2007 U. S. NATIONAL CHEMISTRY OLYMPIAD

NATIONAL EXAM PART 1

Prepared by the American Chemical Society Olympiad Examinations Task Force

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DIRECTIONS TO THE EXAMINER–PART I

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 May 1, 2007, after which tests can be returned to students and their teachers for further study.

Allow time for the student 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 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–PART I

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 both 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 statement before leaving the testing site today.

Not valid for use as an USNCO Olympiad National Exam after May 1, 2007.

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ABBREVIATIONS AND SYMBOLS					
ampere	A	Faraday constant	F	molal	m
atmosphere	atm	formula molar mass	M	molar	M
atomic mass unit	u	free energy	G	molar mass	M
atomic molar mass	A	frequency	ν	mole	mol
Avogadro constant	N_A	gas constant	R	Planck's constant	h
Celsius temperature	°C	gram	g	pressure	P
centi– prefix	c	heat capacity	C_p	rate constant	k
coulomb	C	hour	h	retention factor	R_f
electromotive force	E	joule	J	second	s
energy of activation	E_a	kelvin	K	temperature, K	T
enthalpy	H	kilo– prefix	k	time	t
entropy	S	liter	L	volt	V
equilibrium constant	K	milli– prefix	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}
$N_A = 6.022 \times 10^{23}$ 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 = 760 mmHg

EQUATIONS

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

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** (269)	111 **Rg** (272)	112 **Uub** (277)		114 **Uuq** (2??)		116 **Uuh** (2??)		118 **Uuo** (2??)

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 pencil. Make a heavy, full mark, but no stray marks. If you decide to change an answer, erase the unwanted mark very
- There is only one correct answer to each question. Any questions for which more than one response has been blackened will 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 absorbs gaseous carbon dioxide most effectively?

(A) solid KOH **(B)** solid SiO_2

(C) aqueous HCl **(D)** aqueous NaF

2. Which laboratory results will tell whether an unknown white solid is NaOH or NH_4NO_3?

(A) NaOH is soluble in H_2O but NH_4NO_3 is not.

(B) Aqueous NaOH turns litmus blue but NH_4NO_3 does not.

(C) Aqueous NaOH reacts with copper metal but NH_4NO_3 does not.

(D) NaOH gives a green flame test but NH_4NO_3 is colorless in a flame.

3. Which sets of chemicals, when mixed, produce the observation(s) listed?

	Combination	Observation
I.	$NH_4Cl(s)$ and $H_2O(l)$	endothermic
II.	9 M $H_2SO_4(aq)$ and $H_2O(l)$	exothermic
III.	1M NaOH(aq) and 1 M HCl(aq)	exothermic

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

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

4. What happens when 6 M nitric acid is added to an aqueous solution that contains 0.1 M Cl^- and 0.1 M $Ag(NH_3)_2^+$?

(A) A deposit of silver metal forms.

(B) A precipitate of AgCl forms.

(C) Chlorine gas is released.

(D) Gaseous ammonia is released.

5. A mixture of which 0.2 M aqueous solutions will form a precipitate that dissolves in 6 M nitric acid?

(A) $Co(NO_3)_2$ and NH_4Cl **(B)** $Pb(NO_3)_2$ and NaBr

(C) $Ba(NO_3)_2$ and Na_2CO_3 **(D)** $Al(NO_3)_3$ and K_2SO_4

6. When a liquid is delivered from a volumetric pipet a small amount is typically retained in the tip. How should a student proceed in order to deliver the volume of liquid stated on the pipet?

(A) Leave the small amount in the tip.

(B) Use a pipet bulb to expel the remaining droplet.

(C) Shake the pipet to dispense the amount left in the tip.

(D) Draw the liquid above the line initially to compensate for the amount that remains in the tip.

7. What is the molarity of a 0.500 molal aqueous solution of calcium nitrate that has a density of 1.045 $g \cdot mL^{-1}$?

(A) 0.483 M **(B)** 0.500 M

(C) 0.522 M **(D)** 0.567 M

8. What volume of 0.150 M H_2SO_4 would be required to completely neutralize a mixture of 20.0 mL of 0.200 M NaOH and 40.0 mL of 0.0500 M $Ca(OH)_2$?

(A) 20.0 mL **(B)** 26.7 mL

(C) 40.0 mL **(D)** 53.3 mL

9. A compound with the formula X_2O_5 contains 34.8% oxygen by mass. Identify element X.

(A) arsenic **(B)** carbon

(C) phosphorous **(D)** samarium

10. A solution of 0.0400 mol of $C_2H_4Br_2$ and 0.0600 mol of $C_3H_6Br_2$ exerts a vapor pressure of 145.4 mm Hg at a certain temperature. Determine the vapor pressure of pure $C_3H_6Br_2$ at this temperature. Assume the vapor pressure of $C_2H_4Br_2$ at this temperature is 173 mm Hg and that the solution obeys Raoult's Law.

(A) 76.2 mm Hg **(B)** 118 mm Hg

(C) 127 mm Hg **(D)** 138 mm Hg

11. When 0.1 M aqueous solutions of aluminum nitrate, magnesium nitrate, sodium nitrate and urea, $(NH_2)_2CO$, are arranged in order of increasing boiling point, which order is correct?

(A) $Al(NO_3)_3 = Mg(NO_3)_2 = (NH_2)_2CO = NaNO_3$

(B) $Mg(NO_3)_2 < (NH_2)_2CO < NaNO_3 < Al(NO_3)_3$

(C) $(NH_2)_2CO < NaNO_3 < Mg(NO_3)_2 < Al(NO_3)_3$

(D) $NaNO_3 < Mg(NO_3)_2 < Al(NO_3)_3 < (NH_2)_2CO$

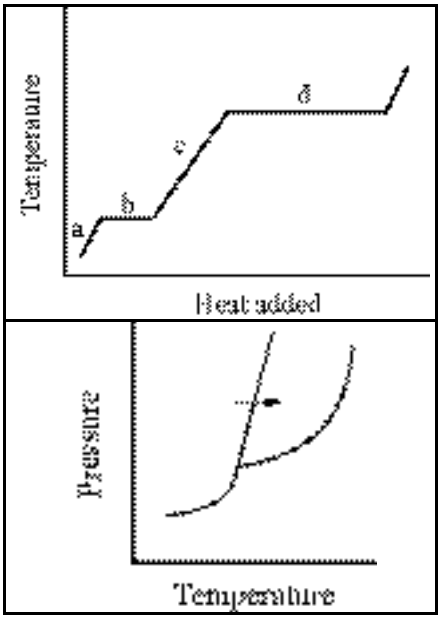
12. What is the maximum mass of $Ba_3(PO_4)_2$ that can be formed from 0.00240 mol of $Ba(NO_3)_2$ and 0.131 g of Na_3PO_4?

Molar Mass / g·mol^{-1}	
$Ba_3(PO_4)_2$	601.84
Na_3PO_4	163.94

(A) 0.240 g **(B)** 0.480 g

(C) 1.44 g **(D)** 7.22 g

13. Which segment of the heating curve obtained at constant pressure corresponds to the transition denoted by the arrow in the phase diagram?



(A) a **(B)** b **(C)** c **(D)** d

14. What is the molar mass of a gas that has a density of 5.66 g·L^{-1} at 35°C and 745 mm Hg?

(A) 127 **(B)** 141 **(C)** 143 **(D)** 146

15. Consider the solids: body-centered cubic (bcc), face-centered cubic (fcc), simple cubic (sc) (or primitive), constructed of spheres of the same size. When they are arranged in increasing order of the percentage of free space in a unit cell, which order is correct?

(A) fcc, bcc, sc **(B)** bcc, sc, fcc

(C) sc, fcc, bcc **(D)** bcc, fcc, sc

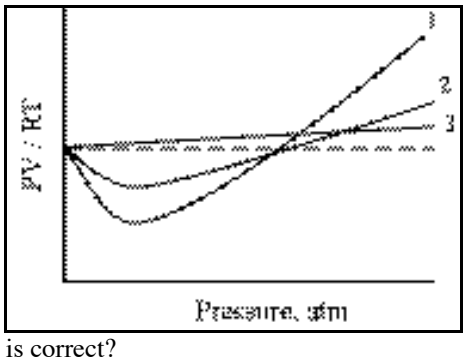
16. The vapor pressure of phosphorus tric
100 mm Hg at 21.0°C and its normal boi
74.2°C. What is its enthalpy of vaporizatio

(A) 0.493 **(B)** 3.93 **(C)** 23.0 **(D)**

17. If the absolute temperature of a sample of gas is increased by a factor of 1.5, by what ratio does the average molecular speed of its molecules increase?

(A) 1.2 **(B)** 1.5 **(C)** 2.2 **(D)** 3.0

18. The curves in the accompanying diagram represent the PV/RT behavior of the gases: He, CH_4 and C_3H_8. Which assignment of behavior to gas is correct?



(A) 1 = He
2 = CH_4
3 = C_3H_8

(B) 1 = C_3H_8
2 = CH_4
3 = He

(C) 1 = CH_4
2 = C_3H_8
3 = He

(D) 1 = C_3H_8
2 = He
3 = CH_4

19. Calculate the standard enthalpy of formation of acetylene (in kJ·mol^{-1}).

$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l)$ $\Delta H^\circ = -2243.6$ kJ

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H^\circ = -393.5$ kJ

$H_2(g) + 1/2\ O_2(g) \rightarrow H_2O(l)$ $\Delta H^\circ = -285.8$ kJ

(A) 49.0 **(B)** 98.0 **(C)** 1121.8 **(D)** 1564.3

20. The boiling point of diethyl ether is 34.6°C. Which is true for the vaporization of diethyl ether at 25.0°C?

(A) $\Delta G^\circ_{vap} > 0$ **(B)** $\Delta H^\circ_{vap} < 0$

(C) $K_{vap} = 1$ **(D)** $\Delta S^\circ_{vap} < 0$

21. Estimate the enthalpy of combustion of methane in kJ·mol^{-1}.

Bond Dissociation Enthalpies / kJ·mol^{-1}			
C–C	350	C–O	350
C–H	410	C=O	732
O–H	460	O–O	180
		O=O	498

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

(A) 668 **(B)** 540 **(C)** –540 **(D)** –668

22. Which reaction has a positive $\Delta S^\circ_{reaction}$?

(A) $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$

(B) $2C_2H_6(g) + 3O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$

(C) $N_2(g) + 2H_2(g) \rightarrow N_2H_4(g)$

(D) $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

23. For reactions conducted at constant pressure, under what conditions are ΔE and ΔH equal?

I. constant number of moles
II. constant temperature
III. constant volume

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

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

24. For the reaction,

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

$K_p = 50.0$ at 721 K. What is the value of ΔG° for this reaction (per mole of H_2) at 721 K?

(A) –32.3 kJ **(B)** –23.5 kJ

(C) –10.2 kJ **(D)** –0.231 kJ

25. Which of these factors affect the value of the rate constant for a reaction?

I. temperature
II. reactant concentration
III. use of a catalyst

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

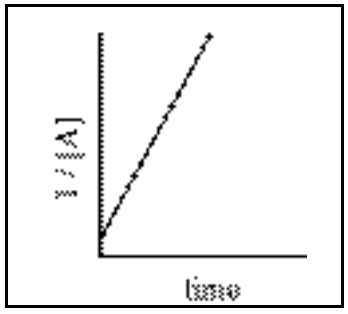
(C) I and III only **(D)** I, II and III

26. Which is the correct exponential form of the Arrhenius equation?

(A) $E_a = Ae^{-k/RT}$ **(B)** $E_a = Ae^{k/RT}$

(C) $k = Ae^{-RT/E_a}$ **(D)** $k = Ae^{-E_a/RT}$

27. For the reaction A → B, what is the order with respect to A that gives this graph?



(A) zero **(B)** first **(C)** second **(D)** third

28. For the reaction A → B that is first-ord… te constant is 2.08×10^{-2} s^{-1}. How long woul… to change from 0.100 M to 0.0450 M?

(A) 0.0166 s **(B)** 16.7 s **(C)** 38.4 s **(D)** …

29. These data were obtained for the reaction: X + Y → Z…

X (M)	Y (M)	Rate: $\Delta Z/\Delta t$ / M·min^{-1}
1.00	1.00	2.36×10^{-4}
2.00	2.00	1.89×10^{-3}
2.00	4.00	3.78×10^{-3}

What is the rate law?

(A) Rate = k[X][Y] **(B)** Rate = k[X]^2[Y]

(C) Rate = k[X][Y]^2 **(D)** Rate = k[X]^2[Y]^2

30. A possible mechanism for the conversion of ozone to oxygen in the upper atmosphere is

$O_3(g) \rightleftharpoons O_2(g) + O(g)$ (fast equilibrium)
$O(g) + O_3(g) \rightleftharpoons 2O_2(g)$ (slow)

Which rate law is consistent with this mechanism?

(A) Rate = k[O_3] **(B)** Rate = k[O_3]^2

(C) Rate = k[O_3][O] **(D)** Rate = k[O_3]^2[O_2]$^{-1}$

31. A 0.050 M solution of an unknown acid is 1.0% ionized. What is the value of its K_a?

(A) 2.5×10^{-7} **(B)** 5.0×10^{-6}

(C) 5.0×10^{-4} **(D)** 5.0×10^{-2}

32. Which mixture(s) form(s) buffer solutions?

I. 100 mL of 0.200 M HF and 200 mL of 0.200 M NaF
II. 200 mL of 0.200 M HCl and 200 mL of 0.400 M CH_3CO_2Na
III. 300 mL of 0.100 M CH_3CO_2H and 100 mL of 0.300 M CH_3CO_2Na

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

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

33. Determine the equilibrium constant for the reaction:

$$HF(aq) + NH_3(aq) \rightleftharpoons NH_4^+(aq) + F^-(aq)$$

given the equilibrium constants for the reactions.

$HF(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + F^-(aq)$ $K_a = 6.9\times10^{-4}$
$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ $K_b = 1.8\times10^{-5}$
$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$ $K_w = 1.0\times10^{-14}$

(A) 1.2×10^{-8} **(B)** 1.2×10^{6}

(C) 8.1×10^{7} **(D)** 3.8×10^{15}

34. Calculate the pH of a 0.15 M solution of HOCl.

	K_a
HOCl	2.9×10^{-8}

(A) 3.77 **(B)** 4.18 **(C)** 6.71 **(D)** 8.36

35. For which reaction does $K_p = K_c$?

(A) $2C(s) + O_2(g) \rightleftharpoons 2CO(g)$

(B) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(C) $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$

(D) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

36. CaF_2 has a $K_{sp} = 3.9\times10^{-11}$ at 25°C. What is the $[F^-]$ in a saturated solution of CaF_2 at 25°C?

(A) 2.1×10^{-4} **(B)** 3.4×10^{-4}

(C) 4.3×10^{-4} **(D)** 6.8×10^{-4}

37. When the reaction: $Cl^- + ClO_3^- \rightarrow Cl_2 + H_2O$ is balanced in acid solution what is the ratio of Cl^- to ClO_3^-?

(A) 1 / 1 **(B)** 2 / 1 **(C)** 3 / 1 **(D)** 5 / 1

38. Which change could occur at the anode of an electrochemical cell?

(A) $Cl^- \rightarrow Cl_2$ **(B)** $H_2O \rightarrow H_2$

(C) $Na^+ \rightarrow Na$ **(D)** $O_2 \rightarrow H_2O$

39. $E^\circ = 0.93$ V for the reaction:

Standard Reduction Potential / E°	
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.41 V

$Fe(s) + 2M^+(aq) \rightarrow Fe^{2+}(aq) + 2M(s)$.
What is the standard potential for $M^+ + e^- \rightarrow M$?

(A) 0.26 V **(B)** 0.52 V

(C) 0.67 V **(D)** 1.34 V

40. For which half-reaction will a 1.0 unit increase in pH cause the greatest increase in half-cell potential?

(A) $V^{2+}(aq) \rightarrow V^{3+}(aq) + e^-$

(B) $VO_3^- + 2H^+ \rightarrow VO_2^+ + H_2O$

(C) $VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$

(D) $VO^{2+} + H_2O \rightarrow VO_2^+ + 2H^+ + e^-$

41. A solution of aqueous $CuSO_4$ is electrolyzed with a 1.50 ampere current for 30.0 minutes. What mass of copper metal is deposited?

(A) 0.889 g **(B)** 1.19 g **(C)** 1.78 g **(D)** 3.56 g

42. According to the tabulated standard re… tials

$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	E
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	E° =
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	E° = 0.3
$O_2(g) + 4H^+(aq) \rightarrow 2H_2O(l)$	E° = 1.23

what products are formed during the electrolysis of a… aqueous $MgBr_2$ solution?

(A) Mg and H_2 **(B)** H_2 and Br_2

(C) H_2 and O_2 **(D)** Mg and O_2

43. Which is the symbol for an element whose ground state atoms have the same total numbers of s electrons and p electrons?

(A) $_5B$ **(B)** $_6C$ **(C)** $_{12}Mg$ **(D)** $_{18}Ar$

44. Which set of quantum numbers is NOT allowed?

	n	ℓ	m_ℓ	m_s
(A)	1	0	0	–_
(B)	2	2	1	_
(C)	3	1	1	_
(D)	4	3	–3	_

45. Which change(s) in electron structure occur when a gas phase Mn atom is converted to a Mn^{2+} ion in the gas phase?

I. The number of occupied energy levels decreases.
II. The number of half-filled orbitals decreases.

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

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

46. Which list gives the symbols of the elements in the order of increasing first ionization energy?

(A) F, Ne, Na **(B)** Al, Mg, Na

(C) Sr, Ca, Mg **(D)** Cl, Br, I

47. How many unpaired electrons are in a gas phase Co^{2+} ion in its ground state?

(A) 2 **(B)** 3 **(C)** 4 **(D)** 5

48. The energy required to ionize a potassium ion is 419 $kJ\cdot mol^{-1}$. What is the longest wavelength of light that can cause this ionization?

(A) 285 nm **(B)** 216 nm

(C) 200 nm **(D)** 107 nm

49. Which species has the same electron distribution around the central atom as SiF_4?

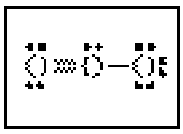
(A) SF_4 **(B)** XeF_4 **(C)** ClF_4^+ **(D)** BF_4^-

50. Which is/are polar species?

I. SF_2
II. SF_4
III. SF_6

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

51. According to the Lewis dot structure for ozone, what is the formal charge on the central oxygen atom?



(A) –2 **(B)** –1 **(C)** 0 **(D)** +1

52. When the species are arranged in order of increasing length of the carbon-oxygen bond, which order is correct?

(A) $Na_2CO_3 < HCO_2Na < CH_3ONa$
(B) $CH_3ONa < HCO_2Na < Na_2CO_3$
(C) $HCO_2Na < Na_2CO_3 < CH_3ONa$
(D) $Na_2CO_3 < CH_3ONa < HCO_2Na$

53. Which ionic solid would require the most energy to form gaseous ions?

(A) NaF **(B)** Na_2O **(C)** MgO **(D)** MgF_2

54. Solid calcium occurs as either cubic closest packing or hexagonal closest packing. What is the most significant difference between these two structures?

(A) the placement of layers of calcium atoms
(B) the distance betweeen calcium atoms in a single layer
(C) the distance between calcium atoms in adjacent layers
(D) the coordination number of the calcium atoms in a single layer

55. How many unsaturated compounds ha… C_4H_8?

(A) 3 **(B)** 4 **(C)** 5

56. Which compound is least soluble in water?

(A) $CH_3CH_2CH_2F$ **(B)** $CH_3CH_2CH_2NH_2$
(C) $CH_3CH_2CH_2OH$ **(D)** $CH_3CH_2CH_2COOH$

57. Which method for characterizing organic compounds relies on the vibration of atoms in the compound?

(A) infrared spectroscopy
(B) nuclear magnetic resonance spectroscopy
(C) UV-visible spectroscopy
(D) X-ray diffraction

58. Which substance reacts most rapidly with water?

(A) C_6H_5Cl **(B)** $(CH_3)_3CCl$
(C) $(CH_3)_2CHCH_2Cl$ **(D)** $CH_3CH_2CH_2CH_2Cl$

59. What type of compound is formed by the mild oxidation of 2-pentanol?

(A) acid **(B)** aldehyde
(C) ester **(D)** ketone

60. Which species is lost during the formation of a disaccharide from a monosaccharide?

(A) CH_2 **(B)** CH_2O **(C)** CH_2OH **(D)** H_2O

END OF TEST

NATIONAL OLYMPIAD PART I
2007
KEY

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

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