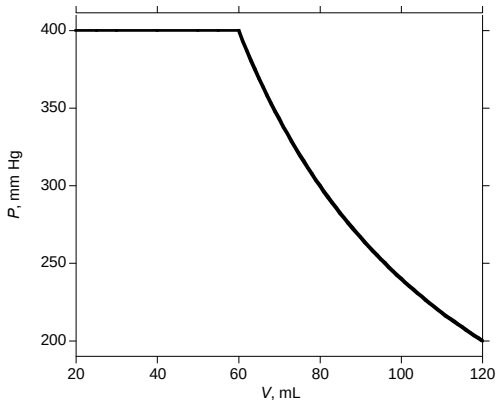
(A) I only **(B)** II only

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

15. Which species has a normal boiling point closest to the normal boiling point of argon, Ar?

(A) H_2 **(B)** N_2 **(C)** F_2 **(D)** Cl_2

16. A sample of methanol, CH_3OH, is introduced into an evacuated chamber with a movable piston. The pressure is measured as a function of the volume of the container while the temperature is maintained at 50 ºC, and the graph below is obtained.



Which statements are correct?

I. At volumes less than 60 mL, only liquid methanol is present.

II. At volumes greater than 60 mL, only gaseous methanol is present.

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

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

17. How many nearest neighbors does each silicon atom have in solid Si?

(A) 4 **(B)** 6 **(C)** 8 **(D)** 12

18. Which sample contains the smallest number of atoms?

(A) 1.0 L of Ar at STP

(B) 1.0 L of H_2 at STP

(C) 1.0 L of Ar at 25 ºC and 760 mm Hg

(D) 1.0 L of H_2 at 0 ºC and 900 mm Hg

19. The standard enthalpy of formation, ΔH°_f, for HCOOH(l) is equal to the standard enthalpy change for which reaction?

(A) $C(g) + 2\ H(g) + 2\ O(g) \rightarrow HCOOH(l)$

(B) $C(s) + H_2(g) + O_2(g) \rightarrow HCOOH(l)$

(C) $C(g) + H_2(g) + O_2(g) \rightarrow HCOOH(l)$

(D) $CO_2(g) + H_2(g) \rightarrow HCOOH(l)$

20. 40.0 mL of 0.200 M aqueous NaOH is added to 200.0 mL of 0.100 M aqueous $NaHCO_3$ in a flask maintained at 25 ºC. Neglecting the effects of dilution, what is q for this reaction?

	ΔH°_f, kJ mol^{-1}
$OH^-(aq)$	–230
$HCO_3^-(aq)$	–692
$CO_3^{2-}(aq)$	–677
$H_2O(l)$	–286

(A) –41 J **(B)** –74 J **(C)** –330 J **(D)** –820 J

21. In a well-insulated vessel, 50.0 g ice at 0.0 ºC is added to 350. g water at 32.0 ºC. What is the final temperature when the mixture reaches equilibrium? (The heat of fusion of ice is 334 J g^{-1}.)

(A) 18.0 ºC **(B)** 20.6 ºC

(C) 22.0 ºC **(D)** 28.0 ºC

22. Which is the best explanation for the negative sign of ΔS° in the following reaction?

$$CaSO_4(s) \rightarrow Ca^{2+}(aq) + SO_4^{2-}(aq)$$
$$\Delta S^\circ = -143\ J\ mol^{-1}\ K^{-1}$$

(A) There are more ways of arranging the Ca^{2+} and SO_4^{2-} ions in aqueous solution than in the crystal lattice.

(B) Solid $CaSO_4$ is a network covalent solid, whereas it separates into ions in aqueous solution.

(C) Aqueous Ca^{2+} and SO_4^{2-} ions are tightly solvated, decreasing the number of ways of arranging water molecules when the solid dissolves.

(D) Calcium sulfate dissolves exothermically, leading to a net loss of entropy.

23. The K_{sp} of $Al(OH)_3$ is 2.0×10^{-31} at 298 K. What is ΔG^o (at 298 K) for the precipitation of $Al(OH)_3$ according to the equation below?

$$Al^{3+}(aq) + 3\ OH^-(aq) \rightarrow Al(OH)_3(s)$$

(A) -175 kJ mol^{-1} **(B)** 14.7 kJ mol^{-1}

(C) 70.6 kJ mol^{-1} **(D)** 175 kJ mol^{-1}

24. The bond dissociation enthalpies of the H–H bond and the H–Cl bond are 435 kJ mol^{-1} and 431 kJ mol^{-1}, respectively. The ΔH^o_f of HCl(g) is -92 kJ mol^{-1}. What is the bond dissociation enthalpy of the Cl–Cl bond?

(A) 88 kJ mol^{-1} **(B)** 96 kJ mol^{-1}

(C) 188 kJ mol^{-1} **(D)** 243 kJ mol^{-1}

25. Which statement about chemical reaction mechanisms is correct?

(A) The overall rate law can be determined from any step in the mechanism.

(B) The rate of a reaction is the rate of the fastest elementary step of its mechanism.

(C) The chemical equation for the sum of all the elementary steps is the chemical equation of the overall reaction.

(D) Species that are produced and subsequently consumed in the mechanism serve as catalysts for the reaction.

26. At 280 ºC, nitrogen dioxide decomposes to nitric oxide and oxygen:

$$2\ NO_2(g) \rightarrow 2\ NO(g) + O_2(g)$$

In one experiment, the concentration of NO_2 decreased from 0.0100 M to 0.0050 M over the course of 100. s. What was the average rate of disappearance of $NO_2(g)$?

(A) 1.0×10^{-2} M s^{-1} **(B)** 1.0×10^{-4} M s^{-1}

(C) 5.0×10^{-5} M s^{-1} **(D)** 2.5×10^{-5} M s^{-1}

27. What is the rate law for the following reaction?

$$A + 2\ B \rightarrow C + D$$

$[A]_0$, M	$[B]_0$, M	Initial rate, M s^{-1}
0.050	0.100	0.085
0.050	0.200	0.170
0.100	0.300	0.510

(A) Rate = k[A] **(B)** Rate = k[B]

(C) Rate = k[A][B] **(D)** Rate = k[A][B]^2

28. What are the units of k if the rate law of a reaction is rate = $k[X]^0[Y]^0$?

(A) M s^{-1} **(B)** s^{-1}

(C) M^{-1} s^{-1} **(D)** k is dimensionless

29. Hydrogen peroxide, $H_2O_2(aq)$, decomposes into water and oxygen. Adding a small amount of $FeCl_3(aq)$ increases the rate of gas evolution in this reaction. What is the best description of the role of $FeCl_3$?

(A) Transition state

(B) Reaction intermediate

(C) Heterogeneous catalyst

(D) Homogeneous catalyst

30. A substance decomposes in a first-order reaction with a rate constant of 6.70×10^{-4} s^{-1}. If the initial concentration of the substance is 1.50 M, what is its concentration after 500. s?

(A) 1.07 M **(B)** 0.503 M

(C) 0.335 M **(D)** 0.128 M

31. A 60.0 g sample of $CaCO_3$ is heated to 950 K in a 1.00 L evacuated container, where it reacts according to the following equation:

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

After equilibrium is attained, the pressure of $CO_2(g)$ is 30.0 mm Hg. When the experiment is repeated using 120.0 g $CaCO_3$, what is the equilibrium pressure P?

(A) 15.0 mm Hg $\leq P <$ 30.0 mm Hg

(B) P = 30.0 mm Hg

(C) 30.0 mm Hg $< P <$ 60.0 mm Hg

(D) P = 60.0 mm Hg

32. Nitrous acid, HNO_2, has $K_a = 4.5 \times 10^{-4}$. What is the best description of the species present in a 0.1 M solution of nitrous acid?

(A) $HNO_2(aq)$ is the predominant species; much smaller amounts of $H^+(aq)$ and $NO_2^-(aq)$ exist.

(B) $H^+(aq)$ and $NO_2^-(aq)$ are the predominant species; much smaller amounts of $HNO_2(aq)$ exist.

(C) Only $H^+(aq)$ and $NO_2^-(aq)$ are present in measurable amounts.

(D) $HNO_2(aq)$, $H^+(aq)$, and $NO_2^-(aq)$ are all present in comparable amounts.

33. Silver sulfate, Ag_2SO_4 (M = 311.87), has $K_{sp} = 6.0 \times 10^{-5}$. What mass of Ag_2SO_4 will dissolve per liter of water?

(A) 0.019 g **(B)** 1.7 g

(C) 2.4 g **(D)** 7.7 g

34. IBr(g) is in equilibrium with $I_2(g)$ and $Br_2(g)$ at 150 ºC:

$$2\ IBr(g) \rightleftharpoons I_2(g) + Br_2(g) \qquad K = 8.50 \times 10^{-3}$$

Initially, a closed vessel at 150 ºC has a partial pressure of IBr of 0.350 atm and partial pressures of I_2 and Br_2 each of 0.750 atm. What is the partial pressure of IBr once the system reaches equilibrium?

(A) 1.01 atm **(B)** 1.09 atm

(C) 1.56 atm **(D)** 1.82 atm

35. 20 mL of an approximately 10% aqueous solution of ethylamine, $CH_3CH_2NH_2$, is titrated with 0.3000 M aqueous HCl. Which indicator would be most suitable for this titration? The pK_a of $CH_3CH_2NH_3^+$ is 10.75.

(A) Thymol blue, color change from pH = 1.2 to 2.8

(B) Bromocresol green, color change from pH = 4.0 to 5.6

(C) Phenolphthalein, color change from pH = 8.0 to 10.0

(D) Alizarin yellow R, color change from pH = 10.0 to 12.0

36. The tetramminecopper(II) ion, $Cu(NH_3)_4^{2+}$, has a formation constant $K_f = 1.1 \times 10^{13}$. What is the minimum concentration of free ammonia in solution required to ensure that at least 99.9% of the dissolved copper(II) ion is found in the form of its ammonia complex?

(A) 9×10^{-14} M **(B)** 9×10^{-11} M

(C) 8×10^{-4} M **(D)** 3×10^{-3} M

37. When the equation

$$ClO_2(aq) + OH^-(aq) \rightarrow ClO_2^-(aq) + ClO_3^-(aq) + H_2O(l)$$

is balanced, what is the ratio of the coefficient of ClO_2 to that of ClO_3^-?

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

38. When an aqueous solution of KI is electrolyzed, what forms at the anode?

(A) O_2 **(B)** I_2 **(C)** K **(D)** H_2O

39. A current of 0.15 A is passed through an aqueous solution of K_2PtCl_4. How long will it take to deposit 1.00 g Pt(s) (M = 195.1)?

(A) 1600 s **(B)** 3300 s **(C)** 6600 s **(D)** 13000 s

40. In the galvanic cell

$$Al(s) \mid Al^{3+}(aq, 1\ M) \parallel Cu^{2+}(aq, 1\ M) \mid Cu(s)$$

which of the following changes will increase the cell potential?

I. Dilution of the Al^{3+} solution to 0.001 M

II. Dilution of the Cu^{2+} solution to 0.001 M

III. Increasing the surface area of the Al(s) electrode

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

(C) III only **(D)** I and III only

41. What is the equilibrium constant for the following reaction at 25 °C?

$$2\ Ag^+(aq) + Cu(s) \rightarrow Cu^{2+}(aq) + 2\ Ag(s)$$

Half-Reaction	E^o, V
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34

(A) 6.0×10^7 **(B)** 3.6×10^{15}

(C) 3.6×10^{38} **(D)** 4.2×10^{42}

42. In the galvanic cell

$$Sn(s) \mid Sn^{2+}(aq) \parallel Cu^{2+}(aq) \mid Cu(s)$$

the standard potential is 0.48 V. Starting with standard concentrations, what are the concentrations of Sn^{2+} and Cu^{2+} when the cell has discharged to a potential of 0.45 V?

(A) $[Sn^{2+}]$ = 0.47 M, $[Cu^{2+}]$ = 1.53 M

(B) $[Sn^{2+}] = [Cu^{2+}]$ = 1.00 M

(C) $[Sn^{2+}]$ = 1.53 M, $[Cu^{2+}]$ = 0.47 M

(D) $[Sn^{2+}]$ = 1.82 M, $[Cu^{2+}]$ = 0.18 M

43. Which of the following statements is best supported by the data from Rutherford's experiment of scattering alpha particles with a thin metal foil?

(A) The mass and positive charge of an atom are concentrated in its center.

(B) Electrons in atoms occupy only certain specific energy levels.

(C) Moving particles can also be described as waves.

(D) Atoms of a given element do not all have identical masses.

44. What is the formula of the most stable oxide of francium?

(A) Fr_2O **(B)** FrO **(C)** Fr_2O_3 **(D)** FrO_2

45. As atomic number increases from 11 to 15, the atomic radii of the elements

(A) increase

(B) decrease

(C) increase, then decrease

(D) decrease, then increase

46. Nitrogen has a greater first ionization energy than oxygen. What is the best explanation for this observation?

(A) Nitrogen is more electronegative than oxygen.

(B) A nitrogen atom is smaller than an oxygen atom.

(C) The electron ionized from nitrogen experiences less electron-electron repulsion than the electron ionized from oxygen.

(D) The electron ionized from nitrogen is a 2*s* electron, while the electron ionized from oxygen is a 2*p* electron.

47. Which set of quantum numbers n, l, m_l, m_s is invalid?

(A) 1, 1, 0, –½ **(B)** 2, 0, 0, +½

(C) 3, 1, 0, +½ **(D)** 4, 3, 2, –½

48. What is the product of alpha emission from the isotope uranium-238?

(A) ^{232}Th **(B)** ^{234}Th **(C)** ^{237}Np **(D)** ^{231}Pa

49. Which molecule is nonpolar, yet contains polar covalent bonds?

(A) CO_2 **(B)** HCN **(C)** NH_3 **(D)** P_4

50. The nitrite ion, NO_2^-, can be represented as a resonance hybrid of two significant Lewis structures. Which statements about this are correct?

I. The two resonance structures contribute equally to the structure.

II. The formal charge of nitrogen is zero in both resonance structures.

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

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

51. Which is not a stable molecule?

(A) NF_3 **(B)** NF_5 **(C)** PF_3 **(D)** PF_5

52. What is the molecular geometry of IF_3?

(A) Trigonal planar **(B)** Trigonal pyramidal

(C) T-shaped **(D)** Tetrahedral

53. N_2 is a stable molecule and the N_4 molecule is unknown. P_4 is much more stable than molecular P_2. Which is the best explanation for this difference?

(A) N_2 has valence electrons only in bonding and nonbonding orbitals, while P_2 has some valence electrons in antibonding orbitals.

(B) The greater electronegativity of N compared to P stabilizes compounds with lower molar masses.

(C) The greater size of P compared to N results in decreased overlap in pi bonds.

(D) The preference of P to adopt smaller bond angles than N favors formation of tetrahedral P_4 molecules.

54. Which contains sp^3-hybridized carbon atoms?

(A) Benzene, C_6H_6 **(B)** Ethane, C_2H_6

(C) Ethene, C_2H_4 **(D)** Ethyne, C_2H_2

55. How many sigma bonds are in 2-butyne ($CH_3C{\equiv}CCH_3$)?

(A) 3 **(B)** 6 **(C)** 9 **(D)** 11

56. Which alcohol will undergo acid-catalyzed dehydration under the mildest conditions?

(A) $CH_3CH_2CH_2CH_2OH$ **(B)** $CH_3CH_2CH(OH)CH_3$

(C) $(CH_3)_2CHCH_2OH$ **(D)** $(CH_3)_3COH$

57. A 1.0 M aqueous solution of which compound has the lowest pH?

(A) CH_3CH_2OH **(B)** CH_3COOH

(C) CH_3CHO **(D)** Cl_3CCHO

58. A six-carbon organic compound containing oxygen is suspected of being either a secondary alcohol or a ketone. Which chemical or physical test would best distinguish between these two possibilities?

(A) Water solubility

(B) Melting point

(C) Treatment with sodium bicarbonate

(D) Treatment with acidic dichromate

59. Which two bases are found as a hydrogen-bonded base pair in DNA?

(A) A and T **(B)** C and T

(C) C and U **(D)** G and U

60. What is the nature of the peptide bonds in a protein?

(A) Hydrogen bonds **(B)** Amide bonds

(C) Disulfide bonds **(D)** Ionic bonds

END OF TEST

AMERICAN CHEMICAL SOCIETY

U.S. National Chemistry Olympiad

Olympiad 2016
USNCO Local Section Exam
KEY

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

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