2010 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

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 26, 2010, 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 statement before leaving the testing site today.**

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

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

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** (266)	107 **Bh** (264)	108 **Hs** (277)	109 **Mt** (268)	110 **Ds** (281)	111 **Rg** (272)	112 Uub (277)	113 (Uut)	114 (Uuq)	115 (Uup)	116 (Uuh)	117 (Uus)	118 (Uuo)

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

DIRECTIONS

- When you have selected your answer to each question, blacken the corresponding space on the answer sheet using a soft, #2 pencil. Make a heavy, full mark, but no stray marks. If you decide to change an answer, erase the unwanted mark very carefully.
- There is only one correct answer to each question. Any questions for which more than one response has been blackened **will not be counted**.
- Your score is based solely on the number of questions you answer correctly. **It is to your advantage to answer every question.**

1. A student prepares a 100 mL aqueous solution containing a small amount of $(NH_4)_2SO_4$ and a second 100 mL solution containing a small amount of NaI, then mixes the two solutions. Which statement describes what happens?

(A) Both compounds dissolve and remain in solution when the two solutions are mixed.

(B) Both compounds dissolve initially but NH_4I precipitates when the solutions are mixed.

(C) Both compounds dissolve initially but Na_2SO_4 precipitates when the solutions are mixed.

(D) The NaI dissolves but the $(NH_4)_2SO_4$ does not. There is no change upon mixing.

2. A colored gas is observed with which combination?

(A) calcium hydride and water

(B) lead metal and nitric acid

(C) sodium carbonate and sulfuric acid

(D) zinc sulfide and hydrochloric acid

3. Mixing which pair of 0.10 M solutions produces two precipitates that cannot be separated from one another by filtration?

(A) aluminum chloride and copper(II) nitrate

(B) strontium bromide and lead(II) acetate

(C) magnesium perchlorate and lithium carbonate

(D) barium hydroxide and copper(II) sulfate

4. Which gas turns limewater, a saturated solution of $Ca(OH)_2$, cloudy?

(A) H_2 **(B)** O_2 **(C)** CO_2 **(D)** CH_4

5. For aqueous solutions of which of the following substances could the concentration be determined by visible spectrophotometry?

I $Cr(NO_3)_3$ II $KMnO_4$ III $Zn(NO_3)_2$

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

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

6. Four elements were tested in the laboratory and gave the results in the table below. Which element is a metalloid?

Element	Appearance	Conductivity	Behavior with HCl
A	Slight luster	High	Bubbles slowly
B	Shiny	Low	No reaction
C	Dull	None	No reaction
D	Shiny	High	Bubbles rapidly

(A) Element A **(B)** Element B

(C) Element C **(D)** Element D

7. What is the molarity of Na^+ ions in a solution made by dissolving 4.20 g of $NaHCO_3$ (M = 84.0) and 12.6 g of Na_2CO_3 (M = 126) in water and diluting to 1.00 L?

(A) 0.050 M **(B)** 0.100 M

(C) 0.150 M **(D)** 0.250 M

8. Which solute has the greatest solubility (in mol/L) in water at 25 ˚C and 1 atm?

(A) CH_4 **(B)** NH_3 **(C)** AgCl **(D)** $CaSO_4$

9. Which 2.00 M solution can be used to separate Al^{3+} from Fe^{3+} in an aqueous solution?

(A) HCl **(B)** H_2SO_4 **(C)** NaCl **(D)** NaOH

10. The percent composition of the high explosive HNS is

C	H	N	O
37.35%	1.34%	18.67%	42.65%

The molar mass of HNS is 450.22. What is the molecular formula of HNS?

(A) $C_{13}H_4N_7O_{12}$ **(B)** $C_{14}H_6N_6O_{12}$

(C) $C_{15}H_{10}N_6O_{11}$ **(D)** $C_{16}H_{12}N_5O_{11}$

11. A student prepares four 0.10 M solutions, each containing one of the solutes below. Which solution has the lowest freezing point?

(A) $CaCl_2$ **(B)** KOH

(C) $NaC_2H_3O_2$ **(D)** NH_4NO_3

12. What is the molarity of a hydrochloric acid solution if 20.00 mL of it neutralizes 18.46 mL of a 0.0420 M $Ba(OH)_2$ solution?

(A) 0.0194 M **(B)** 0.0388 M

(C) 0.0455 M **(D)** 0.0775 M

13. Ar and He are both gases at room temperature. How do the average molecular velocities (V) of their atoms compare at this temperature?

(A) $V_{He} = 10V_{Ar}$ **(B)** $V_{Ar} = 10V_{He}$

(C) $V_{He} = 3V_{Ar}$ **(D)** $V_{Ar} = 3V_{He}$

14. Lithium reacts with water to produce hydrogen gas and lithium hydroxide. What volume of hydrogen collected over water at 22˚C and 750 mm Hg pressure is produced by the reaction of 0.208 g of Li? [VP_{H2O} = 19.8 mm Hg]

(A) 367 mL **(B)** 378 mL

(C) 735 mL **(D)** 755 mL

15. Correct statements about samples of ice and liquid water at 0 ˚C include which of the following?

I Molecules in ice and liquid water have the same kinetic energy.
II Liquid water has a greater entropy than ice.
III Liquid water has a greater potential energy than ice.

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

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

16. A sample of a volatile liquid is introduced to an evacuated container with a movable piston. Which change occurs as the piston is raised? (Assume some liquid remains.)

I The fraction of the molecules in the gas phase increases
II The pressure in the container decreases

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

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

17. The kinetic energy of the molecules in a sample of H_2O in its stable state at –10 ˚C and 1 atm is doubled. What are the initial and final phases?

(A) solid → liquid **(B)** liquid → gas

(C) solid → gas **(D)** solid → solid

18. Barium metal crystallizes in a body-centered cubic lattice with barium atoms only at the lattice points. If the density of barium metal is 3.50 g/cm^3, what is the length of the unit cell?

(A) 3.19×10^{-8} cm **(B)** 4.02×10^{-8} cm

(C) 5.07×10^{-8} cm **(D)** 6.39×10^{-8} cm

19. Calculate ΔE when one mole of liquid is vaporized at its boiling point (80 ˚C) and 1 atm pressure.

[ΔH_{vap} = 30.7 kJ/mol]

(A) 33.6 kJ **(B)** 31.4 kJ **(C)** 30.0 kJ **(D)** 27.8 kJ

20. Use the following data to calculate the molar enthalpy of combustion of ethane, C_2H_6.

$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l)$ $\Delta H = -2511$ kJ/mol
$C_2H_2(g) + 2H_2(g) \rightarrow C_2H_6(g)$ $\Delta H = -311$ kJ/mol
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta H = -484$ kJ/mol

(A) –1428 kJ/mol **(B)** –2684 kJ/mol

(C) –2856 kJ/mol **(D)** –3306 kJ/mol

21. A 10.00 g piece of metal is heated to 80.00 ˚C and placed in 100.0 g of water at 23.00 ˚C. When the system has reached equilibrium the temperature of the water and metal are 23.50 ˚C. What is the identity of the metal? [Specific heat capacity of H_2O = 4.184 J/g ˚C]

(A) Ag (C_p 0.236 J/g ˚C) **(B)** Cu (C_p 0.385 J/g ˚C)

(C) Fe (C_p 0.449 J/g ˚C) **(D)** Al (C_p 0.901 J/g ˚C)

22. For a reaction at constant pressure to be spontaneous, which relationship must be correct?

(A) $\Delta H_{rxn} < 0$ **(B)** $\Delta G_{rxn} < 0$

(C) $\Delta S_{rxn} < 0$ **(D)** $\Delta S_{univ} < 0$

23. Tungsten is obtained commercially by the reduction of WO_3 with H_2 according to the equation:

$WO_3(s) + 3\ H_2(g) \rightarrow W(s) + 3\ H_2O(g)$

The following data related to this reaction at 25 ˚C are available.

	$WO_3(s)$	$H_2O(g)$
ΔH˚ kJ/mol	–840.3	–241.8
ΔG˚ kJ/mol	–763.5	–228.5

The temperature at which this reaction is at equilibrium at 1 atm is closest to which of the following?

(A) 124 K **(B)** 213 K **(C)** 928 K **(D)** 2810 K

24. The gaseous compound NOBr decomposes according to the equation

$NOBr(g) \rightleftharpoons NO(g) + 1/2\ Br_2(g)$

At 350 K the equilibrium constant, K_p, is 0.15. What is the value of ΔG˚?

(A) -5.5×10^3 J/mol **(B)** -2.4×10^3 J/mol

(C) 2.4×10^3 J/mol **(D)** 5.5×10^3 J/mol

25. The rate of decomposition of a certain compound in solution is first order. If the concentration of the compound is doubled, what happens to the reaction's half-life?

(A) It doubles

(B) It decreases to ½ of the original value

(C) It decreases to ¼ of the original value

(D) It remains the same

26. Consider the reaction: $2\ ICl(g) + H_2(g) \rightarrow 2\ HCl(g) + I_2(g)$
At a certain temperature the rate constant is found to be 1.63×10^{-6} L/mol·s. What is the overall order of the reaction?

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

27. For the reaction: $N_2O_4(g) \rightarrow 2\ NO_2(g)$
the number of moles of $N_2O_4(g)$ is

Time, min	0	5	10
Moles $N_2O_4(g)$	0.200	0.170	0.140

What is the number of moles of $NO_2(g)$ at t = 10 min? (Assume moles of $NO_2(g)$ = 0 at t = 0.)

(A) 0.280 **(B)** 0.120 **(C)** 0.110 **(D)** 0.060

28. A compound decomposes with a first-order rate constant of 0.00854 s^{-1}. Calculate the concentration after 5.0 minutes for an initial concentration of 1.2 M.

(A) 0.010 M **(B)** 0.093 M

(C) 0.92 M **(D)** 1.1 M

29. Ozone in the earth's atmosphere decomposes according to the equation: $2\ O_3(g) \rightarrow 3\ O_2(g)$
This reaction is thought to occur via the two-step mechanism:
Step 1 $O_3(g) \rightleftharpoons O_2(g) + O(g)$ Fast, reversible
Step 2 $O_3(g) + O(g) \rightarrow 2\ O_2(g)$ Slow
What rate law is consistent with this mechanism?

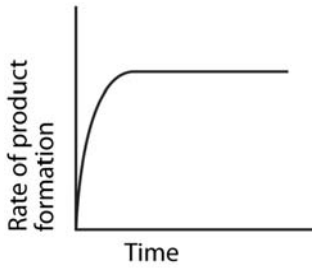
(A) $-\Delta[O_3]/\Delta t = k[O_3]$

(B) $-\Delta[O_3]/\Delta t = k[O_3]^2$

(C) $-\Delta[O_3]/\Delta t = k[O_3]^2/[O_2]$

(D) $-\Delta[O_3]/\Delta t = k[O_3]^2/[O_2]^3$

30.



The rates of many substrate reactions catalyzed by enzymes vary with time as shown. Which factor(s) best account(s) for the constant reaction rate after a certain time?
I The enzyme's active sites are filled.
II The amount of substrate is constant.

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

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

31. Consider the system at equilibrium:

$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g) \quad \Delta H > 0$

Factors which favor the formation of more $H_2S(g)$ include which of the following?

I adding a small amount of $NH_4HS(s)$ at constant volume

II increasing the pressure at constant temperature

III increasing the temperature at constant pressure

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

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

32. A 2.0 L container is charged with a mixture of 6.0 moles of CO(g) and 6.0 moles of $H_2O(g)$ and the following reaction takes place:
$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$
When equilibrium is reached the $[CO_2]$ = 2.4 M. What is the value of K_c for the reaction?

(A) 16 **(B)** 4.0 **(C)** 0.25 **(D)** 0.063

33. Determine *K* for the reaction:
$H_2C_2O_4(aq) + 2OH^-(aq) \rightarrow C_2O_4^{2-}(aq) + 2\ H_2O(l)$

$H_2C_2O_4(aq)$ $K_{a1} = 6.5 \times 10^{-2}$ $K_{a2} = 6.1 \times 10^{-5}$
H_2O $K_w = 1.0 \times 10^{-14}$

(A) 4.0×10^{-34} **(B)** 4.0×10^{-6}

(C) 4.0×10^{6} **(D)** 4.0×10^{22}

34. Which range includes the value of the equilibrium constant, K_{eq}, for a system with $\Delta G^\circ << 0$?

(A) $-1 < K_{eq} < 0$ **(B)** $0 < K_{eq} < 1$

(C) $K_{eq} < -1$ **(D)** $1 < K_{eq}$

35. What volumes of 0.200 M HNO_2 and 0.200 M $NaNO_2$ are required to make 500. mL of a buffer solution with pH = 3.00? [K_a for $HNO_2 = 4.00 \times 10^{-4}$]

(A) 250. mL of each

(B) 143 mL of HNO_2 and 357 mL of $NaNO_2$

(C) 200. mL of HNO_2 and 300. mL of $NaNO_2$

(D) 357 mL of HNO_2 and 143 mL of $NaNO_2$

36. A sample of sparingly soluble $PbI_2(s)$ containing radioactive I-133 is added to 0.10 M KI(aq) and stirred overnight. Observations about this system include which of the following?

I The radioactivity of the liquid phase increases significantly.

II The concentration of the I^- ion in solution increases significantly.

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

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

37. An unknown metal, M, and its salt, $M(NO_3)_2$, are combined with a half-cell in which the following reaction occurs:

$Ag^+(aq) + e^- \rightarrow Ag(s)$ [$E^\circ_{red} = 0.80$ V]

If $E^\circ_{cell} = 1.36$ V, what is E°_{red} for $M^{2+}(aq) + 2e^- \rightarrow M(s)$?

(A) 0.56 V **(B)** 0.24V **(C)** –0.24V **(D)** –0.56V

38. Given the standard reduction potentials:

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	$E^\circ = 1.23$ V
$Br_2 + 2e^- \rightarrow 2Br^-$	$E^\circ = 1.08$ V
$2H^+ + 2e^- \rightarrow H_2$	$E^\circ = 0.00$ V
$Na^+ + e^- \rightarrow Na$	$E^\circ = -2.71$ V

What products are formed in the electrolysis of 1 M NaBr in a solution with $[H_3O^+] = 1$ M?

(A) Na(s) and $O_2(g)$ **(B)** Na(s) and $Br_2(g)$

(C) $H_2(g)$ and $Br_2(g)$ **(D)** $H_2(g)$ and $O_2(g)$

39. According to the standard reduction potentials:

$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	$E^\circ = -0.13$ V
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	$E^\circ = -0.44$ V
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	$E^\circ = -0.76$ V

Which species will reduce Mn^{3+} to Mn^{2+} [$E^\circ = 1.51$ V] but will NOT reduce Cr^{3+} to Cr^{2+} [$E^\circ = -0.40$ V]?

(A) Pb only **(B)** Zn only

(C) Pb and Fe only **(D)** Pb, Fe, and Zn

40. $Zn(s) / Zn^{2+}(aq) // H^+(aq) / H_2(g)$ $E^\circ = 0.76$ V

What must be the pH in the hydrogen compartment of the cell designated above if the cell voltage is 0.70 V? (Assume that both the $[Zn^{2+}]$ and the $H_2(g)$ pressure are at standard values and T = 25 °C.)

(A) 0.51 **(B)** 1.01 **(C)** 2.50 **(D)** 3.21

41. The equilibrium constant, K, is 2.0×10^{19} for the cell

$Ni(s) / Ni^{2+}(aq) // Hg_2^{2+}(aq) / Hg(l)$

The value of E° at 25 °C for this cell is closest to

(A) –1.14V **(B)** –0.57V **(C)** 0.57V **(D)** 1.14V

42. In a battery with a zinc anode, what is the minimum mass of zinc required if a current of 250 mA is drawn for 12.0 minutes?

(A) 0.0610 g **(B)** 0.122 g

(C) 0.244 g **(D)** 1.02 g

43. Which set of quantum numbers (n, ℓ, m_ℓ, m_s) is possible for the outermost electron in a strontium atom in its ground state?

(A) 5, 0, 0, –1/2 **(B)** 5, 0, 1, 1/2

(C) 5, 1, 0, 1/2 **(D)** 5, 1, 1, –1/2

44. How many orbitals are in an f sublevel ($\ell = 3$)?

(A) 3 **(B)** 5 **(C)** 7 **(D)** 14

45. What is the energy of photons with a wavelength of 434 nm?

(A) 2.76×10^5 kJ/mol **(B)** 2.76×10^2 kJ/mol

(C) 2.76×10^{-1} kJ/mol **(D)** 2.76×10^{-4} kJ/mol

46. In which choice are the species listed in order of increasing radius?

(A) Na^+, Mg^{2+}, Al^{3+} **(B)** Cl^-, S^{2-}, P^{3-}

(C) Ar, K^+, Cl^- **(D)** Cl^-, Ar, K^+

47. Which element has the highest melting point?

(A) Na **(B)** K **(C)** Mg **(D)** Ca

48. Which element forms a compound with the formula H_3XO_4?

(A) As **(B)** Cl **(C)** N **(D)** S

49. Which molecule contains the smallest F-S-F angle?

(A) SF_2 **(B)** SOF_2 **(C)** SO_2F_2 **(D)** SF_6

50. Which species has the longest N–O bond?

(A) NO **(B)** NO^+ **(C)** NO_2 **(D)** NO_2^+

51. How many pi bonds and how many lone pairs are in the Lewis structure of hydrazine, N_2H_4?

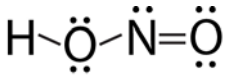
(A) 2 pi bonds, 0 lone pairs

(B) 1 pi bond, 0 lone pairs

(C) 1 pi bond, 1 lone pair

(D) 0 pi bonds, 2 lone pairs

52. In the Lewis structure of nitrous acid:



What is the formal charge on nitrogen?

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

53. How many isomers of octahedral $Co(NH_3)_3Cl_3$ are there?

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

54. The bond angle in H_2O is approximately 105˚ while the bond angle in H_2S is approximately 90˚. Which explanation best accounts for this difference?

(A) H–S bonds are longer than H–O bonds.

(B) H–S bonds are less polar than H–O bonds.

(C) S has d orbitals available for bonding, O does not.

(D) O uses sp^3 hybrid orbitals for bonding, S uses its 3p orbitals.

55. Which compound exists in optically active forms?

(A) $CH_3CFCClCH_3$ **(B)** $CH_2FCH_2CH_2Cl$

(C) $CH_2FCHClCH_3$ **(D)** $CHF_2CH_2CH_2Cl$

56. What product results when 2-butene reacts with chlorine?

(A) 2-chlorobutane **(B)** 1,2-dichlorobutane

(C) 2,2-dichlorobutane **(D)** 2,3-dichlorobutane

57. Which chloroalkane undergoes substitution with OH^- exclusively by an S_N1 mechanism?

(A) $(CH_3)_2CHCH_2Cl$ **(B)** $(CH_3)_3CCl$

(C) $CH_3CH_2CHClCH_3$ **(D)** $CH_3CH_2CH_2CH_2Cl$

58. Which is a monosaccharide?

(A) fructose **(B)** lactose

(C) maltose **(D)** sucrose

59. All of the following statements concerning benzene, C_6H_6, are correct EXCEPT

(A) Each carbon atom forms three sigma bonds.

(B) Each carbon is sp^2 hybridized.

(C) Pi electrons are delocalized over all 6 carbon atoms.

(D) Benzene forms cis and trans isomers when it reacts.

60. Which functional group is not commonly found in nucleic acids?

(A) alcohol **(B)** amine

(C) carboxylic acid **(D)** dialkyl phosphate

END OF TEST

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National Exam Part I

KEY

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