2014 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. Students should be permitted to use non-programmable calculators. A periodic table and other useful information are provided on page two of this exam booklet for student reference.

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		

CONS
R = 8.314 J•mo
R = 0.0821 L•atm•mo
1 F = 96,500 C•mol^{-1}
1 F = 96,500 J•V^{-1}•mol^{-1}
N_A = 6.022 × 10^{23} mol^{-1}
h = 6.626 × 10^{-34} J•s
c = 2.998 × 10^{8} m•s^{-1}
0 °C = 273.15 K
1 atm = 760 mm Hg

EQUATIONS

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

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 (Uuq) (289)	115 (Uup) (288)	116 (Uuh) (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

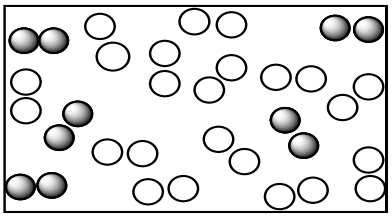
- When you have selected your answer to each question, blacken the corresponding space on the answer sheet using pencil. Make a heavy, full mark, but no stray marks. If you decide to change an answer, erase the unwanted mark ver
- There is only one correct answer to each question. Any questions for which more than one response has been blackened w **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. Which compound contains the highest percentage of magnesium by mass?

(A) $MgNH_4PO_4$ **(B)** $Mg(H_2PO_4)_2$

(C) $Mg_2P_4O_7$ **(D)** $Mg_3(PO_4)_2$

2.



In the diagram above the paired open spheres represent H_2 molecules and the paired solid spheres represent N_2 molecules. When the molecules in the box react to form the maximum possible amount of ammonia (NH_3) molecules, what is the limiting reactant and how many molecules of NH_3 can be formed?

(A) N_2 is limiting. 5 molecules of NH_3 can be formed.

(B) N_2 is limiting. 10 molecules of NH_3 can be formed.

(C) H_2 is limiting. 8 molecules of NH_3 can be formed.

(D) H_2 is limiting.12 molecules of NH_3 can be formed.

3. Vanillin, $C_8H_8O_3$ (M = 152 g/mol), is the molecule responsible for the vanilla flavor in food. How many oxygen atoms are present in a 45.0 mg sample of vanillin?

(A) 1.78×10^{20} **(B)** 5.35×10^{20}

(C) 1.78×10^{23} **(D)** 5.35×10^{23}

4. What is the molarity of sodium ions in a solution prepared by diluting 250. mL of 0.550 M Na_2SO_4 to 1.25 L?

(A) 0.110 M **(B)** 0.138 M

(C) 0.220 M **(D)** 0.275 M

5. The solubility of $K_2Cr_2O_7$ in water is 125 g/L at 20 °C. A solution is prepared at 20 °C that contains 6.0 grams of $K_2Cr_2O_7$ in 50. mL of water. This solution is

(A) dilute. **(B)** saturated.
(C) supersaturated. **(D)** unsaturated.

6. Which of the following is a weak electrolyte in aqueous solution?

(A) HF **(B)** NaF **(C)** HCl **(D)** KCl

7. Which list gives nonmetals that are found in their elemental forms in nature?

(A) neon, phosphorus, fluorine

(B) helium, hydrogen, iodine

(C) nitrogen, oxygen, sulfur

(D) oxygen, chlorine, phosphorus

8. Which one of the following cannot act as an oxidizing agent?

(A) S^{2-} **(B)** SO_3^{2-} **(C)** SO_4^{2-} **(D)** $S_2O_8^{2-}$

9. Which substance is the primary component in stalactites and stalagmites in caves?

(A) CaO **(B)** $CaCO_3$ **(C)** $Ca(OH)_2$ **(D)** $CaSO_4$

10. Five successive determinations of the density of an alloy gave the following results:
10.29 g/mL, 9.95 g/mL, 10.06 g/mL, 9.89 g/mL, 10.18 g/mL
What value should be reported for the density of this alloy?

(A) 10.074 g/mL **(B)** 10.07 ± 0.16 g/mL

(C) 10.1 ± 0.2 g/mL **(D)** 1.0×10^1 g/mL

11. A student is asked to analyze a water sample from a stream for total solids (TS), dissolved solids (DS), and suspended solids (SS). She carries out the experiments below.
1. A 25-mL portion of the water sample is evaporated to dryness in a pre-weighed evaporating dish to give mass 1.
2. A separate 25-mL portion is filtered into a second pre-weighed evaporating dish and evaporated to dryness to give mass 2.

How are values for TS, SS and DS (per 25 mL water) determined?

(A) TS = mass 1, SS = mass 1 – mass 2, DS = mass 2

(B) TS = mass 1, SS = mass 2, DS = mass 1 – mass 2

(C) TS = mass 1 + mass 2, SS = mass 1, DS = mass 2

(D) TS = mass 1 + mass 2, SS = mass 2, DS = mass 1

12. Which method(s) can be used to determine the concentration of HNO_3 in an aqueous solution of nitric acid?
I titration with a standard base
II titration with a standard oxidizing agent
III precipitation with Ag^+

(A) I only **(B)** III only
(C) I and II only **(D)** I, II, and III

13. The kinetic theory of gases assumes all of the following EXCEPT:

(A) Gases are composed of particles in random, ceaseless motion.

(B) The sizes of gas particles are negligible compared to the size of the container.

(C) Gas particles do not attract or repel each other.

(D) When gas particles collide, kinetic energy is lost.

14. A sample of He gas in a flexible container at room temperature exhibits a certain pressure. What will be the new pressure when the absolute temperature and volume of the container are both halved? The pressure of the He will be

(A) the same. **(B)** doubled.
(C) halved. **(D)** quadrupled.

15. The molecules in a sample of pure liquid dichloromethane, CH_2Cl_2, experience which of the following intermolecular forces?
I dispersion forces
II dipole-dipole forces
III hydrogen bonding

(A) I only **(B)** II only
(C) I and II only **(D)** I, II, and III

16. Which property best distinguishes metals from other types of solids?

(A) Metals exhibit three-dimensional order.

(B) Metals melt at low temperatures.

(C) Metals have a shiny, silvery-white appearance.

(D) Metals exhibit three-dimensional electrical conductivity.

17. What type of solid is silicon carbide, SiC?

(A) ionic **(B)** metallic
(C) molecular **(D)** network covalent

18. The normal boiling point and vapor pressure at 25 °C are measured for liquids in two flasks. Flask A contains pure water and flask B contains a 1.0 M aqueous sucrose solution. Which flask contains the liquid with the higher boiling point? Which flask contains the liquid with the higher vapor pressure?

	Higher boiling point	Higher vapor pressure
(A)	Flask A	Flask A
(B)	Flask A	Flask B
(C)	Flask B	Flask A
(D)	Flask B	Flask B

19. Given chemical equations for these reactions
$S(s) + O_2(g) \rightarrow SO_2(g)$ ΔH° –296.8 kJ•mol^{-1}
$H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$ ΔH° –285.8 kJ•mol^{-1}
$H_2(g) + S(s) \rightarrow H_2S(g)$ ΔH° –20.6 kJ•mol^{-1}
What is the value of ΔH for the reaction below?
$2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ H_2O(l) + 2\ SO_2(g)$

(A) –603.2 kJ•mol^{-1} **(B)** –562.0 kJ•mol^{-1}
(C) –1206.4 kJ•mol^{-1} **(D)** –1124.0 kJ•mol^{-1}

20. Consider the following reactions
I $2\ NO_2(g) \rightarrow N_2(g) + 2\ O_2(g)$
II $2\ IBr(g) \rightarrow I_2(s) + Br_2(l)$
For which reaction is $\Delta S^\circ < 0$?

(A) I only **(B)** II only
(C) Both I and II **(D)** Neither I nor II

21. Calculate the energy released by the reaction
$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$
when a 55.8 g sample of iron reacts completely with 1.00 mole of oxygen. The enthalpy of formation (ΔH_f°) of $Fe_2O_3(s)$ is –826 kJ•mol^{-1}.

(A) 206 kJ **(B)** 413 kJ **(C)** 826 kJ **(D)** 1650 kJ

22. The specific heat capacities of three metals are given below.

Metal	Fe	Pb	Zn
Specific heat, J•g^{-1}•°C^{-1}	0.470	0.130	0.388

If 1.00 g of each metal is heated to 100 °C and added to 10.0 g of H_2O at 25.0 °C, what is the order of the temperatures of the final mixtures from the lowest to the highest?

(A) Fe < Zn < Pb **(B)** Pb < Zn < Fe
(C) Zn < Pb < Fe **(D)** Zn < Fe < Pb

23. The enthalpy of formation, ΔH_f°, equals zero at 25 °C for which of the following in their standard states?

(A) elements **(B)** compounds
(C) gases **(D)** solids

24. Liquid water is injected into an oven at 400 K. What are the signs for ΔG, ΔH, and ΔS for the physical transformation that occurs?

	ΔG	ΔH	ΔS
(A)	+	–	–
(B)	+	–	0
(C)	–	+	+
(D)	–	+	0

(A) (A) **(B)** (B) **(C)** (C) **(D)** (D)

25. A device used to test alcohol in the bloodstream uses the reaction

$2\ K_2Cr_2O_7(aq) + 8\ H_2SO_4(aq) + 3\ CH_3CH_2OH(aq) \rightarrow 2\ Cr_2(SO_4)_3(aq) + 2\ K_2SO_4(aq) + 3\ CH_3COOH(aq) + 11\ H_2O$

If the rate of disappearance of $K_2Cr_2O_7$ is 1.24 M/min what is the rate of disappearance of CH_3CH_2OH?

(A) 0.415 M/min **(B)** 0.826 M/min

(C) 1.86 M/min **(D)** 3.72 M/min

26. $C(s) + CO_2(g) \rightarrow 2\ CO(g)$ $\Delta H = 172\ kJ \bullet mol^{-1}$

In a suitable reaction vessel, pieces of graphite are mixed with carbon dioxide gas at 1.00 atm and 1000 K. Which of the following changes will result in an increase in reaction rate?

(A) decrease size of the graphite pieces

(B) decrease temperature

(C) decrease partial pressure of CO(g)

(D) decrease partial pressure of $CO_2(g)$

27. The reaction $CH_3NC \rightarrow CH_3CN$ is first order. Which reaction characteristic changes as the reaction proceeds?

(A) the half life **(B)** the rate constant

(C) the rate law **(D)** the reaction rate

28. $A(g) + B(g) \rightarrow C(g)$

The data below were obtained for the reaction between A and B. What is the rate law for this reaction?

Trial	$[A]_0$ ($mol \bullet L^{-1}$)	$[B]_0$ ($mol \bullet L^{-1}$)	Initial Rate of Reaction ($mol \bullet L^{-1} \bullet s^{-1}$)
1	0.10	0.10	6.5×10^{-5}
2	0.20	0.10	2.6×10^{-4}
3	0.10	0.20	6.5×10^{-5}

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

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

29. A first-order reaction is carried out at [illegible]nt temperatures. The data are plotted as ln [illegible] is the slope of the graph related to E_a?

(A) E_a = slope × 8.314 $J \bullet mol^{-1} \bullet K^{-1}$

(B) E_a = –slope × 8.314 $J \bullet mol^{-1} \bullet K^{-1}$

(C) $1/E_a$ = slope × 8.314 $J \bullet mol^{-1} \bullet K^{-1}$

(D) $1/E_a$ = –slope × 8.314 $J \bullet mol^{-1} \bullet K^{-1}$

30. Which statement about the behavior of a catalyst is correct?

(A) A catalyst reacts with the product and shifts the equilibrium to the right speeding up the reaction.

(B) A catalyst lowers the activation energy of the original reaction pathway.

(C) A catalyst provides additional energy to a reactant so it can achieve the necessary activation energy.

(D) A catalyst provides an alternative reaction pathway with a lower activation energy.

Questions 31 and 32 should be answered with reference to the equation

$2\ C(s) + O_2(g) \rightleftharpoons 2\ CO(g)$ $\Delta H < 0$

31. What is the equilibrium expression for the reaction represented by the equation above?

(A) $K = \dfrac{2[CO]}{2[C]+[O_2]}$ **(B)** $K = \dfrac{2[CO]}{[O_2]}$

(C) $K = \dfrac{[CO]^2}{[C]^2[O_2]}$ **(D)** $K = \dfrac{[CO]^2}{[O_2]}$

32. If the reaction is at equilibrium with excess C(s) remaining, what change will increase the quantity of CO(g) for the reaction at equilibrium?

I Adding C(s)
II Increasing the temperature
III Increasing the pressure

(A) I only **(B)** III only

(C) I, II, and III **(D)** None of these

33. An endothermic reaction has a positive value for ΔS. Which of the following is true about the equilibrium constant for this reaction?

(A) It may be greater than 1 only at low temperatures.

(B) It may be greater than 1 only at high temperatures.

(C) It is greater than 1 at all temperatures.

(D) It is less than 1 at all temperatures.

34. Phosphoric acid, H_3PO_4, establishes the following equilibria in aqueous solution.

$H_3PO_4(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + H_2PO_4^-(aq)$ K_1

$H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HPO_4^{2-}(aq)$ K_2

$HPO_4^{2-}(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + PO_4^{3-}(aq)$ K_3

What is the relationship among the K values?

(A) $K_1 = K_2 = K_3$ **(B)** $K_1 > K_2 = K_3$

(C) $K_1 > K_2 > K_3$ **(D)** $K_1 < K_2 < K_3$

35. Which pair of solutes could be used to prepare an aqueous buffer solution with a pH < 7?

(A) HCl – NH_4Cl **(B)** HF – NaF

(C) NH_3 – NH_4Cl **(D)** NaOH – NaCl

36. What will be the result when 15.0 mL of 0.040 M lead(II) nitrate is mixed with 15.0 mL of 0.040 M sodium chloride?

$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2\ Cl^-(aq)$ $[K_{sp} = 1.7 \times 10^{-5}]$

(A) A clear solution with no precipitate will result.

(B) Solid $PbCl_2$ will precipitate and excess Pb^{2+} ions will remain in solution.

(C) Solid $PbCl_2$ will precipitate and excess Cl^- ions will remain in solution.

(D) Solid $PbCl_2$ will precipitate and no excess ions will remain in solution.

37. What is the oxidation number of As in the compound $K(NH_4)_2AsO_4 \cdot 6H_2O$?

(A) –3 **(B)** +1 **(C)** +3 **(D)** +5

38. When the equation

$\_\_\ MnO_4^- + \_\_\ SO_3^{2-} + \_\_\ H^+ \rightarrow \_\_\ Mn^{2+} + \_\_\ SO_4^{2-} + \_\_\ H_2O$

is balanced correctly with the smallest whole number coefficients, what is the coefficient for H_2O?

(A) 3 **(B)** 5 **(C)** 8 **(D)** 10

39.

Half-Reaction	$E°$ (V)
$2\ H^+ + 2\ e^- \rightarrow H_2$	0.00
$Pd^{2+} + 2\ e^- \rightarrow Pd$	0.90
$O_2 + 4\ H^+ + 4\ e^- \rightarrow 2\ H_2O$	1.23

According to the equations and data in the table above, which species is the strongest reducing agent of the following choices?

(A) H^+ **(B)** H_2 **(C)** H_2O **(D)** Pd^{2+}

40.

Half-Reaction	
$Zn^{2+}(aq) + 2\ e^- \rightarrow Zn(s)$	
$Cr^{3+}(aq) + 3\ e^- \rightarrow Cr(s)$	–0
$Fe^{2+}(aq) + 2\ e^- \rightarrow Fe(s)$	–0.4

Use the $E°$ values in the table above to determine wh of the following reactions will give the highest potentia in a voltaic cell.

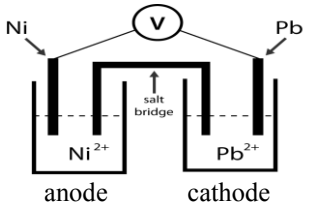
(A) $3\ Zn^{2+}(aq) + 2\ Cr(s) \rightarrow 3\ Zn(s) + 2\ Cr^{3+}(aq)$

(B) $3\ Zn(s) + 2\ Cr^{3+}(aq) \rightarrow 3\ Zn^{2+}(aq) + 2\ Cr(s)$

(C) $Zn^{2+}(aq) + Fe(s) \rightarrow Zn(s) + Fe^{2+}(aq)$

(D) $Zn(s) + Fe^{2+}(s) \rightarrow Zn^{2+}(aq) + Fe(s)$

41. The cell potential for the voltaic cell depicted below is 0.109 V under standard conditions, 1M $Ni^{2+}(aq)$ and 1 M $Pb^{2+}(aq)$.



Which change will increase the voltage?

(A) The 1 M Ni^{2+} solution is diluted with H_2O.

(B) A larger Ni electrode is used.

(C) 50 mL of 1 M NaCl solution is added to precipitate $PbCl_2$.

(D) More 1 M Pb^{2+} solution is added to that half-cell.

42. Aluminum is produced commercially by the electrolysis of Al_2O_3. How many hours would be required to produce 250. g of Al using a 5.00 Ampere current?

(A) 49.7 **(B)** 149 **(C)** 745 **(D)** 4020

43. A sulfur atom in its ground state has the electron configuration

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

How many orbitals are occupied by at least one electron?

(A) 3 **(B)** 5 **(C)** 8 **(D)** 9

44. For which of the following transitions would a hydrogen atom absorb a photon with longest wavelength?

(A) $n = 1$ to $n = 2$ **(B)** $n = 3$ to $n = 2$

(C) $n = 5$ to $n = 6$ **(D)** $n = 7$ to $n = 6$

45. Which set of quantum numbers is *not* possible?

(A) $n = 2, l = 1, m_l = +1, m_s = -½$

(B) $n = 3, l = 2, m_l = +1, m_s = +½$

(C) $n = 4, l = 4, m_l = -1, m_s = +½$

(D) $n = 5, l = 2, m_l = 2, m_s = -½$

46. What property of the oxygen atom is represented by the equation $O(g) + e^- \rightarrow O^-(g)$?

(A) electronegativity **(B)** first electron affinity

(C) first ionization energy **(D)** lattice energy

47. Which of the following isoelectronic species has the largest radius?

(A) K^+ **(B)** Ca^{2+} **(C)** P^{3-} **(D)** S^{2-}

48. Which group best illustrates the transition from non-metallic to metallic behavior with increasing atomic number?

(A) Be, Mg, Ca, Sr **(B)** N, P, As, Sb

(C) F, Cl, Br, I **(D)** Fe, Ru, Os, Hs

49. Which atom is least likely to violate the octet rule in its compounds?

(A) B **(B)** Cl **(C)** F **(D)** H

50. In the Lewis structure for formic acid, HCOOH, how many bonding pairs and lone pairs of electrons are present?

(A) 4 bonding, 2 lone **(B)** 4 bonding, 5 lone

(C) 5 bonding, 0 lone **(D)** 5 bonding, 4 lone

51. Which ionic compound has the largest lattice energy?

(A) LiF **(B)** BeO **(C)** KBr **(D)** CaS

52. When 1.0 mole of H_2O_2 decomposes to form H_2O and O_2, 103 kJ of energy is released. Given the bond energies below, what is the bond energy of the O–O single bond in H_2O_2?

Bond	H–O	O=O
Bond Energy, kJ•mol^{-1}	463	498

(A) +395 kJ•mol^{-1} **(B)** +249 kJ•mol^{-1}

(C) +146 kJ•mol^{-1} **(D)** +103 kJ•mol^{-1}

53. Which species has a different number of pi bonds than the others?

(A) C_2H_2 **(B)** CO_2 **(C)** N_2 **(D)** O_3

54. Which molecule is correctly matched [illegible] as predicted by VSEPR theory?

(A) PCl_3 trigonal pyramidal

(B) OF_2 linear

(C) ClF_3 trigonal planar

(D) SF_6 hexagonal

55. Which of the following statements regarding structural isomers is correct? They have

(A) the same molecular formula but the atoms are bonded in different ways.

(B) the same molar mass but different atoms in their composition.

(C) the same physical properties but different chemical properties.

(D) different isotopes in their structures.

56. What is the IUPAC name for the compound $CH_3CH_2CH_2CH_2CHO$?

(A) pentanal **(B)** pentanoic acid

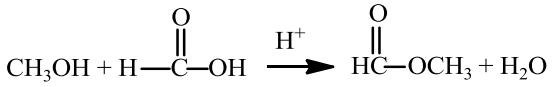
(C) 1-pentanol **(D)** 1-pentanone

57. Which compound will react rapidly with Br_2?

(A) benzene **(B)** hexane

(C) 1-hexene **(D)** 1-hexanol

58. The reaction below is best classified as



(A) addition. **(B)** esterification.

(C) neutralization. **(D)** saponification.

59. Which element is not found in common amino acids?

(A) hydrogen **(B)** nitrogen

(C) oxygen **(D)** phosphorus

60. Which of the following is not classified as a carbohydrate?

(A) glucose **(B)** glycine

(C) lactose **(D)** starch

END OF TEST

Olympiad 2014
USNCO Local Section Exam
KEY

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

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