2009 U. S. NATIONAL CHEMISTRY OLYMPIAD

NATIONAL EXAM – PART I

Prepared by the American Chemical Society Olympiad Examinations Task Force

OLYMPIAD EXAMINATIONS TASK FORCE

Arden P. Zipp, **Chair**, *State University of New York*, Cortland, NY

James Ayers, *Mesa State College*, Grand Junction, CO
Sherry Berman-Robinson, *Consolidated HS*, Orland Park, IL (retired)
Seth Brown, *University of Notre Dame,* Notre Dame, IN
Peter Demmin, *Amherst HS*, Amherst, NY (retired)
Marian Dewane, *Centennial HS,* Boise, ID
Valerie Ferguson, *Moore HS*, Moore, OK
Kimberly Gardner, *US Air Force Academy*, Colorado Springs, CO
Paul Groves, *South Pasadena HS*, South Pasadena, CA
Preston Hays, Glenbrook South HS, Glenbrook, IL
David Hostage, *Taft School*, Watertown, CT
Adele Mouakad, *St. John's School*, San Juan, PR
Jane Nagurney, *Scranton Preparatory School,* Scranton, PA
Ronald Ragsdale, *University of Utah*, Salt Lake City, UT

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 April 29, 2009, 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 April 29, 2009.

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

CONSTA
$R = 8.314\ \text{J·mol}^{-1}\cdot\text{K}$
$R = 0.0821\ \text{L·atm·mol}^{-1}\cdot\text{K}$
$1\ F = 96{,}500\ \text{C·mol}^{-1}$
$1\ F = 96{,}500\ \text{J·V}^{-1}\text{·mol}^{-1}$
$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$
$h = 6.626 \times 10^{-34}\ \text{J·s}$
$c = 2.998 \times 10^{8}\ \text{m·s}^{-1}$
0 °C = 273.15 K

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??)				

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 oxide produces an acidic solution when mixed with water?

(A) Al_2O_3 **(B)** CaO **(C)** CO **(D)** SO_2

2. Which gas should not be collected over water due to its high solubility in water?

(A) H_2 **(B)** N_2 **(C)** NH_3 **(D)** CH_4

3. Which procedure(s) will allow a student to differentiate between solid sodium sulfate and solid sodium sulfite?

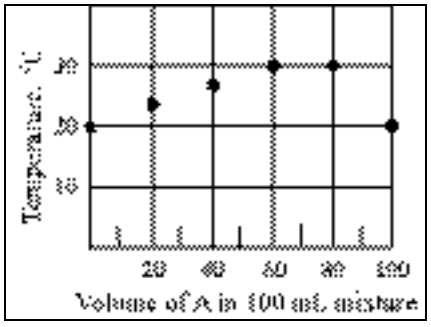
I. Make solutions of each and look for a precipitate when added to 0.10 M $Ba(NO_3)_2$.
II. Add crystals of each to 0.10 M HCl and watch for bubbles.
III. Make solutions of each and test with a pH indicator.

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

4. A student gets fingerprints on a cuvette before using it to determine the concentration of a colored species using its known extinction coefficient. What is the effect on the absorbance and reported concentration?

	absorbance	**reported concentration**
(A)	increased	too low
(B)	increased	too high
(C)	decreased	too low
(D)	decreased	too high

5. Chemicals A and B each initially at 20 ºC react exothermically. A graph of the final temperature reached by mixing equimolar solutions of A and B to a total of 100 mL is given to the right. According to this graph, in what mole ratio do A and B react?



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

6. What color does the strontium ion produce in a flame test?

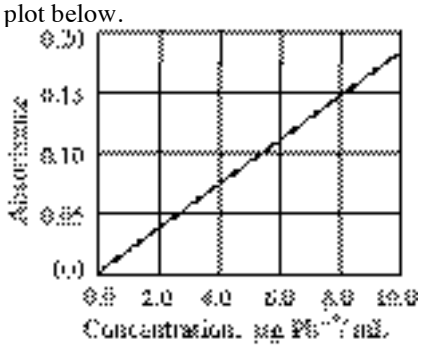
(A) red **(B)** blue **(C)** green **(D)** yellow

7. What is the mass percent of oxygen in the compound $UO_2(C_2H_3O_2)_2{\cdot}NH_4C_2H_3O_2{\cdot}6H_2O$?

Formula Weight, g	
$UO_2(C_2H_3O_2)_2{\cdot}NH_4C_2H_3O_2{\cdot}6H_2O$	573

(A) 5.58% **(B)** 16.8% **(C)** 22.3% **(D)** 39.1%

8. A 25.0 mL sample of waste water is obtained to analyze for Pb^{2+} ions. This sample is evaporated to dryness and redissolved in 2.0 mL of H_2O, mixed with 2.0 mL of a buffer solution and 2.0 mL of a solution of dithizone then diluted to 10.0 mL. The absorbance of the colored Pb^{2+}-dithizone complex is compared with the Beer-Lambert plot below.



The absorbance of a portion of the final solution is 0.13. What is the concentration of Pb^{2+} ions in the waste water in ppm?

(A) 2.9 **(B)** 7.2 **(C)** 18 **(D)** 36

9. Reductic acid contains 52.63% carbon, 5.30% hydrogen, and 42.07% oxygen. Its empirical formula is the same as its molecular formula. What is the number of carbon atoms in a molecule of this acid?

(A) 4 **(B)** 5 **(C)** 6 **(D)** 8

10. Sulfur trioxide, SO_3, is made by oxidizing sulfur dioxide, SO_2, according to the equation, $2SO_2 + O_2 \rightarrow 2SO_3$. If a 16.0 g sample of SO_2 yields 18.0 g of SO_3, what is the percent yield?

(A) 70.0% **(B)** 80.0% **(C)** 90.0% **(D)** 100.%

11. A 1.0 g sample of which substance contains the largest number of molecules?

(A) HN_3 **(B)** N_2H_4 **(C)** H_2O_2 **(D)** HCl

12. What is the maximum mass of PbI_2 that can be precipitated by mixing 25.0 mL of 0.100 M $Pb(NO_3)_2$ with 35.0 mL of 0.100 M NaI?

Molar Mass, g·mol^{-1}	
PbI_2	461

(A) 0.807 g **(B)** 1.15 g **(C)** 1.61 g **(D)** 2.30 g

13. Which statement is not a principle (postulate) of kinetic molecular theory?

(A) The molecules of a gas are in rapid random motion.

(B) The molecules of an ideal gas exhibit no attractive forces.

(C) The collisions of gaseous molecules with one another and the walls of their container are elastic.

(D) Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules.

14. When a sample of an ideal gas is heated from 25°C to 50°C the average kinetic energy of the molecules increases. Which ratio gives the correct relationship between the average kinetic energies at the higher temperature to the lower temperature?

(A) 2 : 1 **(B)** $\sqrt{2} : \sqrt{1}$

(C) 323 : 298 **(D)** $\sqrt{323} : \sqrt{298}$

15. A partially filled tank of propane contains both a liquid and a gas phase. Which of these statements about the contents of the two phases are correct?

I. The two phases have the same potential energy but different kinetic energies.
II. The two phases have the same molar masses but different densities.

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

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

16. Which property or properties of metals can be accounted for by the electron sea model?

I. electrical conductivity
II. malleability

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

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

17. In a crystal of a typical metallic element, an atom has how many nearest neighbors?

(A) 4 **(B)** 6 **(C)** 12 **(D)** 16

18. Which aqueous solution has the highe[illegible]ssure at 25°C? (Assume all ionic compounds i[illegible]ly in solution.)

(A) 0.1 M $Al_2(SO_4)_3$ **(B)** 0.1 M Na_2C[illegible]

(C) 0.2 M $KMnO_4$ **(D)** 0.3 M $C_6H_{12}O_6$

19. Which statement is correct at 25°C and 1 atm pressure?

(A) ΔG°_f for Hg(l) = 0 kJ·mol^{-1}

(B) ΔH°_f for I_2(g) = 0 kJ·mol^{-1}

(C) ΔH°_f for H_2O(l) = 0 kJ·mol^{-1}

(D) S° for O_2(g) = 0 J·mol^{-1}·K^{-1}

20. What is the relationship among the magnitudes of the enthalpies of combustion (ΔH_{comb}), fusion (ΔH_{fus}) and vaporization (ΔH_{vap}) for a hydrocarbon such as hexane, C_6H_{14}?

(A) $\Delta H_{fus} < \Delta H_{comb} < \Delta H_{vap}$

(B) $\Delta H_{vap} < \Delta H_{fus} < \Delta H_{comb}$

(C) $\Delta H_{comb} < \Delta H_{vap} < \Delta H_{fus}$

(D) $\Delta H_{fus} < \Delta H_{vap} < \Delta H_{comb}$

21. Which choice represents the signs for ΔS and ΔH for the sublimation of a compound that is occurring at constant temperature?

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

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

22. Determine ΔH_{rxn} for this reaction in kJ·mol^{-1}

$2NH_3(g) + \frac{5}{2}O_2(g) \rightarrow 2NO(g) + 3H_2O(g)$.

ΔH°_f, kJ·mol^{-1}	
H_2O(g)	–241.8
NH_3(g)	–46.1
NO(g)	90.3

(A) –105.4 **(B)** –226.3 **(C)** –452.6 **(D)** –637.0

23. The enthalpy of fusion for NaF(s) at its melting point (992°C) is 29.3 kJ·mol^{-1}. What is the value of ΔS_{fus}° in J·mol^{-1}·K^{-1}?

(A) 43.2 **(B)** 33.9 **(C)** 29.5 **(D)** 23.2

24. For the reaction at 25°C,

$C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$ $K_p = 5.67\times10^7$

What is ΔG° for this reaction in kJ·mol^{-1}?

(A) –0.436 **(B)** –3.71 **(C)** –19.2 **(D)** –44.2

25. What is the rate law for a reaction, $A + 2B \rightarrow C$, based on the rate data?

$[A]_o$, mol·L^{-1}	$[B]_o$, mol·L^{-1}	Initial Rate, mol·L^{-1}·min^{-1}
0.20	0.10	300
0.40	0.30	3600
0.80	0.30	14400

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

(C) Rate = k[A]^2[B] **(D)** Rate = k[A]^2[B]^3

26. For the irreversible reaction; A → B, which graph gives a straight line for a reaction that is second order in A?

(A) [A] vs. time **(B)** 1 / [A] vs. time

(C) [A]^2 vs. time **(D)** 1 / [A]^2 vs. time

27. A sample of a radioactive element that contains 1.0×10^3 nuclei decays to 6.2×10^1 nuclei in 10. minutes. What is its specific decay constant?

(A) 6.2 min^{-1} **(B)** 1.2 min^{-1}

(C) 0.28 min^{-1} **(D)** 0.062 min^{-1}

28. The oxidation of SO_2 to H_2SO_4 in acid rain is thought to occur by the following mechanism.

$SO_2(aq) + 2H_2O(l) \rightarrow HSO_3^-(aq) + H_3O^+(aq)$
$2HSO_3^-(aq) + O_2(aq) \rightarrow S_2O_7^{2-}(aq) + H_2O(l)$
$S_2O_7^{2-}(aq) + 3H_2O(l) \rightarrow 2SO_4^{2-}(aq) + 2H_3O^+(aq)$

Which species in this mechanism can be given the following designations?

	reactant	catalyst	intermediate
(A)	$SO_2(aq)$	$H_2O(l)$	$HSO_3^-(aq)$, $H_3O^+(aq)$
(B)	$SO_2(aq)$	$HSO_3^-(aq)$	$S_2O_7^{2-}(aq)$
(C)	$SO_2(aq)$, $H_2O(l)$	$S_2O_7^{2-}(aq)$	$HSO_3^-(aq)$
(D)	$SO_2(aq)$, $H_2O(l)$	none	$HSO_3^-(aq)$, $S_2O_7^{2-}(aq)$

29. For the reaction; $H_2(g) + I_2(g) \rightarrow 2HI(g)$, the rate law is Rate = k$[H_2][I_2]$.
Which of the mechanisms given is consistent with this rate law?

I.		**II.**	
$I_2 \rightleftharpoons I + I$	(fast)	$I_2 \rightleftharpoons I + I$	(slow)
$H_2 + I + I \rightarrow 2HI$	(slow)	$H_2 + I + I \rightarrow 2HI$	(fast)

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

(C) Either I or II **(D)** Neither I nor II

30. The rate of a reaction at 100°C is four[illegible]at 50°C. What is its activation energy?

(A) 1152 kJ·mol^{-1} **(B)** 80.1 kJ·m[illegible]

(C) 54.0 kJ·mol^{-1} **(D)** 27.8 kJ·mol^{-1}

31. The equilibrium system, $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, has $K_p = 11$. For which equilibrium system is $K_p = 0.091$?

(A) $2NO_2(g) \rightleftharpoons N_2O_4(g)$ **(B)** $NO_2(g) \rightleftharpoons 1/2\,N_2O_4(g)$

(C) $2N_2O_4(g) \rightleftharpoons 4NO_2(g)$ **(D)** $1/2\,N_2O_4(g) \rightleftharpoons NO_2(g)$

32. A 1.0 L evacuated tank is charged with HI(g) to a pressure of 1.0 atm at 793K. Some of the HI(g) forms H_2 (g) and I_2(g) according to the equilibrium;

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ $K_p = 0.016$

What is the pressure (in atm) of HI at equilibrium?

(A) 0.11 **(B)** 0.13 **(C)** 0.80 **(D)** 1.6

33. A solution of 0.10 M NaZ has a pH = 8.90. What is the K_a of HZ?

(A) 1.6×10^{-4} **(B)** 1.6×10^{-5}

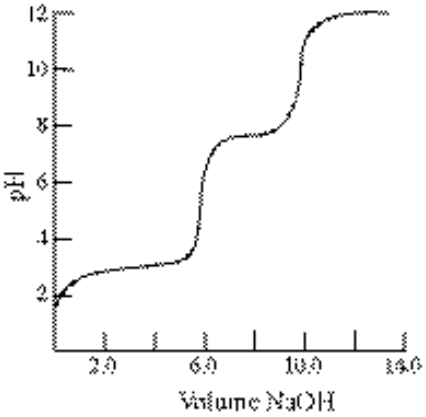
(C) 6.3×10^{-10} **(D)** 6.3×10^{-11}

34. What is the pH of a solution made by adding 0.41g of $NaC_2H_3O_2$ to 100. mL of 0.10 M $HC_2H_3O_2$?

Molar mass, g·mol^{-1}	
$NaC_2H_3O_2$	82.0
K_a	
$HC_2H_3O_2$	1.8×10^{-5}

(A) 4.44 **(B)** 4.70 **(C)** 5.05 **(D)** 8.95

35. The curve represents the titration of



(A) a diprotic acid.

(B) two monoprotic acids with the same K_as but different concentrations.

(C) two monoprotic acids with different K_as but the same concentrations.

(D) two monoprotic acids with different K_as and different concentrations.

36. Which silver compound is the most soluble in water?

(A) AgCl $K_{sp} = 1.8\times10^{-10}$

(B) Ag_2CO_3 $K_{sp} = 8.5\times10^{-12}$

(C) AgBr $K_{sp} = 5.4\times10^{-13}$

(D) Ag_3PO_4 $K_{sp} = 8.9\times10^{-17}$

37. When connected to a Standard Hydrogen Electrode (SHE) electrons flow from an unknown half cell to the SHE. Which statement is correct?

(A) The unknown half cell is the anode.

(B) Oxidation occurs at the SHE.

(C) E°_{red} for the unknown half cell is positive.

(D) E°_{cell} is negative.

38. Given these standard reduction potentials, what is the standard reduction potential for $Co^{3+}(aq) + 3e^- \rightarrow Co(s)$?

$Co^{3+}(aq) + e^- \rightarrow Co^{2+}(aq)$	$E^\circ = 1.82$ V
$Co^{2+}(aq) + 2e^- \rightarrow Co(s)$	$E^\circ = -0.28$ V

(A) 2.10 V **(B)** 1.54 V

(C) 1.26 V **(D)** 0.42 V

39. The cell

$Al(s) \mid Al^{3+}(aq, 0.001\ M) \mid\mid Cu^{2+}(aq, 0.10\ M) \mid Cu(s)$

has a standard cell potential, $E^\circ = 2.00$ V. What is the cell potential for this cell at the concentrations given?

(A) 2.07 V **(B)** 2.03 V **(C)** 1.97 V **(D)** 1.94 V

40. Ethanol reacts with dichromate ions in acid solution according to the equation;

$C_2H_5OH(l) + Cr_2O_7^{2-}(aq) + H^+(aq) \rightarrow CO_2(g) + Cr^{3+}(aq) + H_2O(l)$

What is the coefficient for $H^+(aq)$ when this equation is balanced with the smallest whole number coefficients?

(A) 10 **(B)** 12 **(C)** 14 **(D)** 16

41. Given these standard reduction potentials, what is the free energy change (in $kJ\cdot mol^{-1}$) for the reaction

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

$Ag^+(aq) + e^- \rightarrow Ag(s)$	$E^\circ = 0.80$ V
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	$E^\circ = -0.13$ V

(A) –180 **(B)** –90 **(C)** 90 **(D)** 180

42. Chromium metal can be produced by the electrolysis of molten CrO_3. What current in amperes operating for 100 minutes is needed to produce 104 grams of this metal?

(A) 193 **(B)** 96.5 **(C)** 64.3 **(D)** 32.2

43. What is the frequency of light with a wavelength of 480 nm?

(A) 1.60×10^{-6} s^{-1} **(B)** 6.25×10^{-1} s^{-1}

(C) 6.25×10^{14} s^{-1} **(D)** 1.44×10^{20} s^{-1}

44. Which set of quantum numbers (n,l, m_l) is forbidden?

(A) 3, 2, 0 **(B)** 3, 1, –1

(C) 2, 0, 0 **(D)** 1, 1, 0

45. Which characteristic of an atomic orbital is most closely associated with the magnetic quantum number, m_l?

(A) size **(B)** shape

(C) occupancy **(D)** orientation

46. Which element exhibits the successive ionization energies given in the table?

Ionization Energy, $kJ\cdot mol^{-1}$	
1st	738
2nd	1451
3rd	7733
4th	10540
5th	13628

(A) Na **(B)** Mg **(C)** Al **(D)** Si

47. The energies of the 3s, 3p and 3d orbitals in a multi-electron atom increase in that order. To which factor(s) can this order be attributed?

I. the relative penetrations of these orbitals near the nucleus

II. the relative average distance of the electron from the nucleus

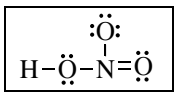
(A) I only **(B)** II only

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

48. Which element has the highest first ionization energy?

(A) Al **(B)** Si **(C)** P **(D)** S

49. What is the formal charge on the nitrogen atom in HNO_3?



(A) 0 **(B)** +1 **(C)** +3 **(D)** +5

50. Which substance has the greatest lattice energy?

(A) CaO **(B)** KCl **(C)** MgI_2 **(D)** BaS

51. Given the bond energies, what is the ΔH_f° $N_2H_4(g)$ in $kJ\cdot mol^{-1}$?

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

Bond Energies, $kJ\cdot mol^{-1}$	
N≡N	946
N=N	418
N–N	163
N–H	389
H–H	436

(A) 156 **(B)** 99 **(C)** –99 **(D)** –156

52. Which species has a trigonal planar geometry?

(A) ClF_3 **(B)** NCl_3 **(C)** CO_3^{2-} **(D)** I_3^-

53. Which of the molecules listed have an sp^3 hybridized central atom?

I. PCl_3
II. $COCl_2$
III. SF_4

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

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

54. How many isomers exist for a square planar platinum compound which has four different groups attached to the platinum atom?

(A) one **(B)** two **(C)** three **(D)** four

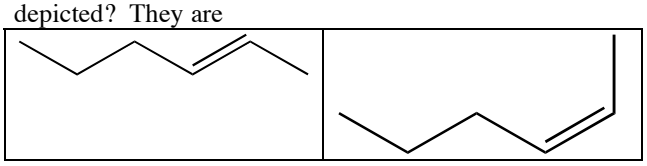
55. Molecules of which type(s) do not contain a C = O bond?

I. amide
II. amine
III. ether
IV. ester

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

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

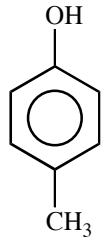
56. What is the relationship between the two molecules depicted? They are

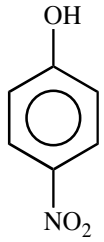


(A) identical. **(B)** geometric isomers.

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

57. For which compound is the –OH group the most acidic?

(A) 

(B) 

(C) $CH_3CH_2CH_2OH$ **(D)** $(CH_3)_3COH$

58. The most notable difference between a saturated fat and an unsaturated fat containing the same number of carbon atoms is that the saturated fat

(A) melts at a higher temperature.

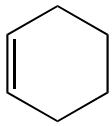
(B) melts at a lower temperature.

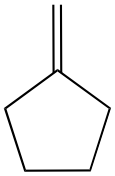
(C) releases much more energy when metabolized.

(D) releases much less energy when metabolized.

59. Which C_6H_{10} isomer is the least stable?

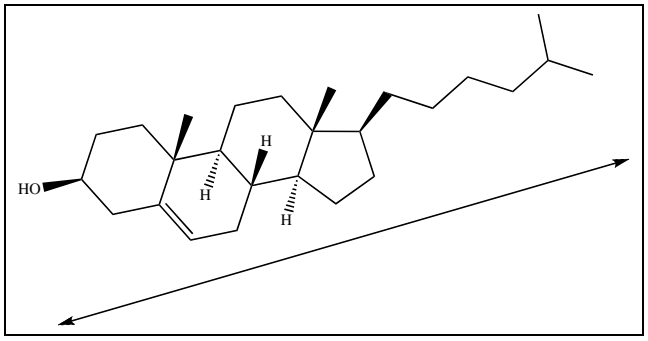
(A) 

(B) 

(C) 

(D) 

60. The structure of cholesterol is shown.



What is the approximate length of this molecule (as indicated by the scale bar)? (1 Å = 1×10^{-10} m)

(A) 1.75 Å **(B)** 17.5 Å

(C) 175 Å **(D)** 1750 Å

END OF TEST

Olympiad 2009 National Exam Part 1

KEY

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

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