2012 U.S. NATIONAL CHEMISTRY OLYMPIAD

NATIONAL EXAM PART I

Prepared by the American Chemical Society Chemistry Olympiad Examinations Task Force

OLYMPIAD EXAMINATIONS TASK FORCE

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DIRECTIONS TO THE EXAMINER – PART I

The USNCO Subcommittee is conducting a survey in an effort to determine the impact of the Olympiad program on students. The first phase of this effort is represented by several questions added to the end of this year's exam, which should be answered on the same Scantron sheet students use for the exam. These questions may be administered before or after the 90 minutes allotted for the exam, at your discretion, but each student should be encouraged to answer these questions.

Part I of this test is designed to be taken with a Scantron answer sheet on which the student records his or her responses. Only this Scantron sheet is graded for a score on Part I. Testing materials, scratch paper, and the Scantron sheet should be made available to the student *only* during the examination period. All testing materials including scratch paper should be turned in and kept secure until April 23, 2012, after which tests can be returned to students and their teachers for further study.

Allow time for students to read the directions, ask questions, and fill in the requested information on the Scantron sheet. The answer sheet must be completed using a pencil, not pen. When the student has completed **Part I**, or after **one hour and thirty minutes** has elapsed, the student must turn in the Scantron sheet, Part I of the testing materials, and all scratch paper.

There are three parts to the National Chemistry Olympiad Examination. You have the option of administering the three parts in any order, and you are free to schedule rest breaks between parts.

Part I	**60 questions**	**single answer, multiple-choice**	**1 hour, 30 minutes**
Part II	**8 questions**	**problem-solving, explanations**	**1 hour, 45 minutes**
Part III	**2 lab problems**	**laboratory practical**	**1 hour, 30 minutes**

A periodic table and other useful information are provided on page 2 for student reference**.**

Students should be permitted to use non-programmable calculators.

DIRECTIONS TO THE EXAMINEE – DO NOT TURN THE PAGE UNTIL DIRECTED TO DO SO. Answers to questions in Part I must be entered on a Scantron answer sheet to be scored. Be sure to write your name on the answer sheet, an ID number is already entered for you. **Make a record of this ID number because you will use the same number on Parts II and III.** Each item in **Part I** consists of a question or an incomplete statement that is followed by four possible choices. Select the single choice that best answers the question or completes the statement. Then use a pencil to blacken the space on your answer sheet next to the same letter as your choice. You may write on the examination, but the test booklet will not be used for grading. Scores are based on the number of correct responses. When you complete **Part I** (or at the end of one hour and 30 minutes), you must turn in all testing materials, scratch paper, and your Scantron answer sheet. **Do not forget to turn in your U.S. citizenship/Green Card Holder statement before leaving the testing site today.**

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 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
1.00 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 **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. Fe_2O_3 reacts with excess CO at a high temperature according to the equation below.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

If 6.50 g of Fe_2O_3 yields 3.85 g of Fe what is the percentage yield of the reaction?

(A) 59.2% **(B)** 69.9% **(C)** 76.3% **(D)** 84.7%

2. What is the final $[Na^+]$ in a solution prepared by mixing 70.0 mL of 3.00 M Na_2SO_4 with 30.0 mL of 1.00 M NaCl?

(A) 2.00 M **(B)** 2.40 M **(C)** 4.00 M **(D)** 4.50 M

3. The mass percentage of O in a potassium salt, $K_2S_2O_x$, is 36.0%. What is the formula of the polyatomic ion?

(A) $S_2O_3^{2-}$ **(B)** $S_2O_5^{2-}$ **(C)** $S_2O_7^{2-}$ **(D)** $S_2O_8^{2-}$

4. Cu reacts with HNO_3 according to the equation

$$Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO + NO_2 + H_2O$$

If NO and NO_2 are formed in a 2:3 ratio, what is the coefficient for Cu when the equation is balanced with the simplest whole numbers?

(A) 2 **(B)** 3 **(C)** 6 **(D)** 9

5. The active ingredient in commercial bleach is sodium hypochlorite, NaOCl, which can be determined by iodometric analysis as indicated in these equations.

$$OCl^- + 2H^+ + 2I^- \rightarrow I_2 + Cl^- + H_2O$$

$$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$$

If 1.356 g of a bleach sample requires19.50 mL of 0.100 M $Na_2S_2O_3$ solution, what is the percentage by mass of NaOCl in the bleach?

(A) 2.68% **(B)** 3.70% **(C)** 5.35% **(D)** 10.7%

6. A 12.0 M acid solution that contains 75.0% acid by mass has a density of 1.57 g/mL. What is the identity of the acid?

(A) HCl (M = 36.5) **(B)** CH_3CO_2H (M = 60.0)

(C) HBr (M=80.9) **(D)** H_3PO_4 (M = 98.0)

7. Which solid is much more soluble in 1 M HCl than in H_2O?

(A) $CaHPO_4$ **(B)** $CaCl_2$

(C) $BaBr_2$ **(D)** $BaSO_4$

8. Which experimental procedure is best suited to determine the H_2O_2 concentration in an aqueous solution?

(A) precipitation with standard $MgCl_2$ solution

(B) reaction with excess Zn to form H_2

(C) titration with standard H_2SO_4

(D) titration with standard $KMnO_4$

9. When equal volumes of 0.2 M solutions of the following compounds are mixed, which combination forms a red precipitate?

(A) $AgNO_3 + Na_2S$ **(B)** $AgNO_3 + K_2CrO_4$

(C) $NiCl_2 + NaOH$ **(D)** $CuSO_4 + NH_3$

10. Which combination represents an n-type semiconductor?

(A) Si doped with Ge **(B)** Si doped with As

(C) Si doped with Ga **(D)** As doped with Ga

11. In an experiment to determine the empirical formula of magnesium oxide, a student weighs an empty crucible then adds a strip of magnesium metal and reweighs the crucible. The crucible and magnesium are heated with a burner flame, which ignites the magnesium and forms a gray-white solid. After cooling, the crucible and solid are reweighed and the data are analyzed to give an empirical formula of Mg_5O_4. Which could account for the observed Mg_5O_4 result rather than the expected MgO?

(A) Some of the magnesium reacts with atmospheric nitrogen to produce magnesium nitride.

(B) A mixture of magnesium oxide and magnesium peroxide forms during combustion.

(C) The piece of magnesium ribbon is shorter than recommended in the procedure.

(D) The crucible and magnesium are heated longer than recommended in the procedure.

12. An acidic solution of methyl red has an absorbance of 0.451 at 530 nm in a 5.00 mm cell. Calculate the molarity of methyl red in this solution.
[molar absorptivity = 1.06×10^5 L•mol^{-1}•cm^{-1} at 530 nm]

(A) 2.13×10^{-6} M **(B)** 4.26×10^{-6} M

(C) 8.51×10^{-6} M **(D)** 1.05×10^{-5} M

13. A sample of H_2 collected over H_2O at 23 °C and a pressure of 732 mm Hg has a volume of 245 mL. What volume would the dry H_2 occupy at 0 °C and 1 atm pressure?

[vp H_2O at 23 °C = 21 mm Hg]

(A) 211 mL **(B)** 218 mL

(C) 224 mL **(D)** 249 mL

14. Two samples of gas, one of argon and one of helium, have the same pressure, temperature and volume. Which statement is true assuming both gases behave ideally?

(A) The helium sample contains more atoms than the argon sample and the helium atoms have a higher average speed.

(B) The two samples have the same number of atoms but the helium atoms have a higher average speed.

(C) The two samples have the same number of atoms and both types of atoms have the same average speed.

(D) The two samples have the same number of atoms but the argon atoms have a higher average speed.

15. For a sample of liquid in a closed container, which aspect(s) of vaporization depend on the surface area of the liquid?

I rate of vaporization II vapor pressure

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

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

16. The formulas and boiling points of three compounds are given in this table.

Formula	$CH_3CH_2CH_3$	CH_3OCH_3	CH_3CHO
BP, K	231	250	294

The trend in boiling points is best attributed to variations in

(A) covalent bonding. **(B)** dipole forces.

(C) dispersion forces. **(D)** hydrogen bonding.

17. Which statement about the triple point of a substance is correct?

(A) The triple point for a substance varies with the pressure.

(B) The three phases (solid, liquid, gas) have the same density.

(C) The three phases (solid, liquid, gas) are in equilibrium.

(D) The three phases (solid, liquid, gas) are indistinguishable in appearance.

18. Diethyl ether has a normal boiling po… and a boiling point of –1.5 °C at 100 mm Hg. … value of $\Delta H°_{vaporization}$ in kJ/mol?

(A) 33.4 **(B)** 39.1 **(C)** 64.2 **(D)** …

19. An ice cube at an unknown temperature is added to 25 g of liquid H_2O at 40.0 °C. The final temperature of the 29.3 g equilibrated mixture is 21.5 °C. What was the original temperature of the ice cube?

[C_p (J/g•°C) water = 4.184, ice = 2.06, $\Delta H°_{fusion}$ = 333 J/g]

(A) –6.5 °C **(B)** –13.1 °C

(C) –35.3 °C **(D)** –56.8 °C

20. One of the steps in the manufacture of nitric acid is represented by the equation

$$3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$$

for which $\Delta H° = -136.5$ kJ/mol. Determine $\Delta H°_{formation}$ for NO_2 in kJ/mol.

Substance	$NO_2(g)$	$H_2O(l)$	$HNO_3(aq)$	$NO(g)$
$\Delta H°_{formation}$	?	–285.8	–207.0	91.3

(A) 33.2 **(B)** 99.6 **(C)** 102.2 **(D)** 157.0

21. For the reaction, $2H(g) \rightarrow H_2(g)$, what are the signs of $\Delta H°$ and $\Delta S°$?

(A) $\Delta H° < 0, \Delta S° < 0$ **(B)** $\Delta H° < 0, \Delta S° > 0$

(C) $\Delta H° > 0, \Delta S° > 0$ **(D)** $\Delta H° > 0, \Delta S° < 0$

22. Which substance has the greatest molar entropy at 298 K?

(A) $NO_2(g)$ **(B)** $N_2O_4(l)$

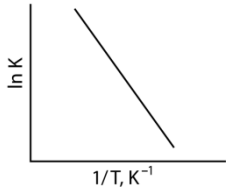
(C) $N_2O_4(g)$ **(D)** $N_2O_5(s)$

23. For the process, $CH_3OH(l) \rightarrow CH_3OH(g)$ $\Delta G° = 4.30$ kJ/mol at 25 °C. What is the vapor pressure of $CH_3OH(l)$ at 25 °C in mm Hg?

(A) 0.176 mm Hg **(B)** 14.0 mm Hg

(C) 134 mm Hg **(D)** 759 mm Hg

24. What quantity is represented by the slope of the line in this graph of the temperature dependence of the natural log of an equilibrium constant?



(A) $-\Delta G°$ **(B)** $-\Delta G°/R$

(C) $-\Delta H°$ **(D)** $-\Delta H°/R$

25. Which elementary reaction characteristic(s) change(s) significantly for a 10 °C temperature increase for a reaction carried out near room temperature?

I fraction of molecules with required E_a
II fraction of molecules with correct orientation

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

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

26. Hemoglobin (Hb) reacts with carbon monoxide according to the equation $4Hb + 3CO \rightarrow Hb_4(CO)_3$
What is the rate law for this reaction at 20 °C?

Trial	[Hb], M	[CO], M	Initial rate of disappearance of Hb $M \cdot s^{-1}$
1	1.50×10^{-6}	1.00×10^{-6}	9.20×10^{-7}
2	3.00×10^{-6}	1.00×10^{-6}	1.84×10^{-6}
3	3.00×10^{-6}	3.00×10^{-6}	5.52×10^{-6}

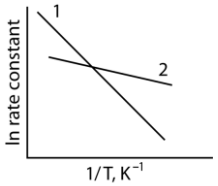
(A) Rate = k[Hb][CO] **(B)** Rate = k[Hb][CO]^2

(C) Rate = k[Hb]^2[CO] **(D)** Rate = k[Hb] [CO]^3

27. What is the first-order rate constant for a reaction that is 36.5% complete in 0.0200 seconds?

(A) 50.4 s^{-1} **(B)** 27.7 s^{-1} **(C)** 22.7 s^{-1} **(D)** 9.86 s^{-1}

28.



The diagram above depicts the temperature behavior of the rate constant, k, for two reactions, 1 and 2. Which statement about the k values at low temperatures and the activation energies, E_a, for these reactions is correct?

	k values at low T	E_a values
(A)	k rxn 1 < k rxn 2	E_a rxn 1 < E_a rxn 2
(B)	k rxn 1 < k rxn 2	E_a rxn 1 > E_a rxn 2
(C)	k rxn 1 > k rxn 2	E_a rxn 1 < E_a rxn 2
(D)	k rxn 1 > k rxn 2	E_a rxn 1 > E_a rxn 2

29. The hypothetical reaction $2A + B \rightarrow C + D$ is catalyzed by E as indicated in the possible mechanism below.

(Step 1) $A + E \rightleftharpoons AE$ (fast)
(Step 2) $AE + A \rightarrow A_2 + E$ (slow)
(Step 3) $A_2 + B \rightarrow C + D$ (fast)

Which rate law best agrees with this mechanism?

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

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

30. Automobile catalytic converters are d

(A) oxidize both CO and NO_x.

(B) reduce both CO and NO_x.

(C) oxidize CO and reduce NO_x.

(D) reduce CO and oxidize NO_x.

31. A 1 M aqueous solution of which molecule has the lowest pH?

(A) HOCl **(B)** H_2SO_3 **(C)** H_3PO_4 **(D)** H_2SO_4

32. If the initial pH values are the same for titrations of separate 25 mL samples of weak and strong monoprotic acids, which other value(s) is(are) also the same?

I the pH at the equivalence point
II the volume of base needed to reach the eq. point

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

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

33. The addition of 0.01 mol of which of the following to 100 mL of H_2O will give the most alkaline aqueous solution?

(A) NH_3 **(B)** $HONH_2$

(C) CH_3NH_2 **(D)** H_2NNH_2

34. What is the pH of a 1.00 L sample of a buffer solution containing 0.10 mol of benzoic acid and 0.10 mol of sodium benzoate to which 0.010 mol of NaOH has been added? [K_a benzoic acid = 6.5×10^{-5}]

(A) 4.27 **(B)** 4.23

(C) 4.15 **(D)** 4.10

35. Equal volumes of 1×10^{-4} M solutions of Cd^{2+} and CO_3^{2-} ions are mixed in one flask and equal volumes of 1×10^{-4} M solutions of Ag^+ and CrO_4^{2-} ions are mixed in a second. Which substances precipitate?

Formula	$CdCO_3$	Ag_2CrO_4
K_{sp}	5.2×10^{-12}	1.1×10^{-12}

(A) $CdCO_3$ only **(B)** Ag_2CrO_4 only

(C) Both **(D)** Neither

36. Consider these reactions and their corresponding *K*s.

$\frac{1}{2}N_2 + O_2 \rightarrow NO_2$ K_1
$2NO_2 \rightarrow 2NO + O_2$ K_2
$NOBr \rightarrow NO + \frac{1}{2}Br_2$ K_3

Express the *K* value for the reaction below in terms of K_1, K_2, and K_3.

$\frac{1}{2}N_2 + \frac{1}{2}O_2 + \frac{1}{2}Br_2 \rightarrow NOBr$ $K = ?$

(A) $K_1 + K_2/2 - K_3$ **(B)** $K_1 + (K_2)^{1/2} - K_3$

(C) $K_1K_2/2K_3$ **(D)** $K_1(K_2)^{1/2}/K_3$

37. What is the average oxidation state of copper in the superconductor $YBa_2Cu_3O_7$?

(A) +2 **(B)** +2.33 **(C)** +2.67 **(D)** +3

38. $Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$ $E° = 0.15$ V
$Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$ $E° = -0.41$ V
According to the standard reduction potentials above, what is the value of E° for the reaction below?
$2Cr^{3+}(aq) + Sn^{2+}(aq) \rightarrow 2Cr^{2+}(aq) + Sn^{4+}(aq)$

(A) –0.97 V **(B)** –0.56 V
(C) +0.56 V **(D)** +0.97 V

39. $Ag^+(aq) + e^- \rightarrow Ag(s)$ $E° = 0.80$ V
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$ $E° = -2.73$ V
Use the equations above to calculate the value of $\Delta G°$ (in kJ/mol) for the reaction:
$Mg(s) + 2Ag^+(aq) \rightarrow Mg^{2+}(aq) + 2Ag(s)$

(A) 681 **(B)** 341 **(C)** –341 **(D)** –681

40. What is the $[Fe^{2+}]$ in a cell at 25 °C for which E = –0.458 V vs a standard hydrogen electrode?
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ $E° = -0.440$ V

(A) 0.246 M **(B)** 0.496 M
(C) 2.01 M **(D)** 4.06 M

41. Rechargeable batteries include which of those below?
I dry cell
II lead-acid storage battery
III nickel-cadmium battery

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

42. How many liters of chlorine gas, Cl_2, measured at 0 °C and 1 atm (STP) are released by the passage of 6.25 amperes for 1.85 hours through molten magnesium chloride?

(A) 0.0805 L **(B)** 0.161 L
(C) 4.83 L **(D)** 9.67 L

43. How many radial nodes does a 3d orbital possess?

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

44. The successive ionization energies (in kJ/mol) for an element are shown below.

E_1	E_2	E_3	E_4	E_5
577	1820	2740	11600	14800

What is the electron configuration of this element?

(A) $1s^2\ 2s^2\ 2p^6\ 3s^1$ **(B)** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
(C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ **(D)** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3$

45. Albert Einstein's explanation of the ph[illegible]ffect confirmed which of the following concep[illegible]

(A) Electrons can absorb energy and change atoms.
(B) Light energy can be converted into the mass of electrons.
(C) Electrons have both particle and wave properties.
(D) Light has both particle and wave properties.

46. Which gas phase ion in its ground state has the greatest number of unpaired electrons?

(A) Cr^{3+} **(B)** Mn^{3+} **(C)** Fe^{3+} **(D)** Co^{3+}

47. For the element with the electron configuration $1s^2\ 2s^2\ 2p^6\ 3s^2$, one of the 3s electrons will be shielded from the nuclear charge most effectively by a

(A) 1s electron **(B)** 2s electron
(C) 2p electron **(D)** 3s electron

48. In which list are atoms of the elements Be, B, Mg and Al arranged from smallest to largest atomic radius?

(A) Be < B < Mg < Al **(B)** Mg < Be < Al < B
(C) B < Be < Al < Mg **(D)** Al < Mg < B < Be

49. Which ionic compound has the smallest lattice energy?

(A) LiI **(B)** NaF **(C)** $MgCl_2$ **(D)** MgO

50. What is the geometry of BrF_3?

(A) seesaw **(B)** T-shaped
(C) trigonal planar **(D)** trigonal pyramidal

51. Three monosulfur fluorides are known: SF_2, SF_4 and SF_6. Of these, polar species include

(A) SF_2 only. **(B)** SF_4 only.
(C) SF_2 and SF_4 only. **(D)** SF_2, SF_4 and SF_6.

52. Which reaction forms a product with a trigonal planar geometry?

(A) $N_2 + 3H_2 \rightarrow$ **(B)** $2CO + O_2 \rightarrow$
(C) $PCl_3 + Cl_2 \rightarrow$ **(D)** $2SO_2 + O_2 \rightarrow$

53. What is the best description of the hybridization of each of the carbon atoms (from left to right) in the compound $NCCH_2CO_2H$?

(A) sp, sp^3, sp^2 **(B)** sp, sp^2, sp^3
(C) sp^2, sp^3, sp^2 **(D)** sp^2, sp^3, sp^3

54. How many isomers exist for the square planar species $Pt(H_2O)(NH_3)ClBr$?

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

55. Which polymer is manufactured by condensation?

(A) Polyethylene terephthalate

(B) Polypropylene

(C) Polystyrene

(D) Polyvinylchloride

56. How many non-cyclic compounds have the formula C_4H_8?

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

57. Which is a Grignard reagent?

(A) $Ag(NH_3)_2^+$ **(B)** C_2H_5MgBr

(C) $FeBr_3 + Br_2$ **(D)** $LiAlH_4$

58. A racemic mixture consists of equal quantities of

(A) cis-trans isomers. **(B)** diastereomers.

(C) enantiomers. **(D)** structural isomers.

59. How many carbon-carbon double bonds are present in linolenic acid, α–$C_{17}H_{29}COOH$?

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

60. Recently scientists reported a bacterium that they believe incorporates arsenic into its DNA by substituting it for another element. Which element in DNA is arsenic most likely to replace?

(A) carbon **(B)** nitrogen

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

END OF TEST

When you have finished answering this examination [illegible] been called by the Examiner please provide responses t[illegible] following 4 items. Your answers will not affect your score [illegible] the exam but will help with a study being conducted by the U[illegible] National Chemistry Olympiad (USNCO) Subcommittee.

61. The amount of time I spend doing experiments in the laboratory per week on average during my chemistry course was/is?

(A) less than ½ hour.

(B) between ½ and 1 hour.

(C) between 1 and 2 hours.

(D) more than 2 hours.

The following questions should be answered using the scale

(A) Strongly agree

(B) Agree

(C) Disagree

(D) Strongly disagree

62. **As a result of my participation in the USNCO program**, I plan to study more chemistry.

63. **As a result of my participation in the USNCO program**, I plan to major in chemistry in college.

64. **As a result of my participation in the USNCO program**, I have a more positive view of chemistry than I did before participating.

Olympiad 2012
USNCO National Exam
Part I
KEY

Number	Answer	Number	Answer
1.	D	31.	D
2.	D	32.	D
3.	B	33.	C
4.	D	34.	A
5.	C	35.	A
6.	D	36.	D
7.	A	37.	B
8.	D	38.	B
9.	B	39.	D
10.	B	40.	A
11.	A	41.	C
12.	C	42.	C
13.	A	43.	A
14.	B	44.	B
15.	A	45.	D
16.	B	46.	C
17.	C	47.	A
18.	B	48.	C
19.	B	49.	A
20.	A	50.	B
21.	A	51.	C
22.	C	52.	D
23.	C	53.	A
24.	D	54.	C
25.	A	55.	A
26.	A	56.	D
27.	C	57.	B
28.	B	58.	C
29.	C	59.	C
30.	C	60.	D