

# 2025 U.S. NATIONAL CHEMISTRY OLYMPIAD LOCAL SECTION EXAM

Prepared by the American Chemical Society Chemistry Olympiad Examinations Task Force

### **OLYMPIAD EXAMINATIONS TASK FORCE**

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#### DIRECTIONS TO THE EXAMINER

This test is designed to be taken with an answer sheet on which the student records their responses. All answers are to be marked on that sheet, not written in the booklet. Each student should be provided with an answer sheet and scratch paper, both of which must be turned in with the test booklet at the end of the examination. Local Sections may use an answer sheet of their own choice.

The full examination consists of 60 multiple-choice questions representing a fairly wide range of difficulty. A periodic table and other useful information are provided on page two of this exam booklet for student reference.

Only non-programmable calculators are to be used on the ACS Local Section exam. The use of a programmable calculator, cell phone, or any other device that can access the internet or make copies or photographs during the exam is grounds for disqualification.

Suggested Time: 60 questions-110 minutes

#### DIRECTIONS TO THE EXAMINEE

#### DO NOT TURN THE PAGE UNTIL DIRECTED TO DO SO.

This is a multiple-choice examination with four choices for each question. There is only one correct or best answer to each question. When you select your choice, blacken the corresponding space on the answer sheet with your pencil. Make a heavy full mark, but no stray marks. If you decide to change your answer, be certain to erase your original answer completely.

	CONSTANTS					
amount of substance	n	Faraday constant	F	molar mass	M	
ampere	Α	free energy	G	mole	mol	$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
atmosphere	atm	frequency	ν	Planck's constant	h	$R = 0.08314 \text{ L bar mol}^{-1} \text{ K}^{-1}$
atomic mass unit	u	gas constant	R	pressure	Р	$F = 96,500 \text{ C mol}^{-1}$
Avogadro constant	$N_{ m A}$	gram	g	rate constant	k	$F = 96500 \text{ J V}^{-1} \text{ mol}^{-1}$
Celsius temperature	°C	hour	h	reaction quotient	Q	
centi– prefix	c	joule	J	second	s	$N_{\rm A} = 6.022 \times 10^{23}  {\rm mol}^{-1}$
coulomb	С	kelvin	Κ	speed of light	С	$h = 6.626 \times 10^{-34} \text{ J s}$
density	d	kilo– prefix	k	temperature, K	Т	$c = 2.998 \times 10^8 \text{ m s}^{-1}$
electromotive force	E	liter	L	time	t	
energy of activation	$E_{\mathrm{a}}$	measure of pressure	mm Hg	vapor pressure	VP	$0 {}^{\circ}\mathrm{C} = 273.15 \mathrm{K}$
enthalpy	H	milli– prefix	m	volt	V	1  atm = 1.013  bar = 760  mm Hg
entropy	S	molal	m	volume	V	Specific heat capacity of $H_2O =$
equilibrium constant	K	molar	М			$4.184 \text{ J g}^{-1} \text{ K}^{-1}$

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

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#### 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.** How many nitrogen atoms are present in 486 g of  $N_2O_5$ ?

(A) $1.35 \times 10^{24}$	<b>(B)</b>	$2.71\times10^{24}$
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- (C)  $5.42 \times 10^{24}$  (D)  $1.90 \times 10^{25}$
- **2.** What is the empirical formula of a compound that is 50% S and 50% O by mass?

(A)	SO	<b>(B</b> )	$S_2O$
(C)	$SO_2$	<b>(D</b> )	$S_2O_3$

**3.** How much chlorine is required to completely consume 13.5 g of aluminum to form aluminum chloride?

(A)	13.5 g	<b>(B</b> )	26.6 g
( <b>C</b> )	40.5 g	<b>(D</b> )	53.2 g

**4.** A solution of 0.500 L of 0.150 M KI is mixed with 0.250 L of 0.200 M CaI<sub>2</sub>. What is the concentration of iodide in the final solution?

(A)	0.167 M	<b>(B)</b>	0.175 M
( <b>C</b> )	0.233 M	<b>(D</b> )	0.275 M

**5.** The only source of copper in an ore sample is the mineral malachite,  $Cu_2CO_3(OH)_2$  (M = 221.1). A 1.00 kg sample of this ore is smelted to obtain 47.0 g of metallic copper. Assuming a complete recovery of the copper, what percentage by mass of the ore is malachite?

(A)	4.70%	<b>(B)</b>	8.18%
( <b>C</b> )	16.4%	<b>(D</b> )	32.8%

6. Which aqueous solution has the highest boiling point when 10.00 g of the substance is dissolved in 100.0 g of water?

(A)	$H_2SO_4$	<b>(B)</b>	$Li_2SO_4$

- (C)  $Na_2SO_4$  (D)  $MgSO_4$
- 7. Which compound could be used to remove Ca<sup>2+</sup> from hard water?

<b>(A)</b>	LiCl	<b>(B)</b>	Na <sub>2</sub> CO <sub>3</sub>
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 $(C) KNO_3 \qquad (D) K_2SO_4$ 

**8.** Addition of silver nitrate solution to 1.0 M solutions of which compounds will result in a yellow precipitate?

	I. NaCl	II. KI
(A)	I only	( <b>B</b> ) II only
( <b>C</b> )	Both I and II	( <b>D</b> ) Neither I nor II

- **9.** A student is cleaning a buret in preparation for a titration in which the buret will be filled with 0.100 M NaOH. What should be used for the final rinse of the buret?
  - (A) Ethanol (B) Distilled water
  - (C) 0.100 M HCl (D) 0.100 M NaOH
- **10.** In which solvent does solid iodine dissolve to give a purple solution?
  - (A) Water (B) Ethanol
  - (C) Carbon tetrachloride (D) 0.1 M aqueous KI
- **11.** Which glassware would be most suitable for preparing a 0.1500 M solution of silver nitrate?
  - (A) 50 mL volumetric flask
  - (B) 50 mL round-bottom flask
  - (C) 50 mL Erlenmeyer flask
  - (D) 50 mL graduated cylinder

**(A)** 

**(C)** 

**12.** A 2.00 g sample of NaHCO<sub>3</sub>(s) is heated in a 10.00 g crucible to drive off H<sub>2</sub>O and CO<sub>2</sub>. The mass data in the table were collected by heating the crucible and then periodically letting it cool to room temperature and reweighing it. Which is the first measurement after which heating could have been stopped?

Measurement	Mass of	of crucible and
		solid
0		12.00 g
1		11.48 g
2		11.24 g
3		11.25 g
4		11.24 g
Measurement 1	<b>(B)</b>	Measurement 2
Measurement 3	<b>(D</b> )	Measurement 4

13. 1.53 g of a gas occupies a volume of 264 mL at 722 mm Hg and 22 °C. What is the molecular formula of the gas?

$(\mathbf{A})  \mathbf{C}_2\mathbf{F}_6 \qquad \qquad (\mathbf{B}$	) $C_3HF_5$
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$(\mathbf{C})  \mathbf{C}_{3}\mathbf{HF}_{5}\mathbf{O} \qquad \qquad (\mathbf{D})  \mathbf{C}_{3}$
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14. A mole of which gas will have a volume closest to 22.4 L at 0 °C and 1 atm pressure?

(A)	$H_2$	<b>(B)</b>	$CO_2$
· /	-		2

( <b>C</b> )	$SF_6$	<b>(D</b> )	Xe
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15. Two identical steel cylinders at the same temperature contain equal masses of CO(g) and  $C_2H_2(g)$ . Which quantities will be greater for the cylinder containing  $C_2H_2?$ 

I. Pressure	II. Average molecular velocity
(A) I only	<b>(B)</b> II only

- (C) Both I and II (D) Neither I nor II
- 16. The critical point of carbon dioxide is 31.0 °C and 72.8 atm. Which best describes the composition of a sample of pure CO<sub>2</sub> at 29.0 °C and 75 atm?
  - (A) Only gaseous CO<sub>2</sub> is present.
  - **(B)** Only liquid  $CO_2$  is present.
  - (C) A mixture of gaseous  $CO_2$  and liquid  $CO_2$  is present.
  - (**D**) Only supercritical  $CO_2$  is present.
- 17. The normal boiling point of ethane  $(C_2H_6)$  is -88.5 °C, while the normal boiling point of fluoromethane (CH<sub>3</sub>F) is -78.4 °C. A difference in which type of intermolecular forces is most responsible for the higher boiling point of fluoromethane?
  - (A) London dispersion forces
  - (B) Dipole-dipole interactions
  - (C) Ion-dipole interactions
  - (D) Hydrogen bonding
- 18. Cadmium metal crystallizes in a hexagonal closest packed structure. How many nearest neighbors does a cadmium atom have in this structure?

( <b>A</b> ) 4	<b>(B)</b> 6	(C) 8	<b>(D)</b> 12
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**19.** The standard enthalpy of fusion of 1,4-dichlorobenzene is 18.2 kJ mol<sup>-1</sup> and its standard entropy of fusion is 55.3 J mol<sup>-1</sup> K<sup>-1</sup>. What is the melting point of 1,4dichlorobenzene?

(A)	37.1 °C	<b>(B)</b>	56.0	$^{\circ}C$
· /				

(C) 101 °C **(D)** 329 °C **20.** What is  $\Delta H^{\circ}_{rxn}$  for the gas-phase reaction of ethene and fluorine shown below?

 $C_2H_4(g) + 6 F_2(g) \rightarrow 2 CF_4(g) + 4 HF(g)$  $\Delta H^{\circ}_{\rm rxn} = ???$ 

	Substance	$\Delta H^{\circ}_{\rm f}$ , kJ mol <sup>-1</sup>	
	$C_2H_4(g)$	52.4	
	$CF_4(g)$	-679.0	
	$\mathrm{HF}(g)$	-273.3	
( <b>A</b> ) –2	2503.6 kJ mol <sup>-1</sup>	( <b>B</b> ) −1004.7 kJ n	nol-1

- 1004.7 kJ mol<sup>-1</sup> 2503.6 kJ mol<sup>-1</sup> **(C) (D)**
- 21. Which reactions are spontaneous under standard conditions?

I. 
$$N_2H_4(l) \rightarrow N_2(g) + 2 H_2(g)$$
  $K_p = 1.4 \times 10^{26}$ 

II. 
$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$$
  $K_p = 7.0 \times 10^{-9}$ 

- (A) I only (**B**) II only
- (C) Both I and II (**D**) Neither I nor II
- 22. Solid gallium melts at 29.8 °C with an enthalpy of fusion of 5.59 kJ mol<sup>-1</sup>. The heat capacity of solid gallium is 26.1 J mol<sup>-1</sup> K<sup>-1</sup> and the heat capacity of liquid gallium is 28.5 J mol<sup>-1</sup> K<sup>-1</sup>. If equal masses of solid gallium at 20.0 °C and liquid gallium at 60.0 °C are mixed in a wellinsulated container, what is the temperature after the mixture has attained equilibrium?

(A) 29.8 °C	( <b>B</b> ) 40.0 °C
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- (C) 40.4 °C (**D**) 40.9 °C
- **23.** What is the  $K_{sp}$  of AgBr at 298 K?

			_
		Species	$\Delta G^{\circ}_{\rm f} (298 \text{ K}),$ kJ mol <sup>-1</sup>
		$Ag^{+}(aq)$	77.1
		Br(aq)	-102.8
		AgBr(s)	-96.9
(A)	3.3	× 10 <sup>-13</sup>	<b>(B)</b> $3.1 \times 10^{-14}$
(C)	1.0	× 10 <sup>-17</sup>	<b>(D)</b> $3.2 \times 10^{-22}$

24. For a chemical reaction under conditions where it is at equilibrium, which statements must be true?

I. $\Delta S_{\rm rxn} > 0$	II. $\Delta G_{\rm rxn} = 0$
(A) I only	( <b>B</b> ) II only
(C) Both I and II	( <b>D</b> ) Neither I nor II

**25.** When iodate ion reacts with iodide ion in acidic solution, which statement about how concentrations are changing is correct?

 $IO_{3}(aq) + 8 I(aq) + 6 H(aq) \rightarrow 3 I_{3}(aq) + 3 H_{2}O(l)$ (A)  $8 \frac{\Delta[I]}{\Delta t} = 3 \frac{\Delta[I_{3}]}{\Delta t}$  (B)  $8 \frac{\Delta[I]}{\Delta t} = -3 \frac{\Delta[I_{3}]}{\Delta t}$ (C)  $3 \frac{\Delta[I]}{\Delta t} = 8 \frac{\Delta[I_{3}]}{\Delta t}$  (D)  $3 \frac{\Delta[I]}{\Delta t} = -8 \frac{\Delta[I_{3}]}{\Delta t}$ 

- **26.** For the irreversible reaction between CO(g) and  $Cl_2(g)$  to form  $COCl_2(g)$ , the rate law is Rate =  $k[CO][Cl_2]$ . In an experiment where equimolar quantities of CO(g) and  $Cl_2(g)$  are reacted, which of the following would change linearly with reaction time?
  - (A)  $\ln([CO])$  (B)  $\ln([COCl_2])$
  - (C) 1/[CO] (D) 1/[COCl<sub>2</sub>]
- 27. A sample containing radium-226 was measured in 1925 to have an activity of  $3.74 \times 10^6$  disintegrations per second. The same sample, re-measured in 2025, has an activity of  $3.58 \times 10^6$  disintegrations per second. What is the half-life of <sup>226</sup>Ra?

(A)	620 years	<b>(B)</b>	1200 years
(C)	1600 years	<b>(D</b> )	2300 years

**28.** The rate constant for the addition of pyridine to an iridium compound is measured at a variety of temperatures, and the variation of  $\ln(k)$  with 1/T is shown below. What is the activation energy of this reaction?



**29.** Cyclopropane is proposed to isomerize to propene through an intermediate diradical as shown below. The overall reaction is observed to follow the rate law Rate = k[cyclo-C<sub>3</sub>H<sub>6</sub>]. If  $k_2$  is much smaller than  $k_{-1}$ , what is the value of *k* in terms of  $k_1$ ,  $k_{-1}$ , and  $k_2$ ?

$$cyclo-C_{3}H_{6} \xleftarrow{k_{1}} \bullet CH_{2}CH_{2}CH_{2}\bullet$$
$$\bullet CH_{2}CH_{2}CH_{2}\bullet \xleftarrow{k_{2}} CH_{3}CH=CH_{2}$$
(A)  $k_{1}$  (B)  $k_{1}/k_{-1}$ 
(C)  $k_{1}k_{2}$  (D)  $k_{1}k_{2}/k_{-1}$ 

**30.** The reaction of  $MnO_4^-(aq)$  and  $H_2C_2O_4(aq)$  in acidic solution is autocatalytic because one of the products,  $Mn^{2+}(aq)$ , is a reducing agent. Starting from a mixture of reactants, which of the following graphs best shows how the concentration of  $MnO_4^-(aq)$  changes over time?



31. Which statements must be correct at equilibrium?

- I. The rate constants for the forward and reverse reactions are equal.
- II. The rates of the forward and reverse reactions are equal.
- (A) I only (B) II only
- (C) Both I and II (D) Neither I nor II
- **32.** What is the equilibrium constant expression for the reaction below?

 $\operatorname{AgCl}(s) + 2 \operatorname{NH}_3(aq) \rightleftharpoons \operatorname{Ag}(\operatorname{NH}_3)_2^+(aq) + \operatorname{Cl}^-(aq)$ 

(A) 
$$K_{\text{eq}} = \frac{[\text{AgCl}][\text{NH}_3]}{[\text{Ag(NH}_3)_2^+][\text{Cl}^-]}$$
 (B)  $K_{\text{eq}} = \frac{[\text{AgCl}][\text{NH}_3]^2}{[\text{Ag(NH}_3)_2^+][\text{Cl}^-]}$ 

(C) 
$$K_{eq} = \frac{[Ag(NH_3)_2^+][Cl^-]}{[AgCl][NH_3]^2}$$
 (D)  $K_{eq} = \frac{[Ag(NH_3)_2^+][Cl^-]}{[NH_3]^2}$ 

**33.** Phosphoric acid has  $pK_a$  values of  $pK_{a1} = 2.15$ ,  $pK_{a2} = 7.20$ , and  $pK_{a3} = 12.35$ . Which species is most abundant at pH = 11.5?

(A) $H_3PO_4$	<b>(B)</b>	$H_2PO_4$
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(C)  $HPO_4^{2-}$  (D)  $PO_4^{3-}$ 

- **34.** A buffer is made by mixing 0.900 mol Na[CH<sub>3</sub>CO<sub>2</sub>] and 0.500 mol HCl in enough water to make 2.50 L of solution. What is the pH of this solution? The  $pK_a$  of CH<sub>3</sub>COOH is 4.75.
  - **(A)** 4.49 **(B)** 4.65
  - (C) 4.85 (D) 5.01
- **35.** A sealed container with a volume of 1.00 L contains an equilibrium mixture of  $N_2O_4(g)$  and  $NO_2(g)$  at a given temperature. Which quantities will increase if the volume of the container is increased to 2.00 L while maintaining the same temperature?
  - I. The number of moles of  $NO_2(g)$
  - II. The partial pressure of  $NO_2(g)$
  - (A) I only (B) II only
  - (C) Both I and II (D) Neither I nor II
- **36.** A solution is 0.05 M in each of the anions fluoride (F<sup>-</sup>), carbonate (CO<sub>3</sub><sup>2-</sup>), and phosphate (PO<sub>4</sub><sup>3-</sup>). As calcium ion is added slowly to this solution, in what order will the solids precipitate? The  $K_{sp}$  values are: CaF<sub>2</sub>, 3.9 × 10<sup>-11</sup>; CaCO<sub>3</sub>, 3.8 × 10<sup>-9</sup>; Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>, 1.0 × 10<sup>-25</sup>.
  - (A) First  $CaF_2$ , then  $CaCO_3$ , then  $Ca_3(PO_4)_2$
  - (B) First  $CaF_2$ , then  $Ca_3(PO_4)_2$ , then  $CaCO_3$
  - (C) First  $Ca_3(PO_4)_2$ , then  $CaF_2$ , then  $CaCO_3$
  - (**D**) First  $Ca_3(PO_4)_2$ , then  $CaCO_3$ , then  $CaF_2$
- **37.** What is the average oxidation state of iron in halotrichite,  $FeAl_2(SO_4)_4 \cdot 22 H_2O$ ?
  - (A) 0 (B) +2 (C) +2.5 (D) +3
- **38.** Which half-reaction takes place at the anode during electrolysis of aqueous sodium iodide?
  - (A)  $\operatorname{Na}^+(aq) + e^- \rightarrow \operatorname{Na}(s)$
  - **(B)**  $2 \operatorname{H}_2\operatorname{O}(l) + 2 e^- \rightarrow \operatorname{H}_2(g) + 2 \operatorname{OH}^-(aq)$
  - (C)  $2 \operatorname{I}^{-}(aq) \rightarrow \operatorname{I}_{2}(s) + 2 e^{-1}$
  - **(D)**  $2 \operatorname{H}_2\operatorname{O}(l) \to \operatorname{O}_2(g) + 4 \operatorname{H}^+(aq) + 4 e^-$
- **39.** In an electrochemical cell, the reaction shown below occurs. Which changes will decrease the cell potential?

 $\operatorname{Fe}^{2+}(aq) + \operatorname{Ag}^{+}(aq) \rightarrow \operatorname{Fe}^{3+}(aq) + \operatorname{Ag}(s)$ 

- I. Decreasing the concentration of  $Fe^{2+}(aq)$
- II. Increasing the size of the silver electrode
- (A) I only (B) II only
- (C) Both I and II (D) Neither I nor II

- **40.** 180 mL of a solution that is 0.024 M in both AgNO<sub>3</sub> and Cu(NO<sub>3</sub>)<sub>2</sub> is electrolyzed with a current of 0.70 A for 350 s. What deposits on the cathode?
  - (A) Ag only
  - $(\mathbf{B})$  Cu only
  - (C)  $2.5 \times 10^{-3}$  mol Ag and some Cu
  - **(D)**  $2.5 \times 10^{-3}$  mol Cu and some Ag
- **41.** What is the standard potential of a fuel cell where methanol is oxidized to carbon dioxide and oxygen is reduced to water?

Half-reaction		$E^{\circ}, V$
$\begin{array}{c} \mathrm{CO}_2(g) + 6 \ \mathrm{H}^+(aq) + 6 \ e^- \rightarrow \\ \mathrm{CH}_3\mathrm{OH}(l) + \mathrm{H}_2\mathrm{O}(l) \end{array}$		-0.02
$O_2(g) + 4 H^+(aq) + 4 e^- \rightarrow 2 H_2O(l)$		1.23
(A) 0.30 V	( <b>B</b> ) 0.31 V	
(C) 1.21 V	<b>(D)</b> 1.25 V	

- **42.** The half-cell potential at 298 K for the reduction of an oxoanion becomes more negative by 0.118 V for each increase of 1 pH unit. How many protons and electrons are involved in this half-reaction?
  - (A) 1 proton, 1 electron (B) 1 proton, 2 electrons
  - (C) 2 protons, 1 electron (D) 3 protons, 2 electrons
- 43. Which atom has the smallest first ionization energy?
  - (A) Mg (B) Al (C) Si (D) P
- 44. How many electrons in a ground-state atom of uranium (U) have the principal quantum number n = 4?
  - (A) 4 (B) 16 (C) 18 (D) 32
- **45.** Which property of a photon is directly proportional to its frequency?
  - (A) Energy (B) Momentum<sup>-</sup>
  - (C) Velocity (D) Wavelength
- **46.** Photoelectron spectroscopy of Ar provides information about which properties of Ar?
  - I. Ionization energy II. Electronic subshell structure
  - (A) I only (B) II only
  - (C) Both I and II (D) Neither I nor II

- 47. Which statements about fluorine are correct?
  - I. It has the highest electronegativity of any element.
  - II. Its electron affinity is the largest in magnitude of any element.
  - (A) I only (B) II only
  - (C) Both I and II (D) Neither I nor II
- **48.** Thorium-232 decays by emission first of an alpha particle, then of a beta particle, then of a second beta particle, and then of a second alpha particle. What is the daughter nucleus after the fourth disintegration?

(A) $^{228}$ Th	<b>(B)</b> $^{228}$ Ac
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- (C)  $^{224}$ Ra (D)  $^{224}$ Rn
- 49. Which molecule is trigonal planar?

(A) 
$$NH_3$$
 (B)  $NF_3$  (C)  $SO_3$  (D)  $ClF_3$ 

**50.** Which molecule has the shortest N–O bond?

(A) NO (B) NO<sub>2</sub> (C) N<sub>2</sub>O (D) N<sub>2</sub>O<sub>4</sub>

- **51.** How many lone pairs are there in the Lewis structure of nitromethane, CH<sub>3</sub>NO<sub>2</sub>?
  - (A) 3 (B) 4 (C) 5 (D) 7
- 52. Which is the strongest acid in aqueous solution?
  - (A)  $NH_4^+$  (B)  $H_2O$  (C)  $PH_4^+$  (D)  $H_2S$
- **53.** Which is the best representation of the three-dimensional arrangement of the atoms in thionyl fluoride, SOF<sub>2</sub>?



- 54. Which ion is diamagnetic?
  - (A)  $Fe(CN)_6^{4-}$  (B)  $CoCl_4^{2-}$
  - (C)  $Ni(H_2O)_6^{2+}$  (D)  $Cu(NH_3)_4^{2+}$
- **55.** What is the relationship between the two alcohols?



(C) Diastereomers

**56.** In ethinylestradiol, shown below, how many  $sp^2$ -hybridized and *sp*-hybridized carbons are there?



- **57.** Which statement most accurately describes the most stable conformation of cyclohexane?
  - (A) All six carbon atoms are in the same plane.
  - (**B**) All bond angles are  $109.5^{\circ}$ .
  - (C) All hydrogens are eclipsed relative to the hydrogen atoms on adjoining carbons.
  - (D) The carbon-carbon bonds alternate between short and long distances.
- **58.** The tertiary alcohol 2-methyl-2-propanol reacts with concentrated aqueous hydrochloric acid at 0 °C to form 2-chloro-2-methylpropane. How is the mechanism of this reaction best described?
  - (A)  $S_N 1$  (B)  $S_N 2$  (C) E1 (D) E2
- **59.** Which statement most accurately describes the properties of ketones and esters?
  - (A) Ketones are weak acids; esters are strong acids.
  - (B) Ketones react by nucleophilic addition; esters react by nucleophilic substitution.
  - (C) Ketones are readily reduced; esters are readily oxidized.
  - (D) The carbonyl group of a ketone is resonance stabilized; the carbonyl group of an ester is not resonance stabilized.
- 60. Which is not found in a typical nucleic acid?

(A) Carboxylic acid

- (**B**) Dialkyl phosphate
- (C) Heterocyclic base (D) Five-carbon sugar

### **END OF TEST**

(**D**) Identical

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## Olympiad 2025 USNCO Local Section Exam KEY

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